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Selection of Plants Species as Feed Sources and Nesting Places Salmon-Crested Cockatoo (*Cacatua moluccensis*) Maluku Endemic in Manusela National Park (MNP)

Maman Rumanta[1], Henderina Lelloltery[2], Rony Marsyal Kunda[3*], Pieter Kakisina[3]

[1]Department of Biology Education, Faculty of Teacher Training and Education, Universitas Terbuka, Pamulang, Indonesia; [2]Department of Forestry, Faculty of Agriculture, Universitas Pattimura, Ambon, Indonesia; [3]Department of Biology, Faculty of Mathematics and Natural Science, Universitas Pattimura, Ambon, Indonesia.

Abstract | Maluku is known by the nickname "*The Spice Island*". This nickname is given based on the Maluku geo-evolution process derived from the Indo-Australian plates with the abundant distribution and composition of flora and fauna. Manusela National Park (MNP) is a tropical rainforest located on the Seram island. Maluku Province based on the distribution of biogeography categorized in the Wallacea zone that has high species endemicity, one of which is *Salmon-Crested Cockatoo* (*C. moluccensis*). This study aims to identify the species of trees that serve as feedsources and nesting places from *Salmon-Crested Cockatoo* (*C. moluccensis*) as Seram endemic species in MNP. This ecological information is very important for designing strategies and development of appropriate *in-situ* conservation units for the sustainability of these wildlife in their natural habitat. This study was conducted for one month, from November to December 2017 in MNP. The results of this study indicate that found fives species of spermatophyta trees that serves as feed sources and Fours species that serve as nesting places of *C. moluccensis*. The trees species that serve as feed sources include *C. vulgare*, *E. rumphii*, *H. globularia*, *C. soulattri,* and *Callamus* sp. while which serves as nesting places such as *T. copelandii*, *N. moluccana*, *O. sumatrana*, and *P. goajava*.

Keywords | Feed sources, Nesting places, Manusela National Park, Seram island

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***Correspondence** | Rony Marsyal Kunda, Department of Biology, Faculty of Mathematics and Natural Science, Universitas Pattimura, Ambon, Indonesia; **Email**: ronykunda14@gmail.com
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INTRODUCTION

Maluku is a unit of Wallacea biogeography which is known to have very high species endemicity as well as several endemic birds species on the Seramisland, one of them is *Salmon-Crested Cockatoo* (*C. moluccensis*). *Salmon-Crested Cockatoo* are Australia wildlife in occurring primarily in Australia and its surrounding islands, theisland of Papua, and the Indonesian archipelago (Kinnaird, 2003). Forshaw and Cooper (1977), asserted that *C. moluccensis* was includedone of the most distinctive parrot families, with a high level of erection, so it becomes the wildlife of choice to be maintained because it provides an entertaining effect.

BirdLife International, (2001); IUCN (2016), asserted that *Salmon-Crested Cockatoo* (*C. moluccensis*), are regularly trapped for the cage-bird trade and, as a result, many populations are considered under serious threat or in danger of extinction. Indonesia has 17 species of cockatoos, of the 17 recognized cockatoo species, three of the six Indonesian species are considered threatened with extinction, one of them *C. moluccensis* (BirdLife International, 2001). Coates and Bishop, (1997), asserted that *C. moluccensis*, has been referred to as the most endangered cockatoo in Indonesia. Kinnaird et al. (2003), asserted that *C. moluccensis* is endemic species in Seram island, in the Wallacean biogeographic region of Indonesia. Poulsen and Jepson (1996), reported that *C. moluccensis* in the past origin from small

islands, neighboring islands, it is unclear whether these satellite populations were natural or introduced. Smith (1985), reported common during the 1970 and early 1980, population *C. moluccensis* began declining. Bowler and Taylor (1989), reported that the pet trade as the primary cause of the decline of *C. moluccensis*.

Maluku Natural Resources Conservation Center (1997), stated that MNP (MNP) is a forest area on the Seram island, Central Maluku Regency with an area of 189,000 hectares is one of the conservation areas in Indonesia which is stipulated based on the Minister of Agriculture Decree No.736/Mentan/X/1982 On October 14, 1982, which was a joint Wai Nua and Wai Mual nature reserve and additional water expansion. Government purpose set Manusela as a National Park, among others to conserve various ecosystems contained in the Seram forest to an area so facilitate management.

Kunda et al. (2015), asserted that species that occupy ecological niches on the islands are very vulnerable to extinction because most are endemic which only live on one or several islands and consist of only one or several local populations. Currently the natural habitat of *C. moluccensis* remaining only on Seram island includes, Roho, Wasa, Kanikeh, Solumena, Milinane, Manusela, Solea, Sinahari, Hatuolo and Kaloa areas are known to be inside MNP (IUCN, 2016; Isherwood et al., 1997). Data released by *International Union for Conservation of Nature* (IUCN), determined the status of *C. moluccensis* as *Vulnerable* since 1994 until now (IUCN, 2016), while according to *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) data is classified as Appendix I.

The facts on the ground prove that modification of the anthropogenic habitat, increasing the extinction of Cacatiudae (cockatoos) is faster because most of these species are on islands with different ecological conditions and areas with high threat (White et al., 2011). Reported by Isherwood et al. (1997), that the population of *C. moluccensis* on the Ambon, Haruku and Saparua islands was declared to be zero, meaning that at this time there was not one individual *C. moluccensis* in the Three islands. Indrawan et al. (2007), states that if an endemic species occupying territory as a result of habitat fragmentation will be more rapidly extinct or threatened with population due to structured disturbances as a result of human intervention. This is very reasonable because each species will occupy a specific ecological niche in the sense that each geographical area has a close relationship with the existence of certain species (Jones, 1997; Brum et al., 1994).

Human activities with minimal awareness of the importance of conservation in MNP areas such as taking endemic wildlife to be traded illegally will threaten the existence population of *C. moluccensis* in their natural habitat. Until now, there is no accurate data on the population of *C. moluccensis* in the MNP, but recently the rate of decline in population is very significant at every years. Observations and reports related to the activity of *C. moluccensis* carried out by Hitipeuw et al. (2017), that the number of these species observed in the MNParea is not more than 10 individuals. Lelloltery and Tjoa (2006), reported that *C. moluccensis* observed during the September to December 2004 study period were 26 individuals. This number indicates that the population of this species is very little in natural habitat.

Over the past dozen years, this species has experienced various threats due to excessive illegal sales Kinnaird et al. (2003). This study aims to determine the trees species that act as feedsources and nesting places of *C. moluccensis* in MNP. The results of this study are useful as a scientific basis in supporting ongoing *in-situ* conservation management in the wildlife rehabilitation center, in MNP area for *C. moluccensis* caught or confiscated from the community who were first adapted to the environment around MNP before being released back to their natural habitat (reintroduction).

MATERIALS AND METHODS

Materials

This study using the following materials: compass, binocular, camera, roll meters, tally sheets, Map of MNP, Field Guide Books, and Altimeter. This research was carried out, in Sawai Village which is a buffer zone of MNP, located in North Seram District, Central Maluku Regency, Maluku Province. This study lasted for 1 month from November to December 2017 and focused on vegetations which serves as the main feedsources and nesting places of *Salmon-Crested Cockatoo* (*C. moluccensis*).

Methods

Determination of vegetations observation path in lines with wild observation. The collected vegetations data are; trees type, number of trees, height and diameters. Vegetations observation as feedsourcesand nesting places using the Line Plot Method, by conducting an inventory of the growth rate, starting from the highest level of the tree to the seedlings by the following criterias:

- Tree categories with a minimum height of 5 meters and having a stem diameters of more than 35 cm with an observation plot area of 20 x 20 meters.
- Pole categories or young trees, with stem diameters of 10-35 cm with an observation plot area of 10 x 10 meters.
- Sapihan (sapling) categories as well as other shrubs, namely vegetation regeneration up > 1.5 meters to

young trees with stem diameters of more than 10 cm. Observation plot area of 5 x 5 meters.
- Seedling categories namely vegetation ranging from sprouts to less than 1.5 meters high including forest floor vegetation. Observation plot area of 2 x 2 meters.

RESULTS

Plants as Feed Sources

Salmon-Crested Cockatoo (*C. moluccensis*), has a type of feed that is generally the same as others birds bent beaks, namely seeds, insects and larvae of other insects species. At this research location there were various types of vegetation which acted as the main sources of feed from *Salmon-Crested Cockatoo* (*C. moluccensis*), such as: *Canarium vulgare*, *Eugenia rumphii*, *Horsfieldia globularia*, *Calophyllum soulattri*, and *Callamus* sp. These types of vegetation are highly favored and utilized by *Salmon-Crested Cockatoo* (*C. moluccensis*) as the main sourcessfeed. Generally *C. moluccensis*, much is seen in these types of vegetations, especially in the fruiting season.

Trees as Nesting Place

Vegetations commonly used as nesting places for *C. moluccensis* is; *Terminalia copelandii*, *Neuclea moluccana*, *Octomeles sumatrana* and *Psidium guajava*. Based on observations at the study site, generally these wildlife are often found in the morning and evening above these trees.The nesting place is usually on a high trees trunk, this is related to security, especially for the safety of nestling from the reach of predators. *Cacatua moluccensis* is a type of bird that diligently cleanses its nest, so that the branches around the tree holes that function as bird nests are almost invisible, meaning that the area around the bird's nest looks clean from the buds and twigs that fall.

DISCUSSION

The results of the study using the Line Plot Method found five trees species that act as feed sources from *C. moluccensis*. The five trees species show the presence of various vegetation types of flora diversity that serves as feedsourcess for *C. moluccensis* in the MNP area. Diversity at trees level>20 meters in diameter found *C. vulgare*, *H. globularia*, and *C. soulattri* species, at the pole level with a 10-19 meter diameter dominated by *E. rumphii*, while diversity in sapihan (sapling) with <10 meters diameter was dominated by *P. guajava*. The existence of variations in the types of vegetation distribution confirms that these wild choose three types of distribution of vegetation as feedsourcess, namely the level of tree, pole, and sapihan (sapling).

The results showed that generally *C. moluccensis* consumed fruits from the five species. Field observations showed that residual feed collected under the *C. vulgare* tree showed that *C. moluccensis* ate fruit flesh (arylus) and seed meat. Characteristics of hard seed wrapping from *C. vulgare* can be solved with a fairly strong *C. moluccensis* pecker. In addition, during the observation process, it was seen that *C. moluccensis* looked for feed in the morning and evening. For aging activities of *C. moluccensis* are usually seen individually or in small groups. It has been observed that *C. moluccensis* for ages with the *Ducula aenea*. This behavior shows symbiosis that is free from competition with members of the Columbidae family. During the observation showed that the *Canarium* genera holds the largest portion and acts as the main feed sources of *C. moluccensis* in MNP. The same thing was reported by the surrounding community during the data collection process in MNP. The results of this study are consistent with research reported by the Reliegh Operation Team which reported that the lowland forest on Seram island was dominated by the Myristicaceae and Ebenaceae families. Isherwood et al. (1997), stated that *C. moluccensis* were commonly observed apparently searching for insect grubs by tearing at the bark of dead and live trees and at the soft bark of rattan, pulling at dead branches, removing small climbers, and dislodging dead leaves on branches. BirdLife International (2001), reported that *C. moluccensis* are known to exploit strangling figs and may occasionally take Pandanus fruits.

Research by Widodo (2006), asserted that almost all birds that live in MNP choose fruit with a percentage of 50.62% as feed sources. In addition by Widodo (2006), that *C. moluccensis* consumed fruit from the trees *of C. vulgare*, *T. aurantica*, and *O. coccinea*.This result caused a difference between the zoning season in MNP. Edwards et al. (1993), reported that Seram climate is ever wet but annual and monthly rainfall are non-uniform and variable by region. The coastal lowlands of the north average 2100 mm annually with a drier season from May to October while the south coast receives 4255 mm annually with the wettest period during July. This causes differences in the fruiting season between trees species that serve as the main feed sources for *C. moluccensis*. There is a correlation of the presence of these wildlife in certain tree species with the fruiting periods. Research by (Putri, 2015), reported that fruit is a very important feed ingredient for birds. This is adhered to the level of palatability possessed by the fruit more dominant than other parts of the tree. Research by Corlett (2011); Plein et al. (2013), states that birds generally use fruit as part of their feed sources.

Two environmental factors that influence the distribution of birds are altitude of places and type of feed, as well as ecological niches inhabited by bird species. Monk et al. (1997), stated that Seram island has unique topographic value because it is dominated by steep mountain peaks and valleys. Ecologically, regions with different altitude com-

positions will have a higher diversity of species (Lomolino, 2001), states that MNP has a composition of forests and habitats that change according to altitude of places, and the altitude of the place also affects the distribution of birds. In this study, we found that some families whose members were separated according to the altitude of places include; Columbidae, Psittacidae, and Alcedinidae. Generally, birds species that belong to this family are very relevant and helpful in analyzing and understanding the concept of island biogeography because of their high endemism values. The presence of *C. moluccensis* in a little population during the study correlated with the island biogeographic concept. Island biogeography theory requires that the number of species on an island (or in isolated habitats) is closely related to the size of the island. This theory must be used to comprehensively understand island biogeography, because generally regions with steep topography will create a combination of complex types of forest vegetation in relatively narrow zoning. The combination of forest vegetation types greatly affects the morphological, physiological and behavioral characteristics of birds. This is because the presence of different forest vegetation structures will correlate with the availability of the types of feed consumed by each bird species.

Availability of sufficient feed sources in the habitat is one of the main keys to the presence of birds. The results of this study indicate that during the observation, the activity of *C. moluccensis* was very little. This is due to the difference in seasonal zoning between the north and south MNP. The difference in zoning this season will have an impact on extreme weather, that is the south wind that is blowing hard. Ecologically, the impact caused by strong winds will cause the fruits consumed by *C. moluccensis*, including members of the *Canarium* genera, to decline dramatically due to falls. This event will have an impact on changes in the daily activity pattern of *C. moluccensis* which is related to the activity of finding feed sources. Generally, *C. moluccensis* will spread to look for feed sources in other locations so that little is seen during observation. Another factors that is suspected of contributing to the *C. moluccensis* abundance is the existence of competition activities with *Rhyticeros plicatus*.

The ecological niche structure and wildlife distribution in MNP whose distribution is based on altitude, results in the presence of very few mammal predators. The presence of mammal predators in very little amounts causes large-sized raptor to take over the ecological niche in the canopy zoning. The composition of birds that occupy MNP is dominated by frugivores, which ecologically act as seed dispersers (Widodo, 2006). Woody trees that form the structure of rainforests on Seram island, are generally spread by certain bird species together with Pteropodidae members. Generally woody tree species produce large and fleshy fruit so it is suitable to act as feed sources from birds and Phalangeride members (marsupials; cuscuses). BirdLife International, (2001), asserted that the species is considered relatively resilient due to high reproductive potential, adaptability to habitat alteration, and lack of predators and competitors.

Some birds species including *C. unappendiculatus*, *Rhyticeros plicatus*, and families members of Psittacidae, play a very important roles in the conservation of flora diversity on Seram island. Research conducted by Beehler and Dumbacher (1996), reported that conservation of members of the Myristicaceae and Meliaceae tribes was highly dependent on frugivores. This is very reasonable because the members of both tribes are only consumed by frugivores. When consuming fruit from Myristicaceae and Meliaceae members, frugivores can separate seeds from capsules, so the presence of members of these two tribes in natural habitat is highly dependent on frugivores. BirdLife International, (2001), asserted that Three birds species are considered relatively resilient because they have high reproductive potential and adaptation, to changes in habitat, as well as predators or competitors. Forshaw and Cooper (1977), stated that diet is catholic, consisting of seeds, berries, insects and their larvae, and in some areas cockatoos become pests by eating domestic coconuts. Ecologically, *C. moluccensis* has an important role in maintaining ecological stability. The ecological role of *C. moluccensis* as an Ornitokori is very important for the sustainability of forest ecosystems in MNP. Seeds from the fruit consumed by *C. moluccensis* that are not destroyed when digested will grow and develop and become new individuals. This event presents a reciprocal relationship between trees as producers with *C. moluccensis* as consumers. This event has a close relationship so that if one of them experiences extinction, it will affect the sustainability of the ecosystem in the region, more specifically to the spermatophyta community in MNP.

Nest is a very important place for birds, especially when they lay their eggs and raise their cheeper. For this reasons, each bird species has a nest shape that varies according to the nature and behavior and wildlife species. *Cacatua moluccensis* is bird species make their nest in tall tree by punching holes in tree stem. The holes are made on broken branches and are somewhat weathered with the diameter of the hole that can be made between 30-50 cm. The observations at the study site showed that generally trees that function as nesting places of *C. moluccensis* have dense canopy trees and cover each other between one part of a twig with another. Usually between the canopy arrangement, there are branches that have experienced weathering. The branch is then cleaned from litter and made as nesting place of this species. This indicates that *C. moluccensis* is very selective in choosing tree species as nesting place.

During this time, available research data on *C. moluccensis* is very limited, while population decline occurs very rapidly every year. At present the sustainability of the endemic species of Seram island, is experiencing serious problems due to forest destruction which have an impact on forest fragmentation including illegal logging. Illegal Logging represents a primary threat to *C. moluccensis* conservation (Kinnaird et al., 2003). Recently, the logging activities occur in overlapping areas in Seram protected areas on a small scale, it is very worrying if this process sustainable logging practices that destroy the forest canopy will dramatically reduce habitat available for cockatoos, especially if large nest trees are harvested. Cockatoo abundance is positively related to the density of a favored nest tree, *O. sumatranus*, and the density of strangling figs, a potentially important feed resources.

The results of this study indicate that there is a positive correlation between the density of species *O. sumatrana* and its effect on increasing abundance of *C. moluccensis*. Observations also prove that the species *O. sumatrana* is the key nest tree of *C. moluccensis*. Kinnaird et al. (2003), asserted that the status of species *O. Sumatrana* acts as a key nest tree for *C moluccensis*. In addition, *C. moluccensis* often occupies tree holes that have been patterned naturally only by cleaning holes. The results of this study are consistent with the data reported by Isherwood et al. (1997); Kinnaird et al. (2003), stated that *C. moluccensis* used *O. Sumatrana* as nesting place. Widodo (2006) states that as much as 24.69% of trees in MNP serve as to nest, sleep, play and sunbathe from birds that live in these location.

Christian et al. (1996), states that it is very dangerous if bird capture has gone along with other factors such as habitat loss. The process that takes place in MNP is the same as that for Sumba cockatoos where the illegal logging and bird capture processes occur together (Hidayat and Kayat, 2014). We assumed that *C. moluccensis* can only be found in MNP, and not in other habitats in Maluku. This is very reasonable because the area outside MNP is not safe for the conservation of these wildlife. The results of discussions with the community and supported by the observation process in the MNP area explained that *C. moluccensis* only occupies forest blocks that are not disturbed and are relatively safe from humans. During observation, *C. moluccensis* was seen resting in three trees namely *T. copelandii*, *N. moluccana*, and *P. guajava*. Observations show that these wildlife put their nests in the *O. sumatrana* tree. This is evidenced by the surrounding community who climbed the tree. Generally *T. copelandii*, *N. moluccana*, and *P. guajava* trees only function as temporary resting place, while the key tree *O. Sumatrana* serves as nesting place (breeding location).

Currently the government and related stackholders have designed conservation programs based on the concept of local community awareness and ecotourism around the MNP area (Metz and Nursahid, 2004) . This program is considered effective enough to encourage local support so that it can control the dynamics of wild populations, local community movements related to illegal wildlife trade, as well as a means to socialize government regulations related to protection of protected wildlife, one of which is endemic species of *C. moluccensis*.

CONCLUSION

The conclusion of this study is that in MNP there are five species of trees that function as feedsources from Seram cockatoos, where the tree *C. vulgare* is a tree whose fruit is most like. There are Thee trees that function as temporary resting places (*T. copelandii*, *N. moluccana*, and *P. guajava*), except for the *O. sumatrana* tree which is the key tree for the nesting place of Seram cockatoo (*C. moluccensis*) in the period November to December 2017. Fruit flesh (arilus) of the *C. vulgare* tree is a feedsources that is highly preferred by *C. moluccensis* compared to four others species. *Octomeles Sumatrana* is a key tree from *C. moluccensis* that functions as a nesting place. We assumed that the remaining *C. moluccensis* habitat is currently only in MNP because outside this conservation area, there is no safe habitat for the survival of these endemic wildlife. The main cause of the decline in *C. moluccensis* population is habitat fragmentation due to illegal logging and uncontrolled hunting and selling of endemic wildlife.

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CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

AUTHORS CONTRIBUTION

Maman Rumanta drafted manuscript, analysis data and provided guidance; Henderina Lelloltery edited manuscript; Rony Marsyal Kunda draft manuscript, analysis data and revised it and Pieter Kakisina edited manuscript and provided guidance. All authors contributed equally to carry out this work.

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