Census of Three Eastern Rainforest Sites North of Ranomafana National Park: Preliminary Results and Implications for Lemur Conservation

Madagascar's eastern rainforests have been subjected to extensive destruction in recent historic times, and such destruction continues to occur (Green and Sussman 1990). The thoughtful establishment and management of National Parks and other protected areas is one important part of conservation efforts, but the vulnerable corridors between protected areas should also be assessed and monitored. The size and health of lemur populations in forest corridors hinges both on the extent (and connectivity) of forest cover, and the density of animals therein. Although the first component can be assessed remotely, the second must be ground-truthed.

The 260-km corridor between Ranomafana National Park (RNP) and Analamazaotra Special Reserve is currently the largest continuous stretch of Malagasy rainforest without formal protection (Nicoll and Langrand 1989). The purpose of this study was to directly assess lemur population densities at three study sites within this corridor (Fig. 1). The first two sites are in or near the northern part of RNP (~20 km from the main research station), and the third is approximately 100 km to the north. By seeking contiguous forest of similar structure and health, it was hoped that comparable density estimates could be made (and therefore, the effects of anthropogenic disturbance could be assessed). The three census expeditions took place between 2 June and 23 July 1999.

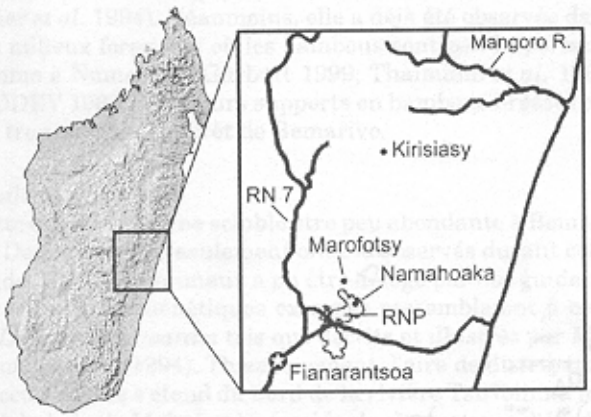

Fig. 1: Survey Locations. RNP: Ranomafana National Park; RN7: Route Nationale # 7.

Study sites

(1) Namahoaka: The village of Namahoaka (21°05.25'S, 47°32.75'E) is located 5.5 km SE of Ambohimiera (21°03.00'S, 47°30.50'E), and just north of the northern boundary of RNP. We established camp 3.5 km south of Namahoaka (21°07.49'S, 47°32.31'E, elevation approx. 1100-1200 m), within the Sahasomangana watershed. The site was accessed by driving to Sandrakely (21°06.30'S, 47°38.20'E) and hiking 13 km. This study area is within the northern parcel of RNP (Parcel I).

(2) Marofotsy: The village of Marofotsy (21°00.00'S, 47°29.70'E) is located 6 km NNW of Ambohimiera. We established camp 2.5 km W of Marofotsy (approx. 21°00'S, 47°28'E, elevation approx. 1000-1200 m). The site was accessed by driving to Sandrakely and hiking 22 km. This study area lies just outside RNP's peripheral zone, and is part of contiguous forest.

(3) Kirisiasy: The village of Kirisiasy (20°17.65'S, 47°38.05'E) is located 16 km SE of Miarinavaratra (20°12.90'S, 47°30.00'E) and approximately 75 km northeast of Ambositra. We established camp 6 km east of Kirisiasy (20°17.35'S, 47°41.38'E, elevation approx. 1200-1400 m), in the forest known locally as "Antsaona". The site was accessed by driving through Ambositra, Fandriana, and Miarinavaratra to Ampitsahandakana (20°15.30'S, 47°34.90'E). After crossing the Fisakana river, we hiked 7.5 km to Kirisiasy. This study area is contiguous with forest to the north and south, although our camp was situated in a fairly narrow strip (5-6 km wide). This region is very distant from the nearest protected forests, RNP (approx. 100 km to the south) and Analamazaotra Special Reserve (approx. 160 km to the north). As Kirisiasy is south of the Mangoro and Nosivolo rivers, this study does not address species range extents and hybrid zones. PCW previously conducted a 4-day informal survey of this region in November 1990 (see below).

Methodology

Lemur Species Richness and Density: At each study site, two 2-km trails were established and censused using standard line-transect census methodology (Struhsaker 1981, Whitesides *et al.* 1988; Johnson and Overdorff 1999). Existing trails were used whenever possible, because of time constraints and in order to minimize forest disturbance. Trails were walked slowly with the assistance of trained research guides from RNP. 19 to 26 diurnal censuses per site were conducted, evenly split between morning (8:00 to 10:00) and afternoon (14:00 to 16:00 / 15:00 to 17:00). In addition, 7 to 8 nocturnal censuses (18:00 to 20:00) per site were conducted. Sample size and summary data (sighting counts and minimum number of groups) are presented in this report (Tab. 1); further data analysis, including density estimates, is currently underway.

Botanical Assessment: Five 10 by 100 m botanical transects were established along each 2-km census trail, evenly spaced at 400 m intervals (total = 10 transects per survey site). For all trees over 10 cm diameter at breast height (dbh), the following data were recorded: local name, dbh, height and crown diameter. An additional 5 by 5 m plot was established within each botanical transect, in order to census smaller trees and lianas. This report includes brief qualitative forest assessments; data analysis currently underway will allow quantitative assessments and comparisons.

Assessment of Forest Disturbance and Hunting: Evidence of human disturbance (e.g. trees felled, tavy, traps, human habitation) was noted whenever encountered. In addition, interviews with local people, whenever possible, were conducted in order to determine the nature and extent of forest use and hunting practices.

Results

A summary of results is presented in Table 1.

Namahoaka: Four diurnal species were seen: *Propithecus diadema edwardsi*, *Eulemur fulvus rufus*, *Eulemur rubriventer* and *Hapalemur griseus*. In addition, *Varecia variegata variegata* was known to our local guides, but according to them, occurred only further south within RNP. *Hapalemur aureus* and *Hapalemur simus* were not reported to exist in the study area. Two nocturnal species were seen: *Microcebus rufus* and *Avahi laniger*. In addition, local guides testified that *Lepilemur microdon* exists in forests to the north. One possible aye-aye trace was found (approx. 1 year old).

Marofotsy: Four diurnal species were seen: *Propithecus diadema edwardsi*, *Eulemur fulvus rufus*, *Eulemur rubriventer* and *Hapalemur griseus*. Local guides reported that *Varecia v. variegata*, *Hapalemur aureus* and *H. simus* did not exist in the study area. Three nocturnal species were seen: *Microcebus rufus*, *Avahi laniger*, and *Lepilemur microdon*.

Table 1: Lemur species richness and abundance at census locations.

Location:	Namahoaka	Marofotsy	Kirisiasy
Elevation:	1100-1200 m	1000-1200 m	1200-1400 m
Sample (diurnal/ nocturnal):	38.5 km/15.7 km	52 km/15 km	37.5 km/11.1 km
Eulemur fulvus rufus	2 (2)	7 (6)	0 (3)
Eulemur rubriventer	7 (3)	7 (5)	0 (1)
Hapalemur aureus	-	-	-
Hapalemur griseus griseus	3 (2)	3 (3)	0 (1)
Hapalemur simus	-	-	-
Propithecus diadema edwardsi	7 (5)	9 (5)	0 (present nearby)
Varecia v. variegata	-	-	-
Avahi laniger	0 (1)	11 (8)	2 (3)
Cheirogaleus major	?	?	?
Daubentonia madagascariensis	+	-	+
Lepilemur microdon	-	3 (2)	1 (1)
Microcebus rufus	3 (2)	3 (4)	-
Hunting	-	+	++

Census data = # census sightings (minimum # of groups detected in study area);
Sightings indicates *group* sightings, not individual sightings

Kirisiasy: Only one species (*Eulemur rubriventer*) was seen on the census trails. *Eulemur fulvus rufus* exists in the study area, as calls were heard five times in three different places. *Hapalemur g. griseus* also likely exists in the study area, as one brief vocalization was heard, and feeding traces were found. However, the census data suggest that all three species exist at extremely low densities relative to the two other study sites. *Propithecus diadema edwardsi* and *Varecia v. variegata* were not encountered on the census trails, but local guides testified that they do exist in the area. Two nocturnal species were seen: *Avahi laniger* and *Lepilemur microdon*. In addition, local guides testified that *Microcebus rufus* and *Cheirogaleus major* exist in the study area. One aye-aye trace was found.

Because of the paucity of lemurs in the study area, we undertook two additional informal surveys: one south of the study area (approx. 20°19'S, 47°41'E; one survey team for one day) and one south of Kirisiasy (approx. 20°20'S, 47°37'E; two survey teams for one day). No lemurs were encountered on the first survey, although recent feeding traces of *Hapalemur griseus* were found. During the second survey, one team encountered *Propithecus diadema edwardsi*, and the other encountered *Eulemur rubriventer* and found two aye-aye traces (approx. 3 years and 1 year old). Local guides reported that this forest also contains *Eulemur fulvus rufus* and *Hapalemur griseus*, but these species were not seen.

During the brief survey of this region in 1990, PCW detected only *Eulemur fulvus rufus*, *E. rubriventer*, *Cheirogaleus major* and *Avahi laniger*.

Forest Use and Disturbance

Zebu (cattle) were common within the forest at both Namahoaka and Kirisiasy. Their absence in the Marofotsy forest was only because of recent thefts attributed to neighbouring villages.

Several forest trees were found to be exploited for local and regional use. At Namahoaka and Kirisiasy, large Rotra trees (*Eugenia/Syzygium* sp.) were found felled and/or stripped of bark, probably for use in flavoring locally-produced rum (tokagasy). At Namahoaka, three felled Rahiaka trees (*Chrysophyllum* sp.) were found on the census trails. Our local guides explained that this is done to harvest latex, which is used to construct traps which prevent birds (especially the forest fody, *Foudia madagascariensis*) from eating rice shoots (Turk 1995). One felled tree is reported to yield enough latex to fill approximately 10 hollow (Volosy) bamboo poles. It is possible to tap living trees, but felling trees and tapping along their length gives a more rapid yield (standing Rahiaka trees with cut marks were also encountered). This practice is especially disturbing because Rahiaka fruits and seeds are important foods for several birds and lemurs (including *Varecia* and *Propithecus*; Turk 1995). At Marofotsy, four felled Voamboana trees (*Dalbergia* sp.) were encountered on the census trails. At each location, there were two stakes driven into the ground, a discarded club fashioned from a nearby tree, and a great deal of wood debris. Local guides testified that the wood is split using clubs and wedges and stacked against the stakes before removal. *Dalbergia* is a very valuable wood, used extensively in wood carving (Turk 1995). The president and elders of Ambohimiera (the regional capital) were aware of this exploitation, and believed that the people responsible were from the Ambositra region (Ambositra is well-known for its wood carvings). Finally, at Kirisiasy, several large Tambonetra trees (*Tambourissa* sp.) had been felled and used for the production of bee boxes.

Evidence for hunting of lemurs was absent at Namahoaka, but present at Marofotsy and Kirisiasy. Two lemur traps were found at Marofotsy (one box trap and one snare) and five were found at Kirisiasy (all snares). Three snares set for fossa (*Cryptoprocta ferox*) were also encountered at Kirisiasy, two of which were set. At Kirisiasy, we also encountered local people in the forest with handmade blowguns, commonly used to hunt lemurs and/or large birds. Altogether, this evidence suggests that the Kirisiasy forest suffers the greatest hunting pressure, while Marofotsy suffers moderate hunting pressure.

Malagasy travellers were encountered at all three study sites; however, the human presence was noticeably higher at Kirisiasy than at Namahoaka or Marofotsy. Not only were more people encountered travelling through the forest, there was permanent habitation (700 m from our camp we encountered a family living in a house surrounded by rice fields), and several areas of old and new tavy (including one in the process of being cut).

Discussion

Four diurnal lemur species (*Propithecus diadema edwardsi*, *Eulemur fulvus rufus*, *E. rubriventer* and *Hapalemur griseus*) were found to exist at or near all three study sites. However, the census data suggest that they exist at much higher densities at Namahoaka and Marofotsy (within or close to RNP) than at Kirisiasy (approx. 100 km away). At Namahoaka and Marofotsy, *Propithecus* seems to exist at highest group densities, *Eulemur* species at medium densities, and *H. griseus* at somewhat lower densities.

Hapalemur aureus and *H. simus* were not found at any of the study sites. This supports previous reports (Mittermeier *et al.* 1994) though both species were found recently at Andringitra (Sterling and Ramaroson 1996) that these two species have a very limited distribution and underscores the need for continuing conservation efforts. *Varecia v. variegata* was also not encountered at any of the study sites. Other studies (White *et al.* 1995, Balko 1998) have shown that *Varecia*, as a specialized frugivore, relies more heavily upon primary forest than other eastern rainforest species; their absence in these three study sites may be due to low levels of forest disturbance which were not extreme enough to affect other lemur species. However, hunting pressure may be a more important factor. *Varecia*, weighing 3.5 kg (Smith & Jungers 1997), is larger than any other local lemur species except for *Propithecus*, and their loud territorial calls can be heard for several kilometers. In addition, *Varecia* is less like-

ly than *Propithecus* to be protected by local fady (as at Namahoaka), as they do not have the upright posture typical of *Propithecus* and therefore bear less resemblance to humans or human ancestors. These results support the assertion that, although *Varecia* has a very large geographic extent, its distribution may be highly discontinuous due to the combined effects of forest disturbance and hunting (Mittermeier *et al.* 1994). Great care should be taken in assessing this species' viability, as population estimates based on the size of its geographic range may be gross overestimates.

The nocturnal species *Avahi laniger, Lepilemur microdon* and *Microcebus rufus* probably exist at all three study sites, although *Lepilemur* may be absent at Namahoaka and *Microcebus* may be absent at Kirisiasy. *Cheirogaleus major* was not encountered, but this species is known to be inactive during the winter (Mittermeier *et al.* 1994); the lack of sightings therefore does not indicate that it is absent. Feeding traces indicate that aye-ayes (*Daubentonia madagascariensis*) are or have recently been present at Namahoaka and Kirisiasy, although they were not directly observed.

Botanically, the three study sites are very similar in species composition and canopy structure (further quantitative analyses may show subtle inter-site differences), and all were within continuous forest of reasonably large area. The bamboo species composition varied considerably between study sites; the lack of volosy bamboo at all three study sites may account for the absence of *Hapalemur aureus* and/or *H. simus* (Tan 1999). The presence of many common lemur foods, such as *Bakerella, Canarium madagascariensis, Chrysophyllum, Cryptocarya, Dombeya, Eugenia* (*Syzygium*), *Ficus, Ocotea*, and *Polyscias* at all three sites suggests that these forests are suitable lemur habitat.

However, of the three study sites examined, Kirisiasy seems to have experienced the most human disturbance. There was much more evidence of recent and current deforestation at Kirisiasy than at the other sites, as well as intense hunting and generally, more human presence. Because the Kirisiasy forest appears, based on qualitative assessments, to be botanically capable of supporting lemur populations, the extremely low lemur densities found there may be due to the effects of intense hunting and disturbance. This is much the same as the general impression of the 1990 survey, implying that these disturbing trends have been ongoing for some time.

Further surveys of corridor forests outside protected areas will be crucial in determining whether Kirisiasy is an exception, or the rule. If such disturbance and hunting is common, and lemurs exist at such low densities throughout the eastern rainforest, estimates of population size and genetic continuity will have to be adjusted accordingly. It is our hope that such surveys (in this and other forest corridors) will continue, and that these questions can be addressed. Currently, the 260 km corridor between Ranomafana and Analamazaotra is the largest continuous stretch of unprotected Malagasy rainforest (Nicoll and Langrand 1989); we recommend that the establishment of a special reserve or national park in this area should be made a priority.

Surveys such as this one should serve to temper the enthusiasm associated with successful parks and ecotourism regimes, such as Ranomafana. While these successes are crucial, it is important to persevere in the implementation of effective *regional* conservation plans which include (geographically) comprehensive assessments of species and ecosystem viability (see Goodman 1999). Otherwise, parks like Ranomafana will become biogeographic islands within a biogeographic island.

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References

Balko, E. 1998. The behavioral plasticity of *Varecia variegata* in Ranomafana National Park, Madagascar. PhD dissertation, Syracuse University, Syracuse, NY.

Goodman, S. 1999. Biological inventories of forest fragments and forest corridors in eastern and central Madagascar. Lemur News 4: 28-29.

Green, G.M; Sussman, R.W. 1990. Deforestation history of the eastern rain forests of Madagascar from satellite images. Science 248: 212-215.

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.

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

Nicoll, M.E.; Langrand, O. 1989. Madagascar: Revue de la conservation et des Aires Protégées. WWF, Gland.

Smith, R.J.; Jungers, W.L. 1997. Body mass in comparative primatology. J. Hum. Evol. 32: 523-59.

Sterling, E.J.; Ramaroson, M.G. 1996. Rapid assessment of primate fauna of the eastern slopes of the RNI d'Andringitra, Madagascar. Pp. 293-305 in S. M. Goodman (ed.). A floral and faunal inventory of the eastern side of the Reserve Naturelle Intégrale d'Andringitra, Madagascar: with reference to elevational variation, Fieldiana: Zoology, Vol. 85. Field Museum Natural History, Chicago.

Struhsaker, T.T. 1981. Census methods for estimating densities. In: Techniques for the Study of Primate Population Ecology. National Academy Press. Washington D.C.

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.

Turk, D. 1995. A Guide to Trees of Ranomafana National Park and Central Eastern Madagascar. Missouri: Missouri Botanical Garden.

White, F.J.; Overdorff, D.J.; Balko, E.A.; Wright, P.C. 1995. Distribution of ruffed lemurs (*Varecia variegata*) in Ranomafana National Park, Madagascar. Folia Primatol. 64: 124-131.

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

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