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Feed Preferences of Yellow-crested cockatoo (*Cacatua sulphurea sulphurea*) in Pasoso Island, Central Sulawesi

(Preferensi Pakan Kakatua-Kecil Jambul-Kuning (Cacatua sulphurea sulphurea) di Pulau Pasoso Sulawesi Tengah)

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ABSTRACT

The yellow-crested cockatoo (Cacatua sulphurea sulphurea) is a sub-species of Cacatua sulphurea widely distributed in Sulawesi and several surrounding islands including Pasoso. Currently, the population has decreased and is categorized as critically endangered, hence, conservation measures are needed. One conservation approach is by understanding feed preference as an important aspect of improving survival. This study, then, aims to determine the feed preferences of yellow-crested cockatoos on Pasoso Island. It was conducted from April-September 2019 using data on the regeneration of forage plants obtained with a 20 m x 20 m plot, while feed preference data were taken using the focal animal sampling method. Furthermore, the data obtained were analyzed using the Jacobs preference index and the results showed that Buchanania arborescens is the type of forage plant that is most consumed. Based on the Jacobs category, it was known that B. arborescens and Ficus benjamina were the preferred types of feed, while Aglaia argentea was less preferred. However, the most preferred feed do not regenerate in the primary forest and had low regeneration in the ecotone habitat type, and an effort to develop the habitats by planting more B. Arborescens is necessary.

1. Introduction

The yellow-crested cockatoo (*Cacatua sulphurea sulphurea*) is one of seven sub-species of *Cacatua sulphurea* found in Indonesia (Collar & Marsden, 2014) and is widely distributed in Sulawesi, Muna, and Butung (Coates & Bishop, 2020). However, it has experienced a sharp decline in population due to over-catching and trading for pet birds. Currently, the population is estimated at 1000-2499 with a declining trend (Coates & Bishop, 2020; BirdLife International, 2021). Due to the rate of population decline, high habitat loss, and a relatively limited distribution area, the International Union for Conservation of Nature (IUCN) has included *C. sulphurea* and all its sub-species in the critically endangered category (BirdLife International, 2021). Consequently, the yellow-crested cockatoo has the status of a protected bird according to PP. No. 7, 1999; Ministry of Environment and Forestry Regulation No. P. 106, 2018 and is included in Appendix I of CITES (CITES, 2021).

Pasoso Island is a conservation area with the status of a wildlife sanctuary and is the habitat of the yellow-crested cockatoo in Central Sulawesi. This status makes the population of the cockatoo more relatively secure from illegal hunting as frequently found in other habitats in Central Sulawesi (Mallo et al., 2000). However, it is not sufficient to guarantee sustainability which reportedly fluctuates and continues to decline. In 2015, the population of small yellow-crested cockatoos was reported to be only 8 (Sandy, 2015) or decreased by 46% from the total population of 15 reported in 1995 (Mallo et al., 2000).

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Conservative measures for the yellow-crested cockatoo on Pasoso Island is needed, considering that it is the only location with a population of these birds in Central Sulawesi. The populations in several other locations including Tanjung Manimbaya, West Coast of Donggala Regency, Palu Valley, and Lore Lindu National Park Area have become locally extinct. To anticipate or minimize the risk of extinction on Pasoso Island, sustainable conservation efforts are needed. This effort requires a variety of information on the ecology of the small yellow-crested cockatoo, especially in relation to the feed which is not widely known. Meanwhile, feed is one of the important aspects of improving wildlife viability which is also a limiting factor for animal life (Musyaffa & Santoso, 2020).

Optimal conservation and management of the yellow-crested cockatoo population are achieved through scientific studies especially in relation to the feed preferences. According to Hidayat (2014), information about feed preferences is important and is applicable as a basis for determining priority plants in habitat development. Consequently, accurate feed data is needed as a basis for the conservation approach and is an important factor that affects animal survival. Therefore, this study aims to determine the feed preferences of the yellow-crested cockatoo in Pasoso Island.

2. Method

2.1. Time and Location

Data collection was carried out from April-September 2019 in the primary forest, ecotone, garden, and bush habitat types of the Pasoso Island Wildlife Reserve, Central Sulawesi (Figure 1).

2.2. Tools and Materials

The materials needed for handling plant specimens include alcohol, plastic bags, newspapers, cutters, threads, and ropes, while the tools used for plant inventory were Global Positioning System (GPS), field guide book, meter tape, plastic mine, spot-light tape, and tally sheet. To collect feed preference data, the following tools were used including binoculars, counters, Nikon Digital Single-Lens Reflex (DSLR) cameras, and the Avenza map application.

2.3. Study Methods

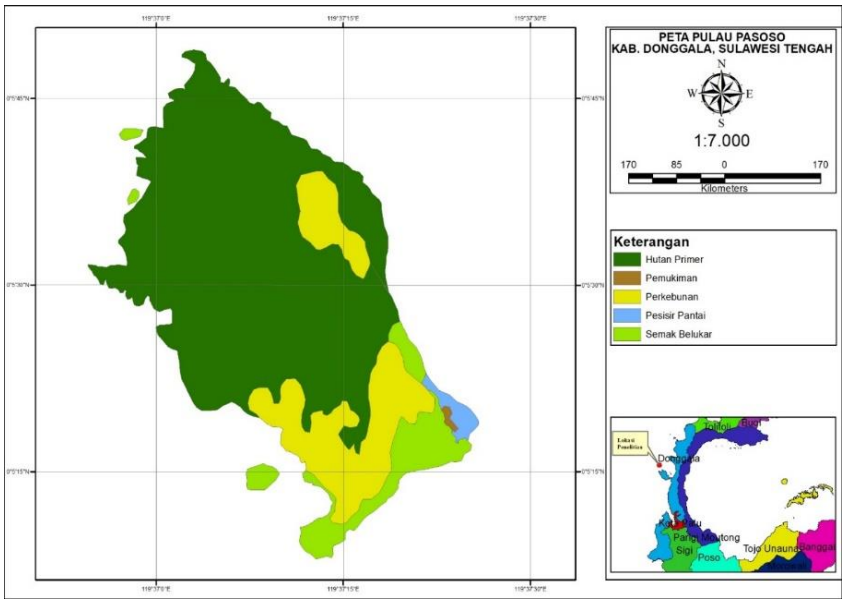
Feed Preference

The daily activity of the yellow-crested cockatoo with records was observed using the focal animal sampling method to determine the preference from the available food sources (Altmann, 1974). The observations were carried out by following the cockatoo movements from morning to evening (06.00 - 17.45) which was recorded every 2 minutes.

Furthermore, the feed preference data were collected by observing feeding activities which included: (1) the type of feed vegetation used (2) the part of the vegetation eaten, (3) the gender of the individual carrying out the feeding activity, and (4) the feeding time.

Feed and regeneration status of feed plants

Feed plant regeneration data were taken using the line plot transect method as shown in Figure 2. The data were collected from several types of habitats on Pasoso Island, including primary forest, ecotone, gardens, and shrubs. Observation of the eating activity was also carried out in the mangrove habitat, but this was not performed with the observation plots, because it is a degraded area with only two mangrove trees. This study used a sampling intensity of 1% or 32 sample units which were placed using the stratified sampling method and allocated proportionally based on the wide-area in all habitat types.



Source: Analysis of Landsat 8 OLI Images for 2019 recording

Figure 1. Study location in Pasoso Island

2.4. Data Analysis

Feed preferences

Feed preferences used by yellow-crested cockatoos were analyzed using the Jacobs Preference Index (Jacobs, 1974):

$$D=(r-p)/(r+p-2rp) \quad (1)$$

Remarks:
D = Preference index
r = Proportion of yellow-crested cockatoos observed in a certain habitat
p = The proportion of feed used by yellow-crested cockatoos

The Jacobs index is positive or preferred, and negative or less preferred.

Feed plant regeneration

The regeneration status of the feed plants was analyzed descriptively by referring to a categorical classification by Shankar (2001).

3. Results and Discussion

3.1. Feed Preferences

Based on the results, the yellow-crested cockatoo consumes four types of plants, namely marangtaipa (*Buchanania arborescens*), *Ficus benjamina*, *Aglaia argentea*, and *Sonneratia alba*. Compared to the others, *B. arborescens* was the most frequently consumed feed with 60%, followed by *F. benjamina* 28%, *S. alba* 75%, and *A. argentea* by 5%. The major part consumed was the fruit in *B. arborescens* and *F. benjamina* as well as the young leaves in *A. argentea* and *S. alba*.

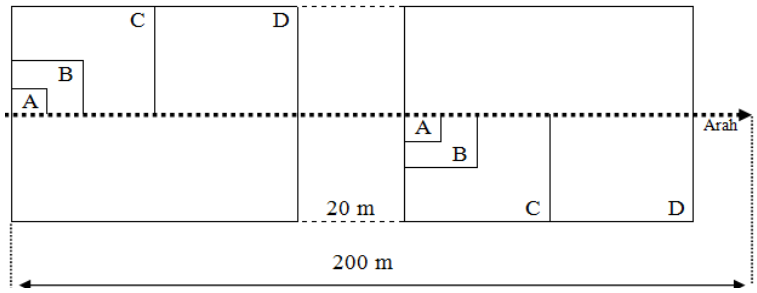


Figure 2. Vegetation observation plots

Table 1. Category and regeneration status of the plant species

Category	Criteria
Just regenerated	S>Pc>Po=0
Sufficient regeneration	S>Po>Pc
Good regeneration	S>Pc>Po
Low regeneration	Pc>Po>A=0
No regeneration	Po>Pc = S=0

Remarks: S= seedlings, Pc = sapling, Po= tree
*Source: Shankar (2001)

The preference analysis results showed that *B. arborescens* and *F. benjamina* were the preferred types of feed, while *A. argentea* was less preferred (Table 2). *S. alba* was not included in the analysis, because it was outside the observation plot, but based on the frequency of visits, it had a visiting frequency of 22 compared to *A. argentea* with 16.

Among the four types of feed plants, *B. arborescens* was the most frequently eaten by the yellow-crested cockatoo, followed by *F. benjamina*. Previous studies showed that ficus is an important plant species that supports tropical forest frugivores and produces fruit throughout the year (Kattan & Valenzuela, 2013; Compton & Greeff, 2020), Moreover, it plays an essential role in ecological food webs (Zahawia & Reid, 2018) and support the life of birds (Kurnianto et al., 2017). However, small yellow-crested cockatoos are often more likely to choose *B. arborescens* as the main feed. In the study location, this species was more abundant than *F. benjamina*, therefore the availability of its fruit as a food source was higher. In contrast, the selection of *F. benjamina* as the other main food source on Pasoso Island has been reported (Mallo et al., 2000), hence, there is an indication of a shift in preferences based on feed availability. According to Molokwu et al. (2011), a decrease in the availability of the preferred feed is one of the factors for switching bird diets.

The part frequently consumed in *B. arborescens* and *F. benjamina* was the fruit with 60% and 28% respectively, while for *S. alba* and *A. argentea*, it was the young leaves with 7% and 5%. The type and portion of feed frequently consumed indicate the preference of the yellow-crested cockatoo. Based on the results, the fruit was more preferred with the young leaves as an additional source. A previous study stated that fruits with a high number of calories are useful as a daily energy intake. Although the leaves are one of the additional sources, the percentage as feed was significantly small. This is presumably caused by the high tannin levels in this part of the plants (Gawali & Jadhav, 2011; Gazali et al., 2020). Tannins are known to bind protein strongly and are anti-nutritional

factors for birds (Zungu & Downs, 2015; Huang et al., 2018), this leads to indigestion and loss of appetite (Molokwu et al., 2011; El-Lamey, 2012). Furthermore, Xie et al. (2019) showed that high tannins reduce the level of birds' consumption and cause slow growth which ultimately leads to death (Karaman et al., 2016). It is assumed that the yellow-crested cockatoo is capable of tolerating the tannins present in the leaves as a source of food. According to Gilardi & Toft (2012), birds of the order Psittaciformes are able to adapt adequately to toxic food sources, hence, they exploit various food sources.

The selection of *B. arborescens* as the main feed source was due to the following factors: 1). It produces maximum fruit in the field compared to *F. benjamina*. 2). *F. benjamina* is a source of food for other frugivore birds found on Pasoso Island, therefore, the small yellow-crested cockatoo needs to compete with other frugivore birds for this source. The competition was often very tight due to a low availability of the fruit. 3). *B. arborescens* is consumed by the yellow-crested cockatoo without any competitor from the frugivore species. 4). The nutritional content of *B. arborescens* sufficiently meets the major needs of the yellow-crested cockatoo. According to Onrizal & Auliah (2018), this plant has better nutritional content than Ficus sp. Besides, there was a significant difference between *B. arborescens* and ficus related to calcium content. According to Foster (2014), ficus fruit contains twice as high calcium as non-ficus fruit. Calcium is an important nutrient for birds, especially for the production of eggshells and the mineralization of the developing skeletons.

3.2. Availability of Feed

Based on the results, the yellow-crested cockatoo eats a feed combination in the form of fruit and leaves. The feed availability on Pasoso Island is relatively abundant and almost evenly distributed every month. Based on the fruiting cycle of feed plants, the highest feed availability is shown in Table 3. Meanwhile, previous studies related to the yellow-crested cockatoo on Pasoso Island showed that *B. arborescens* is the main food for each fruiting. The results showed that this plant bears fruit for 6 months each year, while the other three types bear fruit or produce young leaves throughout the year.

Therefore, high feed availability occurs when *B. arborescens* bears abundant fruits, such as in February, March, April, May, August, and September. In contrast, the lowest was observed in January, June, July, October, November, and December. Although the type of feed tends to be available throughout the year, the production of fruit and young leaves is not the same every month. During the study, *F. benjamina* was available throughout the year but the fruit production was less abundant in August and September.

Table 2. Feed preferences of yellow-crested cockatoo in Pasoso Island

Feeding plant species	Jacobs Index	Category
B. arborescens	0.423	Preferred
F. benjamina	0.069	Preferred
A. argentea	-0.738	Less preferred

Table 3. Availability of feed for yellow-crested cockatoo in Pasoso Island in a year

No.	Feeding plant species	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Agst	Sept	Oct	Nov	Dec
1	*B. arborescens*	-	√	√	√	√	-	-	√	√	-	-	-
2	*F. benjamina*	√	√	√	√	√	√	√√	√√	√	√	√	√
3	*A. argentea*	√√	√√	√	√	√	√	√	√	√	√	√	√√
4	*S. alba*	√√	√√	√	√	√	√	√	√	√	√	√	√√

Remark: √= available; √√= overflow

The results indicate that each feed plant type tends to have a different maximum production period of fruit or young leaves, but they complement each other when the production of one feed source is reduced, therefore, feed availability is mostly abundant all the time. *F. benjamina* was abundant in July and August when *B. arborescens* did not bear fruit nor had not significant numbers of leaves. Meanwhile, the highest leaf production occurred in December, January, and February, when *B. arborescens* had not yet produced fruit and *F. benjamina* had not entered the maximum production phase. It is suspected that *F. benjamina* has passed the maximum fruit production stage during this study. This is consistent with Van Schaik (1986), which showed that the highest fruit production occurred between July and August, leaf between December and February, and flowers from February and April.

The condition of readily available feed provides great benefits to the small yellow-crested cockatoo on Pasoso Island, therefore, they have not been reported of using the garden habitat type as a food source. This is similar to a study by Nandika & Agustina (2018) conducted in the Rawa Aopa Watumohai National Park. The yellow-crested cockatoo does not eat community plants such as cashew nuts or other plants. On the Pasoso Island, there are tamarind, coconuts, papayas, mangoes, and corn trees which are a source of food for the small yellow-crested cockatoos in the Palu Valley and the west coast of Donggala Regency (Mallo et al., 2000).

3.3. Feed plant regeneration

The current condition of the feed plants was determined based on the population in the habitat types analyzed. Based on the results, the four habitats showed differences in the conditions of feed plants. Primary forest and ecotone had three types of feed plants, while garden and shrub only had one, namely *A. argentea* in the garden and *F. benjamina* in the shrub (Table 4). This indicates that primary forest and ecotone have higher feed plants compared to the other two types.

The growth rate of feed plants in each type of habitat is represented by the different species. *B. arborescens* which is the main food plant did not dominate at all growth levels but was only found in two types of habitats. Moreover, this species was more predominant at the level of tree growth in the primary forest habitat but was not found at other levels. In the ecoton habitat type, *B. arborescens* only dominated the tree and pole, but not at the saplings and seedlings levels. The dominance of feed plants at all growth levels only occurred in *F. benjamina* at the bush, and *A. argentea* in the primary forest, while in other habitat types, it only dominated at one or two growth stages.

The population structure of *B. arborescens*, *F. benjamina*, and *A. argentea* in several habitat types showed abnormal regeneration due to the loss of more than one growth rate. This is caused by environmental factors, considering that Pasoso Island being a small island,

often experiences strong winds with steep topographic conditions. Therefore, seeds from the feed plant mostly fall far from the parent, and others that fall closely on the ground are mostly washed away by the rain to the beach. According to Mawazin & Subiakto (2013), disturbances in environmental conditions affect the composition of plant species.

The regeneration status of the yellow-crested cockatoo forage on Pasoso Island was determined by observing the conditions at each growth stage (Table 1). Based on the classification of Shankar (2001), the regeneration status of feed plants on Pasoso Island has different statuses (Table 5). *B. arborescens* which is the main source of food do not regenerate in the primary forest and ecotone, while in the other two habitat types, it was not found. Based on the observations, *B. arborescens* trees were more commonly found outside the observation plot due to its growth area on the Island. This species is majorly found on the coast and cliffs in the primary forest and garden habitat type, making it difficult to locate the observation plot. According to Pitopang (2011), it grows mostly in coastal areas, especially in the lowlands.

Compared to the other types of feed plants, *A. argentea* had a normal vegetation structure in the ecoton habitat type with a greater number of seedlings than the other growth stages namely number of seedlings > saplings > trees. The normal vegetation structure is in the form of an "inverted j", which is the number of individual seedlings. A previous study stated that a stand structure in the form of an "inverted j" indicates that the plant population is growing (Sahu et al., 2012), and has great sustainability potential (Sharkar & Devi, 2014). Additionally, it implies that the vegetation is in good condition (Atmoko et al., 2014).

Consequently, *B. arborescens* which do not have seedlings in all types of habitats and has an abnormal growth structure is at great risk of extinction in the long term. According to Malik & Bhatt (2016), tree species that show poor or no regeneration might be at risk in the future even though it is presently dominant. Therefore, a systematic management plan is needed for conservation and sustainable use (Singh et al., 2016). The results indicate that *B. arborescens* is potentially unsustainable in the long term, hence, to anticipate potential problems in the future, habitat development needs to be carried out by planting this species along with other feed plants throughout the area. This is consistent with Hidayat & Kayat (2020) which stated that the lack of feed plants is overcome by carrying out habitat development directed at prioritizing the types of preferred plants by cockatoos.

Table 4. Number of individual feed plants for yellow-crested cockatoo in four types of habitats in Pasoso Island

Feed plant species	Number of individual / Habitat type															
	Primary forest				Ecotonic				Plantation				Shrub			
	Po	T	Pc	S	Po	T	Pc	S	Po	T	Pc	S	Po	T	Pc	S
B. arborescens	3	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
F. benjamina	0	1	0	0	1	0	0	1	0	0	0	0	2	2	3	1
A. argentea	2	2	7	3	1	2	2	6	0	0	0	3	0	0	0	0

Remarks: S= seedlings, Pc = sapling, T= Poles, Po= tree

Table 5. Regeneration status of feed plant for yellow-crested cockatoo in Pasoso Island based on Shankar criteria (2001)

Species' name	Regeneration status/Habitat type			
	Primary forest	Ecotonic	Shrub	Plantation
*B. arborescens**	No regeneration	Low regeneration	-	-
*F. benjamina***	Low regeneration	Sufficient regeneration	Low regeneration	-
*A. argentea**	Low regeneration	Good regeneration	-	Just regenerated

Remarks: *= main feed; **= feed

4. Conclusion and Suggestion

4.1. Conclusion

Buchanania arborescens was the most consumed feed, followed by *Ficus benjamina*, *Aglaia argentea*, and *Sonneratia alba*. Based on the Jacobs category, *B. arborescens* and *F. benjamina* were the most preferred feed, while *A. argentea* was less preferred. Furthermore, *B. arborescens* did not regenerate in the primary forest and had low regeneration in the ecoton. However, it was not found in the garden and the shrub habitat type, therefore, to anticipate potential problems in the future, habitat development needs to be carried out by planting *B. arborescens* and other feed plants throughout the area.

4.2. Suggestion

Data and information regarding various aspects of the small yellow-crested cockatoo on Pasoso Island are lacking. This is the first study on its feed preference, therefore to get a complete picture, further studies conducted during the maximum fruiting of ficus or the breeding period of the cockatoo are needed. This information is important to determine the possibility of a shift from *B. arborescens*, which is currently the most preferred feed, to other types.

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