Original Research Article

Folia Primatol 2018;89:347–356
DOI: 10.1159/000491790

Received: January 4, 2018
Accepted after revision: July 1, 2018
Published online: September 11, 2018

Effect of Provisioning on the Temporal Variation in the Activity Budget of Urban Long-Tailed Macaques (*Macaca fascicularis*) in West Sumatra, Indonesia

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Keywords
Provisioning · Time budget · Activity pattern · Long-tailed macaque

Abstract

We studied the behavioral ecology of provisioned long-tailed macaques (*Macaca fascicularis*) in Padang, West Sumatra, Indonesia, to examine how temporal changes in food provisioning within a day affect macaque activity. We conducted a field survey from October 2015 to January 2016 at two different sites: Gunung Meru (GM) and Gunung Padang (GP), where macaques receive high and low provisioning, respectively. The time budgets of macaques significantly differed between study groups. At GM, macaques spent more time resting, feeding, acting out agonistic behaviors, and less time moving and searching for food, than the macaques at GP. Diurnal activity patterns significantly changed within a day. The short-term change in activity of the macaques was closely related to the number of tourists: they spent a greater time feeding and searching when more tourists came to feed the monkeys, while time for grooming decreased. Our result showed that the ability of the macaques to adjust their activity in response to the number of tourists (that is, provisioning patterns) indicated their behavioral flexibility. Our result may aid the management strategies to reduce human-macaque conflicts, which has become a major problem in Padang.

Introduction

Food availability and its distribution are the main determinants of time budgets and activity patterns of animals [Leighton and Leighton, 1983; Goodson et al., 1991]. In natural habitats, the availability of food and its distribution are subject to seasonal variation [Ganguly et al., 1964; Ding and Zhao, 2004; Riley, 2007]. Therefore, pri-

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mates regulate their activities according to seasonal changes in food availability [Ménard and Vallet, 1997; Hanya, 2004; Riley, 2007]. In human-altered environments, the influence of seasonality on primate activity is reduced in the presence of human foods [Fa, 1986; El Alami and Chait, 2012; Sha and Hanya, 2013b]. Provisioned food, garbage, and agricultural products are the major food sources for primates living in human-altered environments [Saj et al., 1999; Unwin and Smith, 2010; Fuentes et al., 2011; Malaivijitnond et al., 2011; Sha and Hanya 2013a]. Provisioned food resources tend to be high-calorie, easily digestible, spatiotemporally predictable and available in greater proportions than natural resources [Muruthi et al., 1991; Wong, 1994; Saj et al., 1999].

Previous studies have reported that provisioned primates often regulate their time budgets and activity patterns in response to seasonal food provisioning [Saj et al., 1999; Chauhan and Pirta, 2010; Sussman et al., 2011; Jaman and Huffman, 2013]. For example, bearded capuchin monkeys (*Cebus libidinosus*) in Brazil spent less time searching and moving during periods of high provisioning [Sabbatini et al., 2008]. The home range size and daily path lengths tend to be smaller and shorter during the provisioning period [Altmann and Muruthi, 1988; Forthman-Quick and Demment, 1988; Saj et al., 1999; Unwin and Smith, 2010]. Provisioning may also heighten competition with conspecifics (between and within the groups) over food, because foods provided by tourists are concentrated in a particular area [Ram et al., 2003; Hsu et al., 2009; Sussman et al., 2011].

The behavioral changes that occur in response to seasonal food provisioning have been well investigated [Chauhan and Pirta, 2010; Sussman et al., 2011; Jaman and Huffman, 2013]. However, temporal changes in provisioning can also vary within a day [Ram et al., 2003], because the number of tourists and amount of provisioning foods may differ at different times of the day. Only a few studies have investigated this point. For example, Boug et al. [1994] pointed out that regularly provisioned hamadryas baboons (*Papio hamadryas*) in Al-Hada, Saudi Arabia, spent more time feeding in the evening when large numbers of tourists visited the site, while they spent more time resting and grooming in the morning and afternoon when small numbers of tourists were present. A further example is provided by O'Leary and Fa [1993], where Barbary macaques (*Macaca sylvanus*) in Gibraltar spend more time feeding in the morning and evening, which coincided with large numbers of tourist visitations and often caused intragroup agonistic interactions, while they spent more time being sedentary during the afternoon, when fewer tourists were present.

Flexibility in time budgets is an important aspect of primates' ability to survive in varying environments. Many primates close to humans systematically consume anthropogenic foods including garbage, offerings, and food provisioned by local people and tourists [Asquith, 1989; Wheatley et al., 1996; Fuentes et al., 2011; Malaivijitnond et al., 2011; Aggimarangsee, 2013]. The inclusion of human food in the diet can have significant effects on activity budgets [Brennan et al., 1985; Fa, 1986; Altmann and Muruthi, 1988; O'Leary and Fa, 1993; Saj et al., 1999; El Alami et al., 2012; Sha and Hanya, 2013a]. Several studies have shown that the amount of provisioned food availability is proportional to the number of tourists [Ram et al., 2003; Ilham et al., 2017].

In this study, we examined short-term variation in provisioning on the time budget and activity patterns of free-ranging long-tailed macaques (*Macaca fascicularis*) in Padang, West Sumatra, Indonesia. Food provisioning has become a popular tour-

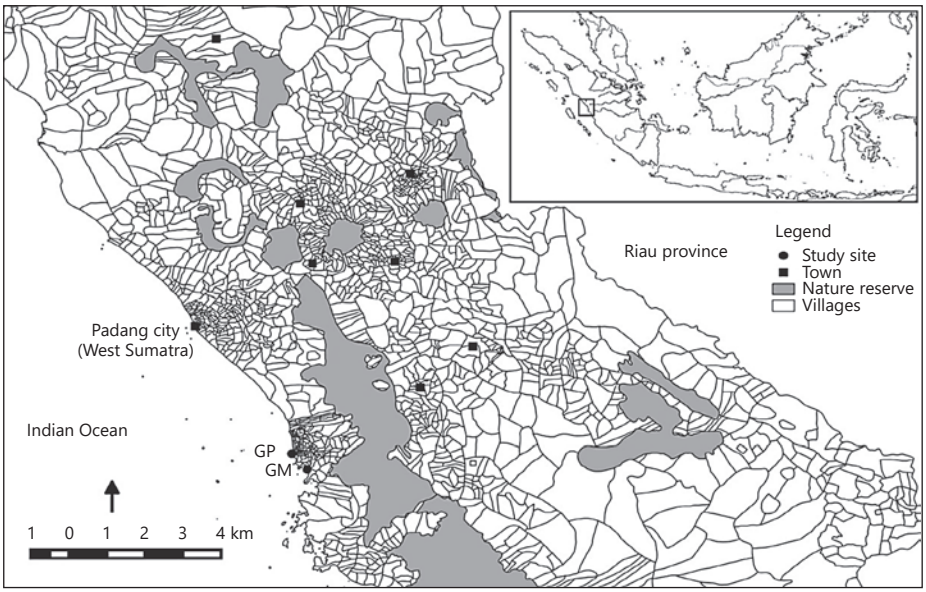

Fig. 1. Map of the study sites. GM, Gunung Meru; GP, Gunung Padang.

ist attraction in Padang [Ilham et al., 2017]; however, it is causing the macaques to invade human settlements and seek out human foods [Ilham, pers. observation]. To investigate the potential effects of temporal change in tourist activity, we compared the daily activity of macaques at two sites where the degree of provisioning differs. We predicted that highly provisioned animals would adjust their activities in response to temporal variation in the number of tourists within a day. Understanding short-term variation in the behavioral responses of macaques to tourist activity is useful to create an effective management strategy for reducing human-macaque conflicts.

Materials and Methods

Study Site

Our study was conducted at two sites: Gunung Meru (hereafter: GM, 01°00'24.75" S and 100°23'14.0" E) and Gunung Padang (hereafter: GP, 0°57'56.76.6" S and 100°20'56.5" E), Padang City, West Sumatra, Indonesia (Fig. 1). The two sites are located in hilly mountains with an altitude range of 76–200 m above sea level. Maximum temperature (32.3–33.9 °C), minimum temperature (23.3–24.0 °C), and monthly rainfall (104–510 mm) were stable during the study [www.accuweather.com, accessed on February 7, 2016]. Each site encompasses approximately 2 ha of secondary forest surrounded by roads, human settlements and traditional farms. The dominant plants were common at both sites: *Ficus elastica*, *F. benjamina* (Moraceae), *Alstonia scholaris* (Apocynaceae), *Arenga obtusifolia* (Arecaceae), *Eurya acuminata* (Theaceae), *Cocos nucifera* (Arecaceae), and *Mangifera indica* (Anacardiaceae), but a detailed vegetation survey of these sites has not been conducted.

The macaques at GM totaled 132 animals in 3 groups (A, B, and C) and were intensively fed by tourists and local people, and they consumed large quantities of human foods (70% of feeding time spent on provisioned food), while macaques at GP (15 animals in 1 group, named X) depend less on human foods (<5% of feeding time spent on provisioned food) [Ilham et al., 2017]. At GM, tourists tended to feed the macaques mostly at the provisioning ground (western part of the GM) which is inside the home range of the C group. At GP, tourists feed the monkeys mostly at the mountain top.

Macaque Activity and Tourist Abundance

Our subjects were the C group (68 animals) at GM and the X group (15 animals) at GP. We were able to make observations at distances of <2 m, as the individuals are habituated to human presence. We collected data on macaque activities at GM from October 20, 2015, to December 6, 2015 (observation time: 30 days or 370 h), and at GP from December 7, 2015, to January 17, 2016 (30 days or 308 h). We observed the macaques on 6 days a week and followed them from dawn to dusk (06:00–17:00). We conducted 5-min instantaneous scan sampling with 15-min intervals [Altmann, 1974] and recorded the activity of visible animals. We omitted infants from recording because they were dependent on their mothers. Based on previous studies [El Alami et al., 2012; Sha and Hanya, 2013a], we categorized activities into six groups: (1) feeding, defined as processing and ingesting food into the mouth, followed by chewing and swallowing without storing the food in the cheek pouches, (2) food searching, defined as movement pattern for finding foods, (3) moving, defined as movement activity (such as walking, running, jumping, and climbing) that was not followed by searching or feeding, (4) resting, such as sleeping, sitting, standing, or lying, (5) agonistic behavior, including branch shaking, baring of the teeth, threat posture with shoulders positioned forward and upright, and active chasing, and (6) grooming, defined as picking out debris and ectoparasites using fingers and mouth.

In parallel, we recorded the number of tourists (without distinguishing age-gender classes) present along the roadside and provisioning ground every 15 min. At the famous monkey tourist site, the GM macaques were provisioned daily along the roadside and at the provisioning ground, while provisioning at GP is more opportunistic. Tourists dropped food on the pavements or threw food out of their car windows or handed it out. The provisioned food mainly consisted of boiled peanuts, roasted peanuts, bread, snacks, and vegetables [Ilham et al., 2017].

Statistical Analyses

We first analyzed the differences in activity budgets of the macaques between the two sites using Mann-Whitney U tests. Secondly, to test the effect of the time of day (morning: 06:00–10:00; afternoon: 10:00–14:00; evening: 14:00–17:00), sites (GM and GP), and their interaction with the number of tourists, we conducted generalized linear models, in which the error structure was assumed to follow the Poisson distribution. Finally, to test effects of the number of tourists and the time of day on the macaque activity (in terms of number of scanned animals in target activity at a given time of day), we conducted generalized linear mixed model in which the error structure was assumed to follow the Poisson distribution. In these analyses, we set study site as a random factor, and total number of scanned animals at a given time of day as an offset term. Statistical analyses were performed using R version 3.2.3 [R Development Core Team, 2016], and statistical significance levels (α) were set at 0.05.

Results

Activity Budgets

We recorded 9,356 animals through 1,005 scans at GM and 8,003 animals through 901 scans at GP. The activity budgets of the macaques were significantly different at the two sites (Fig. 2). Macaques at GM spent more time resting (mean value: 29% at GM, 17% at GP; Mann-Whitney U test, $U = 887$, $p < 0.001$), feeding (GM: 27%,

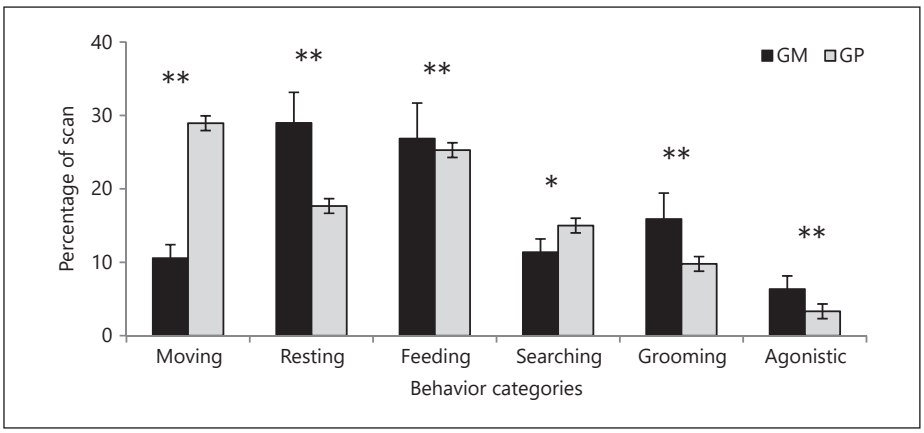

Fig. 2. Mean (±SD) percentage of activity of the long-tailed macaques at GM (black bars) and GP (gray bars). Asterisks represent significant differences between sites (** $p < 0.01$, * $p < 0.05$). n = 30 observation days at each site.

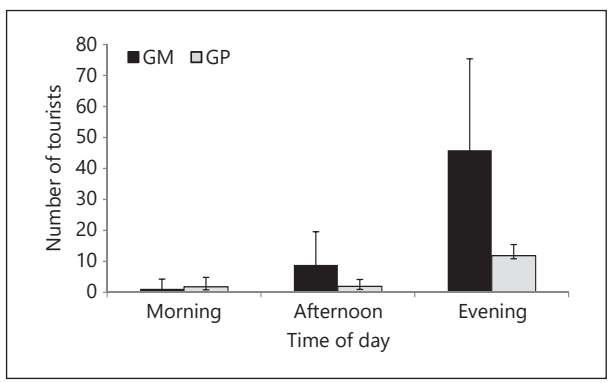

Fig. 3. Mean (±SD) daily number of tourists at GM (black bars) and GP (gray bars) in the morning (06:00–10.00), afternoon (10:00–14:00), and evening (14:00–17:00). n = 30 observation days at each site.

GP: 25%; U = 636, $p = 0.006$), grooming (GM: 15%, GP: 9%; U = 845, $p < 0.001$), and being agonistic (GM: 6.3%, GP: 3.3%; U = 851, $p < 0.001$). Macaques at GP spent more time moving (GM: 10.5%, GP: 29%; U = 900, $p < 0.001$) and searching (GM: 11%, GP: 15%; U = 378, $p = 0.042$).

Visitor Presence and Macaque Activity Pattern

The total number of visitors at GM and GP during the study period was 1,675 (mean ± SD, 55.8 ± 38.9/day) and 467 (15.6 ± 4.4/day), respectively. At GM, visitor numbers were low in the morning (1.1 ± 3.0/day), increased in the afternoon (26.5 ± 10.7/day), and peaked in the evening (45.6 ± 29.5/day). At GP, the number of visitors was low throughout the day (5.4 ± 3.0, 5.8 ± 2.2, and 11.8 ± 3.6/day in the morning, evening, and evening, respectively). The time of day (z = 17.42, $p < 0.001$), site (z = 0.91, $p = 0.362$), and site × time interactions (z = –5.94, $p < 0.001$) significantly affected the number of tourists (Fig. 3).

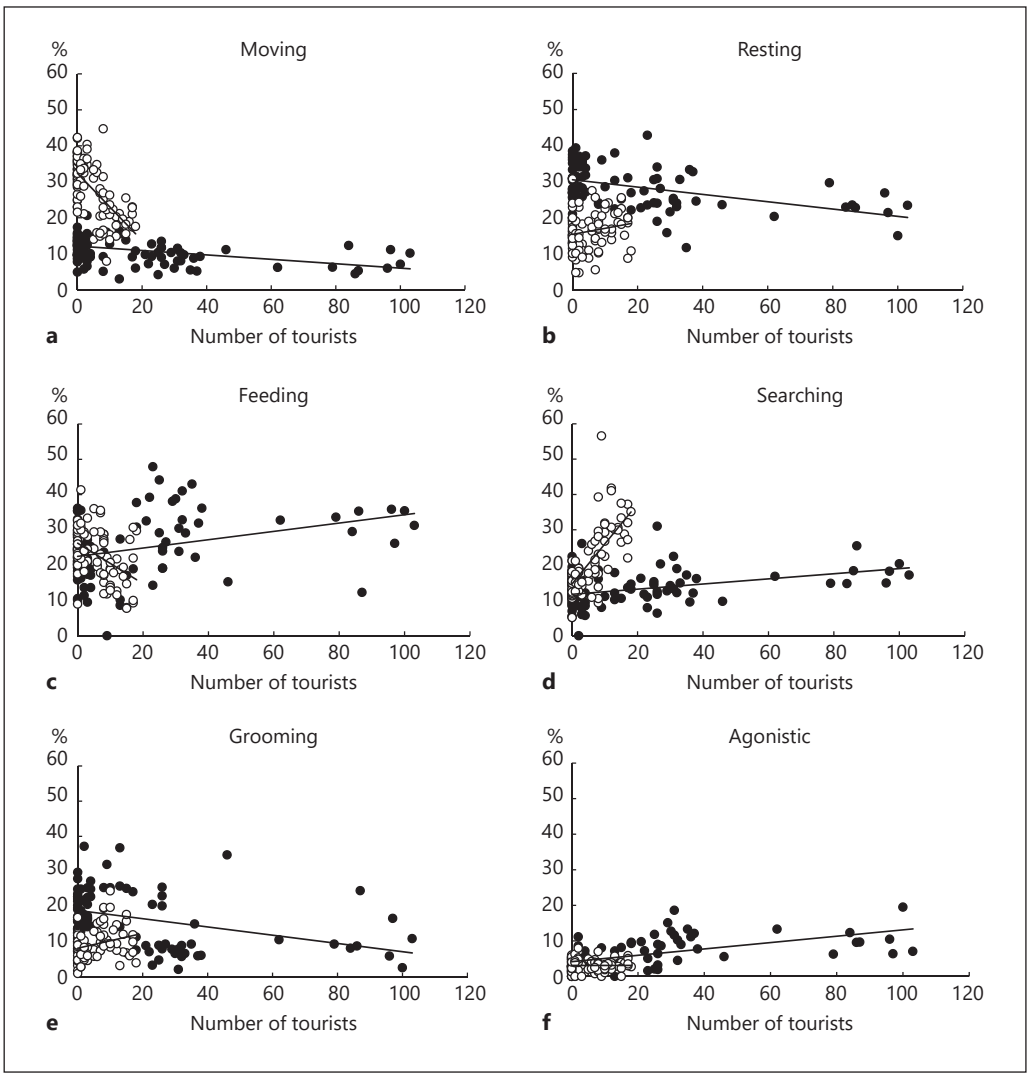

Fig. 4. The relationship between number of tourists and activity (%) at GM (filled circles) and GP (open circles). Each circle represents a time of day (n = 90). **a** Moving. **b** Resting. **c** Feeding. **d** Searching. **e** Grooming. **f** Agonistic behavior. Regression lines are also shown.

The relationships between number of tourists and activity budgets for each group are shown in Figure 4. The macaques spent a greater time feeding (generalized linear mixed model; $t = -3.24$, $p < 0.001$) and searching ($t = -2.10$, $p = 0.036$) when more tourists came, while time grooming decreased ($t = 4.24$, $p < 0.001$). Tourist numbers had no detectable effect on other activities (moving: $t = 1.26$, $p = 0.209$; resting: $t = -0.65$, $p = 0.519$; agonistic behavior: $t = 0.82$, $p = 0.414$). Furthermore, there were no significant effects of group-tourist interactions ($p > 0.05$).

Discussion

The activities of the macaques at GM were characterized by more time spent resting and feeding and less time spent moving and searching than the macaques at GP (Fig. 1). The most likely reason for these differences is the varying degrees of provisioning that exist at the two sites. As the popular monkey tourist site in Padang, tourists and local people fed the macaque at GM daily for pleasure and religious purposes [Koyama, 1984; Ilham et al., 2017]. As a result, provisioning foods are available throughout the year, resulting in macaques waiting rather than searching for their own resources, which indirectly elongated the time spent in resting. The macaques at GP (accidentally provisioned), on the other hand, had to move and search more to obtain their own natural food (e.g., fruits and leaves), which reduced the time for resting and other activities. This was consistent with previous studies, which reported that provisioned primates tend to spend less time moving and searching and more time resting [Marriot, 1988; Ménard and Vallet, 1997; Kogenezawa and Imaki, 1999; El Alami et al., 2012; Jaman and Huffman, 2013].

In this study, the GM macaques spent more time feeding than GP macaques. Most studies of provisioned primates have shown a decrease in time spent feeding associated with provisioning [Brennan et al., 1985; Altmann and Muruthi, 1988; Marriot, 1988; Saj et al., 1999; El Alami et al., 2012]. However, this is not always the case, because provisioned primates have also been shown to spend more time feeding as they have access to natural food resources [Boug et al., 1994; Kogenezawa and Imaki, 1999; Ram et al., 2003; Sabbatini et al., 2008; Ilham et al., 2017]. For example, Sha and Hanya [2013a] found that a group of long-tailed macaques that consumed more anthropogenic food, but also ate natural foods, spent more time feeding than a neighboring one that ate less human-derived food. We speculate that this was the case for our study. We speculate that this was the case for our study.

In this study, we found that macaques at GM invested more time grooming (15%) than macaques at GP (9%). Other studies have also reported that provisioned primates tend to spend more time grooming than their wild-feeding counterparts [Marriott, 1988; Saj et al., 1999; Strum, 2010; Jaman and Huffman, 2013]. Since provisioned food is usually more spatially clumped, more predictable and detectable, provisioned monkeys do not have to invest in searching effort, and extra time might be spent as "reserve" time [Dunbar, 1991; Kamal et al., 1997]. However, a cost related to food provisioning is the increased amount of intragroup competition [Kamal et al., 1997; Hill, 1999; Sinha et al., 2005; Hsu et al., 2009].

In this study we found that macaques at GM showed agonistic behavior more frequently than those at GP. One of the likely reasons is their larger group size [Kamal et al., 1997; Ram et al., 2003; Brotcorne, 2009]. A second reason is the amount and clumped distribution of provisioned foods [Hill, 1999; El Alami et al., 2012; Jaman and Huffman, 2013]. The effect of provisioning on the intensity of aggression has been reported in other primates (chimpanzee, *Pan troglodytes* [Wrangham, 1974], Barbary macaques, *Macaca sylvanus* [El Alami et al., 2012], long-tailed macaques, *Macaca fascicularis* [Wheatley and Putra, 1994], and rhesus macaque, *Macaca mulatta* [Ciani, 1986]), and the intensity of the agonistic behavior is caused by distribution of the provisioned foods. Since provisioning at GM is mainly done at the provisioning ground, the above scenario could be applied to our monkeys.

The diurnal activity of macaques varied between sites and time of day in our study. The most likely reason of the latter variation is temporal change in the number of tour-

ists. We found that macaques spent more time feeding and searching and less time grooming when the number of tourists increased. For other activities we found no significant relationship with number of tourists (that is, the time spent on these activities was stable throughout the day). In the highly provisioned site, the amount of provisioned food is proportional to the number of tourists [Brotcorne, 2009; Fuentes et al., 2011]. Under this condition, as their foraging strategy, the macaques increase the time they spend searching for and eating the food [Ménard and Vallet, 1997; Sha and Hanya, 2013a]. At GM, more than 1,000 tourists visit in a month, and they give approximately 520 kg of provisioned food a month, whereas the corresponding value at GP was only about 48 kg a month [Ilham et al., 2017]. Through long-term provisioning, the macaques at GM might have experienced how to distribute their foraging efforts across a day. O'Leary and Fa [1993] described the same behavior in the provisioned Barbary macaques (*M. sylvanus*) in Gibraltar: the monkeys spent more time feeding in the morning and evening when many tourists were present, while resting and grooming peaked in the afternoon, when fewer tourists were present [O'Leary and Fa, 1993]. A similar feeding pattern has also been reported in Assamese macaques (*Macaca assamensis*) at Tham Pla Temple, Chaing Rai Province, Northern Thailand: the macaques spent more time feeding in the morning when most tourists visit the temple than in the evening [Kaewpanus et al., 2015]. Our data supported the prediction that macaques habituated to provisioned food and adjusted their activity based on the number of tourists across the day.

The ability of the macaques to adjust their activity across a day indicates that they are able to respond flexibly and rapidly to changes in the food environment. Understanding temporal variation in primate activity in response to the visitation patterns of tourists provides important information to create effective management strategies to reduce human-macaque conflicts, which has become a major problem in Padang. Concerning the effects of provisioning on macaque behavior, a potential solution to this issue is to reduce and/or control provisioning through initiatives led by the local government. In addition, educating visitors and local people on how provisioning affects macaque behavior and ecology is required to relieve human-macaque conflicts. Fundamental studies of urban macaques in Padang are still lacking. Continuous monitoring of macaque behavior would provide the scientific data required to facilitate the long-term management of provisioning sites in Padang.

Acknowledgments

We thank the local people of Gunung Meru and Gunung Padang for their cooperation and for providing accommodation during the fieldwork. This study was supported financially by the Cooperative Research Fund, Primate Research Institute, Kyoto University.

Statement of Ethics

This research was noninvasive and abided by the legal requirements in the Republic of Indonesia.

Disclosure Statement

The authors declare no conflicts of interest.

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