**ASIAN JOURNAL OF FORESTRY**
Volume 5, Number 2, December 2021 E-ISSN: 2580-2844
Pages: 101-110 DOI: 10.13057/asianjfor/r050206

# Orchids diversity on six forest types in Wasur National Park, Merauke, Papua, Indonesia

**NOVITYASARI KUSUMASTUTI♥, SURATMAN, ARI PITOYO**
Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A Surakarta 57 126, Central Java, Indonesia. Tel./fax.: +62-271-663375, ♥email: novityasari.kusuma@gmail.com

Manuscript received: 24 June 2021. Revision accepted: 19 August 2021.

**Abstract.** *Kusumastuti NK, Suratman, Pitoyo A. 2021. Orchids diversity on six forest types in Wasur National Park, Merauke, Papua, Indonesia. Asian J For 5: 101-110.* Orchidaceae is one of the two largest families of flowering plants. Wasur National Park is the habitat of many orchid species and one of the in-situ conservation areas in Papua that is very suitable for orchids. This research aimed to determine the orchid species in *Seksi Pengelolaan Taman Nasional Wilayah* III (SPTN III) Wasur, Wasur National Park, Merauke District, Papua Province, Indonesia and to determine the distribution of orchid species in six different types of forest. This research was conducted using the exploratory method. A total of 25 orchid species belonging to 11 genera have been identified from SPTN III Wasur. Monsoon forest is the type of forest with the highest number of orchid species, with 15 orchid species. It is followed by savanna with ten species, *Melaleuca* forest with ten species, woodland forest with nine species, riparian forest with six species, and *Melaleuca-Eucalyptus* forest with 5 species. *Dendrobium smillieae* and *Dendrobium rigidum* are the most widely distributed epiphytic orchid species, and occur in almost all forest types. However, the terrestrial orchids, *Geodorum densiflorum* and *Apostasia wallichii*, are only found in the monsoon forest.

**Keywords:** exploratory method, orchids, SPTN III Wasur, Wasur National Park

## INTRODUCTION

Indonesia is one of the three mega-biodiversity countries known as the world's center of biodiversity and has the largest tropical forest after Brazil and Congo (Turubanova et al. 2018). Indonesia is estimated to have 20,000 species of flowering plants globally (Kusmana and Hikmat 2015), with the plant family with the most species members is Orchidaceae. The family Orchidaceae are one of the two largest families of flowering plants, in number of species, and includes 736 genera in five subfamilies (Chase 2015). One of the islands in Indonesia that has a high diversity of orchids is New Guinea. Most of the orchids in this area are wild orchid species, with some endemic to New Guinea. According to Cámara-Leret et al. (2020), New Guinea has 2,856 species of orchids.

Merauke District is one of the districts in Papua (New Guinea-Indonesia) with a large potential for orchid diversity. This is supported by Pammai et al. (2014) who researched 11 sub-districts in Merauke District (Merauke, Naunkenjerai, Sota, Elikobel, Jagebob, Okaba, Muting, Animha, Kimaam, Ilwayab, and Kaptel). The study found a total of 41 species of orchids that belong to 8 genera. Another study is from Arobaya et al. (2020), who researched biodiversity mapping of *Dendrobium* Sw. section *Spathulata* Lindl. and its host in the Ramsar Site of Wasur National Park. The study found a total of 11 species recorded from *Dendrobium* section *Spathulata*. One of the orchid habitats in Merauke District where the environment is still preserved because it is included in a conservation area is Wasur National Park. The diversity of vegetation in Wasur National Park is spread over several ecosystems, including *Melaleuca* forest, co-dominant *Melaleuca-Eucalyptus* forest, woodland forest, coastal forest, monsoon forest, riparian forest, mangrove forest, savanna, grassland, swampy grassland, *Eucalyptus* forest, lowland forest, and *Exocaria* forest (Wasur National Park 2014). Wasur National Park, especially the *Seksi Pengelolaan Taman Nasional* (SPTN) *Wilayah* III Wasur, is one of the areas that does not yet have many research publications on orchid species. Therefore, it was decided to carry out an inventory of the orchids in the SPTN III Wasur, Wasur National Park to provide additional information on orchid species in Papua.

## MATERIALS AND METHODS

### Study area

This research was conducted during July-August 2019 in six locations in the SPTN III Wasur, Wasur National Park, Merauke District, Papua Province, Indonesia, namely, (i) *Melaleuca-Eucalyptus* forest, (ii) *Melaleuca* forest, (iii) woodland forest, (iv) monsoon forest, (v) riparian forest and (vi) savanna (Figure 1).

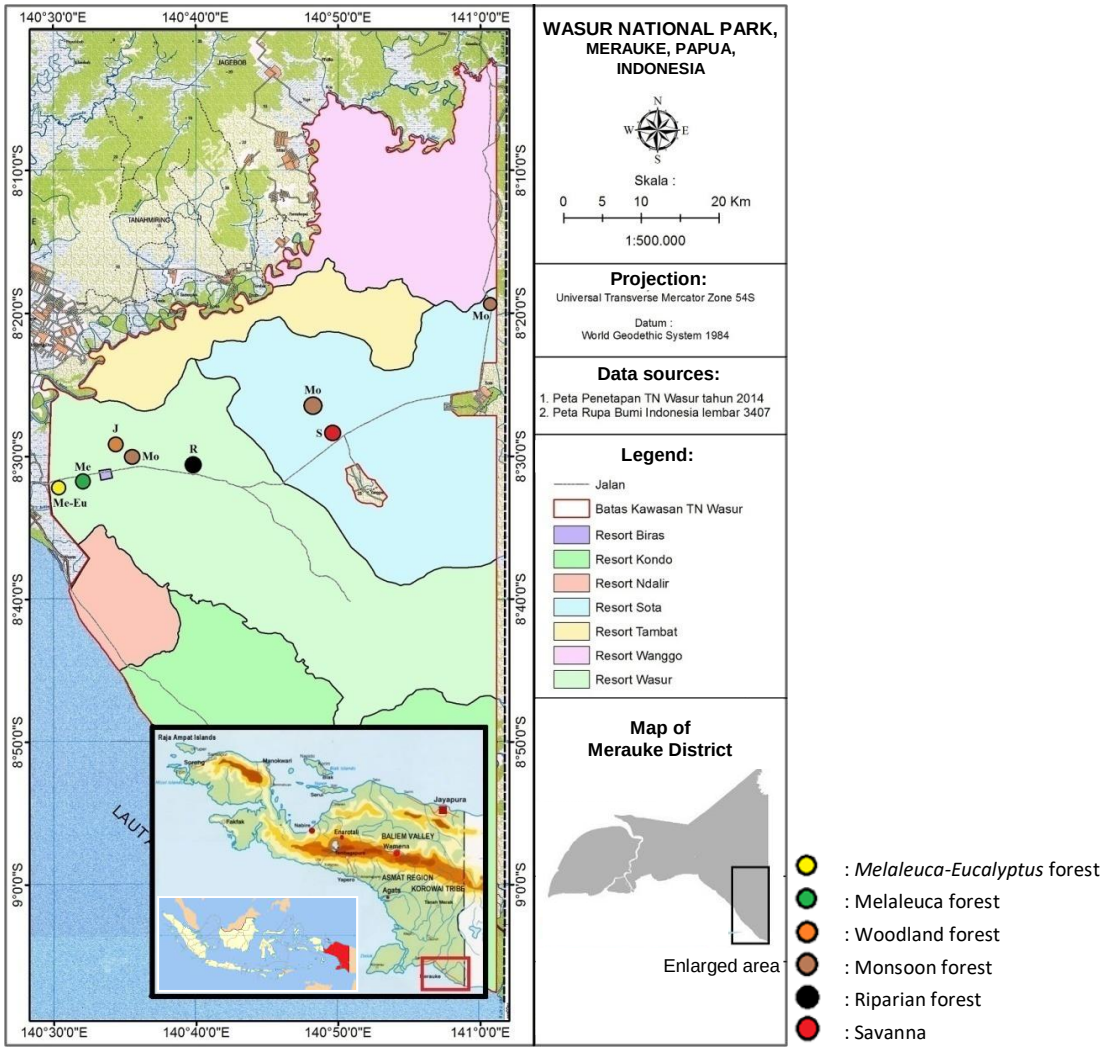


**Figure 1.** Orchid research locations in the SPTN III Wasur, Wasur National Park, Merauke District, Papua Province, Indonesia (Wasur National Park 2014)

## Procedures

Orchid collections were preserved in Copenhagen mix (ethanol 70% and 5% glycerol). The research was carried out by exploratory methods, by exploring accessible forest areas in the selected location (*Melaleuca-Eucalyptus* forest, *Melaleuca* forest, woodland forest, monsoon forest, riparian forest and savanna). The orchid inventory and the making of herbarium specimens were carried out by following the Balgooy method (1987). Collection data and field observations such as collection number, date, name(s) of collector(s), location (latitude and longitude), habitat and ecology information, morphological features that will be lost when the specimen is preserved (the colour of the orchid stems, leaves and flowers), local names and the uses are also recorded in the field book (Balgooy, 1987). Epiphytic orchids were observed based on the distribution of orchids in host tree zoning following the Johansson method (1974) which divides the host tree into five zones. Identification of orchids followed determination keys and some specific scientific papers (Minderhpud and de Vogel, 1986; Watthana 2007; Chowlu and Rao 2015; de Vogel, 1988), using the characters described in Millar (1990) and Schuiteman (2013), and asking Wasur National Park staff and local communities.

At each location, biotic factors were documented by recording the host trees of epiphytic orchids and the zoning of the latter in each host tree, following the Johansson method (1974). Abiotic factors were measured following the Guinness and Walpole (2012) method, including elevation (m asl) and geographical location, light intensity (lux), air temperature (◦C), soil temperature (◦C), humidity (%), soil humidity (%) and soil pH. These abiotic factors were measured three times and then averaged.

## Data analysis

The orchid species found and environmental data (biotic and abiotic factors) were analyzed descriptively.

## RESULTS AND DISCUSSION

Based on the results of our field exploration, orchids (family Orchidaceae) in *SPTN III* Wasur, Wasur NP, comprise 25 species belonging to 11 genera.

### Orchids distribution in each forest type

Based on the results of field exploration, the diversity of orchid species varies in each forest type. Monsoon forest is the type of forest with the highest number of orchid species, with 15 species. It is then followed by savanna with 10 species, *Melaleuca* forest with 10 species, woodland forest with 9 species, riparian forest with 6 species, and *Melaleuca-Eucalyptus* forest with 5 species (Table 1). *Dendrobium smillieae* and *Dendrobium rigidum* are the most widely distributed epiphytic orchid species, found in both open and shady habitats where light intensity can vary from low light intensity to full sunlight.

The differences in orchid species found in each forest type are influenced by several factors including forest structure, tree species composition, and micro-climate such as light intensity, temperature, humidity, and proximity to water sources. Tree species composition affects the epiphytic vegetation through substrate characteristics provided by each tree species, giving rise to epiphytic host specificity (Frei, 1973; Johansson, 1974; Dressler, 1981). Other substrate factors include texture (roughness) and bark porosity (water retention).

**Table 1.** Orchids distribution and host tree in each forest type in the SPTN III Wasur, Wasur National Park, Merauke District, Papua Province, Indonesia

| Species | Host Tree | Mo | S | Me | W | R | Me-Eu |
|---|---|---|---|---|---|---|---|
| *Acriopsis liliifolia* (J.Koenig) Ormerod | *Melaleuca* sp. | + | + | + | | + | |
| *Apostasia wallichii* R.Br. | - | + | | | | | |
| *Bulbophyllum baileyi* F.Muell. | *Syzygium* sp. | + | | | | | |
| *Dendrobium antennatum* Lindl. | *Melaleuca* sp. | | | + | + | | + |
| *Dendrobium canaliculatum* R.Br. | *Melaleuca* sp. | | + | + | | | |
| *Dendrobium carronii* Lavarack & P.J.Cribb | *Melaleuca* sp.<br>*Xanthostemon crenulatus* C.T. White | | + | + | + | | |
| *Dendrobium discolor* Lindl. | *Alstonia scholaris* (L.) R.Br.<br>*Bombax ceiba* L<br>*Melaleuca* sp. | + | | + | | | + |
| *Dendrobium glabrum* J.J.Sm. | *Dillenia alata* (D.C) Martelli<br>*Eucalyptus pellita* F. Muell. | | + | | + | | |
| *Dendrobium goldfinchii* F.Muell. | *Alstonia scholaris* (L.) R.Br.<br>*Barringtonia acutangula* (L.) Gaertn. | + | | | + | + | |
| *Dendrobium insigne* (Blume) Rchb.f. ex Miq. | *Barringtonia acutangula* (L.) Gaertn. | | | | | + | |
| *Dendrobium johannis* Rchb.f. | *Dillenia alata* (D.C) Martelli<br>*Eucalyptus pellita* F. Muell.<br>*Melaleuca* sp. | | + | + | + | | + |
| *Dendrobium lacteum* Kraenzl. | *Buchannia* sp. | + | | | | | |
| *Dendrobium pruinosum* Teijsm. & Binn. | *Barringtonia acutangula* (L.) Gaertn. | + | | | | | |
| *Dendrobium rigidum* R.Br. | *Barringtonia acutangula* (L.) Gaertn.<br>*Melaleuca* sp.<br>*Planchonia* sp.<br>*Xanthostemon paradoxus* F. Muell. | | + | + | + | + | + |
| *Dendrobium smillieae* F.Muell. | *Barringtonia acutangula* (L.) Gaertn.<br>*Eucalyptus pellita* F. Muell.<br>*Maranthes corymbosa* Bl.<br>*Melaleuca* sp.<br>*Xanthostemon paradoxus* F. Muell. | + | + | + | + | + | |
| *Dendrobium trilamellatum* J.J.Sm. | *Eucalyptus pellita* F. Muell.<br>*Melaleuca* sp. | | + | | | | + |
| *Dendrobium* sp. | *Maranthes corymbosa* Bl. | + | | | | | |
| *Geodorum densiflorum* (Lam.) Schltr. | - | + | | | | | |
| *Luisia tristis* (G.Forst.) Hook.f. | *Melaleuca* sp. | | + | + | + | | |
| *Oberonia* sp. | *Decaspermum* sp. | + | | | | | |
| *Pholidota imbricata* Hook. | *Barringtonia acutangula* (L.) Gaertn. | + | | | | + | |
| *Pinalia fitzalanii* (F.Muell.) Kuntze | *Melaleuca* sp.<br>*Xanthostemon paradoxus* F. Muell. | | + | + | + | | |
| *Pomatocalpa macphersonii* (F.Muell.) T.E.Hunt | *Endiandra* sp. | + | | | | | |
| *Pomatocalpa marsupiale* (Kraenzl.) J.J.Sm. | *Syzygium* sp. | + | | | | | |
| *Thrixspermum platystachys* (F.M.Bailey) Schltr. | *Decaspermum* sp. | + | | | | | |

Note: Mo: Monsoon forest, S: Savanna, Me: Melaleuca forest, W: Woodland forest, R: Riparian forest, Me-Eu: *Melaleuca-Eucalyptus* forest

One important factor that also affects the distribution and abundance of terrestrial orchids is soil pH. In this study, terrestrial orchids were found in soil pH 6-6.5. The pH gradient can be considered a resource gradient since soil reactions control mineral uptake either directly or through mycorrhizal associations. However, in highly alkaline soils as well as in highly acidic soils, mycorrhizae cannot survive, which can lead to a reduction in the number of orchids (Dijk et al. 1997). Most orchids can adapt to a broad range of light environments in different habitats (Zhang et al. 2018). In this study, several orchids such as *Dendrobium discolor*, *D. carronii*, *D. canaliculatum,* and *D. glabrum* were found growing in the tree canopy as an epiphyte tolerant of high light intensity than terrestrial orchids i.e. *Apostasia wallichii* and *Geodorum densiflorum* found on shady forest floors.

**Habitat and ecology of orchids in *SPTN III* Wasur, Wasur NP**

Orchids grew at an elevation of 7.8-26.7 m above sea level in SPTN III Wasur, with a varied range of habitats and vegetation. In our field exploration, orchids were collected from 6 different forest types in SPTN III Wasur, namely, monsoon forest, savanna, *Melaleuca* forest, woodland forest, riparian forest, and *Melaleuca-Eucalyptus* forest (Figure 2.A-F). Monsoon forest is the forest type with the highest number of orchid species, followed by savanna, *Melaleuca* forest, woodland forest, riparian forest and *Melaleuca-Eucalyptus* forest.

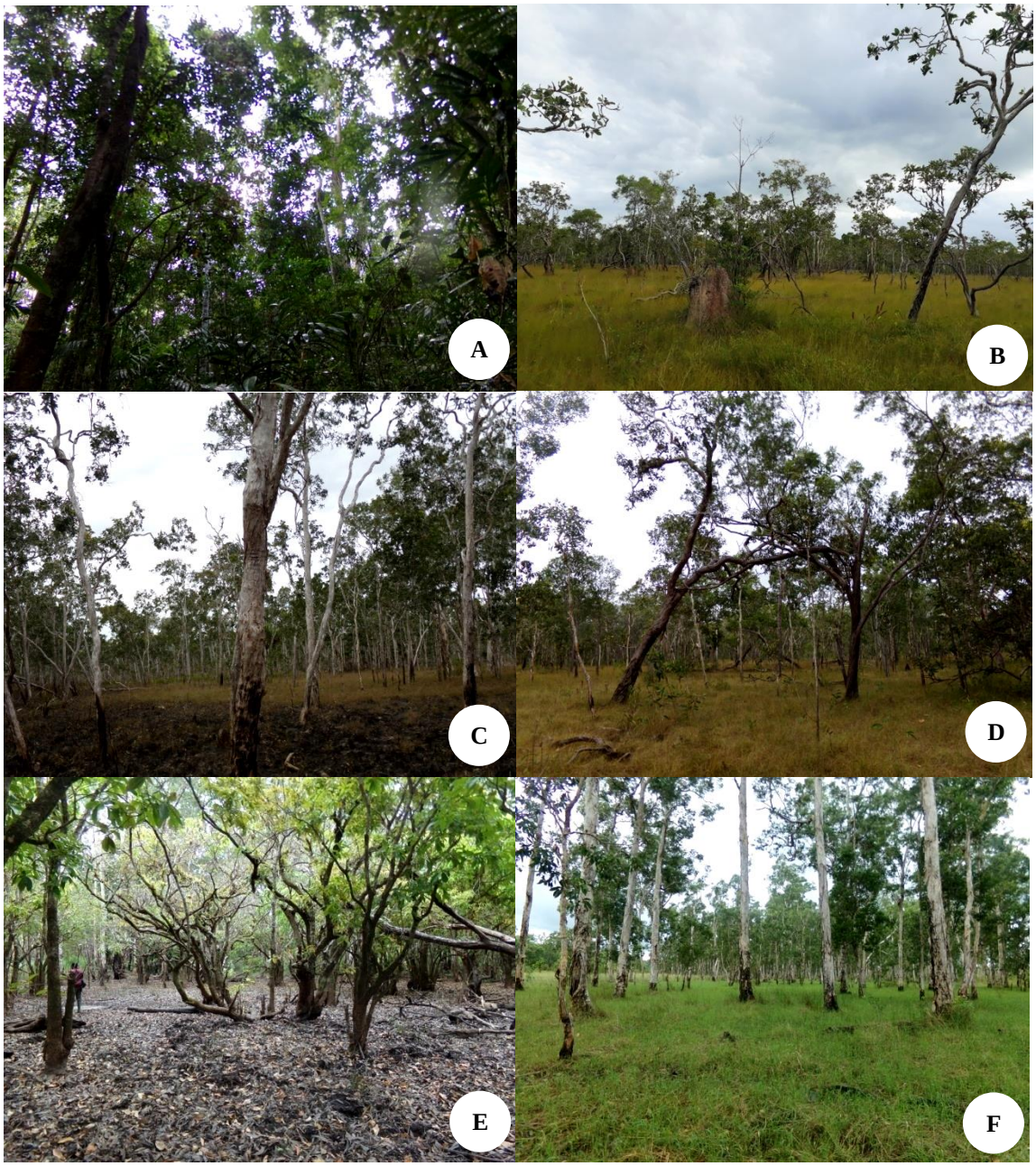


**Figure 2.** Several forest in *SPTN III* Wasur, Wasur NP, Merauke, Indonesia. A. Monsoon forest, B. Savanna, C. *Melaleuca* forest, D. Woodland forest, E. Riparian forest, F. *Melaleuca-Eucalyptus* forest

*Monsoon forest*

Monsoon forest is a forest type in tropical and subtropical regions with warm climate throughout the year. However, it has a longer dry season for several months than the rainy season. The trees in the monsoon forest usually shed their leaves during the dry season. Lianas (woody vines) and herbaceous epiphytes (such as orchids) are found in this forest. The forest, which is located in Yanggandur and Sota at an elevation between 12-27.2 m asl with an average air humidity of 82.6% and an average temperature of 27ºC, is dominated by species like *Eucalyptus* sp., *Acacia auriculiformis, Acacia mangium, Banksia dentata, Rhodomyrtus* sp. and others (Wasur National Park 2014). Trees such as *Syzygium* sp., *Buchanania* sp., *Maranthes corymbosa, Alstonia scholaris, Bombax ceiba, Barringtonia acutangula, Terminalia* sp., *Endiandra* sp. and *Decaspermum* sp. are common hosts of epiphytic orchids in this type of forest.

Monsoon forest is the forest type with the highest number of orchid species, which is 15. Both epiphytic and terrestrial orchids are found in this habitat. This forest has a good environment for orchid survival because its habitat conditions (moisture and nutrient availability) are suitable for the growth of orchids. The dense forest conditions with high canopy cover mean that there is not too much sunlight in this habitat, therefore many orchid species prefer shade or not to be exposed to direct sunlight. In addition, the presence of diverse and healthy host trees provides good support for epiphytic orchids. Forest floors that have much lower light reception conditions, higher air humidity and soil moisture, and lower wind influence than canopy areas can support the development of terrestrial orchids that are compatible with these conditions (Kromer and Gradstein 2007).

*Savanna*

Savannas are grasslands interspersed with several types of trees that grow sparsely. The savanna is located in Yanggandur at an elevation of ± 14.5 m above sea level with an average air humidity of 55.7% and an average temperature of 31.7ºC. It is dominated by species like *Melaleuca cajuputi, Banksia dentata, Asteromyrtus symphyocarpa, Eucalyptus* sp. and *Melaleuca* sp. (Wasur National Park 2014). In addition, trees such as *Melaleuca* sp., *Planchonia* sp., *Timonius timon, Eucalyptus pellita* and *Dillenia alata* are common hosts of epiphytic orchids in this habitat.

Savannas and *Melaleuca* forests have the second highest number of species after monsoon forests, i.e. ten species. Dry savanna conditions with open canopies mean that only a few species of orchids can grow in these environments with high sunlight intensity. In this habitat many epiphytic orchids have effective adaptations to drought and high levels of sunlight. One of the special adaptations of epiphytic orchids to drought conditions is to have pseudobulbs, making them more tolerant of the microclimate such as drought (Werner and Gradstein 2009). In this study, terrestrial orchids are not found in savanna, possibly because terrestrial orchids are prevented from growing into the savanna by fire. According to Eden (1974), in parts of southern Papua there is clear evidence of anthropic disturbance of the vegetation, principally due to shifting cultivation and burning. Burning occurs regularly in the savanna and grassland during the dry season. However, it cannot be assumed that the savanna and grassland are the result of human activity.

*Melaleuca forest*

*Melaleuca* forest is located at an elevation of ± 16 m above sea level with an average air humidity of 50% and an average temperature of 32.6ºC. Species like *Melaleuca* sp dominate it., *Lophostemon lactifluus, Xanthostemon* sp., *Acacia leptocarpa, Asteromyrtus symphyocarpa, Eucalyptus* sp. and others (Wasur National Park 2014). *Melaleuca* sp. are the common hosts of epiphytic orchids in this habitat.

The ecology of the *Melaleuca* forest is similar to the ecology of the savanna, but the canopy cover is slightly more closed than in the savanna. In addition, what distinguishes these two habitats is that the host trees in the savanna are more diverse than the host trees in the *Melaleuca* forest, which are all recorded only as *Melaleuca* sp. As many as 8 out of 10 species of orchids found in these two habitats are the same species. The high number of epiphytic orchid species is not only due to the microclimate that supports it, but also because of the host tree factor. Most of the host trees in both habitats are trees with broken or cracked bark. In the research of Hernández-Pérez et al. (2018), the highest epiphyte richness was also recorded in trees with cracked or broken bark. Other studies have also shown that trees with broken bark can increase water absorption and increase the rate of epiphyte formation, because these characteristics prevent seeds of epiphytes from easily separating from the host (Tupac-Otero et al. 2007; Cascante-Marín et al. 2009; Wagner et al. 2015). In contrast, hosts with smooth and peeled bark have low levels of epiphyte richness, which may be related to increased seed mortality and limited formation of epiphytic plant groups due to unstable substrates (Zimmerman and Olmsted, 1992; López-Villalobos et al. 2008; Woods et al. 2015).

*Woodland forest*

Woodland forest is a low-density forest that forms open habitats with lots of sun and limited shade. It has sparse tree cover (10-30%) and has undergrowth and herbaceous vegetation including grasses. The forest is located at an elevation of ± 12 m above sea level with an average air humidity of 75.5% and an average temperature of 28.6ºC. It is dominated by species like *Vitex pinnata, Melaleuca* sp., *Xanthostemon* sp., *Trichospermum* sp., *Dillenia alata, Eucalyptus* sp., *Asteromyrtus symphyocarpa* and at the bottom grow various shrubs (Wasur National Park 2014). Trees such as *Melaleuca* sp., *Xanthostemon paradoxus*, and *Xanthostemon crenulatus* are common hosts of epiphytic orchids in woodland forests. Woodland forest conditions are similar to savanna, but the canopy cover is more closed

and has more diverse host trees compared to savanna and *Melaleuca* forest.

Woodland forest is the forest with the third-highest number of species after savanna and *Melaleuca* forest. The exciting thing is that *Dendrobium smillieae* is found more frequently in this forest than in other forest types. Besides being found as an epiphyte, *D. smillieae* is sometimes also found as a lithophyte in mossy or littered rocks. The high number of *D. smillieae* in the woodland forest is likely because the orchid has more diverse host trees than in the savanna and *Melaleuca* forests. The host of *D. smillieae* in savanna was recorded only as *Eucalyptus pellita*. The host in *Melaleuca* forest was only *Melaleuca* sp. The host of this orchid in the woodland forest was *Melaleuca* sp. and *Xanthostemon paradoxus*. *X. paradoxus* is a tree commonly found in woodland forests, therefore the orchids that are suitable on this host will grow well and also more abundant, such as *D. smillieae*.

*Riparian forest*

Riparian forests located on the edge of swamp waters, lakes, water sources, or rivers. This type of forest has a unique character, due to the combination of the aquatic and terrestrial environment i.e. the presence of plants that can adapt to the waters. The forest is located at an elevation of ±19 m above sea level with an average air humidity of 70% and an average temperature of 30ºC. It is dominated by species like *Barringtonia acutangula*, *Trichospermum* sp., *Bamboo* sp., *Nypa fruticans* and *Graminae* spp. (Wasur National Park 2014). *B. acutangula* is a common host tree for epiphytic orchids in this habitat.

Riparian forests are the habitat with the second lowest number of species. In this type of forest, only six species of orchids can be found. The condition of riparian forest with high canopy cover and high humidity causes many shade-loving species to grow well in this habitat. Although the environmental conditions of the riparian forest are favorable for the growth of shade-loving orchid species, only the host tree *Barringtonia acutangula* was found at the study site. The slight variation in host trees at the study site may have resulted in the low number of orchid species found.

*Melaleuca-Eucalyptus forest*

*Melaleuca-Eucalyptus* forest is a forest type dominated by *Melaleuca* and *Eucalyptus* species. The forest is located at an elevation of ± 10 m asl with an average humidity of 70% and an average temperature of 30.6ºC. It is dominated by *Melaleuca cajuputi*, *Eucalyptus alba*, *Eucalyptus pellita*, *Eucalyptus* sp., *Asteromyrtus symphiocarpa*, *Rhodomyrtus* sp. and others (Wasur National Park 2014). *Melaleuca* sp. is the common host tree for orchids in the *Melaleuca-Eucalyptus* forests.

*Melaleuca-Eucalyptus* forest is the habitat with the lowest number of orchid species among six forest types, i.e. only 5 species. The condition of this forest is similar to the conditions in the *Melaleuca* forest. The host trees that were found were also the same as those recorded in the *Melaleuca* forest, specifically *Melaleuca* trees. However, humidity in the *Melaleuca-Eucalyptus* forest was higher than in the *Melaleuca* forest. The species of orchid that is commonly found in *Melaleuca-Eucalyptus* forests is *Dendrobium discolor*. The habitat conditions in this type of forest are almost identical to those in the *Melaleuca* forest. Nevertheless, fewer orchids were found. This is probably because the higher humidity in this habitat only allows a few orchids with high light requirements and relatively high humidity requirements to thrive. It may also be caused by scattering the seeds of some orchid species that do not reach this habitat. In orchid reproduction, orchid seeds are blown by the wind. The seeds then attach to the trunk of a suitable host tree. Orchid seeds will germinate, grow, develop and regenerate continuously if the host tree is suitable, supported by temperature, humidity, and light intensity (Sadili 2013).

**Host trees and vertical distribution of epiphytic orchids**

This study found 16 host tree species of 23 epiphytic orchid species in all six different forest types (Table 1). *Dendrobium smillieae* is an orchid that shows the most diverse host range, as it was found growing on five host tree species, followed by *Dendrobium rigidum* which was found growing on four host tree species. It is possibly because these species can adjust, via morphological and physiological changes, to a wide range of environments. Meanwhile, 74% of the total recorded epiphytic orchids were found on less than 2 host tree species.

Of the 16 host tree species, *Melaleuca* sp. is the most common host of orchids, supporting up to 11 species of epiphytic orchids. Other important host tree species are *Xanthostemon paradoxus*, *Eucalyptus pellita*, *Barringtonia acutangula*, *Syzygium* sp. and *Maranthes corymbosa*, each supporting 2 to 7 species of epiphytic orchids. Although, in all six forest types, the lowest number of epiphytic orchid species was found at the base of the host tree (Zone 1 / Z1) and the outer part of the branching of the host tree (Zone 5 / Z5), only one species of orchid was found growing in each of these two zones. Meanwhile, the highest number of orchid species was found at Z2, Z3 and Z4 (Figure 3).

The large number of orchid species recorded in the center of the tree (Z2, Z3 and Z4) can be caused by the fact that the area is characterized by relatively stable environmental conditions (humidity, light intensity and temperature). In contrast, the small number of orchid species in Z1 and Z5 is caused by the zone being the most shaded (Z1) and most open (Z5) part of the tree. This can be related to the intensity of sunlight, temperature and humidity. The lower part of the tree will be more humid than the outermost part, while the outer and most exposed parts of the tree are usually the driest. Light intensity and temperature will change at different tree heights (Hernández-Pérez et al. 2018). Some species of orchids can only tolerate specific ranges of light intensity, temperature and humidity.

Zone 1 is the part that receives less sunlight because it is shaded by the canopy of the host tree and other surrounding vegetation. The only orchid found growing in this zone is *Pomatocalpa marsupiale*. Whereas zone 5 is the part that receives more direct sunlight, causing the evapotranspiration rate to be very high (Marsusi et al.

2001), the only orchid that was found to be able to adapt to this zone is *Dendrobium johannis*.

The study indicates that 91.3% of epiphytic orchid species grow in zone 3 of the host tree. These results are similar to those obtained by other researchers in that the number of epiphytic orchid species is primarily found in zone 3 (Marsusi et al. 2001; Managanta and Pangli 2014; Nurfadilah 2015). This is because zone 3 has the largest branch size and the smallest degree of inclination compared to zone 1 and 2, which are tilted 90º or perpendicular (Marsusi et al. 2001). Whereas in zone 5 the air humidity is lower coupled with high temperatures and strong winds, so that epiphytes are rarely found in this zone (Kromer and Gradstein 2007).

*Dendrobium* is a genus that is common in SPTN III Wasur, Wasur NP. This is because *Dendrobium* can grow in various types of environments such as high and mountainous areas, at moderate temperatures, in humid and foggy environments, in lowlands and in environments with high temperatures. *Dendrobium* is widespread in Asia, Australia and Europe, India, Sri Lanka, China, Japan, Korea, New Guinea, the Pacific Islands and New Caledonia. *Dendrobium* is the second largest genus of orchids in the world with about 1500 species. About 614 species have been recorded in New Guinea, making *Dendrobium* also the second largest orchid genus in New Guinea after *Bulbophyllum* (Cámara-Leret et al. 2020). *Bulbophyllum* is the largest orchid genus in New Guinea with 658 species (Cámara-Leret et al. 2020). Still, only one species of *Bulbophyllum* was found in this study, possibly because of using a purposive sampling method by exploring accessible forest areas. More *Bulbophyllum* species may be found in unreached areas and in other forest types that have not been studied. Some species of orchids of *SPTN III* Wasur was presented in Figure 4.

**Taxonomy treatment**

*Acriopsis liliifolia* (J. Koenig) Ormerod., Opera Bot. 124 (1995) 58

Epiphytic sympodial. Pseudobulbs ovate, 2.2-5 × 0.5-2.2 cm, glossy apple-green, 2-4 leaved. Leaves narrowly oblong, 10-18 × 1-1.5 cm, apex acute, green. Flowers 0.8-1.4 cm long, greenish-white to yellowish-white, with purple spots at the tips of sepals and petals. Lip 3-lobed.

*Apostasia wallichii* R.Br. in Wall., Pl. Asiat. Rar. 1 (1830) 75, pl. 84

Terrestrial. Leaves linear-lanceolate, 4-14 × 0.5-0.7 cm, apex acute. Inflorescences pendant, sometimes erect with 1-6 branches, 2-5 flowers on each branch, appearing at the ends of the stems. Flowers 1-2 × 2 cm long, pale yellow. Sepals oblong-lanceolate, 4-6.5 × 6-1.7 mm. Petals and lip similar to each other, 3.7-6 × 0.5-1.5 mm, the lip sometimes broader and more convex. Two fertile anthers with an unequally bilobed tip.

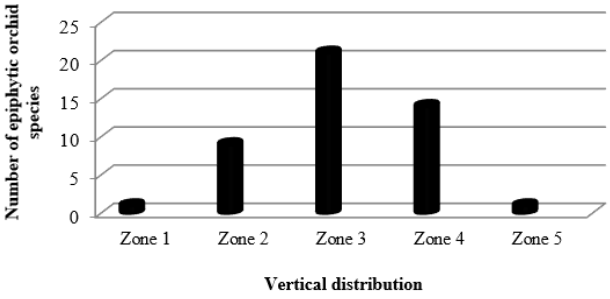


**Figure 3.** Vertical distribution and number of epiphytic orchid species on host trees

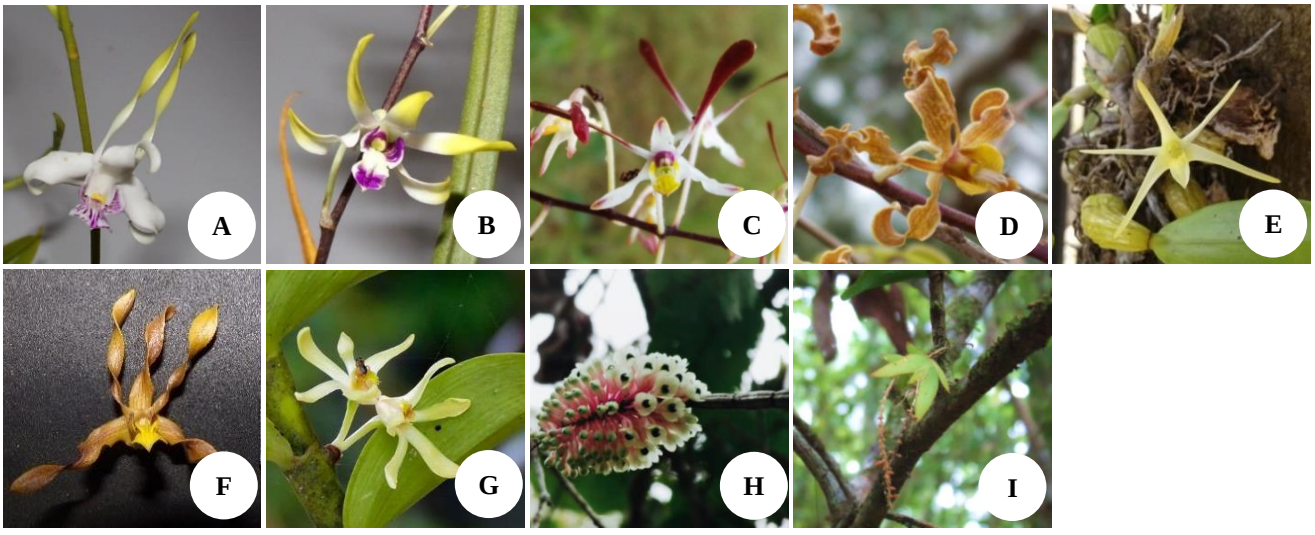


**Figure 4.** Several species of orchids were found in *SPTN III* Wasur, Merauke, Indonesia. A. *Dendrobium antennatum* Lindl., B. *Dendrobium canaliculatum* R.Br., C. *Dendrobium carronii* Lavarack & P.J.Cribb., D. *Dendrobium discolor* Lindl., E. *Dendrobium glabrum* J.J.Sm., F. *Dendrobium johannis* Rchb.f., G. *Dendrobium pruinosum* Teijsm. & Binn., H. *Dendrobium smillieae* F.Muell., I. *Oberonia* sp.

*Bulbophyllum baileyi* F. Muell., Fragm. 9 (1875) 5

Epiphytic sympodial. Pseudobulbs ovate, 1.5-3 × 0.3-1.5 cm. Leaves obovate, 5.5-24 × 1.6-5 cm, apex rounded. Flowers mostly moderately opening. Dorsal sepal elliptic to ovate-triangular, 15-24 × 4-7.5 mm, apex acute, curved downwards at the top. Lateral sepals ovate triangular, 13-24 × 6-8.5 mm, apex acute. Petals elliptic, 13-20 × 3-4.5 mm, shortly acuminate, curved at the top. Flowers cream to yellowish-green with red spots.

*Dendrobium antennatum* Lindl., London J. Bot. 2 (1843) 236

Epiphytic sympodial. Stem fleshy, erect, 15-75 × 1-1.5 cm. Leaves distichous, thick-fleshy, oblong-lanceolate to ovate-elliptic, 4-7 × 0.5-3 cm, apex acuminate. Flowers fragrant, ±6 cm diameter, white with green or greenish-yellow petal tip. Dorsal sepal oblong-lanceolate, 1.6-2.3 × 0.6-0.7 cm, apex acute, twisted. Lateral sepal, oblong-lanceolate, 1.6-2.5 × 0.7 cm, apex acute, twisted. Petal linear, 2.5-5 × 0.2-0.3 cm, acute, spirally twisted. Lip 3-lobed, purple or violet.

*Dendrobium canaliculatum* R.Br., Prodr. (1810) 333.

Epiphytic sympodial. Pseudobulbs fusiform to ovoid, 3-12 × 1.5-3 cm, 2-6 leaved. Leaves flattened cylindrical, 10-17 × 0.5-1 cm, apex acute. Flowers small, ±3 cm diameter. Sepals and petals white with yellow tips. Lip three-lobed, 1.5 × 0.9 cm, white. Midlobe ovate, callus of 3 ridges, apex acute with purple spot, recurved. Side-lobes obovate, apex rounded with purple spot.

*Dendrobium carronii* Lavarack & P.J. Cribb., Austrobaileya 1 (1982 publ. 1983) 497.

Epiphytic orchid. Pseudobulbs fusiform to rounded, 1.5-4 × 1-2 cm, 2-4 leaved. Leaves terete, 7-11 × 0.5-1 cm, apex acute. Inflorescences ± 10 cm long, rachis purple-brown, producing ± 8 flowers. Sepals triangular, 0.5-1 × 0.3-0.5 cm, apex acute, white with purple stripes. Petals oblanceolate, 1.8-2 × 0.2-0.3 cm, apex acute, dark brown, maroon to dark purple with white underside. Lip 3-lobed, 1-1.4 × 0.8 cm, callus of 3 ridges, bright yellow color.

*Dendrobium discolor* Lindl., Edwards's Bot. Reg. (1841) t. 52 Misc. 21.

Epiphytic sympodial. Pseudobulb up to 2.5 m long, with cane-like stems. Leaves distichous, elliptic or ovate-elliptic, fleshy, 5-10 × 2.5-5 cm, apex obtuse-bilobed. Flowers with convoluted and crisped segments, brownish-yellow. Dorsal sepal oblong, 1.5-3 × 0.3-0.5 cm, apex obtuse, spirally twisted. Lateral sepals linear, 2.5-4 × 0.8-1.2 cm, apex acute, spirally twisted. Petals oblanceolate, margin undulate, 2-5 × 0.4-0.8 cm, apex obtuse. Lips 3-lobed, 1-2 cm × 0.3-1.5 cm, with whitish callus.

*Dendrobium glabrum* J.J.Sm., Bull. Dép. Agric. Indes Néerl. 5 (1907) 4; Nova Guinea 8, 1 (1909) 56, t. 20, fig. 64.

Epiphytic sympodial, creeping. Pseudobulbs ellipsoid, 3 × 1 cm, 1-leaved, yellowish-green. Leaves erect, lanceolate, 5.5 × 1.5 cm, apex acute, stiff. Inflorescence 1-flowered, emerging from a pseudobulb. Flowers ± 3.5 cm diameter, yellowish-white to pale yellow. Dorsal sepal lanceolate-linear, 1 × 0.1-0.15 cm, apex acute. Lateral sepals lanceolate- linear, 1.6 × 0.1-0.15 cm, apex acute. Petals lanceolate-linear, 1.6 × 0.1 cm, apex acute to acuminate. Lips 3- lobed, ± 8 mm.

*Dendrobium goldfinchii* F. Muell., S. Sci. Rec. 3 (1883) 4.

Epiphytic sympodial. Stems upwards almost flat. Leaves alternate, distichous, lanceolate-linear, bilaterally flattened, fleshy, 3-7.5 × 0.3 cm, apex acute. Flowers ± 0.9 cm in diameter, inflorescence terminal, glabrous, white or pale green with a faint yellow tinge and a pinkish-purple stripe. Stalklets at the base are closely surrounded by bracts, passing gradually into the narrow and short ovarigerous calyx-tube. Upper calyx-lobe ovate-lanceolate, inner lobes nearly as long as the other lanceolate. Lip rounded, yellowish-white.

*Dendrobium insigne* (Blume) Rchb.f. ex Miq., Fl. Ned. Indië 3 (1859) 640.

Epiphytic orchids. Stems slender, erect, ±45 cm long. Leaves alternate, ovate-oblong, 5-6.5 × 2-2.5 cm, fleshy, somewhat stiff, apex unequally bidentate. Inflorescences lateral, 2-flowered pair. Flowers ±3 cm diameter, pale yellow to cream-yellow with a light brown pattern. Dorsal sepal lanceolate, 2 × 0.53 cm, apex acute. Lateral sepals oblong-triangular, falcate, 1.3-1.8 × 0.95 cm, apex obtuse. Petals lanceolate, 1.65 × 0.4 cm, apex acute. Lip 3-lobed, 1.6 × 0.6 cm, apex acute, whitish-yellow with pale brown to red spots.

*Dendrobium johannis* Rchb.f., Gard. Chron. (1865) 890.

Epiphytic sympodial. Stems fusiform, 8-35 × 0.7-1.2 cm, 7 leaved. Leaves lanceolate, 6-11 × 1 cm, thick, fleshy, apex acute. Flowers ±3.5 cm diameter, brownish-yellow. Dorsal sepal oblong-lanceolate, 2.5 × 0.5 cm, apex acute, twisted. Lateral sepals oblong-lanceolate, 2.5 × 0.5 cm, apex acute, twisted. Petals oblong-lanceolate, 2.5 × 0.5 cm, apex acute, twisted. Lip 3-lobed, 1.5 × 0.5 cm, callus of 3 ridges, bright yellow.

*Dendrobium lacteum* Kraenzl., Österr. Bot. Zeitschr. 44 (1894) 334.

Epiphytic sympodial. Stems slender, clavate, ± 17.5 cm tall, 4-angled, 2-leaved. Leaves lanceolate-ovate, 11-13 × 2-2.5 cm, thin, stiff, acute to acuminate. Inflorescences ephemeral, 2-3 flowered on each stem, appearing from the swollen upper internodes. Flowers ±5 cm across, white. Dorsal sepal ovate-lanceolate, 2.5-3.2 cm long, apex acuminate. Lateral sepal ovate-triangular, falcate, 2.5-3 cm long, apex acuminate. Petal lanceolate, 2.5-3 cm long, apex acuminate. Lips clasping the column, 1.2-1.5 × 1.9-2.2 cm, white inside with orange-red-brown or purple-brown stripes, callus fleshy, golden yellow with brown spots.

*Dendrobium pruinosum* Teijsm. & Binn., Natuurk. Tijdschr. Ned.-Indië 24 (1862) 314.

Epiphytic sympodial. Stems ±100 cm long. Leaves elliptic, apex unequally bilobulate. Inflorescences lateral, flowers born in pairs, opposite each other. Flowers ±5 cm across, cream colors. Dorsal sepal ligulate, 2.6 cm long,

glabrous, apex apiculate. Lateral sepal ligulate, 2.6 cm long, apex apiculate. Petal ligulate, a little shorter than the sepals, apex apiculate. Lip 3-lobed, callus yellowish creamy.

*Dendrobium rigidum* R.Br., Prodr. (1810) 333.

Epiphytic sympodial, creeping. Stems ±1.5 cm long, 1-leaved. Leaves lanceolate, 1.3-4.5 × 0.7-1.1 cm, fleshy, stiff, apex acute. Inflorescences arising from the apex of the stems behind the leaves. Flowers ±1.5 cm across, yellowish cream with purplish spots outside. Dorsal sepal lanceolate-ovate, apex obtuse. Lateral sepals triangular, apex obtuse. Petals lanceolate, apex obtuse. Lip 3-lobed, apex acute, yellow with purplish spots.

*Dendrobium smillieae* F. Muell., Fragm. 6 (1867) 94.

Epiphytic sympodial, sometimes lithophytic. Stems fusiform, 19-35 × 1.5 cm long. Leaves lanceolate, 2-9 × 1-2.5 cm, thin, shiny, green, dark purple when young, apex acute. Inflorescences arising from leafless stems, pedicel and mentum pink to pale purple. Flowers ± 1.5-2.5 cm across, fleshy, sepals and petals greenish-white, apex green. Lip narrow, 1.5-2 cm, concave, fleshy, shiny dark green.

*Dendrobium trilamellatum* J.J.Sm., Bull. Dép. Agric. Indes Néerl. 19 (1908) 21; Nova Guinea 8, 1 (1909) 69, t. 24, fig. 76

Epiphytic sympodial. Stems fusiform, 35-54 × 1.5 cm. Leaves lanceolate, 2-17 × 0.8-4 cm, fleshy, apex acute. Flowers yellow to yellow-brown. Dorsal sepal lanceolate, 2-4 × 0.5 cm, apex acute, twisted. Lateral sepals lanceolate, 2-4 × 0.5 cm, apex acute, twisted. Petals lanceolate, 2-4 × 0.5 cm, apex acute, twisted. Lip 3-lobed, 2.3 × 1.5 cm, callus of 3 ridges, yellow with reddish-brown stripes.

*Geodorum densiflorum* (Lam.) Schltr., Repert. Spec. Nov. Regni Veg. Beih. 4 (1919) 259.

Terrestrial. Pseudobulbs rounded, ±3 cm across. Leaves lanceolate, 20-24 × 6-7 cm, plicate, thin, glabrous. Inflorescences arising from the pseudobulbs. Flowers pink with red or purple lines. Dorsal sepal ovate, 1.4 × 0.3-0.4 cm. Lateral sepal ovate, 1.4 × 0.3-0.4 cm. Petals ovate, 1.4 × 0.3 cm. Lip oblong, 3-lobed.

*Luisia tristis* (G. Forst.) Hook.f., Fl. Brit. Ind. 6 (1890) 25

Epiphytic. Stems erect or ascending, ± 20 × 0.5 cm, terete, stiff, fleshy. Leaves terete, 4-14 × 0.5 cm, apex acute. Inflorescences arising lateral, 0.8 × 1 cm. Flowers 1-1.2 cm across, green to greenish-yellow. Dorsal sepal elliptic, cucullate, apex obtuse. Lateral sepal ovate, concave, apex apiculate. Petals oblong, subspathulate, apex apiculate. Lip 3-lobed, fleshy, maroon, covered with minute brown hairs inside.

*Pholidota imbricata* Hook., Exot. Fl. 2 (1825) t. 138

Epiphytic. Pseudobulbs elliptic to ovate-elongate, 3-4.5 × 1-6 cm, glabrous, sheathing at the base, 1-leaved. Leaf obovate-oblong to lanceolate, ± 30 × 3.5-6 cm, thin, apex acute. Inflorescences pendent, densely many-flowered. Flowers 0.4-0.5 cm across, creamy white with dark yellow-orange lips. Dorsal sepal ovate, 5-6 × 3-4 mm, top obtuse to acute, tip acuminate. Lateral sepals ovate to ovate-oblong, 5-7 × 2.5-3.5 mm, top acute. Petal falcate, 4.5-6 × 1.3-2.2 mm, top acute, tip rounded. Lip broadly inserted.

*Pinalia fitzalanii* (F. Muell) Kuntze., Rev. Gen. Pl. (1891) 679.

Epiphytic. Pseudobulb ovate to elliptic, 4-10 × 2-3.5 cm, covered with scales, 2-4 leaved. Leaves elliptic-ligulate, 10.5-20 × 2-2.5 cm, apex acute. Inflorescence arising near the apices of the pseudobulbs, densely many-flowered. Flowers ± 6 mm across, erect-patent, white. Dorsal sepal oblong, apiculate, 0.6 cm long. Lateral sepal oblique, 0.25 cm long. Petal obliquely oblong, broadly obtuse, glabrous, somewhat shorter than the sepals. Lip obovate-cuneate, glabrous, 0.65 cm long.

*Pomatocalpa macphersonii* (F. Muell.) T.E. Hunt., Queensland Naturalist 16 (1958) 27.

Epiphytic monopodial. Stem short. Leaves subfalcate-oblique, ligulate, base half twisted, 15-29 × 3-4 cm, fleshy, shiny, apex unequally-bilobed. Inflorescences pointing downwards. Flowers small, ±0.8 cm across, non-resupinate. Dorsal sepal, lateral sepal and petals obovate, fleshy, apex rounded to obtuse, yellow with reddish spots. Lip 3-lobed, thickened at the base, white to pale yellow. Spurs bucket-shaped, rounded to obtuse, pale yellow with brown spots.

*Pomatocalpa marsupiale* (Kraenzl.) J.J.Sm., Natuurk. Tijdschr. Ned.-Indië 72 (1912) 105.

Epiphytic monopodial. Stem ±25-100 cm long. Leaves scattered along the stem, strap-shaped, 13-22 × 2.5 cm, falcate, apex obtuse, unequally-bilobed. Flowers non-resupinate, ±0.4 cm across, yellow to yellowish-green. Dorsal sepal, lateral sepal and petals obovate-oblong, slightly falcate, apex obtuse to rounded. Lip 3-lobed. Spur bucket-shaped.

*Thrixspermum platystachys* (F.M.Bailey) Schltr., Orchis 5 (1911) 55.

Epiphytic. Leaves lanceolate, 14 × 2.5 cm, ligulate, glabrous, apex unequally-bilobed. Inflorescences with long, flat and elongated peduncle.

*Dendrobium* sp. (Section Diplocaulobium)

Epiphytic. Stems slender, 1-2.5 × 0.15 cm, 1-leaved. Leaves erect, ligulate, 2-4.5 × 0.3-0.5 cm, fleshy, slightly stiff, apex bilobed.

*Oberonia* sp.

Epiphytic, very small. Stems very short, covered with 3-5 leaved. Leaves lanceolate-elongate, 0.5-2 × 0.1-0.4 cm, arranged like a fan, laterally flattened, thin, apex acute, pale green. Flower buds very small, 1.5-4 cm across, arranged in whorls, reddish-brown. Flowers not seen.

In conclusion, a total of 25 orchid species belonging to 11 genera have been identified from SPTN III Wasur, Wasur National Park. Monsoon forest is the type of forest

with the highest number of orchid species among the forest types, with 15 orchid species. It is then followed by savanna with 10 species, *Melaleuca* forest with 10 species, woodland forest with 9 species, riparian forest with 6 species, and *Melaleuca-Eucalyptus* forest with 5 species. *Dendrobium smillieae* and *Dendrobium rigidum* are the most widely distributed epiphytic orchid species, and their distribution is almost in all forest types. Whereas terrestrial orchids, *Geodorum densiflorum* and *Apostasia wallichii*, are only found in the monsoon forest.

## ACKNOWLEDGEMENTS

The authors would like to thank Wasur National Park for issuing a research permit in SPTN III Wasur, Wasur National Park, Merauke, Papua. In addition, the first author is thankful to La Hisa for helping identify plant specimens and guidance during the research.

## REFERENCES

Arobaya AYS, Heipon A, Sinery AS, Wakum A. 2020. Biodiversity Mapping of *Dendrobium* Sw. section *Spathulata* Lindl. in the Ramsar Site of Wasur National Park of Indonesia New Guinea. World J Adv Res Rev 5 (2): 167-176. DOI:10.30574/wjarr.2020.5.2.0032.

Balgooy MJJ van. 1987. Collecting. In: de Vogel (ed.). Manual of Herbarium Taxonomy: Theory and Practice. UNESCO for Southeast Asia, Jakarta.

Cámara-Leret R, Frodin DG, Adema F, et al. 2020. New Guinea has the world's richest island flora. Nature 584: 579-583.

Cascante-Marín A, von Meijenfeld N, de Leeuw HMH, Wolf JHD, Oostermeijer JGB, den Nijs JCM. 2009. Dispersal Limitation in Epiphytic Bromeliad Communities in a Costa Rican Fragmented Montane Landscape. Journal of Tropical Ecology 25 (1): 63-73. DOI: 10.1017/S0266467408005622.

Chowlu K, Rao AN. 2015. Synopsis of *Pholidota* Lindley ex W.J. Hooker (Orchidaceae) in Manipur, India, with a newly recorded species. Richardiana 16: 4-17.

de Vogel, E.F. 1988. Revisions in Coelogyninae (Orchidaceae) III* The Genus *Pholidota*. Orchid Monogr 3 (1): 1-78.

Dressler L. 1981. The Orchids. Natural History and Classification. Harvard Univ Press, Cambridge.

Eden MJ. 1974. The Origin and status of savanna and grassland in Southern Papua. Trans Inst Br Geogr 63: 97-110. DOI: 10.2307/621534

Frei SJK. 1973. Orchid ecology in a cloud forest in the mountains of Oaxaca, Mexico. Amer Orchid Soc Bull 42: 307- 314.

Guinness P, Walpole B. 2012. Environmental Systems and Societies for the IB Diploma. Cambridge University Press, Cambridge.

Hernández-Perez E, Solano E, Rios-Gomez R. 2018. Host affinity and vertical distribution of epiphytic orchids in a montane cloud forest in Southern Mexico. Bot Sci 96 (2): 200-217. DOI: 10.17129/botsci.1869.

Hinsley A, de Boer HJ, Fay MF, Gale SW, Gardiner LM, Gunasekara RS, Kumar P, Masters S, Metusala D, Roberts DL, Veldman S, Wong S, Phelps J. 2018. Review of the trade in orchids and its implications for conservation. Bot J Linn Soc 186 (4): 435-455. DOI: 10.1093/botlinnean/box083.

Johansson D. 1974. Ecology of Vascular Epiphytes in West African Rain Forest. Acta Phytogeogr Suec 59: 1-136.

Kromer T, Gradstein SR. 2007. Vertical stratification of vascular epiphyte in submontane and montane forest of the Bolivian Andes: The importance of the understory. Plant Ecol 189: 261-278. DOI: 10.1007/s11258-006-9182-8.

Kusmana C, Hikmat A. 2015. Keanekaragaman hayati flora di Indonesia. Jurnal Pengelolaan Sumber Daya Alam dan Lingkungan 5 (2): 187-198. [Indonesian]

López-Villalobos A, Flores-Palacios A, Ortiz-Pulido R. 2008. The relationship between bark peeling rate and the distribution and mortality of two epiphyte species. Plant Ecol 198: 265-274. DOI: 10.1007/s11258-008-9402-5

Managanta A, Pangli M. 2014. Studi habitat dan inventarisasi anggrek hitam (*black orchid*) di Kawasan Hutan Cagar Alam Bancea Kecamatan Pamona Selatan, Kabupaten Poso. Jurnal AgroPet 11 (1): 19-45. [Indonesian]

Marsusi, Mukti C, Setiawan Y, Kholidah S, Viviati A. 2001. Studi keanekaragaman anggrek epifit di hutan Jobolarangan. Biodiversitas 2 (2): 150-155. DOI:10.13057/biodiv/d020205.

Millar A. 1990. Orchids of Papua New Guinea. Australian National University Press, Canberra.

Minderhoud ME, de Vogel EF. 1986. A taxonomic revision of the Genus *Acriopsis* Reinwardt ex Blume (Acriopsidinae, Orchidaceae). Orchid Monogr 1: 1-16.

Nurfadilah S. 2015. The diversity of epiphytic orchids and the host trees (Phorophytes) in the secondary forest of Coban Trisula, Malang Regency, East Java, Indonesia. Biotropia 22 (2): 120-128. DOI:10.11598/btb.2015.22.2.450.

Ormerod P. 2017. Checklist of Papuasian Orchids. Nature & Travel Books, Lismore.

Pammai K, Muhdhar MHIA, Rochman F. 2014. Studi keanekaragaman anggrek di Kabupaten Merauke Propinsi Papua. Prosiding Seminar Nasional XI Pendidikan Biologi FKIP UNS, Sebelas Maret University, Surakarta, 7 June 2014. [Indonesian]

Sadili A. 2013. Jenis Anggrek (Orchidaceae) di Tau Lumbis, Nunukan, Propinsi Kalimantan Timur: Sebagai indikator terhadap kondisi kawasan hutan. Jurnal Biologi Indonesia 9 (1): 63-71. [Indonesian]

Schuiteman A. 2013. A Guide to *Dendrobium* of New Guinea. Natural History Publications (Borneo), Kota Kinabalu.

Tupac-Otero J, Aragón S, Ackerman JD. 2007. Site variation in spatial aggregation and phorophyte preference in *Psychilis monensis* (Orchidaceae). Biotropica 39: 227-231. DOI: 10.1111/j.1744-7429.2006.00258.x.

Turubanova S, Potapov PV, Tyukavina A, Hansen MC. 2018. Ongoing primary forest loss in Brazil, Democratic Republic of the Congo, and Indonesia. Environ Res Lett 13: 074028. DOI: 10.1088/1748-9326/aacd1c.

Wagner K, Mendieta-Leiva G, Zotz G. 2015. Host Specificity in Vascular Epiphytes: a review of methodology, empirical evidence and potential mechanisms. AoB Plants 7: 1-25. DOI: 10.1093/aobpla/plu092

Wasur National Park. 2014. Rencana Pengelolaan Jangka Panjang Taman Nasional Wasur Periode 2014-2023 Kabupaten Merauke Provinsi Papua. Balai Taman Nasional Wasur, Merauke.

Watthana S. 2007. The Genus *Pomatocalpa* (Orchidaceae) a taxonomic monograph. Harvard Papers Bot 11 (2): 207-256. DOI: 10.3100/1043-4534(2007)11[207:TGPOAT]2.0.CO;2.

Werner FA, Gradstein SR. 2009. Diversity of dry forest epiphytes along a gradient of human disturbance in the Tropical Andes. J Veg Sci 20 (1): 59-68. DOI: 10.1111/j.1654-1103.2009.05286.x.

Woods CL, Cardelús CL, DeWalt SJ. 2015. Microhabitat associations of vascular epiphytes in a wet tropical forest canopy. J Ecol 103: 421-430. DOI: 10.1111/1365-2745.12357.

Zhang S, Yang Y, Li J, Qin J, Zhang W, Huang W,. Hu H. 2018. Physiological diversity of orchids. Plant Div 40 (4): 196-208. DOI: 10.1016/j.pld.2018.06.003.

Zimmerman JK, Olmsted IC. 1992. Host tree utilization by vascular epiphytes in a seasonally inundated forest (Tintal) in Mexico. Biotropica 24: 402-407. DOI: 10.2307/2388610.