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Distribution of *Macaca ochreata* and Identification of Mixed *ochreata-tonkeana* Groups in South Sulawesi, Indonesia

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Abstract: We collected data on the distribution of booted macaques (*Macaca ochreata*) in Faruhumpenai Nature Reserve in South Sulawesi, Indonesia, in order to assess its conservation status. Methodology included censuses conducted along piecewise linear transects established at two sites from April–July 2006. The total distance walked was 45 km for the Matano site, and 20 km for the Kasintuwu site. Group density of booted macaques at the Matano site was 0.97–1.56 per km². At the Kasintuwu site, we encountered groups of booted macaques and Tonkean macaques (*Macaca tonkeana*), as well as mixed groups of *tonkeana* and *ochreata*. The group density of booted macaques was 1.45–2.00 per km². Overall macaque group density (i.e., *Macaca* spp.) at this site was 3.25–4.00 per km². Our study demonstrated that two species of Sulawesi macaques, *M. tonkeana* and *M. ochreata*, as well as mixed *tonkeana-ochreata* groups occur in the forests in and surrounding Faruhumpenai Nature Reserve. The results confirm a more extensive range of *M. ochreata* than was previously recognized; one that extends further north and northwest than the provincial boundary of south and southeast Sulawesi. The conservation status of booted macaques may, therefore, not be as precarious as previously thought, since their habitat is protected in not only two large conservation areas in Southeast Sulawesi (Rawa Aopa National Park and Tanjung Peropa Game Reserve), but also in South Sulawesi in the Faruhumpenai Nature Reserve. Nonetheless, because cacao is frequently planted on the borders of these protected forests, human-macaque conflict resulting from crop raiding may eventually pose a threat.

Key words: Sulawesi macaques, *Macaca tonkeana*, *Macaca ochreata*, distribution, density, mixed species groups, conservation

Introduction

The Indonesian island of Sulawesi, which occupies a unique biogeographical position within the transitional zone of Wallacea, harbors a remarkably large number of endemic species (Whitten *et al.* 2002). With regard to nonhuman primates, seven of the 19 species of the genus *Macaca* are endemic to Sulawesi (Fooden 1969: *Macaca nigra*, *M. maura*, *M. tonkeana*, *M. hecki*, *M. ochreata*, *M. brunnescens*, and *M. nigrescens*). Given such high levels of endemism, Wallacea has recently been prioritized as one of the 25 hotspots for biological conservation (Myers *et al.* 2000).

Although the evolution, population genetics, and morphological variation of the Sulawesi macaques have been the focus of a considerable amount of research (for example, Bynum *et al.* 1997; Evans *et al.* 1999, 2001, 2003; Abegg and Thierry 2002; Bynum 2002; Schillaci and Stallman 2005), the behavioral ecology and conservation of these taxa remain

relatively understudied. Long-term ecological and behavioral research with conservation implications has only been conducted on wild populations of three species (*M. nigra*: Lee 1997; O'Brien and Kinnaird 1997; *M. nigrescens*: Kohlhaas 1993; *M. tonkeana*: Riley 2005). The remaining species have been the subjects of short-term observations on aspects of social organization and behavior (Watanabe and Brotoisworo 1982; Reed *et al.* 1997; Matsumura 1998; Kilner 2001). With such limited data, our understanding of their habitat needs, current conservation threats, and their ability to respond to these threats, remain unclear (Bynum *et al.* 1999).

The focus of this research is the Sulawesi booted macaque, *Macaca ochreata*. Given the paucity of information on this species, the booted macaque is currently listed as 'Data Deficient' (IUCN 2006). The goal of our study was to collect basic distributional and ecological data on *M. ochreata* in order to assess its conservation status and to inform conservation efforts aimed at protecting the species and its habitat.

Study Site and Data Collection

The research was conducted at Faruhumpenai Nature Reserve, at the provincial border of Central and South Sulawesi, Indonesia (Fig. 1). Faruhumpenai Nature Reserve was established in 1979 with an area of 90,000 ha, providing habitat for 38 listed wildlife species and 205 plants. Censuses were conducted at two research locations using the line-transect method (NRC 1981; Buckland *et al.* 2001): (1) “Matano”: at the southeastern border of the Faruhumpenai Nature Reserve, 6 km from the village of Matano, and (2) “Kasintuwu”: in the north-northwest section of the nature reserve near the village of Kasintuwu (Fig. 1).

Due to the difficulty of the terrain, three piecewise linear transects were established at each location (Table 1). Piecewise transects are line transects that are segmented due to topography, in which case the length of the survey is obtained by summing all of the transect segment lengths used (Patterson 2001). Transects were walked at the maximum speed of 1 km/hour, beginning at 6:30 am. Each time macaques were encountered, we immediately recorded the animal-observer distance using a rangefinder, and the angle between the forward direction of the transect line and the direction to the macaques. We then recorded the following information: time sighted, location along the transect, species, number of individuals, group

composition (if possible), activity of the first animal detected, height of first animal detected, and mode of detection. In addition, to obtain basic ecological information from the research locations, we measured the Diameter at Breast-Height (DBH) of all trees 5 m to the right and left of the transect, at 100 m intervals.

Analysis

Estimates of macaque group density at each research site were calculated using the formula: $D = N/2Lw$, where N = number of groups encountered, L is the sum of the transects lengths, and w is the width of the transect that is covered. Two estimates of w were used to calculate density: a standard width strip of 50 m and the maximum animal-observer distance (NRC 1981).

Results

Species distribution, mean encounter rate, and group density

Estimated group densities and mean encounter rates per field site are shown in Table 2. An important external characteristic that enables us to discriminate between booted and Tonkean macaques is the color of the forearms and hindlimbs: those of booted macaques are whitish grey while those of *tonkeana* are black, like the trunk (Watanabe *et al.* 1991)

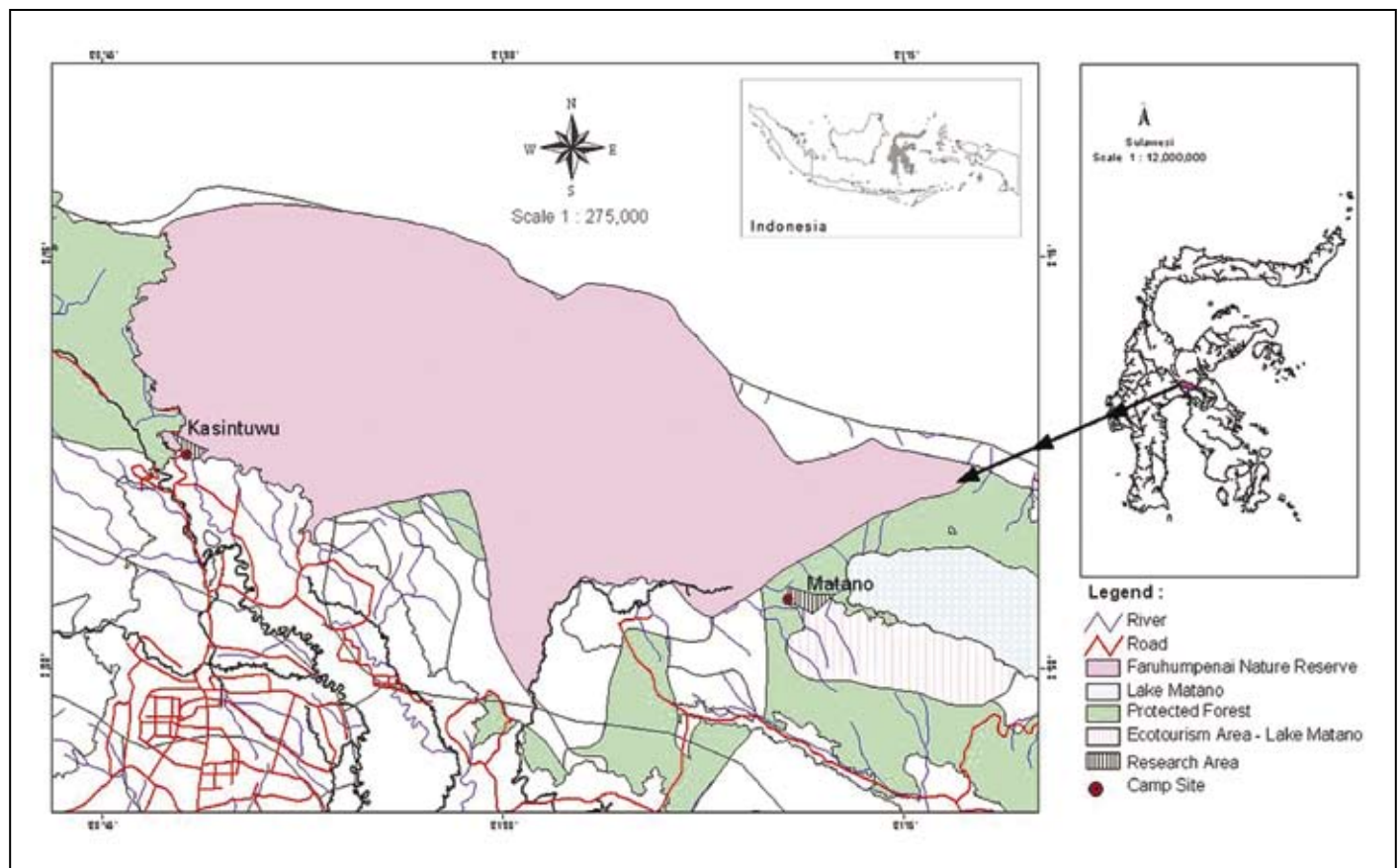


Figure 1. Faruhumpenai Nature Reserve (90,000 ha) at the provincial border of Central and South Sulawesi, Indonesia. The map shows the two research locations: (1) “Matano”: at the southeastern border of the Faruhumpenai Nature Reserve, 6 km from the village of Matano, and (2) “Kasintuwu”: in the north-northwest section of the nature reserve near the village of Kasintuwu.

(see Figs. 2 and 3). Only groups of booted macaques were encountered at the Matano field site. In a booted macaque group that we regularly encountered, however, we identified a subadult male as *tonkeana* based on the black coloring of his forearms and hindlimbs. At the Kasintuwu field site, groups of booted macaques and tonkean macaques, as well as mixed species groups (individuals from both taxa) were encountered. One of the mixed species groups frequently encountered was comprised of *tonkeana* adult males, *ochreata* adult males, *ochreata* adult females, and a number of juveniles and/or small subadults that appeared to exhibit a mix of traits (i.e., black forearms like *tonkeana* and whitish hindlimbs like *ochreata*).

Ecology and conservation threats

The Matano site included protected forest (*hutan lindung*) and forests within the boundary of the Lake Matano Ecotourism Area (*Taman Wisata Alam Matano*). Mean DBH of trees within 5 m of either side of the three transects was 11.02 cm ($n = 101$, $SD = 11.27$). Despite the protected status of these forests, we encountered considerable human-induced disturbance in the form of rattan collection and clearing of forest for agriculture. These activities appear to be facilitated by the recent establishment of a road that connects the villages of Bonepute and Matano to the Trans Sulawesi highway via the village of Tole-Tole. We also found evidence of human-macaque conflict in the form of crop raiding of cacao.

Table 1. Details of transects, sampling efforts, and qualitative evaluation of habitats at research locations.

Transects	Length (km)	Number of walks	Total distance (km)	Protected forest?	Disturbance
Matano	9				
T1	2.5	5	45	No	Moderate
T2	3	5		Yes	Moderate
T3	3.5	5		No	Heavy (road)
Kasintuwu	5				
T1	1.5	4	20	Yes	Low
T2	2	4		Yes	Low
T3	1.5	4		Yes	Low

Table 2. Species distribution, mean encounter rate, and group density per location.

Species	Mean encounter rate ^a (\pm SD)	Density #1 ^b (groups/km ²)	Density #2 ^c (groups/km ²)
Matano			
<i>Macaca ochreata</i>	0.24 (\pm 0.05)	0.97	1.56
Kasintuwu			
<i>Macaca ochreata</i>	0.2 (\pm 0.16)	1.45	2.0
<i>Macaca tonkeana</i>	0.05 (\pm 0.1)	0.36	0.5
Mixed <i>tonkeana-ochreata</i>	0.2 (\pm 0.16)	1.45	1.5
<i>Macaca</i> spp. groups	0.45 (\pm 0.19)	3.25	4.0

^a Number of groups encountered per km walked.

^b Where w = maximum animal-observer distance. (Matano = 126.4 m; Kasintuwu = 69.2 m).

^c Where w = standard 50 m (animal-observer distance).

The Kasintuwu site included habitat within the boundaries of the Faruhumpenai Nature Reserve. Mean DBH of trees within 5 m on either side of the three transects was 15.71 cm ($n = 40$, $SD = 19.89$). Except for the occasional remains of felled ebony trees (*kayu hitam* or *Diospyros celebica*), we found little evidence of human-induced disturbance. On the other hand, the border of the nature reserve is surrounded by cacao plantations, which are frequently raided by macaques. Our camp site was situated at the base of a cacao plantation, the previous owner of which had abandoned his garden due to frequent macaque crop raiding.

Discussion

The estimates of group density of *M. ochreata* (range 0.97–2.0 per km²) obtained in our study are lower than those found for other species of Sulawesi macaques: *M. tonkeana*



Figure 2. Pet juvenile male booted macaque (*Macaca ochreata*) in the village of Non Blok, South Sulawesi. Note the white/grey forearms and hindlimbs. Photo by E. P. Riley.



Figure 3. Adult male Tonkean macaque (*Macaca tonkeana*) from Lore Lindu National Park, Central Sulawesi. Note the all black body, including limbs and trunk. Photo by E. P. Riley.

(2.8 groups/km², Riley 2005) and *M. nigra* (3.9 groups/km², Lee 1997). At the Kasintuwu site, we found groups of *ochreata* and *tonkeana*, along with mixed species groups, and the group density estimate for *Macaca* spp. (range = 3.25–4.0 groups/km²) in this area of the nature reserve is much higher than the group densities of individual macaque species. These results suggest that macaque group density is higher in areas of overlap between *M. ochreata* and *M. tonkeana*. The fact that we observed mixed-species groups and individuals with traits of both species (for example, black forelimbs, but grey/white hindlimbs) suggests that hybridization is occurring in these areas of overlap between *tonkeana* and *ochreata*. Furthermore, because the mixed-species groups we observed were dominated by *ochreata* individuals with *tonkeana* only represented by adult males, it may be *tonkeana* males that are migrating into *ochreata* groups and breeding with *ochreata* females.

Based largely on the sampling of pet monkeys, along with occasional observations of wild groups, Watanabe *et al.* (1991) suggested that the distribution of *M. ochreata* extended north-northwest of the provincial boundary between South and Southeast Sulawesi. Our research confirmed that *M. ochreata* inhabits forests around the Matano, Towuti, and Mahalona lake system and that the distribution of *M. ochreata* extends as far north-northwest as the Faruhumpenai Nature Reserve at the border of South and Central Sulawesi. Our identification of a *tonkeana* subadult male in a group surveyed at Matano suggests that the distribution of *M. tonkeana* may extend further southeast than was previously believed (see Watanabe *et al.* 1991).

Our confirmation of a more extensive range of *M. ochreata* suggests that its conservation status may not be as precarious as was previously thought. We now know that its range includes the protected Faruhumpenai Nature Reserve (90,000 ha), in addition to two other protected areas in Southeast Sulawesi: Rawa Aopa National Park (105,000 ha) and Tanjung Peropa Game Reserve (38,937 ha). Nonetheless, human-macaque conflict resulting from crop raiding may eventually pose a threat as farmers attempt to find ways (for example, hunting, trapping, and/or poisoning) to stop them. This problem is likely to be exacerbated as more habitat is cleared for the planting of cacao. Conservation management of these forest-plantation edges will need to involve coordinated efforts among local farmers, PHKA personnel, and agriculturalists to determine how to minimize crop raiding; experimenting, for example, with the planting of tree crops of no interest to the macaques at forest-plantation edges to serve as buffers.

Future research involving the non-invasive collection of DNA via fecal samples is needed to confirm the occurrence of hybridization between *M. tonkeana* and *M. ochreata* in Faruhumpenai Nature Reserve. Genetic analyses must also be accompanied by research on the behavior and ecology of *M. ochreata* and these mixed species groups to understand the extent of behavioral differentiation between the two species

and to assess how hybridization may be affecting their behavior and ecology. This information will ultimately be critical for conservation management of these hybrid zones.

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