BIODIVERSITAS
Volume 23, Number 11, November 2022
Pages: 5962-5972

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d231150

Inventory of orchid diversity in Merauke District, South Papua Province, Indonesia

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Manuscript received: 14 August 2022. Revision accepted: 24 November 2022.

Abstract. *Pammai K, Al Muhdhar MHI, Sari MS, Sueb, Yuhanna WL. 2022. Inventory of orchid diversity in Merauke District, South Papua Province, Indonesia. Biodiversitas 23: 6082-6092.* The Orchidaceae is a family with the highest diversity among flowering plants. One of the regions that have high biodiversity is Papua, Indonesia, with an estimate to have around 2869 species of orchids. Nonetheless, such wealth of diversity might be threatened due to habitat loss caused by regional development, thus periodical assessment might be required to see the status of orchid diversity. This study aims to inventory orchids in Merauke, South Papua as Indonesia's natural wealth. We used an exploratory method, collecting samples and documentation, then analyzing the results qualitatively by identifying orchid species using several literature. The results of this study obtained 65 species. Among the species found, there were 10 endemic species to Papua, 19 species included in the IUCN Red List and 65 species included in the CITES list. When compared with the previous study, we also recorded several species which were not documented in the previous study, although there were several species that were no longer found. The absence of some species is likely due to overexploitation and human activities in the form of land conversion which causes a decrease in orchid habitat and changes in the microclimate. Based on this research, it can be concluded that the forest in Merauke District still has the potential to become a natural orchid habitat. However, it should be noted that some human activities can be the cause of the decline in the orchid population in Papua.

Keywords: Deforestation, exploratory, inventory, Merauke, orchid

INTRODUCTION

Orchids (Orchidaceae) are a family with the largest diversity among flowering plants (Gaskett and Gallagher 2018). Indonesia as a tropical country has a high diversity of orchids (Yuhanna and Hartati 2021) with estimated 4000-5000 species, yet only about 1500 species have been identified (Fardhani et al. 2015; Semiarti et al. 2015). Papua is one of the islands in Indonesia famous for its high and unique flora biodiversity (Vollering et al. 2016). A study estimates that there are about 2,869 orchid species in Papua (Ormerod 2017), most of which are endemic to this island (Lin et al. 2020). Nevertheless, exploration and data collection of orchids in the Indonesian Papua region is relatively limited compared to Papua New Guinea and Java Island, so there are still many Papuan orchid species that are not widely known (Vollering et al. 2016; Ormerod 2014). Data collection needs to be done periodically to monitor changes in the level of diversity of orchid species in the region.

One of the areas in Papua that has a high diversity of natural orchids is Merauke District. Merauke District is located in the easternmost part of the Indonesian Papua which shares a boundary with the state of Papua New Guinea (Pammai et al. 2013). This area has a unique orchid species similar to orchids in Australia and Papua New Guinea (Beasley 2009), however, not much information is available regarding the orchid diversity in Merauke. A study on the biodiversity of orchids in the southern part of Papua, including Merauke, was only able to reveal the taxonomical information of 76% of species, while the remaining 24% were not identified (Agustini et al. 2013).

Research conducted by Burok et al. (2009) revealed that many orchid species in Merauke District have not yet been known in detail, suggesting that further taxonomical work is required. The study also explained that only 10 species of orchids had been domesticated by the communities. Some are sought after by collectors while the rest are considered to have no horticultural and economic value. Pammai et al. (2013) conducted an analysis of orchid diversity in Merauke and found 41 species of orchids, consisting of 4 terrestrial and 37 epiphytic orchids with some of the epiphytic orchids were endemic to Papua and Papua New Guinea. The study also showed that the diversity of orchids in Merauke District was classified in the moderate category.

Despite the high diversity and less exploration, the existence of orchids in Papua, including Merauke, is threatened by several factors, mainly habitat loss. This is because Papua is one of the provinces being targeted for regional development which might drive deforestation and forest degradation, threatening the habitat of natural

orchids (Agustini et al. 2012). Further, the problem is exacerbated by the overexploitation of certain orchid species, which are the prima donna of collectors and have high economic value (Hinsley et al. 2018). In addition to anthropogenic threats, biotic factors might cause a decline in orchid populations, such as a decrease in the number of pollinators due to reduced forest heterogeneity, reduced mycorrhizal numbers due to soil erosion, and the effects of global climate change (Pfeifer et al. 2006; Barman and Devadas 2013). Climate change causes an increase in temperature which might drive the habitat of several species, including epiphytic and terrestrial orchids, to shift into areas with cooler climates (Kalanowska et al. 2017; Setyawan et al. 2020). Also, the hotter climate might induce forest fires which lead to orchid death and habitat loss.

Therefore, this study aims to collect data on the diversity of orchids in Merauke District after nine years from the initial research from 2013 to 2022. We conducted a botanical expedition in some areas in Merauke and compared the results of this study with the previous one to see the changes in orchid diversity. This study aims to inventory orchids in Merauke, South Papua as Indonesia's natural wealth. We expected the results of this study might provide insight into developing conservation strategies for orchids, especially in Merauke District.

MATERIALS AND METHODS

Study area

Exploration and collection of natural orchids were carried out in the forest area of Merauke District, South Papua Province, Indonesiawith coordinates 6º00'-9º00' S and 137º-141º E (Figure 1). This location shares boundaries with districts of Boven Digoel and Mappi to the north, Papua New Guinea to the east, and the Arafura Sea to the south and west. The observation covered the forest area of Merauke, Semangga, Kurik, Tanah Miring, Jagebob, Sota, Elikobel, and Ulilin Sub-districts with a total area of approximately 15,233.26 km^2. The altitude in this area is 0-60 m asl. with a temperature of 23.2-30.8ºC, annual rainfall of 1558 mm and humidity of 78-81%. Most of this area is an organosol, alluvial, and hydromorphic swamp. The research was carried out for six months, from June to December 2020.

Data collection

Data collection was carried out using the exploratory or roaming method. The roaming method was conducted by exploring or tracing forest areas along forest trails commonly used by local people or creating new paths (Hidayat et al. 2017), and collecting any samples of orchid plants found. The samples found were observed, collected the data and documented using photographs. Unidentified orchids were collected as herbarium for further identification. The tools and materials used in the research included GPS, compass, binoculars, machete, caliper, loop, ruler, newsprint, plastic bag, hanging label, stationery, DSLR camera, distilled water, 70% alcohol, and altimeter.

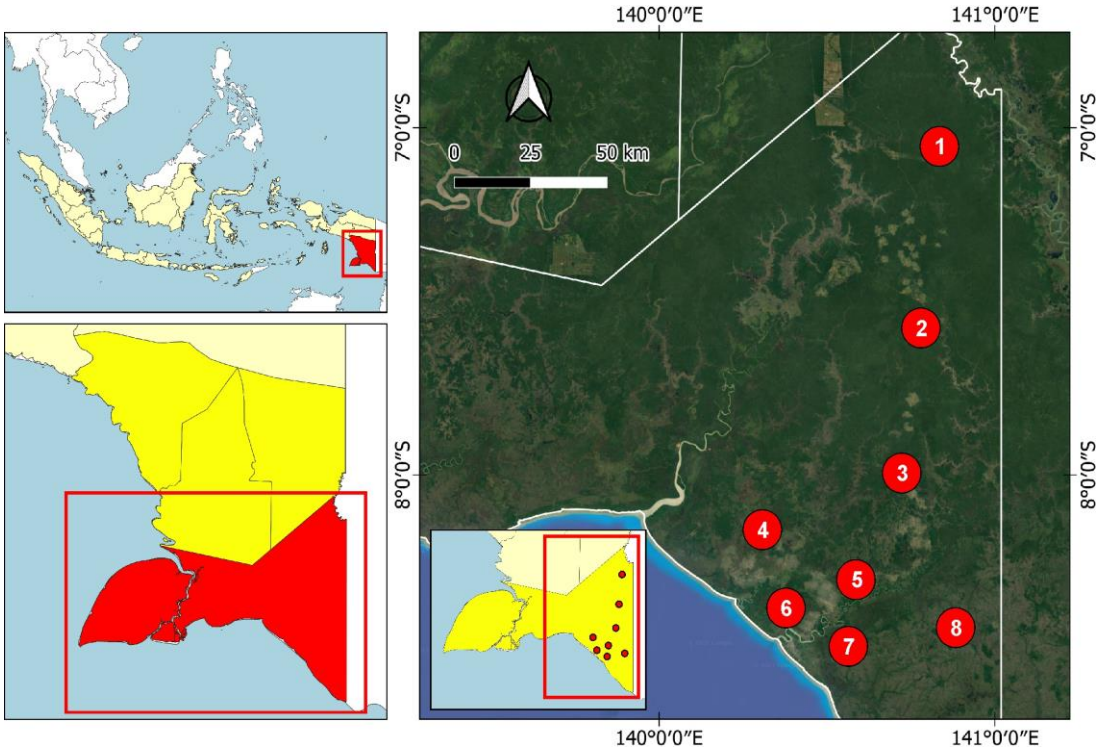

Figure 1. Map of surveyed areas in the Merauke District, South Papua Province, Indonesia, covering sub-districts of: 1. Ulilin, 2. Elikobel, 3. Jagebob, 4. Kurik, 5. Tanah Miring, 6. Semangga, 7. Merauke, and 8. Sota

Data analysis

The data analysis carried out in this study was qualitative, namely by identifying orchids documented during the survey. Identification of orchids was carried out by comparing the morphological characteristics of orchid plants obtained at the location using the book, i.e. O'Byrne (1994), Schuiteman (2013), Adams (2015), Lavarack and Gray (1985), O'Byrne (2017), Tkatchenko (2006), and World Flora Online (WFO 2022). Further identification and verification were carried out at the Botanical Laboratory by an orchid expert from the Biology Program, State University of Malang, Indonesia.

RESULTS AND DISCUSSION

In this study, it was found that the genus that had the highest number of species was the genus Dendrobium which consisted of 33 species. Dendrobium is a genus that is easily adaptable and can grow in a variety of habitats and environments, such as in the lowlands or highlands or mountains, on the coasts of small islands, in moist forests near rivers or beaches, on cliffs and even on rocks. Dendrobium is one of the largest orchid genera in the world with around 2000 species. Dendrobium is widespread in Asia, Australia and Europe, India, Sri Lanka, China, Japan, Korea, the Pacific Islands, New Caledonia and New Guinea. Around 614 species have been recorded in New Guinea, making Dendrobium the second largest orchid genus in New Guinea, and especially in Papua, eastern Indonesia, there are many Dendrobium species and also the best species.

The district or sub-district that has the richest diversity of orchids is the Ulilin Sub-district. This Sub-district has an area of 5,092.57 km^2, the topography is undulating with a slope of 8-12%, is located at an altitude of 90 meters above sea level, classified as a dry area with several rivers flowing in it. This research is a re-inventory of orchid species in Merauke District, which in 2013 was investigated. In this study, as many as 65 orchid species belonging to 23 genera were recorded, consisting of 57 epiphytic orchids and 8 terrestrial orchids (Table 1). There were two orchids unable to be identified to species level, namely *Dipodium* sp. and *Oberonia* aff. titania, and there were two natural hybrid orchids of the genus *Dendrobium*.

Based on our study, as shown in Table 1, there were 10 endemic Papuan orchids. All orchid species found in Merauke District are included in the Appendix II list of CITES (UNEP-WCMC 2021), and in this study one species was included in Appendix I. In addition, there were 19 orchids listed in the IUCN Red List. Among the 65 species identified in this study, several of them are orchids with high economic value, so they are in great demand by orchid lovers (Figure 2). Dendrobium became the genus with the most species found, namely 33 species. There were 10 endemic orchids, namely *B. digoelense*, *B. phalaenopsis*, *D. devosianum*, *D. lasianthera*, *D. lineale*, *D. macfarlanei*, *D. poneroides*, *G. scriptum*, *P. glanduliferum*, and *S. papuana*.

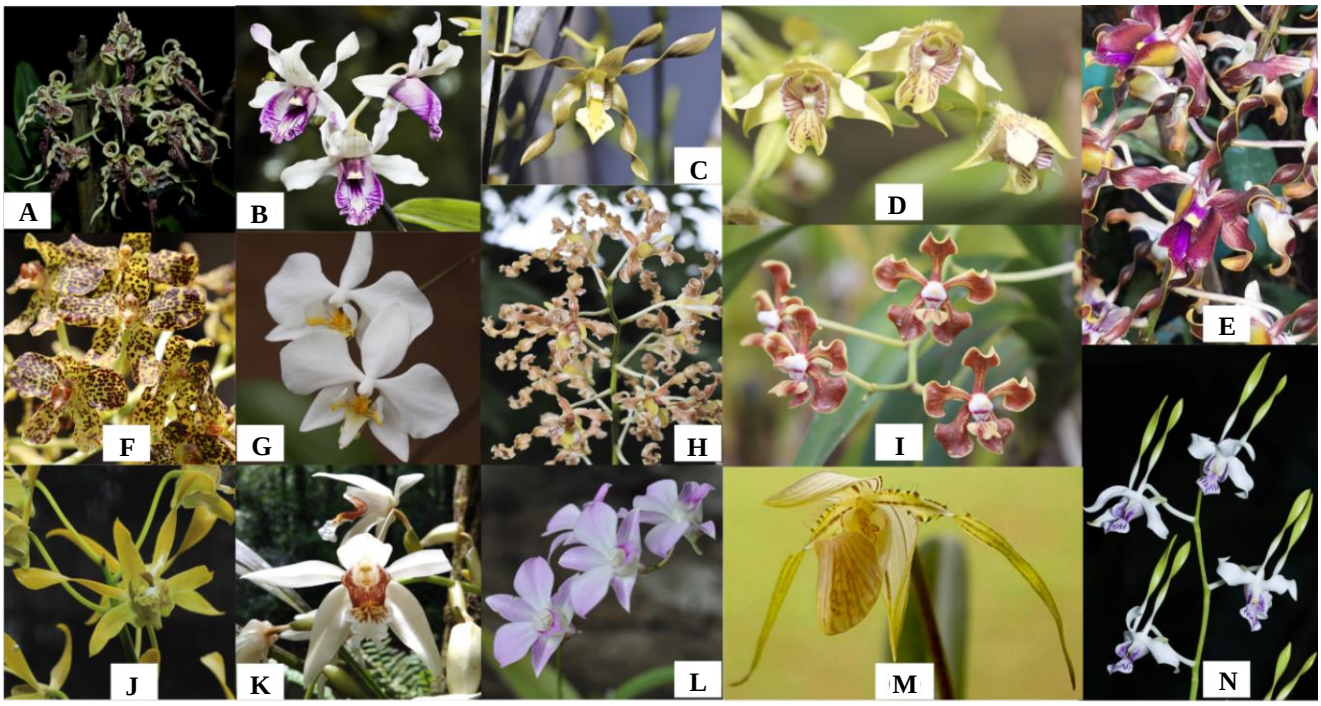

Figure 2. Orchid species in Merauke that have high economic value: A. *D. spectabile*, B. *D. nindii*, C-D. *D. trilamellatum*, E. *D. lasianthera*, F. *G. speciosum*, G. *P. amabilis*, H. *D. discolor*, I. *V. hindsii*, J. *D. mirbelianum*, K. *C. asperata*, L. *D. bigibbum*, M. *P. glanduliferum*, N. *D. antennatum*

Table 1. List of orchid species in some areas in Merauke District, South Papua Province, Indonesia

No	Species	Local name	Habitat	Code
1	*Acanthephippium splendidum* J.J.Sm.	Anggrek tanah	Terrestrial	-
2	*Acriopsis liliifolia* (J. Koenig) Ormerod	Anggrek bawang	Epiphytic	-
3	*Bogoria moorei* (Rchb.f.) M.A.Clem. & D.L.Jones	Anggrek bintik	Epiphytic	-
4*	*Bulbophyllum baileyi* F.Muell.	Anggrek lalat buah	Epiphytic	-
5*	*Bulbophyllum digoelense* J.J.Sm.	Anggrek digul	Epiphytic	Endemic
6*	*Bulbophyllum fractiflexum* J.J.Sm.	-	Epiphytic	LC IUCN
7*	*Bulbophyllum grandiflorum* Blume	-	Epiphytic	-
8	*Bulbophyllum macranthum* Lindl.	-	Epiphytic	LC IUCN
9	*Bulbophyllum maxillare* (Lindl.) Rchb.f.	Anggrek ekor merah	Epiphytic	-
10	*Bulbophyllum phalaenopsis* J.J.Sm.	Anggrek dasi	Epiphytic	Endemic
11*	*Coelogyne asperata* Lindl.	Anggrek mutiara	Epiphytic	-
12	*Dendrobium antennatum* Lindl.	Anggrek kelinci	Epiphytic	LC IUCN
13	*Dendrobium bifalce* Lindl.	Anggrek lebah	Epiphytic	LC IUCN
14	*Dendrobium bigibbum* Lindl.	Anggrek larat bupul	Epiphytic	-
15	*Dendrobium canaliculatum* R.Br.	Anggrek bawang besar	Epiphytic	LC IUCN
16*	*Dendrobium capituliflorum* Rolfe	-	Epiphytic	-
17	*Dendrobium carronii* Lavarack & P.J.Cribb	Anggrek bawang kecil	Epiphytic	NT IUCN
18*	*Dendrobium crumenatum* Sw.	Anggrek merpati	Epiphytic	-
19	*Dendrobium devosianum* J.J.Sm	-	Epiphytic	Endemic
20	*Dendrobium discolor* Lindl.	Anggrek diskalar, keriting	Epiphytic	LC IUCN
21*	*Dendrobium funiforme* Blume	-	Epiphytic	-
22*	*Dendrobium glabrum* J.J.Sm	-	Epiphytic	-
23	*Dendrobium insigne* (Blume) Rchb.f. ex Miq.	-	Epiphytic	-
24	*Dendrobium johannis* Rchb.f.	Anggrek yohanes kecil	Epiphytic	NT IUCN
25*	*Dendrobium lacteum* Kraenzl.	-	Epiphytic	-
26	*Dendrobium lasianthera* J.J.Sm.	Anggrek bor, stuberi	Epiphytic	Endemic, LC IUCN
27	*Dendrobium lineale* Rolfe	-	Epiphytic	Endemic, LC IUCN
28	*Dendrobium macfarlanei* F.Muell	-	Epiphytic	Endemic
29	*Dendrobium macrophyllum* A.Rich.	Anggrek jamrud	Epiphytic	LC IUCN
30	*Dendrobium macrostachyum* Lindl.	-	Epiphytic	-
31	*Dendrobium mirbelianum* Gaudich.	Anggrek merpati kuning	Epiphytic	LC IUCN
32	*Dendrobium nindii* W.Hill	Anggrek nindi	Epiphytic	LC IUCN
33*	*Dendrobium platygastrium* Rchb.f.	-	Epiphytic	-
34*	*Dendrobium poneroides* Schltr.	-	Epiphytic	Endemic, LC IUCN
35*	*Dendrobium pruinosum* Teijsm. & Binn.	Anggrek madu	Epiphytic	-
36	*Dendrobium rigidum* R.Br.	Anggrek anting	Epiphytic	-
37	*Dendrobium smillieae* F.Muell.	Anggrek nenas	Epiphytic	-
38*	*Dendrobium spectabile* (Blume) Miq.	Anggrek kribo	Epiphytic	LC IUCN
39	*Dendrobium strepsiceros* J.J.Sm.	Anggrek tanduk melintir	Epiphytic	-
40	*Dendrobium trilamellatum* J.J.Sm.	Anggrek yohanes besar	Epiphytic	LC IUCN
41	*Dendrobium umbellatum* (Gaudich.) Rchb. f	-	Epiphytic	-
42*	*Dendrobium versteegii* J.J.Sm	-	Epiphytic	-
43*	*Dendrobium antennatum* x *Dendrobium discolor*	Anggrek verninha	Epiphytic	Natural hybrid
44*	*Dendrobium trilamellatum* x *Dendrobium canaliculatum*	Anggrek bawang besar coklat	Epiphytic	Natural hybrid
45	*Dendrochilum longifolium* Rchb.f.	-	Epiphytic	-
46*	*Dipodium* sp.	Anggrek tanah	Terrestrial	-
47	*Geodorum densiflorum* (Lam.) Schltr.	Anggrek tanah merunduk	Terrestrial	-
48	*Grammatophyllum scriptum* (L.) Blume	Anggrek macan	Epiphytic	Endemic
49	*Grammatophyllum speciosum* Blume	Anggrek tebu, raksasa Irian	Epiphytic	-
50	*Luisia tristis* (G. Forst.) Hook.f.	Anggrek jari-jari	Epiphytic	-
51*	*Nervilia concolor* (Blume) Schltr.	Anggrek tanah	Terrestrial	-
52	*Oberonia* aff. *titania* Lindl.	-	Epiphytic	-
53	*Pachystoma pubescens* Blume	Anggrek tanah	Terrestrial	-
54*	*Paphiopedilum glanduliferum* (Blume) Stein	Anggrek kantong	Terrestrial	Endemic, EN IUCN, Appendix I CITES
55*	*Phalaenopsis amabilis* (L.) Blume	Anggrek bulan	Epiphytic	-
56	*Phalaenopsis amboinensis* J.J.Sm	-	Epiphytic	-
57	*Pholidota imbricata* Hook.	Anggrek kalung	Epiphytic	-
58*	*Phreatia micrantha* (A.Rich.) Lindl.	Anggrek kipas	Epiphytic	-
59	*Pinalia fitzalanii* (F.Muell.) Kuntze	-	Epiphytic	LC IUCN
60*	*Pomatocalpa marsupiale* (Kraenzl.) J.J.Sm	-	Epiphytic	-
61*	*Spathoglottis papuana* F.M.Bailey	Anggrek tanah papua	Terrestrial	Endemic
62	*Spathoglottis plicata* Blume	Anggrek tanah ungu	Terrestrial	-
63*	*Thrixspermum congestum* (F.M.Bailey) Dockrill	-	Epiphytic	-
64	*Thrixspermum platystachys* (F.M.Bailey) Schltr.	-	Epiphytic	-
65	*Vanda hindsii* Lindl.	Anggrek panda	Epiphytic	LC IUCN

Note: IUCN: the International Union for Conservation of Nature with classification of NT: Near Threatened, LC: Least Concern, EN: Endangered; CITES: the Convention on International Trade in Endangered Species of Wild Fauna and Flora

Discussion

The number of orchids found in this study was significantly different from the initial research conducted by Pammai et al. (2013) at the same location. Pammai et al. (2013) found that there were 41 orchid species which was much fewer than in our study. They were 25 orchids species that we recorded but not in the study by Pammai et al. (2013), such as *B. Baeleyi* F Muell, *B. digoelense* J.J.Sm, *B. fractiflexum* J.J.Sm and so on (see Table 1 with an asterix sign). Nonetheless, there were some orchids found during exploration in 2013, but no longer found in 2020, namely, *B. macranthum*, *B. phalaenopsis*, *D. bigibbum*, *P. amboinensis*, and *P. pubescens*.

The number of species recorded in our study was higher compared to the previous study by Pammai et al. (2013) possibly because it differs from previous studies due to the larger area and favorable natural conditions and does not necessarily suggest increased conservation. On the other hand, the loss of some species might be due to changes in forest function in Papua. Based on a report by Forest Watch Indonesia (2019) that the area of forest in Papua, including Merauke, continues to decline caused of the conversion of forest into plantations or infrastructure development to improve the economy. The loss of tree cover reduces the forest canopy, which affects the microclimate and changes the natural habitat of epiphytic orchids (Hundera et al. 2013). Habitat change and fragmentation also have an effect on decreasing genetic variation and increasing inbreeding. This condition is the result of a decrease in pollinator variation due to a decrease in plant diversity in the forest. Furthermore, it can trigger the loss of certain orchid species that require special pollinators and specific habitat conditions (Hundera et al. 2013).

Research conducted by Adhikari et al. (2012) showed that human interference that changed the natural habitat of orchids into secondary forests affected the distribution and abundance of orchids. The condition of this study is also almost the same as the conditions in Papua where many primary forests are converted into settlements and plantations. Human interference has an effect on air pollution which affects the pH of the tree bark where epiphytic orchids attach and affect the increase in air temperature. Changes in pH and temperature affect the microclimate of the orchid to be unsuitable.

There is a small population of terrestrial orchids that is able to survive in fragmented forests that have not been logged even though the surrounding area is already logged. The area still has a forest canopy that is good enough for sunlight to penetrate and provides a fairly tolerant environment for orchids. However, in this study, epiphytic orchids had a high abundance in the logging area. This is because in the logging area many tree trunks fell, where many species of epiphytic orchids were found and survived. It is also supported by the quite great adaptability of epiphytic orchids to dry and hot conditions, especially the species found are the Epidendroideae subfamily, which is known for its good adaptability in extreme conditions.

Agustini et al. (2016) conducted a similar study in Lanny Jaya which had almost the same conditions as in Merauke District where regional development is very active, both in the public and economic sectors. These human activities have an effect on the loss of trees in the forest which are hosts for epiphytic plants, including orchids. The study stated that changes on a geographical scale in terms of size, shape and habitat isolation affect the structure and abundance of orchids in a place. This is in line with this study where changes in habitat conditions affect the dynamics of orchid diversity in Merauke District. The decline in the population of a species is also influenced by the existence of massive habitat fragmentation. However, information regarding orchids in Lanny Jaya that have not been discovered remains limited, suggesting further research in the future once new accessibility is available in the area.

All 65 recorded species in this study were listed in appendix II of CITES, implying that although the species are not necessarily threatened with extinction, but their trade must be controlled to avoid overexploitation (CITES 2022). One species is listed in Appendix I CITES, meaning that it has conservation concerns and trade is only allowed under a very strict regulation (CITES 2022). One species is included in the IUCN Endangered (EN) category, implying that the species faces a high risk of extinction in the wild. Two species are included in Near Threatened (NT), meaning that the species is threatened with extinction in the near future but does not yet qualify as Critically Endangered (CR), Endangered (EN), and Vulnerable (VU). There are 19 species that are included in the IUCN Least Concern (LC), meaning that these species have been evaluated yet do not meet the criteria under the CR, EN, VU, or Near Threatened (NT) categories. There are 10 endemic species because of the limited distribution and only found in certain locations, making these orchids vulnerable to extinction.

As many as 14 species are considered to have high economic value, so they are widely cultivated and favored by the community. The high public attraction to several species of orchids causes overexploitation (Puspitaningtyas 2020). Natural orchids are often collected and sold by collectors illegally, exacerbating the scarcity of high-value orchids. However, this is not balanced with good cultivation (Agustini et al. 2016; Puspitaningtyas 2018).

The following is the description of the 23 genera of orchids found in the forests of Merauke District recorded in this study.

Acanthephippium spp.

Acanthepippium has 11 species spread across Southeast Asia to the Pacific Islands, but in Papua only one species was found but not endemic (Thomas 1997). This genus has a characteristic of its jug-shaped flowers so that it is easily distinguished from other genera. The shape of the flower makes this orchid often referred to as the jug orchid (Chung et al. 2005). It grows terrestrially in the shade of dense trees in fairly thick leaf litter near rivers and lives at an altitude of 0-1300 m above sea level. Plant height can reach 80 cm with roots with a diameter of 0.3-0.4 cm along 26 cm. Pseudobulbs are oval to fusiform, covered with stiff fibers, and have 2-3 leaves. Leaves broad oblong with thick

veins on the underside, measuring 30-46 x 10-14 cm (O'Byrne 1994). In this study, one species from this genus was found, namely *Acanthephippium splendidum*. It had flowers with a yellow-orange base color, very fleshy, yellow labellum with red markings inside, sepals with red stripes and red spots, yellow petals with red-orange markings, the color was less bright.

Acriopsis spp.

The name *Acriopsis* comes from the Greek language, referring to the shape of the flower column that resembles a grasshopper (Lok et al. 2009). In general, flowers of the genus *Acriopsis* are difficult to distinguish, but the lip of the flower can be a characteristic of each species. *Acriopsis* grows epiphytes with pseudobulbs shaped like green onions and clusters that support 3-4 linear leaves and become wrinkled and glabrous with age (O'Byrne 1994). *Acriopsis* flower size <2 cm, so it is less desirable as a cross breeder because it is considered less attractive (Yulia and Tarmudji 2007).

In the studied area, *A. liliifolia* was found in coastal swamp forests on trees in the savanna growing above ant nests on trees. This species is almost always found in association with ants that nest in and under the roots (Arditti 1993). The flowers are very small, cream colored with white lips, there is a yellow stripe along the midline of the sepals, petals, and lips, and it has long branched inflorescences (Comber 1990). *A. liliifolia* is one of the orchids of this genus which has the widest range of all congeners, spread throughout most of Southeast Asia, Papua New Guinea, Australia, to the Solomon Islands (Seidenfaden and Wood 1992; Comber 2001).

Bogoria spp.

Orchids from this genus are monopodial epiphytic plants medium in size and prefer shady locations or with high light intensity. In Papua New Guinea, this orchid is often found attached to coastal forest trees, semi-deciduous forests, rainforests, and savannas at an altitude of about 0-600 meters above sea level (O'Byrne 1994). Orchids of this genus have stems measuring 10-20 cm long that grow dangling with the tip of the stem pointing upwards. The leaves also have a characteristic that is up to 35 cm long, 1.5-6 cm wide, rough, and dark green. Species that grow on trees jutting into the sea have purplish leaves (Millar 1978). In this study, it was found that *B. moorei* with the local name of spotted orchid has ephemeral flowers that last only one day, fully bloomed, dangling, fragrant, cream to yellow in color with orange to brown spots, white labellum with purple and brownish orange spots, and the leaves are purple.

Bulbophyllum spp.

Asian tropical forests are central to the diversity of the genus *Bulbophyllum* with 1600 species occuring across the continent with New Guinea alone consists nearly 700 species (Vermeulen et al. 2014). Bulbophyllum is known as an epiphytic orchid and has a creeping or hanging rhizome so that it can propagate in its growth (Gravendeel and Vermeulen 2014). It has pseudobulbs that are ovoid to conical in shape which are sometimes covered by a midrib, and the petiole dangles with the tip turning upwards. Leaves are terminal, oblong to linear with a pointed tip (O'Byrne 1994), and inflorescences emerge from the base of the pseudobulb never from the apex (Teoh 2021).

Seven species of *Bulbophyllum* were found in our study, including *B. baileyi, B. digoelense, B. fractifflexum, B. grandiflorum, B. macranthum, B. maxillare,* and *B. phalaenopsis*. These orchids are all epiphytic with creeping rhizomes, sympodial with the placement of pseudobulbs have varying spacing on the rhizome. Variations of each species are found in the size of pseudobulbs, leaves, and flowers. *B. baileyi* flowers are cream to yellowish green, with red to purple spots with a characteristic fruity aroma. Characteristics of *B. digoelense* are flowers facing downwards, wide open, yellow or cream colored with purple stripes, and the very warty labellum has a dark purple color with a golden center. *B. fractiflexum* flowers are white or cream, barely open wide, sepals are white with yellow tips, petals are white, labellum is pale yellow, inflorescences are dangling, and the flowers last up to two weeks. The inflorescences of *B. grandiflorum* arise from the rhizome at the base of the pseudobulb with single, long-lasting flowers, brown sepals with white patches, dorsal sepals bent forward above the flower-like shields and lateral sepals wrinkled and hanging downwards, petals green with dark green stripes and purple spots, small white labellum with purple spots. *B. macranthum* sepals and petals cream, lateral sepals yellowish along the lower edge and red at the tips, sepals and middle petals with red spots, lateral sepals with red spots only along the upper edge, flowers with a sweet or spicy aroma, and shiny. Flowers of *B. maxillare* erect dorsal sepals are red to purple in color with white hairs at the edges, and lateral sepals are red and yellow or white in color downwards and usually join like a tail, small white petals with purple dots. While the uniqueness of *B. phalaenopsis* is that it has long and wide leaves with a size of 60 x 9 cm shaped like a purplish green tie, purplish green pseudobulbs, and purplish red flowers with yellow spots with yellow hairs (O'Byrne 1994).

Coelogyne spp.

This genus consists of more than 200 species with most of them being epiphytic plants that grow on large trees of primary forest (Sierra et al. 2000). *Coelogyne* is distributed in parts of Southeast Asia and parts of the Oceanic islands such as the Maluku Islands, Solomon Islands and Papua New Guinea (Wood and Cribb 1995). Pseudobulbs are round to very flat and attached to the rhizome. The leaves are thick with sharp tips, oblong to lanceolate (Sierra et al. 2000). Flowers vary in size, from small to large, but are generally pleasantly scented and short-lived (Huda et al. 2021). In this study, it was found that *C. asperata* had white or cream-colored flowers and the labellum was also white or cream-colored with orange-brown spots curved in the middle; pseudobulb ovoid, coarse-textured with two large green leaves on top; its roots enter the humus substrate or in a collection of ferns on tree branches.

Dendrobium spp.

Dendrobium is one type of orchid that is widely cultivated for ornamental plants in pots and hanging plants, as well as used as cut flowers. The main attraction of *Dendrobium* as an ornamental plant is because of its flowers which consist of various colors, sizes and shapes, flowering throughout the year, long-lasting flower life of weeks and even months, and fragrant (Kuehnle 2007). This genus of orchids consists of about 1600 species of epiphytes with sympodial stems. The pseudobulbs are long, some are short, and have a fleshy or almost woody texture with oval to cylindrical shapes. The leaves are green, succulent, and sometimes fall. Subterminal or terminal inflorescences with flowers are usually small but attractive (De et al. 2015). Species of the genus Dendrobium found in this study reached 33 species, two of which are natural hybrids, namely *D. antennatum* x *D. discolor* and *D. trilamellatum* x *D. canaliculatum*.

Dendrobium antennatum x *D. discolor* is an unnamed natural hybrid found in the Yanggandur village of Merauke, very similar to an artificial hybrid that has been created from the same species and has been registered as *Dendrobium* "verninha" (Lavarack and Gray 1985; O'Byrne 1994; Tkatchenko 2006). This species prefers locations with full sun to semi-shady, living epiphytes with stems up to 1 m. It has thick leaves, oval in shape, and has uneven edges. Flower stalks arise from pseudobulbs with 15-20 flowers per raceme. Flowers measure about 40 mm high x 28 mm wide x 20 mm long. The sepals are twisted, bent, wavy edges and are white with thick purple stripes on all surfaces. Petals erect and twist two to three times, brown with purple veins and yellow edges. The labellum is large with a curved middle lobe with thick purple veins, and the side lobes are cream to yellow with purple veins.

Another natural hybrid is *D. trilamellatum* x *D. canaliculatum*, also an unknown species found in the Wasur village of Merauke. This natural hybrid occurs wherever the parents coexist, but is not common in various locations (Lavarack and Gray 1985). This species is epiphytic and has pseudobulbs with purple veins when young. The leaves are 6-15 cm long, straight, thick, and fleshy. The flower stalk emerges from the tip of the pseudobulb and supports 6-20 flowers. The shape of the sepals and petals can be distinguished because the sepals are longer and narrower than the petals. However, both are crooked and predominantly brown in color. The flowering season of this orchid is from August to November (Lavarack and Gray 1985).

Dendrochilum spp.

It grows as an epiphyte or lithophyte attached to rocks. This orchid likes a cool, semi-open and humid location in lowland forests to mountains with an altitude of 2600 meters above sea level. It has a rhizome that grows creeping and branching, nearby there are pseudobulbs of various shapes from oval to conical. Single leaves of various sizes, growing at the terminal stem, thin, with a pointed tip, leaf blade lanceolate to oblong (O'Byrne 1994). In this study, only one species was found, namely *D. longifolium*, which has a single flower, up to 30 cm long with 40-50 small transparent green flowers with a green-brown labellum. *D. longifolium* is the only species found in Papua but is not endemic and a common orchid found on the island. (O'Byrne 1994).

Dipodium spp.

The genus *Dipodium* is a plant that grows as epiphytes, lithophytes, some saprophytes, and terrestrial (Teoh 2021). However, sometimes there are leafless ones (in lowland rainforests), and leafless *Dipodium* is still difficult to cultivate because it is unable to replicate associations with mycorrhizae (O'Byrne 2017). Members of this genus are usually tuber, experience dormancy for most of the year, and can flower when approaching summer producing 3-15 flowers. In this area, one species of *Dipodium* sp. was found but can not be identified until the species level. This species grows terrestrially, flowers are white with purple and maroon spots measuring 40-50 mm, blooms on brownish-green stems 40-120 cm long, and has no leaves. The dorsal sepals are 20-30 mm long and 4-6 mm wide, but the lateral sepals are slightly longer, and the petals are shorter than the two. The sepals and petals are not attached to each other and are slightly curved backward. The labellum is purple and has three lobes with a midline that is light purple in color. It blooms from November to March (O'Byrne 2017).

Geodorum spp.

It grows in small to medium-sized terrestrial areas in the rainforest, moist meadows to sandy areas near the coast with an altitude of 0-250 m above sea level. Has a partially buried oval to round pseudobulb. Experiencing dormancy in the dry season, shoots and leaves will appear in the rainy season, where the leaves will expand at the bottom to form new pseudobulbs. The stems are erect, slender, and have protective leaves. Leaves are thin and semi-folded with a pointed tip (O'Byrne 1994). One species was found in this study, namely *G. densiflorum*, which has pink flowers, only slightly opened, and curved towards the ground.

Grammatophyllum spp.

This genus has 13 species and is found naturally in Southeast Asia, Papua New Guinea, and Oceania. In Indonesia, this plant can be used as an ornamental plant and as medicine. The majority of members of this genus live as epiphytes, but some are found to be terrestrial, lithophytic, or saprophytic. One of the distinctive features of the *Grammatophyllum* genus is its roots which form a basket-like structure to accumulate nutrients. The pseudobulb is ovoid or cylindrical in shape. The leaves are hairless, have a cuticle, and have stomata on the upper surface of the leaf (Ishmah et al. 2021). In this study, two species were found, namely *G. speciosum* which is known as a giant orchid because of its large size, and *G. scriptum* which is an orchid endemic to Papua New Guinea (Lewis and Cribb 1991).

Luisia spp.

This genus is spread from tropical Asia to Australia and is found at an altitude of 0-1700 masl, it lives as an

epiphyte and loves open areas. The roots are very long, emerging from the base of the stem, and aerial roots are rare. The stems grow monopodial to medium size and will droop with increasing size. The leaves are straight teret-shaped green with a slight purple tinge at the base (O'Byrne 1994). In this study, one species was found, namely *L. tristis* which has green or yellow-green flowers with a dark maroon labellum with a velvety texture.

Nervilia spp.

The genus Nervilia has 65 species and lives terrestrially and is often used as medicine. It has spherical - elliptical bulbs and leaves that grow solitary with a heart shape or ovoid, sometimes there are feathers. Solitary terminal flowering emerges from the tuber. This plant is found in nature in the form of leaves only or flowers only with a short flowering period, making it difficult to perpetuate (Gale et al. 2007; Stern 2014). In this study, it was found that *N. concolor* had flowers that emerged from tubers in the soil, did not fully bloom, pale green sepals and petals, and white labellum with green or purplish veins and wavy; green leaves have brown spots, heart-shaped, pleated, tapered leaf tips, and wavy edges. Because of the unique leaf shape, many people do not know if the plant is a type of orchid. This species grows in the open, shady meadows, and under shady trees. Its distribution is widespread from India, China, Southeast Asia, Australia, to the Pacific Islands (Comber 1990).

Oberonia aff. titania

It is an epiphytic orchid that grows on trees in groups to form clumps. The stems are very short with four to ten leaves per clump. It has small, lanceolate to lance-shaped leaves, fleshy, and overlapping leaf bases. It has very small and numerous, red flowers arranged in a circle and hanging. Most species of Oberonia are easy to cultivate, but they are less attractive because the flowers are not only small but also not bright in color. However, like other small-flowered orchids, if looked closely, it turns out to have beautiful flowers (Seidenfaden 1978). This orchid can grow in various habitats, such as subtropical rainforests, mangrove forests, and *Melaleuca* swamps. This study found a species similar to *Oberonia titania* Lindl., but it is still uncertain whether it is a different species or a variation of this species.

Pachystoma spp.

There are 6 species of the *Pachystoma* genus which are widely distributed in India, Sri Lanka, Southeast Asia, Indochina, Papua New Guinea, Australia, to New Caledonia. However, only one species is widely distributed in Papua, namely *P. pubescens* (Pridgeon et al. 2005). These orchids live terrestrial and have a dormant period. It has a cylindrical rhizome and a fleshy cylindrical pseudobulb that resembles a tuber. Leaves emerge from pseudobulbs numbering 1 or 2, thin, straight, erect with several midribs, 28 x 0.7 cm long, tapered ends, and leaves fall at the time of flowering. Inflorescences arise from the rhizome, erect, peduncle 40-55 cm long, there are 5 to 15 flowers. The sepals and petals are pale pink, the labellum is pale pink, the keel and the part between the keel are greenish yellow and the flower stalk is 0.2-0.3 cm long with velvety hair. It grows on high grasslands (usually *alang-alang* grass) in the lowlands and is subject to periodic fires (Pridgeon et al. 2005). This periodic fire is one of the causes of the threat of extinction or habitat loss for *P. pubescens*.

Paphiopedilum spp.

This genus grows terrestrial and sometimes epiphytic, likes hot places and direct sunlight. *Paphiopedilum* lives in groups with 4-6 leaves that are linear to oblong, rounded tips and three-toothed, green, and there are few cilia at the base of the leaves (Pridgeon et al. 1999). In this study, one species was found, namely *P. glanduliferum* which has yellow flowers and maroon veins, petals with maroon warts on the basal edge and usually twisted or twisted. The distinctive feature of this genus is the labellum which is shaped like a bag or sandal, yellow with brownish-purple veins. This species is found at an altitude of 0-200 masl and is one of the endemic species in New Guinea (Morales et al. 2018). This species is also a rare orchid that is included in the IUCN Red List in the endangered category and Appendix I CITES (Govaerts et al. 2019) so its presence in nature must be of great concern.

Phalaenopsis spp.

One of the characteristics of this orchid is its flowers, which resemble moths. It lives as epiphytes at an altitude of 0-1500 masl (Teoh 2016). It has fleshy, fringed roots emerging from the base of the stem. There are 2-3 leaves that are wide, thick, leathery, and dark green with opposite leaves sitting. Flower stalks emerge from the base of the leaves which can reach 1 meter in length. This genus has beautiful flowers, but its growth in the wild is very slow (Kosir et al. 2004). In early research, it was found that *P. amboinensis* had white flowers with thick brown or reddish-brown lines. This species is found only in eastern Indonesia, including Sulawesi, Maluku, Papua and Papua New Guinea, at low elevations in moist shady forests (Sweet 1980; Christenson 2001). In this research, *P. amboinensis* was no longer found, and only the *P. amabilis* orchid was found which had white flowers, yellow callus on the labellum, and on the yellow part, there were streaks with reddish spots. These orchids grow in a wide geographical range, both in the lowlands and highlands, and flower well in natural conditions (Tsai et al. 2015).

Pholidota spp.

This plant grows to form a large clump. It has many roots that arise from the base of the pseudobulb. Pseudobulbs are pear-shaped to conical, smooth, and their young shoots are protected by brown bractea. A single leaf emerges from the pseudobulb, dark green to gray in color, stiff, thick, and pointed at the tip. In this study, it was found that *P. imbricata* has drooping flower stalks with small flowers in two opposite rows and there are 70-80 flower buds so that they form like a necklace. Flowers are about 7 mm long, white or cream with purple hues. Flowering year-round from January to November (O'Byrne 1994).

Phreatia spp.

It is an epiphytic orchid with monopodial stem growth. It grows in rainforests up to 800 m asl, mainly on the branches of large trees. It has a broad but short stem (almost no trunk) because it is hidden by overlapping leaf midribs and is surrounded by fleshy leaves (O'Byrne 1994). One species of this genus was found, namely *P. micrantha*. This species has 6-13 leaves arranged in a fan-like shape around the stem. Two slender and long flower stalks appear at once, then hundreds of white flowers measuring 2 mm bloom from base to tip and flowers bloom for 5-7 days. The flowering period can occur 2 to 3 times a year, namely April-May and August-December (Lewis and Cribb 1991).

Pinalia spp.

The *Pinalia* genus contains 160 species ranging from the Himalayas to China, Indochina, Malesia, Australia and the Pacific (Teoh 2016). In this study, one species was found, namely *P. fitzalanii* which is easily found in forests near the coast and warm lowland forests from an altitude of 0-750 masl. It grows epiphytic or terrestrial and has rhizomes that are difficult to distinguish from pseudobulbs. Pseudobulbs are medium to large ovoid, green to brown in color, and have a sheath. Leaves grow from the tip of the pseudobulb as many as 2-4 strands, inverted ovate to elliptical with a pointed tip. Flower stalks that arise from the lower nodes of the leaves and grow 50 white to yellow and fragrant flowers (O'Byrne 1994).

Pomatocalpa spp.

Pomatocalpa is a genus of small to medium-sized epiphytic orchids with monopodial stem growth. Climbing stems can be short or long, measuring 50-90 cm, but are well-developed and stocky. The leaves are rope-shaped and at the base there is a sheath with a rough surface. Inflorescences appear laterally with many small and tightly arranged flowers. The habitat of this orchid is in lowland forest with an altitude of 0-700 meters (O'Byrne 2001). In New Guinea there are three species, but this study found one species, namely *P. marsupiale* which has yellow, greenish or yellow-brown flowers with red or brown spots; the labellum is cream or yellow in color and has large round sacs that sometimes have brown or red spots; the flowers are not always wide open and have a lemon scent. Usually grows well on tree trunks at low levels (up to 4 meters above the ground) in evergreen lowland forests (Watthana 2007).

Spathoglottis spp.

Grows terrestrially with sympodial stem growth and has a short rhizome. This genus has more than one segmented pseudobulb, some buried in the ground. Leaves arise from pseudobulbs, the base has a sheath, elongated and thin lanceolate. The inflorescence emerges laterally from the pseudobulb. This orchid likes open places in the lowlands (Cribb and Tang 1982). In Papua New Guinea, it is known that there are about 13 species, but in this study only two species were found, namely *S. plicata* and *S. papuana*. *S. papuana* is very similar to *S. plicata*, but *S. papuana* can be distinguished by the bare pseudobulb and fallen leaf base. In addition, the flower bractea is small and there are no hairs on the flower stalk, rachis (mother stalk) or ovaries (O'Byrne 1994).

Thrixspermum spp.

It grows as an epiphyte with monopodial and medium-sized stem growth. It has climbed or fringed stems with leaves spaced apart from one another. The leaves are flat, fleshy, and jointed. Lateral flower stalks, flower profusely, and sometimes several flowers open at once (Xinqi and Wood 2009). In this study, two species were found, namely *T. congestum* and *T. platystachys*. *T. platystachys* has fleshy flowers that are yellow with a slight combination of white, the flowers only last one day and then wither (ephemeral). *T. congestum* is also ephemeral with cream to white, crystalline flowers, and sometimes brownish yellow with yellow-brown spots and the top and front of the labellum have short hairs, many of which are white.

Vanda spp.

In this study, one species of the genus *Vanda* was found, namely *V. hindsii*. This orchid is a large epiphyte with a leaf axis reaching 60 cm, growing upright but then curling. Monopodial stems 50 to 100 cm high. The leaves are arranged in two rows in the form of a ribbon with a length of up to 40 cm, dark green to yellowish green, shiny, rough, and incised ends. The flower stalk about 15 cm with 6-10 flowers measuring about 35 mm. Flowers are mostly shiny red-brown with yellow spots and olive-green edges. This species is native to Papua, Papua New Guinea, Queensland and the Solomon Islands (POWO 2022).

Based on the results of this study, it can be concluded that there are 65 species of orchids in the forests of Merauke District belonging to 23 genera. Dendrobium became the genus with the most species found, namely 33 species. There were 10 endemic orchids, namely *B. digoelense, B. phalaenopsis, D. devosianum, D. lasianthera, D. lineale, D. macfarlanei, D. poneroides, G. scriptum, P. glanduliferum*, and *S. papuana*. In addition, there were 16 species listed in the IUCN with Last Concern status, 2 orchids in the Near Threatened category, and 1 orchid in the Endangered category, namely *P. glanduliferum*. All the species found in this study are listed in Appendix II CITES with one species listed in Appendix I, namely *P. glanduliferum*. This study shows that forests in Merauke are important natural orchid habitats. However, human activities can threaten the survival of the orchid in this area, including exploitation, conversion of land to settlements and plantations, as well as changes in the primary forest to secondary forest.

ACKNOWLEDGEMENTS

Acknowledgments are conveyed to the Merauke District Government, Indonesia for the permission given to carry out the research, the local community who has assisted in the sampling of orchids, and to the Dean of the Faculty of Mathematics and Natural Sciences, State

University of Malang, Indonesia for their assistance and support in the research.

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