

Consumption of Unusual Prey Items in the Barbary Macaque (*Macaca sylvanus*)

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Abstract: We observed the consumption of novel prey items in a wild group of Barbary macaques (*Macaca sylvanus*) living in the Middle Atlas Mountains, Morocco. We witnessed an adult male consuming an adult rabbit and, on a different occasion, two adult males unsuccessfully hunting a rabbit. On four occasions, we also observed three adult males catching and consuming chicks and eggs from two bird nests, on the ground and in a tree, respectively. All of these observations occurred during the May – July period when food was scarce. This is the first report of Barbary macaques consuming vertebrates in the wild.

Key words: Barbary macaque, hunting, meat-eating, vertebrate predation, *Macaca sylvanus*, primate diet

Résumé: Nous rapportons ici les premiers cas de consommation de matière animale chez un groupe sauvage de macaque berbère (*Macaca sylvanus*) habitant dans les montagnes du Moyen Atlas au Maroc. Nous avons observé un mâle adulte consommer un lapin européen (*Oryctolagus cuniculus*) ainsi que 2 mâles adultes chasser sans succès un autre lapin. Nous avons aussi observés des mâles adultes capturer et se nourrir de poussins et d'œufs trouvés dans 2 nids d'Huppe fasciée (*Upupa epops*) et dans des nids trouvés au sol et dans les arbres, d'espèces d'oiseaux non-identifiés. Ces observations ont été faites pendant les mois de Mai à Juillet, période pendant laquelle la nourriture se faisait rare.

Mots clé: macaque berbère, chasse, carnassier, prédation de vertébrés, *Macaca sylvanus*, régime alimentaire

INTRODUCTION

The capture and consumption of vertebrate prey has been reported in only a limited number of primate species, including, for example, chimpanzees *Pan troglodytes* (Boesch, 1994a, 1994b; Gilby *et al.*, 2006), capuchin monkeys *Cebus capucinus* (Rose, 1996), baboons *Papio* spp. (Harding, 1975; Rose, 1978), and stump-tailed macaques *Macaca arctoides* (Estrada & Estrada, 1977). As the hunting behaviour of ancestral human species is thought to have been similar to the current hunting, capture and consumption of vertebrate prey by non-human primates, observations of such behavior in various primates is a subject of interest (Teleki, 1975; Rose, 1978; Butynski, 1981).

The most frequent observations of primates feeding on vertebrates have been recorded in chimpanzees and baboon populations, and less frequently across a broader range of primate species. Feeding on vertebrate prey is

often observed during periods when ecological constraints are more apparent, such as food shortages or during the dry season (Hausfater, 1976; Kumara *et al.*, 2000). In chimpanzees, however, the hunting of vertebrate prey and meat-sharing is thought to play a role beyond satisfaction of nutritional needs. In this species, meat-sharing has been described as functioning as a social tool, and it has been observed throughout the year, although in particular, when fruit abundance is high (Mitani & Watts, 2001). Feeding on vertebrate meat is a high protein food resource for primates in comparison to plant matter. Generally, the consumption of meat involves a larger food item compared with individual grass shoots or small invertebrates, such as ants or spiders (Dart, 1963; Fedigan, 1990). Due to the elusive nature of vertebrate prey and high levels of energy output required to capture such prey, however, plant matter and insects contribute the majority of protein consumed by omnivorous primates (Dart, 1963; Hausfater, 1976; Fedigan, 1990).

The capture and consumption of vertebrate prey has not been reported in wild Barbary macaques, *Macaca sylvanus*. In this species, opportunistic consumption of invertebrates, such as ants, scorpions and earthworms, has been observed, but not the capture and consumption of birds and mammals (Fa, 1984; Mehlman, 1984). The Barbary macaque is considered to be a species with a varied omnivorous diet consisting mainly of leaves, seeds, fruit, fungi and invertebrates (Deag, 1983; Fa, 1984; Ménard, 2002; Hanya *et al.*, 2011). Barbary macaques have been studied in both free-ranging conditions and in captivity, although only a few studies have been conducted in the wild (for example, Deag, 1983; Fa, 1984; Mehlman, 1984; Ménard, 2002; McFarland & Majolo, 2011). In semi-free ranging conditions Barbary macaques have been observed to pursue and capture birds, squirrels and young rabbits, but never were observed to consume these small vertebrates (Kaumanns, 1978; de Turckheim & Merz, 1984).

There have been reports of several macaque species opportunistically consuming vertebrates in both the wild and captivity, including observations during studies of stump-tailed macaques (Estrada & Estrada, 1977; Estrada *et al.*, 1978), Japanese macaques *Macaca fuscata* (Suzuki *et al.*, 1990), lion-tailed macaques *Macaca silenus* (Kumara *et al.*, 2000), bonnet macaques *Macaca radiata* (Krishnamani, 1994), and Assamese macaques *Macaca assamensis* (Schülke *et al.*, 2011).

Here, we report a series of observations, for the first time in the wild, on the capture and consumption of two prey items which previously had not been reported in the diet of the Barbary macaque (Deag, 1983; Fa, 1984; Ménard, 2002): adult European rabbit (*Oryctolagus cuniculus*) and chicks of the hoopoe (*Upupa epops*).

METHODS

Data presented here are part of a longitudinal study on the socioecology of the Barbary macaque which began in January 2008. The field site is in the Middle Atlas Mountains, near the city of Azrou (33°23'45"N, 5°12'07"W). Data on prey capture and consumption were taken opportunistically on a group consisting of 8 adult males, 1 sub-adult male, 7 females, 3 juveniles and 4 infants. This group has been observed continuously since September 2009; the data presented here were collected during the period of September 2009 to July 2011. The study group inhabits an oak and cedar forest and feeds on natural food resources.

RESULTS

Rabbit eating

A mid-ranking (i.e., ranked 4th) adult male was observed to consume a rabbit on 30 June 2010. We found this male after it already had captured the rabbit and while it was biting, chewing and consuming the flesh of the rabbit; we could not determine conclusively how the male had acquired the prey item. As soon as the other monkeys in the group observed this event, various other group members (especially, adults and sub-adult males) began to direct aggressive vocalisations to the male, producing grunts and pants. The male did not consume the entire rabbit; feeding was concentrated around the upper thorax (see Figure 1) and skin was peeled away from the stomach to the neck, exposing the rib cage of the rabbit. There was no consumption of the internal organs. There was no evidence that the male left the carcass as a consequence of the aggressive vocalisations of the other group members. The three males that approached the carcass sniffed it, but none of them grabbed or ate any of it. No other individual approached the carcass and the group eventually moved away from the area. Observers then closely examined the carcass and assessed that it had been freshly killed; the eyes were still moist and the flesh was fresh and bloody. There were no visual signs of disease on the remains.

In a second observation, on 5 July 2010, two males were observed chasing a rabbit, but the hunt was unsuccessful and the rabbit disappeared into dense foliage. The two individuals spent 10 minutes actively searching for the rabbit without success. This appeared to be an uncoordinated hunt with both individuals spotting and pursuing the rabbit simultaneously, but independently. The individuals involved in this incident were ranked 2nd and 7th in the hierarchy and were, respectively, an adult and a sub-adult male. These two males were not observed to be involved in the previous observation of the rabbit eating.

Nest Raiding and Chick Consumption

We witnessed one adult male nest-raiding and consuming bird eggs on two separate occasions. The first incident occurred on 25 May 2010 when the 5th ranked adult male climbed a tree containing a nest and stuffed the eggs into his cheek pouches. During this nest-raid, the male was being attacked by the adult hoopoe occupying the nest. The bird struck several times, especially at the head and upper

body, while the male was swiping at the bird to deter the bird's attacks. The male then quickly descended from the tree and consumed the eggs on the ground. The shells were spat out and the content consumed. Two juvenile males investigated the nest after the male had left. They dismantled the nest and played with it. During this, the bird returned and attacked the juvenile monkeys; the juveniles responded by chasing the bird through the canopy. This chase was accompanied by several grunts from adult group members observing the interaction from the ground.

On 2 June 2010, a second bird nest raid by the same mid-ranking male was observed. The male climbed a tree, located a bird's nest, and quickly consumed all of the eggs. The male then retreated rapidly down the tree as he was attacked by the adult hoopoe of the nest.

On 15 June 2010, the same adult male found a nest of an unknown bird species on the ground which contained 6-8

newborn chicks. The chicks were mobile and able to try to evade capture, but they were unable to fly and could not run fast enough to escape. Three adult males, ranked 1st, 2nd and 5th, were observed to catch and consume all of the chicks. The entire event lasted no longer than 60 seconds.

Finally, on 24 June 2011 the 2nd-ranked male was observed consuming a fledgling chick of an unknown species (Figure 2). The male was observed to leap forward and grab the chick, which was approximately 1.5 m from the male in tall grass undergrowth. The male manipulated the bird into an upright position, bit off the head and consumed it; the rest of the bird, including all body parts and feathers, was consumed over a 2-minute time period. The incident was watched by a one-year old juvenile male who was 1 m away and approached to 0.5 m as the male consumed the bird. After consuming the bird, the male approached a female and received grooming while still chewing and processing parts of the bird from his cheek pouches.



Figure 1. Remains of discarded rabbit.
Photograph by Michael Madole.



Figure 2. 2nd-ranked male consuming chick fledgling of unknown species. Photograph by Christopher Young.

DISCUSSION

This report is the first to document the hunting and consumption of at least two vertebrate species by wild Barbary macaques. It adds the Barbary macaque to the list of macaque species previously known to opportunistically consume vertebrates in both the wild and captivity (Estrada & Estrada, 1977; Estrada *et al.*, 1978; Suzuki *et al.*, 1990; Krishnamani, 1994; Nahallage & Huffman, 2006; Schülke *et al.*, 2011).

With respect to the documented catching and consumption of the rabbit, the observation that the adult male did not consume the entire rabbit suggests that this was not a preferred prey species, perhaps because it is not palatable. It also may be that these macaques show some aversion to novel food, as has been suggested previously for macaques (Weiskrantz & Cowey, 1963; Johnson, 2000). In contrast, many individuals were involved in the investigation and consumption of bird eggs and chicks. Chicks were consumed at a rapid rate and only by high ranking males, suggesting that this was a desirable food item. The macaques were not observed to actively search for birds' nests, however, and chick consumption was probably a case of opportunistic foraging. The chicks were rapidly consumed and the males did not attempt to immobilise the chicks before consumption, a tactic used to reduce the risk of injury by more formidable live organisms (Jolly, 1985). This rapid consumption could be an attempt to reduce competition over a highly desirable food item.

Two male macaques were observed to simultaneously chase an adult rabbit; the chase was unsuccessful and the prey escaped into the dense scrub. There did not appear to be any cooperation or coordination in their techniques, and both individuals seemed to be working independently in trying to catch the prey. As such, this behaviour is unlikely to represent a case of cooperative hunting, as has been observed in chimpanzees (Boesch, 1994a, 1994b; Gilby *et al.*, 2006) and baboons (Strum, 1981). Cooperative hunting is thought to require a high level of cognitive ability, and Barbary macaques do exhibit the ability to cooperate during social interactions, including coalition formation (Kuester & Paul, 1992; Bissonnette *et al.*, 2009; Berghänel *et al.*, 2010, 2011). As such, the absence to date of observations of cooperative hunting in this species could reflect a lack of opportunities and the limited importance of meat in their diet, rather than limitations in the cognitive abilities required for cooperative social behavior.

Our observations of Barbary macaques catching and consuming vertebrate prey indicate that these macaques can feed on novel food when opportunities arise. This

flexibility in feeding behaviour can be very adaptive, and may have allowed macaques to live at high altitudes and in low quality habitats in terms of food abundance. As Barbary macaques are thought to have been pushed to such habitats by competition with humans (Camperio Ciani *et al.*, 2005; Camperio Ciani & Mouna, 2007; van Laviere & Wich, 2009), such behavioural flexibility may have positive consequences for their ultimate survival.

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LITERATURE CITED

- Berghänel, A, O. Schülke, & J. Ostner. 2010. Coalition formation among Barbary macaque males – the influence of scramble competition. *Animal Behavior* 80: 675–682.
- Berghänel, A, J. Ostner, U. Schröder, & O. Schülke. 2011. Social bonds predict future cooperation in male Barbary macaques (*Macaca sylvanus*). *Animal Behavior* 81:1109–1116.
- Bissonnette, A, H. de Vries, & C.P. van Schaik. 2009. Coalitions in Barbary macaque males, *Macaca sylvanus*: success, strength and rules of thumb. *Animal Behavior* 78: 329–335.
- Boesch, C. 1994a. Chimpanzees–red colobus monkeys: A predator–prey system. *Animal Behavior* 47: 1135–1148.
- Boesch, C. 1994b. Cooperative hunting in wild chimpanzees. *Animal Behavior* 48: 653–667.
- Butynski, T.M. 1981. Vertebrate predation by primates: A review of hunting patterns and prey. *Journal of Human Evolution* 11: 421–430.

- Camperio Ciani, A. & M. Mouna. 2007. Human and environmental causes of the rapid decline of the Barbary macaque in the Middle Atlas of Morocco. In *The Barbary Macaque: Biology, Management & Conservation*. J.K. Hodges & J. Cortes, eds. Nottingham University Press, Nottingham, UK. Pp. 257–273.
- Camperio Ciani, A., L. Palentini, M. Arahou, L. Martinoli, C. Capiluppi, & M. Mouna. 2005. Population decline of *Macaca sylvanus* in the Middle Atlas of Morocco. *Biological Conservation* 121: 635–641.
- Dart, R. 1963. The carnivorous propensity of baboons. *Symposia of the Zoological Society of London* 10: 49–56.
- Deag, J.M. 1983. Feeding habits of *Macaca sylvanus* (Primates: Cercopithecinae) in a commercial Moroccan cedar forest. *Journal of Zoology* 201: 570–574.
- de Turckheim, G., & E. Merz. 1984. Breeding Barbary macaques in outdoor open enclosures. In *The Barbary Macaque: A Case Study in Conservation*. J.E. Fa, ed. Plenum, New York. Pp. 241–261.
- Estrada, A. & R. Estrada. 1977. Patterns of predation in a free-ranging troop of stump-tailed macaques (*Macaca arctoides*). Relations to the ecology II. *Primates* 18: 633–646.
- Estrada, A., J.M. Sandoval & D. Manzanillo. 1978. Further data on predation by free-ranging stump-tailed macaques (*Macaca arctoides*). *Primates* 19: 401–407.
- Fa, J.E. 1984. Appendix II: Diet of the Barbary macaque in the wild. In *The Barbary Macaque: A Case Study in Conservation*. J.E. Fa, ed. Plenum, New York. Pp. 347–355.
- Fedigan, L.M. 1990. Vertebrate predation in *Cebus capucinus*: meat eating in a Neotropical monkey. *Folia Primatologica* 54: 196–205.
- Gilby, I.C., L.E. Eberly, L. Pintea & A.E. Pusey. 2006. Ecological and social influences on the hunting behaviour of wild chimpanzees, *Pan troglodytes schweinfurthii*. *Animal Behavior* 72: 169–180.
- Hanya, G., N. Ménard, M. Qarro, N. Ibn Tattou, M. Fuse, D. Vallet, A. Yamada, M. Go, H. Takafumi, R. Tsujino, N. Agetsuma & K. Wada. 2011. Dietary adaptations of temperate primates: comparisons of Japanese and Barbary macaques. *Primates* 52: 187–198.
- Harding, R. 1973. Predation by a troop of olive baboons (*Papio anubis*). *American Journal of Physical Anthropology* 38: 587–592.
- Hausfater, G. 1976. Predatory behaviour of yellow baboons. *Behaviour* 56: 44–68.
- Jolly, A. 1985. *Evolution of Primate Behavior*. MacMillan Publishing Company, New York, NY. Pp. 45–71.
- Johnson, E. 2000. Food-neophobia in semi-free ranging rhesus macaques: effects of food limitation and food source. *American Journal of Primatology* 50: 25–35.
- Kaumanns, W. 1978. Berberaffen (*Macaca sylvana*) im Freigehege Salem. *Zeitschrift des Kölner Zoo* 21: 57–66.
- Krishnamani, R. 1994. Diet composition of the bonnet macaque (*Macaca radiata*) in a tropical dry evergreen forest of southern India. *Tropical Biology* 2: 285–297.
- Kuester, J. & A. Paul. 1992. Influence of male competition and female mate choice on male mating success in Barbary macaques (*Macaca sylvanus*). *Behaviour* 120: 192–217.
- Kumara, H.N., M.E. Singh, A.K. Sharma, M.R. Singh & M. Ananda Kumar. 2000. Faunal component in the diet of lion-tailed macaque. *Primate Report* 58: 57–65.
- McFarland, R. & B. Majolo. 2011. Reconciliation and the costs of aggression in wild Barbary macaques (*Macaca sylvanus*): a test of the integrated hypothesis. *Ethology* 117: 928–937.
- Mehlman, P.T. 1984. Aspects of the ecology and conservation of the Barbary macaque in the fir forest habitat of the Moroccan Rif Mountains. In *The Barbary Macaque: A Case Study in Conservation*. J.E. Fa, ed. Plenum, New York. Pp. 165–199.
- Ménard, N. 2002. Ecological plasticity of Barbary macaques (*Macaca sylvanus*). *Evolutionary Anthropology* 11: 95–100.
- Mitani, J.C., & D.P. Watts. 2001. Why do chimpanzees hunt and share meat? *Animal Behavior* 61: 915–924.
- Nahallage, C.A.D., & M.A. Huffman. 2006. Observations of meat eating by captive juvenile macaques. *Laboratory Primate Newsletter* 45: 1–3.

- Poulsen, J.R. & C.J. Clark. 2001. Predation on mammals by the grey-cheeked mangabey *Lophocebus albigena*. *Primates* 42: 391-394.
- Rose, L.M. 1996. Vertebrate predation and food-sharing in *Cebus* and *Pan*. *International Journal of Primatology* 18: 727-765.
- Rose, D. 1978. The roots of primate predatory behaviour. *Journal of Human Evolution* 7: 179-189.
- Schülke, O., D. Pesek, B.J. Whitman & J. Ostner. 2011. Ecology of Assamese macaques (*Macaca assamensis*) at Phu Khieo Wildlife Sanctuary, Thailand. *Journal of Wildlife in Thailand* 18: 1-15.
- Strum, S. 1981. Processes and products of change: Baboon predatory behavior at Gilgil, Kenya. In *Omnivorous Primates: Gathering and Hunting in Human Evolution*. R.S.O. Harding & G. Teleki, eds. Columbia University Press, New York. Pp. 255-302.
- Suzuki, S., D.A. Hill, T. Maruhashi & T. Tsukahara. 1990. Frog- and lizard-eating behavior of wild Japanese macaques in Yakushima, Japan. *Primates* 3: 421-426.
- Teleki, G. 1975. Primate subsistence patterns: Collector-predators and gatherer-hunters. *Journal of Human Evolution* 4: 125-184.
- Van Lavieren, E. & S.A. Wich. 2009. Decline of the Barbary macaques, *Macaca sylvanus*, in the cedar forest of the Middle Atlas Mountains, Morocco. *Oryx* 44: 133-138.
- Weiskrantz, L. & A. Cowey. 1963. The aetiology of food reward. *Animal Behavior* 11: 225-234.

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