Feeding Behavior of Tonkean Macaques (Macaca tonkeana) in Schmutzer Primates Center and Ragunan Zoo, Jakarta

Fery Dwi Riptianingsih
Department of Animal Bioscience, Faculty of Mathematics and Natural Sciences, Institut Pertanian Bogor, Bogor 16680, Indonesia, fery12bshipb@gmail.com

Dyah Perwitasari Farajallah
Department of Animal Bioscience, Faculty of Mathematics and Natural Sciences, Institut Pertanian Bogor, Bogor 16680, Indonesia

Dewi Apri Astuti
Department of Nutritional Sciences and Feed Technology, Faculty of Animal Sciences, Institut Pertanian Bogor, Bogor 16680, Indonesia

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Cover Page Footnote
We are grateful to Ragunan Zoo for providing the permit to observations in the field and give database about animals especially Tonkean macaque groups.
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Fery Dwi Riptianingsih	extsuperscript{1*}, Dyah Perwitasari-Farajallah	extsuperscript{1}, and Dewi Apri Astuti	extsuperscript{2}

1. Department of Animal Bioscience, Faculty of Mathematics and Natural Sciences, Institut Pertanian Bogor, Bogor 16680, Indonesia
2. Department of Nutritional Sciences and Feed Technology, Faculty of Animal Sciences, Institut Pertanian Bogor, Bogor 16680, Indonesia

\textsuperscript{*}E-mail: fery12bshipb@gmail.com

Abstract

Tonkean macaques are one of seven endemic macaque species on Sulawesi Island. Feeding management in captivity should pay attention to the quality, palatability, and feeding behavior patterns of animals. The goal of this study was to compare the feeding behavior of two social groups of Tonkean macaques at Schmutzer Primates Center (SPC) and Ragunan Zoo (RZ) with different captive management, which was expected to affect feeding behavior. Ad libitum sampling was used to observe daily behavior and hierarchy, while focal animal sampling was used to observe feeding behavior and feed preference. Data were collected from September 2013 until March 2014 with a total of 495 hours of observations. There were significant differences between the daily behavior of two groups of Tonkean macaques. Resting behavior was dominant in RZ group with non-enrichment feed cage, while feeding behavior was more common in the SPC group with an enrichment feed cage. The SPC group spent most of their feeding time in searching for feed, while choosing, carrying and refusing were greater in the RZ group. Both Tonkean macaque groups showed individual dominance in their feeding behavior. Provisioned feed in both locations had different diversity and preference values. The selection of feed required was based on preference values with attention to Tonkean macaques’ feed in nature. Cage construction, such as the SPC cage, was able to reduce abnormal behavior exhibited by individuals.

Introduction

*Macaca* consists of 19 species and has the widest distribution of all nonhuman primate genus in Africa and Asia [1]. The Tonkean macaques (*Macaca tonkeana*) are one of seven endemic macaque species on Sulawesi Island inhabiting Central Sulawesi and Togian Islands [2-3]. Their special feature is their black
forearms and hindlimbs [4]. This type of monkey is included in the vulnerable category by IUCN with an estimated density of only 3-5 individuals/km² [2].

All macaques are fruit eaters (frugivores) [1]. Tonkean macaques in nature also consume alternative feed, such as insects, fungi, young and old leaves, and young shoots and stems [5]. Several field studies have shown that primates do not choose feed or plant parts at random, but instead display marked feed preferences [6]. Feed palatability is a factor that influences selecting behavior in primates, including Tonkean macaques [7].

Tonkean macaques lives in multimale-multifemale groups [1]. Their group size in nature is strongly influenced by the availability of their feed resources [5]. In captivity, diet has a major influence on their feeding behavior because it is the most important activity in daily behavior [8]. Diet is generally recognized as the most important parameter underlying the behavioral and ecological differences among living primates [1]. Primate species show a wide range of behavioral adaptations for obtaining and processing different types of feed [1]. Other factors that influence eating behavior are social status and the dominance degree of individuals [9-10].

Schmutzer Primate Center (SPC) and Ragunan Zoo (RZ) in Jakarta are locations of ex situ conservation of wildlife and serve as recreation and education centers. Tonkean macaques are one species that is conserved in SPC and RZ. The success of Tonkean macaque conservation cannot be separated from the success of captive management. The important aspects in captive management are feeding, social groups, and housing management that pay attention to the behavior and welfare of animals. Animal welfare refers to the actual state of the animals that indicates the characteristic of those animals and describe the quality of life as experienced by individual animals [11-12]. Captivation activities often limit the ability of animals to express natural behavior. Abnormal and aggressive behaviors have been found to increase significantly as a result of the disruption of routine feeding in stump-tailed macaques (Macaca arctoides) in captivity [8]. This indicates the disruption of their psychological well-being.

Feeding is the main source for activity and reproduction of Tonkean macaques. Feeding with adequate nutrient content is absolutely necessary. Feeding in captivity should involve paying attention to the quality, palatability, and feeding behavior patterns of the animals. This study was done to compare the feeding behavior of two social groups of Tonkean macaques with different captive management, which was expected to affect feeding behavior. This study presented the feeding behavior of Tonkean macaques (Macaca tonkeana) in SPC and RZ, Jakarta. Finally, this study can be used for determining the appropriate captive management with regard to the welfare of captive animals.

Materials and Methods

Sampling sites. The study was conducted on a Tonkean macaque group in RZ consisting of four individuals (observation 1) and a Tonkean macaque group in SPC, which consisted of five individuals (observation 2). Data were collected from September 2013 until March 2014 with a total of 495 hours of observations.

Habituation and individual identification. Habituation was conducted for one month. Each individual was then identified and classified according to age [13].

The physical condition of the cage environment. The data consisted of cage aspects (material, type, shape, size, and supporting facilities) and the temperature and humidity of the cage. The temperature and humidity of the enclosure were recorded three times a day at 08.00 (morning), at 12.00 (noon) and at 16.00 WIB (afternoon) using thermo-hygrometer.

Behavioral observations. The observed behaviors were daily behavior and feeding behavior. Observation began when an individual was released from the sleep cage to the display enclosure at 08.00 WIB and continued until it returned back to its sleep cage at 16.00 WIB. The method was used in the study of Martin and Bateson [14]: (1) Ad libitum sampling was used to observe the daily behavior of Tonkean macaques and to determine hierarchy in males and females. Group daily activities were observed referring to Thierry et al. [15]; (2) focal animal sampling was used to observe the feeding behavior and feeding preference. The method of recording was continuous recording at 15-minute intervals of observation for each individual with 5-minute breaks.

Identification of feed. Feed provided by the keeper (provisioned feed) and other feed consumed by Tonkean macaques was identified using the identification books of Heyne [16] by taking notes a part of feed consumed.

Data analysis. Behavioral data were analyzed descriptively and quantitatively. The duration percentage of X behavior was determined with the following formula:

$$\text{Duration of X behaviour} \times 100 \over \text{Total time of observation} \quad (1)$$

Behavioral data were analyzed using t-tests (independent sample t-tests) and focused on individuals who could be compared between the two observation site.
Results and Discussion

Identification of individuals. The RZ group consisted of four individuals with a composition of two adult females (Huti and Ochi), one young male (Okto), and one young female (Febri). The SPC group consisted of five individuals with a composition of one adult male (Godes), two adult females (Iyos and Elly), one young male (Godel), and one baby female (Meilan) (Table 1). Tonkean macaques live in groups consisting of several male and female adults, adolescents, and infants [1]. Age and sex composition in the RZ cage were not complete, which may be a result of the cage’s limited area. In addition, Huti, the parent of Okto should be separated because he displayed sexual behavior toward Huti. This separation is important to avoid inbreeding in the RZ group.

The Tonkean macaque group in SPC had a complete group structure. The ratio of male to female adults in the SPC group was normal and in accordance with Tonkean macaques’ sex composition in nature, which is 1:2. The ratio of adult male to female M. tonkeana in Lore Lindu National Park, Central Sulawesi ranged from 1:1.2 to 1:1.3 [17], while according to Napier and Napier [18] the ratio of adult males to females for multimale-multifemale social groups is generally 1:2. The group structure and the male-to-female ratio are very important so that individuals can express natural sexual behavior.

The physical condition of the cage environment. The enclosure of RZ had an area of 25.18 m², was surrounded by walls, and had a ceramic floor. The front wall and roof were made of iron bars. Inside the enclosure there were two logs laid crosswise on top of a metal gutter and a rubber balloon and some ropes made from rubber materials to use as a tool for swinging and playing. At a distance of 4 m outside the cage, there were some shady areas. They were jackfruit trees (Artocarpus integra Merr.) and fig trees (Ficus benjamina L.). The average air temperature in the morning, afternoon, and evening, respectively, was 26.9 ± 0.8 °C, 28.6 ± 1.3 °C, and 28.5 ±
Table 1. Group Composition in both Cages

<table>
<thead>
<tr>
<th>Fig.</th>
<th>Name</th>
<th>Sex-Age</th>
<th>Class*</th>
<th>Fig.</th>
<th>Name</th>
<th>Sex-Age</th>
<th>Class*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Huti</td>
<td>F-A</td>
<td></td>
<td></td>
<td>Godes</td>
<td>M-A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ochi</td>
<td>F-A</td>
<td></td>
<td></td>
<td>Iyos</td>
<td>F-A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Okto</td>
<td>M-Y</td>
<td></td>
<td></td>
<td>Elly</td>
<td>F-A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Febri</td>
<td>F-Y</td>
<td></td>
<td></td>
<td>Godel</td>
<td>M-Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Meilan</td>
<td>F-B</td>
<td></td>
</tr>
</tbody>
</table>

*Data obtained from animal inventory documents of Ragunan Zoo, Jakarta. F = Female; M = Male; A = Adults; Y = Young; B = Baby

The humidity and temperature recommended for nonhuman primates are 30-70% and 18-29 °C [20]. The temperature in the SPC cage was slightly higher (29.3 °C) during the day, and so was the humidity, reaching 76.4% in the morning. This was caused in part by the lack of large trees around the cage that serve as shade.

**Daily behavior.** Daily behavior observed between the two groups of Tonkean macaques included feeding, resting, locomotion, grooming (self-grooming and allo-grooming), agonistic behavior, and playing in young individuals. A comparison of the daily behaviors of adult females was made between Huti and Ochi (RZ cage) and Iyos and Elly (SPC cage) (Figure 3A). In addition, comparisons were also made between youngsters Okto and Febri (RZ cage) and Godel (SPC cage) (Figure 3B). The daily behavior among adult females differed significantly ($t = 9.11$, df = 11, $P<0.05$), as well as in younger individuals ($t = -1.77$, df = 11, $P<0.05$) between the two cages.
Differences in the cage area and the availability of feed enrichment affected the daily behavior of the two groups of Tonkean macaques. The restriction area made individuals in the RZ cage spend much of their time resting during the day after eating a lot of feed in the morning. In contrast, individuals in the SPC cage, which was larger than RZ and equipped with a feed enrichment as an alternative feed, tended to spend their time feeding, particularly foraging, to explore and find feed from their environment.

Feeding behavior and social behavior (agonistic, sexual, and grooming) can be used to determine the hierarchy of individuals in each Tonkean macaque group. Dominant individuals had the greatest access to feed, mates, grooming, and often showed aggression [14]. In the RZ cage group, hierarchy can only be determined for female individuals because this group only had one adult female (Iyos) and her infant (Meilan). Jaman and Huffman [21] reported that Japanese monkeys (M. fuscata) maintained in captivity with vegetation enrichment spent twice as much time feeding as those kept in captivity without vegetation. In the long-tailed macaque (M. fascicularis), it has been found that high levels of feeding behavior will decrease resting behavior. In other words, feeding behavior is inversely related to resting behavior, while resting behavior is positively associated with grooming behavior [22]. However, this statement is inconsistent with individuals in the SPC cage engaging in less grooming behavior. This was due to differences in resting behavior in the RZ cage of those that were close together and followed by grooming behavior, while resting behavior in the SPC cage was solitary and rarely followed by grooming behavior, except between an adult female (Iyos) and her infant (Meilan).

Feeding behavior observed included searching, choosing, carrying, biting, chewing, and then refusing feed (Table 2). The feeding behavior among adult females significantly differed (t = -0.0001, df = 4, P<0.05), and so did that of younger individuals (t = -3.48, df = 4, P<0.01) between the two cages. Biting and chewing were dominant feeding behaviors in both cages. Searching behavior was more common in the SPC group than the RZ group. This was due to the SPC cage area having a wider enclosure and being equipped with some feed enrichment. Therefore, individuals would actively looking for alternative feed in the cages in the morning before the feeding routine and in the evening when the feeding supply was depleted.

Choosing behavior and refusing feed in the SPC group were less common than the RZ group. This was due to the high competition in getting feed in the SPC group, so there was no chance to choose, especially for individuals with low social status. The percentage of carrying feed behavior was also lower in the SPC group. Tonkean macaques in the SPC group more often took as much feed into their mouths as possible, slightly chewed it, and then stored it in their cheek pouch. In contrast, the RZ group often carried feed by hand, mouth (bitten), and feet to go to a safe place for eating. Carrying feed behavior (walking or running) was more frequently displayed by individual Tonkean macaques with low social status (Ochi and Febri). This was done to avoid dominant individuals’ aggressive behavior and a struggle for feed, while dominant individuals had more dominate feed resources because they were always eating close to the source of feed.

The types of feed given in the SPC cage were more diverse than those in the RZ cage (Table 3). Tonkean macaques in the RZ group consumed 16 species from 14 families of plants and alternative feed, such as fig leaves and jackfruit leaves dropped into the cage, insects, and feed from visitors. Feed composition by weight was 78.55% fruit, 1.59% leaves, 19.43% tubers, and other feeds such as insects and feed from visitors accounted for as much as 0.42%.

The SPC group consumed 34 species from 20 families of feed plants. Alternative feed consumed by Tonkean macaques in the SPC group were earthworms, guava leaves, fungi in wood and soil, paitan grass, and several insects.
The composition of the feed in the SPC group was 73.11% fruit, 13.56% leaves including paitan grass, 9.81% tubers, 0.65% flowers, 0.42% seeds, 0.32% shoots, 0.87% chicken eggs, and 1.26% others (insects, fungi, and mollusca). Tonkean macaques’ feed composition in both cages showed that fruits were the main feedstuff because *M. tonkeana* is a fruit-eating animal (frugivorous) [1]. In nature, Tonkean macaques consume as much as 85.8% fruit (mature and immature), 4.2% young leaves, 5.6% insects, 3.1% shoots, 0.3% mushrooms, 0.8% flowers, and other interest (exudate and crustaceans) account for as much as 0.4% [5]. The percentage composition of insects in both Tonkean macaque groups was very low, while there was a very high percentage of tubers in the cages, particularly the RZ cage. This differs from the feed composition of the Tonkean macaques in the wild with a high percentage of insects; they do not choose tubers as their preferred feed. The determination of preference is based on the frequency of the feed ingredients selected first, second, and so on [23]. For one type of feed, several pieces were provided. This was to minimize the likelihood that individuals would not get the feed they like. Feed was grouped into strongly like, like, somewhat like, somewhat dislike, and dislike and rated respectively as 5, 4, 3, 2, and 1. The total preference value of each feed type was calculated from the total preference value of each individual in the cages (Table 3). Of the 16 species of feed consumed by Tonkean macaques in the RZ cage, there were varied feed preference values, with the highest value of 20 (papaya and tomato) and the lowest values of 4 (carrots) and 5 (sweet potato). The SPC group, which consumed 23 species of feed, also showed varied feed preference values, with the highest value of 25 (bananas) and the lowest value of 5 (carrots and purple eggplant). Much of the feed with low preference values was left over, wasted, and caused feed inefficiency. Feed with lower preference values should be replaced with feed with high nutritional value and palatability.

Feed additives such as chicken eggs, peanuts, and sunflower seeds were given at noon. Bean sprouts were given when the individuals in cages were in the pregnancy phase, and spanish onions were given when the weather was quite cold.

Soil feeding (geophagia) was found in all members in the SPC group except Meilan (Table 3). Geophagia was also found in some primates such as gorillas in the mountains of Rwanda (*Gorilla gorilla beringei*) and orangutan (*Pongo pygmaeus*) in SPC [24-25].

Soil can be a source of essential minerals and partially ingested soil material can help absorb and remove toxins. In addition, the soil material can help keep the intestinal pH suitable for bacteria that help to digest feed [24].

Chapman and Chapman [23] observed the relationship between nutritional components and secondary components in the diet selection of red colobus monkeys (*Procolobus badius*) in Kibale National Park, Uganda. Red colobus monkeys prefer young leaves over old leaves due to the phytochemical difference between the two leaves.
This suggested that the selection of a diet is affected by the chemical content of feed. Chapman and Chapman [23] found that feed with a combination of high protein and low fiber is more often the choice. However, no evidence was revealed that red colobus monkeys avoid plants with high levels of secondary compounds. In the SPC and RZ groups some feed containing phytochemicals, such as apples, carrots, broccoli, and purple eggplants had varying palatability levels (Table 3). This suggests that the feed selection process in primates is very complex [23].

We had not found the relationship between the preference value and feeding behavior of individuals in both cage completely. However, the preference value

<table>
<thead>
<tr>
<th>Table 3. Feed Consumes in both Tonkean Macaques Cages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local Name</strong></td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>Aple (1)</td>
</tr>
<tr>
<td>Banana (1)</td>
</tr>
<tr>
<td>Bean sprouts (6)</td>
</tr>
<tr>
<td>Bengkuang (4)</td>
</tr>
<tr>
<td>Broccoli (5)</td>
</tr>
<tr>
<td>Cantaloupe (1)</td>
</tr>
<tr>
<td>Carrot (4)</td>
</tr>
<tr>
<td>Chinese green cabbage (2)</td>
</tr>
<tr>
<td>Cucumber (1)</td>
</tr>
<tr>
<td>Chicken egg (7)</td>
</tr>
<tr>
<td>Eggplant purple (1)</td>
</tr>
<tr>
<td>Guava (1)</td>
</tr>
<tr>
<td>Kailan (2)</td>
</tr>
<tr>
<td>Kumei (2)</td>
</tr>
<tr>
<td>Long beans (1)</td>
</tr>
<tr>
<td>Longan fruit (1)</td>
</tr>
<tr>
<td>Orange (1)</td>
</tr>
<tr>
<td>Papaya (1)</td>
</tr>
<tr>
<td>Passion fruit (1)</td>
</tr>
<tr>
<td>Peanuts (3)</td>
</tr>
<tr>
<td>Pears (1)</td>
</tr>
<tr>
<td>Pineapple (1)</td>
</tr>
<tr>
<td>Rambutans (1)</td>
</tr>
<tr>
<td>Salak (1)</td>
</tr>
<tr>
<td>Siomak (2)</td>
</tr>
<tr>
<td>Snap (1)</td>
</tr>
<tr>
<td>Spanish onion (4)</td>
</tr>
<tr>
<td>Starfruit (1)</td>
</tr>
<tr>
<td>Sunflower seeds (3)</td>
</tr>
<tr>
<td>Swamp cabbage (2)</td>
</tr>
<tr>
<td>Sweet corn (3)</td>
</tr>
<tr>
<td>Sweet potato (4)</td>
</tr>
<tr>
<td>Tomato (1)</td>
</tr>
<tr>
<td>Watermelon (1)</td>
</tr>
</tbody>
</table>

**Alternatif feed**

- Earthworm (7) - - o - √ -
- Elephant paiatan grass (2) | *Axonopus compressus* | Poaceae | o - | √ -
- Fig leaves (2) | *Ficus benjamina* L. | Moraceae | √ - | o -
- Guava leaves (2) | *Psidium guajava* L. | Myrtaceae | o - | √ -
- Jackfruit leaves (2) | *Artocarpus integrifolia* | Moraceae | √ - | o -
- Mushroom (7) - - o - √ -
- Soil (7) - - o - √ -
- Stingless bee (7) | *Trigona* sp. | Apidae | √ - | o -
- Unidentified insect (7) - - √ - √ -

*(1) Fruits; (2) Leaves; (3) Seeds; (4) Tubers; (5) Flowers; (6) Shoots; (7) Another feeds. √ : exist; o : no exist. *FA : Feed Additive*
could be used as a consideration for the zoo management to maximise the feed effectively. The provisioned feed in both cages was too diverse and some types of feed had similar nutritional content. The author recommends eliminating feed with preference values ≤ 10 for RZ and ≤ 15 for SPC and replacing it with feed sources of carbohydrates, proteins, fats, vitamins, and minerals. This was due to the observation of several behaviors, such as geophagia indicating mineral deficiencies [24] and searching for insects from the environment to fulfill their protein requirement.

The number of additional feed such as boiled chicken eggs, peanuts, and sunflower seeds must be increased at the both cage. In addition, as a result of this research, it was recommended to add palatable insects to Tonkean macaques' feed in both cages. Tonkean macaques' feed in captivity should be similar to their feed in natural habitats, which includes a high percentage of insects [5]. According to FAO (2003), insects are natural food sources that are high in fat, protein, vitamins, fiber, and minerals and are highly prospective feed in the future [26].

According to the Farm Animal Welfare Council (FAWC) [27], the welfare of animals, including captive animals, are known to include "five freedoms" i.e., 1) free from hunger and thirst; 2) free from discomfort; 3) free of pain, illness, and disease; 4) free to express normal behavior; and 5) free from fear and suffering. Captive activities may disturb the welfare of animals. The fifth concept of animal freedom should be used as guidelines in the management of captivity. Knowing the behavior exhibited when animals in are captivity on a regular basis can reduce the captive effects on the welfare of animals.

Conclusions

Resting behavior was the main daily behavior of the Tonkean macaque RZ group with a non-enrichment feed cage, while feeding behavior was the main behavior in the SPC group with an enrichment feed cage. Besides biting and chewing feed, the most common feeding behavior was searching in the SPC group, while choosing, carrying, and refusing were more commonly observed in RZ groups. The RZ group consumed 16 species from 14 families, while the SPC group consumed 34 species from 20 families of feed plants. Zoo management should consider eliminating feed with low preference values to improve feed efficiency. Cage construction with feed enrichment and appropriate temperature and humidity in the SPC cage was able to reduce the abnormal behaviors exhibited by individuals in the cage.

Acknowledgement

We are grateful to Ragunan Zoo for providing the permit to observations in the field and give database about animals especially Tonkean macaque groups.

References

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