Orchid conservation in a small island: current study and challenges of *Dendrobium striaenopsis* conservation in Angwarmase island nature reserve, Moluccas, Indonesia

B Broto¹, T H Kuswoyo² and A D Setiyani²

¹ Environment and Forestry Research and Development Agency, Makassar
² Maluku Nature Reserve Agency, Maluku

E-mail: wisnubroto87@gmail.com

Abstract. Orchids are considered one of the most commercially valuable in ornamental plant. *Dendrobium striaenopsis*, an endemic orchid to Tanimbar Islands, Moluccas, is widely notable species for orchid hybridizing. However, with its restricted distribution to small islands, this species is prone to extinction. To date, the ecological aspects of *D. striaenopsis* are not well studied, thus can hamper its conservation efforts. 30 plots in 3 different types of habitat in Angwarmase Island Nature Reserve were surveyed to assess its abundance and habitat. The locals surrounding the reserve were interviewed to identify potential threats. 165 individuals *D. striaenopsis* were found during survey. The result indicated that *D. striaenopsis* was not host-specific orchid species. The species was found in 15 species host trees with *Lumnitzera racemose* was the common host species. Zone 2 (upper part of the main stem) was revealed as the most favorable part at the host tree (105 individuals). It was found that the habitat of the species was threatened by agriculture activities. Besides, *D. striaenopsis* was also traded illegally by locals.

1. Introduction

Orchids is one of notable plant groups in global horticultural and floricultural trades [1,2]. This group is utilized, cultivated and traded for wide range of purposes, including as horticultural products, medicinal products and food [2]. The total economic value of global orchid trades is about US$ 504 million with 39% of total global orchid exports is from the Netherland and 30% of global orchid imports is Japan[1]. In Indonesian orchid market, Taiwan is the top exporter country with 56.6% of total Indonesian orchid imports, whereas Japan is the most importer country with 41.15% of total Indonesian orchid exports [3]. Globally, the largest orchid products were fulfilled from orchid cultivation [4] with Dendrobium as the majority genus traded in artificially propagated live plants [5]. However, despite the majority orchid products from legal process (e.g. cultivation), illegal harvest still occurs due to high demands on wild orchid species, especially rare species, thus it potentially threatens their existence in nature [6].

Maluku, Indonesia, a part of Wallace region, is a biodiversity hotspot [7]. Its geographic position, geologist and bio-geographical isolation have contributed to its complex ecosystems and high numbers of
endemic {Merging Citations}, including orchids [10]. At least 272 orchid species are found in Maluku islands [10]. Yet this high potential of Moluccas floras is threatened by anthropogenic activities, such as mining [11] and agriculture [12]. The efforts to conserve Maluku orchids are limited by inadequate data. Thomas and Schuiteman [10] noted that the information of Maluku orchids is the least known compared to other regions in Southeast Asia. Further, Maluku orchids also have received relatively little attention. In last decade, there are only 3 orchid studies conducted in Moluccas [14-16].

The study focuses on *Dendrobium striaenopsis* (Anggrek larat) as a case study since this species is an endemic orchid to small islands, Tanimbar islands, Maluku [17], making them prone to extinction. Further, due to its beautiful flowers, *D. striaenopsis* may be particularly vulnerable to over-harvest. This species has high economic value as ornamental plants or hybridization materials. Many valuable orchid hybrids are produced using this species as parentage, such as Dendrobium Cesar and Dendrobium David Sander. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has listed this species in Appendix II [18]. Further, Indonesian Government has stated this species as flora identity for Maluku according to Decree of the Minister of Home Affairs number 48/1989. To date, however, the ecological aspects of *D. striaenopsis* are not well studied, thus can hamper its conservation efforts. Here, we provide preliminary study on ecological study of *D. striaenopsis*, focused on its abundance, habitat and potential threats.

2. Material and Methods

The study was conducted on December 1\textsuperscript{st} - 10\textsuperscript{th}, 2018 in Angwarmase Island Nature Reserve (AINR) (Figure 1). Angwarmase Island stated as a Nature Reserve according to Decree of the Monistry of Forestry (KepMenHut) No. 403/Kpts-II/1988 on August 11, 1978, covering 295 ha landmass. Geographically, the reserve range between 8°0' - 8°2' LS and 131°5' -131°6' BT, located in Selaru Village, Adaut Subdistrict, Tanimbar island Regency, Maluku Province. The Reserve altitude is from sea level up to 75 m a.s.l with relatively hilly topography. Climate type is monsoon with peak dry season on December-January and rainy season on April-May, with average rain fall is 1752 mm/year. Humidity is about 80,3% with temperature of 20-34°C [18].

![Figure 1. Map of Angwarmase Island Nature Reserve, Adaut, Tanimbar Island, Maluku](image)

Three forest types, i.e. Primary Forest, Secondary Forest and Mangrove, with 30 study plots within the Nature Reserve were selected. The number of plots were calculated on each forest type in proportion to the area. The plots of 20 m x 20 m were established using systematic random technique. The line was placed perpendicular to the contour with the distance between plots along 50 m. To avoid the edge effects, starting plot was placed 100 m away from the boundary of each forest type. In each plot, number of individuals were calculated, species of host tree, zone growth of orchid in host tree [20] were noted and
four habitat parameters were taken, namely elevation, temperature, humidity, and light intensity. This study also calculated Importance Value Index (IVI) [21] to depict vegetation composition and structure of its habitat. Further, the locals surrounding the reserve were interviewed to identify potential threats. The data was analyzed using descriptive statistics.

3. Result and discussion
In total, this study found 165 individuals *D. striaenopsis* in AINR. A total of 34 individuals were recorded in Primary forest, 131 individuals were found in Secondary forest and no single individual of *D. striaenopsis* was found in Mangrove. The highest number of the species found in secondary might be influenced by the distribution of its host tree. Epiphyte orchids are host-tree dependent, thus their distribution is affected by the availability of host tree. The study on epiphytic orchids in Bangladesh showed that the presence of orchids is related to the distribution of their host tree [22].

During study, 15 species of trees were identified as hosts trees of *D. striaenopsis*, but only 9 of them has been identified until species/genus (Table 1). It indicates that *D. striaenopsis* is not host-specific orchid species. This result supports other studies conducted in Indian tropical forests, where epiphytic orchid species were found growing on various types of host trees [23]. In addition, another review on orchid-host tree association showed specific associations between host tree and epiphytic orchids are more influenced by a combination of stochastic factors (e.g. inadequate samples size) and host biases (e.g. incomplete variables) than the individual host tree itself [24]. For example, research on Australian orchids showed that the presence of fungi associated with certain tree species was the main factor driving the presence of three types of orchids than the existence of the tree Error! Reference source not found..

![Figure 2. Plant and flower of *Dendrobium striaenopsis*](image)

Table 1. Host tree, family, frequency as host tree, total of individual orchid, and average of individual orchids on each host tree in Angwarnase Island Nature Reserve, Maluku.

| Species of host tree       | Family       | Frequency as host tree | Σ individual of orchid | Individual of orchid/host tree |
|----------------------------|--------------|------------------------|------------------------|---------------------------------|
| Lumnitzera racemose        | Combretaceae | 12                     | 82                     | 6.83                            |
| Champeria millana          | Opiliaceae   | 1                      | 1                      | 1                               |
| Pentaspodon motleyi        | Anacardiaceae| 3                      | 8                      | 2.66                            |
| Malanococca tomentosa      | Anacardiaceae| 2                      | 8                      | 4                               |
Thespesia populnea Malvaceae 2 2 1
Diospyros sp.1 Ebenaceae 7 25 3.56
Diospyros sp.2 Ebenaceae 1 5 5
Pangium edule Achariaceae 2 5 2.5
Manilkara kanosiensis Sapotaceae 4 14 3.5

_Lumnitzera racemosa_ was a host tree with the highest number of orchid individuals/trees, with an average number of 6.83 individuals/trees (Table 1). The rough and fleshy _Lumnitzera racemosa_ bark (Figure 3) might be able to accumulate nutrients and maintain the moisture needed for the growth of epiphytic orchids. The roughness and substrate type of bark are the most important factors influencing the abundance of epiphytic orchids [25].

![Figure 3. The bark characteristic of _Lumnitzera racemosa_](image)

Most of individuals were found in zone 2 (upper part of the main stem), 89 individuals (50% of the total individuals). This indicates that the species preferred moderate light intensity and humidity. The temperature of the research location was relatively high with a range of 32 °C - 39.3 °C, low humidity between 54% to 76.2% and high light intensity ranges from 795-6726. Epiphytic orchids choose certain zones to get the right light and humidity to maximize their growth [26]. The results of this study are in line with the results of research from Hirata et al [27], where epiphytic orchids were found growing in zone 2 (upper part of the main stem) and zone 3 (⅓ part of the total length of the branch).

From the IVI (Important Value Index) calculation, _Pentaspadon motley_ has the highest IVI value (29.35 %) (Table 2). _Pentaspadon motley_ and _Malanococca tomentosa_ were the host tree with a high IVI (29.35%) and (24.28%), respectively. This indicates that these species play an important role in the component of orchid habitat at the research location. Furthermore, although species with relatively high IVI is not a host trees, their presence is also essential in creating a suitable microclimate for orchid. Benavidas et al [28] stated that forest type affected the diversity and composition of orchids.

Furthermore, this study also found that coconut trees (_Cocos nucifera_) had relative high IVI value (27%) (Table 2). This result indicates that the presence of this species is relatively abundant in the study area. The abundance of coconut tree was driven by agricultural activities in the research location. The locals have utilized a part of the reserve for agriculture (e.g. coconut, corn, sweet potato) for decades. This agriculture activities, moreover, will threaten the existence of the habitat and eventually drive the orchids to extinction.
Table 2. The tree species with the highest IVI, number of plots, number of individual, relative density (RD), relative frequency (RF), relative basal area (RBA), and importance value index (IVI).

| No | Species                  | N plot | N | RD  | RF  | RBA | IVI (%) |
|----|--------------------------|--------|---|-----|-----|-----|---------|
| 1  | Pentaspadon motleyi      | 9      | 10| 8.47| 13.04| 7.83| 29.35   |
| 2  | Cocos nucifera          | 5      | 11| 9.32| 7.25 | 10.43| 27.00   |
| 3  | Malanococca tomentosa    | 6      | 7 | 5.93| 8.70 | 9.65 | 24.28   |

Based on interview, the AINR’s communities, called Tnyafar, had strong relation to the pattern of wild-orchid harvesting and utilization. The harvesters collected wild orchids from the reserve for subsistence and commercial purposes. As a subsistence purpose, the people gathered the orchids for ornamental plants. The locals planted the orchid in dead trees and put it in front of their houses. Further, they also plant the orchid using natural host tree in some places outside the AINR. They would give the orchid to their relative and sometimes they sell it if there is any demand. Subsistence purposes of D. striaenopsis had strong relation to the local culture. People know that this species is an endemic orchid to Tanimbar Islands, thus possessing the orchid becomes a pride for them. This culture drove the people to have high desire to collect and grow the orchid. Thus, it leads to increase the demand of D. striaenopsis and has serious consequences to the existence of the species in its habitat.

Meanwhile for commercial uses, the locals harvested the orchids based on order. The orders came from many places from surrounding Tanimbar Islands (e.g. Selaru subdistrict) to other islands like Java, Ternate and Sulawesi. The harvesters do not really understand about the market value of the orchid. Then, it enters the trade in inexpensive prices which was approximately IDR 50,000 to 100,000 each box containing around 100 plants of D. striaenopsis. D. striaenopsis commonly uses as parents in hybrid orchid and it has high price among the breeders, florist and plant sellers.

4. Conservation Recommendation

The future research should be prioritized on basic ecological data, especially on population, habitat and distribution of D. striaenopsis in adjacent islands. These data are important to set monitoring programs for future conservation efforts. In addition, the future efforts also should be conducted to understand the factor affecting the presence of D. striaenopsis on host tree, especially on Lumnitzera racemose known as the most preferable host tree of the species. Wegner et al. [24] explained that the study on mechanism of vascular epiphytes-host tree should be carried out using comprehensive approach to avoid false decisions. There are several variables affecting the degree of host specificity, namely host tree traits, epiphyte trait, cascading effects, Climate, potential host pool and the spatial scale [24].

The main factor driving orchid extinction is habitat loss due to human activities [29]. This study showed that coconut trees are relatively abundance in study area. It indicates that encroachment activities have been occurred at the study area. Thus, law enforcement should be applied to protect the reserve since the reserve is essential in preserving orchid species. Protecting the reserve is a necessity because orchids require specific microclimate or soil conditions, which are very difficult to be restored [30].

Besides strict law enforcement, enhancing knowledge and awareness are essential aspects to tackle wild orchid harvesting. The study showed that the locals have lack of knowledge about the status of AINR and the population of D. striaenopsis. Arenas et al [31] stated that important gaps in orchid conservation are lack of knowledge, inaccurate information on orchid diversity and conservation status and lack of public awareness about conservation of certain species. Further, The Minister of Environment and Forestry issued D. striaenopsis from protected species list, and it might increase possibility of overexploitation.
This study found that orchid utilization is driven by local culture. Thus, conservation strategies that allow sustainable use of orchid should be proposed. The traditional knowledge of \textit{D. striaenopsis} among the Tnyafar communities can be useful for conservation actions like a case in Northeastern region in India [32]. Liu et al. [33] proposed restoration-friendly cultivation in natural setting as an effective conservation tool with minimum investment. This strategy allows sustainable uses of certain species and increasing income for the communities[33]. In line to this, some studies showed that sustainable utilization is effective in conservation of epiphytic plants [34]. Sustainable use can be applied by setting quota (the number of species to be utilized) [35] and cultivating orchids through propagation techniques, such as the use of biotechnology [36]. Propagation, furthermore, is also beneficial in reducing the pressure of illegal harvest and assisting conservation efforts through restoration [37] and reintroduction. Some research showed that orchid reintroduction is success in increasing the population of several endangered orchids [38].

5. Conclusion
In total, this study found 165 individuals \textit{D. striaenopsis} in Angwarmase Island Nature Reserve. This study indicated that \textit{D. striaenopsis} is not a host-tree specific orchid. \textit{Lumnitzera racemosa} was the most preference host tree for the species. The conservation efforts are needed since the species was threatened by illegal harvest and encroachment.

Acknowledgment
This study was a part of long-term cooperation between Nature Conservation Agency (BKSDA) Maluku and Plant Filling Depot (Depot Pengisian Pesawat Udara (DPPU)) Pertamina Pattimura Airport Ambon, Maluku. We gratefully acknowledge funding from DPPU Pertamina Pattimura Airport, Ambon which allowing us to conduct this study. We thanked to local communities, especially Nyafar, for support and many informative conversations.

References
[1] De L C 2015 Commercial orchids (Berlin: De Gruyter)
[2] Hinsley A, de Boer H J, Fay M F, Gale S W, Gardiner L M, Gunasekara R S, Kumar P, Masters S, Metusala D, Roberts D L, Veldman S, Wong S and phelps J 2018 a review of the trade in orchids and its implications for conservation \textit{Botanical Journal of the Linnean Society}. 186 435–455
[3] Pusat Data dan Sistem Informasi Pertanian Sekretariat Jenderal Kementerian Pertanian 2015 outlook anggrek (Poslithortki: Komoditas Pertanian Subsector Holtikultural)
[4] Hinsley A, Verissimo D, Roberts DL. 2015. heterogeneity in consumer preferences for orchids in international trade and the potential for the use of market research methods to study demand for wildlife. \textit{Biological Conservation} 190 80–86
[5] UNEP-WCMC. 2017. \textit{CITES} trade statistics derived from the \textit{CITES} Trade Database (Cambridge: UNEP World Conservation Monitoring Centre)
[6] Thomas B 2006 slippers, thieves and smugglers-dealing with the illegal international trade on orchids. \textit{Environmental Law Review} 8 85–92
[7] Myers N 2003 biodiversity hotspots revisited. \textit{BioScience} 53 916
[8] Coates B J and Bishop K D (1997) \textit{Birds of Wallacea} (Queensland, Australia: Dover Publications) pp 535.
[9] Monk K, de Fretes Y, Reksodiharjo-Lilley G 1997 the ecology of Nusa Tenggara and Maluku (Singapore: Periplus Editions) pp 965
[10] Thomas S and Schuiteman A 2002 orchid of Sulawesi and mollucas: the primary catalogue \textit{Lindleyana} 1 1–72
[11] Butt N, Beyer H L, Bennett J R, Biggs D, Maggini R, Mills M, Renwick AR, Seabrook L M, and Possingham H P 2013 biodiversity risks from fossil fuel extraction. *Science* 342 425–426
[12] Ellen R 1997 The human consequences of deforestation in the Moluccas. *Civilisations* 44 176–193
[13] Butt N, Beyer H L, Bennett J R, Biggs D, Maggini R, Mills M, Renwick AR, Seabrook L M, and Possingham H P 2013 biodiversity risks from fossil fuel extraction. *Science* 342 425–426
[14] Tirta I G 2013 inventory of orchids in some area of Manusela National Park, Maluku. ICGRC proce: 218–221.
[15] Ivakdalam L M, Pugesehan D J 2016 keragaman jenis tanaman anggrek (Orchidaceae) di Cagar Alam Angwarmase, Kabupaten Maluku Tenggara Barat. *Jurnal Agroforestri* 11: 163–168.
[16] Purnomo S A 2016) species diversity of epiphytic orchids in Natural Reserve of Mount Sibela, North Moluccas. *AIP Conf. Proc.*, 1–6.
[17] Lavarack B, Harris W, Stocker G (2006). *Dendrobium and its Relatives* (Portland: Timber press)
[18] CITES (Convention on the International Trade in Endangered Species of Wild Flora and Fauna) 2013 CITES species. Available from https://www.cites.org/eng/disc/species.php [accessed August 2019].
[19] Masruroh S, Lita S. Poliploidisasi Anggrek Vanda lombokensis J. J. Sm. Menggunakan Kolkisin Secara In Vivo. *Jurnal Produksi Tanaman* 7
[20] Johansson D 1974 Ecology of vascular epiphytes in West African rainforest. (Svenska vaxtgeografiska sallskapet) pp 129
[21] Kusmana C 1997 Metode Survey Vegetasi. (Bogor: PT. Penerbit Institut Pertanian Bogor)
[22] Huda M K and Wilcock C C 2011 colonisation and diversity of epiphytic orchids on trees in disturbed and undisturbed forests in the Asian tropics. *Gardens’ Bulletin Singapore* 63 341–356
[23] Annaselvam J and Parthasarathy N 2001 diversity and distribution of herbaceous vascular epiphytes in a tropical evergreen forest at Varagalaiaar, Western Ghats, India. *Biodivers. Conserv.* 10 317–329
[24] Wagner K, Mendieta-leiva G, and Zott G 2015 host specificity in vascular epiphytes : a review of methodology , empirical evidence and potential mechanisms. *AoB Plants* 7 1–25
[25] de la Rosa-Manzanoa E, Andradea J L, Zotzc G, Reyes- García C 2014 epiphytic orchids in tropical dry forests of Yucatan, Mexico–Species occurrence, abundance and correlations with host tree characteristics and environmental conditions Flora 209 100–109
[26] Dressler R 1982 The Orchids Natural History and Classification. (Boston, US: Harvard University Press)pp 332
[27] Hirata A, Kamijo T, and Saito S 2009 host trait preferences and distribution of vascular epiphytes in a warm-temperate forest. *Plant Ecology* 201 247–254.
[28] Benavides A M, Vasco A, Duque A J, Duivenvoorden J F 2011 Association of vascular epiphytes with landscape units and phorophytes in humid lowland forests of Colombian Amazonia. *Journal of Tropical Ecology* 27: 223–237
[29] Dixon K and Phillips R 2015 the orchid conservation challenge. *Lankesteriana* 7 10–12
[30] Barman D and Devadas R 2013 climate change on orchid population and conservation strategies : a review. *Journal of Corp and Weed* 9 1–12.
[31] Arenas M A S, Gomez R S and Hágsater E 2007 risk of extinction and patterns of diversity loss in mexican orchids. *Lankesteriana* 7 114-121
[32] Medhi R P and Chakrabarti S 2009 traditional Knowledge of NE people on conservation of wild orchids. Ind J Trad Know 8 11-16
[33] Liu H, Luo Y, Heinen J, Bhat M and Liu Z 2014 eat your orchid and have it too: a potentially new conservation formula for Chinese epiphytic medicinal orchids *Biodivers. Conserv.* 23:1215–1228
[34] Pickens K A, Affolter J M, Wetstein H Y, Wolf J H D 2003 enhanced seed germination and seedling growth of Tillandsia Eizii In Vitro. *HortScience* 38 101–104
[35] Wolf J H D 2000 epiphytic bromelia’s: toward the sustainability of yield from natural populations in
the highlands of Chiapa’s, Mexico. *European Tropical Forest Research Network* **32** 64–67

[36] Semiarti E 2002 orchid biotechnology for Indonesian orchids conservation and industry Orchid Biotechnology for Indonesian Orchids Conservation and Industry. *AIP Conf. Proc.* 020022 1–5

[37] Swarts N D and Dixon K W 2009 terrestrial orchid conservation in the age of extinction Nigel *Annals of Botany* **104** 543–556

[38] Wu K, Zeng S, Lin D, Teixeira JA, Bu Z, Zhang J 2014 in vitro propagation and reintroduction of the endangered Renanthera imschootiana Rolfe. *PLoS ONE* **9** 1–12