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Dietary Variation of Long Tailed Macaques (*Macaca fascicularis*) in Telaga Warna, Bogor, West Java

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The genus *Macaca*, member of sub-family *Cercopithecinae*, is the most widely distributed non-human primates in Asian countries. The habitats are strongly influence the dietary variation of the populations. The dietary variation of the macaques reflect ecological plasticity in coping with differences both in availability and abundance of food. The macaques are plastic in taking any kind of food that available in their home range and adjust their behaviour according to its abundance. Here, we present the dietary variation of long-tailed macaques (*Macaca fascicularis*) in the high altitude rain forest of Telaga Warna, West Java, Indonesia. The proportion of their food from natural sources is greater than those from visitors. The natural food consisted of plants, small animals (insects and earthworm), fungi and water from lake. The plant food comprised of 29 species plus a few mosses. The frequency of eating artificial food was influenced by visitors who come for picnic. In this site, the macaques learned that the visiting of tourists is identical with food.

Keywords: dietary variation, high altitude rain forest, *Macaca fascicularis*

INTRODUCTION

The genus *Macaca*, member of sub-family *Cercopithecinae*, is the most widely distributed non-human primates in Asian countries; the only non-Asian macaque is the North African Barbary macaque (*M. sylvanus*) (Fooden 2006). These macaques live in various habitats such as lowland forest, montane forest and coastal mangrove forest (Fooden 2006). These habitats are strongly influence the dietary variation of the populations.

The dietary variation of the macaques reflect ecological plasticity in coping with differences both in availability and abundance of food. The macaques are plastic in taking any kind of food available in their home range. Their food may varies across seasons and altitudes. For example, Japanese macaques in temperate zone such as Yakushima (Japan) show considerable altitudinal variation in the diet. The macaques consume seed/fruit and animal matter in lower zones; while in the higher zones, they consume more fiber and fungi. There was also seasonal variation in this sites where in autumn (September-November) the macaques consumed mostly seed/fruits then shift to fibrous food in spring (Hanya *et al*. 2003). The rhesus macaques in other high altitude site (at Baimaxueshan Nature Reserve, China) showed that their preference of foods were to fruits (Grueter *et al*. 2010). In Jentse, Northeastern Taiwan, dietary variation of *Macaca cyclopsis* was influenced by seasons. In summer, the macaques spent a higher proportion on fruits and insects while in winter they consumed more leaves and stems (Su & Lee 2001).

The feeding ecology of long-tailed macaques have been reported mostly in lowland areas (Wheatley 1989; Fuentes *et al*. 2007; Hadi *et al*. 2007). Those study sites are recreational parks where the macaques get food from visitors in addition to consuming the natural food items. This diet plasticity might be because of the artificial foods contain more calories (Wheatley 1989); however, the proportion of artificial food are different in each sites which leads to differences in abundance. In some parks, local staffs feed the macaques; while in other study sites, visitors bring picnics or buy some food from vendors to feed the macaques. However, there are no reports about the feeding ecology of long-tailed macaques in the high altitude. Here, we present the dietary variation of long-tailed macaques in Telaga Warna, a high altitude rain forest with human-artificial food. We found that the proportion of their food from natural sources is greater than those from visitors. The natural food consisted of plants, small animals (insects and earthworm), fungi and water from lake. The plant food comprised of 29 species plus a few mosses. The frequency of eating artificial food was influenced by visitors who come for picnic. In this site, the macaques learned that the visiting of tourists is identical with food.

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MATERIALS AND METHODS

Research Site. Present research was conducted in Telaga Warna, Sub-district Cisarua, District Bogor, West Java Province, Indonesia (6°702'S, 106°996'E) (Figure 1). This study area is a Nature Reserve (Cagar Alam in Bahasa) and Nature Recreational Park (Taman Wisata Alam). The Nature Reserve is a conservation area for 549.66 ha tropical rainforest with high plant diversity. The reserve is hilly terrain with altitude ranges from 1097-1600 m above the sea level. Area of the Nature Recreational Park is about 5 ha. There is a lake in the middle of the Nature Recreational Park. The lake is surrounded by a steep cliff. There are four primate species inhabited the Nature Reserve: two Leaf monkeys [surili (*Presbytis comata*) and lutung (*Trachypithecus auratus*)], Long-tailed macaques (*Macaca fascicularis*) and Javan gibbon (*Hylobathes moloch*). The long-tailed macaques and lutung are also visiting the Nature Recreational Park. The observation was done in the Nature Recreational Park.

There are also many local people and foreigners come to visit this Nature Recreational Park. The number of visitors who visited Telaga Warna in 2012 is shown in Table 1.

Data Collection Methods. We conducted preliminary study from January until July 2012 in order to familiarize and to count the population parameters. We fed the macaques with crumps of dried noodle every weekends.

There are two troops of long-tailed macaques, Troop A (max = 43 individuals, min = 30 individuals, n = 19 censuses) and Troop B (20 individuals in 4 censuses). Although both troops visited the Nature Recreational Park, we concerned only to observe the Troop A. Troop A visited the recreational area more frequently, so it was easier to observe them. Troop A was mostly found near the lake or in the hill surround it. We marked those places as the home range of Troop A (Figure 1). The Troop A composed of 8 adult males (> 5 years old), 8 adult females (> 5 years old), 3 subadult males (3.5-6 years old), 2 subadult females (3.5-6 years old), 20 juveniles (1-3 years old) and 2 infants (<1 years old) (Tsuji & Takatsuki 2009). We could identified all individual of the adults and the subadults, and some of juveniles by differentiating their faces, hair colours, body sizes, shapes of head and body, and scars in their body. This identification helped in the recording of food items.

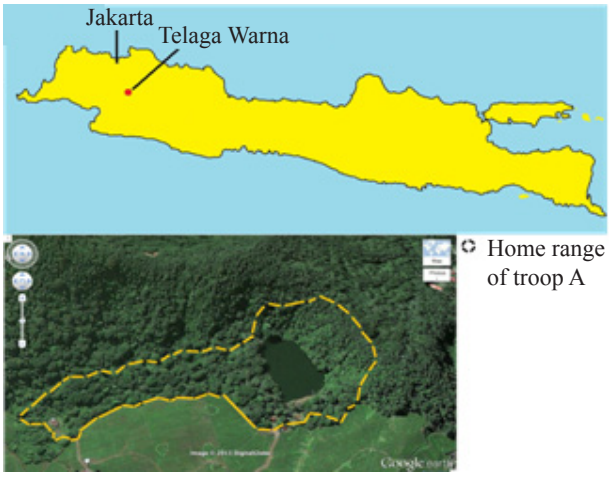

Figure 1. Research location and home range of Troop A long-tailed macaques in Telaga Warna. Perimeter of the home range was drawn by connecting outer location of the troop. The map of Telaga Warna was taken from Google Map.

Table 1. The number of visitors in Telaga Warna Nature Recreational Park 2012

Months	Number of visitors
January	1619
February	1104
March	1783
April	1744
May	1944
June	2461
July	1870
August	2137
September	1783
October	1526
November	1063
December	1166

From July to November 2012, we collected the data every day from morning (06:00) to the evening (16:00). We observed the macaques using two type of methods: scanning and *ad libitum* sampling methods (Altman 1974). The scanning method was used to estimate the proportion of every categorized behaviours (see below) that individuals performed in their activities. We observed seven behavioural categories of daily activities. We divided these activities into social and non-social behaviour. Social behaviour consisted of agonistic, grooming, mating and playing. Resting, feeding and moving were non-social behaviour. Resting refers to individual who sit on the ground or tree. Moving refers to displacements of each individual or the group from their position. These behavioural categorization were similar with Md-Zain *et al*. (2010). We took a scan of behaviour performed by randomly observed individual in one minute cycle. After we familiarized with the subjects and their behaviour, we used also *ad libitum* method (Altman 1974). In *ad libitum* method, we recorded the behaviours of macaques

without time cycle. The results were duration and frequency of each behaviour. The observation were stopped when the macaques were not visible.

Diet and Foraging Behaviour. Foraging is a set of activities where the macaques are looking for and eating food. We recorded the name of individuals that fed on food and the food items that they consumed. We categorized food items into natural and artificial foods. Artificial food were items that were given to macaques manually by visitors or macaques got it in the trash bin. Incidentally, the manually given items were distinct from that of taken from trash pots although some may overlap in the uncategorized garbages. Other foods that were available in the home range were defined as natural food. This method was based on Yeager (1996), Hadi *et al*. (2007), and Md-Zain *et al*. (2010).

Identification of Plants. We put number to every trees that have been eaten by the macaques. We asked the local people for the local name of those trees. We made herbarium from every part of plant samples. We brought those herbarium to be identified by Herbarium Bogoriense LIPI Cibinong Bogor.

Data Analysis. We calculated and summarized the data using basic statistical methods. To test proportion of natural food items taken in Ramadhan versus other months, we used Chi-square test. We used regression analyses to see the relationship between rainfall and manually given artificial food.

RESULTS

Daily Behaviour. The most common daily activity of long-tailed macaques in Telaga Warna was moving (39% of the time observed). It was followed by feeding (33.5%), resting (12.2%), playing (9.8%), grooming (3.5%), agonistic (1.2%), and mating (0.6%) (Figure 2). The three most frequent activities were related to foraging behaviours. The macaques moved to places that provided any kind of food items in their home range which consisted of Nature Reserve and Recreational Park. They were also seen feeding the food in their resting time or took rest after moving. They usually rest on the tree branches, terrestial spots or sitting on the vendor building in the Nature Recreational Park.

This result is similar with behaviours of wild long-tailed macaques which inhabit the residential area of University Kebangsaan Malaysia (UKM), Selangor, Malaysia. Md-Zain *et al*. (2010) reported that all macaques in UKM spent most of their activity in moving to find food. In UKM, the macaques spent less time in feeding (16.3%) and resting (16.1%) compare to moving (18.8%). It is in contrast with long-tailed macaques in Mauritius that spent time mostly in feeding (32.2%) than moving (23.2%) and resting (21.9%). The habitat of the macaques in Mauritius is a lowland vegetation made up almost entirely of introduced species. It is characterized by savanna formation with scattered trees and shrubs up to 75 m apart (Sussman & Tattersall 1981). This habitat provided more foods so the macaques did not have to move long way to find it.

Long-tailed macaques in Telaga Warna spent less time in social behaviours (Figure 2). Some social behaviours such as playing, grooming and mating occured while they were resting. The agonistic behaviours usually occurred in the moving and feeding times.

Diet and Foraging Behaviour. Long-tailed macaques in Telaga Warna consumed natural (60.1% of total) and artificial (39.9%) foods (Table 2). The higher proportion of natural source was comparable to the long-tailed macaques in Cikakak Monkey Park (Central Java) which obtained it at 76.4% (Hadi *et al*. 2007). In contrast, the long-tailed macaques in some recreation area prefered

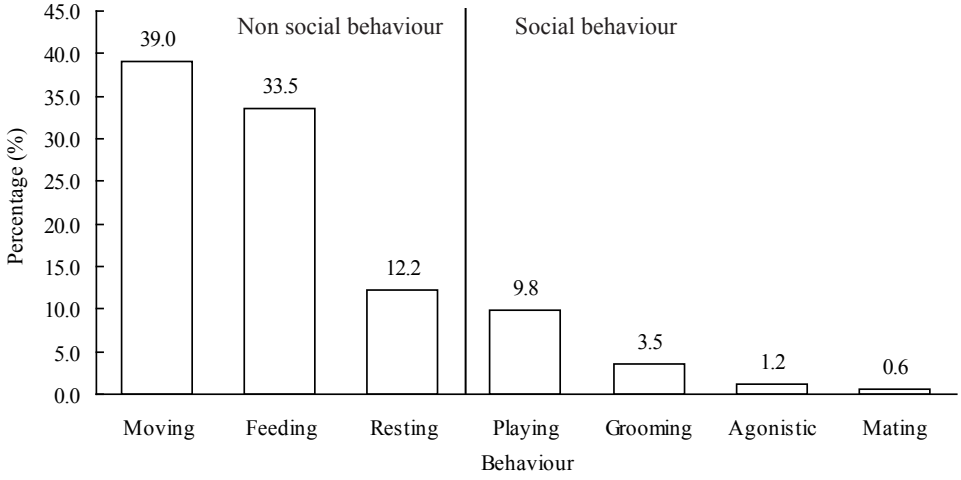

Figure 2. Seven behaviour categories of long-tailed macaques daily activities (total scans = 9333).

the artificial food. In Padangtegal (Bali), the macaques consumed artificial food about 70% of the time. In this site, the local staff also provide foods to be given to the macaques, beside the food that was brought by visitors (Fuentes *et al*. 2007). Long-tailed macaques in Ubud (Bali) had 58% of their diet composition from human (Wheatley 1989). In addition, the macaques in Pangandaran Recreational Park (West Java) got food from human up to 52% of their feeding time (Hadi pers.comm). This differences depend on the tourist with picnics who come to the sites. Padangtegal, Ubud and Pangandaran are national tourism spots that attract huge visitors annualy (Hadi *et al*. 2007).

Table 2. Type of food items of *Macaca fascicularis* in Telaga Warna

Food items	Percentage (%)
Natural food	60.1
Plants	56.0
Water (from lake)	2.7
Animals	0.9
Soil	0.3
Fungi	0.1
Artificial food	39.9
Food from human	22.9
Garbage	17.1

In Telaga Warna, the natural food consisted of plants, small animals (insects and earthworm), fungi and water from lake. The plant food comprised of 29 species plus a few mosses which is similar in number compare to plants consumed by the macaques in the East Kalimantan (33 plant species, Yeager 1996) and Cikakak (31 plant species, Hadi *et al*. 2007). This indicates that the home range of the macaques in these three sites is the same in terms of natural food item diversity. Table 3 provides list of plant items and parts (flowers, stems, fruits, and seeds) consumed by the macaques in Telaga Warna. In Telaga Warna, the most frequent diet of natural food was stalk of grass (*Axonopus compresus*). For the natural food items, the macaques in Cikakak were also observed to feed on leaves and seeds of grass (Hadi *et al*. 2007). The macaques in Mauritius ate fruits, leaves, flowers, stems, and insects; the fruit was the most important component of the diet (Sussman & Tattersall 1981). The ecological condition between Telaga Warna and Mauritius is different. The long-tailed macaques in lowland tropical rain forest in East Kalimantan are primarily frugivorous from January through May (Yeager 1996). On June to December, they turned to feed on

Table 3. Plant natural species and parts consumed by *Macaca fascicularis*

Family	Species	Local name	Part of plant	Location		Percentage (%)
				Nature reserve	Nature recreational park	
Poaceae	*Axonopus compresus*	Rumput teki	Stalks	v	v	36.0
Urticaceae	*Villebrunearubescens*	Nangsi	Flowers	v	v	21.7
Arecaceae	*Caryota mitis*	Sarai	Fruits		v	12.4
Fagaceae	*Lithocarpus sundaicus*	Pasang	Fruits	v	v	8.6
Actinidiaceae	*Saurauiadistasosa*	Ki leho badak	Flowers	v	v	4.8
Theaceae	*Schimawallichii*	Puspa	Flowers	v		4.7
Compositae	*Blumea lacera*	Bolostrok	Fruits	v	v	2.4
Staphyllaceae	*Turpinia sphaerocarpa*	Ki bangkong	Fruits	v	v	2.4
Moraceae	*Ficusribes*	Wallen	Fruits	v	v	1.6
Moraceae	*Ficusfistulosa*	Bisoro	Fruits	v		0.8
Loganiaceae	*Fagraea ceilanica*	Ki terong areuy	Fruits	v	v	0.6
Musaceae	*Musa acuminata*	Pisang hutan	Fruits	v		0.5
Moraceae	*Ficus* sp.	Amis mata	Fruits	v	v	0.4
Araliaceae	*Schefflera scandens*	Darangdan	Fruits	v		0.4
Euphorbiaceae	*Homalanthus populneus*	Kareumbi	Leaves	v		0.4
Elaeocarpaceae	*Sloaneasigun*	Beleketebe	Leaves	v	v	0.4
Urticaceae	*Poikilospermum suaveolens*	Ki kejoan	Flowers	v		0.3
Compositae	*Chromolaena odorata*	Ki rinyuh	Leaves	v	v	0.3
Polygonaceae	*Persicaria chinensis*	Katutungkul	Leaves	v		0.2
Urticaceae	*Laportea stimulans*	Pulus	Flowers	v	v	0.2
Solanaceae	*Datura metel*	Kecubung	Stems	v	v	0.2
Fagaceae	*Castaneaargentea*	Saninten	Fruits	v	v	0.2
Ericaceae	*Vaccinium korthalsii*	Kayu putih lembut	Fruits	v	v	0.1
Vitaceae	*Tetrastigma laevigatum*	Ki racun	Leaves	v		0.1
Myrtaceae	*Syzygium laxiflorum*	Kopoleutik	Flowers	v	v	0.1
Melastomaceae	*Clidemiaherta*	Harendong bulu	Fruits	v	v	0.1
Elaeocarpaceae	*Elaeocarpusfloribundus*	Ganitri	Fruits	v	v	0.1
Fagaceae	*Castaneajavanica*	Riyung anak	Leaves	v		0.1
Compositae	*Ageratum conyzoides*	Babadotan	Leaves	v	v	0.1

a combination of leaves, flowers, insects, and fruits. They appeared to be selective in their dietary choice (Yeager 1996). The macaques also spent much time beside the streams which flow through the study area, both to drink the water and to obtain aquatic food items (Sussman & Tattersall 1981). In Telaga Warna, the macaques only drank the water from the lake and were not observed to consume the aquatic food.

Table 4 showed that the most frequent manually given artificial diet were peanut (19.8%), banana (18.4%), and biscuit (5.0%). When the macaques stayed in the trash pots, they consumed more rice (11.6%) and peeled-skin banana (11.1%) compared to others, although the biggest proportion was uncategorized garbages (12.1%) (Table 5). Similar with Telaga Warna, the most frequent dietary artificial item of macaques in Ciung Wanara West Java (Yudanegara 2006) and Ubud Bali (Wheatley 1989) was peanut. The visitors could buy the peanut easily from vendors near the study sites. Peanuts are effectively handled, nutritious and enhance fat deposit which in turn affects the thermoregulation in cold temperature in high altitude (Tsuji & Takatsuki 2009). In contrast, the macaques in University Kebangsaan Malaysia, Selangor-Malaysia consumed leaves, fruits, bread, rice, carbonate drink, ice cream, and other food from garbage in the hostel area (Md-Zain *et al*. 2010).

The frequency of eating artificial food was influenced by visitors (Table 6). August 2012 was the fasting month for Moslem, when visitors came mostly in the afternoon waiting to break the fasting without bringing the picnic; they dine some where else. At the month, since morning to afternoon the

Table 4. Artificial food that manually given by human

Food items	Percentage (%)
Peanut	19.8
Banana	18.4
Biscuit	5.0
Chicki	4.1
Bread	2.0
Chips	1.7
Chocolate	0.8
Gemblong	0.8
Candy	0.8
Corn	0.5
Orange fruit	0.5
Kwaci	0.5
Manggo fruit	0.5
Cake	0.4
Melon fruit	0.2
Pineapple fruit	0.2
Jack fruit	0.2
Pear fruit	0.2
Strawberry	0.2
Banana cake	0.2
Cakwe	0.1
Dodol	0.1
Fried food	0.1
Ice cream	0.1
Sweet potato	0.1

Table 5. Artificial food which taken from trashes

Food items	Percentage (%)
Uncategorized garbage	12.1
Rice	11.6
Peeled-skin of banana	11.1
Bottled water	2.8
Vegetables	1.3
Noodle	1.2
Fried chicken	0.6
Peeled-skin of orange	0.5
Tea bag	0.4
Cotton	0.1
Peeled-skin of corn	0.1
Peeled-skin of nut	0.1
Butter	0.1
Satay	0.1

Table 6. Diet variation of long-tailed macaques on August, September, October, and November 2012

		August	September	October	November
Natural food items (%)	Plants	72.9	52.4	58.8	57.3
	Water (from lake)	4.2	2.8	2.9	2.2
	Animals	-	0.9	1.2	0.7
	Fungi	-	-	0.9	0.2
	Soil	-	-	0.3	-
Total		77.1	56.0	64.0	60.4
Artificial food items (%)	Food manually from visitors	12.5	27.9	21.1	16.3
	Food from trashes	10.4	16.0	14.9	23.3
Total		22.9	44.0	36.0	39.6
Number of visitors		2137*	1783	1526	1063
Frequency of rainfall (mm)**		14.3	1.21	269	810

*The huge number of visitors on August 2012 was becaused of the Idul Fitri festival on August 19th, 2012 which last for about one week. After fasting season before the festival, very view visitors visited daily. **The frequency of rainfall was taken from Stasiun Klimatologi Klas 1 Indonesian Meteorological, Climatological and Geophysical Agency (BMKG) Darmaga Bogor.

macaques stayed around the cliff and consumed more natural food. Proportion of natural food items taken at Ramadhan (77.1%) was much higher than other months (56, 64, and 60.4%), although not statistically significant (X^2 = 3.853, P = 0.278). This showed that they consumed less artificial food when it was scarce. This situation was reversed on September 2012 where we could see the increasing consumption of artificial food that manually given by the visitors. The frequency of consuming the manually artificial food decreased on October through November 2012 and it correlated with the increasing rainfall. Regression analyses of manually artificial food on rainfall gave negative slope (-0.005), although not statistically significant. The visitors brought picnics in the rainy days, but the macaques stayed on trees so visitors couldn't give it directly. The visitors discarded those remaining picnic to trash pots, and after rain the macaques consumed those food on the trash pots.

DISCUSSION

The macaques are ecologically plastic in taking any kind of foods available in their home range and adjust their behaviour according to its abundance. This plasticity can be seen in foraging behaviour and how the macaques get foods from visitors, in addition to the natural ones. Foraging behaviour is the activity of searching for, picking, manipulating, masticating, or placing food in mouth (Sueur *et al*. 2011). There are strategies in foraging activity that will depends on a variety of environmental factors, such as food quality, availability, and distribution; and physiological factors, such as rate of metabolism, digestive ability, and tolerance of starvation (Agetsuma 1995). Foraging on foods that have low energy content and dense distribution (for instance, mature leaves) will increase the macaques' feeding time, while foods which they must search intensively and widely distributed (fruits, seeds, insects, and fungi) will induce longer moving time (Agetsuma 1995). In Telaga Warna, the macaques spent much time in moving to seek fruits scattered in their home range. Fruits contain more energy and require less manipulation. By taking fruits, the macaques increase their energy intake as ambient temperature was low in their high altitude site. Beside moving, the macaques in Telaga Warna also spent much of their feeding time to feed on grass. Chivers and Langer (1994) explain that radiating from insectivorous ancestor, increasing body size of mammals allowed a more voluminous gut that able to ferment plant cell walls. This may be true of long-tailed macaques, so they may be able to digest the stalk. This may be thought of as an effort to get protein as the stalk of grass has low energy content. However, it is also possible that they ate the grass just as a choice out of 29 plant species of their dietary variation. On the other hand, the macaques did not feed on the mature leaves. It may be because the mature leaves contain digestion inhibitors for the macaques (Goldstein & Richard 1989).

The macaques in Telaga Warna are the major attraction to be watched and fed by tourists. The changing of dietary behaviour because of habituation to human can also be seen in Telaga Warna. In Ramadhan (August 2012), because of Moslem fasting season, there were less visitors and the visitors who came brought less picnics. Somehow the macaques were adapting to reduced abundance of food due to the particular human behaviour. On that month, the macaques stayed with consuming more natural food items. When the fasting season was over, the visitors come for picnic and the frequency of provisioning increased. In the next months, the proportion of consuming the artificial food was stable at about 40%. With recurrent provision, it seemed that the long-tailed macaques learned that the visiting of tourists is identical with food.It is also interesting to note that they changed their behaviour in getting food because of rain reduced the abundance of artificial food. The artificial food can be broadly categorized as those that manually given from human and those which taken from trash pots. The proportion of food directly taken from human was negatively correlated with the amount of rainfall. The greater the rainfall, the lesser they took the manually given artificial food. The macaques usually stayed on the trees when it was raining so the visitors couldn't feed the macaques manually. The visitors usually trashes the food to the pots. After rain, the macaques took the food from trashes. In sum, the amount of artificial food remain stable at 40%.

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