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Authors: Hekkala, Evon R., Rakotondratsima, Marius, and Vasey, Natalie

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Habitat and Distribution of the Ruffed Lemur, *Varecia*, North of the Bay of Antongil in Northeastern Madagascar

Evon R. Hekkala¹, Marius Rakotonratsima², and Natalie Vasey³

¹Department of Biology, University of Nevada, Reno, Nevada, USA

²Peregrine Fund Madagascar Project, Antananarivo, Madagascar

³Department of Anthropology, Portland State University, Portland, Oregon, USA

Abstract: Here we present information on the conservation status of ruffed lemurs (*Varecia*) north of the Bay of Antongil in northeastern Madagascar. Two contiguous protected areas were recently established that traverse this region via blocks of forest connected by narrow forest corridors: the Masoala National Park, which expands further to the east, and the Makira Protected Area, which expands further to the west and northwest. The two extant ruffed lemurs, *Varecia variegata* and *V. rubra*, overlapped in this region historically and, on rare occasions, hybridized. As such, land north of the Bay of Antongil is a critical part of the ruffed lemur's northern geographic range. Habitat surveys and interviews with local informants were carried out in this region to determine the extent of suitable habitat for *Varecia* populations, to assess the extent of human exploitation of this genus, and to obtain data on the western and northern range limits of *V. rubra*. Interviews indicated that there are populations of *V. rubra* as far northwest as the confluence of the Antainambalana and Sahantaha Rivers. Surveys and interviews revealed extensive habitat degradation and lemur hunting in the three major river drainages north of the Bay of Antongil. The recent establishment of protected forest blocks and forest corridors in the region was critical, as these links will provide the only connections between *Varecia* populations that would otherwise be entirely isolated in forest patches surrounded by agricultural land. The geo-referenced habitat survey and the summary of interview results provided here can be used as comparators for future population and habitat assessments following the establishment of the protected areas. A primary direction for future work should be to examine how *Varecia* populations are adapting to conditions in and near forest corridors.

Key Words: Black-and-white ruffed lemur, *Varecia variegata*, red ruffed lemur, *Varecia rubra*, population and habitat survey, hybrids, hunting

Introduction

The red ruffed lemur, *Varecia rubra*, and the black-and-white ruffed lemur, *Varecia variegata*, inhabit the eastern rain forests of Madagascar. The most recent IUCN assessment treated them as subspecies, with the former categorized as Critically Endangered and the latter as Endangered (IUCN 2006), but they have recently been reclassified from subspecies to full species (Groves 2001, 2005; Vasey and Tattersall 2002). The two taxa currently exhibit a parapatric distribution, with the Antainambalana River in northeastern Madagascar considered the primary geographic boundary between them (Fig. 1; Petter *et al.* 1977; Tattersall 1982). *Varecia variegata* has a range extending from south of the Mananara River in southeastern Madagascar to the Antainambalana River, northwest of the Bay of Antongil (Petter *et al.* 1977; Tattersall 1977). *Varecia rubra* has a smaller geographic range occurring only

in northeastern Madagascar. While it is known to occur on the Masoala Peninsula to the exclusion of *V. variegata*, there is little data on the western or northern boundaries of its range (Tattersall 1977).

A recent review of a wide variety of data, including historical documents and museum collections, has revealed several localities in northeastern Madagascar where more than one species of *Varecia* was collected in the late 19th and early 20th centuries (Vasey and Tattersall 2002). These localities span the three major river drainages north of the Bay of Antongil: from east to west, they are the Mahalevona, the Andranofotsy, and the Antainambalana Rivers (Fig. 1). Despite this area of historical overlap, hybridization appears to have been rare in the wild, although it evidently spanned all three river drainages. Only a handful of wild hybrids are known from northeastern Madagascar. All were collected in the late 19th and early 20th centuries, and diagnosed on the basis of their

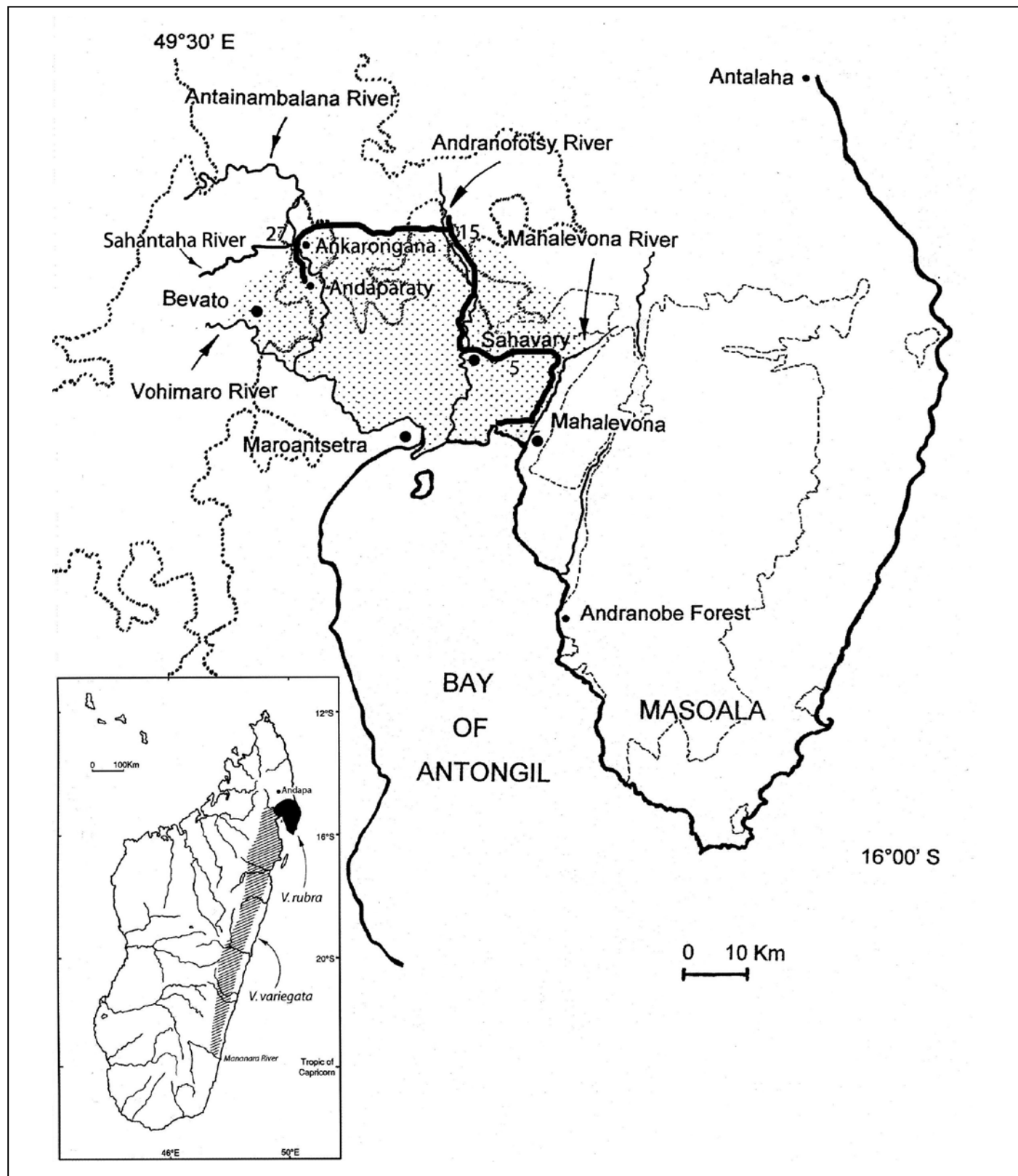


Figure 1. Masoala Peninsula and region north of the Bay of Antongil and its major river drainages. Small black arrows indicate the Mahalevona, Andranofotsy, Antainambalana, Vohimaro, and Sahantaha Rivers. Labelled dots (●) indicate towns or villages mentioned. Stippling (▨) shows area of historical overlap between different species of ruffed lemur where hybridization has occasionally occurred, with hybrids collected at Mahalevona and Bevato (Vasey and Tattersall 2002). Dashed lines (----) mark boundaries of the Masoala National Park. Dotted lines (.....) mark the boundaries of the Makira Protected Area and its link to the Masoala National Park near Sahavary. (Note that boundaries of the Makira Protected Area extend beyond the region depicted to the north, west, and south). Thick black line (—) running from Mahalevona to Andaparaty represents the route for the habitat survey, September 1998. Numbers along route indicate localities where *Varecia* were observed or heard, and correspond to geo-referenced localities in Table 1 (5 = Belampona River; 15 = Ampoantsatroka Village; 27 = Sahantaha Village). Inset shows the general distributions of black-and-white and red ruffed lemurs (hatching and black areas indicate approximate distributional limits of each species but do not imply continuous distributions within the indicated regions. Figure adapted from Vasey and Tattersall (2002).

pelage patterns (Buettner-Janusch and Tattersall 1985; Vasey and Tattersall 2002).

Beginning in the late 1980s, habitats surrounding the Bay of Antongil were identified as priority areas for Integrated Conservation and Development Projects (ICDP). The region north of the Bay of Antongil, in particular, was considered an area of exceptional biological importance (e.g., Ganzhorn *et al.* 1997). Two protected areas have since been established there: the Masoala National Park, created in 1996, encompassing 230,000 ha, most of which lies on the Masoala Peninsula east of the Bay of Antongil; and the Makira Protected Area, established in 2004, encompassing 371,000 ha, mostly west and northwest of the Bay of Antongil (Fig. 1). North of the bay, in their narrowest sections, the two protected areas are contiguous, joined together by forest blocks that are linked by narrow forest corridors, thereby spanning all three river drainages mentioned above. The Masoala National Park harbors *V. rubra*, while the Makira Protected Area contains both *V. rubra* and *V. variegata*, including some zones where the two species overlapped historically.

The establishment of ICDPs, such as those surrounding the Bay of Antongil, depended upon information on the distribution, abundance, and habitat requirements of threatened species, and the size, condition of, and threats to forest remnants (e.g., Merenlender *et al.* 1998; Kremen *et al.* 1999). The accomplishments of ICDPs should not be undervalued, even though this approach is currently undergoing considerable revision—creating protected areas hand-in-hand with improving livelihoods for local people proved more difficult to implement than to plan (Randrianandianina *et al.* 2003; Kauffman 2006). The Masoala National Park, for example, was created to protect the largest remaining tracts of lowland rainforest in Madagascar and, although designed to maintain a large, relatively pristine core area, its management regime allows for experimental timber harvesting along a number of river drainages previously subjected to substantial disturbance in the form of slash-and-burn agriculture, referred to in Malagasy as *tavy* (CARE/WCS/TPF 1995). Thus, the protected forest blocks in the northern part of the Masoala National Park lie between river drainages, while the protected forest corridors run across (or near) their headwaters.

Surveys conducted in the Antainambalana and Andranofotsy river drainages in the mid-1980s appeared to validate the species boundaries for *V. rubra* and *V. variegata* established by Petter *et al.* (1977). Few animals were sighted, however, suggesting that *Varecia* populations were small and difficult to detect in these areas due to anthropogenic habitat degradation and hunting (Simons and Lindsay 1987). Recent ecological studies on *Varecia* suggest that this obligate frugivore is a denizen of the largest trees in primary forest and for this reason is the most susceptible of the extant lemurs to habitat disruption resulting from selective logging and forest clearing (Vasey 1997, 2002; Balko and Underwood 2005). Ecologically sensitive taxa are prime candidates for population and habitat viability analysis because the conservation measures designed to protect them are likely to contribute to

the survival of many other species residing in the same biotic community (see, for example, Soulé 1987).

The goals of this project were threefold: 1) to determine the extent of suitable habitat for *Varecia* populations in selected areas of the three river-drainages directly north of the Bay of Antongil; 2) to assess the extent of human exploitation of this taxon in the region; and 3) to obtain data on the northern and, particularly, the western boundaries of *V. rubra*. Our work thus provides information on the conservation status of ruffed lemurs in a critical part of their range—an area where the two *Varecia* species overlapped historically, would occasionally hybridize, and where periodic reassessments of their habitat in and near protected areas are warranted in order to further implement and adapt current conservation measures. The enduring value of the geo-referenced habitat survey and interview results presented below comes from their use as comparators for future population and habitat assessments in the region north of the Bay of Antongil subsequent to the establishment of protected areas.

Methods

Survey techniques and data collection

Our aim was to conduct a brief survey over a relatively large area north of the Bay of Antongil, integrating local knowledge *en route*. With the help of several local assistants we conducted interviews with local informants, completed habitat surveys, and monitored the presence or otherwise of *Varecia*. We worked among the three major river drainages that enter the bay, which are from east to west, the Mahalevona, Andranofotsy, and Antainambalana. For habitat surveys, we used existing trails, which varied in condition from well-used with open canopy to freshly cut trails within relatively intact (i.e., primary) or secondary forest. *En route*, we listened for *Varecia* vocalizations and monitored for any signs of lemur activity (e.g., fruit dropping from the canopy). At sites with intact forest we split into three teams of two, and monitored for lemur activity off trail for 50–100 m. Work was suspended when heavy rain reduced audibility and visibility in the forest. Most rainstorms were brief, however, and we were able to resume our surveys after a pause of 1–2 hrs. In total, we surveyed on every day between 2–14 September 1998, between 0700 and 1800 h. Total effort each day depended on the condition of the forest (i.e., intact or secondary) with an average of 4 hrs spent in each intact forest patch encountered.

Local people were interviewed for information on *Varecia* populations and asked under what circumstances they interacted with the lemurs in their community ($n = 16$, Table 1). Interviews were conducted in Malagasy by Marius Rakotonratsima. Only open-ended questions were asked. We searched for *Varecia* in the forests where informants indicated they occurred, and carried out assessments of the habitat, estimating canopy cover and the presence of dominant plant species. One of our guides (Jao Aridy) had worked extensively with researchers on a forestry project in the area and was familiar

with intact and secondary forest communities. We assessed each area for evidence of recent anthropogenic activity, including the collection of wood or other materials. We used a Garmin GPS12XL unit to collect waypoints at 15-min intervals along the route. These were used to determine total distance covered and to note forest condition between waypoints. Intact forest in surveyed areas was quantified as the percent of the total linear distance surveyed in kilometers. This was repeated for each type of habitat observed (i.e., secondary forest, agricultural land). We also noted the presence of *tavy* and *laly*. *Laly* are long narrow swaths of forest cleared for the purpose of setting snare traps for lemurs. When *Varecia* were sighted, we noted the tree species in which they were located and whether they were feeding, resting, or engaged in other activities. We noted pelage color and patterns and photographed animals using a 300 mm lens. The other diurnal lemur that occurs in the survey area is *Eulemur fulvus albifrons*;

when sighted we noted the location, but it was otherwise not a focus of our study.

Survey route

The survey route is shown in Figure 1. Twenty-seven villages, rivers, mountains, and other localities were geo-referenced (see Table 1). On 2 September 1998, we began traveling up the Mahalevona River drainage. We then launched an east-west survey between the village of Fizona and the Andranofotsy River, crossing first into the Sahavary watershed, a tributary of the Andranofotsy. This region contains the westernmost section of the Masoala National Park, a finger-like projection separated from the rest of the park by a narrow corridor less than 1 km wide (Fig. 1). Here, we surveyed an area just south of the park boundary in a region that appeared to be relatively well-forested and sparsely populated according to maps and data collected in 1994 (CARE/WCS/

Table 1. Geo-referenced localities, habitat types, and interview results for the occurrence of *Varecia* north of the Bay of Antongil, northeastern Madagascar.

Locality ¹	Latitude (s)	Longitude (e)	Habitat type ²	Dist. ³	<i>Varecia rubra</i>	Comments ²
1. Fizona V.	15°20' 36.7"	49°56' 53.3"	Agriculture	4 km	None	Medium-sized village
2. Besot V.	15°18' 40.9"	49°56' 29.5"	Agriculture/ <i>Tavy</i>	3 km	None	Vanilla, bananas, rice
3. Mampay R.	15°18' 34.7"	49°56' 10.4"	Agriculture/ <i>Tavy/Laly</i>	7 km	None	Rice, zebu
4. Mampay V.	15°18' 21.1"	49°55' 21.0"	Agriculture/ <i>Tavy/Laly</i>	3 km	Yes. Interview	Rice, zebu, coffee
5. Belampona R.*	15°18' 50.9"	49°54' 30.5"	Secondary/ <i>Tavy/Laly</i>	6 km	Yes. 4 wild indiv.	Mining camp, wood collecting
6. Abode L.	15°19' 55.0"	49°52' 26.0"	Intact forest	1 km	Unknown	Closed canopy
7. Mahafidy R.	15°20' 31.3"	49°52' 51.8"	Agriculture/ <i>Tavy</i>	5 km	None	Zebu
8. Jaofaly V.	15°19' 59.6"	49°52' 27.5"	Agriculture/ <i>Tavy</i>	5 km	None	Zebu, vanilla, coffee
9. Navana R.	15°19' 55.9"	49°52' 27.5"	Intact forest	1 km	Unknown	Mature <i>Canarium</i>
10. Sahafotra R.	15°19' 33.9"	49°50' 49.6"	<i>Tavy</i>	4 km	Yes. Interview	<i>Afromomum</i>
11. Sahavary V.	15°19' 31.9"	49°50' 34.3"	Intact forest/ <i>Tavy</i>	2 km	Yes. Interview	<i>Afromomum</i> , rice, bananas
12. Sakatihina V.	15°15' 11.4"	49°48' 18.6"	Agriculture/ <i>Tavy</i>	2.5 km	Yes. Interview	Rice, bananas, hunters w/guns
13. Village 1 V.	15°14' 38.6"	49°49' 50.9"	<i>Tavy</i>	2.5 km	Yes. Interview	Rice
14. Betsirebika M.	15°12' 13.1"	49°49' 3.1"	Intact forest/ <i>Tavy</i>	5.6 km	Yes. Interview	Claim <i>V. rubra</i> present to northwest
15. Ampoantsatroka V.*	15°08' 40.9"	49°48' 38.5"	<i>Tavy</i>	8 km	Yes. Vocalization	Zebu, bananas
16. Ambanivaletra V.	15°07' 12.0"	49°48' 38.5"	Agriculture/ <i>Tavy</i>	5 km	No. Interview	Rice
17. Antsahimbazono L.	15°07' 58.0"	49°44' 45.8"	Intact forest/ <i>Tavy/Laly</i>	5 km	Yes. Interview	Zebu
18. High ridge L.	15°08' 0.0"	49°43' 30.0"	Intact forest/ <i>Laly</i>	3 km	Unknown	Closed canopy
19. Ampasimbola V. ⁴	15°09' 11.3"	49°44' 43.1"	Agriculture/ <i>Tavy/Laly</i>	8 km	Yes. Interview	Old camp, >10 <i>laly</i> /km
20. Betihina 1 M. ⁵	15°09' 25.3"	49°43' 6.1"	Intact forest/ <i>Tavy/Laly</i>	7 km	Yes. Interview	Large patches of intact forest
21. Betihina 2 M.	15°09' 19.6"	49°42' 31.4"	Intact forest/ <i>Tavy</i>	2 km	Unknown	Extensive clearing
22. Maintimbato V.	15°08' 15.4"	49°40' 19.6"	Agriculture/ <i>Tavy</i>	4 km	Yes. Interview	Claim <i>V. rubra</i> present to north
23. Manakana V. ⁶	15°08' 24.9"	49°40' 18.3"	Agriculture/ <i>Tavy</i>	3 km	Yes. Interview	Claim <i>V. rubra</i> present till 1996
24. Anjiafotsy V.	15°08' 38.8"	49°38' 40.4"	Agriculture/ <i>Tavy/Laly</i>	5 km	Yes. Interview	560 m elevation
25. Ambodi-Bihalay M.	15°10' 4.5"	49°35' 47.1"	Intact forest/ <i>Tavy/Laly</i>	8 km	Yes. Interview	Extremely steep terrain cleared
26. Ankarongana V.	15°10' 47.2"	49°35' 27.5"	Agriculture/ <i>Tavy/Laly</i>	8 km	Yes. Interview	Claim <i>V. rubra</i> present N and E
27. Sahantaha V.* ⁷	15°11' 18.0"	49°34' 54.0"	Agriculture/ <i>Tavy</i>	4 km	Yes. Interview	Claim <i>V. rubra</i> present E and 2 km N

¹ Localities are listed in the order in which they were visited along the survey route. Localities with asterisks (*) indicate *Varecia* observations. Abbreviations: V = village; R = river; M = mountain; L = other locality.

² Malagasy vernaculars: *Tavy* = slash-and-burn agriculture, *Laly* = narrow swaths of forest cleared for the purpose of setting snare traps for lemurs, Zebu = cattle.

³ Distance covered over which forest conditions were observed and surveyed (e.g., intact, secondary, agriculture).

⁴ *Varecia* difficult to catch, so primarily *Eulemur fulvus* is hunted.

⁵ *Eulemur fulvus* observed.

⁶ Villagers described red form (i.e., *V. rubra*) but with *V. v. subcincta* coat pattern.

⁷ Two captive *V. variegata* (kept as pets).

TPF 1995). We then traveled along the Andranofotsy River as far north as the village of Ambanivaetra. On 11 September, we began traversing the area between the Andranofotsy and the Antainambalana rivers, arriving at the village of Ankarongana. On 15 September, we returned to Maroantsetra traveling down the Antainambalana River in a dugout canoe, and noting forest condition along the shore and adjacent hillsides.

Results

In total, we covered over 120 km of trails in forest remnants. Table 1 provides the results of our geo-referencing and interviews, along with a summary of our findings on habitat for the 27 localities along our route. Habitats were significantly degraded throughout the region, with even intact forest showing evidence of human activity. Only 22% of the total linear distance surveyed was considered to be intact primary or secondary forest. Thirty-seven percent of the geo-referenced localities had one or more recent or active *laly*, and most areas (23 of 27) contained *tavy* (Table 1). In particular, areas thought to be relatively free of human disturbance during earlier surveys (CARE/WCS/TPF, 1995) were clearly used regularly for small scale *tavy* and wood gathering, and some showed evidence of *laly* as well (Table 1). Residents interviewed in 15 of 16 villages (94%) trap and eat *Varecia* despite knowing that it is prohibited by law (Table 1). Many villagers were aware of the declining numbers of ruffed lemurs, and suggested that their absence might be due to forest clearing and hunting. Villagers confirmed that *V. rubra* had disappeared from areas adjacent to villages where they had been present in the previous five years.

We sighted four *V. rubra* individuals in the region east of the Andranofotsy River, along the smaller Belampona River, prior to entering the Sahavary watershed (#5 in Fig. 1 and Table 1). These individuals were either resting or feeding on leaf tips or *Pandanus* seeds. They had large patches of white fur on the outer side of the ankle extending to the mid-thigh, a pelage pattern not seen in captivity. We later heard *Varecia* vocalizations on the west bank of the Andranofotsy at the village of Ampoantsatroka (#15 in Fig. 1 and Table 1). These two records indicate that *Varecia* still occurs between the Mahalevona, Andranofotsy and Antainambalana river drainages, and this is in agreement with interview results and the abundance of *laly* (Table 1). Most villagers indicated that *Varecia* were more active in December, a time when they are more frequently captured in *laly*.

At the village of Ankarongana, near the junction of the Antainambalana and Sahantaha rivers, villagers claimed that *V. rubra* was present to the north on Ambodi-Bilahay Mountain and to the east on Anjanaharibe Mountain (note that this is not the same location as the Réserve Spéciale d'Anjanaharibe-Sud lying further north). Residents of the nearby village of Sahantaha (#27 in Fig. 1 and Table 1) also stated that there were many *V. rubra* on Anjanaharibe Mountain. Furthermore, they related that it was not the "culture" of *varignena* (vernacular name for *V. rubra*) to cross the Antainambalana River,

and that only *varikandana* (vernacular for *V. variegata*) is known from further west on Anjorompingotra Mountain.

Families living on both sides of the Antainambalana River at Sahantaha kept *V. variegata* as pets. The two pet lemurs we observed were captured as babies in *laly*, 1–2 km north of the village on the west side of the river, and both exhibited a *subcincta* coat pattern, the variety of *V. variegata* known from the west side of the Antainambalana River (Petter *et al.* 1977). These families regularly cross the river by canoe, taking chickens and other domestic animals with them, and presumably their pet *V. v. subcincta* arrived on the east side of the Antainambalana River in this manner.

Although we did not sight any wild *Varecia* between the Andranofotsy and Antainambalana rivers, villagers consistently referred to the ruffed lemurs in this area as *varignena* (i.e., *V. rubra*). Yet in the village of Manakana some informants described these animals as having a belt of white fur encircling the torso, as seen in the *subcincta* variety of *V. variegata* known from the west side of the Antainambalana River (Table 1; Petter *et al.* 1977).

Discussion

Our interviews with villagers suggest that the Antainambalana River currently remains the western limit of *V. rubra*'s range. The westernmost distribution of *V. rubra* that we were able to detect (through interviews) was near the confluence of the Antainambalana and Sahantaha rivers. *Varecia rubra* has been observed further northeast; several animals were sighted in the Besariaka forest corridor, about 20 km southwest of Andapa, in what is now part of the Makira Protected Area (Ranorovelohanta 1996). This is the northernmost confirmed report of *V. rubra* in recent years. Our sighting of *V. rubra* along the Belampona River was approximately 10 km east of a previous sighting near the village of Sahavary (Simons and Lindsay 1987). Limited observations of *Varecia* during our survey were likely due to their rarity and sparse distribution on account of hunting and habitat disturbance, as well as their relative inactivity at this time of year (*V. rubra*, for example, spends more time resting [~60%] in June–September than at other times of the year [Vasey 2005; see also Morland 1993]). Early September is also a period of limited fruit availability for *Varecia*, when even their keystone fruit *Canarium* is unavailable (Vasey 2000).

Villagers in the survey area noted only the presence of *V. rubra*, not *V. variegata*. However, the pelage pattern of *V. rubra* described by villagers at Manakana, between the Antainambalana and Andranofotsy rivers, is unusual, and seems to resemble that of a specimen on display at the American Museum of Natural History which has been described as a hybrid (Buettner-Janusch and Tattersall 1985). This AMNH specimen has a belt of white fur encircling its torso, similar to the *subcincta* variety of *V. variegata* known from west of the Antainambalana River (Petter *et al.* 1977; Simons and Lindsay 1987). However, as we saw no *Varecia* near Manakana village, any intimation concerning natural hybridization

between *V. rubra* and *V. variegata* in this locality remains speculative—it may simply be clinal variation, as seen in *V. variegata* along the east coast of Madagascar (Vasey and Tattersall 2002).

Only 22% of the area surveyed in the region north of the Bay of Antongil was considered primary or secondary forest. Furthermore, *tavy* and *laly* were ubiquitous along the survey route. From these findings we conclude that the natural habitat of the westernmost populations of *V. rubra* is disappearing at a dramatic rate. At the time of our survey, populations of *V. rubra* west of the Masoala National Park appeared extremely fragmented and were all under threat of extirpation by trapping and hunting. In fact, it appeared that populations of *Varecia* between the Andranofotsy and Antainambalana rivers (south of the east-west trail we surveyed at latitude 15°08'15"S) were completely isolated from other populations. The recent establishment of protected forest blocks and forest corridors in the region was critical (Hekkala and Rakotonratsima 1999), as these will provide the only connections between certain *Varecia* populations that appeared entirely isolated in forest patches surrounded by spreading agricultural land. The only links between the Masoala National Park and the north-south belt of eastern rain forest in Madagascar are these passages in the Antainambalana and Andranofotsy river drainages, now part of the Makira Protected Area.

The establishment of such corridors, in the sense described by Holloway (2000), includes the replanting of native trees to reconnect the forest blocks. Although *Varecia* are known to be highly sensitive to habitat disturbance, their densities can become quite high in coastal regions experiencing frequent natural habitat perturbation (Vasey 1996, 1997), and they have even incorporated large portions of pioneering, invasive species into their diet in protected forests that are being allowed to recover from cyclone damage and human degradation (e.g., *Clidemia hirta*, *Cecropia peltata*; see Ratsimbazafy 2002; Ralainasolo *et al.* 2005). Forest corridors created north of the Bay of Antongil, especially when planted with native trees, may ultimately prove successful in maintaining and connecting *Varecia* populations. The next round of surveys and in-depth field studies should focus on an examination of how *Varecia* populations are adapting to conditions in and near forest corridors.

The establishment of protected areas, however, can comprise only one part of an effective conservation management plan for ruffed lemurs. As food, *Varecia* has dual status, being both less expensive and more tasty (according to local palates) than domestic meats, such as chicken and beef (Golden 2005). In the Makira region, these two factors are paramount in reinforcing hunting activity among remote, rural people who do not have the means to either buy or produce domestic meats (Golden 2005). As indicated above, residents trap and eat *Varecia* in all but one of the 16 villages visited in the region north of Antongil Bay. Hence, conserving *Varecia* will require multi-pronged efforts involving the establishment and maintenance of forest corridors, monitoring of the protected areas, and enforcement of environmental legislation, as well as

environmental education and development programs that capitalize on and are sensitive to traditional beliefs and practices (including palates). The enduring value of the geo-referenced interviews and habitat survey presented here is that they can be used as comparators for future population and habitat assessments in the region north of the Bay of Antongil subsequent to the establishment of protected areas and allied conservation measures.

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Authors' addresses:

Evon R. Hekkala, Department of Biology, University of Nevada, Reno, NV 89557, USA, e-mail: <ehekkala@yahoo.com>.

Marius Rakotonratsima, Peregrine Fund Madagascar Project, B.P. 4113, Antananarivo 101, Madagascar, e-mail: <pfundmad@wanadoo.mg>.

Natalie Vasey, Department of Anthropology, Portland State University, Portland, OR 97207, USA, e-mail: <nvasey@pdx.edu>.

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