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Food Preference of Semi-Provisioned Macaques Based on Feeding Duration and Foraging Party Size

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The long-tailed macaques (*Macaca fascicularis*; also called crab-eating monkeys) have broad geographic distribution in continent and archipelago of Southeast Asia. They have wide ecological plasticity to adapt to various environments. Due to disturbance of habitat and intensive contact with human, long-tailed macaques change their feeding behavior. Here we present food preferences of long-tailed macaques that live in Cikakak Monkey Park in Central Java. By recording the number of individuals who fed on a food patch and the duration of eating the food, we found that proportion of their food from natural resources is greater than those from human sources. They shifted to omnivory feeding mode to adapt to the changing environment. At many times, this omnivorous feeding brought forth crop-raiding which were not in natural behavioral repertory. Conservation effort of long-tailed macaques, and primate in general, should consider the aspect of human-modulated behavior in feeding ecology if we wish to be successful.

Key words: feeding ecology, long-tailed macaques, Cikakak monkey park, party size, feeding duration, omnivorous

INTRODUCTION

The long-tailed macaques (*Macaca fascicularis*; also called crab-eating monkey) have broad geographic distribution covering southernmost Bangladesh, continent of Southeast Asia, Malayan Peninsula, Sunda Archipelago, Nicobar Islands, and the Philippines (Fooden 1995), but do not extend to Sulawesi Island because of restriction imposed by Wallace Line. They were suspected to be introduced into Lesser Sunda Archipelago, Kabaena Island, Angaur Island, and Mauritius (Kawamoto *et al*. 1988; Matsubayashi *et al*. 1992; Kondo *et al*. 1993; Morwood *et al*. 2004). They adapt to various habitats ranging from mangrove swamp forests (Hock & Sasekumar 1979) to lowland-dense-tropical forests, to sub-alpine forests, and also to places where humans live (Wheatley 1989). These facts indicate that they have wide ecological plasticity to adapt to various environments; indeed, they were regarded as "weed" species (Richard *et al.* 1989). This plasticity is reflected in differences in feeding ecology, reproduction parameters, sizes of group, and also home ranges of populations living in diverse environments.

Long-tailed macaques who live in forest with minimum frequency of contact with human tend to be frugivorous because 57-67% to the total of feeding items are fruits (Ungar 1994; Yeager 1996). In Kalimantan they were noted to consume 17 (Wheatly 1980) up to 24 (Yeager 1996) different fruiting plant species. In the teak forest at Cepu (Java Island) Hasanbahri *et al.* (1996) recorded that fruits were the most preferable to be chosen as the food. They are organized in small-sized groups with large home ranges to find food. In many places, due to disturbance of habitat and intensive contact with human, long-tailed macaques change their feeding behavior. They exploit any available food resources to become more omnivorous (Wheatley 1989). Their main dietary items are not only fruits but include flowers, leaves, seeds, insects, tubers and also take food from human. They are organized into big-sized groups with small home ranges and higher reproduction index (Wheatley 1989; Aggimarangsee 1992).

Most data of feeding ecology in genus *Macaca* came from Japanese macaque (*M. fuscata*). Inter-regional, inter-seasonal, and altitudinal variation of food choices in this species had been studied (Hanya *et al* 2003). Data of feeding ecology of Formosan rock macaques (*M. cyclopis*) had also been reported (Su & Lee 2001). There is no intensive research to supply data on feeding ecology of long-tailed macaques in Java Island, where for centuries most of the environments had been changed by human. In this island many of them live in remnant populations within habitats that provide food and sanctuary because of anthropomorphic reasons. These provisioned troops can be found in recreational areas and places where people considered them as sacred, such as religious complexes and cemeteries (see Aggimarangsee 1992 for Thailand and Wheatly 1989 for Bali). Almost all of the troops live in small areas with decreasing space for searching foods and it is suspected that they face higher individual competition because food sources tend to be concentrated. Few studies exist on the interaction of long-tailed macaques and human provisioning. However, to our knowledge, their feeding ecology in terms of feeding duration and foraging party size had not been documented. Here we present food preferences of long-tailed macaques that live in a Monkey Park in Central Java. When foraged for food, instead of all individuals entered a food patch, the troop formed a party with size that was restricted by particular food patch characteristics. The variable party size seemed to minimize

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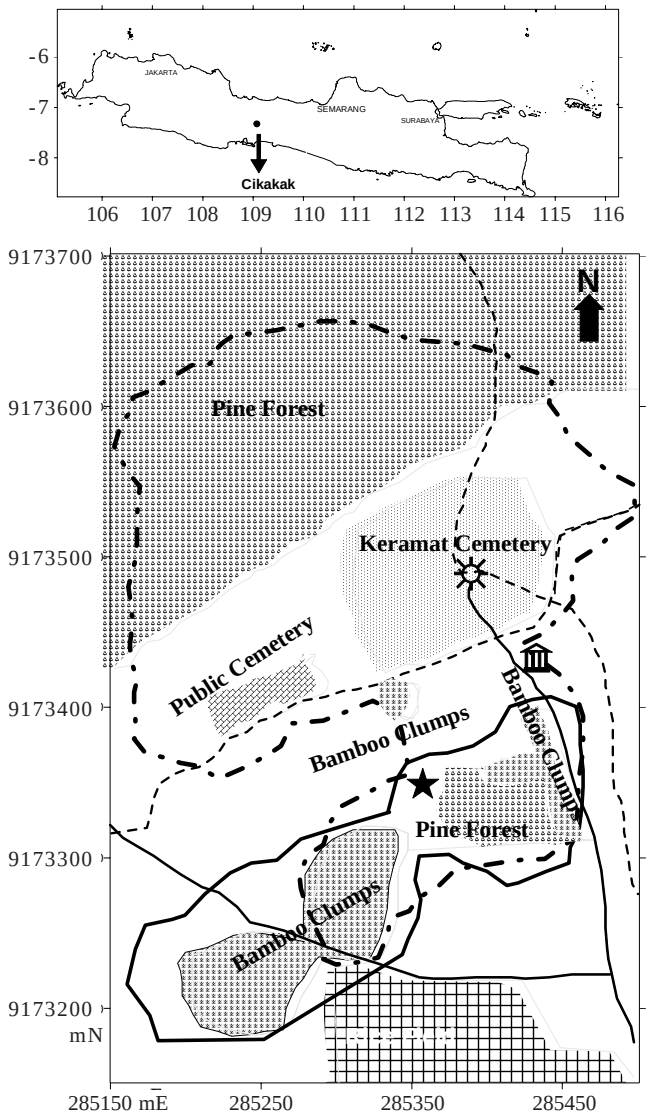
agonistics among individuals during foraging. By recording the number of individuals who fed on a food patch and the duration of eating the food, we found that proportion of food from natural resources is greater than those from human sources.

MATERIALS AND METHODS

Research Site and Subjects. This research was conducted in Cikakak Monkey Park, a part of Sub-district Wangon, District of Banyumas, Central Java Province, Indonesia (Figure 1). The study area lies on 9173400 mN to 9173550 mN and 285300 mE to 285450 mE, UTM coordinate system zone 48, based on map from National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL), Indonesia. This site was a remnant of primary forest that was surrounded by human settlements, farming fields, and pine forest. The forest was under the authority of Perum Perhutani Division I Central Java, a subsidiary forestry company under the Ministry of Forestry of Indonesia. The area was a special purpose land (lahan dengan tujuan istimewa, LDTI, Bhs. Indonesia) for conservation of long-tailed macaques and cultural heritage consisting of old cemetery called *keramat* and an old mosque called *Saka Tunggal* (single pole, Jv.) that was built in 1522 AD. Tourists come to visit the *keramat* and to see the monkey troop. The troop was provisioned by care takers of *keramat* and also got food from tourists.



Legends

Home range of G1 Home range of G2 Sleeping site of G1
Sleeping site of G2 Saka Tunggal Mosque Road River

Figure 1. Research location and home ranges of troops (G1 and G2) long-tailed macaques in Cikakak Monkey Park. The map was using UTM coordinate system zone 48. Each number in the edges of map represent position or coordinate in meters. mN: meter North, mE: meter East.

The research site encompassed 4.2 ha of LDTI with altitude 30-125 m above sea level and annual rainfall of 2810 mm. The highest rainfall occurs during mid-November to mid-December. A troop of long-tailed macaque inhabited this area. The troop consisted of 84 individuals based on the first incomplete census on September 2003. At the middle of November 2003, one adult male (M09) and four sub-adult males moved out from their troop and settled at the eastern part, 2.5 km from *keramat*. At the end of February 2004, the troop split into two which were named as G1 and G2. The second census was conducted in March 2004 revealed that G1 and G2 consisted of 66 and 27 individuals, respectively; during observation five infants were born but one of them was died. After the troop splitted, the observation was focused on G1 that remained in the home range of the original troop. Data was collected during September-November 2003 (September = 18, November = 18 days) and March-April 2004 (March = 16, April = 11 days) from 07:00-12:00 am and 02:00-05:30 pm daily.

Data Collection Method. Typically monkeys ate food as a troop. When the troop foraged for a food item, its activity was determined by characteristics of the food patch; that is, by the type or habitus of the source (tree, shrub, or herb), by the scattering of the food (e.g. peanuts in grass field) and by the abundance of the food (e.g. number of fruit in a tree). Sizes of the food patch restricted the number of individuals to enter the patch. Other members of the troop waited outside the patch until some individuals stopped to forage and/or moved to different patch, that is, to different food item. The fact that numbers of individual varied among periods and food items resemble to those proposed by Read (1987). By considering this fact, present report defined a feeding session as a foraging activity of the troop in a particular food patch at a certain time. Food preferences of the troop can empirically be described by knowing party sizes and feeding durations on different foods using the following method.

During a feeding session on a food item, the number of individuals n who fed on the food and the duration t of eating the food were recorded. On session x (x = 1 to m), feeding duration t_{ix} was measured from the time the first individual entered the food patch i (i =1 to k) and manipulated manually and/or orally part of the food item to the time when the last individual stopped to feed and/or leave the feeding site. Since the availabilities and duration of the availability among foods

are asynchronous, the feeding duration *T* of a particular food were accumulated for all sessions of an observation period (that was, month):

$$T_i = \sum_{x=1}^{m} t_i x$$

Individuals who formed a party in a food patch were shifted and overlapped among different sessions. Because size of the food patch restricted the maximum number of individuals to forage, for every session we took that maximum as the party size n_{ix} to represent the troop. Furthermore, to eliminate variability of the size of food patch variability present analysis averaged party size (N_i) across feeding sessions:

$$N_i = \frac{\sum_{x=1}^{m} n_i x}{m}$$

The foraging activity *P* on food item *i* was defined as proportion of food that was consumed by the troop in an observation period:

$$P_i = \frac{N_i T_i}{\sum_{i=1}^{m} N_i T_i} \times 100\%$$

The foraging activity P_i was the empirical preference of the troop to eat food *i*.

All food items, including natural and artificially provided foods, were recorded. Food items that were given manually by human or left-over of tourist meals were categorized as artificial food. Other foods that were available in the home range were defined as natural foods. The parts of food items eaten by each individual were also recorded. Plant specimens were identified in reference to Backer and van den Brink (1965) and Sudarnadi (1996). A specimen of plant was identified as *Microcos panniculata* at Herbarium Bogoriense, Research Center for Biology, Indonesian Institute of Sciences.

RESULTS

Observation on the troop of long-tailed macaque in Cikakak Monkey Park revealed 8686 minutes of feeding duration in 363 feeding sessions (Table 1). They were observed to feed on 32 natural and nine artificial food items (Tables 2 & 3). The items obtained from natural resources were furthermore categorized based on part eaten (fruits, leaves, seeds, flowers, tuber, *nira* (raw coconut sap) and insects) (Table 4). In total, the troop obtained 76.39% food from natural sources and 23.61% from human.

Proportion of food part eaten were significantly different each month (df = 6, P < 0.01, X^2 for September = 117.32, November = 171.48, March = 236.74, April = 234.49). Proportion of leaves and fruits eaten were not different significantly ($t_{0.05\,(2)}$, 6 = 0.47 n_1 = 4, n_2 = 4). Between source of food, natural source and human source also differ significantly each month (df = 1, p = 0.05, X^2 for September = 13.3, November = 56.49, March = 56.73, April = 172.45).

Long-tailed macaque in Cikakak spent much time to feed on leaves, especially young leaves of bamboo (*Gigantochloa apus*). They consumed fruits mainly from two tree species, sadang (*Corypha utan*) and bulu (*Ficus virens*). They were observed to feed on leaves and seeds of four species of grass. They were also observed to feed on young leaves and seeds of putri malu (*Mimosa pudica*).

Some individuals were recorded to eat imago of insects. They obtained it manually from the leaves and flowers of salam (*Syzygium polyanthum*) and matoa (*Pometia pinnata*). The troop obtained grasshoppers from grass field. Another method to be used to get small animals by some sub-adult males was moving stones by hand to search for termites and soil arthropods. They also consumed some caterpillars from leaves of coconut trees and salam. They were observed to raid corn (*Zea mays*) and cassava (*Manihot esculenta*) fields.

DISCUSSION

Foraging activity of long-tailed macaque troop was determined by food patch characteristics which restricted the maximum number of individuals to forage at one time. Obviously, α-male exerted dominant control to individuals who join the party. However, he could not be in full control all the time and general social domination influences who and with whom individuals eat together. These effectively segregated individuals in time with a function to minimize agonistics among individuals during foraging. Present research focused on this behavior and used the resulting party size as a unit in measuring food preference. As to what extend this approach was better than using individual as a unit in reflecting feeding ecology of macaques, further data remains to be obtained.

By recording feeding duration and foraging party size, present research found that most of the food of the troop of long-tailed macaques in Cikakak Monkey Park came from natural rather than from human resources. Even though this park is one of the popular recreational areas in Banyumas where many people come and give food to the macaques, the proportion of food they took from human is only a quarter of their total diet. It was in contrast with the long-tailed macaques who live in other provisioned areas. In Pangandaran Recreational Park, also in Java, long-tailed macaques spent their time to feed on the offering from human up to 52% of

Tabel 1. Details of feeding duration and feeding sessions during observation

Month of observation	Number of observation days	Number of feeding session	Feeding duration (minutes)	Number of daily food item (average, min, max)
Sep	18	129	2489	6.9, 3, 11
Nov	18	102	3081	5.9, 2, 12
Mar	16	78	2014	5.7, 1, 11
Apr	11	54	1102	4.9, 2, 9

Table 2. List of natural items that were eaten by long-tailed macaques in Cikakak Monkey Park

Food item (species)	Vernacular name	Family	Part eaten	Proportion (%)				Maximum Party Size
				Sep	Nov	Mar	Apr	
Gigantochloa apus	bambu tali	Poa	YL	3.42	12.37	57.54	50.78	19
Corypha utan	sadang	Pal	FR	23.85	24.61	0	0.25	11
Arenga obtusifolia	langkap	Pal	FR	4.22	0.07	0.50	0	7
A. pinnata	kawung	Pal	FR	0.16	0.01	0	0	2
Leucaena leucocephala	kemlandingan	Leg	ML	0.38	0.03	0	0	3
Centrosema pubescens	bunga kupu-kupu	Leg	ML	0.28	0.31	0.02	0.03	10
Musa sp.	pisang	Mus	YL	0.51	0.05	0	0	4
Musa sp.	pisang	Mus	FR	0.31	0.06	0	0	3
Mimosa pudica	putri malu	Leg	YL	17.89	0	0	0	21
M. pudica	putri malu	Leg	S	0	0	1.16	0	9
Ficus benjamina	beringin	Mor	YL	5.50	0.14	0	0	8
F. benjamina	beringin	Mor	FR	2.35	0	0.60	0	7
F. virens	bulu	Mor	FR	0	28.84	17.00	6.32	13
F. racemosa	lo	Mor	YL	0	0	1.73	0	3
Lantana camara	telekan	Ver	FL	0.03	0.05	0.02	0	8
Paraserianthes falcataria	jeungjing	Leg	S	0.54	0	0	0	8
Manihot esculenta	singkong	Eup	TB	4.71	4.21	1.70	0.08	12
Ananas comosus	nanas	Brom	FR	0.32	0	0	0	5
Zea mays	jagung	Poa	S	0.48	0	0	0	6
Digitaria ciliaris	genjoran	Cyp	ML	0.38	2.16	0.38	0.03	12
Cyperus monocephalus	teki	Cyp	S	0.62	0	0.03	0	30
C. elatus	teki	Cyp	S	0.53	5.87	0.03	0.03	30
Aneilema sp.	petungan	Com	ML	0	0	0.02	0	30
Acacia auriculiformis	akasia	Leg	S	0.72	0	0	3.10	11
Solanum americanum	leunca	Sol	FR	0	0	0	0	12
Curcuma xanthoriza	kunyit	Zin	YL	0	0.23	0	1.10	3
Psychotria viridiflora	kikores	Til	FR	0	0	0.02	0.64	3
Cocos nucifera	kelapa	Pal	N	0	0.07	2.25	0	2
Micrococos panniculata	-	Til	FR	0	0	0.72	0	4
Syzygium polyanthum	salam	Myr	FL	0	0	0	1.46	6
Mangifera indica	mangga	Ana	FL	0	0	0	0.43	2
Insect	serangga		B	1.07	8.16	1.62	0.41	10
Totals				68.27	87.24	85.34	64.66	

Ana = Anacardiaceae Poa = Poaceae/Gramineae, Pal = Palmae/Arecaceae, Leg = Leguminosae, Mus = Musaceae, Mor = Moraceae, Eup = Euphorbiaceae, Brom = Bromeliaceae, Ver = Verbenaceae, Cyp = Cyperaceae, Com = Commelinaceae, Zin = Zingiberaceae, Myr = Myrtaceae, Til = Tiliaceae, Sol = Solanaceae, YL = young leaf, ML = mature leaf, FR = fruit, S = seed, FL = flower, N = Nira (raw coconut sap), B = body, Sep = September 2003, Nov = November 2003, Mar = March 2004, Apr = April 2004

Table 3. List of artificial food that were eaten by long-tailed macaques in Cikakak Monkey Park

Food item	Proportion (%)				Maximum party size
	Sep	Nov	Mar	Apr	
Pisang (banana)	0	0	0.11	1.36	6
Kacang (peanut)	11.76	4.25	6.46	23.56	20
Ubi jalar (sweet potato)	6.84	1.05	0	5.43	31
Nasi (cooked rice)	13.13	0	0.64	0	5
Gabah (raw rice)	0	0	7.39	0.87	16
Jambu	0	5.87	0	0	2
Kelapa (coconut)	0	1.59	0	0	5
Kripik Pisang (banana crispy)	0	0	0	3.83	8
Bengkuang	0	0	0	0.29	5
Totals	31.73	12.76	14.6	35.34	

Tabel 4. Part eaten of natural food by long-tailed macaques in Cikakak Monkey Park

Food item	Proportion (%)				Maximum party size
	Sep	Nov	Mar	Apr	
Leaf (mature + young leaf)	28.36	15.29	59.69	51.94	38.82
Fruit	31.21	53.59	18.84	7.21	27.71
Seed	2.89	5.87	1.22	3.13	3.28
Flower	0.03	0.05	0.02	1.89	0.50
Tuber	4.71	4.21	1.70	0.08	2.68
Nira (raw coconut sap)	0	0.07	2.25	0	0.58
Insect	1.07	8.16	1.68	0.41	2.83
Totals	68.27	87.24	85.40	64.66	76.40

their feeding time (Hadi, unpublised data). In temple of Ubud, Bali, based on individual observation, long-tailed macaques also obtained food from human up to 58% of their total diet (Wheatley 1989). Irrespective of differences in methodology, in comparison, long-tailed macaques in Cikakak got human-provisioned food that amounting to only half of that given to Pangandaran and Ubud populations. Wheatley (1989) noted that the provisioning in Ubud increased of number of human-provisioned food due to the increasing visit of tourists in the decade of 1980s; the same case can also be said to Pangandaran. It is possible that the difference in provisioning between Cikakak with Ubud and Pangandaran relates to the difference in the frequency of visit and economics of tourism. Cikakak is a local tourism spot which is small compared to national tourism spots of Ubud and Pangandaran that attract huge visitors annualy. It can be said that, despite the provisioning, long-tailed macaques in Cikakak were not dependent to human; they were semi-provisioned.

In secondary forest in Kalimantan, Yeager (1996) observed non-provisioned troop of long-tailed macaques. These troops had no contact with human and depended on the food from

natural resources. The macaques were primarily frugivorous with 66.7% of their food were fruits. Hasanbahri *et al*. (1996) reported that in teak forest, which was poor in fruit trees since the forest was of monocultural type, diet of long-tailed macaques was also dominated by fruits from fig trees (*Ficus* spp.). In Cikakak, long-tailed macaques exploited all categories of food items both from natural and human supplies. In the months when fruits were available they preferably took them. Two species of trees provide fruits which were high in preference to long-tailed macaque. They were sadang (*C. utan*: Arecaceae/Palmae) and bulu (*F. virens*:Moraceae). The first fruit was available from July to November and the second was from November to July. Even though this area was poor in fruit trees, long-tailed macaques could obtain fruit continuously along the year from those two species. However, while in months when fruits were rare (in March and April during the study period) young leaves of bamboo were the chosen food. It seemed that they shifted their frugivory to omnivory feeding to be adapted to the changing environment. This omnivorous behavior had also been noted in Ubud (Wheatley 1989) where monkeys have been in interaction with human for centuries.

It is the omnivorous feeding characteristic of long-tailed macaques that potentially bring forth conflict with human. Instead of searching fruit trees with comparatively small food patches, they raid crop fields which contained more calories with secure availability. Present research documented this behavior which was also reported in many places (e.g. Nicobar Island, Das & Ghosal 1977; Bali, Wheatley 1989; Lombok, Hadi 2005). Wheatley (1989) described some behavior in crop-raiding, e.g. cassava root pulling and potato washing, which are not in natural behavioral repertory. Conservation effort of long-tailed macaques, and primate in general, should consider the aspect human-modulated behavior in feeding ecology if we wish to success.

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