

# Golden Eagles (*Aquila chrysaetos*) as potential predators of Barbary macaques (*Macaca sylvanus*) in northern Morocco: evidences of predation

(Águilas reales como depredadores potenciales de los macacos de berbería en norte de Marruecos: evidencias de su depredación)

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## Summary

We describe Golden Eagle *Aquila chrysaetos* predation on Barbary macaques *Macaca sylvana* in the Rif Mountains of Morocco. Four direct interactions between Barbary macaques and Golden Eagles were observed in three of the four Golden Eagle territories studied; five encounters with other raptors are also reported. Although we did not obtain unequivocal evidence of depredation of Barbary macaques by Golden Eagles, the behavioral reactions of that primate in the presence of an eagle strongly suggests that predation events do occur. We report antipredator strategies by the macaques, especially adult males, to avoid or thwart eagle predation. These include alarm calls, group congregation, concealment, and aggressive counterattack. The responses of Barbary macaques towards smaller raptors like Short-toed Snake Eagles *Circaetus gallicus* and Booted Eagles *Aquila pennata* were very different. The adult baboons gave no alarm barks but merely intently observed these smaller raptors.

**Key words:** apes, defense behavior, hunting behavior.

## Resumen

Describimos la depredación del águila real *Aquila chrysaetos* sobre los macacos de Berbería *Macaca sylvana* en las montañas del Rif de Marruecos. Se observaron cuatro interacciones directas entre los macacos de Berbería y las águilas reales en tres de los cuatro territorios estudiados; cinco encuentros con otras rapaces también fueron documentados. Aunque no obtuvimos pruebas inequívocas de la depredación de los macacos de Berbería por parte de las águilas reales, las reacciones de comportamiento de este primate en presencia de las águilas sugieren fuertemente que ocurren eventos de depredación. Divulgamos diferentes estrategias

antidepredadoras de los macacos, especialmente por hombres adultos, para evitar o frustrar la depredación de las águilas. Estas incluyen llamadas de alarma, congregación grupal, ocultamiento y contraataque agresivo. Las respuestas de los macacos de Berbería hacia aves rapaces más pequeñas, como las águilas culebreras *Circus gallicus* y las águilas calzadas *Aquila pennata* fueron muy diferentes. Los babuinos adultos no emitieron ladridos como señal de alarma, sino que simplemente observaron atentamente a estas rapaces más pequeñas.

**Palabras clave:** simios, comportamiento de defensa, comportamiento de caza.

## Introduction

The antipredator behavior of many species of primates provides good evidence that eagle predation has exerted a strong selective pressure (Van Schaik *et al.* 1983; Terborgh & Janson 1986; Janson 1992; Isbell 1994). This pressure may have affected group composition and size, ecological niche, reproduction and social behavior, body size, and cognitive abilities. Primate antipredator behavior includes vocalizations (alarm calls that can convey specific information about the level of danger associated with various predators) (Isbell 1994), flight, self concealment, increased vigilance, and counterattacks (Seyfarth *et al.* 1980; Mehlman 1984; Mehlman 1989; Zinner & Peláez 1999; Shultz 2001; Paciência *et al.* 2017). Golden Eagle predation is normally very difficult to witness directly by researchers, and there are only a few such systematic studies (Collopy 1983; Cheney & Wrangham 1986), so opportunistic observations of this type of behavior can be very valuable.

Raptors of many species are known to regularly prey upon small primates in most tropical regions (Hart 2000). In the holarctic region there is no documented case of (nonhuman) primate predation by large raptors, probably because few primate species exist in these latitudes.

The Barbary macaque is the only surviving nonhuman primate in North Africa and Europe, and the only member of the *Macaca* genus outside of Asia. In natural conditions, the Barbary leopard *Panthera pardus panthera* must have been an important predator of the Barbary macaque when these two species coexisted, but today, that feline is extinct (Aulagnier & Thévenot 1986). Because Barbary macaques respond to the presence of large eagles with alarm calls and evasive maneuvers, the great eagles likely were and are also macaque predators (Mehlman 1984; Mehlman 1989). The macaques respond similarly to large domestic dogs, but with foxes *Vulpes vulpes* and jackals *Canis aureus*, they show little fear (Mehlman 1984; Mehlman 1989; Menard & Vallet 1993; Menard 2002).

The Golden Eagle is exclusively a species of the northern hemisphere, and the most widely distributed species of the genus *Aquila* (Fergusson-Lees & Christie 2001). In many aspects of its biology, it is eclectic, being able to adapt to many types of habitats. It is also catholic in its eating habits, with more than 400 species of vertebrates having been registered as prey (Watson 2010). Despite the great variety of prey, in none of the numerous studies on the trophic ecology of the Golden Eagle worldwide have primates been reported. There is only one doubtful note of an observation of possible remains of a macaque in an eagle's nest on Jebel Musa (extreme northern Morocco; Torralvo 2012).

We describe interactions between Golden Eagles and Barbary macaques in four Golden Eagle territories on the Tingitana Peninsula (northern Morocco).

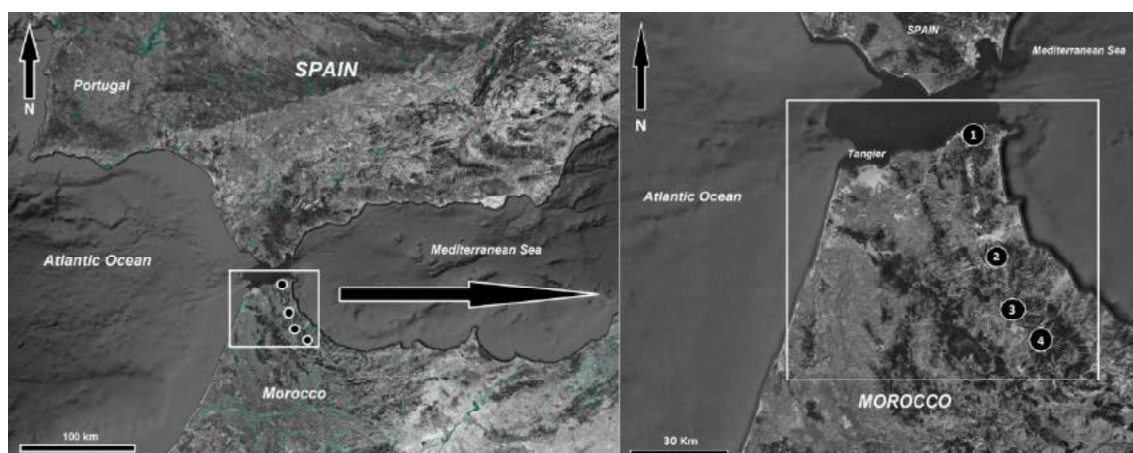
## Study area and methods

The study was carried out in early October 2016 and 2017, on the calcareous ridge of the Tingitana Peninsula (ca 36° N and 5° E) in northern Morocco (Figure 1). The climate is usually temperate and warm, and is typical Mediterranean.

Fieldwork consisted of confirming the presence of Golden Eagles in previously known territories, verifying the presence of macaques there, and then studying macaque responses to Golden Eagles and other large raptors.

Most of the observations were carried out at distances between 500 and 1500 m so as not to alter the behavior of either raptors or primates. We used 10 × 42 and 12 × 50 binoculars and a × 20–60 Leica Televit 80 spotting scope fixed on a tripod. We collected data during 2–3 days of monitoring in each of 4 eagle territories and accumulated 75 hr of observation. During each macaque observation period, we recorded the number of individuals, age and sex, and activity. Once the presence of an eagle was detected, one team (1 or 2 observers) watched the eagles while a second group of observers watched the response of the macaques.

Finally, we located alternate nests of Golden Eagles in each territory and collected prey remains to quantify the importance of the Barbary macaque in the diet of the Golden Eagle. The skeletal remains of the collected prey were identified by comparison with remains in public and private collections.



**Figure 1.** The study area. Circles 1, 2, 3, and 4 are Golden Eagle territories monitored during the study

## Results

### Golden Eagle survey and number of territories studied

We found 3 active Golden Eagle territories (zones with a nest and two adult eagles) and another recently abandoned. The latter, territory 1, corresponding to Jebel Musa, was included despite its having been abandoned in 2012 (Javier Martín, pers. comm.; SEO/BirdLife 2013). Because of the constant migratory flow of smaller eagles there, we were able to observe macaque responses to them as well.

### Numerical estimation of Barbary macaques in the territories studied

Of 119 Barbary macaques observed in the four Golden Eagle territories, 58 were observed in territory 1. These were in three groups of 17–22 individuals each. In territory 2, 20 individuals were seen in two groups of 6 and 14 individuals. In territory 3, only a single group composed of seven individuals was observed, and in territory 4, we found 34 macaques in two groups of 9 and 25 individuals. It should be noted that 119 is our best minimum estimate of macaques. The rugged terrain or dense vegetation resulted in some uncertainty. Large groups were, of course, easier to detect but much harder to count.

### Encounters between Barbary macaques and Golden Eagles

We observed four direct interactions between Barbary macaques and Golden Eagles. We also report five encounters with small eagles in one of the territories.

#### *Observation 1, Territory 4: 6 October 2016, 1205–1221H*

At about 1300 m distance, atop a large rocky cliff on the slope of the valley opposite our position, we saw a group of approximately 25 macaques. All the macaques were sunning themselves and busy in social interactions (grooming and play). About 1000 m away from the group of macaques, an adult Golden Eagle was approaching slowly along the cliff top a few meters from the edge of the cliff. When the eagle was ca 500 m away from, and in sight of, the macaques, the whole group began to issue alarm calls that consisted of a shrill "ah-ah" that resembled a dry bark. As the eagle continued to approach the group, the adult females with young and larger juveniles ran quickly towards the larger adults and clumped behind them. A large adult male interposed himself between the eagle and the group. In a quadrupedal and threatening position, he stared at the eagle without looking away and constantly barked. The eagle, observing the clumping of the group and the defiant attitude of the adult male, began to rise shortly before reaching the group. While above the group, the eagle turned in flight, then returned in the same direction from where it had come. It then settled among

boulders about 500 m from, and out of sight of, the group of macaques. After 5 min, it resumed flight and disappeared. Meanwhile, the group of macaques, once the eagle was out of sight, began to cautiously resume their former activities, leaving the large macaque male as a sentinel about 20 m from the group, sitting and gazing the direction where the eagle disappeared and scanning, from time to time, in all directions. This observation lasted 16 min.

*Observation 2, Territory 2: 10 October 2017, 1115–1145 H*

From our position, about 600 m away, we observed a group of macaques composed of about 14 individuals of all age and sex classes. The majority were feeding; others were grooming. The juveniles were playing. After watching for an hour, we observe an adult Golden Eagle approaching about 600 m away, slowly gliding along the wall of a rocky cut and about 20 m above the ground. When it was about 200 m from, and in sight of, the macaques, some members of the group emitted the same alarm calls as in the previous case, a high frequency and high volume "ah-ah" that was quickly transmitted in series, each of three or four vocalizations, while the macaques ran. The immediate response of some of the members of the group to this vocalization was to run quickly towards dense vegetation, some of the immature macaques ran toward the adult males or females and others ran under the bushes or nearby rocks. Some of the adult females (with clinging offspring) also approached the males. Most of the macaques looked steadily towards the sky, observing the eagle. The eagle then made about 5 passes about 20 m above the group before settling ca 10 m up in a small tree located at the bottom of the rocky cut about 30 m from the macaques. As soon as the eagle landed, two of the adult males ran toward the base of the cut and climbed quickly up into the eagle's tree. They released constant grunts of threat but remained ca 5 m below the eagle. They then energetically began to shake the branches of the tree and to emit grunts. This rushing approach resulted in the eagle instantly flushing and flying to another tree about 40 m above the previous one. The two macaques stayed at the first tree, growling and violently shaking the branches. This observation lasted 30 min. Soon, all the females with young and the immatures cautiously emerged from the dense vegetation and remained vigilant near the adult males. Next, the group began to advance until it was lost in the dense vegetation. The two adult males which rushed the eagle stayed in the rear guard for 15–20 min, then disappeared. This observation is illustrated in Figure 2.

*Observation 3, Territory 2: 10 October 2017, 1420–1421 H*

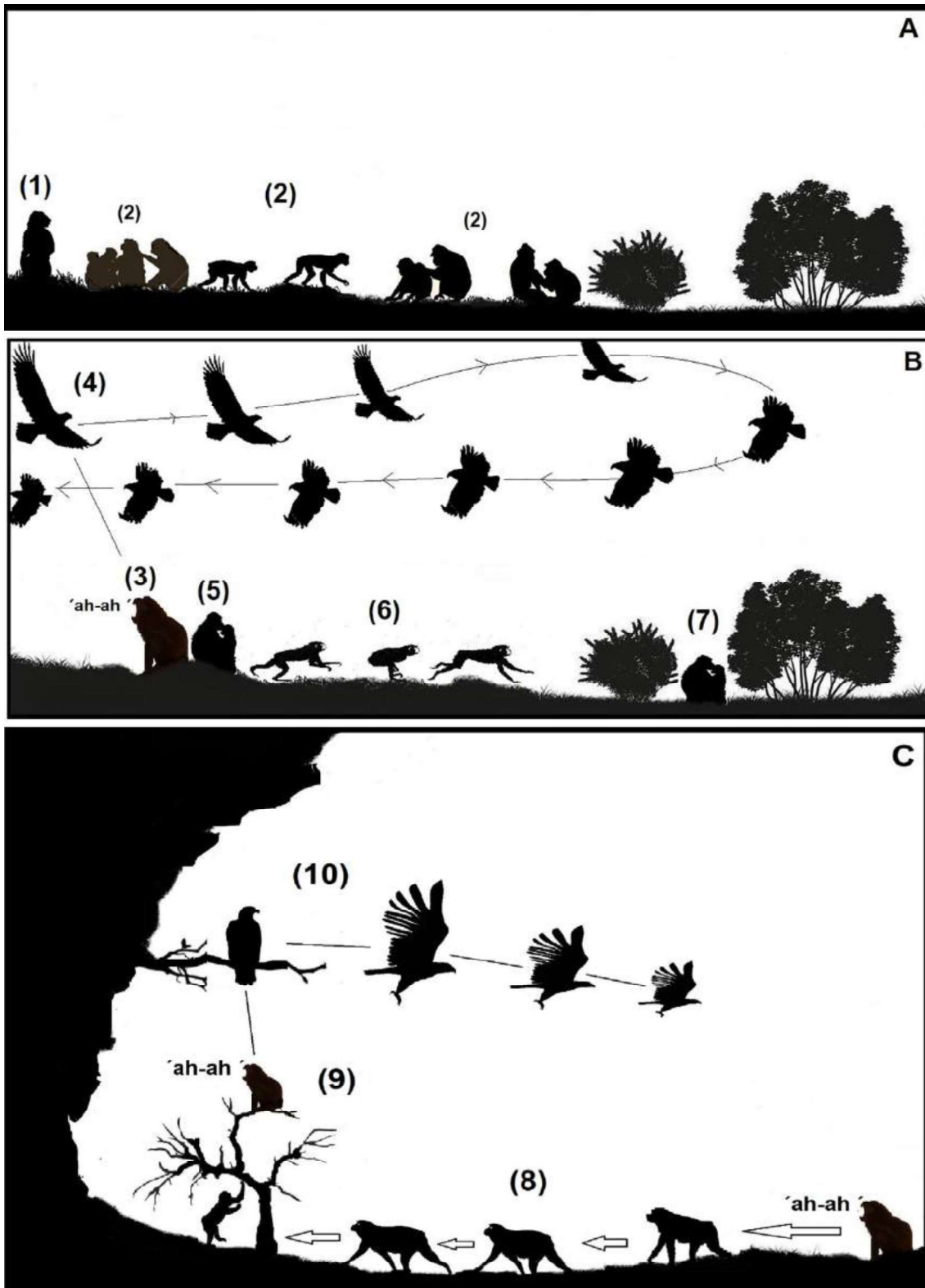
Two hours after the previous observation, one of the macaque adults that was part of the previous group was feeding near some rocks, when suddenly he looked up at the sky and barked two quick alarm calls ("ah-ah"). At that moment, two adult Golden Eagles swept past at high altitude (ca 40 m up), gliding at great speed, toward the mouth of the valley. The adult macaque commenced feeding again but kept watching the sky. This interaction lasted about 1 minute.

*Observation 4, Territory 3: 13 October 2017, 1130–1135 H*

When observation 4 began, four adult female and three immature macaques were interacting with each other (grooming and playing) about 500 m from our position. After 30 min, we heard a roar of alarm calls increased by the echo, and the whole group, with an adult at the head, ran very fast down a steep slope to take refuge in large boulders that were at the foot of a nearby cliff. We immediately noticed that there was a Golden Eagle gliding along the crest of the cliff (probable hunting flight) immediately above where the macaques had taken refuge. At that same time, the eagle rose slightly in response to being harassed by two crows that came from a nearby cliff. The eagle then accelerated its flight and perched on a rock about 1500 m from, and out of sight of, the macaques. After 5 min, we saw one of the adult female macaques appear among the rocks where the group had taken refuge. She intently watched the sky. Soon the rest of the group began to timidly emerge but all remained alert. The sequence lasted 5 min.

*Observations 5–9: Encounters with other birds of prey*

In territory 1 (Jbel Musa), we observed five encounters with Short-toed Eagles *Circaetus gallicus* and Booted Eagles *Aquila pennata* flying at low altitude (10–15 m) above the macaques. The adult members of the group largely ignored these birds. The macaques did not give alarm calls, but some of them carefully watched the eagles. Some of the young macaques gave low frequency calls, but they never showed signs of panic.



**Figure 2.** Illustration of observation 2, territory 2: 10 October 2017, between 1115 and 1145 H. Scene A: (1) An adult male as sentinel on alert; (2) The rest of the group, especially the females with offspring and subadults, are feeding and grooming. The older juveniles are engaged in play. Scene B: (3) The sentry, upon detecting the approaching eagle, alarm calls; (4) The eagle makes up to five low passes over the group of macaques, then abandons the attempt and perches in a nearby tree; (5) Some of the females with infants approach the nearest adult males; (6) Other members of the group, upon hearing the sentinel's alarm calls, quickly flee toward the

nearest bushes; (7) Some of the juveniles find adult females nearby and cling to them. Scene C: (8) Two of the adult males, including the sentinel, initiate a quick counterattack upon seeing the eagle perched on a nearby tree; (9) Next, they run to the tree below the eagle's perch, climb quickly while emitting grunts and barks and constantly waving the branches of the tree in a threatening manner; (10) The eagle, threatened by the rushing males and their intimidating behavior, quickly flees.

### Analysis of the prey remains

Of 34 skeletal prey remains found below two Golden Eagle nests (located in territories 2 and 3), none were of macaques. The most frequently consumed prey were the common tortoise *Testudo graeca* (n = 18) and the domestic goat *Capra aegagrus hircus* (n = 9). We also found remains of one hare *Lepus sp.* and three unidentified diurnal raptors the size of a buzzard *Buteo sp.*

### Discussion

The wide distribution of the Golden Eagle depends upon its trophic eclecticism. Its prey includes more than 400 species of vertebrates mostly between 0.5 and 4.5 kg (average weight = 1.5 kg) (Watson 2010). The general tendency of the species is to capture terrestrial prey. However, none of the numerous studies on the trophic ecology of the Golden Eagle list primate prey<sup>1</sup>. Although in this study we did not record unequivocal evidence of depredation on Barbary macaques, we obtained strong indications there must be at least occasional depredation. These signs are our observations of alarm calls, evasive maneuvers, group congregation, concealment, and protection of the offspring shown in the presence of Golden Eagles (but not other avian predators).

Mehlman (1984) cites the same behavior and the same reactions in the groups of macaques studied by him in another location in the western Rif Mountains. He stated that the group members emitted vocalizations when they saw a large eagle approaching, but he did not specify which species. Immediately after vocalizing, the macaques ran quickly to the nearest tree, jumping or climbing to a short distance from the ground (less than 10 m), and sat on branches near the main trunk until the danger passed. In our case, this type of behavior only manifested itself when detecting the Golden Eagle, but not when other species of raptors appeared.

In the Amboseli National Park and in the Eritrean highlands, yellow baboons *Papio cynocephalus* and hamadryas baboons *P. hamadryas* also do not respond or do so weakly (grunts) to the presence of African Hawk-eagles *Aquila spilogaster*, Tawny Eagles *A. rapax*, and Black Kites *Milvus migrans*. However, they do show behavior similar to that of the Barbary macaques (when Golden Eagles are near) when in the presence of Martial Eagles *Polemaetus bellicosus* and Verreaux's Eagles *A. verreauxii* (Zinner & Peláez 1999; Altmann & Altmann 1970). The Japanese snow monkey *Macaca fuscata*, another temperate latitude macaque, seems not to be prey of the Golden Eagle, but there is one observation of the smaller Mountain Hawk-eagle *Nisaetus nipalensis* delivering a macaque carcass to its nest (Toru Yamazaki, pers. comm.).

From our observations, adult males contributed most in protecting the macaque groups from large eagles. Isbell (1994) states that, due to the differences between males and females in body size and their defenses (e.g., large canine teeth), males of many primate species are less vulnerable to predation and are also able to harass, threaten, and attack certain predators, including eagles, while defending the group. This pattern matches our observations (especially observation 2), wherein two males rushed toward and chased away a Golden Eagle perched near the group.

The Golden Eagle worldwide uses at least seven basic hunting techniques (Watson 2010). One of the most common is called "contour flight with a short glide attack," during which the eagle remains below the skyline as if to go unnoticed by prey on the ground. Some of the eagle behavior we observed seems to fit into this class. This method is also widely used by the Golden Eagle's congener, the Verreaux's Eagle, to hunt baboons and monkeys across much of Africa (Zinner & Peláez 1999; Watson 2010; Boshoff *et al.* 1991). This propensity by a closely related and similarly sized eagle is a further argument in favor of the hypothesis that macaques are prey for Golden Eagles in North Africa.

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<sup>1</sup> Attacks of wild Golden Eagles on humans were reviewed by Ellis (2013: 113-116, 169-189). Most were on humans near eagle nests, so should be viewed as nest defence, not predation. Very few attacks on human infants are well substantiated and seem to be mostly legendary.

Because of their smaller size (average weight of adult males: 14.5 kg; adult female: 10 kg; juvenile: 7 kg; infant: 1 kg) and their unsuspecting habits, young macaques are much more likely to be taken by Golden Eagles than are adults. Young spend most of their time in social play. We have also observed that juveniles are prone to venture alone along the crests of cliffs and to stray far from the protection of adults. All this would increase their vulnerability to eagles, especially along escarpments and rocky ridges. In these situations, the hunting techniques described above for the Golden Eagle (and other conspecifics) would be particularly effective.

The observations made in the present study offer new data on the predatory behavior of the Golden Eagle. Although we did not obtain unequivocal evidence of depredation of Barbary macaques by Golden Eagles, the reactions of the macaques strongly suggest that Golden Eagles do prey, at least occasionally, on these primates. Continued study of the interactions between Barbary macaques and Golden Eagles are of interest, especially because they represent a predator-prey relationship unique in the Palearctic.

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