

## RESEARCH ARTICLE

Differences in Activity Budgets and Diet Between Semiprovisioned and Wild-Feeding Groups of the Endangered Barbary Macaque (*Macaca sylvanus*) in the Central High Atlas Mountains, MoroccoABDERRAZAK EL ALAMI<sup>1\*</sup>, ELS VAN LAVIEREN<sup>2</sup>, ABOUFATIMA RACHIDA<sup>3</sup>, AND ABDERRAHMAN CHAIT<sup>1</sup><sup>1</sup>Laboratory of Pharmacology, Neurobiology and Behavior, Faculty of Sciences, Semlalia, University of Caddy Ayyad, Rue de Prince Moulay Abdellah, Marrakech, Morocco<sup>2</sup>Moroccan Primate Conservation Foundation, Amsterdam, The Netherlands<sup>3</sup>Laboratory of Bioengineering, Faculty of Sciences and Technology, University of Sultan Moulay Slimane, Beni Mellal, Morocco

The Barbary macaque, *Macaca sylvanus* is a very adaptable primate species occupying a wide range of habitats in Morocco and Algeria. Several groups of this endangered macaque can be found in tourist sites, where they are affected by the presence of visitors providing food to them. We compare the activity budgets and the diet of semiprovisioned and wild-feeding groups of Barbary macaques in the central High Atlas Mountains of Morocco from February to August 2008. We used instantaneous scan sampling at 15-min intervals. The behaviors included in the activity budget were feeding, moving, foraging, resting, and aggressive display. Food items were grouped into seven categories. We found no differences between the two groups in the daily percentages of records attributed to feeding. The semiprovisioned group spent significantly more time engaged in resting and aggressive behavior, and foraged and moved significantly less than the wild-feeding group. There was no significant difference between the two groups in time spent eating leaves, fruits, or roots and bark. The semiprovisioned group, however, spent significantly less time per day feeding on herbs, seeds, and acorns than the wild-feeding group. Human food accounted for 26% of the daily feeding records for the semiprovisioned group and 1% for the wild-feeding group. Our findings agree with previous studies and indicate that in the tourist site, where food is highly clumped, macaques decreased foraging time yet showed higher levels of contest competition. Our results support the common claim that the diet of the Barbary macaque is highly flexible, differing among its varied habitats. Conservation efforts for the Barbary macaques should take into account the changes in behavior that human-modified environments may cause. *Am. J. Primatol.* 74:210–216, 2012. © 2012 Wiley Periodicals, Inc.

**Key words:** activity budget; conservation; diet; human food; *Macaca sylvanus*

## INTRODUCTION

In nonhuman primates, plasticity in activity budgets and diet is a key factor for surviving in varied or changing environments. Increasing human population pressure and decreasing natural resources have enhanced opportunities for contact between humans and monkeys, and there are now increasingly many situations in which monkeys have access to human food [Kamal et al., 1995; Saj et al., 1999]. Human food, such as cultivated plants and garbage, can become part of the diet [Lee et al., 1986; Richard et al., 1989], and in a few situations nonhuman primates have become dependent on humans for survival [Strum, 1994]. The inclusion of human food in the diet can have significant effects on activity budgets [Brennan et al., 1985; Fa, 1986; Lee et al., 1986; Altmann & Muruthi, 1988; Forthman-Quick & Demment, 1988; Lee, 1988; Fa, 1991; O'Leary & Fa, 1993; Saj et al., 1999]. For example, in rhe-

sus monkeys (*Macaca mulatta*) and baboons (*Papio anubis*), provisioned groups spend less time feeding and more time grooming than unprovisioned groups [Forthman-Quick & Demment, 1988; Malik & Southwick, 1988; Marriot, 1988]. In hamadryas baboons (*P. hamadryas*) in Saudi Arabia, the frequencies of most social interactions were related to food availability and distribution [Kamal et al., 1995], and periods of heavy provisioning of these baboons were characterized by more play behavior in juveniles and

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increased agonistic and mounting behavior in adults [Kamal et al., 1997]. Habitat disturbance and intensive contact with humans led long-tailed macaques (*M. fascicularis*) to change their feeding behavior, exploiting any available food resources to become more omnivorous [Wheatley, 1989; Hadi et al., 2007].

The Barbary macaque (*M. sylvanus*) is categorized as endangered by the IUCN [IUCN, 2010] and is listed in CITES Appendix II [CITES Trade Database Report 2011]. The species is threatened by the destruction of its habitat, overgrazing by livestock causing habitat degradation, and the illegal capture of infants for the pet trade [Taub, 1977; Van Lavieren, 2004, 2008; Camperio Ciani et al., 2005; Waters et al., 2007; Van Lavieren & Wich, 2009]. Nevertheless, it is generally recognized for its great adaptability, as it occurs in diverse habitats with extreme weather conditions that range from  $-10^{\circ}\text{C}$  in the winter to  $40^{\circ}\text{C}$  in the summer, and it also has an eclectic diet [Deag, 1974; Drucker, 1984; Mehlman, 1984; Ménard, 1985; Ménard & Vallet, 1986]. Time budget and grouping patterns are also highly flexible in Barbary macaques [Ménard, 2002].

The activity budget and feeding behavior of primates that live in tourist sites are influenced by human activities [Forthman-Quick, 1986; Saj et al., 1999]. Several groups of Barbary macaques live in tourist sites, where they are affected by the presence of visitors providing food to them [Fa, 1981, 1991; Unwin & Smith, 2010; Maréchal et al., 2011]. In Morocco, there are three popular sites where visitors provide food to Barbary macaques: at the Cascades d'Ouzoud in the central High Atlas, in forests located near the town of Azrou in the Middle Atlas, and in the north of Morocco near the city of Nador in the Rif Mountains. Although Barbary macaques have been observed feeding on human food, no quantitative information on their habits is available. Information on ecology and behavior of groups living in human-modified environments is crucial for the conservation of the surviving populations.

We conducted this study in the central High Atlas Mountains of Morocco, where the species' ecology is unknown and relatively few studies have been published [Fa et al. 1984; Cuzin 1996, 2003]. We report the activity budgets and the diet of two groups of Barbary macaques observed over a 7-month period: one lived in a tourist site where it was provisioned while the other group was wild-feeding. We compared our results with previous studies to understand the ability of this species to survive in human-modified environments.

## METHODS

### Research Sites and Subjects

The two study groups were located in the tourist region of Cascades d'Ouzoud ( $6^{\circ} 44' \text{W}$ ,  $32^{\circ} 00' \text{N}$ ), in

the province of Azilal, central High Atlas of Morocco (700–960 m; Fig. 1). The two groups were part of a small population covering approximately  $18 \text{ km}^2$  in this area [Cuzin, 1996, 2003]. The climate in the province of Azilal is not well documented. The study area has a Mediterranean climate with four distinct seasons: winter, spring, summer, and autumn, and the annual mean rainfall is 561 mm [Ouchbani & Romane, 1995]. Temperatures range from  $2.2^{\circ}\text{C}$  (winter) to  $34^{\circ}\text{C}$  (summer) [Sauvage 1963a]. The bioclimate is semiarid [Sauvage 1963b].

The semiprovisioned group lived in the tourist site of Cascades d'Ouzoud (Fig. 1), and contained 19 individuals: five adult males, six adult females, five juveniles, and three infants. This site is an area of biological importance in Morocco [Administration of Waters and Forests, and of the Conservation of Soils of Morocco, 1995], and is the only location in the central High Atlas where Barbary macaques are fed by people. Here the habitat of the macaques is mainly a rocky valley where waterfalls plunge down into a river; cliffs on both sides are where the tourist and commercial activities take place. The group has intensive contact with humans and consumes both natural food and that from human sources. Monkeys feed on natural food in the wetter areas and also search for food in the garbage dump. Tourists walk specific routes, and when the monkeys observe tourists with food they approached them to get food. The food provisioned by humans was mainly bread, fresh and dried fruits, vegetables, and candy. During the study period, the semiprovisioned group lived in the tourist site where it obtained the major part of its diet. In August, when the total number of tourists was high and the visitors camped in the tourist site, the macaques moved out of the tourist site. Perhaps the level of human disturbance became too high for the macaques to feel comfortable in the valley.

The wild-feeding group lived in the gorges of Oued El Abid (Fig. 1). It included 11 individuals: two adult males, four adult females, three juveniles, and two infants. This group had no contact with humans and fed almost only on natural foods. The habitat of this group consisted of a rocky gorge dissected by the river of Oued El Abid.

Vegetation maps (map of Morocco, page NI-29-VI-1b. Ministère de l'agriculture et de la réforme agraire. Direction de la conservation foncière et des travaux topographiques. Division de la topographie, Rabat, Maroc.) classified the two study sites similarly. Both sites were characterized by diverse land use practices that included natural vegetation, olive plantation, pine plantation, agricultural surface (plantation of olive and cereals), and forest of Barbary thuya and juniper. The following plant species were common in both areas: *Olea europaea*, *Ceratonia siliqua*, *Pistacia lentiscus*, *Ficus carica*, *Tetraclinis articulata*, *Juniperus oxycedrus*,

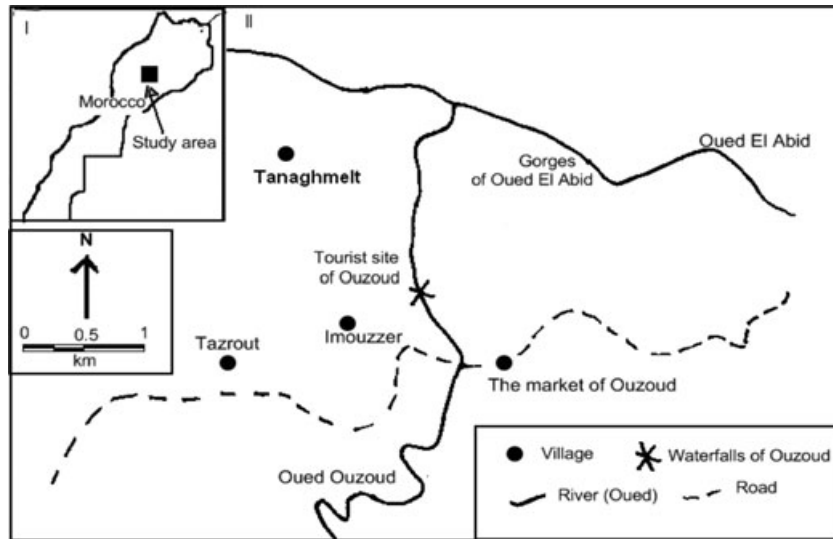


Fig. 1. (I) Location of the study area in Morocco. (II) Map of the study area showing main rivers, roads, villages, and locations of the two study sites (i.e., the tourist site of Cascades d'Ouzoud and the gorges of Oued El Abid).

*J. phoenicea*, *Genista tricuspidata*, and *Globularia alypum*.

### Data Collection

The monkeys of the semiprovisioned group were habituated and indifferent to observers at the onset of the study. By contrast, the monkeys of the wild-feeding group were not habituated and before the period of data collection began, preliminary observations were made on 23 days in the home range of this group. This period allowed the observers to become familiar with the terrain and increased habituation of the monkeys. We observed each group continuously from dawn to dusk for 6–8 days per month from February to August 2008. To reduce differences between groups that might relate to different conditions (food, weather, tourist flux) in different periods, we alternated days between the two sites in each observation session.

We used instantaneous scan sampling [Altmann, 1974] at 15-min intervals. Each scan took about 5 min. The mean number of individual behavioral records per scan was 9 for the semiprovisioned group and 6 for the wild-feeding group. During each scan, we noted the location of the group and recorded the activities of as many individuals as possible, excluding infants. For each individual, we scored the first activity that lasted at least 10 sec. Scan length was determined by the position and distance of the observer from the group, the location of the group, the dispersion of individuals, and the degree to which tourists disturbed the monkeys. Using binoculars occasionally, we observed the animals of the semiprovisioned group from distances of 1–20 m and animals of the wild-feeding group from distances of 30–50 m.

The behaviors that we considered in the activity budget included feeding, moving, foraging, resting, and aggressive display. Feeding animals were manipulating, placing food in mouth or chewing, but feeding from the cheekpouches was not included because it occurred mainly while monkeys rested or moved, and was therefore scored as such. Moving included walking, running, climbing, and jumping. Foraging included searching for, preparing, and handling food items. Resting corresponded to an inactive position as sitting, lying down, standing, and sleeping. Aggressive displays included branch shaking, baring of the teeth, threat posture with shoulders positioned forward and upright, and active chasing. We also noted playing and grooming, but these two activities were included in “other activities” because they were very rare (<5% of the scans). Other behaviors also included vigilant behavior, urinating, and any other activities not fitting into the other categories.

Following common practice [e.g. Doran, 1997; Kirkpatrick, 1998; Van Doorn et al., 2010; Óscar et al., 2011], we described the diet in terms of the percentage of time spent feeding on different items. During the scans in which an individual was eating we recorded the food category and the species' names or plant families. We recognized seven food categories: (1) human food, which was provided by tourists or that was taken from garbage dumps; (2) tree and shrub leaves; (3) fruits; (4) seeds and acorns; (5) roots and bark; (6) herbs (all parts); and (7) other foods such as flowers, insects, lichens, and bryophytes. In addition, we made running notes about the proximity of macaques to agricultural land, stealing of food by macaques from the restaurants, people chasing the macaques away from farms and restaurants, and injuries inflicted by humans or group mates.

## Data Analysis

In Morocco, there are significant differences in day length between seasons. The transformation of scan data into hours is therefore important when one analyzes monthly, seasonal or inter-habitat variation (e.g. Ménard and Vallet 1997). We compared two groups living in the same habitat with same climatic conditions during same periods. Therefore, the comparison of the percentage of scans in different activities is sufficient to evaluate the differences between the two groups in activity budget and in feeding time spent on different food categories.

The daily time spent on each activity was estimated for each group as:

$$T_a = \frac{1}{S} \sum_{i=1}^s \frac{n_{ai}}{N_i} \times 100,$$

where  $T_a$  = Percentage time spent on activity "a" per day,  $S$  = Total number of scan in a day,  $n_{ai}$  = Number of records of activity "a," in scan "i," and  $N_i$  = Total number of records in scan "i." The mean time spent on an activity for each group was calculated as an average of the daily records for the total number of days of the study period.

The daily feeding time spent on different food categories was estimated for each group as:

$$P_{aj} = \left( \frac{n_{aj}}{N_j} \right) \times 100,$$

where  $P_{aj}$  = Percentage feeding time spent on food category "a" in day "j,"  $n_{aj}$  = Number of feeding records on food category "a" in day "j,"  $N_j$  = Total of feeding records in day "j,"  $j$  = one day. The mean feeding time spent on each food category by each group was calculated as an average of the daily feeding time for the total number of days of the study period. To assess the differences between the two groups in an activity and in the percentage feeding time spent on different food categories, we used the Mann-Whitney U test.

This research was conducted with authorization of the University of Caddy Ayyad, Marrakech, Morocco. The methods of this survey complied with the Legal and Ethical statements of the *American Journal of Primatology*. The study was conducted in cooperation with the Moroccan Forestry department ("Haut Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification," is the responsible authorities in Morocco), and complied with the American Society of Primatologists' Principles for the Ethical Treatment of Non Human Primates, and the current law in Morocco.

## RESULTS

Instantaneous scan sampling of the two study groups yielded a total of 15,637 individual behavioral records during 2,081 scans over a total of 694 hr. We recorded 8,741 individual behavioral records during 958 scan samples on the semiprovisioned group, and 6,896 individual behavioral records during 1,123 scan samples on the wild-feeding group.

The two groups did not differ in the proportion of daily records devoted to feeding but the semiprovisioned group spent a higher percentage of daily records resting and in aggressive display, while foraging and moving less than the wild-feeding group (Fig. 2). There was no significant difference between the two groups in the proportion of feeding records spent eating leaves, fruits, and roots and bark (Fig. 3). Human food accounted for 26% of the daily feeding records for the semiprovisioned group, and 1% for the wild-feeding group. The semiprovisioned group had lower daily percentages of feeding records on herbs, seeds, and acorns than the wild-feeding group (Fig. 3).

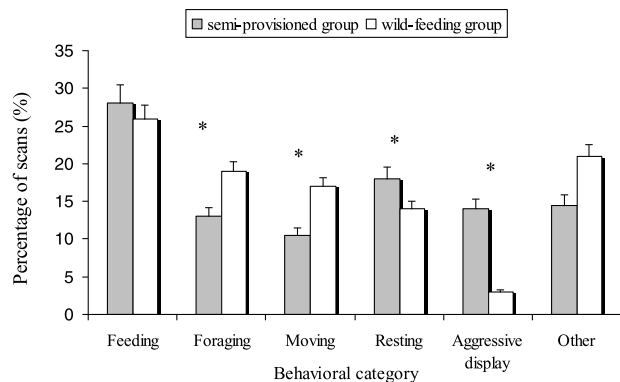


Fig. 2. The daily percentages of records (median  $\pm$  IQR) in which monkeys engaged in different activities from February to August 2008. Significant differences (Mann-Whitney U test,  $n_1 = 44$ ,  $n_2 = 49$ , two-tailed  $P < 0.001$ ) between the two study groups are denoted by an asterisk. Analyses were based on 44 days for the semiprovisioned group and 49 days for the wild-feeding group.

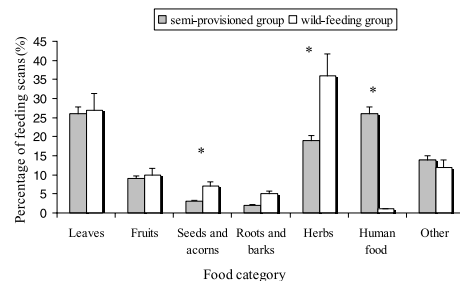


Fig. 3. The daily percentages of feeding records (median  $\pm$  IQR) spent on different food categories from February to August 2008. Significant differences (Mann-Whitney U test,  $n_1 = 44$ ,  $n_2 = 49$ , two-tailed  $P < 0.05$ ) between the two study groups are denoted by an asterisk. Observation days as in Fig. 2.

The natural food of the semiprovisioned and wild-feeding groups included, respectively, 34 and 21 species of angiosperms and gymnosperms. Trees and shrubs that contributed to the diet of the two groups during the study period were *C. siliqua* (Fabaceae), *O. europaea* (Oleaceae), *F. carica* (Moraceae), *P. lentiscus* (Anacardiaceae), *T. articulata* (Cupressaceae), and *Vitis vinifera* (Vitaceae). In both groups, macaques were observed to feed on herbs that belong to the families of Gramineae, Liliaceae, Joncaceae, Malvaceae, Labiatae, Papaveraceae, Compositae, Rosaceae, Rhamnaceae, Brassicaceae, and Leguminosae.

During the study period, injured individuals were permanently present in the semiprovisioned group. We counted seven cases of injuries of monkeys. These injured macaques tended to come closer to farms and restaurants, and they were often actively chased by people.

## DISCUSSION

Even though the tourist site of Cascades d'Ouzoud is one of the popular recreational areas in Morocco where many people feed the Barbary macaques, the monkeys spent only a quarter of their feeding time on human food. Nonetheless, this level of provisioning affected most of the behavioral activities and the time spent on other food items in the diet.

Feeding was the major activity of both study groups and this activity alone accounted for 26–28% of the time budget. Previous studies of wild Barbary macaques give similar averages of daytime hours spent on feeding [24–25%, Fa, 1986; 24–25%, Ménard & Vallet, 1997]. Monkeys at the two sites appeared to have different feeding strategies. Although actual feeding time was similar, the semiprovisioned group showed a lower-energy search strategy that minimized foraging and moving, allowing more resting time. The wild-feeding group adopted a more active search strategy, spending more time foraging and moving and less time resting. These differences likely reflected the abundance and distribution of resources. The semiprovisioned group obtained human food from two concentrated sources: along a tourist pathway and at a garbage dump. Individuals did not have to move and forage much to obtain this food. By contrast, the habitat of the wild-feeding group was affected by human activities and resource exploitation, leading to scarce and widely scattered food resources for the monkeys which had to move continuously to forage successfully. The same behavioral response in foraging and moving time in unprotected areas where food is scarce has been found in groups of wild Barbary macaques in Algeria [Ménard and Vallet, 1997]. In Gibraltar's Barbary macaques, the difference in time spent foraging and feeding between provisioned and non-provisioned groups was

similar to our results. Foraging time was highest in non-provisioned Barbary macaques, while the proportion of time that the individual macaques devoted to feeding did not differ [Unwin & Smith, 2010].

The semiprovisioned group also showed more aggressive behavior, which was likely related to higher levels of competition for the clumped human foods it consumed. In natural habitats, foraging in groups has advantages such as maximizing feeding efficiency and reducing the risk of predation but it can also lead to intra-group competition and higher aggression levels [Wrangham, 1980; Theimer, 1987; Majolo et al., 2009]. In wild capuchin monkeys, for example, aggression was less frequent when individuals foraged in dispersed patches, like the wild Barbary macaque focal group, than when they foraged in larger groups, especially where food was clumped, similar to the area where our semiprovisioned focal group lived [Phillips, 1995a, 1995b; Vogel & Janson, 2007]. In provisioned groups of captive hamadryas baboons, aggression could be artificially decreased by increasing food availability or by increasing distance between food resources [Wasserman & Cruikshank, 1983].

Although the semiprovisioned macaques spent considerable time on natural foods that resembled those of the wild-feeding group, they spent less time feeding on leaves, herbs, seeds, and acorns than their wild counterparts. It appears that the Barbary macaques in this region, living in habitat with minimal contact with humans (the wild-feeding-macaques) tend to be folivorous during the months of our study, but in the tourist site (the semiprovisioned macaques) they exploit additional food resources to become more omnivorous. This result is in line with previous studies [Ménard & Vallet, 1997; Ménard & Qarro, 1999; Ménard, 2002], and indicates that overall, the Barbary macaque is a generalist and opportunistic feeder with a highly flexible diet [Ménard 2002]. Indeed, the monkeys in both of our study sites had a broad and varied diet, including many different items. A similarly broad diet characterizes other populations of Barbary macaques and other macaque species as well [Mehlman, 1988: *M. sylvanus*; Yeager, 1996: *M. fascicularis*; O'Brien & Kinnaird, 1997: *M. nigra*].

Our results support previous findings that dietary diversity in Barbary macaques is greatest in forested environments. The diet of the two study groups, which included 34 and 21 species of angiosperms and gymnosperms respectively, contained fewer plant species than in the diets of forest-dwelling populations: 107 species in the Middle Atlas of Morocco [Deag, 1983; Drucker, 1984], 100 species in the Moroccan Rif: [Fa, 1983; Mehlman, 1988] and 130 species in the Algerian Grand Kabylie: [Ménard, 1985; Ménard & Vallet, 1986; 1996]. Our results were comparable, however, to those obtained in

non-forest habitats; for example, in one locality in Algeria, the macaques fed on 31 plant species [Ménard & Vallet, 1986] and in the Moroccan Rif Mountains, they fed on 46 plant species [Fa, 1983].

Most habitats in the region of Ouzoud and gorges of Oued El Abid are degraded or at risk of degradation from threats such as livestock grazing, agricultural practices, and tourism activity. These activities have enhanced the opportunities for contact between humans and wildlife, but not without negative consequences. For example, in the Middle Atlas region, the presence of tourists has led to higher stress levels in wild male Barbary macaques [Maréchal et al., 2011]. The Barbary macaques can facilitate ecotourism, but the inclusion of human food and human disturbance often results in the modification of macaques' behavior. The present study documented the effects of the human food on Barbary macaques similar to that reported in many other tourist sites [Fa, 1981, 1991; O'Leary & Fa, 1993; Unwin & Smith, 2010]. Conservation efforts on behalf of Barbary macaques should consider the effects of tourism and provisioning on the behavior and feeding ecology of the species. For example, placing clear information panels for tourists and sufficient training of the local tourist guides could reduce human provisioning in Cascades d'Ouzoud.

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