Article

List of Orchid Species along the Northern Trekking Route of Mount Binaiya, Seram Island, Maluku - Indonesia

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Abstract

Orchidaceae is widely distributed on Earth with major distribution in the tropical regions, including Indonesia. Seram Island located in Maluku Province Indonesia has a high potential to become a habitat for various species of Australasian orchids. Orchid diversity tends to be related to altitude variations in the area that indirectly contribute to creating microclimate variations. One area on Seram Island with various variations in altitude is Mount Binaiya within the Manusela National Park area. This study aims to identify orchid species found on Mount Binaiya. The exploration method was used on the northern trekking route of Mount Binaiya, divided into Waisamata, Kanikeh, Waiansela, and Waihuhu areas. Based on the result, 47 species of orchids were obtained, which belong to the subfamilies Epidendroideae (35 species), Orchidoideae (11 species), and Vanilloideae (1 species). Based on the life form, 25 species were epiphytes, while 22 species were terrestrial orchids. Waisamata had the highest number of species (23 species), followed by Waiansela (14 species), Waihuhu (14 species), and Kanikeh (8 species). Of all these species, some that need further research are *Corybas spp., Cyrtosia nana, Pterostylis papuana, Glomera papuana*, and *Mediocalcar pygmaeum*. Some species are new records in their distribution or rediscoveries of existing records.

Keywords: *Australasian Orchidoideae; mycotrophic; Kanikeh; Orchidaceae; Waihuhu; Waisamata*

1. Introduction

Indonesia is a tropical country that has biodiversity hotspots with conservation priority (Myers et al., 2000). This shows that Indonesia is a country with high species endemicity. In plants, the family of Orchidaceae or orchids is a plant family that has a high level of endemicity with more than 25,000 orchid species distributed worldwide (Chase et al., 2015). Kusmana & Hikmat (2015) reported that Indonesia has around 4,000 orchid species, most of which are endemic. One of the factors that cause the high endemicity of orchids in Indonesia is the arrangement of islands and variations in land elevation in Indonesia which become a natural geographical barrier to the distribution of orchids.

Orchids have many factors that limit their distribution. In addition to geographical barriers, the distribution of orchids is also influenced by the presence of mycorrhizae, pollinators, and seed dispersal agents. Mycorrhizae is a major limiting factor because most orchid species have symbiosis with mycorrhizae, either with generalist or specialist mycorrhizae (Davis et al., 2015; Jacquemyn et al., 2015; Suetsugu et al., 2021). Mycorrhizae provide minerals, nutrients, and even organic compounds in exchange for carbohydrates and other metabolites produced by orchids (Alghamdi, 2019; T. Li, Yang, et al., 2021) through specific metabolites signaling since the early phase of seed germination (Favre-Godal et al., 2020). The holomycoheterotrophic orchid species such as

achlorophyllous orchids, the presence of mycorrhiza is absolutely necessary from the seed germination process, as in Epipogium, Gastrodia, Erythrorchis, (Ogura-Tsujita et al., 2018).

The other factor is the pollinator. Orchids have various pollination mechanisms, particularly by animals such as butterflies, bees, ants, and even birds (Luo et al., 2021). Without the presence of pollinators, orchids would be ecologically extinct because they could not increase population size and dispersal. In addition, the interaction of orchids with pollinators is also one of the mechanisms that cause explosive speciation in orchids (Han et al., 2022). Some orchids in particular areas with limited potential pollinators tend to develop self-compatibility, such as at the top of the mountain or under the shade of a forest floor where insect-pollinators are limited (Suetsugu, 2013). Orchids also require the assistance of seed dispersal agents to reach more areas. Orchid seeds are very small and lightweight, because they have very little (even none) endosperm, so the seeds consist only of embryos and testa (Favre-Godal et al., 2020; Suetsugu et al., 2015). Therefore, orchid dispersal agents are dominated by wind. However, some orchids that cannot be spread by the wind, especially the one with a fleshy fruit orchid. Cyrtosia is a genus of orchids with fleshy fruits that has avian as its seed dispersal agent (Suetsugu et al., 2015).

The main islands with a large diversity of orchids in Indonesia are Sumatra, Kalimantan, Java, Sulawesi, and Papua, so there has been a lot of research done in the area. Maluku Province is one of the regions with insufficient orchid diversity data, even though the variety of orchid habitats in Maluku is relatively diverse, both to support the existence of epiphytic orchids and terrestrial orchids. Epiphytic orchids are orchids that grow attached to other trees, while terrestrial orchids grow above the ground. Some terrestrial orchids are geophytic with tubers residing in the soil.

Seram Island, Maluku, is an island dominated by mountains, so it has many variations in microclimate. Orchids have pan-tropical distribution and are strongly influenced by microclimates as the impact of elevation (Kurniawan et al., 2020; T. Li, Wu, et al., 2021). Elevation occurs structurally in mountain topography. Each mountain elevation will have distinctive vegetation in response to physical and chemical factors. The interaction between vegetation with physical and chemical parameters will form a microclimate that is by the adaptation of orchids leads to speciation (Bertolini et al., 2000; T. Li, Wu, et al., 2021) or development of plastic characteristics (Wijaya et al., 2020).

The highest area on Seram Island is Mount Binaiya with a height of 3,027 m.asl. which is included in the Manusela National Park area. Manusela National Park is located at E: 129°9'3" - 129°46'14" and S: 2°48'24" - 3°18'24" and has various types of ecosystems, such as marine ecosystems, beach formation, mangroves, swamps, lowland forests, and highland forests. Mount Binaiya is an area with several types of ecosystems that can be observed on trekking routes, thus providing a more varied spectrum in forming niches of various organisms, including orchids. Then, this research aimed to identify the orchid species in Mount Binaiya to increase the awareness of orchid diversity and forest conservation.

2. Materials and Methods

3.1 Study Site

The research was conducted in May – December 2014, with intensive field data collection in May to June. The study site can be divided to four main areas: (1) Waisamata, a low – middle elevation forest that dominated by wet soil and river; (2) Kanikeh, a traditional village at the foot of Mount Binaiya; (3) Waiansela, a dense forest with some waterfall and swift water flow; and (4) Waihuhu, a dense forest filled with mosses.

3.2 Data Collection

Data collection using an explorative method based on Rugayah et al. (2004) along the northern routes of Mount Binaiya with a 10 m radius of observation. The species name and its distribution were recorded. The dried and spirit specimens were made for further identification of unidentified species. The identification was held on the field and continued in the Laboratory of Plant Systematics, Faculty of Biology, Universitas Gadjah Mada, collaborating with the Biology Research Center, Indonesian Institute of Science (LIPI – BRIN). Some of the specimens were deposited at Herbarium Bogoriense, Indonesia.

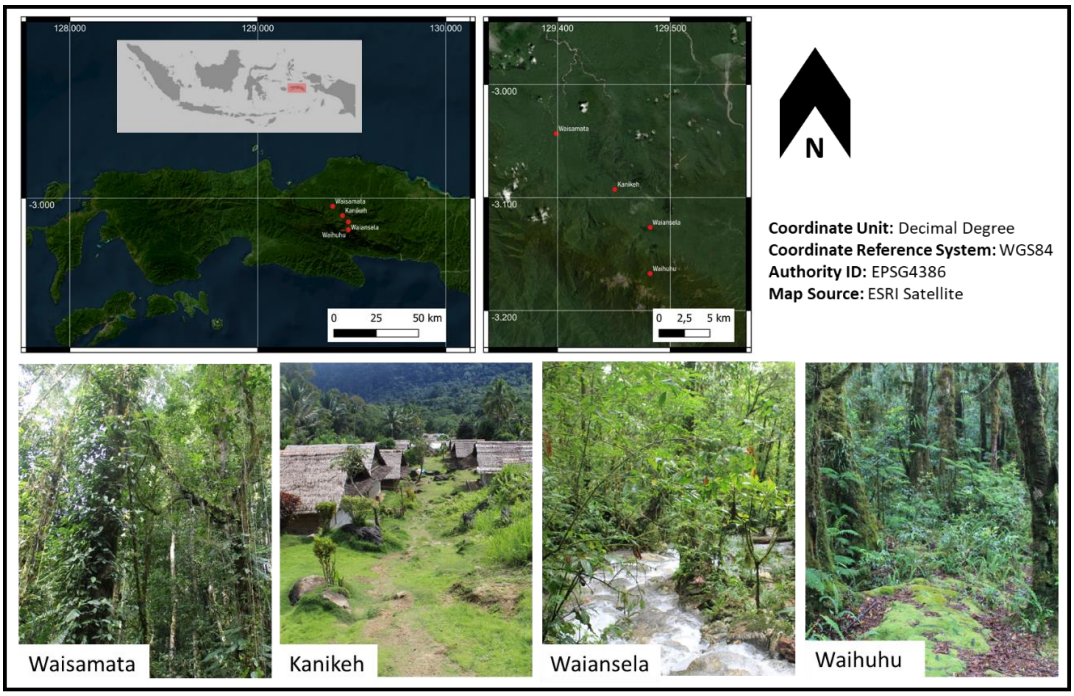

Figure 1. The research location in Mount Binaiya

Dried specimens were made by collecting the plant parts (mainly with flower, leaves, and stem) as samples, tagged with hanging labels, and placed on brown paper. The samples were then stacked and put in a plastic bag and filled with 70% alcohol until all the samples were wet by alcohol. The plastic bag were sealed and stored for about 2 months until laboratory processing. In the laboratory, the samples removed from the plastic bag and placed in the new brown paper, and then stacked. The samples stack following the arrangement of plywood, cardboard, 3 samples, cardboard, 4 samples, cardboard, and plywood. The arrangement samples were then tied up tighly, and dryed in the oven about 7 days. The dried samples were moved to the herbarium sheet and completed with the new hanging and sticky label.

The spirit specimens are created by cleaning the plant parts (mainly flower or fruit, or all parts of small orchid), then putting the sample in the bottle jam. The 70% alcohol was then poured into the bottle jam until all the plant parts were soaked in alcohol. The lid then closed tightly. The specimens were then added to the sticked label.

3. Results and Discussion

3.1 The orchid diversity of Mount Binaiya

The result of the exploration obtained 47 orchid species that belong in three subfamilies as shown in Table 1 and some documentation in Figure 2. The Epidendroideae is the subfamily with the highest species (35 species), while the other has 11 species in Orchidoideae, and 1 species in Vanilloideae. Among 47 orchid species, 9 species were identified in the genus, while 38 species were identified to species. Based on the lifeform, 25 species were epiphytes and 22 were terrestrials.

The area with the highest species was Waisamata (23 species), followed by Waiansela (14 species), Waihuhu (14 species), and Kanikeh (8 species). Waisamata covers more forest formations, such as riverbanks, swamps, and lowland and highland forests. The diversity in the ecosystem led to the orchid species diversity, both in epiphyte and terrestrial species. The traditional village Kanikeh has the lowest orchid species which might be caused by the traditional land use in the village. Apart of *Agrostophyllum elongatum*, all species in Kanikeh were similar to the species from Waiansela since those areas have quite identical environments except for the land use.

Table 1. The orchid diversity and its distribution in the northern trekking route of Mount Binaiya

Num	Num	Subfamily	Species	Lifeform	Distribution
1	1	Epidendroideae	*Agrostophyllum elongatum* (Ridl.) Schuit.	Ep	KN
2	2	Epidendroideae	*Agrostophyllum javanicum* Blume	Ep	WM
3	3	Epidendroideae	*Brachypeza indusiata* (Rchb.f.) Garay	Ep	WM
4	4	Epidendroideae	*Calanthe rhodochila* Schltr.	Tr	KN; WS
5	5	Epidendroideae	*Calanthe tankervilleae* (Banks) M.W. Chase, Christenh. & Schuit.	Tr	KN; WS
6	6	Epidendroideae	*Calanthe triplicata* (Willemet) Ames	Tr	WM; KN; WS
7	7	Epidendroideae	*Ceratostylis subulata* Blume	Ep	WM
8	8	Epidendroideae	*Coelogyne imbricata* (Hook.) Rchb.f.	Ep	WM
9	9	Epidendroideae	*Coelogyne rumphii* Lindl.	Ep	WM; WS
10	10	Epidendroideae	*Dendrobium anosmum* Lindl.	Ep	WM
11	11	Epidendroideae	*Dendrobium arfakense* J.J.Sm.	Ep	WM
12	12	Epidendroideae	*Dendrobium macrophyllum* A.Rich.	Ep	KN; WS
13	13	Epidendroideae	*Dendrobium odoratum* Schltr.	Ep	WM
14	14	Epidendroideae	*Dendrobium oreodoxa* Schltr.	Ep	WH
15	15	Epidendroideae	*Dendrobium rhipidolobum* Schltr.	Ep	WM
16	16	Epidendroideae	*Epiblastus* sp.	Ep	WH
17	17	Epidendroideae	*Eria javanica* (Sw.) Blume	Ep	WM
18	18	Epidendroideae	*Eulophia cernua* (Willd.) M.W. Chase, Kumar & Schuit.	Tr	WM
19	19	Epidendroideae	*Eulophia nuda* Lindl.	Tr	WM
20	20	Epidendroideae	*Glomera papuana* Rolfe	Ep	WH
21	21	Epidendroideae	*Grammatophyllum scriptum* (L.) Blume	Ep	WM
22	22	Epidendroideae	*Grammatophyllum speciosum* Blume	Ep	WM
23	23	Epidendroideae	*Grosurdya* sp.	Ep	WS
24	24	Epidendroideae	*Liparis bootanensis* Griff.	Tr	WH
25	25	Epidendroideae	*Mediocalcar pygmaeum* Schltr.	Ep	WH
26	26	Epidendroideae	*Mediocalcar* sp.	Ep	WH
27	27	Epidendroideae	*Nervilia concolor* (Blume) Schltr.	Tr	WM
28	28	Epidendroideae	*Nervilia punctata* (Blume) Makino	Tr	WM
29	29	Epidendroideae	*Oberonia equitans* (G.Forst.) Mutel	Ep	WM
30	30	Epidendroideae	*Phreatia densiflora* (Blume) Lindl.	Ep	WS
31	31	Epidendroideae	*Phreatia navicularis* J.J.Sm.	Ep	WH
32	32	Epidendroideae	*Phreatia sulcata* (Blume) J.J.Sm.	Ep	WH
33	33	Epidendroideae	*Pomatocalpa spicatum* Breda	Ep	WS
34	34	Epidendroideae	*Spathoglottis plicata* Blume	Tr	WM; KN; WS
35	35	Epidendroideae	*Tropidia curculigoides* Lindl.	Tr	WM; KN; WS
36	1	Orchidoideae	*Anoectochilus flavescens* Blume	Tr	WM; WS
37	2	Orchidoideae	*Anoectochilus papuanus* (Schltr.) W.Kittr.	Tr	KN; WS

Num	Num	Subfamily	Species	Lifeform	Distribution
38	3	Orchidoideae	*Cheirostylis* sp.	Tr	WS
39	4	Orchidoideae	*Corybas subalpinus* P.Royen	Tr	WH
40	5	Orchidoideae	*Corybas* sp. (1)	Tr	WH
41	6	Orchidoideae	*Corybas* sp. (2)	Tr	WH
42	7	Orchidoideae	*Corybas* sp. (3)	Tr	WH
43	8	Orchidoideae	*Erythrodes blumei* (Lindl.) Schltr.	Tr	WM
44	9	Orchidoideae	*Pterostylis papuana* Rolfe	Tr	WH
45	10	Orchidoideae	*Vrydagzynea* sp. (1)	Tr	WM
46	11	Orchidoideae	*Vrydagzynea* sp. (2)	Tr	WH
47	1	Vanilloideae	*Cyrtosia nana* (Rolfe ex Downie) Garay	Tr	WS

Note: Ep = Epiphyte; Tr = Terrestrial
WM = Waisamata; KN = Kanikeh; WS = Waiansela; WH = Waihuhu

Orchidaceae comprised of five accepted subfamilies: Apostasioideae, Cypripedioideae, Orchidoideae, Epidendroideae, and Vanilloideae (Chase et al., 2015; J. Li et al., 2018). Before this taxonomic revision, there are known for six subfamilies of Orchidaceae composed by Apostasioideae, Cypripedioideae, Orchidoideae, Spiranthoideae, Epidendroideae, and Vandoideae (Dressler, 1981). The subfamily Spiranthoideae merged with Orchidoideae as a new sub-tribe Spiranthinae under the tribe Cranichideae, and Epidendroideae divided into Epidendroideae and Vanilloideae along with the merge of Vandoideae in Epidendroideae. All members of vandoids are known as the Higher Epidendroids group. Among those subfamilies, Epidendroideae is the subfamily with the highest number of species (J. Li et al., 2018).

Calanthe triplicata, *Spathoglottis plicata*, and *Tropidia curculigoides* were the species found in three areas, Waisamata, Waisanhutuni, and Kanikeh, while the other species were only found in one or two areas. Those three species are known for their wide range of vertical distribution, especially in high-humidity area. In orchid nurseries, *C. triplicata* and *S. plicata* were the popular orchid species that are planted as a decorative plant because of their easy growing in various environments and can produce many flowers.

The orchid species that have the highest economic value as decorative plant comes from *Dendrobium* genus (Hinsley et al., 2018). *Dendrobium anosmum* and *D. macrophyllum* were propagated in tissue culture because of its economical value as decorative plants. In its habitat, *D. anosmum* and *D. macrophyllum* have different preferences in evelation. *Dendrobium anosmum* tend to be distributed in lower elevation than *D. macrophyllum,* so *D. anosmum* common to observed as an epiphyte on the local commodity plant such as clove and nutmeg.

Corybas is a genus of terrestrial orchids that are small in size (only a few centimeters) and have habitat preferences in the highlands (Go et al., 2015). On Mount Binaiya, four species of *Corybas* are found in the Waihuhu forest at high altitude on the moss and litter. Of the four species, only one species has been identified up to the species level, *Corybas subalpinus*, while the other three species have yet to be identified. *Corybas* belonging to the 'spider/helmet orchid' group that known to have taxonomic uncertainty with highly variable characters (Lehnebach et al., 2016), so identification is relatively difficult to do. In global, *Corybas* distributed in the Indo-Malaysian-Australasian region, known for their unique morphological traits and mushroom-mimesis pollination hypothesis (Han et al., 2022).

The spiranthoids orchid that has glittering leaf nerves are known as jewel orchids. Some popular genera in jewel orchids are *Anoectochillus, Goodyera, Ludisia, Macodes,* and *Rhomboda*. In this study, one of the jewel orchids found was *Anoectochillus papuanus*. *Anoectochllus papuanus* has blackish-dark green leaves that contrast with stunning red veins. In Mount Binaiya, this species tends to be found solitary, rarely in a cluster. So, although it is found along the Waiansela and Kanikeh, the population size is relatively low. The *Anoectochillus* is characterized by the flower, so some species have a common green

leaf, such as *Anoectochillus flavescens*. Compared with *A. papuanus*, *A. flavescens* prefer in lower elevations and has a wider distribution in Indonesia.

Cyrtosia nana was the only orchid species from Vanilloideae on this trekking route. This species has a unique characteristic because its life form obligately relies on the mycorrhiza. As a holomycoheterothropic orchid species, *C. nana* commonly found on the humid forest floor that is full of leaf litter (Kumar et al., 2018). Waiansela is frequently flooded, thus, this species occupied an area that is secure from the flood but still has a high humidity.

The distribution of *C. nana* in Indonesia was unclear, and this is also the new record of *C. nana* in Maluku. The prior research by Kumar et al. (2018) recorded Taiwan and India as the new distribution area for *C. nana*. Based on the online database, the distribution of *C. nana* was in Assam, China South-Central, China Southeast, Laos, Thailand, and Vietnam (POWO, 2023).

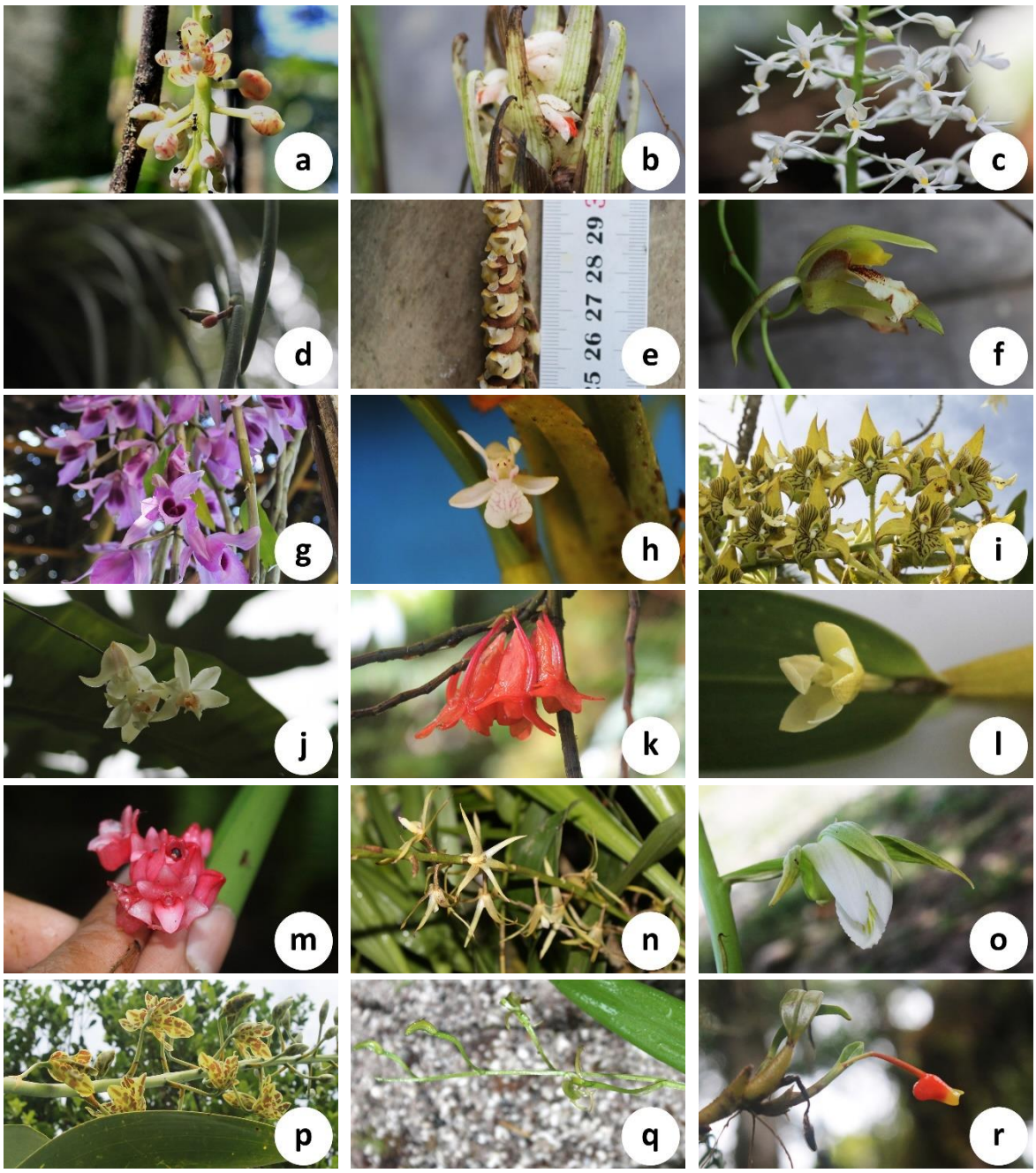

Figure 2. Documentation some of the orchids in Mount Binaiya (a) *Brachipeza indusiata;* (b) *Calanthe rhodochila;* (c) *Calanthe triplicata;* (d) *Ceratostylis subulata;* (e) *Coelogyne imbricata;* (f) *Coelogyne rumphii;* (g) *Dendrobium anosmum;* (h) *Dendrobium arfakense;* (i) *Dendrobium macrophyllum;* (j) *Dendrobium odoratum;* (k) *Dendrobium oreodoxa;* (l) *Dendrobium rhipidolobum;* (m) *Epiblastus* sp.; (n) *Eria javanica;* (o) *Eulophia nuda;* (p) *Grammatophyllum scriptum;* (q) *Liparis bootanensis;* (r) *Mediocalcar* sp.; (s) *Oberonia equitans;* (t) *Phreatia densiflora;* (u) *Phreatia navicularis;* (v) *Phreatia sulcata;* (w) *Pomatocalpa spicatum;* (x) *Spathoglottis plicata;* (y) *Tropidia curculigoides;* (z) *Anoectochilus flavescens;* (aa) *Anoectochilus papuanus;* (ab) *Cheirostylis* sp.; (ac) *Corybas subalpinus;* (ad) *Corybas* sp. (1); (ae) *Corybas* sp. (2); (af) *Corybas* sp. (3); (ag) *Vrydagzynea* sp. (1); (ah) *Vrydagzynea* sp. (2); and (ai) *Cyrtosia nana,*

3.2 The notable orchid species of Mount Binaiya

Some species in Mount Binaiya have its unique values, especially in the newly recorded species and the unidentified species. There is also an updated record of the *Pterostylis papuana* (Fig. 3a-b) with the latest record in 1930 by J.J Smith (Smith, 1930). *Pterostylis* is mainly distributed in Australia, with minor distribution in Eastern Indonesia, Papua New

Guinea, New Caledonia, and New Zealand (Janes & Duretto, 2010). The record of *Pterostylis* occurrence in Indonesia was insufficient since this species is relatively hard to observe due to their specific habitat requirement. Based on the description by Smith (1930), the *P. papuana* in this research might belong to the *P. papuana* var. *seranica*. In addition, Smith (1930) also stated if *P. papuana* var. *seranica* was a species that was categorized as a rare species with limited distribution in Central Maluku, particularly in Mount Binaiya (around 2,750 m. asl. in 1911) and Mount Murkele (around 2,500 m. asl. in 1918).

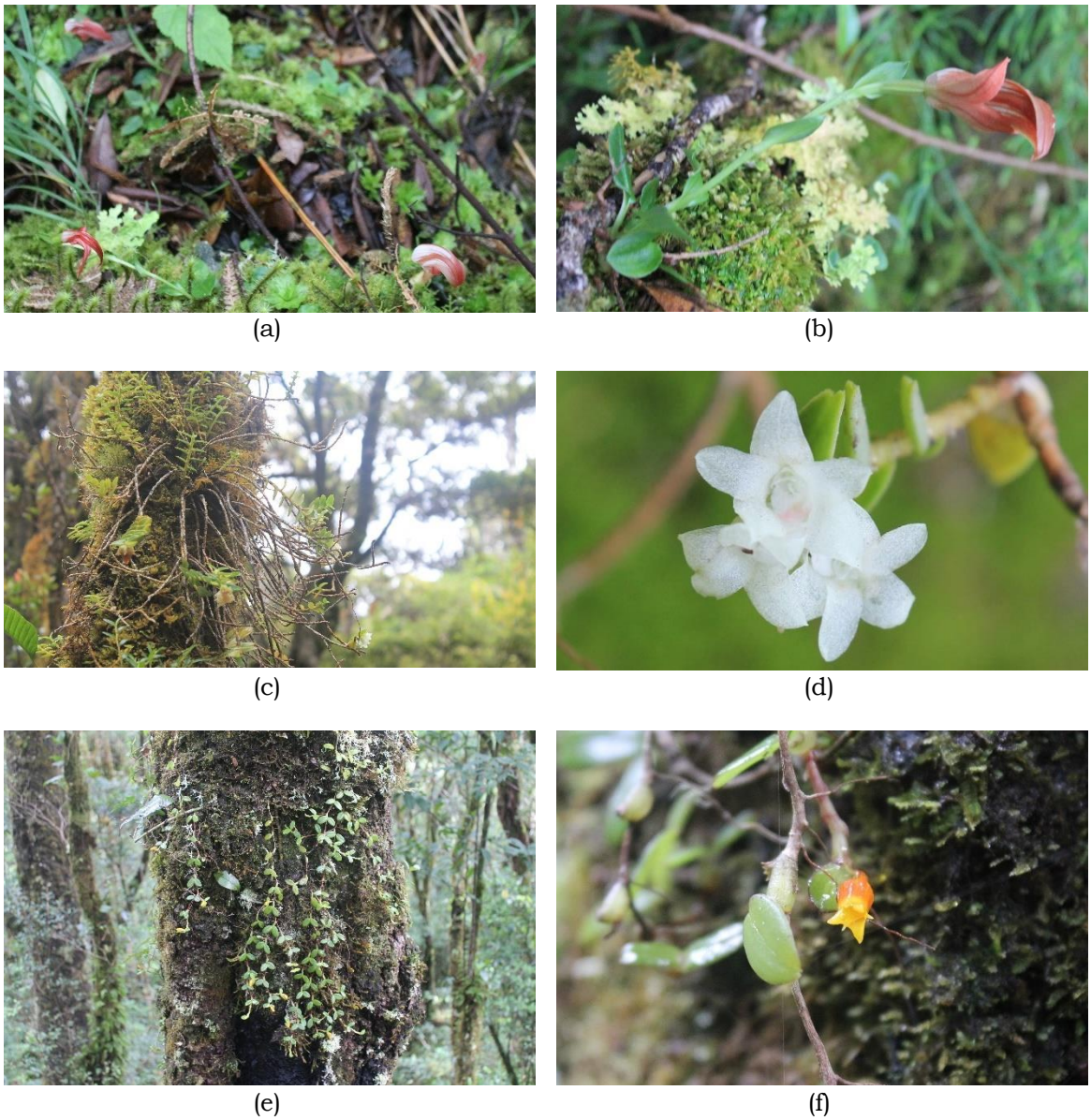

Figure 3. The noteworthy orchid species in Mount Binaiya (a-b) the *Pterostylis papuana* in its habitat; (c) the *Glomera papuana* as an epiphyte on the stem that full with foliose liverworts; (d) the close up of the *Glomera papuana* flower with pinkish color on the labellum; (e) *Mediocalcar pygmaeum* as an epiphyte on the tree; (f) the flower of *Mediocalcar pygmaeum*.

Pterostylis is a genus with a relatively small species composition but very diverse in morphological variation, so this genus is devided to two subgenus: subgenus *Pterostylis* with 3 sections and subgenus *Oligochaetochilus* with 10 sections (Janes & Duretto, 2010). The *P. papuana* belong to the subgenus *Pterostylis* in section *Pterostylis* (Janes & Duretto, 2010) which imply if the *P. papuana* is one of the species types for subgenus and section nomenclature.

Glomera is a genus that belongs in Coelogyninae tribe that is frequently overlooked because of their vegetative appearance resembles a small ericaceous plant. *Glomera* are characterized by elongated and branching stems with many leaves, stems enveloped by

warty sheaths at the base, and ecological features particularly the distribution (Wati et al., 2018). In this study, only one species of *Glomera* was observed, there was *Glomera papuana*. This species occupies the stem of a tree that is covered with moss in montane forest Waihuhu. The occurrence of *G. papuana* in Mount Binaiya is a new record in this species distribution. Based on the digital database by POWO (2023), the *G. papuana* was distributed in Bismarck Archipelago, New Guinea, Papua, and Sulawesi. The record in Maluku can be the bridge that connects the species from Papua to Sulawesi.

Mediocalcar pygmaeum is a new recorded species in Arfak Mountain of West Papua (Schuiteman et al., 2017) and a new recorded species in Maluku. In this research, *M. pygmaeum* only found in montane forest of Waihuhu as an epiphyte on the stem that was filled with mosses (Fig. 3e-f). This microhabitat also correspondence with the annotation from (Schuiteman et al. (2017) that states the *M. pygmaeum* was an epiphyte on logs in disturbed mossy montane forest with 2,100 m. asl. elevation.

4. Conclusions

Orchids in Mount Binaiya are composed of 47 species, classified in 3 subfamilies (35 species in Epidendroideae, 10 species in Orchidoideae, and 1 species in Vanilloideae). Some species have unique scientific value, such as the *Corybas* spp., *Cyrtosia nana*, *Pterostylis papuana*, *Glomera papuana*, and *Mediocalcar pygmaeum*. Lowland rainforest Waisamata is the area with the highest orchid diversity, while the traditional village Kanikeh is the lowest. Further study needs to emphasize the sampling area with a taxonomical study to reveal more orchid species in Mount Binaiya.

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Conflicts of Interest

The authors declare no conflict of interest.

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