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Diversity, composition and important tree species for Cenderawasih bird activities in Rhepang Muaif ecotourism forest, Jayapura, Papua, Indonesia

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Abstract. *Lahallo W, Tanjung RHR, Suharno, Sujarta P. 2022. Diversity, composition and important tree species for Cenderawasih bird activities in Rhepang Muaif ecotourism forest, Jayapura, Papua, Indonesia. Biodiversitas 23: 742-749.* Trees, the major component of forest, affect the interaction between flora and fauna contained in the forest. Among them, birds are the group of fauna which are highly dependent on the presence of trees in the forest. The inter-relationship between birds and trees is particularly important in forest utilized for bird-watching ecotourism, more over for endemic birds such as Birds of Paradise, or locally named as Cenderawasih. This study aimed to determine the diversity and floristic composition of tree species in the Rhepang Muaif ecotourism forest, Jayapura District, Papua and identify important tree species that support the activites of Cenderawasih birds. A survey was employed using line-transect method to record species diversity and vegetation structure of trees with diameter of > 20 cm. A total of 62 observation plots were established representing around 51 hectares of ecotourism forest with each plot measuring 20 x 20 m. The findings revealed that there were around 63 tree species belonging to 23 different families recorded in the observation plots. Based on the stand structure, it can be stated that the ecotourism forest in Rhepang Muaif was secondary forest with density of roughly 20 trees per hectare (diameter > 20 cm). Species with the highest Important Value Index were *Intsia bijuga*, *Areca* sp., *Syzygium versteegii*, and *Pometia pinnata*. Important tree species used for the activities of Cenderawasih birds included *I. bijuga* (perching, chirping), *P. pinnata* (playing), *Teijsmanniodendron hollrungii* (perching, chirping), *P. pinnata* (eating, perching) and *Macaranga* sp (playing). *Macaranga* sp., *F. benjamina*, and *T. hollrungii* had limited population whereas *I. bijuga*, and *P. pinnata* were more abundant. Our study implies that to ensure the survival of Cenderawasih birds in the ecotourism areas, the carrying capacity of tree species for bird activities must be maintained so that these birds do not migrate to other locations.

Keywords: diversity, ecotourism, Papua, paradise, trees

INTRODUCTION

Forest is among the richest ecosystems on the Earth in term of biodiversity than any other ecosystems and plays a significant role in global biodiversity conservation. According to the Forest Resources Assessment (FRA), currently forests cover 30.8 percent of the global land area (FAO & UNEP 2020). Among various forest types in the world, tropical rain forests are the most complex ecosystems with a wide variety of habitats and a great number of species (Aluri 2013). Indonesia harbors a large extent of tropical forest due to its position near the equator and has great contribution to the biodiversity of the world (Suharno et al. 2021). Beside the large number of species diversity, Indonesia is also home to a diverse range of endemic and rare flora and fauna (Henri et al. 2017; von Rintelen et al. 2017; Suharno et al. 2021).

Trees are the major component of the forest. The importance of tree species in the forest can be explained from their role in the interaction among living creatures including flora and fauna. The relationships between trees and other plant and animal species are intricate, complicated, and functional which are also largely influenced by abiotic environments, such as temperature, humidity, sun light and so on (Aluri 2013; Murdjoko et al. 2016). Among organisms interact with trees within the forest ecosystem, birds are very conspicuous and highly dependent on the presence of trees (Anderson 2009; Scholes 2020). Trees and forests as whole serve as habitats of birds which provide essential resources in their life cycle, such as feeding sources and nesting grounds (Anderson 2009; Stratford and Ekercioğlu 2015).

Bird of Paradise refers to group of birds endemic to New Guinea and it is estimated that there are 37 species identified so far (Heads 2002; Pattiwael and Turot 2020). In Papua (Indonesian New Guinea), they are often called as Cendrawasih. These birds are particularly interesting because they have remarkable morphological features of the skull, beak, facial wattles and trachea, and exhibit more variation in feather structure and color than any other bird families (Heads 2002; 2008). The beauty of these birds have attracted the attention of the world community, making them as the target of bird hunting. Their population has begun to decline due to various factors, including poaching, habitat destruction, and the difficulty of breeding.

The notion of ecotourism has been promoted and expanded rapidly across the world over the last few decades. Ecotourism differs from other forms of mass tourism in that it uses natural resources as a recreational attraction (Hill and Gale 2009; Li et al. 2020). In ecotourism, the beauty of nature and landscape as well as the diversity of flora and fauna are the main attractions for tourist visits (Henri et al. 2017; Zhong et al. 2020). Ecotourism is frequently argued as a form of sustainable natural resources management since it offers a win-win option between biodiversity conservation and cash income generation, which provide economic benefits especially for the surrounding community.

Rhepang Muaif is one of the village in the area of Grime Valley where we can enjoy bird watching. It belongs to Nimbokrang Sub-district, Jayapura District, Papua Province and has total area about 190.5 km^2. Nimbokrang Sub-district is surrounded by Nimboran, Yokari, Demta, Kemtuk, Namlong, and Urunum Guay Sub-district (Barri et al. 2019). Rhepang Muaif Village is one of ecotourism destination which is well known for its bird watching together with Tablasupa (Sub-district of Depapre) in Jayapura District. The other destination for bird watching in Papua Province is located in Yapen Island (BKSDA 2017). For Rhepang Muaif, the location for bird watching is in the customary forest (Sufaati et al. 2017; Barri et al. 2019). The existence of forest is important in order to mantain ecotourism system at the area (Hill and Gale 2009; Sufaati et al. 2017). This study aims to understand the diversity, composition, and species of the trees that important for the bird of paradise especially in the area of bird watching at Nimbokrang. This study will provide keys information regarding trees variety, which can be usefull as basic information in order to sustainly manage the ecotourism area.

MATERIALS AND METHODS

Research period and area

The research was carried out for eight months from January to August 2021. Data collection took place in the village of Rhepang Muaif, Nimbokrang Sub-district, Jayapura District, Papua Province, Indonesia (Figure 1). The detailed information regarding the observation sites is presented in Table 1.

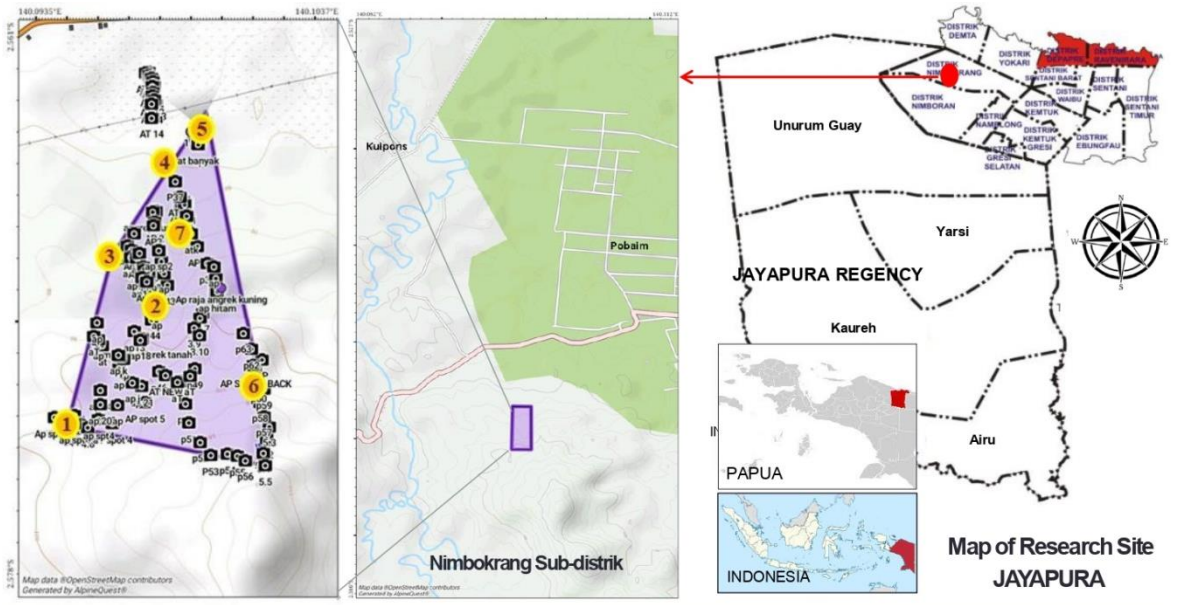

Figure 1. Map of the location of Cenderawasih bird watching spots and observation plots for vegetation analysis in Rhepang Muaif Village, Nimbokrang Sub-district, Jayapura District, Papua Province, Indonesia

Table 1. Location of Cenderawasih bird watching spots in Rhepang Muaif Ecotourism Forest, Nimbokrang, Jayapura, Indonesia

Spot location	Geographical coordinates	Observation object	Information
Spot 1	S: 02°33'50,37"; E: 140°05'56,29"	*Seleucidis melanoleuca*	Especially for Cenderawasih "mati kawat" birds
Spot 2	S: 02°34'15.84"; E: 140°05'47,32"	*Paradisaea minor*	Especially for Cenderawasih minor birds
Spot 3	S: 02°34'13.63"; E: 140°05'57,32"	*Paradisaea minor*	Especially for Cenderawasih minor birds
Spot 4	S: 02°34'24.3"; E: 140°05'41,98"	Bird watching, *Paradisaea minor*	Monitoring place for all birds, Cenderawasih minor birds
Spot 5	S: 02°34'27.04"; E: 140°06'04,74"	Salvadori's Fig-Parrot (*Psittaculirostris salvadorii*)	Especially for Salvadori's Fig-Parrot bird
Spot 6	S: 02°33'28.00"; E: 140°08'04,70"	Bird watching	Spot for observing all kinds of birds
Spot 7	S: 02°34'24.22"; E: 140°05'59,73"	Bird watching	Spot for observing all kinds of birds

Data collection

Data on tree diversity was collected by identifying tree species found at the ecotourism location of Bird Watching Isyo Hills, Rhepang Muaif, Nimbokrang, Jayapura. The extent of forest used for ecotourism spots is about 51 hectares. The number of plots for tree sampling was 64 plots with a size of 20 x 20 m which represents about 5% of the total forest area. The measured trees were those with a diameter of >20 cm.

The trees observed were those used by Cenderawasih birds for nesting, food sources, and playing. Observations were made by survey method. The survey was carried out at the Cenderawasih bird observation spots (Figure 1, Table 1) and the surrounding environment. Observations of the activity Cenderawasih birds were carried out from morning to evening.

Tree identification was carried out at the Plant Taxonomy Laboratory, Department of Biology, Cenderawasih University, Jayapura. Identification of tree species used several literatures, including Handbooks of the Flora of Papua New Guinea, and Trees of Papua New Guinea. Unidentified herbarium samples were sent to Herbarium Manokwariense in Manokwari, West Papua.

Data analysis

Observational data were analyzed qualitatively and quantitatively. The Important Value Index (IVI) was analyzed according to Indriyanto (2006) which refers to Mueller-Dombois and Ellenberg (1974). This included the calculation of relative density, relative frequency, and relative dominance.

The density (Ds) and relative density (RDs) was calculated with the equation:

$$Dsi = \frac{number\ of\ individuals\ for\ the\ \sim i\ species}{area\ of\ the\ entire\ sample\ plot}$$

$$RDs = \frac{density\ of\ \sim i\ species}{density\ of\ all\ species} \times 100\%$$

The frequency (F) and relative frequency (RF) was calculated as follow:

$$Fi = \frac{number\ of\ sample\ plots\ the\ \sim i\ species}{sum\ of\ all\ sample\ plots}$$

$$RF_i = \frac{frecuency\ of\ \sim i\ species}{frecuency\ of\ all\ species} \times 100\%$$

The dominance (Dm) and relative dominance (RDm) was calculated as follow:

$$Dmi = \frac{basal\ area\ of\ the\ \sim i\ species}{wide\ area\ of\ intire\ sample\ plot}$$

$$RDm_i = \frac{closing\ of\ the\ \sim i\ species}{closing\ of\ all\ species} \times 100\%$$

Where: the basal area was calculated based on the diameter of the trunk at chest height.

Meanwhile, to calculate the Important Value Index (IVI), it was done by summing the relative density, relative frequency and relative dominance ($IVI = RDs + RF + RDm$).

RESULTS AND DISCUSSION

Diversity of trees

The results showed that there were 63 tree species (23 families) in the Ecotourism Forest area of Rhepang Muaif Village, Jayapura, Papua (Table 2). In an observation area of 2.56 hectares, there were 498 individual trees, or an average of 20 trees per hectare. According to Indriyanto (2006) and Susanto (2012), the high diversity of plant species can be influenced by stratification or canopy layering. This is because of the interaction of life competition between plants. Competition between species resulted in the emergence of species that are able to compete and have good growth and domination compared to other types.

Table 2 shows that the ten most abundant tree species were *Intsia bijuga*, *Areca* sp., *Pometia pinnata*, *Ficus elastica*, *Pterocarpus indicus*, *Ficus* sp., *Canarium indicum*, Maskay (local name), *Neonauclea papuana*, and *Canarium hirsutum*. On the other hand, the fewest tree species found were *Cerbera floribunda*, *Grewia paniculata*, *Gnetum gnemon*, *Homalium foetidum*, *Livistona* sp., Mambrang (local name), *Manilkara* sp.1, *Livistona* sp., *Psychotria* sp., and *Syzygium* sp. each species found only one individual in the observation plot. The condition of the forest is a secondary forest, thus there were only small number of trees with large diameters of > 50 cm (Figure 3).

The results showed that the Burseraceae family dominated the studied site, followed by the Moraceae, Dipterocarpaceae, Myrtaceae, Rubiaceae, and Arecaceae families. The familes with the lowest number of species included Callophyllaceae, Dilleniaceae, Flacourtiaceae, Gnetaceae, Meliaceae, Ochnaceae, Pandanaceae, and Phylanthaceae (Figure 2). According to Suharno et al. (2021), Suharno and Kadir (2021) Moraceae, Burseraceae, Myrtaceae and Rubiaceae are among the families with a higher number of species than other groups in the Pagai and Dabra Sub-district which is part of the same area in the lowlands in north of Papua.

The abundant of trees tended to decrease along with the increasing diameter. Most of the trees belonged to the class with the diameter 17-33 cm, followed by the class 33-47, and 46-63 cm (Figure 3). As many as 20 trees had 63-78 cm diameter, while for the tress with diameter more than 78 cm reached 32 individuals. This forest can be categorized as secondary forest as they had high number of trees with small diameter. Some decades before, this area was a part of wood proccessing company. This forest area are expected to have more trees with smaller diameter since it is related to the regeneration proccess of the vegetation of this area. Regarding to Banda et al. (2008) and Zimudzi et al. (2013), the regeneration for trees within the forest area have affected the stability of the forest itself. Moreover, Zimudzi et al. (2013) revealed that the change of forest structure and its composition of trees diameter are affected by human actiities, such as deforestation, forest fire, footpath making, tourism, and religious rituals.

Table 2. List of tree species and floristic composition of tree-level species in the ecotourism forest in Isyo Hills, Rhepang Muaif, Nimbokrang, Jayapura, Indonesia

Tree species	Family	Number of individuals	RDs	RF	RDm	IVI
Intsia bijuga (Colebr.) Kuntze.	Fabaceae	81	16.27	12.17	0.22	28.66
Areca sp.	Arecaceace	69	13.86	10.43	0.42	24.71
Syzygium versteegii (Lauterb.) Merr. & L.M.Perry	Myrtaceae	2	0.40	0.58	17.31	18.29
Pometia pinnata J.R. Forster & J.G. Forster.	Sapindaceae	34	6.83	7.25	0.22	14.29
Durio zibethinus Murr.	Malvaceae	4	0.80	0.87	9.34	11.02
Pterocarpus indicus Willd.	Fabaceae	19	3.82	5.22	0.27	9.31
Ficus sagittata Vahl.	Moraceae	17	3.41	3.19	2.30	8.90
Ficus elastica Roxb.	Moraceae	19	3.82	4.35	0.28	8.44
Neonauclea papuana Valeton.	Rubiaceae	14	2.81	2.61	2.06	7.48
Canarium hirsutum L.	Burseraceae	12	2.41	2.32	2.74	7.47
Hopea forbesii Sloot.	Dipterocarpaceae	11	2.21	2.32	2.74	7.27
Canarium indicum L.	Burseraceae	15	3.01	2.90	0.38	6.29
Syzygium sp.	Myrtaceae	1	0.20	0.29	5.36	5.85
Maskay (Burseraceae)	Burseraceae	14	2.81	2.61	0.32	5.74
Cynometra ramiflora L.	Fabaceae	2	0.40	0.29	4.54	5.23
Canarium decumanum Gaertn.	Burseraceae	7	1.41	1.16	2.47	5.04
Ficus benjamina L.	Moraceae	10	2.01	2.32	0.51	4.84
Calophyllum austrocoriacium	Calophyllaceae	4	0.80	0.87	3.06	4.74
Ficus fulva Rein. Ex. Bl.	Moraceae	4	0.80	0.87	2.89	4.56
Dillenia papuana Mart.	Dilleniaceae	8	1.61	1.74	1.14	4.48
Campnospermae sp.	Annacardiaceae	6	1.20	1.16	2.07	4.43
Hopea sp.	Dipterocarpaceae	6	1.20	1.16	1.92	4.28
Hopea papuana Diels.	Dipterocarpaceae	9	1.81	2.03	0.33	4.17
Monoon congregatum King.	Annonaceae	8	1.61	2.03	0.23	3.86
Alstonia scholaris L.R.Br.	Apocynaceae	5	1.00	1.16	1.49	3.66
Psychotria sp.	Rubiaceae	2	0.20	0.29	3.09	3.58
Gnetum gnemon Linn.	Gnetaceae	1	0.20	0.29	3.07	3.56
Syzygium pycnanthum Merr. & L.M.Perry.	Myrtaceae	7	1.41	1.74	0.34	3.48
Mastixiodendrom pachyclados	Rubiaceae	7	1.41	1.45	0.59	3.45
Monoon membranifolium King.	Annonaceae	3	0.60	0.87	1.92	3.39
Buchanania arborescens Blum.	Annacardiaceae	2	0.40	0.29	2.69	3.38
Sterculia shillinglawii K. Schum.	Malvaceae	7	1.41	1.45	0.18	3.03
Psychotria sp2	Rubiaceae	1	0.40	0.58	2.00	2.98
Pandanus tectorius Soland.	Pandanaceae	3	0.60	0.87	1.47	2.94
Bischofia javanica Blume.	Phylantaceae	3	0.60	0.58	1.75	2.93
Pothiostemon javensis	Euphorbiaceae	6	1.20	1.16	0.52	2.89
Schuurmansia henningsii Hassk.	Ochnaceae	4	0.80	0.87	1.10	2.77
Grewia paniculata L.	Tiliaceae	1	0.20	0.29	2.22	2.71
Macaranga sp.	Euphorbiaceae	5	1.00	1.16	0.46	2.63
Hopea novoguineensis Sloot.	Dipterocarpaceae	4	0.80	0.87	0.88	2.55
Tectona grandis Linn.f.	Lamiaceae	6	1.20	1.16	0.18	2.54
Canarium sp.	Burseraceae	5	1.00	1.16	0.27	2.44
Akrey	Burseraceae	3	0.60	0.58	1.18	2.36
Cerbera floribunda K.Schum.	Apocynaceae	1	0.20	1.16	0.96	2.32
Palaquium sp.	Sapotaceae	3	0.60	0.87	0.79	2.27
Syzygium aqueum (Burm.f.) Alston.	Myrtaceae	2	0.40	0.58	1.23	2.21
Hopea iriana Slooten.	Dipterocarpaceae	3	0.60	0.58	0.84	2.02
Ficus septica Bl.	Moraceae	2	0.40	0.58	0.94	1.92
Livistona sp.	Arecaceae	1	0.20	0.29	1.42	1.91
Protium macgregorii (F.M.Bailey) Leenh.	Burseraceae	4	0.80	0.87	0.23	1.91
Pimeleodendron amboinicum Hslk.	Euphorbiaceae	4	0.80	0.87	0.19	1.87
Aglaia sapindina (F.Muell.) Harms.	Meliaceae	4	0.80	0.87	0.18	1.85
Ficus racemosa L.	Moraceae	4	0.80	0.87	0.18	1.85
Manilkara sp.	Sapotaceae	3	0.60	0.87	0.36	1.84
Pinanga kuhlii Blume.	Arecaceae	2	0.40	0.58	0.72	1.71
Litsea glutinosa C.B. Rotb.	Lauraceae	3	0.60	0.58	0.41	1.59
Livistona sp.2	Arecaceae	1	0.20	0.29	1.01	1.50
Buchanania sp.	Anacardiaceae	3	0.60	0.58	0.27	1.45
Mambrang	Rubiaceae	1	0.20	0.29	0.88	1.37
Gossypium sp.	Malvaceae	2	0.40	0.58	0.12	1.10
Pometia sp.	Sapindaceae	2	0.40	0.58	0.12	1.10
Manilkara sp1	Sapotaceae	1	0.20	0.29	0.36	0.85
Homalium foetidum (Roxb.) Benth.	Flacourtiaceae	1	0.20	0.29	0.25	0.74
Total		498	100	100	100	300

Notes: RDs: relative density, RF: relative frequency, RDm: relative dominance, IVI is an index value of the importance of plant species based on an ecological assessment

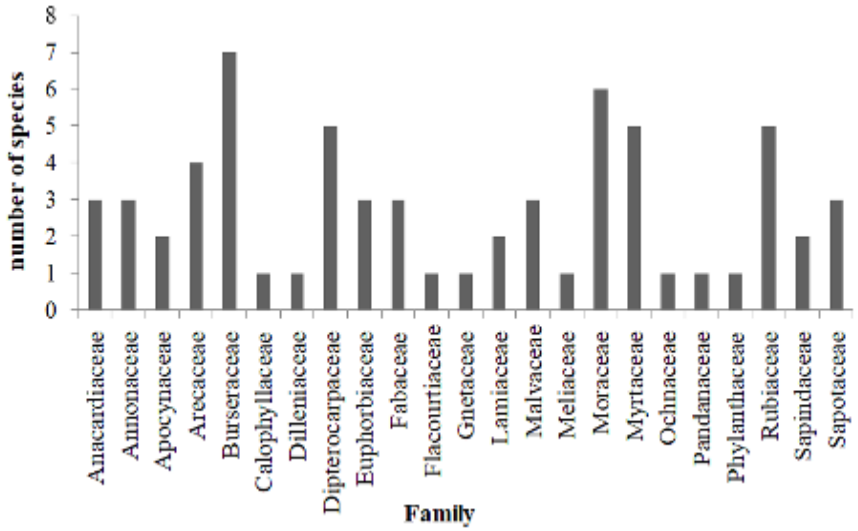

Figure 2. Number of tree species in each family in the ecotourism forest in Isyo Hills, Rhepang Muaif, Nimbokrang, Jayapura, Indonesia

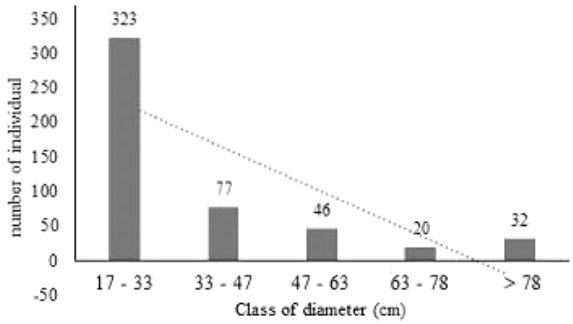

Figure 3. Tree diameter classes in the ecotourism forest in Isyo Hills, Rhepang Muaif, Nimbokrang, Jayapura, Indonesia

Tree vegetation analysis

Based on vegetation analysis, merbau (*I. bijuga*) had the highest Important Value Index (IVI) with 28.66, followed by *Areca* sp., *S. versteegii*, *P. pinnata*, and *D. zibethinus*, each of which had an IVI of more than 10.00% (Table 2). In addition, *I. bijuga* had the highest relative density (16.27%), while *C. floribunda*, *D. paniculata*, *G. gnemon*, *H. foetidum*, *Livistona* sp., Mambrang (local name), *Manilkara* sp.1, *Psychotria* sp. and *Syzygium* sp. had a low value. The results of the analysis showed that the highest relative frequency also occurred in *I. bijuga* (12.17%), followed by *Areca* sp. (10.43%), *P. pinnata* (7.25%), *F. elastica* (5.22%), *P. indicus* (4.35%), Maskay (local name) (3.19%), *N. papuana* (2.90%), *H. papuana* (2.61%), while tree species that had the lowest presence was *C. floribunda* with a relative frequency value of 0.29%. In addition, the results of the analysis showed that the *F. benjamina* had the highest relative dominance value (17.31%) compared to other tree species.

The high IVI value of *I. bijuga* is due to this species has a wide ecological niche (Piskaut 2006). In general, the genus of *Intsia* grows on dry rocky soil, sometimes sandy soil, clay and moist soil that is not waterlogged. Particular for *I. bijuga*, it grows in sandy and rocky habitats, especially on sedimentary soils in lowland forests (Tokede et al. 2006). Beside *I. bijuga*, *P. pinnata* and *Ficus* spp. are species that have a wide distribution in the lowlands of Papua (Suharno et al. 2021). The importance of plants in a community is related to the composition of the species, habitus and structure of the vegetation. Important Value Index is also commonly used to determine the condition of plant community which consists of three basic analyzes namely density, frequency and dominance (Susanto 2012).

Diversity of tree species for Cenderawasih bird activities

Based on observations, there were five tree species that were often used by Birds of Paradise for various activities (Table 4). These species were *Macaranga* sp., *I. bijuga*, *P. pinnata*, *F. benjamina*, and *Teijsmanniodendron hollrungii*. Species *I. bijuga*, *P. pinnata*, and *F. benjamina* are common species with wide distribution in the lowlands of Papua. Those five species are trees with large stem diameter and are able to grow tall. The tendency of Cenderawasih birds to use tall and large trees for their activities is of particular concern. This condition occurs because birds of paradise are more sensitive to disturbances of human activity. Merbau (*I. bijuga*), *T. hollrungii*, and *Macaranga* sp. serve as habitat for playing, perching and chirping (Table 4). Besides *I. bijuga*, *Pometia* sp., and *F. benjamina*, Pattiwael and Turot (2020) found *Agathis* sp. and forest nutmeg (*Myristica* sp.) were used for the activity of Cenderawasih birds in the forest area of Klayili Sub-district, Sorong District.

F. benjamina is one species of plant that is often used by various species of birds for activities in Indonesia. Not only frugivorous birds, at least 14 bird species were found, most of which are insectivorous species, in the forests of the University of Indonesia's Depok campus. The bird species found as frugivores were *Pycnonotus aurigaster* and *Dicaeum trochileum* (Pradana et al. 2018).

Table 4. Tree species used by Cenderawasih birds in Isyo Hills, Rhepang Muaif, Nimbokrang, Jayapura, Indonesia

Activity	Tree type	Local name	Species of Cenderawasih
Playing	*Macaranga* sp.	Sepat	Cenderawasih "mati kawat" (*Seleucidis melanoleuca*)
Perching, chirping	*I. bijuga*	Merbau	Cenderawasih minor (*Paradisaea minor*)
Eating, perching	*P. pinnata*	Matoa	*S. melanoleuca* and *P. minor*
Eating	*F. benjamina*	Beringin	*S. melanoleuca* and *P. minor*
Perching, chirping	*T. hollrungii*	Kemutun	*P. minor*

Table 5. Number of individual trees at Cenderawasih bird watching spots in Isyo Hills, Rhepang Muaif, Nimbokrang, Jayapura, Indonesia

Tree species	Distribution of species at the observation site					
	Spot 1	Spot 2	Spot 3	Spot 4	Spot 5	Total (ind. of trees)
Macaranga sp.	3	0	2	0	0	5
I. bijuga	0	10	10	15	45	81
P. pinnata	5	6	13	19	26	69
F. benjamina	0	1	2	3	4	10
T. hollrugii	0	6	1	0	1	8
Total (ind. of trees)	8	23	28	37	76	173

Figure 4. Trees for Cenderawasih bird activities: A. *Teijsmanniodendron hollrungii*; B. Dead *Intsia bijuga* trees are still used for roosting in the morning

In this study, no tree species used as nesting sites were found. The results of an interview with the manager of Ecotourism, Waisimon (2021) revealed that until now they have never found a Cenderawasih bird's nest in the bird watching ecotourism area. According to Raunsay (2020) one species of tree that is used as a nesting site is *Gnetum gemon*. However, the results showed that in the observation plot, only one individual *G. gnemon* was found. In more detail, Wazaraka et al (2019) revealed that several species of plants were used as basic materials for making *P. minor* nests, including *Bidens pilosa*, *Macaranga mappa*, *Timonius timon* and *Ficus septica*.

Observations at several bird watching spots showed that the number of individual trees of *Macaranga* sp., *F. benjamina*, and *T. hollrungii* was very limited, only less than 10 individual trees were found in the observation plots although there were higher number of *I. bijuga*, and *P. pinnata*. The distribution of plant species in the observation spots was also uneven (Table 5). In spot 1, only *Macaranga* sp., and *P. pinnata* were found, which were used for playing and as a source of food, with a limited number of trees. However, at this spot, only dead birds of paradise were found. According to Suharno and Tanjung (2011) matoa plants bear fruit in certain seasons which can be a limiting factor for the existence of these fruit-eating

birds. In more detail, Pattiwael and Turot (2020) and Waltert et al. (2004) revealed that the level of bird diversity in a forest area is highly dependent on the availability of food.

At other Cenderawasih bird watching spots, the number of tree species and individuals were higher. At spot 4, there were three species of plants supporting the activity of Cenderawasih birds, namely *I. bijuga, P. pinnata,* and *F. benjamina*. These three species were found in adequate population for perching, chirping and eating. In spot 3, the diversity of plant species was higher, because five species of plants were found including *T. hollrungii* which supports perching and chirping activities.

Area management and conservation

Most studies suggest a positive correlation between habitat diversity and animal species diversity. Nonetheless, different species groups are closely related to the particular key structures that determine the diversity of animal species by their presence. The knowledge on key structures of vegetation is thus very important for nature conservation (Jones et al. 1995; Tews et al. 2004). The understanding on vegetation structure is very influential on bird communities for their conservation and area management (Lee et al. 2007; Bouvet et al. 2016).

Problems that often occur related to forests, such as fragmentation, illegal logging and fires, greatly affect the presence and population of birds (Lambert and Collar 2002; Prabowo et al. 2016). Therefore, plants that play a key role such as *I. bijuga*, *F. benjamina* must be targeted for conservation. The change in people's way of thinking that is no longer illegal hunting of Cenderawasih birds is very encouraging. This effort needs to be supported by maintaining the existence of trees that support the life of Cenderawasih birds. Land tenure based on customary systems and good management will facilitate the management and conservation system of this area.

The diversity of plants used by birds must be maintained properly so that the interaction between the two will be sustainable (Jones et al. 1995; Bouvet et al. 2016). Thus, the management of the area as a location for tourist visits remains sustainable. The activity of human visits greatly influences the condition of flora and fauna (Isworo and Oetari 2017). The occurrence of disturbances in vegetation that causes changes in plant composition both as a place to play, perch, chirp, nest, and source of food will have a negative impact on various trophic levels of birds (Waltert et al. 2004; Putri et al. 2017; Latumahina and Mardiatmoko 2019).

Another aspect that is equally important is feed. Feed is a limiting indicator that greatly affects animal life. Sources of feed need to be considered both in terms of quality and also the effect on animal health. Latupapua (2006) revealed that *Eugenia* spp. are the tree species favored by Cenderawasih birds. Buntu (2002) reported that the habitats used as feed for Cenderawasih were *Ficus* sp., *Celtys* sp., *Myristica* sp., *Endospermum medulosun* and *Disoxylon acuntangulum.* In addition to food derived from plants, birds of paradise also eat animals such as caterpillars and crickets.

To maintain the sustainability of ecotourism, efforts are needed to maintain the existence of tree species that are often used by Birds of Paradise. If there is a change in the structure of the tree vegetation used by Cenderawasih birds, it will take more energy, cost, and time to maintain the existence of Cenderawasih birds in a forest area. According to Brauer (2003) and Hunter (1996), the costs required for restoration will be greater than the need for maintaining a conservation area. Thus, the relationship between the diversity of flora, especially tree species and fauna is very important in the ecotourism management system (Mubarik et al. 2020). The development of research, social, and management in the management of natural resources that are used directly by humans is very important (Hanley 1994; Zhong et al. 2020). The research will be used as the basis for determining policies and management systems, including ecotourism.

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