

lemur that was still lying on the ground. The mouse lemur had suffered a bleeding, semi-circular head injury and an eye injury. The mouse lemur, which was a known male, was convulsing and died within one minute. As we walked away, five adult mongooses were observed climbing up and down various trees in the vicinity.

It appears that the ring-tailed mongooses were systematically searching for food high up in the trees and possibly targeting mouse lemur sleeping sites. Sleeping mouse lemurs may be easy prey for arboreal hunters. Within our study population we had previously identified a female, who upon her second capture in our live-traps, appeared to have had suffered a recent, rather severe head injury with half of one ear freshly torn off. On the top of her head she had a semi-circle shaped wound very similar to the one suffered by the dead male, and her skull cap appeared to have been injured as indicated by numerous bumps. The characteristics of her injuries suggest that she may have recently been bitten in the head by a mongoose. When we trapped her again one month later, she was in good health and her external wounds had healed, however, her skull remained bumpy suggesting bone damage. These findings hint that *G. elegans* attacks on the brown mouse lemur may not be a rare occurrence in RNP. Our observations of the mongoose pair involved in the attack on the mouse lemur nest further suggests that they may have been cooperating because one individual was up in the tree while the other was at the base of the tree possibly waiting for prey to fall to the ground. We suggest that even though mouse lemur sleeping nests are usually well camouflaged and may provide some protection from diurnal raptors as suggested by Karpanty (2003, 2006), they may provide less protection from viverrids.

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Low elevation silky sifakas (*Propithecus candidus*) in the Makira Conservation Site at Andaparaty-Rabeson: Ranging, demography, and possible sympatry with red ruffed lemurs (*Varecia rubra*)

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"It is not acceptable to joke about the silky sifaka because there is much mystery surrounding them. We do not see them very often...we don't know how many there are." English Translation of Mr. Rabeson, Andaparaty, Madagascar. October 22, 2007.

Introduction

Determining the home range size, altitudinal range, and habitat preferences of critically endangered lemurs is crucial for conservation management and understanding lemur behavioral ecology (Ganzhorn *et al.* 1997; Cowlshaw and Dunbar 2000; Sussman 2000). Additionally, long-term observations of known individuals within focal groups can be an effective monitoring system for critically endangered wild primates and permit population viability analyses (Ross and Reeve 2003; Irwin 2007). In this report, we present the results of a two month study of silky sifaka (*Propithecus candidus*) ranging and demography within the Makira Conservation Site at the new Andaparaty-Rabeson field site (Fig. 1 and 2) where we plan to initiate a long-term monitoring program. Silky sifakas are one of the four most critically endangered lemurs in Madagascar (Patel *et al.* 2007), and are the most critically endangered lemur

within the Makira Conservation Site which arguably contains 20 species of lemurs, the highest lemur diversity of any protected area in Madagascar (Rasolofson *et al.* 2007).

Silky sifakas have been rumored to exist near Maroantsetra for many years (Tattersall 1982; Dr. Christopher Holmes, WCS Technical Advisor, pers. comm.). Recent rapid surveys by ONG Antongil Conservation, Wildlife Conservation Society-Projet Makira (WCS) and the Groupe d'Etude et de Recherche sur les Primates de Madagascar (GERP) noted that some silky sifakasi inhabited the low altitude hilly rainforests adjacent to the land of Mr. Rabeson by the Antsahabe River 3 km north of the village of Andaparaty (population 1028), which lies along the large Antainambalana River approximately 30 km northwest from Maroantsetra (Rasolofson *et al.* 2007; Ratelolahy and Raivoarisoa 2007; Rakotondratsima *et al.* this volume). A more detailed history of this field site can be found in Patel *et al.* (2008).

This location is remarkable for several reasons. It is the southern-most geographic range limit of *P. candidus*, which are not found west or south of the Antainambalana River. These silky sifakas are approximately 44 km southeast from the nearest known *P. candidus* at Manandriana (Rasolofson *et al.* 2007). They are so far south that their habitat is actually just a few kilometers southwest from red ruffed lemurs (*Varecia rubra*) that have been observed at Anjiafotsy within the same block of continuous forest (Ratelolahy and Raivoarisoa 2007). Although prior reports have never suggested sympatry between *P. candidus* and *V. rubra*, we discuss new evidence suggesting some shared habitat.

Our general goals were to update the status of the silky sifakas at Andaparaty-Rabeson and develop this field site for longer term monitoring, research, and possibly eco-tourism. We began long-term data collection on silky sifaka ranging and demography and conducted numerous structured interviews using a questionnaire with local residents in order to assess local knowledge of the silky sifaka and the extent of bushmeat hunting. Our six specific goals included:

- 1) Determination of the number *P. candidus* groups and individuals.
- 2) Comparison of the elevational range of *P. candidus* at Andaparaty-Rabeson and Marojejy.
- 3) Comparison of the home range size of *P. candidus* at Andaparaty-Rabeson and Marojejy.
- 4) Development of a flagged trail system.
- 5) Assessment of *P. candidus* conservation threats at Andaparaty-Rabeson.
- 6) Assessment of sympatry with *V. rubra*.

Methods

Two expeditions were made to Andaparaty-Rabeson in the Makira Conservation Site: October 20 2007 to December 15 2007 and March 15 2008 to March 21 2008. We searched for silky sifakas and their traces (i.e. gouge marks made by males on tree trunks) daily with several research guides. When *P. candidus* were encountered, we followed them as long as possible, never approaching closer than 10 m since the sifakas were not habituated. During these encounters, GPS coordinates and altitude were recorded every 30 minutes using powerful Garmin 60csx GPS units. Physical descriptions were recorded for all individuals, and photos taken whenever possible. GPS points were also collected for all gouged trees encountered. A flagged (every 25 m) trail system was cre-

ated along existing foot paths and travel routes used by *P. candidus*. A GPS point was also recorded for every trail marker. Whenever anthropogenic habitat disturbance was encountered, a GPS point was recorded, photos were taken, and the intensity of the disturbance was classified using Lehman *et al.*'s (2006) 4-point scale.

Home range size was determined using the Ranges VI software package (Anatrack, Ltd.). 100 % minimum convex polygon (MCP), 95 % kernel, and 50 % kernel values were calculated using all of the GPS points recorded during silky sifaka encounters at Andaparaty-Rabeson (2007-2008) and at Marojejy Camp 2 (2001 to 2007) for comparison. Currently, 100 % MCP is not considered the best estimate of mammalian home range size since it is overly sensitive to outliers. It is the simplest and oldest way to calculate home range size by fitting the smallest convex polygon that fits all points (Sterling *et al.* 2000). Kernel methods provide more realistic estimates of home range size by using a probabilistic model that weights highly used areas. 95 % kernel is generally considered home range size while 50 % kernel is considered the core area (Worton 1989; Irwin 2007).

In order to learn more about local knowledge of the silky sifaka, bushmeat hunting, and socio-economics, adult local residents were interviewed in Andaparaty (n=35) and nearby Ankarongana (n=22) using a questionnaire of 27 open and closed ended questions that we created with Rachel Kramer (United States Peace Corps/WCS Project Makira). All interviews were conducted in the Betsimisaraka dialect of the Malagasy language by a native speaker, Anjaranirina Evelin Jean Gasta. Before starting, we first requested permission from the President of COBA and Fokontany, Mr. Bakalariat. Each subject was told before the interview began, that participation was completely voluntary, anonymous, and no salary would be given. In this report, we present results from the few questions directly pertinent to silky sifaka conservation.

Results

Silky Sifaka Encounters

Two groups of silky sifakas were encountered and followed on 10 days: Oct. 25 2007, Nov. 1, 6, 10, 21 2007, Dec. 1, 3, 5 2007, and March 20 2008. These encounters lasted from 15 minutes to 7 hours (when the sifakas were successfully followed all day). Group 1 contained four individuals (1 adult male, 1 adult female, 1 sub-adult male, and a young infant). Group 2 contained two individuals (1 adult female and 1 adult male). During these encounters the animals fled from us while emitting "Zzuss!" alarm calls on only a few occasions. They did appear quite vigilant however and engaged in extensive staring towards the observers. Overall, the sifakas did not behave as if there was hunting pressure on them at this particular site. They behaved as one would expect a wild unhabituated group to behave that was not yet fully accustomed to continual human observation (but not utterly unfamiliar with human presence).

Silky Sifaka Home Range Size and Elevational Range
167 GPS points were collected during silky sifaka encounters at Andaparaty-Rabeson (Fig. 1) and 134 previously at Marojejy (error range: 4 to 7 m). Table 1 displays 100 % MCP, 95 % kernel, and 50% kernel home range sizes for *P. candidus* at these two sites in compari-

son to other eastern sifakas. At Andaparaty-Rabseon, *P. candidus* was observed at altitudes between 289 m and 558 m above sea level (a.s.l.; n=167). *Propithecus candidus* at this Makira field site inhabit a much lower elevational range than at Marojejy Camp 2 where they range between 670 and 1030 m a.s.l. which is actually the lowest elevation that silky sifakas are found within Marojejy. Patel *et al.* (2008) contains all of the GPS points used in the analyses for Table 1.

Interviews of Local Residents

When shown a picture of a silky sifaka, only 19 % (11/57) of respondents said they had seen this animal before. When asked where they had last seen this animal, most of these people said at this Andaparaty-Rabeson field site (55 %; 6/11), but several people claimed to have seen silky sifakas in the Ambalangira forest near Antsahabe (27 %; 3/11). One respondent said at the Antselipoagna forest near the big lake. Similarly, another respondent said at Antselipoagna on the way to Andapa. No one reported that *P. candidus* was hunted, but 53 % (30/57)

answered "yes" when asked "Are there people in this town who hunt other lemurs?" Most respondents reported that the most commonly hunted wild animals were bush pig (44 %) and white-fronted brown lemurs (38 %). Tenrec (10 %), civet (4 %), and fossa (4 %) were also reported to be hunted locally.

Red Ruffed Lemur Sightings

The unmistakable loud "roar-shriek" vocalizations of red ruffed lemurs were heard three times within the habitat of the silky sifakas at this field site. Based upon the high volume and direction of these roar-shrieks, we estimate that the red ruffed lemurs were approximately 1 km from us, within the habitat of the silky sifakas. Moreover, one of our research guides saw several red ruffed lemurs within known silky sifaka habitat, near trail marker MIT 650, on November 29 2007 (Sassidy, pers. comm.). Finally, the landowner, Mr. Rabeson said he knew of a ruffed lemur nest around this same location, and that he had recently seen red ruffed lemurs in that region.

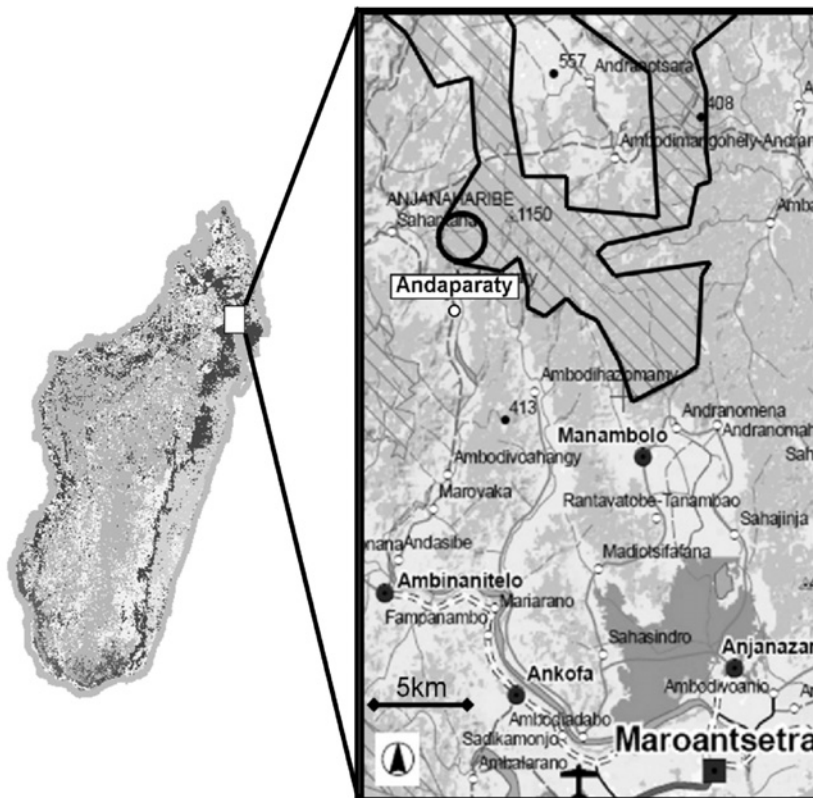


Fig. 1: Map of the region surrounding the Andaparaty-Rabeson fieldsite. Black circle represents *Propithecus candidus* sightings within the Makira Conservation Site (black polygon with stripes).

New Trail System

When we arrived there was a single long trail (approx. 2 km) flagged as AJB. We replaced all old AJB flags with fresh flags and created 11 new trails totaling approximately 5.5 km. Further details of the new trail system can be found in Patel *et al.* (2008).

Anthropogenic Disturbance

The habitat of the silky sifakas at this field site should not be considered undisturbed primary forest. As seen in Figure 1 and 2, the southern and western border of their habitat is an abrupt forest edge adjacent to land cleared and occasionally farmed by the Rabeson family. Aside from the pre-existing AJB trail, five locations of slight habitat disturbance (Level 1: Lehman *et al.* 2006) were found. These included a few old zebu corrals, remains of *Pandanus* harvest, and several small (< 0.3 ha) patches of tall

Table 1: Home range sizes in eastern sifakas.

Species (Field Site)	100 % MCP (ha)	95 % Kernal (ha)	50 % Kernal (ha)	Reference
<i>P. tattersalli</i> (Daraina)	12.2 ^b , 6.2 ^a , 9.2 ^b			Meyers (1993)
<i>P. diadema</i> (Tsinjoarivo)	83.2 ^a , 76.0 ^a , 21.2 ^b , 40.1 ^b	72.2 ^a , 79.3 ^a , 19.6 ^b , 36.8 ^b	8.6 ^a , 13.4 ^a , 3.5 ^b , 5.9 ^b	Irwin (2007)
<i>P. diadema</i> (Mantadia)	42 ^a , 33 ^a			Powzyk (1997)
<i>P. candidus</i> (Marojejy: Camp 2)	37.5 ^a	33.7 ^a	12.3 ^c	This Manuscript
<i>P. candidus</i> (Makira: Andaparaty-Rabeson)	40.2 ^c	47.3 ^c	11.1 ^c	This Manuscript
<i>P. edwardsi</i> (Ranomafana: Talatakely)	38 ^c			Wright (1995)
<i>P. perrieri</i> (Analamera: Antobiratsy)	1.0 ^b , 1.1 ^b			Lehman and Mayor (2004)

^aContinuous forest; ^bFragmented forest; ^cContinuous forest with selective logging

wild ginger (lingoza). Importantly, one major disturbance site was discovered (Level 3: Lehman *et al.* 2006) that has not been reported in prior surveys at this site. A large region (approx. 1 hectare) of about 100 five to ten meter tall *Harungana madagascariensis* (Clusiaceae), a common colonizing species of slashed-and-burned rainforest, was found hidden away from the main AJB tail within silky sifaka habitat adjacent to a branch of the Antsahabe river (S 15° 11.912; E 49° 37.236). We estimate that the land was cleared five to ten years ago, but has not been much disturbed since that time.



Fig. 2: *Propithecus candidus* habitat in hills of rainforest adjacent to anthropogenic clearings. Note the pronounced habitat edge. Photo credit: Rachel Kramer

Conclusions

Andaparaty-Rabeson is important for four major reasons. Primarily, it offers two groups of wild silky sifakas in a relatively accessible location. Once habituation is achieved, the silkies at Andaparaty-Rabeson will be as accessible as the *P. candidus* at Camp 2 (Marojejy) of Marojejy National Park for example. Secondly, the elevational range of the silky sifakas at Andaparaty-Rabeson is the lowest ever reported. Within Marojejy National Park and Anjanaharibe-Sud Special Reserve where the majority of *P. candidus* are found, they have never been observed below 700 meters a.s.l. (Patel *et al.* 2007). Thus, the results of this report extend the altitudinal range of the silky sifaka and confirm that this sifaka species, despite their extreme rarity, exhibits the greatest altitudinal range of any sifaka species (*Propithecus* spp.) in Madagascar.

This field site is also remarkable in that it is the southern-most geographic range limit of *P. candidus*. The results of this report suggest that these silky sifakas are so far south they may actually share some habitat with red ruffed lemurs (*Varecia rubra*). If true, the Andaparaty-Rabeson field site would be the only known habitat in the world where these two high profile lemur species are sympatric. Finally, this field site offers a unique opportunity to examine how silky sifakas cope with habitat disturbance and edge effects. *P. diadema* and *P. edwardsi* groups inhabiting forest fragments exhibit reduced frugivory and body mass compared to groups inhabiting continuous forest. Compared to western sifakas, these rainforest sifaka species will seldom cross nonforested regions between fragments (Mayor and Lehman 1999; Irwin 2006; Arrigo-Nelson 2006; Dehgan 2003). *P. diadema* is edge-tolerant and prefers

to feed in moderately disturbed regions of their home range (Irwin 2007). It is unknown whether *P. candidus* reacts similarly to disturbance and edge effects. The Andaparaty-Rabeson field site presents an opportunity to find out.

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Initiation and leading of travel in - *Lemur catta*

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Ring-tailed lemurs (*Lemur catta*) travel in groups through the forest foraging for food, searching for suitable resting sites, and guarding the perimeters of their

territory. As with all group-living animals, ring-tailed lemurs must coordinate their activities to maintain spatial cohesion (Boinski and Garber 2000; Conradt and Roper 2003). Individual group members have different optimal foraging strategies and schedules resulting in conflicting interests over where to travel to and when (Kappeler 2000). Thus, coordination of group movement requires that individuals communicate their desired trajectories while also making compromises in their optimal activity budgets (Conradt and Roper 2003). Research on group travel can provide insight into the social dynamics of lemur troops and the mechanisms that govern their travel decisions (Trillmich *et al.* 2004). In this study we consider the roles of group members – male and female, adult and juvenile, dominant and subordinate – in the initiation and leading of group movements in a troop of ring-tailed lemurs. *Lemur catta* live in female-dominant (Kappeler 1990; Pereira *et al.* 1990) groups that are female-resident, with males migrating at adolescence (Jones 1983; Sussman 1991, 1992). Since females are dominant and philopatric, do they lead more often than males? Similarly, do dominant members initiate and lead more than subordinates? Finally, are males and females, with their differing optimal activity budgets, leading to different activities?

The null-hypothesis of this study was that propensity to initiate and lead is independent of sex and dominance. The study took place at the Berenty Reserve in Madagascar. *Lemur catta* troop D1A was observed on 21 days for a total of over 200 hours during the months of October and November, 2002. Troop D1A had four females, two males, one sub-adult male, two juveniles, and four infants. Prior to beginning the study, both authors were able to reliably recognize all adult and juvenile members. For the study, the authors documented when they saw the acts of "initiation", "leading", and troop "progression". Initiation was defined as the act of a lemur separating itself from the edge of the troop by at least 10 m and indicating its desire to travel by facing away from the troop while continuously looking back and calling with quiet to medium meowing. Leading referred to a lemur being the first in line during a progression. Progressions were defined as the troop following a leader in a formation resembling a line over a distance of at least 10 m from one activity or feeding site to another. Co-initiation was the display of initiation behavior by two or more individuals. In a co-led progression there was an interchange between two lemurs for the lead position in line. Co-initiations and co-leads were excluded when analyzing the role of individual adult lemurs but included when comparing the difference between sexes in travel destinations and initiation success. An initiation was considered to be successful when the act of initiation resulted in a troop progression led or co-led by the initiator. Chi-square tests were used for statistical analyses.

One hundred eight documentations of travel behavior were made. These included 28 unsuccessful initiations, 49 successful initiations resulting in travel, and 31 progressions with no prior initiation detected by the observers. Every adult lemur initiated and independently led the troop in travel (Table 1). However, the dominant female and dominant male were the most frequent initiators and leaders.