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

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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.

Abstrak

Perilaku Makan Monyet Tonkean (*Macaca tonkeana*) di Pusat Primata Schmutzer dan Taman Margasatwa Ragunan, Jakarta. Monyet Tonkean adalah salah satu dari tujuh spesies monyet endemik di Pulau Sulawesi. Manajemen pakan di penangkaran harus memperhatikan kualitas, palatabilitas, dan pola perilaku makan hewan. Tujuan dari studi ini adalah untuk membandingkan perilaku makan pada dua kelompok sosial monyet Tonkean di Pusat Primata Schmutzer (SPC) dan Taman Margasatwa Ragunan (RZ) dengan manajemen penangkaran yang berbeda, yang diduga dapat memengaruhi perilaku makan. *Ad libitum sampling* digunakan untuk mengamati perilaku harian dan hirarki, sementara *focal animal sampling* digunakan untuk mengamati perilaku makan dan preferensi pakan. Data dikumpulkan dari September 2013 sampai Maret 2014 dengan total 495 jam pengamatan. Terdapat perbedaan yang nyata pada perilaku harian antara dua kelompok monyet Tonkean. Perilaku istirahat dominan dalam kelompok RZ dengan kandang tanpa pengkayaan pakan, sementara perilaku makan lebih umum di kelompok SPC pada kandang dengan pengkayaan pakan. Kelompok SPC menghabiskan waktu makan terbesar adalah untuk mencari pakan, sedangkan memilih, membawa dan menolak lebih besar dalam kelompok RZ. Kedua kelompok monyet Tonkean menunjukkan dominansi individu pada perilaku makan mereka. Makanan yang diberikan di kedua lokasi memiliki keanekaragaman dan nilai preferensi yang berbeda. Seleksi pakan perlu dilakukan berdasarkan nilai preferensi dengan memerhatikan pakan monyet Tonkean di alam. Konstruksi kandang, seperti kandang SPC, mampu mengurangi perilaku abnormal yang ditunjukkan oleh individu.

Keywords: feeding behavior, captive management, Tonkean macaques

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/km^2 [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:

$$\frac{Duration\,of\ X\ behaviour}{Total\,time\,of\ observation} \times 100 \qquad (1)$$

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

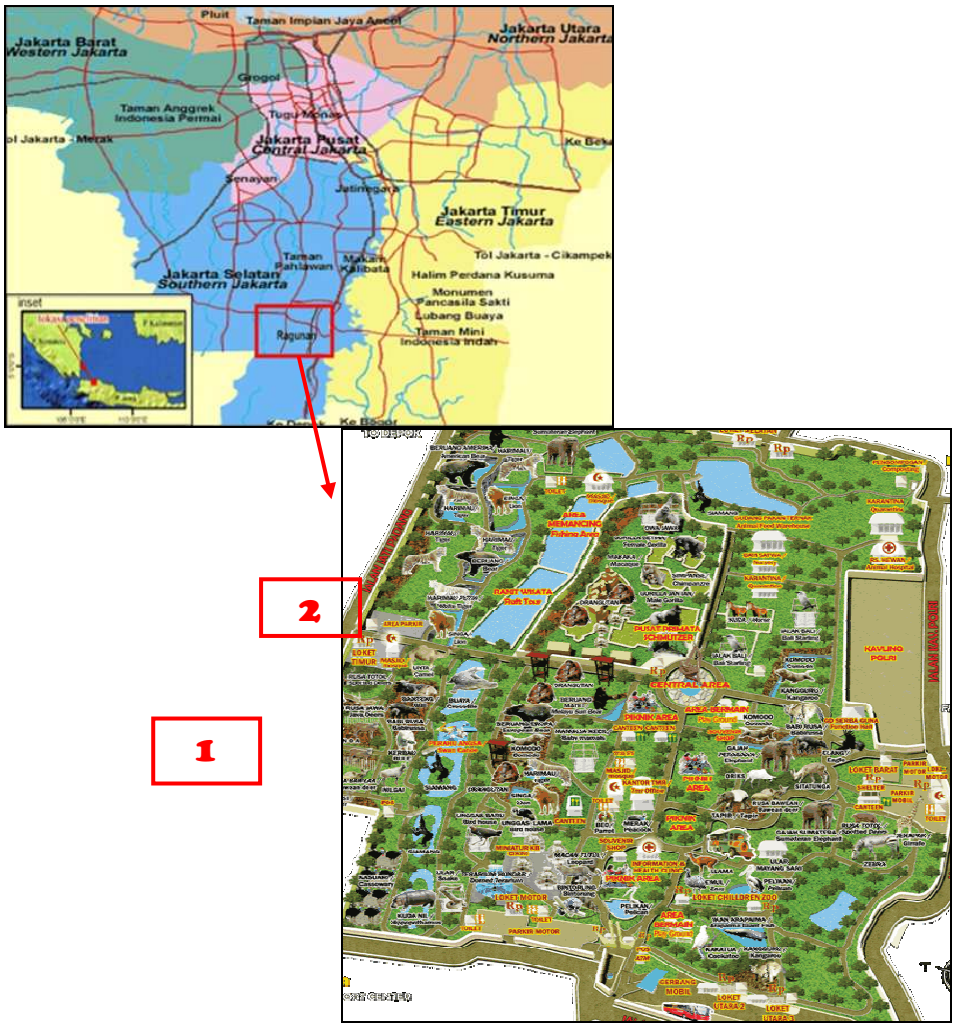


Figure 1. Map of the Study Site; 1. Ragunan Zoo (RZ) Cage; 2. Schmutzer Primate Center (SPC) Cage

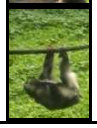
Results and Discussion

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 m^2, 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

RZ Group			SPC Group		
Fig.	Name	Sex-Age Class*	Fig.	Name	Sex-Age Class*
	Huti	F-A		Godes	M-A
	Ochi	F-A		Iyos	F-A
	Okto	M-Y		Elly	F-A
	Febri	F-Y		Godel	M-Y
				Meilan	F-B

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

1.6 °C, while the average humidity in the morning, afternoon, and evening, respectively, was 71.2 ± 5.2%, 63.7 ± 7.5%, and 66.3 ± 8.1%

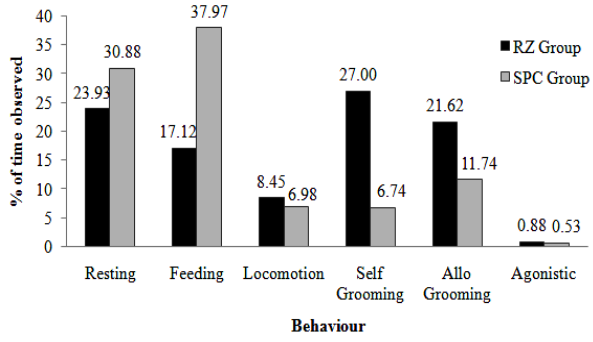
The SPC enclosure had an area of 182.89 m^2 with partial walls made from glass. The roof of the cage was made of wire with a ground base enclosure dominated by elephant paitan grass (*Axonopus compressus*). Inside the enclosure, there were some natural trees and artificial trees with ropes and toys made from rubber material. The SPC cage was also equipped with a sleep cage and some trap cages that serve as place to treat the animals. The average air temperature in the morning, afternoon, and evening, respectively, was 28.2 ± 0.9 °C, 29.3 ± 1.5 °C, and 29.1 ± 1.4 °C, while the average humidity in the morning, afternoon, and evening, respectively, was 76.4 ± 8.8%, 72.5 ± 12.8%, and 75.0 ± 13.5%.

The minimum cage size for primates, according to the National Institutes of Health (1985), with a body weight of 3-10 kg is 0.40 m^2/individual, while that for a body weight of 10-15 kg is 0.56 m^2/individual [19]. The size of both cages was appropriate for the standard recommended minimum size. When conducting the observation, Ochi in the RZ cage found injured on the pads sit because it was entangled in the sleep cage door. In addition, Okto and Febri often fell to the floor while playing and chasing each other due to the lack of play enrichment facilities.

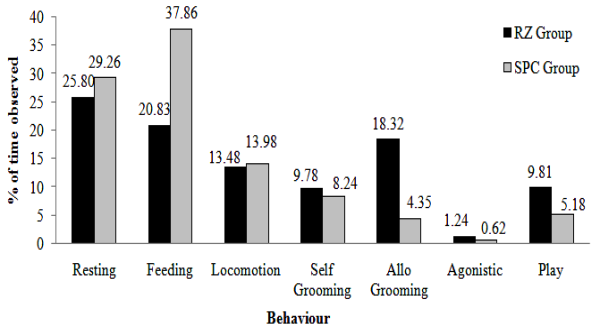
The humidity and temperature recommended for nonhuman primates are 30-70% and 18-29 °C [20]. The temperature in the SPC cage was slightly higher (29.3 °C) during the day, and so was the humidity, reaching 76.4% in the morning. This was caused in part by the lack of large trees around the cage that serve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

Figure 2. RZ Cage (Left) and SPC Cage (Right)



(A)



(B)

Figure 3. Daily Behavior: (A) Adult Female; (B) Young Individuals

Figure 3A and 3B showed that adult females and young individuals in the RZ cage engaged in more rest behavior and grooming behavior (self-grooming and allo-grooming) than feeding behavior and locomotion. In contrast with RZ, the SPC cage engaged in more feeding behavior than rest and locomotion behaviors and even less grooming behavior (except allo-grooming in adult female). 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. fasicularis*), 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).

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 male individual. Huti was the dominant adult female with the highest hierarchy, while Ochi was subordinant, and Febri had the lowest hierarchy in the RZ group. In the SPC cage group, Godes was a dominant male while Godel was subordinant. In the hierarchy of females, Iyos was dominant, while Elly was subordinant.

Certain individuals in both cages showed abnormal behaviors that were classified as stress-related behavior [8]. According to Waitt and Smith [8], abnormal behaviors include excessive grooming, eye poking, consuming fecal material, self-aggression, self-clasping, pacing, rocking, and wall-licking. Individuals in the RZ group displayed excessive grooming behavior, especially the mother and child pairs, Huti and Okto and Ochi and Febri. Huti very often groomed Okto, but Okto also rejected Huti and sometimes ended with aggression. Members in the RZ group also showed other abnormal behaviors: pacing, rocking, and wall-licking. In contrast, only Godel in the SPC group showed abnormal behavior: eating fecal material. Baby Meilan also consumed fecal material. However, Meilan's behavior was imitating and learning behavior.

Feeding behavior. Feeding behaviors 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.

Table 2. Feeding Behavior in Both Tonkean Macaques Group

Feeding Behaviour	RZ cage (% Duration)				SPC cage (% Duration)				
	Huti	Ochi	Okto	Febri	Godes	Iyos	Elly	Godel	Meilan
Searching	4.64	7.59	9.82	9.09	17.05	36.28	34.52	34.48	11.88
Choosing	3.55	6.55	4.81	3.91	0.92	1.10	0.00	0.00	0.38
Carrying	7.92	16.37	9.82	19.45	5.07	4.24	5.86	4.80	10.73
Bitting and chewing	83.47	68.75	75.24	67.55	76.73	58.38	59.41	60.72	77.01
Refusing	0.41	0.74	0.31	0.00	0.23	0.00	0.21	0.00	0.00
Total	100	100	100	100	100	100	100	100	100

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 in their daily feed composition. The selection of the provisioned feed for Tonkean macaques should involve paying attention to their feed in natural habitats.

The sequence of taking feed was determined when feed was first given by the keeper and then recording sequentially individuals who take feed. The sequence of taking feed in the RZ and SPC groups showed the effects of the dominance of each individual. A dominant individual was the first to take the feed given by the keeper, followed by subordinant individual. The sequence of taking feed was thus influenced by the social status of individuals [14]. However, Huti (dominant adult female in the RZ cage) did not show a striking percentage of first order versus next order feeding. Huti thus did not show dominant feeding behavior over the other individuals in the group. Individuals' dominant feeding behavior in a group, if continued, will affect the development of individuals, particularly subordinant individuals, due to the competition to obtain nutrients occurring between individuals within a group. Therefore, provisioning the feed by spreading it in various places is one strategy to reduce the effects of individual dominance.

Feed preferences are observed a moment after the feed is given by the keeper so individuals are free to choose 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 ora ngutan (*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.

Table 3. Feed Consumes in both Tonkean Macaques Cages

Provisioned Food			Cages + Preference Value[b]			
Local Name[a]	Scientific Name	Family	RZ		SPC	
Aple (1)	*Malus domestica* Borkh.	Rosaceae	√	12	√	19
Banana (1)	*Musa paradisiaca* L.	Musaceae	√	17	√	25
Bean sprouts (6)	*Phaseolus radiatus* L.	Fabaceae	o	-	√	FA
Bengkuang (4)	*Pachyrhizus erosus*	Fabaceae	√	6	√	10
Broccoli (5)	*Brassica oleracea* L.	Brassicaceae	o	-	√	7
Cantaloupe (1)	*Cucumis melo* L.	Cucurbitaceae	√	17	√	18
Carrot (4)	*Daucus carota*	Apiaceae	√	4	√	5
Chinese green cabbage (2)	*Brassica chinensis* L.	Brassicaceae	√	12	o	-
Cucumber (1)	*Cucumis sativus* L.	Cucurbitaceae	√	9	√	15
Chicken egg (7)	-	-	o	-	√	FA
Eggplant purple (1)	*Solanum melongena* L.	Solanaceae	o	-	√	5
Guava (1)	*Psidium guajava* L.	Myrtaceae	√	11	√	20
Kailan (2)	*Brassica oleracea* var. Alboglabra	Brassicaceae	o	-	√	17
Kumek (2)	*Lactuca indica*	Asteraceae	o	-	√	15
Long beans (1)	*Vigna sinensis*	Fabaceae	√	14	√	19
Longanfruit (1)	*Euphoria longana* Lamk.	Sapindaceae	o	-	√	10
Orange (1)	*Citrus sinensis* (L.) Osbeck	Rutaceae	√	10	√	15
Papaya (1)	*Carica papaya*	Caricaceae	√	20	√	22
Passionfruit (1)	*Passiflora edulis* Sims.	Passifloraceae	o	-	√	13
Peanuts (3)	*Arachis hypogaea*	Papilionaceae	o	-	√	FA
Pears (1)	*Pyrus communis* L.	Rosaceae	o	-	√	19
Pineapple (1)	*Ananas comosus*	Bromeliaceae	√	9	√	10
Rambutans (1)	*Nephelium lappaceum* L.	Sapindaceae	o	-	√	12
Salak (1)	*Zalacca edulis* Reinw.	Arecaceae	o	-	√	13
Siomak (2)	*Lactuca* sp.	Asteraceae	o	-	√	15
Snaps (1)	*Phaseolus vulgaris* L.	Fabaceae	√	12	√	15
Spanish onion (4)	*Allium cepa* L.	Liliaceae	o	-	√	FA
Starfruit (1)	*Averrhoa carambola* L.	Oxalidaceae	o	-	√	15
Sunflower seeds (3)	*Helianthus annuus* L.	Asteraceae	o	-	√	FA
Swamp cabbage (2)	*Ipomoea aquatica* Forsk	Convolvulaceae	o	-	√	15
Sweet corn (3)	*Zea mays* var. *saccharata*	Poaceae	√	15	√	23
Sweet potato (4)	*Ipomoea batatas* Poir.	Convolvulaceae	√	5	√	12
Tomato (1)	*Solanum lycopersicum* L.	Solanaceae	√	20	√	19
Watermelon (1)	*Citrullus vulgaris* Schrad.	Cucurbitaceae	o	-	√	22
Alternatif feed						
Earthworm (7)	-	-	o	-	√	-
Elephant paitan 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 integra* Merr.	Moraceae	√	-	o	-
Mushroom (7)	-	-	o	-	√	-
Soil (7)	-	-	o	-	√	-
Stingless bee (7)	*Trigona* sp.	Apidae	√	-	o	-
Unidentified insect (7)	-	-	√	-	√	-

[a] (1) Fruits; (2) Leaves; (3) Seeds; (4) Tubers; (5) Flowers; (6) Shoots; (7) Another feeds. √ : exist; o : no exist. [b] FA : Feed Additive

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

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.

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