Biodiversity mapping of Dendrobium Sw. section Spathulata Lindl. in the Ramsar Site of Wasur National Park of Indonesia New Guinea

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Abstract
Wasur National Park is a vast area of tropical lowland forest, swamp forest, savannah and wetland in the far southeast corner of Papua-Indonesia. It is bordered by the sea to the south and PNG to the east. It lies within the Trans-Fly region of New Guinea and both the habitat and birds have much in common with northern Australia only 200 km to the south. The site is very seasonal, with both a pronounced wet and dry season. This park displays a tremendous biodiversity of flora and fauna. One prime example of flowering plants is Orchids species. Most orchids in this park resembles to the Australian plants as it share similar vegetation types of heath forest and savanna woodland. Knowledge of orchid diversity from this park is poorly acknowledged. This preliminary study aims to document species diversity, to map diversity and distribution of orchid species of Dendrobium section Spathulata and the host plants in the national parks. The study is conducted in six sites i.e. Bokem, Sota, Rawa Dongami, Rawa Biru, Wasur village, and Yanggandur. The plants were collected and recorded whenever they are encountered on the host trees. In total 40 orchid plants are collected and identified using bio-molecular techniques combined with morphological characters. 11 species recorded from Dendrobium section Spathulata i.e. Dendrobium canaliculatum, Dendrobium carronii, Dendrobium d’albertisii, Dendrobium devosianum, Dendrobium discolor, Dendrobium ionoglossum, Dendrobium johannis, Dendrobium nindii, Dendrobium semifuscum, Dendrobium sylvanum and Dendrobium trilamellatum. Other species from Dendrobium section Phalaenanthe such as Dendrobium bigibum, Dendrobium section Calyptrorchis i.e. Dendrobium smilliae dan Dendrobium capituliferum, Dendrobium section Dendrocorynaceae, and one species of Pomatocalpa marsupiale. During the field observation, we noticed hunting activity run by vendors and hunters. This activity brings impact to the sustainability of the plants. Vendors are mainly locals who inhabit and land tenure in this park.

Keywords: Diversity; Orchids; Epiphyte; Phorophyte; Ramsar Site; Wasur NP-Papua

1. Introduction
Wasur National Park is geographically located at 140°27’ to 141°2’ E and 8°5’ to 9°7’ S. The Park is border to Sungai Maro in the the North and Arafura Sea in the South, Merauke City in the West and Tonda Negara Wildlife reserve of Papua New Guinea. The Park was established by the Ministry of Forestry in 1997 as National Park with 413,810 ha. Wasur National Park is a vast area of tropical lowland forest, swamp forest, savannah and wetland in the far southeast corner of Papua. It is bordered by the sea to the south and PNG to the east. It lies within the Trans-Fly region of New Guinea and both the habitat and birds have much in common with northern Australia with only 200 km to the south. The site is very seasonal, with both a pronounced wet and dry season. The main objective of preserving the
park is to protect biodiversity and water resources. Aside of this, the national park is sheltering a remarkable biodiversity of flora and fauna. The vegetation type is dominated by tree family of *Myrtaceae* to which is predominantly known to the heath forests ecosystem. This family host many epiphytic plants. One prime example of an epiphytic plant occurs in the park, well-known as an ornamental plant, is *Orchidaceae*.

Most studies from this park were focus on a landscape and socio-cultural based. Not many work has been published which gives a comprehensive review of diversity and distribution of orchids as well as the host plants (phorophyte) in this particular sites [1]. The fact that this park is well-known for unique vegetation types that can only be found in the southern part of New Guinea Island. Uniqueness of the vegetation types resemble to the Australian Plants [2]. As well as many localities are relatively inaccessible has led to difficulties in estimating the actual distribution of the orchid species. Notwithstanding, information about orchid diversity and distribution from this park is limited. Comprehensive research is required to determine species diversity and the localities of population, the habitat preferences providing suitable environment for this plant. This preliminary study is designed to assess species diversity, documented and mapping the distribution of orchids in particular *Dendrobium* Sw. section *Spathulata* Lindl. in Wasur National Park. This knowledge will contribute significantly in filling the gap of flowering plant diversity atlas from the park in particular and biodiversity of Papua in general.

2. Material and methods

2.1. Location and Time

The study was conducted in six sites inside the National Park i.e: Bokem, Rawa Dongami, Sota Wasur Kampung, Rawa Biru and Yanggandur from July 25th to August 8th 2013, 25 October- 1 November 2018. The study sites were purposively selected according to the possible accessibility by road and the nurseries own by local community inside the park. The last location is Sota district which located at the border line between RI and PNG. In depth interview was conducted to the respondents to gain knowledge of locals on species diversity and their hunting activity of the orchid species. We did not set the line transect and plot sampling during the fieldwork due to the circumstance of the park that are mostly cover with the swamp area. Instead we explore the dry heath forest and conduct and interview with respondents. These sites are visited as there are few orchid’ nurseries run by locals who are land tenure and inhabit the parks over generations.

2.2. Data Collection and Analysis

To map distribution of species within the park, all data were recorded using GPS and transfer into QGIS software. Details of individual and species distribution are not presented in this manuscript due to the conservation matter. However, general information to where the plants are collected is presented on the map as well as coordinate of each location.

All data involve scientific and vernacular name, morphological features are recorded into tally sheet for further analysis. 40 Orchid plants were collected and preserve as herbarium materials and living collections. 37 pressed-floral dissection cards were used to assist in morphological identification of species (Figure 1). Description of morphological characters of orchid were recorded, determined and identified with references [3] [4] [5] [6] [7] [8] [9], whereas the host trees are refer to [10] and [11]. For thoroughgoing identification process, DNA samples was extracted from dried-silica-gel leave tissues, proceed and stored at the Australian Tropical Herbarium for further species determination.
Figure 1 A pressed-floral dissection cards from *Dendrobium devosianum* J.J. Smith collected from the field (a. bract; b. lateral sepals; c. dorsal sep; d. petals; e. labellum; f. gynostemium; g. pedicel; h. pollen cap; i. pollinia) (Collected and pressed by AYSA).

3. Results and discussion

3.1. Species Diversity

In total 40 samples are collected from the field. Of these 24 specimens were identified using morphological features combined with biomolecular technique as *Dendrobium canaliculatum* R.Br., *Dendrobium carronii* Lavarack & P.J. Cribb, *Dendrobium d'albertisi* Rchb.f., *Dendrobium devosianum* J.J.Sm., *Dendrobium discolor* Lindl., *Dendrobium johannis* Reichb.f., *Dendrobium ionoglossum* Schltr., *Dendrobium nindii* W. Hill, *Dendrobium semifuscum* (Reichb.†) Lavarack & P.J. Cribb, *Dendrobium sylvanum* Reichb.f. and *Dendrobium trilamellatum* J.J.Smith, (Figure 2). These species were classified into *Dendrobium* Sw. section *Spathulata* Lindl. [12]. Morphological characters define as character states were adopted from [13]. The remaining 16 orchids were classified as the out-group i.e. *Dendrobium biggiba* Lindl., *Dendrobium phalaenopsis* Fitzg., *Dendrobium litorale* Schltr. *Dendrobium bracteosum* Rchb.f., *Dendrobium smiliae* (F. Muell.) Fitzg., *Dendrobium sp1*. All recorded species epiphytes to the host plants that identified as *Acacia mangium* Wild., *Anthocepalus chinensis* A. Rich., *Banksia* sp., *Corymbia* sp., *Melaleuca cajuputih* Powell, *Melaleuca leucadendron* (L.) L., and *Melaleuca viridiflora* Sol ex. Gaertn (Figure 3).
As can be seen from datasets in Table 1, the most common host trees for the orchids belongs to family Myrtaceae. Data indicates the genus *Melaleuca* is the preferable host tree and profitable habitat for these orchids group. The bark of this genus offers best positioned-media for a dust-like seed of orchids nesting to the stem. This family is an indicator of the vegetation type of heath forests that can only be found in the southern part of New Guinea Island. Other genera of host trees recorded from family Proteaceae is *Acacia* and *Banksia*. They are the common genera associated with *Melaleuca* in the heath forest vegetation. These last two genera were spotted at one study site in Sota district.

Based on this checklist, *Dendrobium d'albertisii* is scattered evenly in the national park as it can be spotted in all host trees. Followed by *Dendrobium discolor* and *Dendrobium canaliculatum*. Most orchids grow as epiphyte covering the tree trunk from zone 1 to zone V [14]. The inland of the park still display a suitable environment for both the orchids and its host trees. The park displays an area with a rugged terrain covering with the wetland of swamp area that is still becoming a pristine forest inside the park, in particular nearby by Rawa Dongami and Rawa Biru where many migrant birds from the southern hemisphere frequently visit these swamps. *Dendrobium nindii* identified by [15] share the similar morphological characters as it does in *Dendrobium ionoglossum*. Dissimilarity appears on the length of petals and sepals in which *D. nindii* possess long petals and sepals than that of *D. ionoglossum*. These characters were tested through molecular approach to which they split the two species into two branches (Arobaya et al., unpublished work). These species are dispersed following the host trees of *Melaleuca cajuputih* and *Acacia mangium*.

**Table 1** Checklist of orchids recorded with the host trees in the Wasur National Park

<table>
<thead>
<tr>
<th>No</th>
<th>Species</th>
<th>Host tree</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Dendrobium d'albertisii</em></td>
<td><em>Anthocephalus chinensis</em></td>
<td>Bokem</td>
</tr>
<tr>
<td>2</td>
<td><em>Dendrobium d'albertisii</em></td>
<td><em>Melaleuca leucandendron</em></td>
<td>08°38’33”</td>
</tr>
<tr>
<td>3</td>
<td><em>Dendrobium d'albertisii</em></td>
<td><em>Melaleuca viridiflora</em></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td><em>Dendrobium d'albertisii</em></td>
<td><em>Melaleuca cajuputih</em></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><em>Dendrobium canaliculatum</em></td>
<td><em>Melaleuca cajuputih</em></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><em>Dendrobium discolor</em></td>
<td><em>Melaleuca cajuputih</em></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><em>Dendrobium johannis</em></td>
<td><em>Melaleuca leucandendron</em></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><em>Dendrobium johannis</em></td>
<td><em>Melaleuca cajuputih</em></td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Species (Genus)</td>
<td>Habitat</td>
<td>Location</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------</td>
<td>--------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>1</td>
<td>Dendrobium canaliculatum</td>
<td>Melaleuca viridiflora</td>
<td>Rawa Dongami</td>
</tr>
<tr>
<td>2</td>
<td>Dendrobium johannis</td>
<td>Melaleuca leucadendron</td>
<td>08°31'11&quot;</td>
</tr>
<tr>
<td>3</td>
<td>Dendrobium semifuscum</td>
<td>Melaleuca leucadendron</td>
<td>Yuss Indicen</td>
</tr>
<tr>
<td>4</td>
<td>Dendrobium johannis</td>
<td>Melaleuca viridiflora</td>
<td>08°31'27&quot;</td>
</tr>
<tr>
<td>5</td>
<td>Dendrobium canaliculatum</td>
<td>Melaleuca leucadendron</td>
<td>08°31'26-28&quot;</td>
</tr>
<tr>
<td>6</td>
<td>Dendrobium johannis</td>
<td>Melaleuca viridiflora</td>
<td>08°31'11&quot;</td>
</tr>
<tr>
<td>7</td>
<td>Dendrobium semifuscum</td>
<td>Melaleuca leucadendron</td>
<td>08°32'08-19&quot;</td>
</tr>
</tbody>
</table>

**Note:** The species and their habitats are listed for various locations and times. The specific habitats are Melaleuca leucadendron, Melaleuca viridiflora, and Melaleuca cajuputih. The locations include Rawa Dongami, Yuss Indicen, Wasur Kampung 2, Yanggandur, and 08°31'11" to 08°32'08-19".
Grammatophyllum speciosum  Melaleuca leucadendron
Oncidium sp. Melaleuca leucadendron
Pholidota imbricata Melaleuca leucadendron
Vanda sp. Melaleuca leucadendron

13 Bulbophyllum sp. Banksia sp. Sota
2 Dendrobium aff. polysema Melaleuca cajuputih 08°25’25”
3 Dendrobium d’albertisii Banksia sp
4 Dendrobium bifalce Banksia sp
5 Dendrobium bigibum (big flower) Banksia sp
6 Dendrobium bigibum (small flower) Banksia sp
7 Dendrobium discolor Anthocepalus chinensis
8 Dendrobium smilliae Anthocepalus chinensis
9 Dendrobium ionoglossum Acacia mangium
10 Flickingeria sp. Acacia mangium
11 Grammatophyllum speciosum Acacia mangium

3.2. Threat and opportunity
Almost all species of Dendrobium section Spathulata have exotic and economic values. These rewards have triggered the species to be hunted. The intensive exploration of orchid species was spotted during the observation. This activity is mostly conducted by the locals who manage the nurseries and other orchid hunter who visits the park (Figure 4). On the other hand selling these orchids bring economic benefit to locals instantly. Species observed that were sold in the nurseries are D. canaliculatum, D. carronii, D. devosianum, D. discolor and its variety, D. johannis, D. trilamellatum, D. ionoglossum and D. trilamellatum. These species become a preferable species to buyers as the plants display colorful and have long lasting flowers aside from its variable size of stems. Few of these species have fragrance that of interest of the buyers. Buyers can be classified as researchers, plant enthusiasts such as vendors and collectors that come not only from around Merauke Regency but also from outside Papua.

According to IUCN red list for threaten species [16], most of these orchids are categorized as least concern (LC) to vulnerable (VU) in the wild, some of the species are classified to data deficiency (DD) due to the lack of information and documentation as well limited input from research in the region (Figure 5). As can be seen from the figure, the trend toward threaten species tends to increase by 2018. This figure provides the highest number of species in each category. The IUCN categories for threaten species is congruent with the Indonesian law for biodiversity [17]. The threat spotted during the fieldwork were listed as: residential and commercial development, agriculture and aquaculture practices, transportation and corridor services, biological resources uses, human intrusion and disturbance to the habitat, natural modification for development of new administrative area, climate changes and severe weather. The most current threaten activity is development of infrastructure of road inside the park. These threats contribute significantly to the existence and sustainability of habitat for orchid and its host species in the wild. Some of the orchid species tends to grow on certain host plants such as Melaleuca cajuputih and Eucalyptus sp. These host plants are used by locals as firewood. Intensity of cutting down the trees for such purposes is promptly endangered the orchid species.
Figure 4 Orchid's nursery runs by locals who inhabit the national park (photo: Agape Heipon †).

Figure 5 Number of species listed in each IUCN Red List categories for threatened species between 2004 and 2019. DD-Data Deficiency, LC-Least Concern, NT-Near Threatened, VU-Vulnerable, EN-Endangered, CR-Critically Endangered (Source: IUCN Red List, accessed 2/2/2020, 12:00am).

3.3. Orchid map

Details of location of species distribution on the map are not presented due to the conservation strategy. The presentation of this map can only give brief information to where the species occurred and collected in their natural habitat (Figure 6). Two study sites noted as the wetland i.e. Rawa Dongami and Rawa Biru. Rawa Dongami is a trans-fly spot for migrant birds from southern hemisphere. The Rawa Biru is a water source to supply clean water for inhabitants in Merauke regency. The remaining study sites represent dry heath forests in the tropic that have vegetation type resemble to the Australian plants of savanna woodland [10]. The species indicate this type of vegetation mostly dominated by family Myrtaceae such as Eucalyptus, Banksia and Melaleuca species [2]. Further management strategy on how to conserve as well as benefit from this orchid diversity requires multi stakeholder joint venture involving locals who own the land.
Figure 6 Map of study sites of orchid distribution from Dendrobium section Spathulata, adopted and modified from Google Earth Pro (Accessed 01/02/2020; 4:48pm). Red mark indicates the location where interview being conducted as well as orchid samples are collected.

4. Conclusion

Taking into consideration that Wasur National Park holds substantial biodiversity treasures. The resources have supporting locals who inhabit the land over generation. One of the most natural prosperity is orchid plants from genus Dendrobium section Spathulata. In relation to orchid’s diversity, the study sites have 11 species of section Spathulata. While the remaining 16 samples were categories as an out-group species. Should transect method was applied in collecting specimens, level of diversity may increase and more species will be discovered. Diverse Melaleuca species were dominant as host tree in surrounding study sites with small number of A. chinensis, A. mangium and Banksia Sp. This preliminary study has indicated the benefit come from this plant and supporting daily life of people living in and around the national park. Biodiversity mapping within the national park will further help the management of the park for development of orchid conservation program. This requires a lot of work for improvement as there are other prospective for economic benefit such as recreational park inside and field station for student who has interest in conservation to do their field work and gain knowledge from the park as well.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare no conflict of interest regarding the publication of this paper.
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