

Preliminary Study of the Conservation Status of Lemur Communities in the Betsakafandrika Region of Eastern Madagascar

Regions where lemur subspecies are sympatric or hybridize are of great interest to scientists and conservation authorities. If two subspecies of lemur are sympatric and do not interbreed, then both may warrant recognition at the species level. Such taxonomic changes have important implications for conservation authorities. If the lemur subspecies interbreed, then they form a hybrid zone. There are, however, few published accounts of primate hybrid zones, and only two for lemurs (Meyers *et al.* 1989; Sterling and Ramaroson 1996; S. Johnson, pers. com.). Preliminary surveys by Goodman and Schütz (1999) north of the Onive River at Mahatsinjo forest observed the nominate form of diademed sifakas (*Propithecus diadema diadema*) nearly daily and no Milne-Edward's sifakas (*P. d. edwardsi*). However, the possibility of a sifaka hybrid zone in the region was suggested by a recent Duke expedition that captured two females and a male sifaka (K. Glander, pers. comm.). Rakotondraparany (1997) suggested that there may be a hybrid zone between common brown lemurs (*Eulemur fulvus fulvus*) and red-fronted brown lemurs (*E. f. rufus*) in his survey between Tsinjoarivo and Ambatolampy, while Goodman and Schütz (1999) observed only *E. f. fulvus* at both Mahatsinjo and Anilahila.

Survey data in the Onive River basin are also of interest because it has been suggested that this river limits the range of Indri (*Indri indri*), two subspecies of brown lemur (*E. f. fulvus* and *E. f. rufus*), red-bellied lemurs (*Eulemur rubriventer*), and *P. d. diadema* and *P. d. edwardsi* (e.g., Tattersall 1982; Mittermeier *et al.* 1994; Garbutt 1999; Goodman and Schütz 1999). Although surveys have been conducted north of the Onive River (Goodman and Schütz 1999) and 35 km south of the Onive River (Irwin *et al.*, this volume), there are few data on lemur communities in the forest region immediately south of the Onive River. Given the seemingly conflicting status of the Onive River as either an area of lemur sympatry/hybridization or barrier to lemur distribution, survey data are needed to help resolve some of the issues associated with this region.

The goal of our project was to determine the community structure of primates in forests south of the Onive River. Specifically, we wanted to: (1) document the diversity of sifakas and other lemurs and (2) determine if there are hybrid zones or areas of sympatry for *P. d. diadema* and *P. d. edwardsi* as well as other lemur species.

Methods

We conducted surveys from October 19 to November 3 1999 in the Betsakafandrika region of eastern Madagascar (Fig. 1). The Betsakafandrika region lies between the Onive and Nosivolo Rivers, and is located approximately 25 km NW of Marolambo. Steep mountainous slopes, many of which exceeded 45°, and deep gorges, characterize this region. A narrow logging road along the west bank of the Impotaka River descends from the central high plateau down to the village of Ambinanindrano (19°54'26"S, 47°45'58"E, elevation 868 m). This village is located near the confluence of the Impotaka and Manorika Rivers and served as a base for lemur surveys.

Two camps were established in forests slopes above Ambinanindrano. Camp Jangajilo (19°54'22"S, 47°47'15"E, 1277 m elevation) was set up along the southern flank of Mt. Jangajilo, 2.2 km NE of the village. Two transects were established at Camp Jangajilo. Transect 1 ran 1.5 km at 53° from Camp Jangajilo along the east slopes of Mt. Jangajilo.



Fig. 1: Locations of study sites in Betsakafandrika Region of eastern Madagascar.

Transect 2 (2.0 km) ran 220° from the camp along the south ridge of the mountain. Surveys along these transects revealed extensive forest destruction and many lemur traps (Lehman and Wright, in prep). Because of these perturbations, we decided to limit surveys at Camp Jangajilo to only 4 days (Oct 22-25 1999) and focus on locating less disturbed habitats on the opposite side of the valley. The second camp, Bezavona (19°55'02"S, 47°45'21"E, 1223 m elevation), was located 1.6 km south of Ambinanindrano. Three 2.0 km transects were established at Camp Bezavona: transect 3 ran 310° from Camp Bezavona; transect 4 (271° from the camp) traversed a mountainous ridge SW of the camp; and transect 5 ran south along the eastern slopes of Mt. Sahanamanka.

Each transect was walked slowly (0.5 - 1.0 km/h) twice per day during the times of the day best suited for locating lemurs (0800-1100 hours and 1400-1700 hours). Only one night survey, along transect 3, could be conducted due to torrential evening rain showers as well as extremely steep and muddy slopes. The following data were collected whenever a lemur group was seen: date, time, transect number, participants, latitude/longitude/elevation using a Garmin GPS 12, distance along trail, species/subspecies, group composition and size, sighting distance from trail at 90°, height (m) of first animal seen, group spread, and method of detection. We noted lemur groups sighted during travel to and from the camps. Contact was maintained with all lemur groups for as long as possible to determine species and subspecies identification. Species and subspecies characteristics described in Mittermeier *et al.* (1994) and Garbutt (1999) were used for field identifications. No animals were captured. Density estimates were not made because the number of census walks was low (Whitesides *et al.* 1988). Following Schmid and Smolker (1998), the number of lemur groups per kilometer censused were calculated for each species or subspecies sighted during surveys.

Results

Table 1 shows the number of primate groups and the sighting rates for each species or subspecies sighted during surveys. A total of 28 primate groups were seen during surveys at Camp Jangajilo (N= 1 group) and Camp Bezavona (N= 27 groups). Notes and observations for each species or subspecies are given below.

Cheirogaleus major: Four individuals were observed during the night survey at Camp Bezavona. Local people did not recognize pictures of this primate.

Daubentonia madagascariensis were not observed during surveys. Bite marks (all less than 2 weeks old) on vines and tree stumps were found along transects at both camps. Local guides recognized pictures of this species and reported that the animals were killed if they were found near the village.

Table 1. Number of primate species sighted and sighting rates (groups sighted/km) along five transects in the Betsakafandrika Region of eastern Madagascar.

Species	Number of groups sighted						Sighting Rate
	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Total	
<i>Cheirogaleus major</i>	0	0	0	4	0	4	2.00 ^a
<i>Eulemur fulvus fulvus</i>	0	0	0	0	4	4	0.10
<i>Eulemur fulvus hybrid?</i>	0	0	0	2	0	2	0.05
<i>Eulemur rubriventer</i>	1	0	1	4	5	11	0.25
<i>Microcebus rufus</i>	0	0	0	7	0	7	3.50 ^a
Total Nocturnal	0	0	0	11	0	11	5.50 ^a
Total Diurnal	1	0	1	6	9	17	0.43
Census distance (m)	1,500	4,000	10,000	12,000	12,000	39,500	

^a = Sighting rate based on one night census of transect 4

Eulemur fulvus fulvus were not seen during surveys at Camp Jangajilo but four groups were censused along transects at Camp Bezavona. Group size ranged from 4-5 individuals, composed of 1-2 males and 2-4 females (Table 2). Each group also contained one infant, which was observed to ride dorsally on a female. Local guides informed us that this species was the most common one among the local lemur community.

Table 2: Size and composition of *Eulemur* groups seen during surveys in the Betsakafandrika Region of eastern Madagascar.

	N	Mean±SD	Range	Adult Males	Adult females	Adult females with infants
<i>Eulemur f. fulvus</i>	3	5.3 ± 0.6	5-6	1-2	2-4	1
<i>Eulemur rubriventer</i>	11	3.7 ± 1.1	3-5	1-3	1-3	0-1
<i>Eulemur fulvus hybrid?</i>	2	4.5	4-5	2	1	1,2

Eulemur fulvus hybrid: Two groups of what appeared to be a hybrid form of *E. f. fulvus* and *E. f. rufus* were observed at Camp Bezavona (Table 2). The body pelage of both the males and females was a light rufus color, easily distinguishable from the brown to the gray-brown color of *E. f. fulvus* seen in the area, but lighter in color than that seen in *E. f. rufus*. The coat of male *E. f. fulvus* and *E. f. rufus* is brown to gray (Mittermeier *et al.* 1994; Garbutt 1999). The black facial and head fur of these males was similar to that seen in *E. f. fulvus*, but the collar resembled that of *E. f. rufus*, being considerably fuller and whiter. None of the animals had red crowns, as in *E. f. rufus*. The males and females also had white eye patches similar to but slightly lighter in color than those seen in common brown lemurs. None of the *E. f. fulvus* seen in the area had discernible eye patches, as had been suggested by Mittermeier *et al.* (1994).

Eulemur rubriventer: A total of eleven groups of this species were seen during surveys at Camp Jangajilo (N=1 group) and Camp Bezavona (N=10 groups). Group size ranged from 2-5 individuals, and was composed of 1-3 males and 1-3 females (Table 2). One female in the group from Camp Jangajilo and a female in each of the nine groups from Camp Bezavona carried an infant. The infants were estimated to be at least three weeks old due to their size and position on the females (riding dorsally). The body pelage of the male *E. rubriventer* at both camps was a darker brown and the under-eye spots whiter than for conspecifics at Ranomafana National Park.

Hapalemur aureus: The highly distinctive loud call of this species was heard by Rajeriarson Emile, Ratsimbazafy Ray-

mond, and Solo Justin at 0510 hours on 10/24/99 approximately 50m from Camp Jangajilo. These guides have extensive experience working with *H. aureus* in Ranomafana National Park. Most bamboo patches near the camp had fresh signs of feeding by *H. aureus*. Although local people reported frequent sightings of bamboo lemurs, they could not distinguish between pictures of *H. aureus* and eastern grey bamboo lemurs (*Hapalemur griseus griseus*).

Hapalemur griseus griseus: There were no sightings of this species. However, fresh remains of feeding bouts by *H. g. griseus* were found in many of the bamboo patches near both camps as well as along the road to Ambinanindrano.

Microcebus rufus were seen frequently (N=7 individuals) during the one night survey. Local people reported that this species is abundant throughout the region.

Discussion

Although we did not census sportive lemurs (*Lepilemur*) and eastern woolly lemurs (*Avahi laniger*), it is possible that they exist in the region and were not seen due to limited night surveys (N=1 night). The composition of the lemur community in Betsakafandrika is broadly similar to that seen by Goodman and Schütz (1999) north of the Onive River and by Irwin and colleagues (this volume) SW of Marolambo, with a few notable and important exceptions (Table 3). *P. d. diadema* were seen at the sites north of the Onive River (Goodman and Schütz 1999) but absent in forests south of the Onive River (this study, Irwin *et al.*, this volume). *P. d. edwardsi* were not seen during the present study and only once by Irwin *et al.* (this volume). Local guides for both studies reported that *P. d. edwardsi* exist in the areas. None of the people from Ambinanindrano described *fady* (taboos) against hunting lemurs.

Table 3: Species composition of lemur communities at five sites in eastern Madagascar.

Species	Beza-vona	Janga-jilo	Mahat-sinjo ¹	Ankila-hila ¹	Kirisi-asy ²
<i>Avahi laniger</i>	?	?	+	-	+
<i>Cheirogaleus major</i>	+	?	+	+	?
<i>Daubentonia madagascariensis</i>	+	+	-	+	+
<i>Eulemur fulvus fulvus</i>	+	-	+	+	-
<i>Eulemur fulvus rufus</i>	-	-	-	-	+
<i>Eulemur fulvus hybrid?</i>	?	-	-	-	-
<i>Eulemur rubriventer</i>	+	+	-	+	+
<i>Hapalemur aureus</i>	-	?	-	-	-
<i>Hapalemur griseus griseus</i>	+	+	+	+	+
<i>Hapalemur sinus</i>	-	-	-	-	-
<i>Lepilemur mustelinus</i>	?	?	+	+	+
<i>Microcebus rufus</i>	+	?	+	+	?
<i>Propithecus diadema diadema</i>	-	-	+	+	-
<i>Propithecus diadema edwardsi</i>	-	-	-	-	+
<i>Varecia variegata variegata</i>	-	-	?	?	?
Total	6	3	7	8	7

Sources of Information: ¹ Goodman and Schütz (1999), ² Irwin *et al.* (this volume)

The presence of the *E. f. fulvus* in the Betsakafandrika region is noteworthy. The Onive River has been suggested to form the southern limit to the geographic distribution of *E. f. fulvus* (Tattersall 1982; Mittermeier *et al.* 1994; Garbutt 1999). These sightings of *E. f. fulvus* at Camp Bezavona extend the southern range for this subspecies across the Onive and Manorika Rivers.

Sightings of what appears to be a hybrid form of *E. f. fulvus* and *E. f. rufus* may represent only the third documented hybrid zone for lemurs. The other lemur hybrid zones are for black lemurs (*Eulemur macaco macaco*) and Sclater's black

lemurs (*E. m. flavifrons*) near Maromandia in NW Madagascar (Meyers *et al.* 1989), and a hybrid form of *E. f. albocollaris* and *E. f. rufus* NE of Andringitra National Park (Sterling and Ramaroson 1996; Johnson and Wyner, in prep.). Although it has been suggested that hybrid forms of *E. f. fulvus* may exist in eastern Madagascar (Mittermeier *et al.* 1994), the Mangoro and Onive Rivers were thought to separate *E. f. fulvus* and *E. f. rufus*. Based on the surveys we conducted in the Betsakafandrika region, the Onive River may not serve as an effective barrier to dispersal for *E. f. fulvus*, and this subspecies may have hybridized with *E. f. rufus*. Perhaps the most important finding made during the project was the possible presence of *H. aureus* in the survey region. The critically endangered *H. aureus* is known to occur only in Ranomafana and Andringitra National Parks (Wright *et al.* 1987; Meier *et al.* 1987; Meier and Rumpler 1987; Ganzhorn *et al.* 1996/1997; Sterling and Ramaroson 1996; Tan 1999). The lack of sightings during our surveys is not surprising given the cryptic and shy nature of *H. aureus* (Wright and Randriamanantena 1989). Steig Johnson (in prep.) on 22-27 replicates of three transect walks (0.775-2.5 km) at Andringitra National Park sighted *H. aureus* only once on a transect; yet, he observed them frequently when doing all-day follows of *Eulemur*. The conservation status of this population cannot be ascertained at this time. Therefore, the Betsakafandrika region requires immediate attention from conservation authorities and forest managers because it represents only the third reported natural hybrid zone for lemurs and may contain a population of *H. aureus*.

Acknowledgments

We thank the Government of the Democratic Republic of Madagascar, especially the Ministry of Water and Forests (MEF), for permission to conduct our research. We are grateful to Dr. Benjamin Andriamihaja and the staff of the Malagasy Institute for the Conservation of Tropical Environments (MICET) and Institute for the Conservation of Tropical Environments (ICTE) for their support. We thank the people of Belanitra and Ambinanindrano for their hospitality. We gratefully acknowledge the MEF agents; ICTE and ANGAP research assistants Rajeriarson Emile, Ratsimbazafy Raymond, Rasabo Paul, Solo Justin; as well as Rasolonjatovo Louis and Ranaivonindriana Benjamin for their expertise and assistance in the field. This research was supported in part by grants from the Saint Louis Zoological Park Field Research for Conservation Program, Primate Conservation Inc., and Margot Marsh Biodiversity Foundation. We thank Steig Johnson, Mitch Irwin and Chia Tan for insightful comments on this manuscript.

Bibliography

Ganzhorn, J.U.; Langrand, O.; Wright, P.C.; O'Connor, S.O.; Rakotosamimanana, B.; Feistner, A.T.C.; Rumpler, Y. 1996/1997. The state of lemur conservation in Madagascar. *Primate Cons.* 17: 70-86.

Garbutt, N. 1999. *Mammals of Madagascar*. Pica Press, Sussex.

Goodman, S.; Schütz, H. 1999. Observations of lemurs in the forest east of Tsinjoarivo, Ambatolampy. *Lemur News* 4: 14-16.

Irwin, M.T.; Smith, T.M.; Wright, P.C. 2000. Census of three eastern rainforest sites north of Ranomafana National Park: Preliminary results and implications for lemur conservation. *Lemur News* 5.

Johnson, S.E.; Overdorff, D.J. 1999. Census of brown lemurs (*Eulemur fulvus* spp.) in Southeastern Madagascar: Methods-testing and conservation implications. *Amer. J. Primatol.* 47: 51-60.

Meier, B.; Albignac, R.; Peyrieras, A.; Rumpler, Y.; Wright, P. 1987. A new species of *Hapalemur* (Primates) from southeast Madagascar. *Folia Primatol.* 48: 211-215.

Meier, B.; Rumpler, Y. 1987. A preliminary survey of *Hapalemur simus* and a new species of *Hapalemur* in Eastern Betsileo, Madagascar. *Primate Cons.* 8: 40-43.

Meyers, D.; Rabarivola, C.; Rumpler, Y. 1989. Distribution and conservation of Sclater's lemur: implications of a morphological cline. *Primate Cons.* 10: 78-82.

Mittermeier, R.A.; Tattersall, I.; Konstant, W.R.; Meyers, D.M.; Mast, R.B. 1994. *Lemurs of Madagascar*. Conservation International. Washington, DC.

Rakotondraparany, F. 1997. Inventaire faunistique de la Forêt Naturelle de Tsinjoarivo-Ambatolampy. *Projet de Développement Forestier Intégré dans la région du Vakinankaratra*. GTZ, Antananarivo.

Schmid, J.; Smolker, R. 1998. Lemurs of the Reserve Spéciale d'Anjanaharibe-Sud, Madagascar. In Goodman S.M. (ed.) *A Floral and Faunal Inventory of the Reserve Spéciale d'Anjanaharibe-Sud, Madagascar: With Reference to Elevational Variation*. *Fieldiana: Zoology, new series* 90: 227-238.

Sterling, E.J.; Ramaroson, M.G. 1996. Rapid assessment of the primate fauna of the eastern slopes of the Reserve Naturelle Intégrale d'Andringitra, Madagascar. In Goodman S.M. (ed.) *A Floral and Faunal Inventory of the Eastern Slopes of the Reserve Naturelle Intégrale d'Andringitra, Madagascar: With Reference to Elevational Variation*. *Fieldiana: Zoology, new series* 85: 293-305.

Tan, C. 1999. Group composition, home range size, and diet of three sympatric bamboo lemur species (Genus *Hapalemur*) in Ranomafana National Park, Madagascar. *Int. J. Primatol.* 20: 547-566.

Tattersall, I. 1982. *The Primates of Madagascar*. Columbia University Press. New York.

Whitesides, G.H.; Oates, J.F.; Green, S.M.; Kluberanz, R.P. 1988. Estimating primate densities from transects in a West African rain forest: A comparison of techniques. *J. Anim. Ecol.* 57: 345-367.

Wright, P.C., Randriamanantena, M. 1989. Comparative ecology of three sympatric bamboo lemurs in Madagascar. *Amer. J. Phys. Anth.* 78: 327.

Wright, P.C.; Daniels, P.S.; Overdorff, D.J.; Meyers, D.M.; Rabaso, B. 1987. A census and study of *Hapalemur* and *Propithecus* in southeastern Madagascar. *Primate Cons.* 8: 84-88.

Shawn M. Lehman and Patricia C. Wright

Department of Anthropology & Institute for the Conservation of Tropical Environments, SUNY-Stony Brook, Stony Brook, NY 11794-4364, slehman@notes.cc.sunysb.edu

Notes on the Biogeography of *Eulemur fulvus albocollaris*

The brown lemur (*Eulemur fulvus*) is among the most widespread of the Malagasy lemurs (Jolly 1986; Mittermeier *et al.* 1994). However, this diverse species has several threatened subspecies, including the white-collared lemur (*E. f. albocollaris*) (Harcourt and Thornback 1990). The population densities of *E. f. albocollaris* appear to be low in several sites relative to neighboring brown lemur subspecies (Johnson and Overdorff 1999). Moreover, this subspecies maintains a highly restricted range in southeastern Madagascar (Tattersall 1982). Like all lemurs, these populations are threatened primarily by the conversion of suitable habitats into agricultural land (Jolly 1986; Harcourt and Thornback 1990), potentially exacerbated locally by selective logging and hunting practices (Harcourt and Thornback 1990; Johnson and Overdorff 1999). Also like most lemurs, the range limits of *E. f. albocollaris* are not entirely resolved. Many earlier reports indicate the subspecies is restricted to the eastern rain forest corridor, from the Faraony River in the north (bordered by *E. f. rufus*)