LEMUR NEWS

The Newsletter of the Madagascar Section
of the IUCN/SSC Primate Specialist Group
Volume 17, 2013

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Vol. 17, 2013 ISSN 1608-1439

Front cover: The indri (*Indri indri*), the largest extant lemur, was up-listed to Critically Endangered on the IUCN Red List in 2012 based on a suspected severe future population decline due to habitat loss and unsustainable levels of hunting. © Andy Rouse/naturepl.com

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Lemur News online
All 17 volumes are available online at www.primate-sg.org, www.aeecl.org and www.dpz.eu

This volume of Lemur News was kindly supported by the Margot Marsh Biodiversity Foundation (through Conservation International's Primate Action Fund), WWF Madagascar and Houston Zoo.

Printed by Goltze GmbH & Co. KG, Göttingen, Germany

Editorial

Much has happened in Madagascar since I wrote the Editorial for Lemur News 16, about a year and a half ago (of course it should have been only a year between the two volumes, so please accept my apologies for the significant delay with publishing Lemur News 17). On the taxonomic front, three lemur species have been added to the previous list of 98, thus bringing the total number of species to 101, with 105 taxa. Of the three newcomers, two mouse lemurs, *Microcebus marohita* and *M. tanosi*, were described by Rasoloarison *et al.* (2013) from the Marolambo and Manantantely/Ivorona areas, respectively. The third one, the Lavasoa dwarf lemur (*Cheirogaleus lavasoensis*), was described by Thiele *et al*. (2013) from the Lavasoa Mountains in the Ambatotsirongorongo protected area. If lemur species descriptions continue at their current rate, then Madagascar may soon surpass Brazil as the country with the highest primate species diversity on Earth (it is of course already the country with the highest number of endemic primate species).

As already announced in my Editorial to Volume 16, in July 2012 the IUCN SSC Primate Specialist Group held a lemur Red-Listing and conservation-planning workshop in Antananarivo. The Red-Listing was part of a global reassessment of all mammal species that will be completed in 2015, and that will see three more workshops, for Neotropical, Asian and African primates respectively, being held in the coming two years. The outcome of the lemur reassessment was eye-opening not only to the members of the Primate Specialist Group: With 94 % of all taxa in the Red List's three 'Threatened' categories (i.e. Vulnerable, VU; Endangered, EN; or Critically Endangered, CR), up from 74 % at the last assessment in 2005, lemurs had become the most threatened larger group of vertebrates on the planet. This increase was due, to an extent, to genuine and sometimes dramatic status changes, for example the mongoose lemur (*Eulemur mongoz*; EN to CR), the ring-tailed lemur (*Lemur catta*; Near Threatened, NT to EN) and the aye-aye (*Daubentonia madagascariensis*; NT to EN). The majority of the increase in the percentage of threatened lemurs was however brought about by status changes in those species, mainly sportive lemurs (genus *Lepilemur*), that were previously categorised as Data Deficient (DD) and for which sufficient data were now available to allow us to move them into one of the other Red List categories. Many of them were assessed to have very small distribution ranges that have already been severely fragmented, thus meeting the threshold of one of the 'Threatened' categories under the 'B' criterion of the Red List (small geographic range). Since most populations of larger, relatively immobile forest-dependent organisms are undergoing continuing decline in Madagascar (with a background deforestation rate of about 0.8 % per annum), the status of these species often changed from DD to VU, EN or CR.

Once we had reassessed the conservation status of all lemurs (103 taxa at the time of the workshop), we spent another three days on drafting a new conservation action plan (nowadays called a 'conservation strategy'). The last, and thus far the only action plan for lemurs, had been written in 1992 and "expired" in 1999. The bulk of the work started after the actual workshop, and it took the better part of a year for 83 authors to write 41 chapters, including 30 site-based conservation strategies with nominal three-year budgets. The action plan, entitled "Lemurs of Madagascar – A Strategy for Their Conservation 2013–2016" (Schwitzer *et al.*, 2013), was launched in July/August 2013 in Antananarivo and Ranomafana and will serve both as a tool for fundraising and for guiding conservation action to get lemurs over the worst of the environmental crisis that Madagascar is currently engulfed in, partly as a direct consequence of the ongoing political crisis and the resulting breakdown of law enforcement.

Encouragingly, after four and a half years of political deadlock, the Malagasy people were finally called to vote for a new President – almost a year later than what people were hoping for when we published the last volume of Lemur News. As I am writing this Editorial, the first round of elections has been held without major troubles or irregularities, and since no candidate obtained an outright majority, a second round will be held in a few weeks time. The challenges ahead are plentiful for whoever wins this election, with poverty levels skyrocketing and public coffers pretty much empty; the environment will be only one of the new President's many concerns. But it is hoped that once democracy has been reinstated, foreign aid to Madagascar will quickly resume and help the country and its people, its new government and its NGOs to find solutions to the enormous environmental problems that Madagascar is facing.

To end on a satirical note, a friend of mine alerted me to the caricature from *L'Express de Madagascar* that we have reproduced below, which refers to Madagascar's rugby team, the "Makis", winning the Africa Cup's B league on home soil against Namibia in July 2012. I liked this, not only because it depicts how bushmeat consumption in Madagascar has increased dramatically since the onset of the crisis in 2009,

but also because it shows that the precarious situation lemurs and their habitats are facing has certainly arrived in the public consciousness in Madagascar and the world.

The Margot Marsh Biodiversity Foundation, through Conservation International's Primate Action Fund, the WWF Madagascar and West Indian Ocean Programme Office and Houston Zoo kindly supported this volume of Lemur News.

Christoph Schwitzer

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Short Communications

Distribution of school reconstruction materials following Cyclone Giovanna to local communities working to conserve greater bamboo lemurs in and around the Ankeniheny-Zahamena Corridor, eastern Madagascar

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February 2012 will be remembered in Madagascar for the destruction caused by Cyclone Giovanna followed closely by Tropical Storm Irina. During the night of February 13 to 14, Giovanna, graded 6.5 on the 8 grade-Dvorak scale, hit the east coast near Vatomandry and Brickaville, crossed the country and left by the west coast late morning, causing great damage. The last evaluation of human victims on February 20 was 25 dead, 90 injured, 3 disappeared and 263,190 impacted in other ways, mainly through loss of homes (www.sobika.mg). On February 26, the island's east coast was hit by a second storm, Irina, less intense, but still destructive, with a lot of rains which provoked many land slides and cut roads and railways.

The combination of these two natural events was very damaging for the country and, for several months, the humanitarian agencies were concerned about the high risk of famine due to the destruction of rice paddies, fields and fruit trees. This was certainly the case for the sites in and around the Ankeniheny-Zahamena Corridor (CAZ) where The Aspinall Foundation works with local communities to conserve Critically Endangered greater bamboo lemurs (*Prolemur simus*) (King and Chamberlan, 2010; Ravaloharimanitra *et al.,* 2011). Several sites located in the Brickaville District (Bonaventure *et al.*, 2012; Lantovololona *et al.*, 2012; Mihaminekena *et al.*, 2012) felt the full force of Cyclone Giovanna, whilst those in the western part of the CAZ corridor (Olson *et al.*, 2012; Randrianarimanana *et al.*, 2012) were also strongly impacted.

In the Brickaville District many houses and schools were destroyed or damaged, rice fields flooded, litchi and other fruit tree plantations destroyed. The *Prolemur simus* habitats surrounding the Andriantantely lowland rainforest sites were seriously affected, with virtually all trees and bamboos (*Valiha diffusa*) uprooted or broken (H. Randriahaingo, unpubl. data; Fig. 1). The ranging behaviour of the *P. simus* groups was impacted for two weeks, but returned to normal afterwards with the growth of new bamboo

Fig. 1: *Prolemur simus* habitat damaged in February 2012 by Cyclone Giovanna at the Anjinjanaomby site, near Andriantantely forest, Brickaville District.
(Photo: Hery Randriahaingo)

Fig. 2: *Prolemur simus* habitat damaged in February 2012 by Cyclone Giovanna at the Sakalava site in the Ankeniheny Zahamena Corridor. (Photo: Lucien Randrianarimanana)

Fig. 3: The village of Tanamboa, near Andriantantely forest, Brickaville District, following Cyclone Giovanna in February 2012. (Photo: Hery Randriahaingo)

shoots. According to our local research assistants, one juvenile *P. simus* was killed by the cyclone at the Lanonana site, and two *P. simus* individuals disappeared at the Ambodimanga site (FKT Ambinanifanasana).

In the western CAZ hundreds of hectares of local rice-fields were flooded for over two weeks, zebu cattle died in the forest, two people died at the village of Ranomainty, many houses were destroyed, schools and bridges damaged. Forest disturbance was most severe in the southern sites of Sakalava and Raboana. In some places an estimated 80 % of the bamboo (*Cathariostachys madagascariensis*) and 40 % of the trees were uprooted (H. L. Randrianarimanana, unpubl. data; Fig. 2). We found some lemurs (not *P. simus*) dead in the forest following the cyclone, and monitoring of the *P. simus* groups became more difficult due to the damage to the forest and the groups splitting into sub-groups (group fission). After the cyclone, new bamboo shoots sprouted fairly rapidly, attracting an influx of zebu cattle to eat them.

All around the sites, much local infrastructure required complete or partial reconstruction, such as roads, houses and schools (Figs. 3, 4, 5). We found it important to bring assistance to the local populations with whom we collaborate for the conservation of Madagascar's biodiversity. Thanks to funds sent primarily by the "Association Française pour la Sauvegarde du Grand Hapalémur", and also from a private donor in the UK, we purchased 440 corrugated iron sheets to help repair the roofs of 14 primary schools and one secondary school used by communities with whom we collabo

Fig. 5: The public primary school in the Hananhana village, near Andriantantely forest, Brickaville District, following Cyclone Giovanna in February 2012.
(Photo: Mandimbisoa Rakotomanga)

Fig. 4: The public primary school in the Lanonana village, near Andriantantely forest, Brickaville District, damaged by Cyclone Giovanna in February 2012.
(Photo: Hery Randriahaingo)

Fig. 6: The primary school in the village of Ranomainty, Didy Commune, in Nov 2012, repaired following damage by Cyclone Giovanna.
(Photo: Lucien Randrianarimanana)

Fig. 7: Conservation education session led by Lova Ranaivosoa at the public primary school in Ambodimolaina, Brickaville District, following the distribution of the roofing materials, June 2012. (Photo: Hasimija Mihamienekena)

Tab. I: Communities which received corrugated iron sheets for repairing school class rooms. (Note: CEG: Lower secondary school; EEP: Public primary school; FKL: Primary school temporarily funded by parents).

Commune	Town/ village	School type	Class rooms	Sheets distributed	Date
Communities concerned with conservation of Ambalafary, Vohiposa and Sahavola sites, Brickaville District					
Anivorano Est	Anivorano Est	CEG	4	10	14/05/2012
	Anivorano Est	EEP	7	10	14/05/2012
	Sandraka	EEP	2	30	06/06/2012
	Ambodimolaina	EEP	5	30	03/06/2012
Fanasana	Fanasana	EEP	3	30	14/05/2012
	Mangabe	EEP	5	60	14/05/2012
Communities concerned with conservation of Andriantantely forest, Brickaville District					
Fanasana Gare	Lanonana	EEP	3	40	14/05/2012
	Hanahana	EEP	3	30	14/05/2012
Loharian-dava	Tanambao	FKL	3	30	14/05/2012
Fetraomby	Ambinanifanasana	EEP	3	30	17/06/2012
	Sahavily (FKT Ambinani)	EEP	2	30	17/06/2012
	Ampasimiady (FKT Ambinani)	EEP	2	30	17/06/2012
Communities concerned with conservation within the western portion of the CAZ corridor					
Morarano Gare	Sakalava ambany (FKT Sakalava)	EEP	2	40	13/04/2012
	Raboana (FKT Morarano Gare)	EEP	2	26	27/04/2012
Didy	Ranomainty (FKT Ambohibe)	EEP	1	14	05/06/2012
Total		15 schools	43	440	

used to distribute the materials to their final destination, rate (Tab. I; Fig. 6). All sorts of transport methods weremany of which are isolated and lacking vehicle access, such as car, train, small tractor, "pousse-pousse", or simply carried by local people.

Usually attracting a large gathering of adults and children at each destination, the distribution of the material was also an opportunity to hold outreach sessions with the local communities, regarding *Prolemur simus*, its conservation, and related Malagasy laws (Fig. 7).

Acknowledgements

We thank all the local authorities and communities with whom we work for their collaboration in conserving endangered lemurs and their habitats in eastern Madagascar.

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Ring-tailed lemurs (*Lemur catta*) using cliffs as sleeping sites

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Primate sleeping habits and habitat preferences are important factors for understanding primate behaviours (Anderson, 1998). While the majority of primates sleep in trees, several haplorhine primates have been observed to sleep on vertical cliff faces and/or in caves. It has been postulated that such unique sleeping sites may be selected based upon their inaccessibility to predators, thermoregulatory benefits, proximity to food sources, and/or to aid in territorial defence (Anderson, 1984, 1998; Li *et al.*, 2011: Tab. 1). Species known to utilise cliffs or caves are largely terrestrial. To our knowledge, the selection of vertical rock habitats for sleeping by the primarily arboreal strepsirrhine primates has been confirmed at only one locality, the high mountains of the Andringitra Massif (Goodman *et al*., 2006).

Tab. 1: Primate species known to make use of cliff faces and caves as sleeping sites and their dominant substrate use. *A term used to describe locomotion on a rocky substrate. See Workman and Schmitt (2012).

Species	Cliff	Cave	Source
Arboreal			
Formosan rock macaque (*Macaca cyclopis*)	X		Reviewed in: Anderson (1984)
Francois's langur (*Trachypithecus francoisi*)	X		Qihai *et al.* (2009)
Hatinh langur (*T. hatinhensis*)	X		Ha (2006)
White-headed langur (*T. poliocephalus leucocephalus*)	X		Huang *et al.* (2003)
Semi-terrestrial			
Japanese macaque (*Macaca fuscata*)	X		Hayashi (1969)
Barbary macaque (*M. sylvanus*)	X		Reviewed in: Anderson (1984)
Terrestrial			
Tibetan macaque (*Macaca thibetana*)	X		Ogawa and Takahashi (2003)
Chimpanzee (*Pan troglodytes*)		X	Pruetz (2007)
Olive baboon (*Papio anubis*)	X		Nagel (1973)
Yellow baboons (*P. cynocephalus*)	X		Reviewed in: Anderson (1984)
Hamadryas baboon (*P. hamadryas*)	X	X	Hamilton (1982)
Chacma baboon (*P. ursinus*)	X	X	Reviewed in: Anderson (1984)
Gray langur (*Semnopithecus entellus*)	X		Reviewed in: Anderson (1984)
Gelada baboon (*Theropithecus gelada*)	X		Reviewed in: Anderson (1984)
Petrous*			
Delacour's langur (*Trachypithecus delacouri*)	X		Workman and Schmitt (2012)
Unconfirmed			
Laotian langur (*Trachypithecus laotum*)	X	X	Steinmetz *et al.* (2011)
Cat Ba langur (*T. p. poliocephalus*)	X		Nadler and Long (2000)

Within the strepsirrhine clade, the ring-tailed lemur (*Lemur catta*) exhibits the most terrestrial behaviour, spending up to 33 % of its time on the ground (Sussman, 1974, 1999). This species is found across the arid south of Madagascar, the canyon lands and grasslands of Isalo, and in the rainforests and high montane scrublands of the Andringitra Massif (Sussman, 1974; Goodman and Langrand, 1996; Goodman and Rasolonandrasana, 2001; Sussman *et al*., 2003; Goodman *et al*., 2006). They are adept rock climbers, and individuals have been noted to scale vertical rock faces at Andringitra and Isalo National Parks, as well as rock cliffs in the Vohimena Forest (Goodman and Langrand, 1996) and in the Anja Community Reserve (authors' personal observations).

During the months of June and July 2012, biological inventories were conducted in the Ifotaka-North Protected Area (PA) as part of a long-term species monitoring study in accordance with the site's Participatory Environmental Monitoring Plan (Ferguson, 2011, unpubl. data). The PA is located within the Mandrare Valley, approximately 30 km to the northwest of the Berenty Private Reserve (Fig. 1). Large cliff outcroppings can be found along the eastern tributaries of the Mandrare River, as well as along exposed ridgelines of the adjacent mountains. *L. catta* were frequently observed near the Mahavelo camp, situated along the Isantoria River, an ephemeral tributary of the Mandrare (24°45'52.02"S, 46° 9'14.15"E).

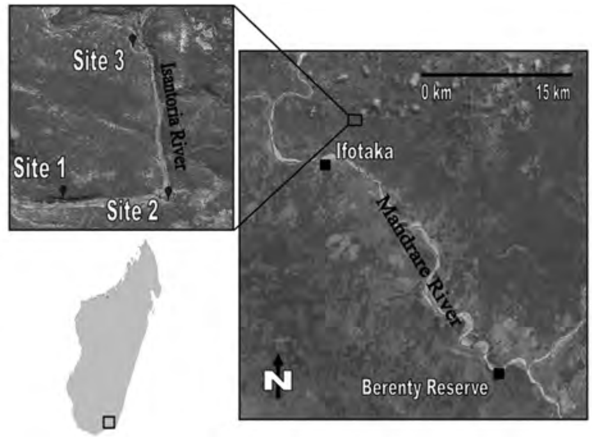

Fig. 1: Map showing locality of study site and three cliff faces where *L. catta* were observed to sleep at night.

One group of approximately 15 individuals was repeatedly observed sleeping on the cliff face on the south side of the river, opposite the camp (Fig. 1; Site 2). Two other troops also were observed to use vertical cliff faces as sleeping sites on several occasions. One was 0.5 km downstream (Site 1), the other 1.0 km upstream (Site 3). The dimensions of the cliff faces varied, with bare rock exposures ranging from 60 x 40 m and 100 x 30 m, to a maximum of 300 x 55 m. All rock faces were of igneous origin and oriented facing the east, northeast, and south, respectively. Sleeping sites along the rock faces were consistent over a prolonged period as evidenced by large piles of *L. catta* faeces at the base of the cliffs. Lemurs would arrive at the sleeping sites just before dark (ca. 17:40 hrs) and leave in the morning at first light (ca. 05:40 hrs; Fig. 2).

It is possible that the rocks aid in thermoregulation by providing radiant heat during cool nights (Anderson, 1984). However, after leaving the cliffs each morning, troops would relocate themselves in places more exposed to the morning sun to sunbathe. In addition, the cliffs may serve as refuge from mammalian predators. Direct sightings and footprints

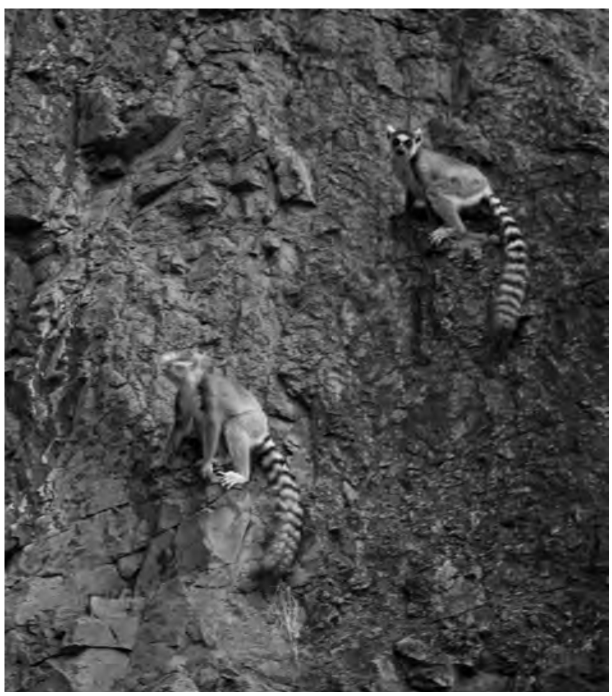

Fig. 2: *L. catta* traversing cliff face where they were observed to sleep at night. (Photo: Mark Scherz)

from known predators, including fossa (*Cryptoprocta ferox*), domesticated dogs (*Canis lupus familiaris*), and cats (*Felis silvestris*), were found in the immediate area over the course of the study (Goodman, 2003; Jolly, 2003). Lemurs were not observed to engage in geophagy on the cliff side, though observations were difficult in the dark. Due to the short nature of the study period, any effects of seasonality were not observed.

While it was suggested by local sources that *L. catta* (as well as *Propithecus verreauxi*) may use caves as shelter during storms, or even sleep in them, that behaviour was not directly observed at Ifotaka. Although Goodman *et al.* (2006) and Goodman and Langrand (1996) describe *L. catta* using fissures and overhangs for sleeping sites, neither manuscript references the use of caves as sleeping sites. Local guides have reportedly witnessed *L. catta* sleeping in caves in the Anja Reserve, and *L. catta* has been observed drinking water from the edge of a large cave system around the arid Mahafaly plateau in the southwest of Madagascar (Reviewed in: Goodman *et al.*, 2006). Future research on cliff sites may confirm the use of caves as sleeping sites by *L. catta* and will tell us what ecological factors lead to cliff use by these primates.

Acknowledgements

The authors would like to thank the Ministry of Environment and Forests (Research permit Number: 234/12/MEF/SG/DGF/DCB.SAP/SCB) and the collaboration between Operation Wallacea, the community of Ifotaka, the Libanona Ecology Centre (Fort Dauphin), and ESSA-Forêts of the University of Antananarivo, which facilitated this research. Special thanks to Dr Ken Glander and Brad Semel for reviewing drafts of this manuscript.

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Sensibilisation à la conservation de *Prolemur simus* dans le District de Brickaville

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Les activités effectuées dans le cadre du projet «Sauver *Prolemur simus*» de The Aspinall Foundation (King et Chamberlan, 2010) ont permis d'identifier sept associations communautaires (COBAs) impliquées dans la gestion des sites de basse altitude abritant *Prolemur simus* au niveau du District de Brickaville (Ravaloharimanitra *et al.*, 2011; Bonaventure *et al.*, 2012; Lantovololona *et al.*, 2012; Ravaloharimanitra et King, 2012). Ces COBAs sont réparties dans quatre Communes Rurales (Tab. 1).

Tab. 1: Sites abritant *Prolemur simus* dans le District de Brickaville, et les COBAs impliquées dans leur gestion.

Commune	Site	COBA	Description du site
Anivorano Est	Vohiposa	Tsiriniala	Bonaventure *et al.*, 2012
		Vohiposa	
		Maevasoa	
	Sahavola	Néant (propriété privée)	Mihaminekena *et al.*, 2012
Fanasana Gare	Ambalafary	Ainga Vao	
	Lanonana	Dimbiazan-jafy	
Lohariandava	Ambodiantafana	Fiasamirindra	
Fetraomby	Ambodimanga	Soafaniry Sahatoana	

Prolemur simus est considéré en danger critique d'extinction (IUCN, 2012) et a été classé par Mittermeier *et al.* (2009) parmi les cinq espèces de lémuriens les plus menacées. Malgré cela, les études et suivis effectués depuis 2010 dans les sites du District de Brickaville ont démontré l'existence de pressions et menaces qui pesant encore sur l'espèce (Bonaventure *et al.*, 2012; Lantovololona *et al.*, 2012; Mihaminekena *et al.*, 2012). Cette situation traduit une grande méconnaissance de l'importance de l'espèce et de ses conditions de vie, d'où l'intérêt de la grande campagne de sensibilisation que nous avons mise en place pendant l'année 2012 (Tab. 2). L'éducation a pour finalité le changement de comportement et de mentalité de la population locale vis-à-vis l'espèce.

Les thèmes que nous avons traités tournent autour de l'information sur les textes et législations en vigueur, afin que toute la population locale sans exception soit consciente de l'existence de réglementations régissant l'accès, l'utilisation et la conservation des ressources naturelles. Le but est de faire comprendre que l'accès libre et sans contrôle aux ressources naturelles est révolu, pour le bien de la biodiversité et de l'humanité.

L'éducation consiste à inciter un changement de mentalité de la population locale, et de la façon dont elle considère les lémuriens, en particulier *Prolemur simus* (Figs. 1, 2, 3). L'objectif est de faire passer l'espèce de l'état de gibier à une richesse à préserver.

La plupart des documentaires disponibles sur les lémuriens sont en langue étrangère alors que le niveau de scolarisation dans nos zones d'intervention est encore relativement bas. En effet, la plupart des écoliers n'atteignent même pas la dernière année de l'école primaire. Cette situation perdure depuis plusieurs années, si bien que même au niveau des adultes, une grandes quantités d`eux sont illettrés et analphabètes.

La solution envisageable à court terme est alors la production et l'augmentation de supports audio-visuels en langue malgache, pour une assimilation totale des informations à faire passer. A moyen terme, une alphabétisation des adultes est à envisager, et à long terme, l'amélioration de la qualité et de l'accès à l'éducation en milieu rural. En outre, la production de matériels scolaires parlant des lémuriens et l'organisation de visites de parcs figurent parmi les meilleurs moyens pour diriger la population locale vers la considération des lémuriens autrement que comme gibier, et développer l'amour de la nature chez les écoliers. D'ailleurs, un

Fig. 1: Lova Ranaivosoa effectuant une séance d'information sur *P. simus* à Ambodimolaina en août 2012. (Photo: Hasimija Mihaminekena)

Fig. 2: Posters simples présentant les espèces de lémuriens régulièrement observées au sein des divers habitats du District de Brickaville, affichés dans les villages et aux bureaux des COBAs. (Photo: Anjara Bonaventure et Felaniaina Lantovololona)

Fig. 3: Animation de jeu avec les écoliers de Mangabe en février 2012, avec comme récompense des cahiers avec des photos de lémuriens. (Photo: Maholy Ravaloharimanitra)

Fig. 4: Distribution de cahiers *P. simus* dans l'école primaire d'Ambinanifanasana, CR Fetraomby, en 2011 par, de gauche à droite, les représentants de The Aspinall Foundation (M. Ravaloharimanitra et T. King), le Président de la COBA Soafaniry et le Directeur de l'école. (Photo: Lova Ranaivosoa)

Tab. 2: Descriptions des sessions de sensibilisation que nous avons effectuées dans le District de Brickaville en 2012, autour des sites abritant *Prolemur simus*.

Date	Lieu	Membres de la COBA (2012)	Population locale (2009)	Thèmes et matériels	Participants
01/02/2012	Mangabe COBA Ainga Vao	47	880	Projection de films documentaires sur *Prolemur simus* et les différents lémuriens de Madagascar	L'ensemble de la population locale du Fokontany Mangabe, adultes comme enfants
03/02/2012	Lanonana COBA Dimbiazan-jafy	46	450	Les textes et législation forestiers en vigueur	29 membres de la COBA
12/05/2012	EPP PK206 (CR Lohariandava)			Projection du film documentaire intitulé «Vision Madagascar», produit par USAID	1 instituteur 35 élèves
03/06/2012	Ambodimolaina (Fokontany du site Sahavola)	Pas de COBA		Présentation de posters décrivant les caractéristiques de *Prolemur simus*, les autres lémuriens présents dans le district et les menaces pesant sur les lémuriens en général	Les enseignants et les 244 élèves de l'EPP Ambodimolaina
06/06/2012	EPP Sandraka COBA Tsiriniala	59	951		Les enseignants et élèves de l'EPP Sandraka
14/06/2012	EPP Mangabe COBA Ainga Vao	47	300		4 enseignants 189 élèves
23/08/2012	Ampasimazava (Fokontany Lanonana) COBA Dimbiazan-jafy	46	245	Textes et législation relatifs à l'utilisation et l'exploitation des ressources naturelles	La population locale du village d'Ampasimazava
24/08/2012	Hanahana COBA Dimbiazan-jafy	46	700	Conservation des lémuriens, gestion de l'exercice du droit d'usage	La population locale du village Hanahana (adultes et enfants)
10/09/2012	Fanasana Gare			Projection de films documentaires sur *Prolemur simus* et les différents lémuriens de Madagascar	Les enseignants et élèves de l'EPP Fanasana Gare
16/09/2012	Ambinanifanasana COBA Soafaniry Sahatoana	86	327	Projection de films documentaires sur *Prolemur simus* et les différents lémuriens de Madagascar	47 adultes et tous les enfants du village
10/12/2012	Anivorano Est			IEC sur la conservation de l'environnement, avec les enseignants du CEG	Les élèves et enseignants du CEG Anivorano

résultat positif a déjà été ressenti, après notre distribution de cahiers scolaires montrant les photos et noms vernaculaires de *Prolemur simus* et d'autres lémuriens auprès des écoles primaires des quatre communes d'intervention en 2011 (Chamberlan, 2012; Fig. 4).

Les travaux d'information, éducation et communication (IEC) réalisés en 2012 dans le District de Brickaville constituent une activité pionnière qui mérite un élargissement à tous les sites, en traitant divers thèmes relatifs à la conservation de l'espèce et de son habitat, ainsi que le rôle que la population locale aura à jouer. Les travaux d'IEC sont à intensifier, en abordant différents thèmes sur *Prolemur simus* et la conservation de l'environnement en général, lors de passages réguliers tout au long de l'année, afin d'accélérer l'acquisition et l'adhésion à la conservation. Si le développement d'activités alternatives aux pressions reste le meilleur moyen de conviction auprès des adultes, les voyages d'études organisés ont un effet bénéfique sur les écoliers qui, par ce biais, acquièrent une plus grande ouverture d'esprit vis-à-vis l'environnement et deviennent de fervents défendeurs de la nature au sein de la société.

Remerciements

Nous adressons nos vifs remerciements à toutes les personnes et institutions publiques ou privées ayant contribué, de loin ou de près, à la réalisation de ces travaux, en particulier le Ministère de l'Environnement et des Forêts, qui nous a délivré le permis de recherche. Nous tenons également à remercier vivement les représentants des hiérarchies administratives et traditionnelles locales, les patrouilleurs locaux et les membres des COBAs pour leurs collaboration et compréhension. Enfin, nos vives reconnaissances s'adressent à tous les généreux donateurs et partenaires de The Aspinall Foundation dans le cadre du Projet «Sauver *Prolemur simus*» qui, par leur soutien, ont permis la réalisation de ces activités.

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A case of a mouse lemur (*Microcebus lehilahytsara*) being inextricably entangled in a spider's web

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A considerable literature exists on the types of animals predating cheirogalid lemurs, particularly members of the genus *Microcebus*. To our knowledge, these are exclusively vertebrates, including an assortment of endemic and introduced Carnivora, snakes, birds of prey, and other lemurs (e.g. Goodman, 2003; Karpanty and Wright, 2007). Here we report on the case of a mouse lemur entangled in a spider web, where it may have ultimately been preyed upon by this invertebrate.

During the night of 30 March 2013, while on a night walk in the Analamazaotra Forestry Station, we observed a large spider's web that had been constructed as a deep bowl shape and attached between a few smaller branches (Fig. 1). This type of web, constructed by members of the spider family Pisauridae or Theridiidae family is common in the Andasibe forest. On closer inspection, the web contained a mouse lemur, presumably referable to *M. lehilahytsara*, the only species known to occur in this immediate area (Kappeler *et al.*, 2005).

Fig. 1: Spider web of the family Pisauridae or family Theridiidae found within forested habitat in the Analamazaotra Forestry Station that contained an entangled *Microcebus lehilahytsara*. (Photo: Emily Crane)

The lemur had become trapped in the bottom of the non-sticky web sheet, presumably after falling into it from above. The upper portion of the web was covered and camouflaged with leaves and other forest detritus, and the upper portion of the web opened into a closed space between two connected silk curtains. A small vertebrate passing on the upper surface of the branches, from which the web was suspended, could easily fall into this sort of "trap door" device. When discovered, the mouse lemur was having difficulty trying to get out of the bottom of the web as the sides were both too steep and did not provide enough traction. The exhausted animal was apparently unable to break its way through the sides of the dense web. It was only after our intervention, by pulling down the branch of the tree and opening the upper portion of the web, that the animal was able to escape.

Without this interference, the ultimate fate of the mouse lemur is unclear. However, this observation illustrates that spiders are able to trap vertebrates, as large as mouse lemurs weighing 30–64 g (Kappeler *et al.*, 2005). While to our knowledge, this is the first published case of a mouse lemur being captured in a spider's web, other vertebrates, including bats, birds and geckos, for example, have been documented in other portions of the world to have been trapped and consumed by spiders (Diniz, 2011; Nyffeler and Knörnschild, 2013). Given the density of this type of spider web in the eastern humid forests of Madagascar, this type of predation, whether accidental or deliberate, may have been previously overlooked.

Acknowledgements
We are grateful to Charles Griswold and Ingi Agnarsson for their opinions on the identification of the spider's web.

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Survey of the Critically Endangered Perrier's sifaka (*Propithecus perrieri*) across most if its distribution range

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Key words: presence survey, *Propithecus perrieri*

Abstract
Propithecus perrieri (Perrier's sifaka) is one of the most endangered lemur species due to its small and fragmented distribution range. Despite a Critically Endangered (CR) conservation and flagship species status, there are still many uncertainties regarding its actual distribution and its presence in some forests of its putative distribution range. We report the results of diurnal and nocturnal surveys carried out in 2012 across most forest fragments of its putative distribution range, namely the Ankarana National Park, the Analamerana Special Reserve and Andrafiamena-Andavakoera Protected Area. During our surveys the species was only observed in Andrafiamena and Analamerana protected areas.

Introduction
In the last couple of decades there has been a significant increase in our knowledge of the distribution and number of lemur species across Madagascar (Mittermeier *et al.*, 2008). However, there are still many regions and species for which very little basic data is available. This is true of recently discovered species, as expected, but this is also true for species that have been known for decades but have limited distribution or live in little studied regions. Historically, Perrier's sifaka (*Propithecus perrieri*) was reported to inhabit a small area in the north of Madagascar. The species range was thought to cover most of the forest fragments comprised between the Analamerana Special Reserve and the Ankarana National Park (Meyers and Ratsirarson, 1989; Hawkins *et al.*, 1990; Tab. 1). Some studies suggested that the distribution range might also extend southward toward the Andavakoera forest (Schwitzer *et al.*, 2006). However, reports of the species presence across the putative range have been limited. Two studies by Banks *et al.* (2007) and Rasoloharijaona *et al.* (2005) failed to find Perrier's sifakas in the Ankarana National Park in 2003/2004 (Tab. 1), and Zaonarivelo *et al.* (2007) also failed to observe it in the Andavakoera forest in 2006. On the other hand Ranaivoarisoa *et al.* (2006) confirmed its presence in the Andrafiamena forest in 2005 and Banks *et al.* (2007) also found individuals in a forest corridor between the Analamerana Special Reserve and the Andrafiamena forest (Tab. 1, Fig. 1). Since then, no survey has been published yet, leaving Perrier's sifaka distribution range partially unresolved and controversial. The rapid fragmentation of the forest habitat across Madagascar suggested that an update of the species status was necessary and urgently needed.

Methods
All forests presented in Fig. 1 were surveyed by multiple independent teams, over different periods of the day from May to September 2012. Diurnal surveys were performed

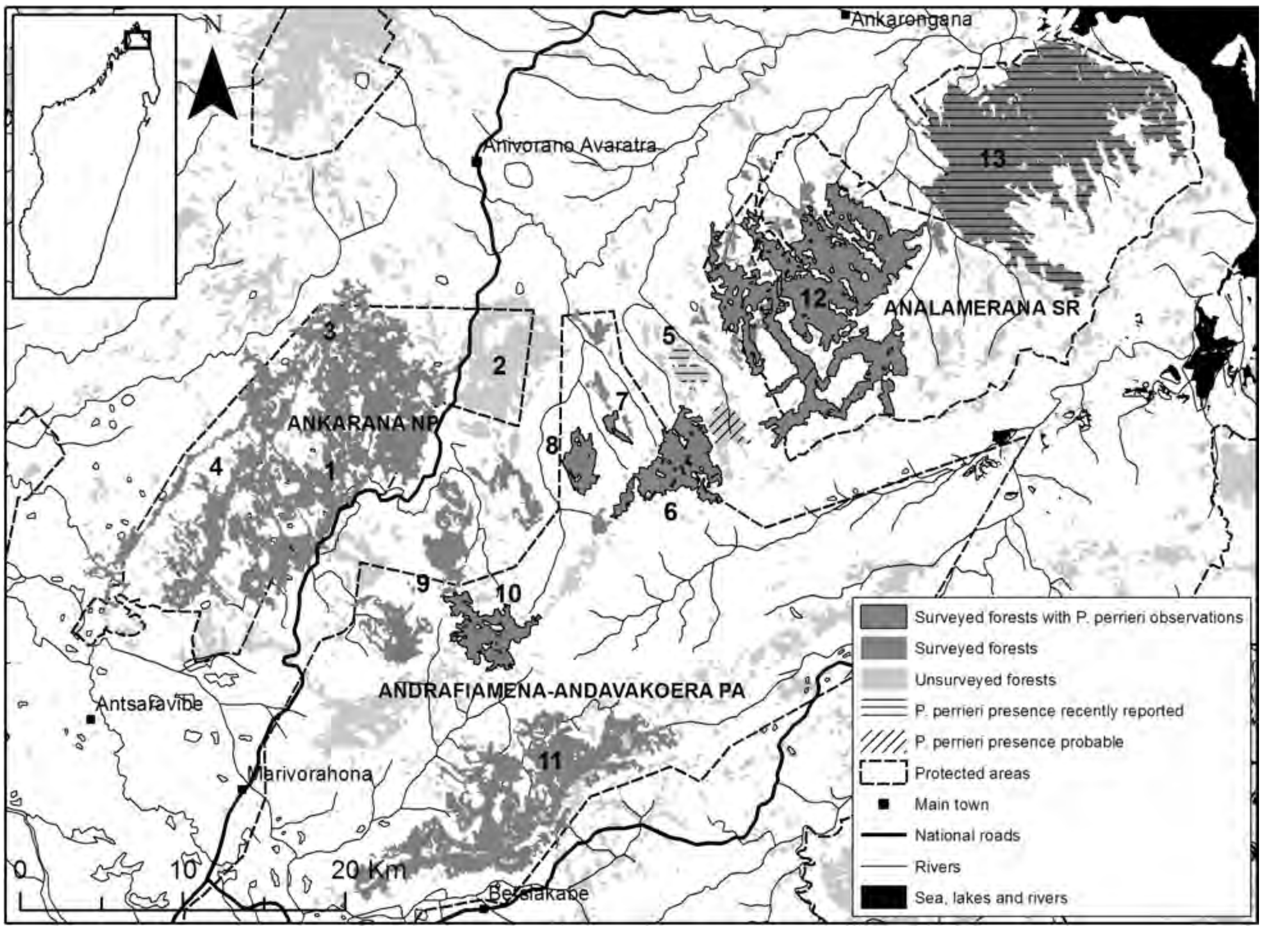

Fig. 1: Map of the surveyed area and Perrier's sifaka presence/absence. This map represents the surveyed forests, the locations of bibliographic data report of *P. perrieri* recent presence and the putative distribution area of the species. Numbers refer to study sites or forests and correspond to the locations numbered (Tab. 1). The locations are as follows, 1: Second river, 2: North-eastern degraded forest, 3: North-western forest, 4: rest of the reserve, 5: Ambery, 6: Andrafiamena, 7: Madorimasina, 8: Antsahabe, 9: Antserasera, 10: Mahanoro, 11: Andavakoera, 12: Antsohy, 13: Analamerana. SP: Special Reserve, PA: Protected Area, NP: National Park. The forest polygon data are from Moat and Smith (2007).

Tab. 1: Bibliographic review of *P.perrieri* surveys.
Notes: PA: Protected Area; CP: Conservation Plan; ER: extremely rare, R: Rare; N.O: Not Observed; P: Present; TBC: to be confirmed. *Perrier's sifaka presence in Ankarana was reported by Meyers and Ratsirarson (1989) with no distinction by site.

Reference	Year	Ankarana				Out of PA	Andrafiamena-Andavakoera						Analamerana	
		Second river (1)	North-eastern degraded forest (2)	North-western forest (3)	Rest of the reserve (4)	Ambery (5)	Andrafiamena (6)	Madorimasina (7)	Antsahabe (8)	Antserasera (9)	Mahanoro (10)	Andavakoera (11)	Antsohy (12)	Analamerana (13)
Meyers & Ratsirarson, 1989	1988	ER*	ER*	ER*	ER*		R					N.O	P	P
Hawkins *et al.*, 1990	1988	P	P		N.O									P
Mayor & Lehman, 1999	1998													P
Rasolaharijaona *et al.*, 2005	2003				N.O								P	P
Schwitzer *et al.*, 2006	CP											P	P	P
Ranaivoarisoa *et al.*, 2006	2005						P						P	P
Zaonarivelo *et al.*, 2007	2006											N.O		
Banks *et al.*, 2007	2003-2004	N.O	N.O		N.O	P							P	P
This study	2012			N.O	N.O		P	P	P	N.O	P	N.O	P	
Consensus		TBC	TBC	N.O	N.O	P	P	P	P	N.O	P	N.O	P	P

on and/or out of existing trails looking and listening for lemur presence. Nocturnal surveys were performed using acoustic and visual Distance Sampling techniques on existing trails and/or transects. All Perrier's sifaka observations were recorded using a global positioning system.

Results

During our surveys, we observed Perrier's sifakas in Andrafiamena, and in Antsohy, the eastern forest of the Analamerana Special Reserve (Tab. 1, Fig 1). For both protected areas most groups (42 out of 49) were observed diurnally (Fig 2). Two groups were also observed in two small fragments east of the Andrafiamena forest, namely Antsahabe and Madiromasina.
However, no *P. perrieri* individuals could be observed or detected in the Ankarana National Park, in Andavakoera, in the eastern forests fragments of the Andrafiamena-Andavakoera protected area, and in the eastern forest of Analamerana Special Reserve frequently called Analamerana (Tab. 1, Fig 1).

Discussion

Altogether, our results confirm the presence of *P. perrieri* in Andrafiamena and Antsohy forests. Meyers and Ratsirason (1989, Tab. 1) had found it difficult to observe *P. perrieri* in Andrafiamena and had therefore considered the species to be "rare". Our results suggest that this may not be the case. Indeed, more than one third of the groups (37 %, n = 17) were spotted in the Andrafiamena forest during a 19 days survey effort, compared to the remaining 63 % (n = 31) who were spotted during a 29 days survey effort in Antsohy. This suggests that the density of *P. perrieri* in the Andrafiamena forest could be as high as in Antsohy, and not "rare". Beyond these two forests we also report for the first time its presence in Antsahabe and Madiromasina, two forest fragments located close to the Andrafiamena forest.
Despite an eight-day survey effort in the Analamerana forest (east fragment of the Special Reserve), we did not sight any Perrier's sifaka. Indeed, the species was recently reported to occur in this forest, but at lower densities than in the Antsohy forest (2.2 ind/km² against 5.2 ind/km² respectively; Banks *et al.*, 2007). Unfortunately our limited effort in the Analamerana forest did not allow us to survey its eastern side and to perform a complete survey of the forest fragment.
One of the main objectives of this survey was also to confirm Perrier's sifaka presence/absence in the forests of Andavakoera and Ankarana. Indeed, Meyers and Ratsirarson (1989) mentioned that "*Andavakoera contained no or few Propithecus*". Similarly, Zaonarivelo *et al.* (2007) did not spot any Perrier's sifaka in 2006 while surveying the forest with one team during a period of 10 days starting from the southern town Betsiaka. In the present study we surveyed the Andavakoera forest during 17 days with three teams, starting from three different camps located in the north of the forest. Our results therefore confirm the probable absence

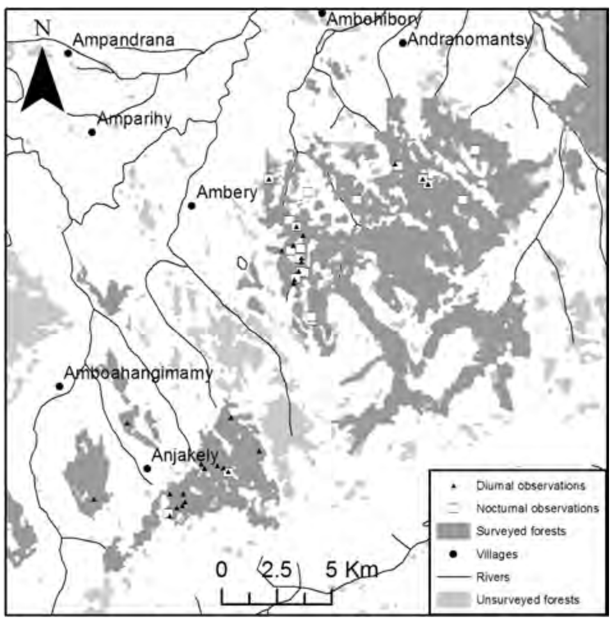

Fig. 2: *P. perrieri* observations. This map represents the Anjahankely and Antsohy forests visited during our survey (between May and September 2012) with details regarding diurnal and nocturnal observation of Perrier's sifaka; Forest polygon data from Moat and Smith (2007).

of Perrier's sifaka from this forest. Regarding the Ankarana forest, Perrier's sifaka was mentioned as extremely rare in 1998 (Meyers and Ratsirarson, 1989) and its presence in 1989 was reported only in two sites, "Second river" and "Northern degraded forest" (Hawkins *et al.*, 1990; Tab. 1). Later, in 2003-2004, Banks *et al.*, (2007) did survey both sites again using distance sampling but reported no observation of *P. perrieri*. Given that distance sampling might not be the best method to detect the presence of a species at very low densities, we aimed to verify its absence in Ankarana. Despite 32 days of survey in Ankarana, we did not spot any sifaka but must add that we did not have enough time to visit the two crucial areas where the species had been observed by Hawkins *et al.* (1990).
We consequently propose a consensus distribution of Perrier's sifaka based on the review of the literature and on the results of our survey (Tab. 1; Fig. 1). We suggest that the small non surveyed forest fragment located between Andrafiamena and Antsohy forest might contain Perrier's sifaka, due to its geographic location and the type of vegetation it harbours.

Conclusion

In conclusion we were able to confirm the presence of Perrier's sifaka in the Andrafiamena and Antsohy forests, with both sites exhibiting similar densities. We also report the presence of Perrier's sifaka in two small forest fragments neighbouring the Andrafiamena forest, Anstahabe and Madiromasina. We confirm the very likely absence of *P. perrieri* from the Andavakoera forest in the south of the Andrafiamena-Andavakoera protected area and also from Antserasera forest fragments in the east of the same protected area. Finally, we confirm the absence of the species from the south and the west of the Ankarana National Park and leave unresolved the question of its presence in the north-east of the park.

Acknowledgements

We thank CAFF/CORE, the "Direction Générale de l'Environnement et des Forêts", Madagascar National Park for giving us permission to conduct this study. Financial support for this study was provided by the "Fundação para a Ciência e a Tecnologia" (FCT, ref. PTDC/BIA-BEC/100176/2008, and SFRH/BD/64875/2009), the "Institut Français de la Biodiversité", the GDRI Madagascar, the "Laboratoire d'Excellence" (LABEX) entitled TULIP (ANR -10-LABX-41), the "Instituto Gulbenkian de Ciência", the "Optimus Alive!" Biodiversity grant and The Rufford Small Grant for Nature Conservation (ref. 10941-1). The field work was possible thanks to the continuous support of the Département de Biologie Animale et Ecologie (D.B.A.E.), Faculté des Sciences, University of Mahajanga, the University of Antsiranana, and the Fanamby NGO (in particular S. Rajaobelina). We would also like to acknowledge Madagascar National Park and its staff in Antananarivo, in Analamerana Special Reserve and in Ankarana National Park. This study was made in agreement with the laws of the countries of Portugal, France and Madagascar.

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Brown lemur (*Eulemur fulvus*) in the lowland forest of Vohitrambo, south of the Nosivolo River, Eastern Madagascar

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Vohitrambo is a small (200 ha) fragment of lowland rainforest situated on the south bank of the Nosivolo River of eastern Madagascar, near its confluence with the Mangoro River (19.94°S 48.48°E; 75 to 500 m altitude; Fig. 1). It is degraded, and surrounded by traveller's palm (*Ravenala madagascariensis*), an indicator of deforestation. Apparently much of the forest was burnt accidentally in 2005. The forest is managed by a community association based in the village of Anivorano (19.94°S 48.46°E, altitude 110 m), situated approximately 15 km north of the Rural Commune of Ankazotsifantatra, District of Mahanoro. On the opposing north side of the Nosivolo River is the Vohibe forest, where the presence of Critically Endangered greater bamboo lemurs (*Prolemur simus*) has recently been reported (Rakotonirina *et al.*, 2011; Andrianandrasana *et al.*, in prep.). We therefore undertook a lemur survey of Vohitrambo in November and December 2011 to search for signs of *P. simus* presence, and also to look for black-and-white ruffed lemurs (*Varecia variegata*) which had been reported to occur there by local people (Z. A. Andrianandrasana, pers. comm.).
Following methods we have used elsewhere in Madagascar to search for these focal lemur species (Rajaonson *et al.*, 2010; Rakotonirina *et al.*, 2011), one of us (AR) worked with local guides to survey the Vohitrambo forest from 25 November to 12 December 2011. We searched for signs of *P. simus*, *V. variegata*, and other lemurs from 06:00 to

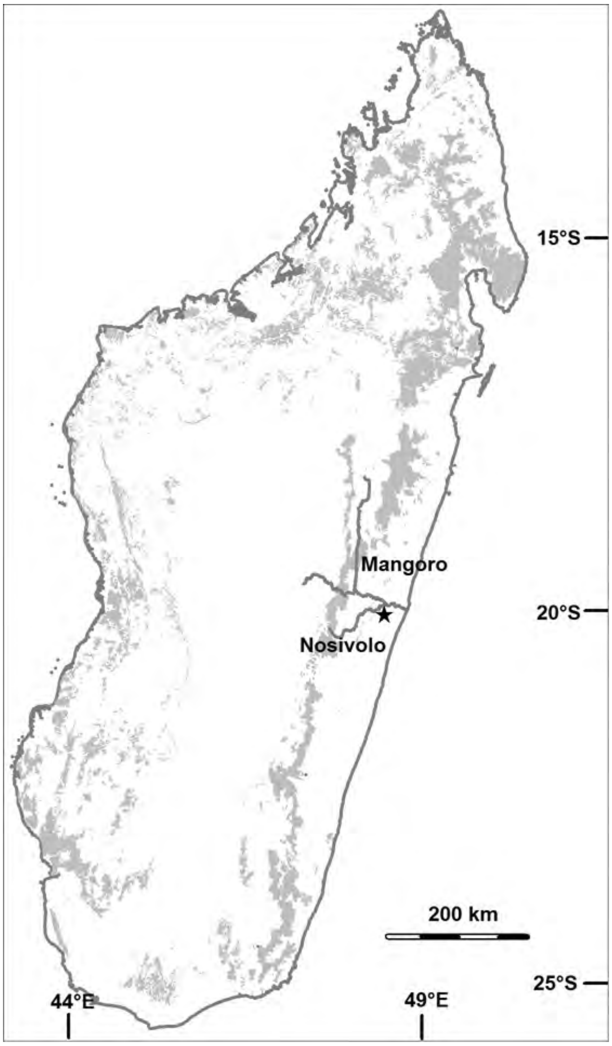

Fig. 1: Spider web of the family Pisauridae or family Theridiidae found within forested habitat in the Analamazaotra Forestry Station that contained an entangled Microcebus lehilahytsara. (Photo: Emily Crane)

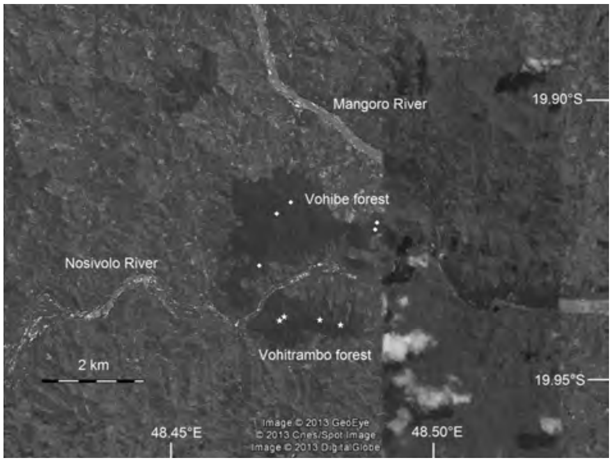

Fig. 2: Locations of direct observations of *Eulemur fulvus* made in 2011 in the Vohitrambo forest south of the Nosivolo River (white stars, this study), and in the Vohibe forest to the north of the Nosivolo River (white diamonds, Z.A. Andrianandrasana unpubl. data).

Fig. 3: Brown lemur *Eulemur fulvus* in the Vohitrambo forest, November 2011 (Photo: Andry Rajaonson)

16:00 each day. From the 13 to 16 December we organised meetings with several villages (Ambalafatsy, Ambinanidilana, Ampasimadinika II, Ambatofotsy and Ankazotsifantatra) to collect local knowledge concerning lemur occurrence and distribution.

We made direct observations of three lemur species (Tab. 1): brown lemur (*Eulemur fulvus*; Figs. 2 and 3), eastern bamboo lemur (*Hapalemur* cf. *griseus*) and woolly lemur (*Avahi* sp.). We did not find any feeding signs or other evidence of *Prolemur simus* in the *Valiha diffusa* bamboo stands surrounding the forest (the principle food plant of *P. simus* at several lowland sites (Ravaloharimanitra *et al.*, 2011; Bonaventure *et al.*, 2012; Lantovololona *et al.*, 2012; Mihaminekena *et al.*, 2012), and did not find any *Cathariostachys* sp. in the forest (one of the two principle food plants of *P. simus* in the Vohibe forest on the opposite bank of the Nosivolo River; Andrianandrasana *et al.*, this volume.). Local people confirmed the recent presence of *Varecia variegata* at Vohitrambo, even during 2011, but we found no evidence of the species during our survey.

Our observations of *Eulemur fulvus* at Vohitrambo, and also those at Vohibe (Fig. 2; Andrianandrasana *et al.*, this volume), are noteworthy as the species is currently considered to occur only as far south as the Mangoro River (Mittermeier *et al.*, 2010). This report therefore represents a small southern extension to the known range of the species, but a significant one as the Mangoro River is considered a major biogeographical barrier to distributions of various lemur species (Mittermeier *et al.*, 2010). Further work in the remaining lowland forest fragments on both sides of the Nosivolo River may reveal more information about the role of the Mangoro and Nosivolo rivers in

Tab. 1: Lemurs observed directly during the survey of Vohitrambo forest.

Species	Date	Adults & Juveniles	Infants	Latitude (°S)	Longitude (°E)	Altitude (m)
Avahi sp.	26/11/2011	1		19.9342	48.4696	106
Eulemur fulvus	26/11/2011	5		19.9387	48.4716	116
Eulemur fulvus	27/11/2011	6	1	19.9402	48.4824	407
Eulemur fulvus	27/11/2011	4		19.9393	48.4785	493
Eulemur fulvus	06/12/2011	2	1	19.9394	48.4708	376
Hapalemur cf. griseus	01/12/2011	2	1	19.9380	48.4754	435
Hapalemur cf. griseus	07/12/2011	3		19.9393	48.4649	78

defining distributions of various taxa. This would ideally include genetic studies of the various lemur species occurring in the Vohitrambo and Vohibe forest fragments, several of which we have only identified to genus at the present time.

Acknowledgements
We thank the Ministry of the Environment and Forests of the Government of Madagascar for delivering the permit to undertake this survey, the Association Française pour la Sauvegarde du Grand Hapalémur (AFSGH) and The Aspinall Foundation for funding the survey, the local authorities and community associations with whom we worked, our local guides, and Anselmo Andrianandrasana, Christelle Chamberlan, Mohamad Mbaraka, Rose Marie Randrianarison, Jonah Ratsimbazafy and Delphine Roullet.

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Gone in a puff of smoke? *Hapalemur alaotrensis* at great risk of extinction

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Lake Alaotra and its wetlands is of importance to international conservation, hence its inclusion in the Ramsar Convention. It has been a Protected Area since 2007. The region is of national importance for fish and rice production and therefore attracts immigration into the area. The pressure on this wetland system is continuously increasing with a growing human population, currently surpassing 550,000 inhabitants. Fire is one of the main disturbances threatening the marshy habitat of the Alaotra gentle lemur (*Hapalemur alaotrensis*) a unique primate found only in the Alaotra marshes. Its population is on a downwards spiral. If the socio-economic situation cannot be improved and the growing poverty alleviated, the future of this primate risks finding its place in history books alone.
Lake Alaotra is located in the Alaotra-Mangoro of Madagascar in the central highlands (17031'S, 48026'E) (Andrianandrasana *et al.*, 2005). With 20,000 ha, it is Madagascar's largest lake and of high economic importance. Alaotra was classified as a Ramsar site in 2003 to encourage the management of the whole wetlands. The government of Madagascar recognized the conservation value of this area by classifying it and the marshes as a New Protected Area within national law N°381-2007/ MINENVEF/MAEP on 17 January 2007. The surrounding 23,000 ha of fresh-water marshes are dominated by cyperus *Cyperus madagascariensis* (family Cyperaceae) and reed *Phragmites communis* (family Poaceae) and adjoining this 120,000 ha of rice-fields within a watershed encompassing 722,500 ha. The lake and marshes are in one of Madagascar's 15 centres of endemism. Analanjirofo (Wilmé *et al.*, 2012), supporting at least three Critically Endangered and locally endemic mammal and bird species, including *H. alaotrensis* (Andrianandrasana et al., 2005) and the recently described small carnivore *Salanoia durrelli* (Durbin et al., 2010). It is the only primate taxon in the world that lives exclusively in a wetland habitat. The species is classified as Critically Endangered according to IUCN 2012 criteria due to its extremely reduced geographic range. The brown mouse lemur (*Microcebus* aff. *rufus*) is also found in the marshes. Lake Alaotra and its surrounding wetlands are also of great importance for water birds with populations of Malagasy endemics such as Meller's duck (*Anas melleri*) (Pidgeon, 1996; Kaufmann, 2012). Two endemic bird species, the Madagascar pochard (*Aythya innotata*) and the Alaotra

little grebe (*Tachybaptus rufolavatus*), have disappeared from the lake (Wilmé, 1994); the former was rediscovered at a lake in northern Madagascar in 2007 (Rene de Roland *et al*., 2007; Rabearivony *et al*., 2010) but the latter is now considered extinct.

The human population in this area has increased from 109,000 people in the 1960's to more than 550,000 in 2003 (Plan Régional de Développement, 2003). Commonly used crops are maize and cassava, but the primary economic drivers in the Alaotra region are based on fisheries and rice production (providing one third of the country's total rice output) (Andrianandrasana *et al*., 2005; Ferry *et al*., 2009). Annual fish catches at Lake Alaotra amounted to 4,000 tonnes in the 1960's (Pidgeon, 1996), with recent numbers dropping to about 2,000 tonnes per annum probably as a result of over-fishing, acidification of the lake, introduced fish species and siltation (Razanadrakoto, 2004; Andrianandrasana *et al*., 2005). Recent unpublished data suggests as little as 600–800 tonnes were caught in recent years. Lake Alaotra constitutes the major fish production for the urban population of Antananarivo and Toamasina. Alaotra is also called the "granary" of Madagascar in terms of rice production; a majority of the marshland fringing the lake has already been converted for rice production (Ranarijaona, 2007), with some 120,000 ha outputting about 300,000 tonnes per year; however, the agricultural production is continuously declining. The lands surrounding the lake and marshland have already been widely deforested for agricultural production and livestock leading to a continuous increase of soil erosion. This is especially aggravated during the rainy season. Consequently, every year a considerable amount of sedimentation reaches the marshes and lake, which has led to a reduction in open water surface of more than five square kilometers in the past 30 years (Wright and Rakotoarisoa, 2003; Bakoariniarina *et al*., 2006). Another factor impacting negatively on the agricultural production and wetland ecosystem is the sinking hydric level in the entire area (Ferry *et al*., 2009).

The aquatic environment has been more seriously altered by sedimentation and invasion of exotic plants (mainly *Eichhornia crassipes*) and fish (*Tilapia* spp., *Channa maculata*, *Ophicephalus striatus*). Urgent action is needed to safeguard the marsh home of *Hapalemur alaotrensis* to prevent this species from disappearing like the endemic Alaotra water birds. Population numbers for *H. alaotrensis* are in continuous decline. While its total population was estimated in the 1990's to over 11,000 individuals (Mutschler and Feistner, 1995, 2001), it had been reported to have dropped below 6,000 individuals by early 2000 (Ralainasolo, 2004), and to below 2,500 individuals after 2005 (Ralainasolo *et al*., 2006). It is unclear how big the population is since the last census undertaken in 2007 by Durrell Wildlife Conservation Trust Madagascar (Durrell). However, given the growing threats it is suggested to be much lower than the last census estimation. For *H. alaotrensis*, the main causes of its decline have been the conversion of its marsh habitat to rice fields, widespread and repeated burning of remaining areas of marsh and hunting for local consumption. Disturbance to habitat caused by fire represents the main threat to the survival of this lemur species.

The years 2000 and 2004 have so far been the most severe in terms of fire, affecting over 40 % of the total marshlands (Tab. 1). However, 2012 represented another extreme year for fires. Currently no exact numbers exist, but deducing from the point fires based on NASA-FIRMS MODIS data, over 159 single fires were identified during the peak drought period in the region, between 7 October and 28 December 2012 alone (Tab. 2). It is apparent that a vast extent of *H. alaotrensis* habitat has been affected. Burning of the marshland takes place for manifold reasons (Ralainasolo *et al*., 2006; Copsey *et al*. 2009a, b; Guillera-Arroita *et al*., 2010). The main reasons are land conversion into rice paddies and creating better access to fishing ponds (e.g. fishing of *Channa maculate* or *Ophicephalus striatus*) (Copsey 2009a, b). Informal discussions with villagers from the main areas of Anororo, Andilana Sud and Andreba Gare during November 2012 revealed that the main drivers for the year's fires were likely to be due to employment from key people who do not live at or depend on the lake hiring the locals for small amounts of money to set fire to the area and then buy off the destroyed marshlands, converting them into profitable land. This pattern of resource depletion also seems to be occurring in the forested areas of eastern Madagascar, where rich people hire locals for the illegal rosewood cutting (Randriamalala and Liu, 2010; Innes, 2010).

Tab. 1: Marsh area burned in hectares during the years 2000–2009.

Year	Hectares burned	Percentage burned
2000	7,300	32
2001	4,430	19
2002	392	2
2003	2,600	11
2004	10,408	45
2005	300	1
2006	903	4
2007	1,135	5
2008	617	3
2009	2,210	10

Tab. 2: Point fire coordinates (with respective date and time of observation) between 7 October and 28 December 2012 in the marshlands Alaotra.

Latitude	Longitude	Date	Time
-17,551	48,401	07/10/2012	10:25
-17,550	48,411	07/10/2012	10:25
-17,549	48,420	07/10/2012	10:25
-17,542	48,400	07/10/2012	10:25
-17,541	48,409	07/10/2012	10:25
-17,364	48,291	07/10/2012	10:25
-17,356	48,280	07/10/2012	10:25
-17,317	48,294	07/10/2012	10:25
-17,842	48,502	10/10/2012	10:55
-17,792	48,493	10/10/2012	10:55
-17,874	48,539	12/10/2012	10:45
-17,819	48,617	12/10/2012	10:45
-17,362	48,215	12/10/2012	10:45
-17,283	48,323	12/10/2012	10:45
-17,282	48,329	12/10/2012	10:45
-17,323	48,244	13/10/2012	07:00
-17,901	48,520	14/10/2012	10:30
-17,788	48,601	14/10/2012	10:30
-17,779	48,600	14/10/2012	10:30
-17,706	48,410	14/10/2012	10:30
-17,675	48,427	14/10/2012	10:30
-17,665	48,435	14/10/2012	10:30
-17,656	48,433	14/10/2012	10:30
-17,654	48,443	14/10/2012	10:30
-17,503	48,215	14/10/2012	10:30
-17,417	48,243	14/10/2012	10:30
-17,357	48,208	14/10/2012	10:30

Latitude	Longitude	Date	Time
-17,316	48,240	14/10/2012	10:30
-17,307	48,238	14/10/2012	10:30
-17,251	48,243	14/10/2012	10:30
-17,741	48,467	15/10/2012	06:50
-17,884	48,201	16/10/2012	10:20
-17,865	48,439	16/10/2012	10:20
-17,864	48,451	16/10/2012	10:20
-17,672	48,427	16/10/2012	10:20
-17,670	48,438	16/10/2012	10:20
-17,660	48,437	16/10/2012	10:20
-17,614	48,327	16/10/2012	10:20
-17,613	48,338	16/10/2012	10:20
-17,605	48,325	16/10/2012	10:20
-17,603	48,331	16/10/2012	10:20
-17,603	48,337	16/10/2012	10:20
-17,545	48,392	16/10/2012	10:20
-17,505	48,625	16/10/2012	10:20
-17,497	48,612	16/10/2012	10:20
-17,495	48,623	16/10/2012	10:20
-17,309	48,248	16/10/2012	10:20
-17,575	48,347	17/10/2012	11:00
-17,568	48,367	17/10/2012	11:00
-17,683	48,523	18/10/2012	10:05
-17,680	48,405	18/10/2012	10:05
-17,680	48,517	18/10/2012	10:05
-17,678	48,423	18/10/2012	10:05
-17,677	48,535	18/10/2012	10:05
-17,671	48,521	18/10/2012	10:05
-17,615	48,434	18/10/2012	10:05
-17,609	48,445	18/10/2012	10:05
-17,566	48,384	18/10/2012	10:05
-17,564	48,402	18/10/2012	10:05
-17,327	48,209	18/10/2012	10:05
-17,281	48,277	18/10/2012	10:05
-17,279	48,295	18/10/2012	10:05
-17,580	48,348	21/10/2012	10:35
-17,571	48,347	21/10/2012	10:35
-17,570	48,357	21/10/2012	10:35
-17,330	48,235	21/10/2012	10:35
-17,883	48,312	23/10/2012	10:25
-17,721	48,365	23/10/2012	10:25
-17,675	48,303	23/10/2012	10:25
-17,657	48,624	23/10/2012	10:25
-17,656	48,634	23/10/2012	10:25
-17,614	48,344	23/10/2012	10:25
-17,612	48,353	23/10/2012	10:25
-17,568	48,410	23/10/2012	10:25
-17,567	48,420	23/10/2012	10:25
-17,558	48,418	23/10/2012	10:25
-17,426	48,233	23/10/2012	10:25
-17,419	48,226	23/10/2012	10:25
-17,418	48,236	23/10/2012	10:25
-17,363	48,297	23/10/2012	10:25
-17,356	48,206	23/10/2012	10:25
-17,334	48,233	23/10/2012	10:25
-17,333	48,243	23/10/2012	10:25
-17,327	48,237	23/10/2012	10:25
-17,326	48,258	23/10/2012	07:35
-17,325	48,246	23/10/2012	10:25
-17,263	48,426	23/10/2012	10:25
-17,832	48,494	24/10/2012	11:05
-17,588	48,321	24/10/2012	11:05
-17,582	48,328	24/10/2012	11:05
-17,271	48,410	24/10/2012	11:05
-17,264	48,404	24/10/2012	11:05
-17,619	48,330	25/10/2012	10:10

Latitude	Longitude	Date	Time
-17,617	48,344	25/10/2012	10:10
-17,615	48,337	25/10/2012	07:25
-17,615	48,337	25/10/2012	07:25
-17,550	48,414	25/10/2012	10:10
-17,548	48,428	25/10/2012	10:10
-17,541	48,399	25/10/2012	10:10
-17,539	48,413	25/10/2012	10:10
-17,538	48,427	25/10/2012	10:10
-17,360	48,205	25/10/2012	10:10
-17,269	48,202	25/10/2012	10:10
-17,268	48,217	25/10/2012	10:10
-17,267	48,214	25/10/2012	07:25
-17,266	48,231	25/10/2012	10:10
-17,257	48,232	25/10/2012	07:25
-17,298	48,391	26/10/2012	10:55
-17,270	48,326	26/10/2012	10:55
-17,268	48,340	26/10/2012	10:55
-17,267	48,345	26/10/2012	10:55
-17,570	48,308	28/10/2012	10:45
-17,690	48,416	30/10/2012	10:30
-17,688	48,426	30/10/2012	10:30
-17,427	48,298	31/10/2012	06:50
-17,461	48,283	08/11/2012	10:25
-17,460	48,293	08/11/2012	10:25
-17,259	48,351	08/11/2012	10:25
-17,252	48,343	08/11/2012	10:25
-17,687	48,419	12/11/2012	07:15
-17,901	48,52	14/11/2012	10:30
-17,788	48,601	14/11/2012	10:30
-17,779	48,600	14/11/2012	10:30
-17,706	48,410	14/11/2012	10:30
-17,675	48,427	14/11/2012	10:30
-17,665	48,435	14/11/2012	10:30
-17,656	48,433	14/11/2012	10:30
-17,654	48,443	14/11/2012	10:30
-17,503	48,215	14/11/2012	10:30
-17,417	48,243	14/11/2012	10:30
-17,357	48,208	14/11/2012	10:30
-17,316	48,240	14/11/2012	10:30
-17,307	48,238	14/11/2012	10:30
-17,251	48,243	14/11/2012	10:30
-17,859	48,630	15/11/2012	10:30
-17,792	48,641	15/11/2012	10:30
-17,740	48,623	15/11/2012	10:30
-17,638	48,307	15/11/2012	10:30
-17,637	48,316	15/11/2012	10:30
-17,572	48,262	15/11/2012	10:30
-17,570	48,271	15/11/2012	10:30
-17,537	48,438	15/11/2012	10:30
-17,832	48,635	17/11/2012	10:20
-17,831	48,629	17/11/2012	10:20
-17,249	48,612	24/11/2012	10:25
-17,580	48,392	27/11/2012	10:55
-17,570	48,450	27/11/2012	10:55
-17,584	48,342	03/12/2012	07:30
-17,589	48,374	08/12/2012	10:35
-17,588	48,384	08/12/2012	10:35
-17,617	48,379	10/12/2012	10:25
-17,614	48,329	10/12/2012	10:25
-17,609	48,368	10/12/2012	10:25
-17,583	48,424	10/12/2012	10:25
-17,581	48,433	10/12/2012	10:25
-17,577	48,417	10/12/2012	10:25
-17,575	48,427	10/12/2012	10:25
-17,276	48,433	25/12/2012	06:55
-17,567	48,438	28/12/2012	10:15

In marshes, frequent fires often contribute to weed invasion, inducing loss of native plants and the slowing down or impediment to the recovery of a pre-disturbance state, depending on fire frequency and intensity, therefore further reducing suitable habitat for *H. alaotrensis*. In contrast to forests, control and management of marshland fires is more challenging because the vegetation is floating. Fire breaks cannot be installed a priori. The only effective management action would be the establishment of a fire alert and brigade system for early detection and immediate intervention. The costs for this however would be extremely high. With increasing climatic variation or change, the region risks extended drought periods further affecting the entire hydric balance. A vicious circle begins: the search for irrigated and cultivable land pushes the growing human population further into marshland and *H. alaotrensis* habitat. Increased numbers of so called 'riz de contre saison' (rice paddies established in the dry season during the months of August to December) within the boundaries of the lakefront (i.e. the transition zone from lake to vegetated area) is increasing from year to year. An example is given from Andreba Gare, in 2005 there were only a few such fields visible. In 2012, there were over 30 fields transforming the natural marshes into floating rice fields. A couple of such fields have even been found in November 2012 within the 2004 established and officially protected Park Bandro boundaries. These 85 ha of intact and dense habitat hosts the biggest *H. alaotrensis* sub-population with more than 170 individuals. Since the beginning of February 2013 in the northern portion of Lake Alaotra (around Vohimarina) as well as south of Andreba Gare (Ambodivoara) organized groups are encroaching on the intact marshes and deliberately destroying them to convert them into rice fields. To date it is unclear who is instigating the villagers to such actions.

Concerted conservation efforts have been ongoing to preserve the biological uniqueness of the marsh system while ensuring the continued provision of ecosystem services for a growing human population. Since 2005, Durrell Wildlife Conservation Trust Madagascar has conducted rural development projects and sustainable natural resource management in 13 communities around Alaotra to improve the livelihoods of approximately 33,000 local people. Over time Durrell has developed strong working relationships with the communities to improve the livelihood situation. In order to promote the participation and increase motivation of the villagers, Durrell applied the "Ecological Monitoring Participatory Competition" as a strategic approach. Likewise, 18 villages participated in the competition in which the criteria of selection are based on efforts made for the conservation of the natural habitat of *H. alaotrensis*, the management of the marsh fires and wetland fauna. Durrell has created the CFL ("Contrôle Forestier Local") in the main villages around the lake in order to patrol the marshes and to collect data. Every week birds and mammals encountered and observed human infractions are recorded and GPS points taken.

In 2006 Madagascar Wildlife Conservation (MWC) started its environmental education programme targeting children at public primary schools around the lake. Over 3,000 Malagasy comic books have been distributed to date (cf. Maminirina *et al*., 2006). Another segment of resource users is being targeted by MWC's ecotourism project, where economic benefits from its Camp Bandro (situated in Andreba Gare) are invested in the community development to show the link between intact ecosystem (e.g. as presented in the Park Bandro), tourists who visit the area for lemur watching (*H. alaotrensis* or with vernacular name "Bandro"), and economic incentives for the community.

Since 2012, the Project AMBio (Alaotra Marshland Biodiversity) has been run as a collaboration between the University of Hildesheim and MWC, and aims to gain a better understanding of the Alaotra socio-ecological wetland system to inform policy and decision makers for adapting management and conservation practices to balance conservation with development needs. A region-wide assessment of the ecological integrity of the lake and its surrounding marshlands allows comparison between today's conditions with, for example, Mark Pidgeon's study conducted in 1993–4, some 20 years ago and published in 1996. Assessing drivers and barriers to environmental education at the primary teachers' level allows focus on the efficacy of transmitting conservation values and appreciation to future resource users. A third component of the research works on the development of alternative resource use options for improving the resource users' livelihoods, focusing on the utilization potential of *Eichhornia crassipes* (e.g. the use of the invasive water hyacinth as handicraft, briquettes or compost).

A note of conclusion: current trends show that all *H. alaotrensis* habitat, and with it the unique wetland lemurs, risk going up in a puff of smoke if the respective decision and policy makers do not support the conservation efforts to better protect the marshland and *H. alaotrensis* habitat from anthropogenic fires and other disturbances. Policy and management mechanisms need to be established to impede ("remotely controlled") burning in the Alaotra. A fire alert system needs to be put in place. This would be an opportunity for the international donor community to support habitat conservation to save one of the most peculiar lemurs, but especially to further secure the hydric balance of this agro-economically important region for Madagascar. Only one thing is certain in times of high uncertainty: as long as the socio-economic situation around the lake is not improved and poverty continues to thrive, any kind of conservation effort risks being of short-term value and too volatile to show any lasting positive impacts.

Acknowledgements

We would like to thank the Malagasy government institutions in Ambatondrazaka for the permission to carry out this survey. We are grateful to the *Direction Générale des Forêts* and the Directeur Régional des Eaux et Forêts in Ambatondrazaka, Mr. Ramenason Rasolonirina. Our thanks also go to Bary Jean Rasolonjatovo, the Durrell Wildlife Conservation Trust Programme Responsible of Alaotra and Sandanionja Rakotoarimanana, the Madagascar Wildlife Conservation Responsible in Ambatondrazaka, and to all Community Associations and their Presidents as well as the President of the Federations in Lac Alaotra. We finally thank the Jersey Overseas Aid and the Bauer Foundation in cooperation with the Fritz-Hildegard Berg Foundation (Stifterverband for German Sciences) for financially supporting our projects in Lake Alaotra.

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Articles

Diet overlap of *Propithecus verreauxi* and *Eulemur rufifrons* during the late dry season in Kirindy Forest

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Key words: scarcity, competition, diet overlap, activity pattern

Abstract
The aim of this short research project was to investigate whether two lemur species, Verreaux's sifaka (*Propithecus verreauxi*) and the red-fronted brown lemur (*Eulemur rufifrons*), showed significant dietary overlap during the late dry season in Kirindy Forest in Madagascar. We hypothesised that the species would show a significant overlap in diet composition due to limited food availability during this period of the year. To limit direct competition, we expected niche separation to occur in terms of spatial and temporal preferences. During focal observations of two weeks at the end of the dry season, a total of 21 plant species were observed to be consumed by the two species of lemur, of which five were used by both species. Furthermore, we found that brown lemurs tended to rest more in the morning and feed more in the (late) afternoon. They tended to feed mostly on the lower half of the trees as well as on the ground, while sifakas preferred the upper part of the tree. Brown lemurs appeared to have a more diverse diet compared to sifakas as they included fruit in their diet as well. Nevertheless, both species seemed to rely on leaves during this period of the year. The species thus showed some overlap in diet composition, both in their preferred tree species and in food items consumed, but they showed niche separation to a certain extent in terms of spatial and temporal preferences.

Résumé
L'objet de ce projet de recherches était d'étudier si les deux espèces de lémuriens, *Propithecus verreauxi* et *Eulemur rufifrons,* montrent d'importants chevauchements alimentaires au cours de la fin de la saison sèche dans la Réserve Forestière de Kirindy à Madagascar. Nous supposons qu'il y aurait un chevauchement important dans la composition du régime de ces espèces, en raison de la disponibilité limitée de nourriture en cette période (Novembre). Nous avons observés que 21 espèces végétales ont été consommées par les deux espèces de lémuriens. Cinq de ces espèces végétales ont été mangées par les deux espèces. En outre, nous avons constaté que les individus d'*Eulemur rufifrons* ont tendance à se reposer surtout le matin et à se nourrir plutôt en fin de journée. Ils ont tendance à se nourrir principalement sur la cime inférieure des arbres ainsi que sur le terrain, tandis que les

individus de *Propithecus verreauxi* préfèrent la partie supérieure de l'arbre. Les individus d'*Eulemur rufifrons* semblent avoir une alimentation plus variée, qui comprend des fruits, mais cependant, les deux espèces semblent dépendre sur les feuilles pendant cette période de l'année. Les espèces montrent donc un certain chevauchement dans la composition de leur régime, à la fois dans leurs espèces d'arbres préférés et dans les produits alimentaires consommés.

Introduction

Insight into the overlap of resource use is central to understanding the forest ecosystem structure (Schoener, 1968). Higher food intake often leads to higher growth rates for individuals within a population, which can enhance their fitness. Despite the short time available to perform this project, we have tried to gain useful insights into the interspecific exploitation competition between two lemur species: Verreaux's sifaka (*Propithecus verreauxi*) and the red-fronted brown lemur (*Eulemur rufifrons*). Here we report the diet overlap of the two lemur species in Kirindy, during the late dry season in November 2010.

To exhibit diet overlap, species must overlap in habitat use and in food items they consume (de Boer and Prins, 1990; Tokeshi, 1999). When resources become limited, intraspecific competition for shared resources between those lemur species will probably occur, as individuals try to gain access to similar food items. During the dry season, the main food source of the red-fronted brown lemur (fruit) is present in relatively low diversity and quantity (Sorg *et al.*, 2004). It might be expected therefore, that this species needs to include other food items in its diet and will show more overlap with the diet of Verreaux's sifaka. The intensity of this interspecific exploitative competition is likely to vary with seasonal changes in climate and food availability, but may also depend on predator avoidance and reproductive stages (Vasey, 2002).

Overlap between two species can occur along several niche aspects, of which resource utilization is considered to be the most important (Schoener, 1974). Lemur species can show overlap in spatial preferences as well, especially during foraging. Furthermore, temporal niche overlap in terms of daily activity cycles can be present (Schoener, 1974; Wright, 1989; Overdorff, 1991).

Because only limited food resources are available at this time of the year (i.e. towards the end of the dry season) (Sorg *et al.*, 2004), our hypothesis was that Verreaux's sifaka and the red-fronted brown lemur would show substantial overlap in their diet composition, but to limit direct competition, we expected niche separation to occur in terms of spatial and temporal preferences. To get more insight into overlap and niche separation of the two species, we addressed the question whether species niche overlap can be found in: (1) the species' diet composition (i.e. food items and tree species they used for feeding); (2) their temporal activity pattern; and (3) their spatial preferences (i.e. the height in the trees).

Methods

Study site

The study was conducted in Kirindy Forest in western Madagascar (44°40´E, 20°04´S) (Sorg *et al.*, 2004). The climate in Kirindy is highly seasonal and is characterised by a wet season of 4 months (December-March) and a relatively long dry season of 8 months (April-November). In this dry season, progressive defoliation of several plants occurs (Sorg and Rohner, 1996). The forest consists of a dense understorey and an average canopy height of 12-15 metres, with maximum heights of 20-25 metres in more humid areas (Garbutt *et al.*, 2008).

Observations

During November 2010, we observed two different groups of red-fronted brown lemurs and two groups of Verreaux's sifakas. The lemurs were radio collared on previous occasions by the German Primate Centre (DPZ), which enabled us to identify individuals and to locate and follow the four groups by using radio tracking. Data on the activity pattern of both species were collected during two time periods of the day (from 06:30-10:00 and from 04:00-06:00), because these periods seemed to show the highest feeding activity. We recorded the behaviour of each focal animal using instantaneous focal time sampling (Altmann, 1974), while scoring the individual's behaviour every 30 seconds for 15 minutes, giving a total of 31 data points for each observation. A total of 70 focal samples were collected (39 for brown lemurs and 31 for sifakas) from randomly selected focal adults.

During each focal sampling we recorded the individual's activity (feeding, moving, resting, other), its height in the tree (categorized into ground (0); understorey (1); lower canopy (2); and upper canopy (3)), the food items consumed (fruits, flowers, buds, leaves, other) and the tree species it used (according to Wright *et al.*, 2005). We attempted to identify all tree species used by the lemur and confirmed all tree species identifications with a botanist, providing him with a photo of the tree and subsamples of leaves and fruits, seeds or flowers, if available.

Data analysis

Because of our relatively small sample size we treated all focal samples grouped per individual as independent samples and we were not able to take the social group structure into account in our analyses. Because the data were not normally distributed, we used non-parametric statistical tests on the data.

Results

Food items

The brown lemurs' diet seemed to be more diverse compared to the diet of the sifakas (Fig. 1). Both species included leaves, buds and flowers in their diet, but only brown lemurs were observed to feed on fruits (18.5 % of the total observed feeding time). For both species though, the main component of their diet were leaves (51.9 % for the brown lemurs and 77.8 % for the sifakas).

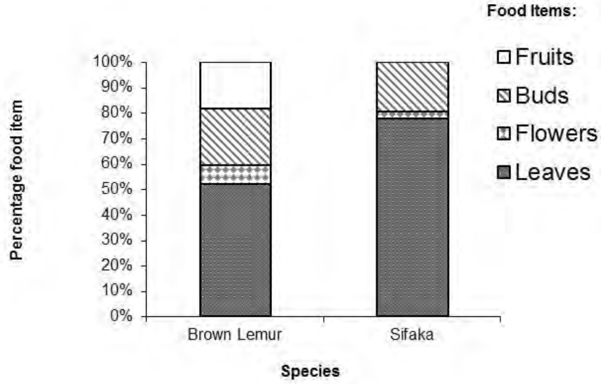

Fig. 1: Food items used by brown lemurs and sifakas.

Tree species

In total, 21 plant species were observed to be consumed by either or both species (Fig. 2, Tab. 1). Ten tree species were exclusively used for feeding by sifakas and six by the brown lemurs. Five species of food trees (*Stereospermum* sp., *Combretum* sp., *Berchemia* sp., *Tamarindus indica* and an unknown sp.) were used by both lemur species. In these tree species they had in common, the lemur species used similar food items (e.g. leaves, flowers) except for one (unidentified) tree species, in which the leaves were consistently selected by the sifakas, while fruits were selected by the brown lemurs.

Tab. 1: Genus and family names of the tree species that were recorded at Kirindy as food plants of brown lemurs or sifakas during this study.

	Genus	Family
SP. 1	*Securinega* sp.	Phyllanthaceae
SP. 2	*Stereospermum* sp.	Bignoniaceae
SP. 3	*Combretum* sp.	Combretaceae
SP. 4	*Strychnos mostueoides*	Loganiaceae
SP. 5	*Commiphora* sp.	Burseraceae
SP. 6	*Berchemia* sp.	Rhamnaceae
SP. 7	*Baudouinia fluggeiformis*	Fabaceae
SP. 8	UNKNOWN SPECIES 1	
SP. 9	*Tamarindus* sp.	Fabaceae
SP. 10	UNKNOWN SPECIES 2	
SP. 11	*Breonia perrieri*	Rubiaceae
SP. 12	Liana	
SP. 13	UNKNOWN SPECIES 3	
SP. 14	*Coptosperma* sp.	Rubiaceae
SP. 15	*Hyperacanthus grevei*	Rubiaceae
SP. 16	UNKNOWN SPECIES 4	
SP. 17	UNKNOWN SPECIES 5	
SP. 18	*Terminalia mentaliopio*	Combretaceae
SP. 19	*Chadsia* sp.	Fabaceae
SP. 20	*Cordyla madagascariansis*	Fabaceae
SP. 21	UNKNOWN SPECIES 6	

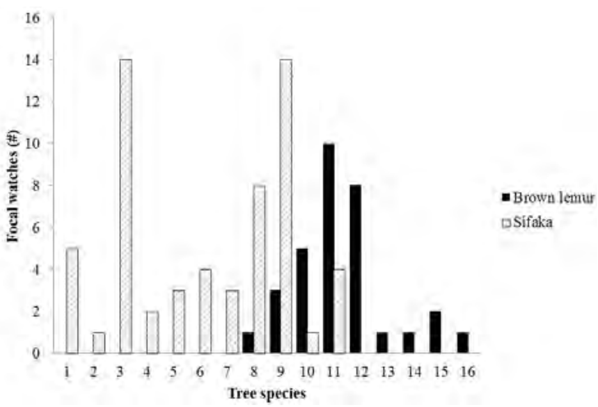

Fig. 2: Tree species consumed by brown lemurs and sifakas, see Tab. 1 for the names of the 21 species.

Activity pattern

Brown lemurs spent significantly more time feeding in the afternoon than in the morning (Kruskal-Wallis, $Chi^2 = 8.61$, df = 3, P = 0.035). Furthermore, their time spent resting was significantly higher in the morning compared to the afternoon (Kruskal-Wallis, $Chi^2 = 8.86$, df = 3, P = 0.031). Contrastingly, sifakas seemed to spend the same amount of time on feeding and resting in the morning compared to the afternoon.

Spatial pattern

The difference between the two species in feeding height in the tree approached significance ($Chi^2 = 5.65$, df = 2, P = 0.059; Fig. 3). Sifakas were never observed feeding on the ground and they tended to forage more in the upper canopy. Contrastingly, brown lemurs were regularly observed feeding on the ground and they were mostly observed in the lower canopy.

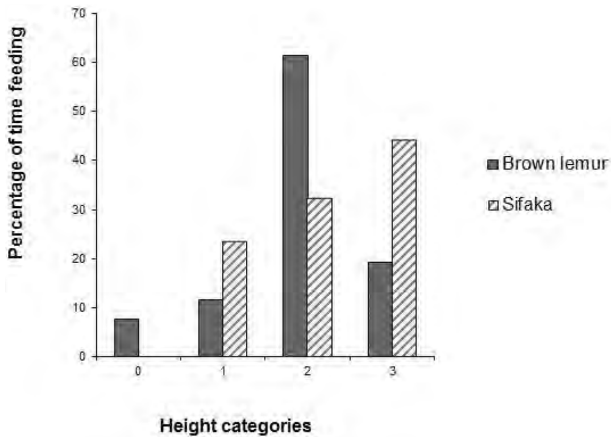

Fig. 3: Feeding heights of the brown lemurs and the sifakas.

Discussion

Food items

The diet of the brown lemurs seemed to be more varied compared to that of the sifakas in terms of food items they used. Brown lemurs included fruit as well as specific items on the ground, branches and parts of invertebrates, like the exoskeletons of big cockroaches. It has previously been shown that leaves are the main component of the diet of sifakas (Lewis and Kappeler, 2005), just as we found in our observation. In comparison, brown lemurs generally prefer relatively more nutritious foods, like flowers and fruits (Overdorff, 1993). In the dry deciduous forest of Kirindy though, we found that leaves formed the highest proportion of the *Eulemurs'* diet during our study period of low fruit availability, while in areas with higher fruit availabilities, the proportion of leaves in their diet can drop to 8 % (Overdorff, 1993; de Winter *et al.*, under review). Therefore, it seems that populations of brown lemurs are forced to specialise more in leaves in this area (Mittermeier *et al.*, 2006), while fruits form the main component of their diet in the eastern rainforests (Overdorff, 1993).

Sifakas are known to be opportunistic feeders (Wright *et al.*, 2005), which means that they will mostly feed on food items that are most abundant or easy to reach. This characteristic can explain why they mainly fed on leaves during our study, as leaves were the most abundant food resource at this time.

Tree species

The observed overlap in the use of tree species was likely to be high during the dry season, as only a few tree species are able to produce nutritious food items, like fresh leaves or fruits, compared to the wet season (Schoener, 1974; Chase and Leibold, 2003). The tree species that can cope with the limiting circumstances seemed to be preferred by both species.

Activity pattern

Based on our observations, brown lemurs seemed to spend less time on feeding during the day compared to sifakas. In contrast to sifakas, brown lemurs are known to be cathemeral, which means that they can be active throughout the 24-hour cycle (Tattersall, 1987; Overdorff, 1993; Rasmussen, 1999). Our observations confirmed that brown lemurs fed longer in the evening, especially when the moon was bright. This cathemeral behaviour can explain why brown lemurs spent more time resting and less time feeding during the day compared to sifakas. Being active at different times of day may lower the amount of direct interactions between both species (Pianka 1973; Overdorff, 1996a,b).

Spatial pattern

Although it has been reported that brown lemurs rarely spend time on the ground (Mittermeier *et al*., 2006), we regularly observed them resting, moving or feeding on the ground, despite the high density of fossas (*Cryptoprocta ferox)*, their main predator (Hawkins and Racey, 2008). The differences we found in the spatial preferences between brown lemurs and sifakas may limit direct intraspecific competition for resources, as the species seem to use different heights for feeding (Schoener, 1974; Wright, 1989; Overdorff, 1991).

Conclusion

Our observations in this short research project add to the understanding of the diet composition of brown lemurs and Verreaux's sifakas. We observed that in this period of the year with low food availabilities, these two species showed some diet overlap in terms of food items and tree species they used. It seems that both species show different dietary preferences in periods of scarcity and rely on similar food resources to meet their energy and nutrient requirements. To limit direct competition, niche separation seems to occur in terms of tree species, spatial and temporal preferences. Further studies on diet composition in both the dry and wet season are needed to investigate the coexistence pattern of brown lemurs and Verreaux's sifakas more thoroughly.

Acknowledgement

We would like to thank the complete Tropical Biology Association (TBA) staff and teachers for their help, and especially Dr Nigel Mann, who supervised our project. Many thanks go to Dr Peter Green, Nivo Raharison and Veloarivony Rence Randrianindrina who helped us identify the tree species. We would also like to thank the German Primate Center (DPZ), especially Flavia Koch, who offered us the opportunity to use radio tracking equipment and gave essential information on the species' ranging behaviour. We also want to thank the anonymous reviewers of this article. We want to thank the very friendly Malagasy staff in Kirindy as well.

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Habitat structure and grey mouse lemur (*Microcebus murinus*) abundance in the transitional littoral forest of Petriky, South-East Madagascar

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Key words: *Microcebus murinus*, littoral forest, fragmentation, forest structure, mining

Abstract
The littoral forests of south-eastern Madagascar are among the most threatened biodiversity hotspots in the country due to heavy anthropogenic encroachment around the remaining fragments. The southernmost forest fragment, Petriky (~920 ha), represents a unique transitional littoral ecosystem between the wet and the dry area and currently lacks systematic lemur studies. QIT Madagascar Minerals, a mining company extracting ilmenite in the area, plans to mine the area of Petriky in the near future. The company is committed to achieving a Net Positive Impact on biodiversity, and the establishment of 120 ha of conservation zone in Petriky is among several conservation actions used to achieve this goal. In this paper, we compared habitat structure and density of grey mouse lemurs (*Microcebus murinus*) between the conservation zone and the rest of Petriky to rapidly assess whether different levels of protection resulted in different degrees of disturbance. Additionally, we also aimed to survey other nocturnal lemur species in the area as well as to record the presence of *Lemur catta*, known to occur in Petriky forest. From April to July 2012, forest structure was assessed with 20 plots (20 x 50 m) and a line intercept technique used to estimate canopy cover. Ten transects between 0.5 and 1 km (five in the conservation area and five in the unprotected area) were walked five times each. The data were then analysed with DISTANCE 6.0 software. 2,040 individual trees were measured, representing 72 species from 42 families. The results indicate that the conservation zone contains more trees, taller trees, and better canopy cover. We recorded 180 *M. murinus* sightings, resulting in mean density values of 4.8 ind/ha (95 % confidence interval: 3.0–7.4) in the unprotected zone, and 6.5 ind/ha (95 % confidence interval: 4.6–9.3) in the conservation zone. Mouse lemur abundance, however, was not significantly different between the two zones. Besides *M. murinus*, only one observation of *Avahi meridionalis* at night and two opportunistic observations of *Lemur catta* were collected. We discuss our results in view of the future conservation plans in the area.

Introduction
The littoral forests of Petriky, Mandena and Sainte Luce are located along the south-eastern coast of Madagascar, on notably mineralized sandy substrates, and are co-managed by QIT Madagascar Minerals (Rio Tinto QMM), a Canadian-Malagasy mining company which has a large project in the region, and local forest management committees (Dumetz, 1999; Vincelette *et al.*, 2007a). Over 42 plants and at least 14 invertebrate species are endemic to this area (Temple *et al.*, 2012). Due to the fast rate of forest destruction and increasing number of endangered species, the littoral forests have been identified as a national conservation priority (Ganzhorn *et al.*, 2001; Temple *et al.*, 2012; Dumetz, 1999). Over the past 50 years, the littoral forests of south-eastern Madagascar have lost 60 % of their area because of the increasing anthropogenic pressure, and approximately 3.5 % of the remaining forests are expected to be lost over the next 40 years as a result of mining and associated activities (Vincelette *et al.*, 2003, 2007a; Temple *et al.*, 2012). Thus, by incorporating recommendations from the World Conservation Union and International Council on Mining and Metals, QMM proposed an Environmental Action Plan (Vincelette *et al.*, 2007a). Rio Tinto is committed to achieve a Net Positive Impact (NPI) on biodiversity, a strategy launched at the 2004 IUCN World Conservation Congress, and QMM has been chosen as a pilot site to test the tools designed to achieve and quantify an NPI on biodiversity. The establishment of conservation zones in each littoral forest area is among several conservations actions to achieve the NPI.

This study took place in Petriky, the southernmost fragment of littoral forest in south-eastern Madagascar (Fig. 1). The remaining forest totals ~920 hectares, 120 hectares of which are included in a conservation zone and will become a new protected area of Madagascar. The Petriky forest is biologically interesting because it is transitional between the wet and the dry zone of south-eastern Madagascar and is home to both dry- and wet- typical lemur species that live sympatrically (Lahann, 2007). The Petriky forest is remarkably understudied compared to the companion littoral forests in the region. Petriky is considered degraded because of cattle grazing, crop farming and extraction of timber for the purpose of firewood/charcoal and building shelters (Dumetz, 1999; Rabenantoandro *et al.*, 2007). However, no hunting or logging has been allowed in the conservation zone during the last years, and approximately 30 local forest police enforce this today.

The most abundant lemur species residing in Petriky is the grey mouse lemur (*Microcebus murinus*). *Microcebus* is an adaptable, widespread, nocturnal genus that is found in a variety of habitats throughout Madagascar including: littoral forest, tropical dry forest, gallery forest, spiny forest, sub-arid thorn forests and secondary and degraded forests (Andrainarivo *et al.*, 2008). This species is not considered a *fady* (taboo) by locals, and the two main threats for the population residing in Petriky are habitat loss due to logging, and opportunistic hunting (Rakotoarison *et al.*, 1993).

The main objective of this study was to assess vegetation structure and diversity of tree species in the conservation zone of Petriky and compare it to the unprotected portion of the forest fragment. Additionally, the density and population size of *Microcebus murinus* in the two zones was estimated. The purpose was to determine whether the conservation zone in Petriky has been less affected by anthropogenic pressure compared with the rest of the fragment, using forest structure and the abundance of the most common lemur species as indicators. Comparisons of vegetation structure and mouse lemur densities were also made to previously collected data in Petriky and other littoral forests. Additionally, we also aimed to survey other nocturnal lemur species in the area as well as to record the presence of ring-tailed lemurs (*Lemur catta*), known to be present in this forest. The results presented are meant to help future conservation plans along with restoration projects in Petriky.

Methods
This research was conducted from April to July 2012 in Petriky (25°03'S, 46°52'E) (Fig. 1). The forest has an aver-

age elevation of 13 m and receives annual rainfall of 1,200 mm (Vincelette *et al*., 2007b; QMM, 2001). This study site is unique because it is transitional between the dry and the wet zone, grows on sandy soil and has a low canopy (5–7 m). Based on previous reports, four lemur species are thought to be present in the area: the grey mouse lemur (*Microcebus murinus*), the fat-tailed dwarf lemur (*Cheirogaleus medius*), the southern woolly lemur (*Avahi meridionalis*), and the ring-tailed lemur (*Lemur catta*) (Ganzhorn *et al*., 2007).

The plot method and the line-intercept technique were used to characterize forest structure (Ganzhorn, 2003). Plot locations were chosen at random along 10 measured transects (National Research Council, 1981). We selected a total of 20 plots measuring 20 x 50 m (10 in the conservation area and 10 in the unprotected area) and measured all trees with diameter at breast height (DBH) ≥ 5 cm with the help of a local guide, who provided vernacular names (Ganzhorn et al., 2007; Ingram et al., 2005). Although usually the DBH threshold used by botanists is 10 cm, we decided to use a lower threshold because trees growing in littoral forests become generally adult at a smaller size compared to other habitats (Rabenantoandro, pers. comm.). In order to describe the vertical structure, a line-intercept technique was used to document the height at which vegetation made contact with a canopy measuring stick (Ganzhorn *et al*., 2007). We set up one line of 20 metres marked at 1m intervals and crossing the centre of each plot. The mean canopy height was calculated as the sum of the maximum values of the canopy height at each line, divided by the total number of lines. Vegetation cover was expressed as the percentage of the intervals where the stick touched vegetation over the total number of intervals (Rabenantoandro *et al*., 2007).

The scientific names of all tree species were provided by the botanists of QMM. To determine species abundance, the number of trees of each species was divided by the total number of trees measured. The Shannon-Weaver (SW) index was used to measure floristic diversity (Peet, 1974).

Line-transect sampling was used as survey method for collecting lemur density data (Anderson *et al*., 1979). Ten transects, 0.5 km to 1 km in length and approximately 0.5 km apart, were set up using existing straight trails; five were marked inside the conservation zone and five in the unprotected zone (Peres, 1999; Buckland *et al*., 2010). Each transect was walked five times at a speed of approximately 1 km/hr over 31 days during the time window 18:30–22:00 (Plumptre, 2000; Ross and Reeve, 2011). The total distance surveyed was 31.24 km. Headlamps were used to detect lemur eye shine. For each observation, the lemur species was identified, and the time, height in tree, species of tree, diameter at breast height (DBH) of tree and perpendicular distance from transect were recorded. All data were recorded by the same individual to avoid inter-observer bias (Buckland *et al*., 2010).

The software DISTANCE 6.0 (Thomas *et al*., 2010) was used to estimate encounter rate, density and population size of *M. murinus*. The best-fit model was chosen by comparing the Akaike Information Criterion (AIC). To test for goodness of fit, the Kolmogorov-Smirnov test was conducted, adding supporting evidence that the model fits appropriately with the profile of our observations (P = 0.236 unprotected zone; P = 0.218 conservation zone). The 10 % most distant observations were excluded from the analysis as recommended in cases of nocturnal survey (Buckland *et al*., 2010). All data were analysed with SPSS Statistics 19 for Windows, and comparisons were performed using Mann-Whitney non parametric test.

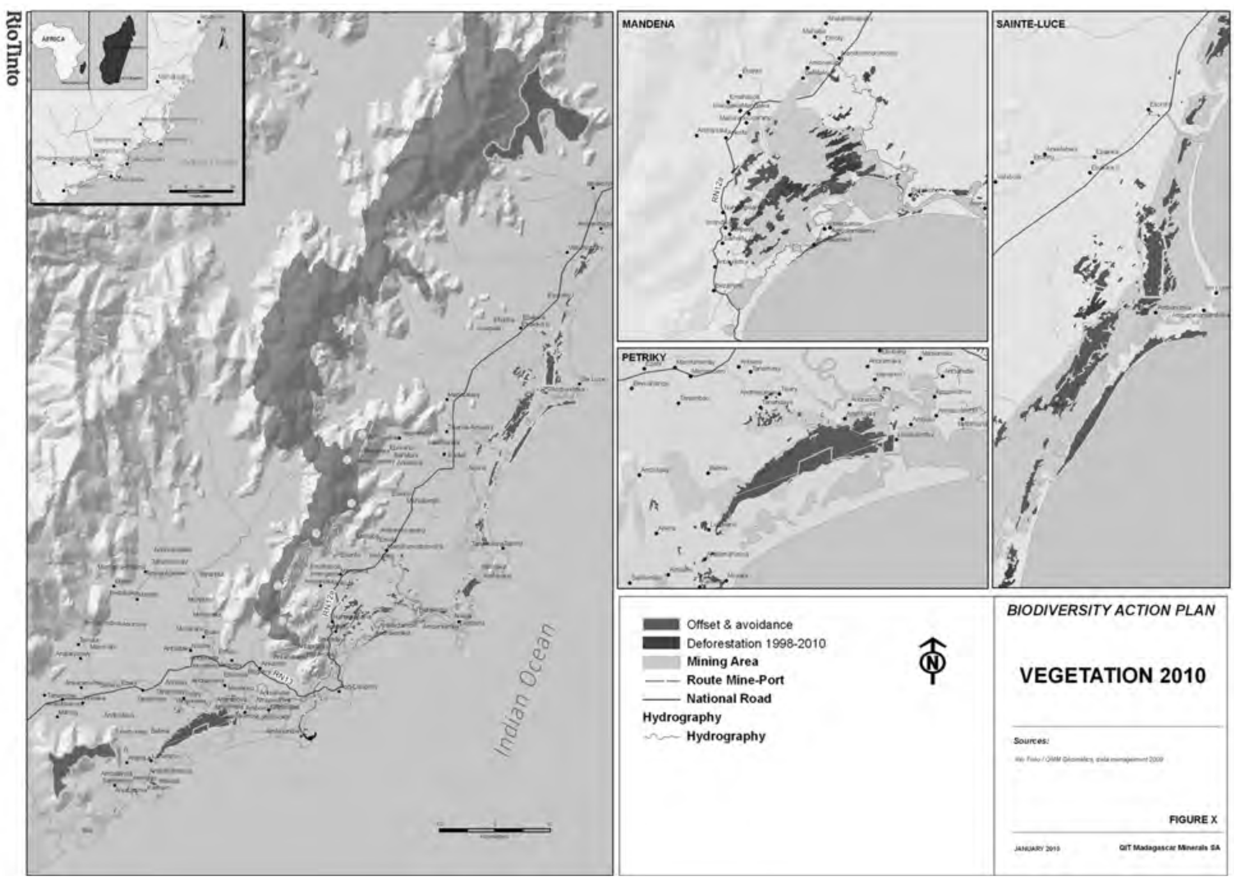

Fig. 1: Map of Tolagnaro region with the location of Petriky (modified from Rio Tinto/QMM 2010).

Results

We measured 2,040 individual trees from 72 species. The most abundant trees were *Syzgium* sp., *Erythorxylum platycladum* and *Intsia bijuga*. Eight of the 10 most abundant species were the same in both zones (Tab. 1).

Tab. 1: Abundance of the top 10 tree species in the unprotected and in the conservation zones.

Unprotected Zone		Conservation Zone	
Scientific Name	**% Abundance**	**Scientific Name**	**% Abundance**
Syzgium sp.	17.68	*Syzgium* sp.	23.18
Erythorxylum platycladum	13.55	*Erythorxylum platycladum*	8.81
Intsia bijuga	5.51	*Intsia bijuga*	6.50
Rhopalocarpus coriaceus	4.71	*Cassipourea microphylla*	6.33
Eugenia sp.1	4.13	*Euphorbia araka*	6.07
Euphorbia araka	3.90	*Rhopalocarpus coriaceus*	5.47
Asteropeia micraster	3.33	*Asteropeia micraster*	4.70
Oplonia vincoides	2.87	*Diospyros gracilipes*	4.36
Pollycardia sp.	2.53	*Pollycardia* sp.	4.28
Eugenia sp.2	2.41	*Eugenia* sp.1	3.25

The mean canopy height for the conservation zone was 4.55 m (SD = 0.29), and 3.71 m (SD = 0.27) for the unprotected zone. The conservation zone had more vegetation cover in both the understorey (below 3 m), 63 % (SD = 10.7), and canopy area (above 3 m), 38 % (SD = 18.8), compared to the unprotected zone, respectively: 51 % (SD = 12.1) and 12 % (SD = 7.6) (Below 3 m: U = 20; n = 10; P = 0.023 and above 3 m: U = 5.5; n = 10; P = 0.001). A box diagram was created to illustrate the canopy layer through each zone (10 plots per zone; Fig. 2).
The conservation zone had taller trees than the unprotected zone and a strong tendency for a higher density in the former area was also present (Tab. 2). Trees in both zones had very similar DBH and floristic diversity (Tab. 2).

During the 31 nights of surveying, we observed *Microcebus murinus* on 180 occasions, resulting in a mean encounter rate of 5.8 individuals/km (SD = 1.87) in the 31.24 km surveyed. The encounter rates for the unprotected zone were slightly lower (5.4 individuals/km; SD = 1.74) than in the conservation zone (6.2 individuals/km; SD = 2.09), although not significantly different (U = 12, n = 10, P = 0.917). *M. murinus* were seen at a mean height above ground of 3.6 m (SD = 1.3); the mean height of the visited trees was 4.6 m (SD = 1.4) and the mean DBH was 11.4 cm (SD = 9.9). The mean density of *M. murinus* in the conservation zone was 6.53 / ha (95 % confidence interval: 4.6–9.3), while it was 4.75 / ha (95 % confidence interval: 3.0–7.4) in the unprotected zone. The total population size in the 120 ha conservation zone is estimated at 784 individuals (confidence interval: 552–1112), while 3,802 (confidence interval: 2,438–5,929) is the result for the unprotected zone of approximately 800 ha.
No other lemurs were observed during the transect work, while *Avahi meridionalis* (on one occasion) and *Lemur catta* (on two occasions) were observed opportunistically.

Tab. 2: Diameter at breast height (DBH), height of tree, Shannon diversity index, and density of trees per hectares in the unprotected and in the conservation zones. Values are means plus standard deviations.

	Mean DBH	**Mean Height**	**Shannon Index**	**Density/ha**
Conservation Zone	10.03 ± 0.74 (n = 1169)	4.55 ± 0.29 (n = 1169)	1.11 ± 0.12 (n = 10)	1169 ± 290.42 (n = 10)
Unprotected Zone	10.06 ± 1.49 (n = 871)	3.71 ± 0.27 (n = 871)	1.16 ± 0.16 (n = 10)	871 ± 319.67 (n = 10)
Mann-Whitney U Test	U = 45.5 P = 0.734	U = 9.0 P = .002	U = 49.5 P = 0.970	U = 24.5 P = 0.054

Discussion

The results on vegetation structure showed a clear difference between the conservation zone and the unprotected zone. First, there was a higher density of trees and more continuous canopy cover within the conservation area compared to the unprotected area. Even though the diameter at breast height (DBH) was relatively the same between the zones, the protected area contained taller trees, creating a denser canopy. The level of tree species diversity between the two zones was not significantly different. Eight of

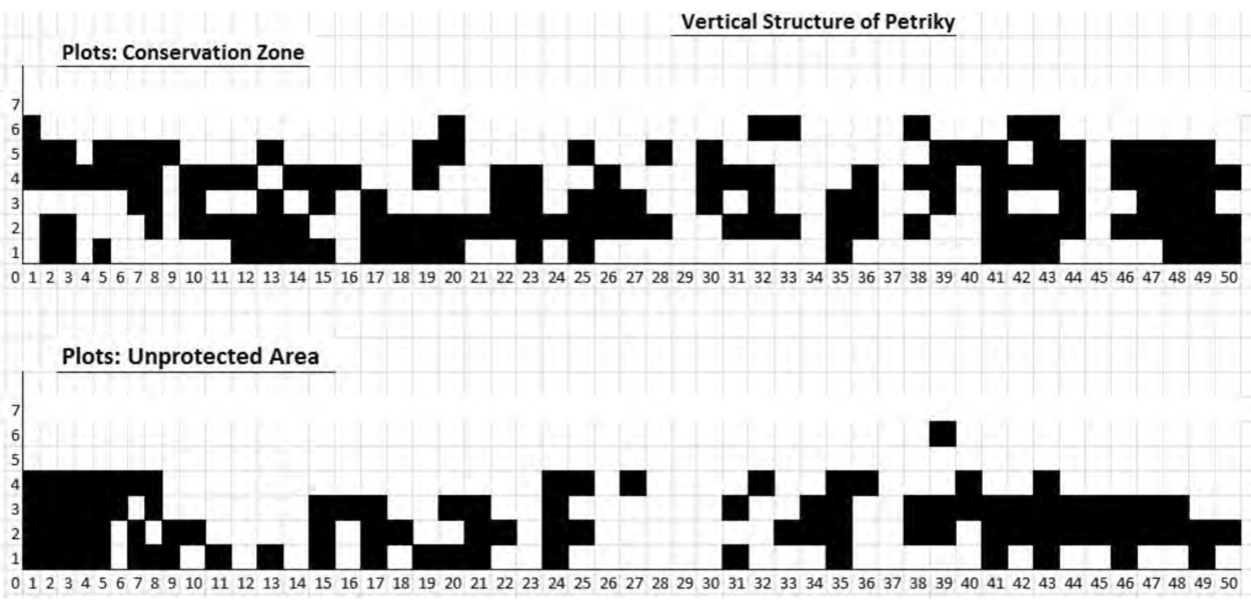

Fig. 2: Vertical structure of the Petriky forest. The values on the horizontal and on the vertical axis are in metres.

the top 10 measured tree species were the same between zones. Thus, overall the Petriky forest's conservation zone is showing a less disturbed structure when compared to the unprotected zone, although degradation does not seem to have severely affected the overall botanical diversity. Forest police employed by the local management committee of natural resources are patrolling the conservation zone and reporting logging and hunting (Ramanamanjato, pers. comm.). Our rapid assessment shows that this activity was effective to reduce logging and should be continued in the future.

Our data on vegetation structure confirmed previous analyses showing that Petriky is less similar to either Mandena or Sainte Luce than Mandena is to Sainte Luce (Rabenantoandro *et al*., 2007). Yet, the three littoral forests all have low DBH and low canopy heights compared to other humid forests (Dumetz, 1999). Comparisons to previous studies in Petriky (Rabenantoandro *et al*., 2007) highlight that the canopy height in the conservation zone is still within the range of previous results: the average canopy height in 2005 was 4.4 m, while 4.6 m was the average value in 2012. Both the understorey and the canopy cover were also consistent in both years (Rabenantoandro *et al*., 2007).

The results also pointed out that there is still a large population of *Microcebus murinus* residing in the transitional littoral forest of Petriky. When considering the structure of the Petriky forest, together with the differences revealed by our results between the two zones there are also evident signs of degradation due to previous charcoal burning and current logging, both in the conservation and in the unprotected area. Yet the population density of *Microcebus* was relatively high in all areas and there were no significant differences in encounter rates, meaning that this lemur species does not seem heavily affected by the degradation of the forest. Not unexpectedly, *Microcebus* species can endure degraded habitats to some degree (Ganzhorn, 1995; Nash, 2000).

The results from this study were also compared to previous studies providing encounter rates of *Microcebus* sp. in other littoral forests as well as in other wet and dry forests in Madagascar (Tab. 3). This may help to identify whether Petriky's forest is "transitional" also in terms of lemur densities between the wet and the dry domains. Overall, Petriky shows higher encounter rates compared to other littoral forests and/or humid forests, with the exception of Marojejy, while the highest values were reported in the dry habitats (Tab. 3).

There is a delicate balance between plants and lemurs facilitated by climate, meaning that even a small difference in rainfall or impact of humans could affect populations (Dunham *et al*., 2011; Ganzhorn *et al*., 1999; Wright, 2007). *Microcebus* species are common in all the Malagasy habitats and they can adapt to living even in areas modified by humans (Ganzhorn, 1995; Lahann *et al*., 2006). It has been suggested that a possible reason for higher densities in dry habitats may be due to the fruiting pattern, which makes food available year-round as a possible consequence of richer soils (Ganzhorn *et al*., 1999). Petriky shows higher encounter rates when compared to other humid forests, including littoral forests, despite the area having been heavily impacted by villagers logging and hunting daily (Rabenantoandro *et al*., 2007). However, being a forest on sand, Petriky is not likely to differ in terms of soil composition when compared to other littoral forests. Short-term isolation in small, very isolated fragments may have produced an overcrowding effect due to the lack of a full set of predators and/or competitors, which could be a possible reason why the density of *M. murinus* is high in this area (Estrada *et al*., 2002; Donati *et al*., 2011).

Although the mouse lemur population residing in the conservation zone may be considered large, this is not the case for other lemur species occurring in the area like the endangered *Lemur catta* and *Avahi meridionalis*. The latter species has been spotted only once during this study (not during the surveys), which may indicate that the species is almost extinct in the area. A similar situation seems to be true for *Lemur catta*. Although we only analyzed nocturnal transects in this paper, a systematic research for diurnal species was conducted at the beginning of this study to assess the feasibility of research on ring-tailed lemurs. This pilot work resulted in the encounter on two occasions of only one group of *Lemur catta*, which seems to range over a large area, partly outside of the forest boundaries (Malone, pers. obs.). We cannot discuss the situation of the other lemur species known to occur in Petriky, *Cheirogaleus medius*, since this species is hibernating during the winter months and thus it was not spotted over the study period.

Summarizing, on the basis of this recent survey work a conservation plan to protect the full set of lemur species originally present in Petriky may prove to be extremely dif-

Tab. 3: Encounter rates (species/km walked) of *Microcebus* sp. from line transects in three littoral forests and other dry and wet sites in Madagascar. *UZ = Unprotected Zone; CZ = Conservation Zone

Forest Type	Study Site	Time Period	Encounter rate (individuals/km)	Range	Reference
Wet	Maromizaha	May - September, 2005	3.4	-	Randrianambinina and Rasoloharijaona, 2006
	Anka	November, 2004	4.0	-	Norscia *et al*., 2006
	Marojejy Strict Nature Reserve	August - October, 1988	7.0	-	Duckworth *et al*., 1995
Littoral	Petriky	April - July, 2012	5.4 UZ* 6.2 CZ*	2.7-7.4 UZ* 4.2-9.3 CZ*	Current Study
		1998-1999	3.0	0.8-6.5	Ganzhorn et al., 2007
	Mandena	April - May, 2004	4.0	0.8-5.0	
	Sainte Luce	November 2000 - January 2001	0.5	0.0-0.5	
		October - December 2004	1.0	0.3-0.8	
	Antevialakoro	September, 2008	3.0	2.0-4.0	Rakotondravony and Rabenandrasana, 2012
	Menagisy	September, 2008	1.0	2.0-4.0	
Dry	Beza Mahafaly Special Reserve	September 1992 - July 1993	9.6	5.3-13.6	Nash, 2000
	National Park, Kirindy Mitea	September, 1999	-	0.3-5.0	Zinner *et al*., 2001
	North Mikea	September, 1999	6.7		
	Reserve Naturelle d'Ankarafantsika	September, 2000	21.1	20.0-26.3	Radespiel and Raveloson, 2001

ficult because of the likely non-viable populations of the endangered species which still occur in this forest. That said, the established conservation zone in Petriky still seems to contain the most intact area of this unique forest in terms of structure and botanical diversity.

Acknowledgements
We would like to thank the Malagasy Institute for the Conservation of Tropical Environments (MICET), the Department of Animal Biology of the University of Antananarivo, and QMM for their collaboration and permissions to work in Madagascar. Thanks to the QMM Environmental Team for their help with the logistics. A special thanks to Tim Eppley and Katie Hall for their guidance and scientific advice. Thank you to the entire staff of the Oxford Brookes Primate Conservation MSc programme.

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Population recovery of two diurnal lemur species, *Varecia rubra* and *Eulemur albifrons*, following cyclonic disturbance in Masoala National Park, Madagascar

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Key words: *Varecia rubra*, *Eulemur albifrons*, cyclone, demography, population recovery, Masoala

Résumé
La forêt de Masoala a été dévastée par un cyclone très intense dénommé Hudah le mois d'Avril 2000. Une étude d'impact de cette catastrophe naturelle sur les populations de deux sous-espèces de lémuriens diurnes: *Varecia rubra et Eulemur albifrons* a été menée un an après (du janvier à mars 2001) dans deux sites situés sur la côte est de la presqu'île de Masoala, région la plus affectée par le cyclone. De cette étude, des variations sur les paramètres démographiques de ces sous-espèces et sur la structure de la forêt dues aux dommages qui affectaient les arbres ont été rapportés. Cette étude (du janvier à mars 2004) consiste à déterminer le recouvrement de population de ces lémuriens quatre ans après le passage du cyclone. En général, une tendance au rétablissement des paramètres démographiques vers leur état avant la perturbation cyclonique est observée chez *E. albifrons*. Il en est de même pour *V. rubra*, seulement, cette tendance dépend du degré de perturbation du site. De cette étude ressort une différence de réponses de ces espèces à la perturbation de leur habitat. *Eulemur albifrons* se montre plus résistant et plus résilient à une dégradation de la forêt que *Varecia rubra* qui en est plus vulnérable.

Introduction

Madagascar ranks among the world's top biodiversity hotspots (Conservation International, 2004), with 90 % of its species endemic to the island (Dufils, 2003). It is recognized as the world's highest primate conservation priority, with very high species diversity and unmatched endemism at the species, genus, and family levels (Mittermeier *et al*., 2010). Lemurs are tree-dwelling primates occupying forest habitats in Madagascar. Forests are the principal habitats of these animals, and the trees' dense foliage provides refuge from predation and bad weather. Trees are also the lemurs' main conduits of travel as well as their sources of food. Therefore forest disturbance could negatively affect lemurs.

Madagascar is prone to cyclones that create extreme ecological disturbance. In April 2000, a devastating cyclone named Hudah ravaged the Masoala Peninsula in north-east Madagascar. Aerial photographs showed that the majority of trees lost their leaves and branches, while others broke, fell or were uprooted (Hatchwell, 2000; Birkinshaw *et al*., 2001; Ratsisetraina, 2001). Two species of diurnal lemurs lost half their populations: 101 individuals of *Eulemur albifrons* were counted before the cyclone, whereas 46 individuals were counted after. For *Varecia rubra,* 26 individuals were recorded before the cyclone, while 17 individuals were counted after (Ratsisetraina, 2001).

These two species have been subject to annual ecological monitoring (Rakotondratsima and Kremen, 2000; Ratsisetraina, 2002) and a substantial amount of conservation research has been dedicated to understanding the diet (Rigamonti, 1993), ecology and behaviour (Vasey, 1997), and impact of human disturbance (Rakotondratsima, 1995; Merenlender *et al*., 1998). Yet, their recovery from cyclonic disturbance has not yet been studied. Research has addressed the effects of drought on *Lemur catta* (Gould *et al*., 1999); storms in the Berenty reserve, southeast of Madagascar (Rasamimanana *et al*., 2000); and the effects of cyclone on *Varecia variegata* behaviour (Ratsimbazafy *et al*., 2002). Yet there have been no studies into lemur population recovery following a cyclonic disturbance in the forest ecosystem of Madagascar. Thus it is important to build a better understanding of the long-term effects of cyclonic disturbance on the lemur species *Varecia rubra* and *Eulemur albifrons*.

The main objectives of this study were to (1) provide information on the state of these two species' populations four years after disturbance from cyclone Hudah; and (2) describe the resilience or ability of these populations to recover and respond to habitat disturbances following the Hudah cyclone. Results from this study will serve as a reference to establish a long-term strategy for their conservation.

Methods

Site description

With its 540,000 ha, Masoala is not only the biggest national park but also one of the largest forests remaining in Madagascar. Masoala forest belongs to the oriental moist lowland forest type (Faramalala and Rajeriarison, 1998; Humbert and Darnes, 1965) and is home to hundreds of endemic species. The area provides habitat for the red ruffed lemur *Varecia rubra*, unique and endemic to the Masoala Peninsula, and the white-fronted brown lemur *Eulemur albifrons*, endemic to the eastern rainforest of Madagascar.

This study took place at two sites on the Masoala Peninsula that had been monitored annually since 1996 (Merenlender *et al*., 1998): Antsahamanara and Sahafary. Compared to other areas in the region, Antsahamanara and Sahafary, which are located in the north-eastern portion of the peninsula, were heavily damaged by cyclone Hudah.

Fig. 1: Study site location: Antsahamanara and Sahafary localization map.

Antsahamanara has a system of four transects totalling 6 km, and Sahafary has a system of three transects totalling a distance of 2.5 km.

Demographic analyses
For both lemur species, I described the variation of abundance, density, group size, sex ratio and reproductive rate for the three periods before the cyclone, one year and four years after the cyclone, respectively.

I first conducted direct counts of each species at both sites (Sahafary and Antsahamanara) at the three time periods. These counts were performed along the observation paths, which had been used for lemur annual ecological monitoring since 1996. For each sighting I collected geographical coordinates with a handheld GPS.
Observations began early in the morning at 06:30, and took place slowly along the observation path with frequent stops to better locate noises and calls of the animals. I made eight observations for each transect because previous studies had shown that at least eight days of observation must be carried out on each path in order to identify the maximum number of groups. This observation method was used for all three study periods and had been adopted since the launch of the Masoala project for ecological monitoring in 1993 (Merenlender *et al.*, 1998).
For each observation, the following data were recorded: the date of the observation, the name of the site, the name of the path, hours of beginning and ending the observation.
During each animal observation, the following data were recorded:

- The hour during which the animal or the group had been seen or heard.
- The species met (*E. albifrons* or *V. rubra*) and the total number of animals observed.
- The location of the path on which the first animal was met.
- The number of individuals by age class: adult (age of more than one year), subadult (age of less than one year), infant (age of less than three months). Because age estimation of each individual was difficult, large individuals were considered adults, those of small size with the ability to move independently were considered as subadults, and infants were those which were still on their mother's back.
- The number by sex for *E. albifrons*.
- The distance of the animal from the observer and its orientation in relation to north.
- Geographical coordinates of the animal location, read with GPS.

Data analysis
Because *Varecia rubra* and *Eulemur albifrons* live in groups, identification of the groups was made in two stages. Firstly, groups of individuals met more than three times on the ground in the same place and its surroundings (approximately 10 to 20 m proximity) during the eight days of observations were considered to be one group. Secondly, all groups identified on the ground were checked and justified during data processing. If two or more groups had large areas of overlap in their home ranges (see below for calculation of home range area), i.e. more than 60 % after data processing by GIS software, they were considered as one group.

Group size
For the two species studied, the group size was defined as the number of individuals that formed a social group at the time of observation. However, it should be noted that *V. rubra* has a more complex social structure compared with other lemurs; a group of individuals often observed at the same time during the counting could be a sub-group of a larger group.

Density
The density was calculated as the relationship between the number of individuals of all social groups assigned in each site (abundance) and surface area sampled by site.
Abundance was the total number of individuals in all groups determined for each species in each site. Sampled surface was obtained from the GIS data processing and geographical points of the group location already identified along all study paths. It tries to establish home ranges of each group in a circular model of radius ranging from 350–500 m for *Eulemur* and 100–500 m for *Varecia* (Merenlender *et al.*, 1998). The sampling surface of each species was calculated from the overall length of the observation transect and their respective maximum radius of home ranges.

Sex ratio
The sex ratio was defined as the ratio between the number of males and females. Distinguishing males from females by visual observation for *Varecia* was very difficult; the sex ratio was evaluated only for *Eulemur* because this species exhibits sexual dimorphism from which the male was characterised by its white face.

Age structure and reproductive rate
For *E. albifrons*, the reproductive rate was defined as the number of infants in relation to the number of adult females observed. In general, the species has an age structure divided into three classes: adult (older than 1 year), subadult (less than 1 year) and infant (individuals less than 3 months). By definition, infants were individuals born during the same biological season. The number of infants used for the calculation of the reproductive rate included the number of individuals known to be subadult that were in the same generation as the individuals known to be infants. For *Varecia*, the reproductive rate was obtained from the number of infants in relation to the number of adults, which corresponds to birth rate.

Test of comparison of the demographic parameters
The three demographic parameters (group size, sex ratio, reproduction rate) compared in the three periods (before, one year and four years after the cyclone) were analysed by a nonparametric test (Wilcoxon test). The present study compared two paired measurements, a measure taken one year after the passage of the cyclone and a second four years after in the same sites, on the same paths; and two other paired measurements: a measure taken before the catastrophe and a second one taken four years after, according to Chalmers *et al.* (2001).
It was necessary to analyse differences between the two paired measurements, therefore a Chi-square test was used to show the validity of this probability. The Chi-square test was used to compare observed values with the calculated values.

Results

Abundance and number of groups
In both areas of the park, individuals and groups of *Eulemur albifrons* had decreased one year after the cyclone, but appeared to have partially recovered by four years after the cyclone (Tab. 1). At the Antsahamanara site, individual and

Tab. 1: Abundance and group number of *E. albifrons* and *V. rubra* in Antsahamanara and Sahafary.

Period	Antsahamanara				Sahafary			
	No. of individuals		No. of groups		No. of individuals		No. of groups	
	E. albifrons	*V. rubra*	*E. albifrons*	*V. rubra*	*E. albifrons*	*V. rubra*	*E. albifrons*	*V. rubra*
Before cyclone	61	10	10	4	40	16	5	4
One year after cyclone	37	8	6	5	9	9	2	2
Four years after cyclone	47	14	8	6	24	3	3	1

group numbers decreased by 60 % and 60 %, respectively one year after the cyclone, whereas individual and group numbers decreased by 23 % and 40%, respectively at the Sahafary site. By four years after the cyclone, *E. albifrons* had recovered to 80 % of its original size at Antsahamanara and to 60 % at Sahafary.

It is probable that the increase in the number of individuals was due to group fusion. Growth of the *E. albifrons* population can be explained by the recruitment of newborns or of other individuals migrating from other places (or parts) of the forest.

At Antsahamanara, after showing a decreased population one year after the cyclone, *V. rubra* recovered to beyond its original population numbers. The increase of the *V. rubra* population may be due to individuals coming from outside the study site. In Sahafary, individual and group numbers declined over the first year after the cyclone and then declined even further four years after the cyclone.

Density

For *E. albifrons*, the calculated home range size was 5.23 km^2 in Antsahamanara and 1.48 km^2 in Sahafary. The estimated density of *E. albifrons* in both areas decreased one year after the cyclone and showed recovery four years after the cyclone to 77 % and 60 % of their original densities (Tab. 2). The average home range for *V. rubra* was 1.04 km^2 for Sahafary and 3.72 km^2 for Antsahamanara. In Antsahamanara, the density decreased one year after the cyclone, but recovered to 60 % of the original density four years after the cyclone. In Sahafary, density decreased by 56 % one year after the cyclone and to 19 % of the original density four years after the cyclone.

Tab. 2: Density of *E. albifrons* and *V. rubra* in Antsahamanara and Sahafary (individuals/km^2).

Period	Antsahamanara		Sahafary	
	E. albifrons	*V. rubra*	*E. albifrons*	*V. rubra*
Before cyclone	11.66	2.68	27.02	15.38
One year after cyclone	7.07	2.15	6.08	8.65
Four years after cyclone	8.98	3.76	16.21	2.88

Group size

In Antsahamanara, a light reduction in the mean group size of *E. albifrons* four years after the passage of the cyclone was observed, but the variation of this parameter for each period was not significant (P = 0.55, Z = 0.60). On the other hand, in Sahafary, a reduction by half was recorded one year after the cyclone, but a return to the initial size occurred after four years. However, this recovery was not significant (P = 0.36, Z = 0.45). This fact may be explained by *E. albifrons*' tendency to live in small groups in Antsahamanara, at least for this study period, while they tended to form larger groups in Sahafary.

For V. rubra in Antsahamanara, the cyclonic disturbance led to a decrease in group size to 64%. The group size between the two periods proved to be not significant (P = 0.82, Z = 0.91). Indeed, the group of *V. rubra* in Antsahamanara reached its initial size again four years after the cyclone. A significant reduction (P = 0.04, Z = 0.13) was observed in Sahafary four years after the cyclone. The reduction in the number of groups was accompanied by a reduction in group size that may have resulted from a tendency to live in small groups.

Tab. 3: Group size of *E. albifrons* and *V. rubra* in Antsahamanara and Sahafary.

Period	Antsahamanara		Sahafary	
	E. albifrons	*V. rubra*	*E. albifrons*	*V. rubra*
Before cyclone	6.1 ± 1.6	2.5 ± 1.3	8.0 ± 1.5	4.0 ± 0.0
One year after cyclone	6.2 ± 3.6	1.6 ± 0.5	4.5 ± 0.7	4.5 ± 0.7
Four years after cyclone	5.6 ± 1.3	2.3 ± 0.8	8.0 ± 3.6	3.0 ± 0.0

Age structure and reproductive rate

In Antsahamanara, adults were increasingly more abundant in both sexes. Numbers of adult males were low before the cyclone, but after the passage of the cyclone they exceeded pre-cyclone numbers. For subadult and infant classes, male and female numbers were proportional four years after Hudah. The population of *E. albifrons* in Antsahamanara was an old population (in reversed pyramid form) marked by the abundance of adults.

For the Sahafary site, adult females were observed during all periods of study (before the cyclone, one and four years after the cyclone), while no female infants were recorded during the post-cyclone period. Among the male population, infants were more numerous than adults after the cyclone passage.

A recovery of adult numbers was noted in Antsahamanara four years post-cyclone following a slight decline in preceding years. The same was observed for infants. For Sahafary, a progressive reduction in adult numbers as well as among infants was observed, but no recovery was noted. The population of *V. rubra* was an aging one and there was a deficiency of subadult individuals.

Tab. 4: Reproductive rate of *E. albifrons* and *V. rubra* in Antsahamanara and Sahafary.

Period	Antsahamanara		Sahafary	
	E. albifrons	*V. rubra*	*E. albifrons*	*V. rubra*
Before cyclone	0.2 ± 0.3	0.0 ± 0.0	0.9 ± 0.4	0.0 ± 0.0
One year after cyclone	1.1 ± 1.2	0.0 ± 0.0	0.0 ± 0.0	0.8 ± 0.2
Four years after cyclone	0.5 ± 0.5	0.3 ± 0.3	0.4 ± 1.0	0.5 ± 0.0

Reproductive rate

TIn Antsahamanara, the reproductive rate of *E. albifrons* was low before the passage of the cyclone compared to after. One year after the cyclone, the number of newborns was proportional to the number of adult females. This rate decreased considerably four years after the cyclone. But the test of comparison showed that this decrease was not significant (P = 0.38, Z = 0.42). In Sahafary, the reproductive rate was higher before the passage of the cyclone. Almost each adult female in a group gave birth to an infant. But no

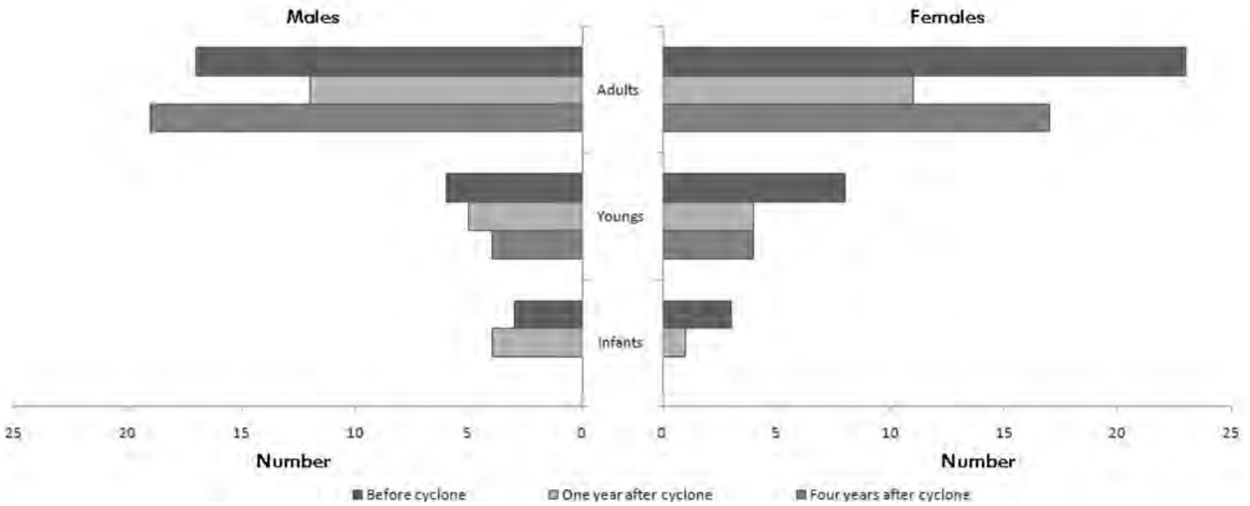

Fig. 2: Age structure of *E. albifrons* in Sahafary.

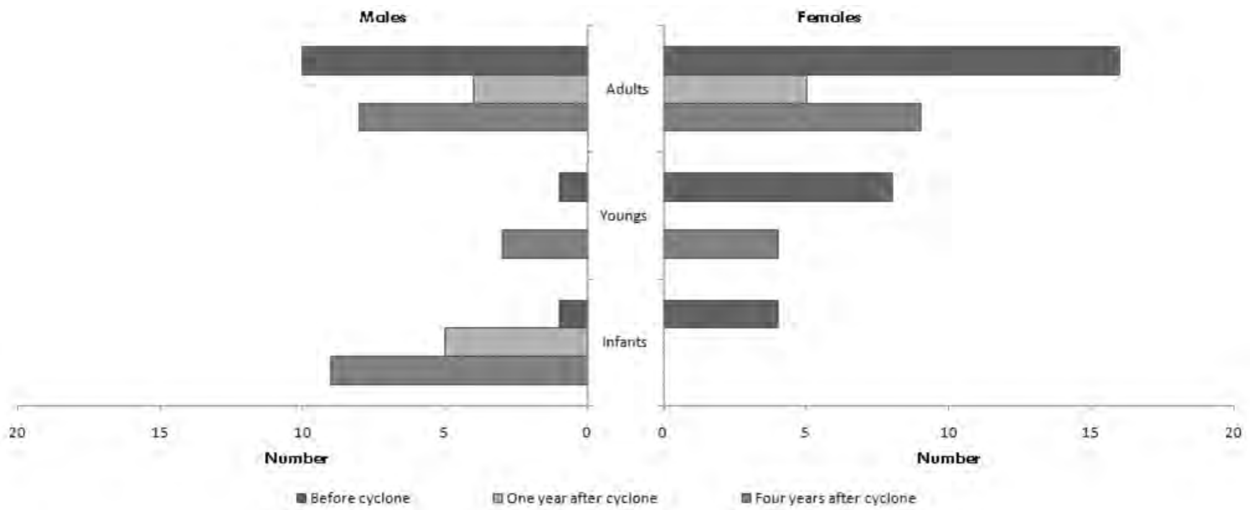

Fig. 3: Age structure of *V. rubra* in Antsahamanara.

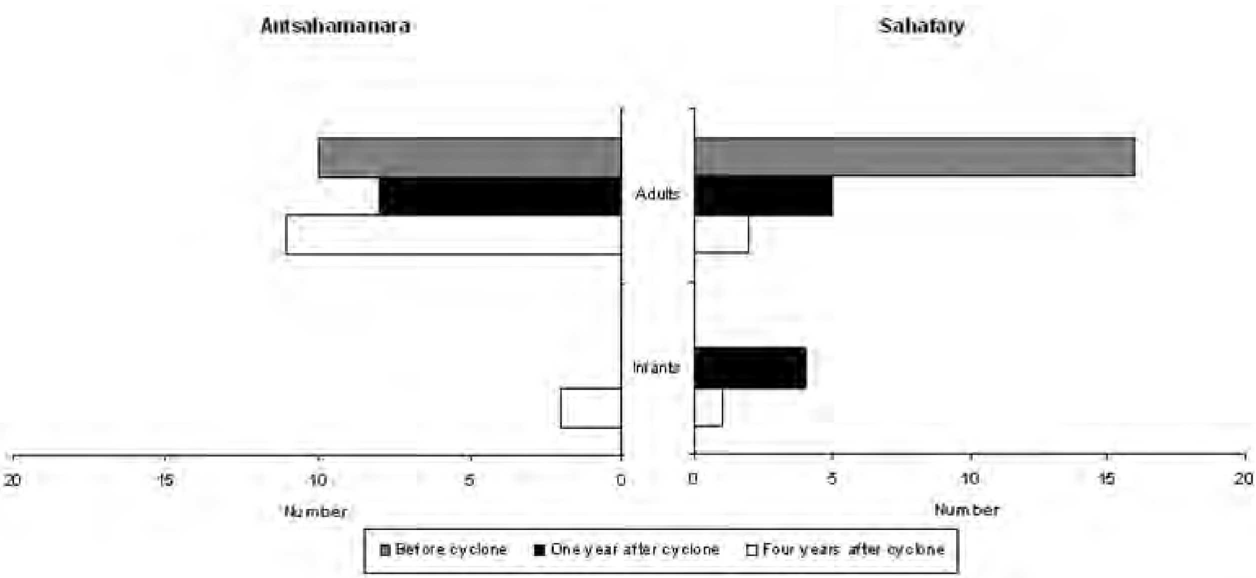

Fig. 4: Age structure of *V. rubra* in Antsahamanara and Sahafary.

birth was recorded after the passage of Hudah. Low reproduction resumption was marked four years after the cataclysm, but it did not reach the initial rate before the cyclone. After the stress due to the cyclone disturbance, *E. albifrons* may eventually have recovered its population by increased birth rates.

Birth rate is considered to express the reproductive rate, as mentioned in the methodology section. No birth was recorded for *V. rubra* in the two sites before the cyclone; it was the same during the post-cyclonic year in Antsahamanara. A low level of reproduction occurred four years after the cyclone, but the difference was still not significant (P = 0.10, Z = 0.14) compared to the absence of birth. For Sahafary, a fluctuation was observed during post-cyclonic periods, showing birth compensation. The one group remaining in the site had an infant. The significant difference (P = 0.04, Z = 0.13) between the birth rate before and four years after the cyclone indicates that there was, however, birth expansion among *V. rubra* in Sahafary.

Sex ratio

In Antsahamanara, there were as many females as males in the post-cyclonic period. The number of males and females tended to be proportional despite a slight nonsignificant variation four years after the cyclone (P = 0.79, Z = 0.84). In Sahafary there was female sex predominance but there was no variation of the sex ratio one year and four years after the cyclone (P = 1, Z = 0.77); the number of females was always higher. For the two sites, a tendency towards a stability of the sex ratio starting from the passage of Hudah was noted.

Tab. 5: Sex ratio of *E. albifrons* and *V. rubra* in Antsahamanara and Sahafary.

Period	Antsahamanara	Sahafary
Before cyclone	0.7 ± 0.2	0.4 ± 0.1
One year after cyclone	1.0 ± 0.4	0.8 ± 0.2
Four years after cyclone	1.3 ± 0.8	0.8 ± 0.5

Discussion

This study showed that the two species responded differently to habitat disturbance. Their responses also depended on the degree of disturbance to the vegetation. According to an assessment of the vegetation after the cyclone, the Antsahamanara site was less disturbed and less affected by the cyclone than Sahafary, which showed more damage (Ratsisetraina, 2001; Birkinshaw *et al*., 2001). In Sahafary, 33 % of trees with a diameter between 50 and 60 cm were uprooted, while in Antsahamanara only 7% were (Ratsisetraina, 2001). Indeed, a study on vegetation recovery reported that Antsahamanara recovered more successfully than Sahafary (Randrianjanahary, 2004).

In Antsahamanara, the reduction in abundance and number of groups by half one year after the cyclone could be the consequence of fission-fusion phenomena, the social organisation of the groups, or simply due to high mortality during the cyclonic event (Ratsisetraina, 2001) as shown in bats after hurricanes (Gannon and Willig, 1994). The increase in numbers of individuals and groups four years after the cyclone may have been the result of both, recruitments of new individuals and births, in more recent years. It is likely that individuals or groups migrated from more disturbed habitats with lower recovery rates. It remains to be known if these immigrants will live in this site permanently or only temporarily.

In Sahafary, in spite of the degree of habitat disturbance associated with the cyclone, recovery in abundance and group numbers were observed. *E. albifrons* tended to live in bigger groups in disturbed habitat. This may be a strategy to protect themselves from predators in a forest with an open canopy. The increase in population size was probably related to an increase in food availability in the low and medium strata of the opened forest, the strata most used by this species (Gannon and Willig, 1994).

Taking into account the abundance of *E. albifrons* in the two sites four years after cyclone Hudah, the population of this species could have reached the level of pre-cyclonic abundance had there been no human activities such as hunting and forest clearing. Thus, how many years are necessary for this species to recover after a cyclonic disturbance? Normally, the more the habitat is disturbed, the less available food there is and the larger the home range becomes, with density decreasing. In general, if the habitat is intact and groups do not migrate towards other places, then the density follows the same fluctuation. Yet, studies on birds showed that forest damage could affect the distribution of the population following cyclonic disturbances (Waide, 1991; Rene de Roland and Andrianarimisa, 2001). In the case of this study an increase in density was observed in the two sites. This phenomenon would be relative to recruitment of new individuals coming from outside the sites and also of the accumulation of newborns from the year post-cyclone. In turn, vegetation recovery four years after the cyclone would improve the availability of food for the lemurs, with the result that they would not need to disperse further to find food.

According to a post-cyclone study by Birkinshaw *et al.* (2001) and Ratsisetraina (2001), Sahafary was more disturbed than Antsahamanara. Indeed, the absence of newborns was probably the consequence of a reduction in the fertility and fecundity of the females due to malnutrition. Moreover, the quality of their food was reduced as a consequence of damage to trees. This decrease could have been a result of the disappearance of many adult females and a loss of newborn infants during or after the cyclonic event (Ratsisetraina, 2001), inducing insufficient reproductive females. The study after the passage of Hudah reported that the adult females were most vulnerable to the disturbance of their habitat (Ratsisetraina, 2001). This phenomenon was observed in a study of the effect of the Hugo cyclone on bat populations in the tropical forest of Puerto Rico, which mentioned the absence of births during the two years following natural catastrophes (Gannon and Willig, 1994).

Natural disturbances such as cyclones slow down the birth rate of *V. rubra*. Malnutrition resulting from the deficiency in nutritive elements would decrease fecundity of adult females. Also, the cyclonic damage affecting the trees could involve the disturbance of tree phenology, which consequently decreases the production of flowers and fruits that compose their main food. Very few births were recorded in Antsahamanara following the cyclonic disturbance, as observed in *Varecia variegata* where no birth was listed during the three years following the Gretelle cyclone in the forest of Manombo (Ratsimbazafy *et al*., 2002). Furthermore, the opening of the canopy would facilitate predators to attack *Varecia* infants (Ratsisetraina, 2001) that remain nest-dwellers until their third month (Vasey, 2000). The absence of births could also be explained by the generally low birth rate of *Varecia* and the high infant mortality, even in habitats without cyclonic disturbance (Morland, 1990).

Conclusion

The results of this study showed that *Varecia* was more affected by the habitat disturbance than *Eulemur*. The perturbation of their habitat may have induced changes to their demography. The two species had different responses to habitat disturbance. The cyclone's impact on the two lemur species in the more severely damaged site of Sahafary was different to the moderately disturbed site of Antsahamanara, and it was the same for population recovery. *Varecia rubra,* being canopy-dwelling, was more sensitive and vulnerable to habitat disturbance and its population recovery depended on habitat quality. However, *Eulemur albifrons* was more resilient and able to live in damaged habitat. This may have been due to *E. albifrons'* ability to live in different strata of the vegetation and the diversity of its food available during each season.

Each year, the Masoala region is prone to cyclone disturbances that accentuate threats to *Varecia rubra*. The species' distribution area is restricted on the Masoala Peninsula, and *Varecia rubra* has recently been classified as Critically Endangered on the IUCN Red List following the lemur reassessment in 2012. The survival of this species is now worrying in light of its vulnerability to habitat disturbance. Further studies on its population, such as population estimation, birth and/or habitat surveys, and regular ecological monitoring are needed to clarify if this species can adopt a lasting ability to live in a severely damaged habitat.

Acknowledgements

This study was supported by the British Ecological Society through its overseas bursaries fellowship programme. I would like to thank Dr Emilienne Razafimahatratra, Marius Rakotondratsima and the Wildlife Conservation Society Madagascar Programme for their scientific, administrative and logistic support, and the Madagascar National Parks team in Masoala, especially Bemieky Emilien and Raharison, for their assistance with the field work. My warm thanks go to Dr Kari Veblen for the helpful advice and instructions on writing this paper.

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Body size variation in ruffed lemurs (*Varecia variegata editorum*): implications for reproduction at Manombo Forest in Madagascar

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Key words: body size, reproduction, habitat quality, ruffed lemurs, *Varecia variegata editorum*, Madagascar

Abstract

By comparing the body masses of ruffed lemurs (*Varecia v. editorum*) at three sites with different levels of disturbance in the south-eastern rainforests of Madagascar, we found that there were body mass differences between those inhabiting highly disturbed habitats and those living in medium and least disturbed habitats. Among the three sites, Ranomafana National Park (RNP) was the least disturbed forest and Manombo Forest was the most disturbed. In February 1997, Manombo was hit by a cyclone, which caused tremendous damage to the forest, and to the *Varecia* food

trees in particular. Kianjavato Forest was the smallest in size, but animals were not hunted in this area. A total of 35 adult *Varecia* (n = 20 at RNP; n = 7 at Kianjavato; and n = 8 at Manombo) were captured, weighed and measured. The *Varecia* at Manombo were weighed after the 1997 cyclone to investigate the effects of potential environmental stress and habitat changes. We found that the *Varecia v. variegata* at Manombo weighed significantly less than those in RNP and Kianjavato. There were no significant differences in *Varecia* size between RNP and Kianjavato. Despite their smaller body mass, the *Varecia* at Manombo were slightly, but not significantly, longer than those at RNP when comparing head-body length. These results are important because they suggest that the *Varecia* at Manombo are not just smaller overall. We suspect that in this species there is a body mass threshold below which females cannot give birth or sustain pregnancy. None of the *Varecia* at Manombo had gave birth after the extreme cyclone damage, whereas births were seen in the two other sites. This study suggests that mass loss due to environmental stress is linked to reproduction failure in ruffed lemurs.

Introduction

The effects of environmental variation on female reproduction have been well examined in many species of birds (Sanz, 1996), but remain poorly studied in mammals. Birds living in harsh environments have been reported to have reduced hatching success (Martin, 1987; Webb, 1987) and prolonged incubation periods (Martin, 1987; Arcese and Smith, 1988; Moreno and Carlson, 1989; Smith *et al*., 1989). Reduced food availability has been found to delay the age at first reproduction in macaques (Mori, 1979; Sugiyama and Ohsama, 1982), baboons (Strum and Western, 1982) and vervets (Cheney *et al*., 1986). The study of female reproductive ecology of non-human primates in the wild has received serious consideration recently (Lee, 1987; Sterck *et al*., 1997). In prosimians, very little research has quantitatively addressed the issue of morphological changes associated with habitat disruption and its possible effects on fertility and/or infant mortality (Ganzhorn and Schmid, 1998; Richard *et al*., 2000; Gould *et al*., 1999; Koyama *et al*., 2001). A major difficulty in carrying out this kind of natural experiment is obtaining large enough samples for statistical analyses for each sex. It can also be quite difficult in some circumstances to make a clear distinction between fully adult and sub-adult individuals and between estimates of body mass obtained in different seasons (Smith and Jungers, 1997; Richard *et al*., 2000).

In field studies, primates have been shown to be sensitive to habitat disturbance (de Thoisy and Richard-Hansen, 1997; Johns, 1983; Johns and Skorupa, 1987; Strushasker, 1997). To measure the effects of disturbance on primates, different techniques and data have been used, such as behaviour and genetics (e.g. assessing the effects of inbreeding), but the use of body size and mass remains one of the most common tools for comparative purposes (Altmann *et al*., 1993; Garber and Leigh, 1997). A number of authors (see Goldizen *et al*., 1988; Koenig *et al*., 1997; Ganzhorn and Schmid, 1998; Fietz, 1998; Schmid and Kappeler, 1998; Gould *et al*., 1999; Richard *et al*., 2000) have used the fluctuations in body mass as good indicators of change in the nutrition of individual animals. Studies of Western human populations indicate that male reproductive function is sensitive to environmental stresses, including weight loss, dietary composition, disease, and psychological stress (Campbell and Leslie, 1995). During the past decade, considerable interest has developed in the suggestion that stress can somehow precipitate reproductive suppression (Dunbar, 1998; Wasser and Starling, 1988). Among primates, several studies provide circumstantial evidence of a sudden loss of fertility following physical injury, severe aggression or psychological trauma (humans: Matsumato *et al*., 1968; baboons: Rowell, 1970; Samuels *et al*., 1987; macaques: Dittus, 1986; Ehardt and Bernstein, 1986; gelada: Alvarez, 1973). As noted by Dunbar (in press) in *Colobus* sp., high stress levels can arise from competition for access to limited food resources, and their effects are more conspicuous in females (Dunbar, 1998).

It has been demonstrated that in some non-human primates both males and females display similar patterns of seasonal mass change, but the pattern is stronger in females (Goldizen *et al*., 1988; Ganzhorn and Schmid, 1998; Richard *et al*., 2000). Recently, Richard *et al*. (2000) demonstrated that there are great differences in individual fertility rates among *Propithecus verreauxi* females, and this variation is strongly related to differences in mass. They found that lighter females were not able to reproduce during the two years immediately following drought. Females that were heavier at the time of the mating season were more likely to give birth in the following birth season. Similarly, Ganzhorn and Schmid (1998) examined the effects of habitat disturbance on body mass in mouse lemurs. They noted that *Microcebus murinus* from secondary forests have lower body masses than in primary forests. From long-term studies on ring-tailed lemurs (*Lemur catta*), Gould *et al*. (1999) showed the effects of environmental stress resulting from natural disasters, such as droughts and cyclones. These authors reported that, during the subsequent drought and immediate post-drought years, the Beza-Mahafaly ring-tailed lemur population decreased rapidly and infant mortality was very high (80 %). However, the population had begun to recover, exhibiting high birth rates, four years later. Gould *et al.* (1999) assumed that dietary adaptability might be a contributing factor to the recovery, pointing out that some species of macaques and baboons respond in the same way as ring-tailed lemurs in adapting to the disturbance and recovery of their preferred habitat.

In this chapter we investigated if the type of habitat had an effect on body size and fertility in the black-and-white ruffed lemur (*Varecia v. editorum*). *Varecia v. editorum* is an ideal candidate for this natural experiment. *Varecia* displays a number of life history traits that are rarely observed among primates (e.g. multiple births per litter, nest building, etc.) (see Klopfer and Dugard, 1976; Boskoff, 1977; Foerg, 1982; Jolly *et al*., 1984; Rasmussen, 1985; Pereira *et al*., 1987; Morland, 1990). *Varecia* is the only large-bodied diurnal primate (mass = 3–5 kg) that has multiple births per litter (see Fleagle, 1999; Morland, 1991b; Glander *et al*., 1992; Smith and Jungers, 1997). According to Tilden (1993), *Varecia variegata* is the most reproductively stressed of non-human primates, because its prenatal maternal investment rate relative to maternal body weight is greater than in any other primate species. Ruffed lemurs, together with the galagids, are estimated to have the greatest prenatal investment and highest rates of daily energy deposition in fetal tissues among prosimians (Tilden, 1993). In addition, *Varecia variegata* must produce milk for litters of one to five rapidly growing infants (Petter-Rousseaux, 1964; Boskoff, 1977; Foerg, 1982; Shideler and Lindburg, 1982; Morland, 1991a), whereas other primates generally nurse single young. In addition, *Varecia* produce milk that is higher in dry matter, fat, protein, and gross energy (kcal/g) than other lemurids. Protein concentrations are similar to those of lorisoids whose milk is more concentrated in nutrients than any other group of primates (Tilden and Oftedal, 1995). In the wild, the average litter size of *Varecia* is two (Morland, 1993, 1991b), whereas semi-free ranging *Varecia* (food-supplemented) at Duke University Primate Center can produce and raise litters of five, and triplets are common (Foerg, 1982; Shideler and Lindburg, 1982; Brockman *et al*., 1987). This suggests that female fecundity may be reduced or increased as food availability decreases and the level of disturbance increases.

There are several important factors that can affect female reproduction in non-human primates living in a continuously disturbed habitat. These factors include: social stress (see van Schaik *et al*., 1983; Wasser and Starling, 1988), disease (Dobson and May, 1986), and competition among females for access to limited resources within the group's territory, either directly (for example, through falls induced by fights) or indirectly (through the females' inability to produce enough milk) (Dunbar, 1987). Therefore, in highly degraded habitats, reproduction might be especially stressful due to limited food availability.

We tested the following two hypotheses: (1) differences in body mass in *Varecia v. editorum* are due to the availability of food differences, which is related to the degree of disturbance; and (2) in this species, there is a body mass below which females do not conceive.

Methods

Study sites

The study subjects in this research were from three populations of black-and-white ruffed lemurs in south-eastern Madagascar, which are separated by 100 km at their extremes by grassland and disturbed habitat (Fig. 1). Those sites were specifically chosen because they have different levels of disturbance, ranging from more pristine to highly disturbed.

Ranomafana National Park (RNP)

Ranomafana National Park is the least disturbed forest among the three sites. Habitat disturbance, including human-induced pressures and natural disturbances, is lower or even absent within the national park as it has been well protected since 1991. Limited anthropogenic pressures transform land in the peripheral zones into slash-and-burn agricultural areas, however, a reforestation programme has been conducted to restore these degraded marginal habitats. RNP lies in the Central Domain in south-eastern Madagascar. The park ranges in altitude from 500–1,500 m and contains relatively undisturbed lowland forest, cloudy, and high plateau forest. The core protected area of RNP comprises an area of 43,500 ha.

Kianjavato Forest

Kianjavato Forest lies in the Eastern Domain in south-eastern Madagascar. This forest is much smaller than RNP and is considered as less, or moderately, disturbed compared to Manombo. The forest is surrounded by bamboo patches and at some parts of the edge local people maintain coffee plantations. Kianjavato is about 50 km from RNP and lies on fairly steep mountains. Kianjavato Forest contains 100–150 ha of lowland rainforest and ranges in elevation from 100–400 m. Some parts of the Kianjavato Forest are cultivated for commercial coffee plantations, but the *Varecia* are not hunted there.

Manombo Forest

Manombo Forest is a coastal forest, and it is a highly disturbed habitat. In Manombo, habitat disturbance is not restricted to anthropogenic pressures as natural disturbances (cyclones and wind storms) are also a concern. During the last fifteen years, a great part of the forest was severely deforested and most of the forested land was turned into cassava plantations. In addition, cutting and burning within forested zones and setting uncontrolled fires in grassland are common. Commercial timber exploitation by companies from outside the area and illegal logging for construction, firewood and other activities (e.g. cattle grazing inside of the forest) have had impacts on the remaining forests in these areas. These combined practices have resulted in the deforestation of nearly 75 % of the reserve. Regarding natural disturbances, cyclone damage caused obvious changes to the overall structure and floristic composition of Manombo Forest. For instance, on January 24, 1997, a cyclone named "Gretelle" with winds over 245 km/h hit Manombo for a 12-hour period. It was a monumental disturbance event, causing extensive damage. Post-cyclone botanical transect studies revealed 85 % canopy loss. Invasion of alien plant species (such as *Lantana camara*, *Clidemia hirta*, *Psidium cattlianum*, and *Eucalyptus robusta*) due to the opening of the canopy altered species diversity and density. Hardwood exploitation increased as villagers reconstructed their houses. These losses represented a greater than 70 % reduction in fruit-producing vegetation in the forest. Due to the long-term shortage of their food supply, *Varecia* became opportunistic feeders (Ratsimbazafy, 2002).

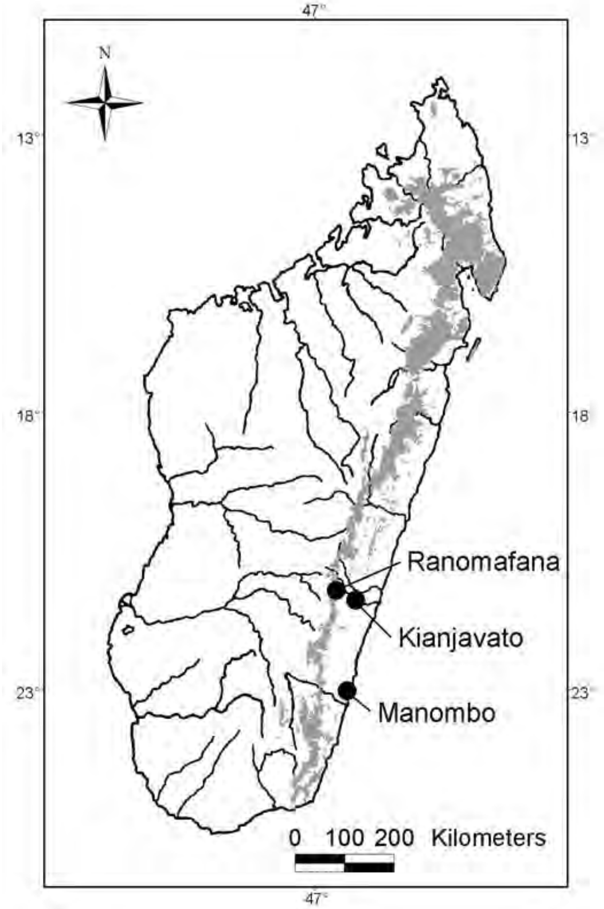

Fig. 1: Location of the three study populations of black-and-white ruffed lemurs (*Varecia variegata*) in southeastern Madagascar. Grey represents remaining eastern rainforest (after Green and Sussman, 1990).

To test the hypothesis that differences in body mass and female reproduction in *Varecia* are correlated with the type of habitat and level of disturbance, we captured and weighed a total of 35 individuals (n = 20 at RNP; n = 7 at Kianjavato;

and n = 8 at Manombo). At Ranomafana, 11 individuals were captured in 1993 and 1994, and 9 in March and November 1999; at Kianjavato, all individuals were captured in 1999; and at Manombo, one individual was captured in June 1997 and recaptured in 2000 among the other 7 in the sample. Pregnant and non-adult individuals were excluded from the analysis.

Results and discussion

An analysis of variance with LSD post-hoc comparisons showed that the *Varecia* of Manombo were lighter than the *Varecia* of Kianjavato and RNP (Anova, F = 7.071; $P < 0.001$). In particular, the female *Varecia* at Manombo were significantly lighter than all other individuals, except the male *Varecia* at Manombo. The latter were significantly smaller than all individuals except the males at Kianjavato and females at Manombo. There were no significant differences between Kianjavato and RNP. In both Kianjavato and RNP, females were heavier than males (Kianjavato: 3.59 kg (n = 4) for males and 4.23 kg (n = 3) for females; RNP: 3.76 kg for males (n = 13) and 3.98 kg (n = 7) for females). In contrast, at Manombo, males were heavier than females (3.24 kg (n = 3) for males and 2.98 kg (n = 5) for females) (Tab. 1).

Tab. 1: Site and sex-specific body masses for *Varecia variegata* in southeastern Madagascar. N = sample size; SD = standard deviation; *without Manombo

Site	Sex	Month and year of capture	Body mass (kg)		
			N	Mean	SD
Manombo	M	Jun 1997, Feb and Sep 1999	3	3.24	0.39
	F		5	2.98	0.56
Kianjavato	M	Nov 1999, Jan 2000	4	3.59	0.19
	F		3	4.23	0.67
Ranomafana (RNP)	M	Jan and Feb 1993, Jun 1994, Mar–Nov 1999	13	3.76	0.21
	F		7	3.98	0.35
* Males			17	3.72	0.44
* Females			10	4.06	0.35
* Sexes combined			27	3.84	0.35

In this study, only one male at Manombo was recaptured. In June 1997, 5 months after the cyclone, this individual weighed 3.30 kg, and in February 1999 it weighed 2.75 kg. Within 20 months this individual had lost 16.67 % of its body mass. We did not include individual *Varecia* at Manombo before the cyclone of 1997 because the samples were very small and could have biased the results, but we want to emphasize how abrupt changes of habitat and chronic stress can affect body mass and fertility. For comparison, the weight of one female we studied in 1994 at Manombo was 3.4 kg, whereas the mean average of the female body mass at Manombo after the cyclone was 2.98 kg.

Other body measurements of the samples, such as snout-body length, arm and foot length were also collected, but due to the small size of our samples, significant differences between populations could not be evaluated. However, from the measurements of the snout-body length of the samples we found that the *Varecia* at Manombo were slightly longer than *Varecia* at RNP. For males: Manombo 55.6 cm [range: 54–57.2 cm] (n = 2); RNP 52.3 cm [range: 47.7–55.4 cm] (n = 3); and for females: Manombo 57.6 cm [range: 57.3–57.8 cm] (n = 2); RNP 49.8 cm [range: 46.2–52.9 cm] (n = 4). This is important because it indicates that the *Varecia* at Manombo were not just smaller overall, but rather they were carrying less body mass for their snout-body length. There was

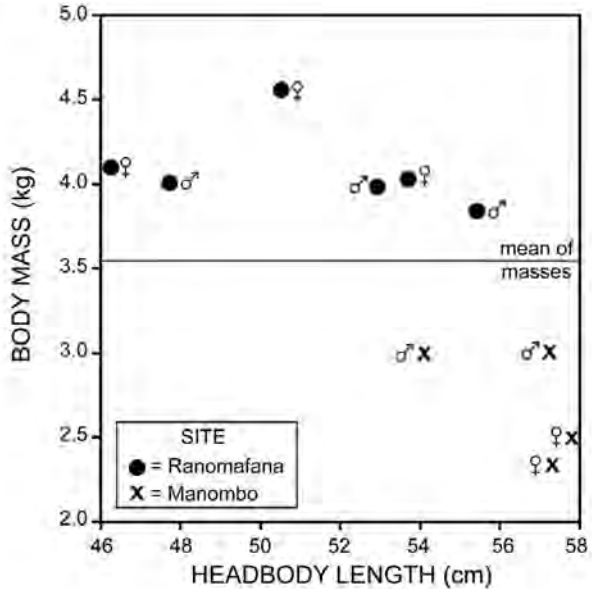

Fig. 2: Covariation between body mass and body length in *Varecia variegata* editorum.

no relationship between the two parameters (body mass and snout-body length), and it is apparent that the body masses were low for a given body length at Manombo in both sexes (Fig. 2).

These results suggest that at certain levels of disturbance (e.g. Kianjavato), female *Varecia* can maintain body mass and are able to conceive infants. But when the habitat is very disturbed and food becomes scarce all year round, both males and females exhibit significant body mass losses. Because the *Varecia* females at Manombo Forest (n = 8 groups) have failed to conceive after the monumental cyclone event in 1997, we suspect that there is a body mass below which females cannot give birth in this species. Four years later, the *Varecia* at Manombo forest still relied on foods that were not nutritious and sufficient to satisfy their daily requirements (Ratsimbazafy, 2002). From 18 months of behavioral study of two *Varecia v. editorum* groups at Manombo Forest, we noted that because of the low density of food availability and food production, most of their preferred tree fruits were depleted before ripening. In addition, especially during the months of January and February, people hunting tenrecs in the forest disturbed and changed the normal behaviour of the animals. For example, it was noticed on several occasions that the animals travelled far away from the area to avoid these poachers. Therefore, we believe that the combined effects of low nutrition, psychological stress and other ecological causes, such as disease, could have a significant impact on the female reproductive function of *Varecia* in the short term and on their fertility in the long term.

Analyses of different population dynamics of mouse lemurs in primary and secondary deciduous dry forests of Madagascar demonstrated that *Microcebus murinus* from secondary forests have significantly lower body mass than those in primary forests (Ganhzorn and Schmid, 1998). Fewer females go into torpor in secondary forests than in primary forest. As noted by these authors, the capacity to enter energy-saving torpor during the dry season is very important for mouse lemurs. In the Morondava region the population densities of this species are lower in secondary than in primary forests (Ganzhorn, 1996; Smith *et al.*, 1997). This may be a consequence of reduced food availability, but additionally the possibility to enter into torpor and hibernation may be limited in secondary forests (Ganzhorn, 1996). In mouse lemurs, females are more likely than males to enter hibernation, however females with low body mass do not hibernate (Fietz, 1998; Schmid, 1998). As concluded by Ganzhorn and Schmid (1998), the survival rates are lower in secondary than in primary forests.

Studies on three lemur species (*Propithecus verreauxi, Lemur catta,* and *Microcebus murinus*) illustrated how sensitive the females are to disturbances of their habitat. In response to long-term food scarcity, mass loss is more pronounced in female than male *Varecia*. Results from these studies suggested that these 3 species have a body mass threshold below which females do not give birth. *Varecia variegata* appear to exhibit the same response when living in highly disturbed habitats, in which food availability is reduced and/or deficient in fats and proteins. This indicates that environmental changes due to the effects of habitat disturbance can have a significant impact on reproduction and/or infant survival. Louis *et al.* (2005) also reported that a nutritional deficit has a negative impact on the reproductive success of *V. variegata* at Manombo Special Reserve.

Although we did not have enough data to detect sexual body mass differences, recent papers reported that females have a trend to be heavier than males, though only insignificant differences were seen (Baden *et al.*, 2008). The study into the correlation between nutrition and growth is very important, but due to an inadequate availability of samples of individuals of different age/sex categories, we could not further investigate whether the quality of habitat differentially affects individuals in different age-sex classes. However, for further studies, it will be very important to explore how nutrition affects body mass of newborns. Nevertheless, the present study strongly suggests that habitat quality impacts body mass and probably female fertility in black-and-white ruffed lemurs. The long-term effects leading to morphological differences among populations of the same species living in different conditions requires more research, but body mass is one good indicator for detecting the relationship between animal life history and their environment.

Acknowledgements

We would like to acknowledge Madagascar National Parks and the Ministry of the Environment and Forests (MEF) for permission to work at Ranomafana National Park, Kianjavato, and Manombo Special Reserve and the Classified Forest Reserve. Thanks to the Malagasy Institute for the Conservation of Tropical Environments (MICET), and in particular Benjamin Andriamihaja, for logistical assistance. We are grateful to the Department of Anthropology of the University of Antananarivo. Our thanks also go to the staff of the Institute for the Conservation of Tropical Environments (ICTE) at SUNY Stony Brook. We appreciate the help, comments and advice of numerous colleagues. Funding and support for the project have been provided by: the Wildlife Trust; the Rockefeller Foundation; the Margot Marsh Biodiversity Conservation Foundation; Primate Conservation Inc.; the Wildlife Conservation Society; the Brookfield Zoo, and the Earthwatch Institute.

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Lemur distributions in a fragmented landscape, northern Madagascar

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Key words: deforestation, fragmentation, patch size, dispersal, connectivity

We surveyed transitional forest fragments between two protected areas in the extreme north of Madagascar by listening for vocalizations at dusk and at night, active searching and through casual observations. The forests of this area are remnants of a forest that once may have extended from Mt. d'Ambre south to Ankarana. Fragments ranged from 1.4 ha to 427.8 ha in size. Despite small forest size and sometimes distant and prolonged isolation, we found either *Eulemur coronatus* or *Eulemur sanfordi* in all surveyed fragments. Group number was significantly related to forest size in both species. *Lepilemur ankaranensis* were restricted to only six forests that were almost always larger in size. Both *Eulemur* species were observed utilizing narrow riparian corridors consisting mainly of mango trees, running alongside natural streams and rivers, whilst *L. ankaranensis* was not. Despite extensive fragmentation, the anthropogenic landscape in this area may promote the persistence of partially frugivorous *Eulemur* species by providing pathways between patches and a food source to promote their usage.

Introduction

Habitat destruction and fragmentation threaten many forest-dependent species and are the greatest threat to primate populations (Anderson *et al*., 2007). Madagascar's forests have continued to become smaller and more fragmented in recent decades (Harper *et al*., 2007). Species are likely to respond differently to fragmentation, and distributions may be influenced by a species' ability to move between patches (Ueza *et al*., 2005). This survey considered lemur distributions in a fragmented forest landscape, with reference to patch size and ability to move between patches. The study site lies in the extreme north of Madagascar, in unprotected forests that lie between the humid forests of Mt d'Ambre to the north and the dry forests of Ankarana to the south. In this area, many remnant forest fragments lie within a human-modified matrix, dominated by grasslands. Although matrix habitats in this area usually have low structural complexity, due to annual burning of grasslands, a number of patches remain linked by thin corridors of trees which grow alongside rivers and drainage channels. These consist mostly of mango trees which the local human population conserves for their fruit.

Four lemur species are known from these forests; *Eulemur coronatus, Eulemur sanfordi, Lepilemur ankaranensis* and *Microcebus* sp. *E. coronatus* and *E. sanfordi* have some degree of niche overlap, associate with each other and are largely sympatric throughout their range (Freed, 2006). Their diet is primarily frugivorous. Both species have decreasing populations, and *E. coronatus* is considered Vulnerable whilst *E. sanfordi* is considered Endangered (IUCN, 2011). *L. ankaranensis* is poorly studied. *Lepilemur* are predominantly folivores. This species is listed as Endangered and its population is decreasing (IUCN, 2011). *Microcebus* sp. was not considered in this study, as encounters were rare.

Methods

Forest Cover
A 1984 Landsat image was coreferenced to Landsat Global Land Cover (GLC) images from 2010 and the two were combined into a single multitemporal image (Harper *et al.*, 2007). A supervised classification was performed on the image, and the resulting raster was reclassified into three categories that represented areas of constant non-forest, areas of constant forest, and areas that were forest in 1984, but not in 2010. Classification was verified through ground truthing and the use of 2012 GeoEye images. Patches below 1 ha were removed from the image and patch size was calculated.

Lemur surveys
E. coronatus and *E. sanfordi* are very vocal and active both day and night. The nocturnal *L. ankaranensis* is also vocal, although less frequently so, and is easily located by eye-shine. Between October and December 2010, survey groups listened for *E. coronatus* and *E. sanfordi* territorial calls at forest fragments for half an hour at dusk (17:45 to 18:15). Survey teams noted the position of each group. Calls were deemed to come from the same group if they were heard within 100 m of the first group within a 10-minute period (Lowin, 2012). A total of twelve patches were surveyed between October 15th and December 12th 2010 (Fig. 1). The number of survey groups varied between 1 and 5 and depended on the size of the fragment. The majority of patches were small and a single team could survey an entire patch effectively. We visited each patch a maximum of three times or until lemurs were recorded.
In March 2011, forest fragment 4 was visited to confirm the presence of *E. coronatus* and count the number of individuals present. The small size of the patch meant that a single survey was sufficient to obtain a reasonable estimate. Between January and March 2011, nine forest fragments were visited after nightfall (approximately 18:45 to 19:30), with the purpose of establishing *L. ankaranensis* presence or absence. Surveyors listened for vocalisations and searched using headlamps. This was repeated four times at each site. Researchers were active in this area for more than two years, during which time knowledge of patches where lemurs were present was obtained. We included this information in presence/absence analysis.

Statistics
Logistic regressions of *E. coronatus, E. sanfordi* and total group number in patches were performed. Binary logistic regression was performed on *L. ankaranensis* presence/absence data. Non-normal data was Log10-transformed.

Results

Forest cover
Patches ranged from 1.36 ha to 427.8 ha (Fig. 1). The largest patches were subject to most clearance, and two of our survey forests once formed part of a single, much larger fragment (patches 4 and 10). However, for the majority of patches, size appeared relatively constant over a 26-year period. Therefore, lemurs found in these patches must have either persisted since before 1984, or were able to colonise patches across matrix habitats, mainly grasslands or mango corridors.

Eulemur *species*
At least one *Eulemur* species was found in every forest directly surveyed, even the smallest patch which measured only 1.4 ha (Table 1). *E. coronatus* group number (F = 5.705, P = 0.041, R^2 = 0.388), *E. sanfordi* group number (F = 10.963, P = 0.009, R^2 = 0.549), and total group number (F = 14.405, P = 0.004, R^2 = 0.615), all increased significantly with patch size. During the study period, both species were observed using the corridors connecting a number of patches. We recorded a total of 19 *E. sanfordi* groups and 38 *E. coronatus* groups. Three fragments contained only *E. coronatus* and two fragments only *E. sanfordi*. We found one group consisting of four *E. coronatus* individuals in the 1.4-ha fragment (patch 1). Both species were observed moving and feeding on mango trees, and were encountered in these mango corridors more often when trees were fruiting during the rainy season.

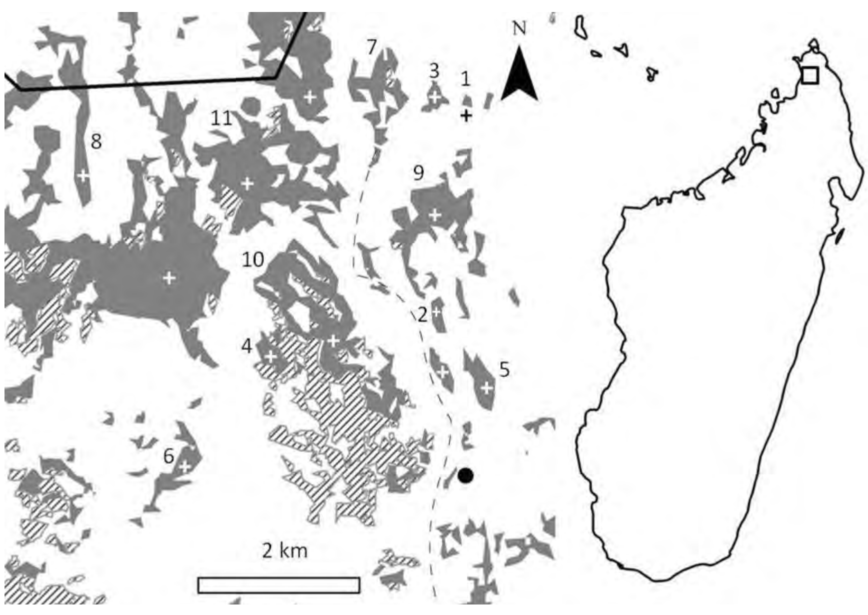

Fig. 1: Map of study area. Dark grey = forest; cross hatching = forest cleared between 1984 and 2010; dashed line = river; black line = Mt d'Ambre National Park boundary; dot = village. Numbers indicate patches surveyed for *Eulemur*, + indicates patch where *L. ankaranensis* presence/absence is known.

Tab 1: Forest patch size, percentage of area lost between 1984 and 2010, and number of lemur groups observed.

Patch	2010	1984	% loss	*Eulemur coronatus*	*Eulemur sanfordi*	Total
	area (ha)					
1	1.4	1.4	0.0	1	.	1
2	5.7	5.7	0.0	4	1	5
3	6.4	6.4	0.0	1	.	1
4	9.7	260.7	96.3	.	1	1
5	15.4	15.4	0.0	.	2	2
6	22.3	22.3	0.0	4	1	5
7	33.9	34.2	0.7	2	.	2
8	42.5	42.5	0.0	2	3	5
9	57.1	58.5	2.4	8	3	11
10	86.8	260.7	66.7	8	5	13
11	132.9	143.6	7.4	8	3	11

Lepilemur ankaranensis

L. ankaranensis was found in 6 of 14 patches where presence/absence was determined (Table 2). Presence was almost significantly related to patch area (wald = 3.66, P = 0.056; chi square = 6.722, df = 1, P = 0.01), with *L. ankaranensis* found in larger patches. This species was only on the east side of a river valley that cut through the study area. This species was not observed using any potential corridors.

Tab.2: Forest patch size and presence/absence of *Lepilemur ankaranensis*.

Area (ha)	*L. ankaranensis*
1.4	.
3.8	.
6.4	.
7.7	.
9.7	Yes
15.4	.
22.3	.
42.5	Yes
57.1	.
57.3	.
86.8	Yes
122.9	Yes
132.9	Yes
427.8	Yes

Discussion

Eulemur species were much more widely distributed than *L. ankaranensis*, and were found in even the smallest patches surveyed. Patches where only one species was found could support either *Eulemur* species. Group number increased with patch size, as predicted, but as group size is not constant (Freed, 1996), actual population sizes are not known. *L. ankaranensis* was less widely distributed and tended to be restricted to larger patches, and only on the western side of the river. *L. anakaranensis* was never observed using mango corridors, whilst *Eulemur* species were often seen moving and feeding on mango trees within these corridors, particularly when trees were fruiting. Dispersal between patches may be relatively common at this time of year.

Although inter-patch dispersal was not measured, a number of observations support the notion that *Eulemur* and *Lepilemur* distributions might be influenced by their ability to disperse between patches. The second smallest patch (2) contained a relatively high number of *Eulemur* groups. This patch is connected by mango trees to patches 5 and 9, and it is possible that groups may be able to disperse into and out of this patch. *L. ankaranensis* was present in patch 4, which was only a quarter of the size of the next largest patch where this species was found. Unlike other small patches, patch 4 was until recently a part of a much larger patch where *L. ankaranensis* is still present, and this might help to explain the species' persistence here.

Although the majority of forests considered here appear to be stable in extent, there are exceptions, with the largest patch in 1984 halving in size in the intervening years, leaving several much smaller fragments. Other large patches in the area that were not surveyed also appear to have shrunk. The linkages that may facilitate movement between patches for *Eulemur* species do not appear to be under threat, as they are maintained anthropogenic habitats, valued for their fruit. Although survey effort was low, this survey indicates that *Eulemur* and *Lepilemur* species in this area may respond differently to habitat change. Although all three species are considered threatened, *L. ankaranensis* may be of more immediate concern in view of its absence from smaller patches and the continuing habitat loss in this area.

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Rapid assessment of lemur abundance in the lowland rainforest of Ampasy, Tsitongambarika, south-east Madagascar

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Key words: collared brown lemur, nocturnal lemurs, Tsitongambarika, hunting pressure

Abstract
The Tsitongambarika (TGK) Forest in the south-eastern corner of Madagascar was recently assessed by the IUCN as an area of highest conservation priority and still contains some of the last areas of lowland rainforest in the country. We conducted a preliminary survey of lemur abundance within the Ampasy Valley, in the northern section of the TGK Forest, in July 2012. Line transect sampling was used to determine the abundance of lemur species. Results from our survey showed that lemur abundance was low in Ampasy, although the forest was structurally relatively undisturbed. Our results are in agreement with previous reports showing very low lemur abundance in TGK compared with other areas. The synergistic effect of a natural low abundance and the growing slash-and-burn cultivation and hunting should be carefully considered in ongoing conservation plans to preserve viable lemur populations.

Introduction
The Tsitongambarika (TGK) Forest was recently assessed by the IUCN as an area of highest conservation priority, as it is not only among the most endangered habitat types in Madagascar (Nicoll and Langrand, 1989; Morris and Hawkins, 1998) but is also biologically distinct from other lowland rainforests found to the north (BirdLife International, 2011). Covering an area of over 60,000 ha, TGK gained protected status as a Nouvelle Aire Protegee (NAP) in 2008 as a continuous lowland and mid-altitude humid evergreen forest that runs north from Fort Dauphin (Tolagnaro) along the Vohimena Mountains for approximately 60 km. The area is currently managed by ASITY Madagascar (BirdLife International, 2011). While approximately 80 % of humid forest in Madagascar is mid-altitude, between 800 and 1,500 m (Morris and Hawkins, 1998), the Vohimena Mountains are mostly below 800 m, making TGK of critical importance as relatively little of this forest type remains at such low elevation due to increased slash-and-burn agriculture, or *tavy* (Goodman *et al*., 1997).
The aim of this study was to conduct a preliminary assessment of lemur abundance within the Ampasy Valley, in the northern section of the TGK Forest (Fig. 1). This lowland humid forest valley lies almost entirely below 350 m, making it an area of significant ecological interest. Additionally, the area has been proposed for inclusion among the offset sites of the large mining project conducted by QMM (QIT Madagascar Minerals) in the south-eastern coastal region (M. Vincelette, pers. comm.). This implies that an effort will be made to protect the local biodiversity in this section of TGK in order to compensate the inevitable loss in the mining area, especially in the littoral forest. This survey is meant to provide preliminary information to all stakeholders involved in the conservation management of the region.

Methods
Surveys were carried out over the course of nine days, from 8 July to 16 July 2012, in the lowland rainforest of Ampasy (24°34'S, 47°09'E), located 52 km NNE of Fort Dauphin in the extreme south-east of Madagascar. Based on previous reports, seven lemur species were thought to be present in the area: collared brown lemur (*Eulemur collaris*), southern bamboo lemur (*Hapalemur meridionalis*), southern woolly lemur (*Avahi meridionalis*), greater dwarf lemur (*Cheirogaleus major*), mouse lemur (*Microcebus* sp.), sportive lemur (*Lepilemur* sp.), and aye-aye (*Daubentonia madagascariensis*). Line transect sampling was used to determine the presence of

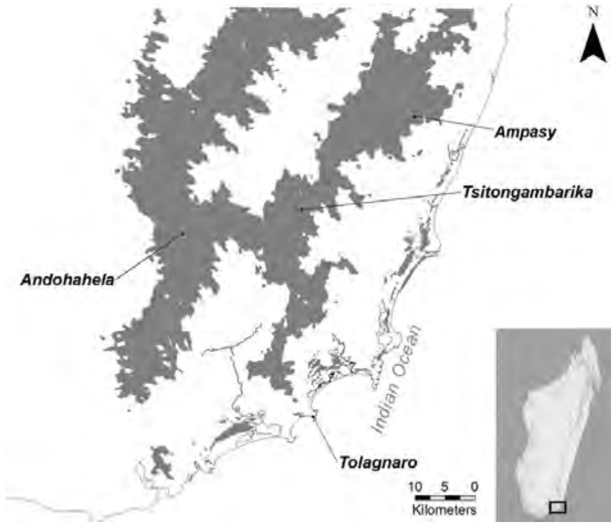

Fig. 1: Location of Ampasy Valley within the northern area of the Tsitongambarika lowland rainforest.

lemur species at Ampasy (Ganzhorn *et al*., 2007; Irwin *et al.,* 2000; Johnson and Overdorff, 1999). Six straight transects were identified from pre-existing trails for the diurnal survey, with three of these transects utilized for the nocturnal survey. Transects varied in length due to the forest terrain, from 0.55 km to 1.28 km.
Two observers walked each transect quietly at a speed of 1 km/h. We walked three transects per day to survey cathemeral lemurs (06:00–07:30; 08:00–09:30 and 15:00–16:30), and two transects per night for nocturnal lemurs (18:00–19:30 and 20:00–21:30). Each transect was walked a total of three times. Data on the sex of the animal was collected only on *E. collaris*, as sexual dichromatism is present in this lemur; only males show the typical brown collar around the cheeks, and the face of the male *E. collaris* is dark grey or black, while females are grey (Mittermeier *et al*., 2008). Due to the small number of observations for each species, we used the encounter rates (total number of lemurs observed divided by total length of transects) as a measure of abundance (Ganzhorn *et al*., 2007). In addition to transects, we systematically searched the Ampasy Forest (both along existing trails and off trails) for opportunistic observations of lemur species.
In order to investigate the condition of the forest, vertical structure was described quantitatively by using the line-intercept method (Gautier *et al*., 1994). We defined a vertical plan of 50 m along each of our six transects, and recorded the points of contact of vegetation within each vertical metre. A diagram of the vertical structure was produced to estimate the percentage of canopy cover.

Results
During the study period, a total of 17.04 km and 10.14 km were surveyed for cathemeral and nocturnal species, respectively (Table 1). Collared brown lemurs were observed on three separate occasions, totalling 15 individuals (7 females and 8 males).
Regarding the nocturnal survey, individuals from three species were observed: 5 solitary individuals of *A. meridionalis*, 12 solitary *Microcebus* sp., and 7 *Lepilemur* sp. from four groups.
Opportunistic observations included a group of approximately 15 collared brown lemurs, as well as four other groups of 3 individuals each. Additionally, two groups of southern bamboo lemurs were observed within the study

site, one with 6 individuals and the other with 4 individuals, despite not being observed during the survey. As *H. meridionalis* fled immediately upon sightings, further observation of them was not possible.

While walking many of the existing trails throughout the valley (19.31 km in total), 16 corridor trap-lines were discovered (Fig. 2), providing us with an occurrence rate of 0.83 trap-lines per km. The trap-line hunting method consists of clearing a 10 m corridor gap and constructing a series of bridges with two to three snares each. This forces the lemurs to descend from the canopy and use them. While some of these traps were new and baited with fresh fruits, most of them were old and deactivated. We also found a large terrestrial snare set for African bush-pig (*Potamochoerus larvatus*), while four small fence-type snares and a box trap were set to target both ring-tailed mongoose (*Galidia elegans*) and broad-striped mongoose (*Galidictis fasciata*), both of which were observed within the area. Furthermore, three snares were found in areas that had recent feeding signs of the Madagascar crested ibis (*Lophotibis cristata*).

The vegetation cover profiles did not differ between the transects we used. The highest canopy cover reached up to 31 m, with the understorey consistently forming a continuous band cover (Fig. 3).

Fig. 2: Two snares placed on a log bridge connecting trees along a man-made corridor meant to cause a break in the continuous canopy, forcing arboreal animals to use the bridges. (Photo: T. Nguyen)

Tab. 1: Encounter rates (ind/km) of the seven lemur species reported at Ampasy, Ivohibe, Antsiriky, Ivorona (TGK) and Andohahela. + indicates that the species has been reported at the site but not recorded during the survey.

Species	Site	Elevation	Number of transects	Total transect length (km)	Encounter rate (ind/km)	References
Avahi meridionalis	Ampasy	29-351	3	10.14	0.50	Present study
	Ivohibe	87-302	2	5.88	0.25	Birdlife, 2011
	Antsiriky	340-420	2	6.60	1.33	Birdlife, 2011
	Ivorona	282-300	2	6.00	3.83	Birdlife, 2011
	Andohahela	440-1875	12	18.90	0.26	Feistner and Schmid, 1999
Cheirogaleus major	Ampasy	29-351	3	10.14	+	Present study
	Ivohibe	87-302	2	5.88	0.38	Birdlife, 2011
	Antsiriky	340-420	2	6.60	0.65	Birdlife, 2011
	Ivorona	282-300	2	6.00	2.92	Birdlife, 2011
	Andohahela	440-1875	12	18.90	2.12	Feistner and Schmid, 1999
Daubentonia madagascariensis	Ampasy	29-351	3	10.14	+	Present study
	Ivohibe	87-302	2	5.88	+	Birdlife, 2011
	Antsiriky	340-420	2	6.60	+	Birdlife, 2011
	Ivorona	282-300	2	6.00	+	Birdlife, 2011
	Andohahela	440-1875	12	18.90	+	Feistner and Schmid, 1999
Lepilemur spp.	Ampasy	29-351	3	10.14	0.90	Present study
	Ivohibe	87-302	2	5.88	0.50	Birdlife, 2011
	Antsiriky	340-420	2	6.60	0.21	Birdlife, 2011
	Ivorona	282-300	2	6.00	2.00	Birdlife, 2011
	Andohahela	440-1875	12	18.90	0.11	Feistner and Schmid, 1999
Microcebus sp.	Ampasy	29-351	3	10.14	1.50	Present study
	Ivohibe	87-302	2	5.88	2.04	Birdlife, 2011
	Antsiriky	340-420	2	6.60	1.00	Birdlife, 2011
	Ivorona	282-300	2	6.00	2.50	Birdlife, 2011
	Andohahela	440-1875	12	18.90	1.59	Feistner and Schmid, 1999
Eulemur collaris	Ampasy	29-351	6	17.04	0.60	Present study
	Ivohibe	87-302	6	13.72	1.90	Birdlife, 2011
	Antsiriky	340-420	6	15.40	0.76	Birdlife, 2011
	Ivorona	282-300	6	14.00	1.38	Birdlife, 2011
	Andohahela	440-1875	12	65.70	0.27	Feistner and Schmid, 1999
Hapalemur meridionalis	Ampasy	29-351	6	17.04	+	Present study
	Ivohibe	87-302	6	13.72	0.52	Birdlife, 2011
	Antsiriky	340-420	6	15.40	0.23	Birdlife, 2011
	Ivorona	282-300	6	14.00	1.10	Birdlife, 2011
	Andohahela	440-1875	12	65.70	0.27	Feistner and Schmid, 1999

Discussion

Overall, our preliminary results indicate that lemur abundance is low in Ampasy as expected for lowland rainforests when compared with other habitats, including the nearby littoral forests (Norscia *et al.*, 2006; Ganzhorn *et al.*, 2007). This finding should be carefully considered for future management plans if the Ampasy area is to be included in the QMM offset site plans in the region. The results of the surveys suggest that *Microcebus* sp. is the most abundant nocturnal lemur species in the Ampasy forest, followed by *Lepilemur* sp. and *A. meridionalis*. As the survey was conducted in July, *C. major* was not observed as it is typically in hibernation during the austral winter (Petter *et al.*, 1977; Ganzhorn *et al.*, 2007). Interestingly, the sportive lemur observed in the area appeared phenotypically different than the species which has been reported in the closest locality, i.e. *Lepilemur fleuretae* from the rainforest section (Parcel 1) of Andohahela National Park, the only forest that is contiguous with TGK (Louis *et al.*, 2006). Future molecular studies will help to clarify the taxonomic status of this *Lepilemur* sp. The encounter rate of *E. collaris* appeared to be relatively low at 0.6 ind/km compared to previous surveys conducted at various sites in TGK by BirdLife International (2011), but higher than in the nearby Andohahela National Park (Feistner and Schmid, 1999) (Tab. 1). Encounter rates for the other lemur species were relatively low, ranging from 0.2 to 3.8 animals per km walked. Until additional in-depth studies are

Fig. 3: Vertical profile of two transects with the lowest and the highest canopy covers at Ampasy measured by the line intersect technique.

conducted in Ampasy, it is difficult to say whether the low numbers of lemur abundance reported here are due to low sampling effort, ecological differences with other areas, or anthropogenic pressure (Irwin, 2008; BirdLife International, 2011; Randall and Sauther, 2006; Schwitzer *et al*., 2011).

Previous studies in the nearby littoral forests show that *Microcebus* sp. is marginally affected by habitat degradation while *A. meridionalis* and *E. collaris* respond negatively to habitat fragmentation (Ganzhorn *et al*., 2007). Interestingly, we opportunistically observed the three species also within areas of shifting cultivation. Furthermore, on three separate occasions we observed a large group of approximately 15 collared brown lemurs moving through these areas, feeding on shrub-layer fruits, unaffected by our presence.

Our data on vertical profile obtained from transects showed that the structure of the forest had been moderately affected by human activity, mainly timber harvesting, slash-and-burn agriculture, and cattle ranching. The profile of vegetation at all six vertical lines in Ampasy corresponded to the typical lowland rainforest of Madagascar, with an upper canopy of approximately 31 m (Amstrong *et al*., 2011), although overall the Ampasy Forest is in better condition than other areas within the south-east region (BirdLife International, 2011).

During our observations, the collared brown lemurs did not show any defensive behaviors (e.g. alarm call, lowered tail while facing observers, fleeing) and they often completely ignored the observers, whereas southern bamboo lemurs fled immediately during our opportunistic observations, often without ever alarm-calling. The differences between these two species' reactions to humans can be explained by the way they are hunted by the local people. Locals living near the forest do not directly hunt *E. collaris*, but they use the traditional method of creating corridor trap-lines or *tandroho* (Randriamanalina *et al*., 2000; Bollen and Donati, 2006). As this species is mainly arboreal and tends to stay in the upper canopy (Johnson, 2006), locals have difficulty shooting the animals with slingshots, and they rely mainly on trap-lines to catch them. As females often initiate travel, this hunting technique is hypothesized to lead to an unbalanced sex-ratio in the collared brown lemur (Bollen and Donati, 2006). In the case of southern bamboo lemur, this species often stays close to the river and tributaries, using the middle or lower canopy, thus it is easier to target them with available weapons (i.e. slingshots). A few locals from nearby villages use dogs to assist in locating/hunting lemurs and other animals, but more often local fishermen accessing the river and its small tributaries at night opportunistically capture/kill *H. meridionalis* when they come across them in trees near riverbanks.

In summary, this preliminary assessment indicates that the Ampasy Forest is structurally relatively undisturbed, but similar to other zones of TGK, slash-and-burn cultivation and hunting represent a potential threat for the future of this site. In order to preserve viable lemur populations in this region, it should be kept in mind that relatively low lemur abundances are recorded in this habitat and therefore large areas need to be effectively managed.

Acknowledgements

We would like to thank the Département de Biologie Animale, Université d'Antananarivo, the Direction du Système des Aires Protégées, and the Ministère de l'Environnement et Forêts of Madagascar for permission to conduct research. TN would like to thank MICET (Madagascar Institut pour la Conservations des Ecosystèmes Tropicaux), and TME would like to thank Jacques Rakotondranary and Tolona Andrianasolo, for their logistical assistance and obtaining research permits. We would also like to thank Asity Madagascar. We greatly appreciate the assistance and logistical support provided by the Biodiversity team at Rio Tinto QMM, most especially Johny Rabenantoandro, Jean-Baptiste Ramanamanjato, Laza Andriamandimbiarisoa, and Soanary Claude Hery. Many thanks to Jörg Ganzhorn for his continuous encouragement and support, as well as the entire staff of Oxford Brookes University's Primate Conservation MSc programme, especially Anna Nekaris and Vincent Nijman. We are grateful for the generous financial support and field gear provided by the American Society of Primatologists, Conservation International/Margot Marsh Biodiversity Foundation Primate Action Fund, IDEAWILD, Mohamed bin Zayed Species Conservation Fund (Project Number: 11253008), Primate Conservation Inc., Primate Society of Great Britain/ Knowsley Safari Park, and Wild Futures.

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Etude préliminaire de *Prolemur simus* (Ramaimbangy) dans la forêt de basse altitude de Vohibe, bassin versant Nosivolo, Madagascar, et implications pour sa conservation

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Mots-clés: *Prolemur simus*, conservation, forêt Vohibe, bassin versant Nosivolo/Marolambo

Résumé
En 2010, des traces de nourrissage de *Prolemur simus* ont été observées à Vohibe, une forêt tropicale sempervirente de basse altitude (67–607 m), située à la confluence des rivières Mangoro et Nosivolo, dans la partie orientale de Madagascar. Suite à cette découverte, nous avons réalisés, en 2011 et 2012, une étude préliminaire de ce lémurien en danger critique d'extinction. Nous avons ainsi identifiés un minimum de cinq groupes de *Prolemur simus* vivant dans et autour de la forêt. Un total de 27 individus, avec des observations indirectes suggérant l'existence d'autres groupes, a été enregistré à la fin de l'étude, en décembre 2012. Deux types de bambou de grande taille poussent sur le site: *Cathariostachys* cf. *capitata* et *Valiha diffusa*. Apparemment, *Cathariostachys* cf. *capitata* constitue la principale source de nourriture, avec une fréquence de 82,76 % de nos observations directes. De nombreuses menaces à la survie de la population ont également été identifiées, notamment la chasse (à l'aide de pièges à lémuriens, mais aussi avec sarbacanes et chiens), la perte d'habitat (en partie due à un défrichement non autorisé), la perturbation de l'habitat (par coupe d'arbres et de bambou, et pâturage du bétail), et le manque de prise de conscience de la conservation ou des questions environnementales par les collectivités locales. Nous avons alors créé en 2012 un projet pour la conservation des grands hapalémurs à Vohibe, au travers d'activités visant à atténuer les menaces identifiées en 2011. Le «Projet Ramaimbangy», d'après l'appellation locale de *Prolemur simus* (Vohibe est d'ailleurs le seul site actuellement connu où ce nom est utilisé) sera coordonné par The Aspinall Foundation-Madagascar, en collaboration avec Durrell Wildlife Conservation Trust Madagascar, engagé dans la gestion environnementale de la nouvelle aire protégée de la rivière Nosivolo.

Abstract
In 2010, feeding signs of the greater bamboo lemur (*Prolemur simus*) were found at Vohibe, a low-altitude (67–607 m) rainforest fragment situated at the confluence of the Mangoro and Nosivolo rivers in eastern Madagascar. Following this discovery, we undertook a preliminary study of this Critically Endangered lemur during 2011 and 2012. We identified a minimum of five groups of greater bamboo

lemurs at the site, totalling 27 individuals, with indirect evidence suggesting other groups are also present. Two species of large-culmed bamboo occur at the site, *Cathariostachys* cf. *capitata* and *Valiha diffusa*. Based on our preliminary study, *Cathariostachys* cf. *capitata* appears to be the principle food source of *P. simus* at the site, comprising 82.8 % of our direct observations. Numerous threats to the survival of the *P. simus* population were also identified, notably hunting (with traps, blow-pipes and dogs), habitat loss (especially due to unauthorized slash-and-burn agriculture), habitat disturbance (including tree and bamboo cutting, and cattle grazing) and a lack of awareness of conservation and environmental issues among local communities. During 2012 we began a project to mitigate the threats identified in 2011, ensuring the conservation of greater bamboo lemurs at Vohibe through the organisation of activities. The project is called "Project Ramaimbangy" because Ramaimbangy is the local name for greater bamboo lemurs (this is currently the only known site where this local name is used). It will be coordinated by The Aspinall Foundation Madagascar in collaboration with the Durrell Wildlife Conservation Trust Madagascar, who are responsible for the newly created Nosivolo River protected area, which includes the communities surrounding Vohibe.

Introduction

Le grand hapalémur *Prolemur simus* est un lémurien mangeur de bambou en danger critique d'extinction sur la liste rouge de l'IUCN (2012). À l'état sauvage, les pressions identifiées sont d'origine anthropique: la chasse, la perturbation de l'habitat, sa dégradation et sa fragmentation (Wright *et al.*, 2009; Ravaloharimanitra *et al.,* 2011; Rakotonirina *et al.,* 2011). Ceci confirme la nécessité de mettre en place un programme de conservation pour la survie de ce grand hapalémur (Ganzhorn *et al.*, 1996/1997; The Aspinall Foundation, 2008; King et Chamberlan, 2010; Rakotonirina *et al.*, 2011).

Dans un passé récent, une série d'études collaboratives a redéfini la distribution connue de l'espèce à l'état sauvage et grandement augmenté le nombre de sites connus (King et Chamberlan, 2010; Rakotonirina *et al.*, 2011; Ravaloharimanitra *et al.*, 2011). Parmi ces nouveaux sites un des plus significatifs est Vohibe, parce qu'il est situé approximativement à mi-chemin entre les populations "du nord" et "du sud" auparavant identifiées, au confluent des rivières Nosivolo et Mangoro à l'est de Madagascar (Rakotonirina *et al.,* 2011). Suite à cette découverte, nous y avons mis en place, à travers le «Projet Ramaimbangy», un système de suivi écologique participatif dans le but de déterminer la taille de la population, collecter des données écologiques, identifier les facteurs menaçant la survie de *Prolemur simus*, et élaborer les stratégies de conservation de l'espèce à l'état sauvage.

Le nom vernaculaire de *P. simus* dans la zone d'intervention, «Ramaimbangy» signifie «celui à la canine au sec» car, au repos, l'animal laisse apparaître les impressionnantes canines tranchantes de sa mâchoire supérieure (Andrianandrasana *et al.*, 2011).

Cet article résume les résultats de nos recherches sur *Prolemur simus* réalisées à Vohibe en 2011 et 2012, et leurs implications pour l'élaboration d'une stratégie de conservation à long terme de cette population.

Méthodes

Site d'étude

Vohibe (19,9231°S 48,4695°E) est une forêt dense humide sempervirente de basse altitude (67–607 m), située dans la partie orientale de Madagascar (Fig. 1). Sur le plan administratif, elle fait partie de la Commune Rurale d'Ambinanidilana, District Mahanoro, Région Atsinanana, à la confluence des rivières Nosivolo et Mangoro (Rakotonirina *et al.,* 2011; Rajaonson et King, 2013). C'est un reliquat de forêt couvrant une ligne de crête, avec une superficie estimée à 500 ha, entouré de terrains de culture sur brûlis ou *tavy* et de formations secondaires sur champs en friche (Fig. 2).

Système de suivi écologique participatif

Des enquêtes participatives auprès des villageois vivant dans et autour de la forêt ont été effectuées pour tester leurs niveaux de connaissances sur la zone fréquentée par ce grand hapalémur et déterminer la répartition des bambous. En outre, des patrouilles par des guides issus de la population locale ont été mises en place pour rechercher *Prolemur simus* sur le site d'étude et inventorier les espèces de lémuriens sympatriques. Nous avons réalisé trois missions en 2011 (Tab. I) pour former les guides et initier le système de suivi écologique participatif. En juin 2012 nous avons embauché six patrouilleurs afin de continuer le suivi des groupes identifiés en l'absence des chercheurs, à raison de 21 jours par mois. Nous avons fait une dernière mission en décembre 2012 (Tab. I). Les résultats que nous présentons ici sont issus de nos propres missions, et n'incluent pas les données collectées par les guides locaux en notre absence.

Tab. I: Nombre de jours de suivi (n'incluent pas les données collectées par les guides locaux durant notre absence).

Année	Mois	Nombre de jours de suivi	Total
2011	Mai-Juin	27	53
	Septembre	12	
	Décembre	14	
2012	Juin-Juillet	22	36
	Décembre	14	
Total			89

Nos observations ont été réalisées de 5h à 12h tous les matins et de 14h à 18h tous les après-midis, pour obtenir des données préliminaires sur l'abondance, la distribution et la composition des groupes de *Prolemur simus*, ainsi que les caractéristiques de l'habitat et le régime alimentaire. Nous avons repérés les animaux par traces fraîches (reste d'aliments, fèces, forte odeur d'urine) ou vocalisations, et ensuite compté les individus du groupe. Pour chaque observation, nous avons noté sur une fiche préconçue: la date, l'heure, l'espèce, le nombre d'individus, la ressource alimentaire en situation de nourrissage et les coordonnées géographiques prises à l'aide d'un GPS. Nous avons procédé de la même manière pour l'inventaire des lémuriens sympatriques de *P. simus*.

Cartographie de la distribution spatiale et la caractérisation de l'habitat

Un GPS a été utilisé pour enregistrer les coordonnées géographiques des observations directes ou traces d'activités, en vue de la délimitation du domaine vital de chaque groupe et des zones à bambous, et de la schématisation des pistes de suivi et cours d'eau. Avec le logiciel Arc GIS 9.3, nous avons réalisés des cartes de localisation du site, de la distribution spatiale des groupes de *Prolemur simus* et autres lémuriens, des pressions, et des groupements botaniques à essence de bambous pour la caractérisation de l'habitat et la distribution des espèces alimentaires consommées par *P. simus*.

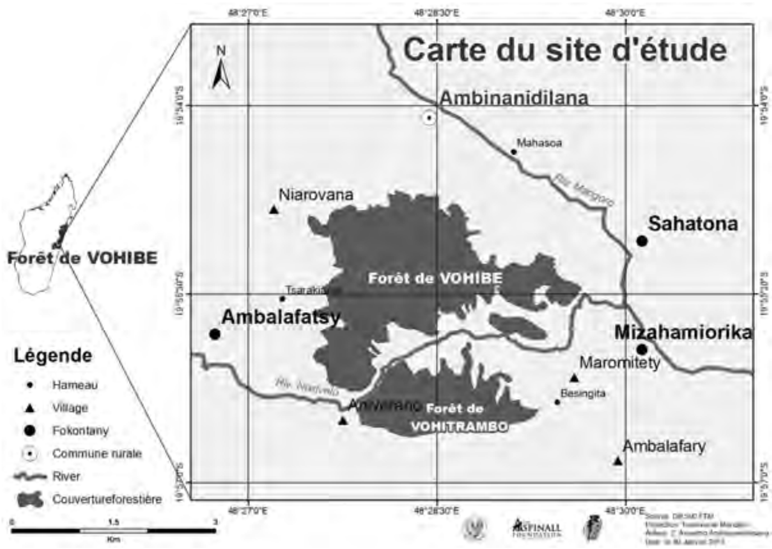

Fig. 1: Localisation du site d'étude.

Fig. 2: La forêt de Vohibe sur la colline en arrière-plan de la rivière Nosivolo en juin 2011. (Photo: Z.A. Andrianandrasana)

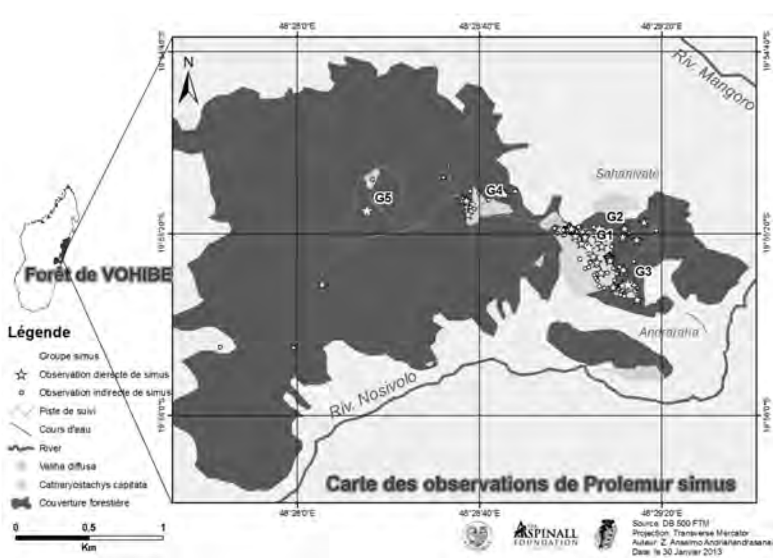

Fig. 3: Carte des observations directes et indirectes de *Prolemur simus* à Vohibe en 2011 et 2012.

Identification des facteurs menaçant la survie de Prolemur simus

Outre les enquêtes participatives auprès des villageois et utilisateurs de la forêt, nous avons relevé toute pression et menace pesant sur la survie de *P. simus* dans et autour de Vohibe. Ces informations nous ont également servi de moyen de sensibilisation et d'éducation environnementale des communautés locales.

Résultats

Nombres de groupes et taille de la population de Prolemur simus

En 89 jours de suivi (Tab. 1), nous avons effectué 44 observations directes et 84 observations indirectes de *Prolemur simus* dans et autour de la forêt de Vohibe, entre 200 et 571 m d'altitude. Cinq groupes de *Prolemur simus* ont été directement aperçus sur le site, et les traces de nourrissage suggèrent qu'il y en ait probablement davantage (Figs. 3, 4). Lors de la dernière mission, en décembre 2012, nous avons compté 27 individus répartis dans ces cinq groupes, dont 21 adultes, 2 juvéniles, et 4 nouveau-nés d'octobre et novembre 2012 (Tab. 2).

Cartographie de la distribution spatiale et la caractérisation de l'habitat

La cartographie des points d'observations et traces de nourrissage ou de passage de *Prolemur simus* ont abouti à la représentation spatiale de la distribution des cinq groupes (Fig. 3). D'après cette carte, les groupes G1, G2 et G3 habitent dans la partie de l`est de Vohibe, avec des domaines vitaux rapprochés, voire chevauchés, tandis que les groupes G4 et G5 vivent dans la partie de l`ouest. La plupart de nos observations ont été faites à l'intérieur de la forêt, surtout dans la partie de l`est, où le bambou *Cathariostachys* cf. *capitata* est abondant (Fig. 3), mais quelques observations ont été fait à l'extérieur, dans les champs de culture ou les zones à bambou *Valiha diffusa*.

Une estimation préliminaire de la superficie du domaine vital de chaque groupe montre une moyenne approximative de 8,7 ha, avec un maximum de 18 ha pour le groupe G5 et un minimum de 3,5 ha pour le groupe G2. Les trois premiers groupes occupent une surface totale presque équivalente à celle occupée par le groupe G5. Nous n'avons pas fait assez d'observations pour identifier des mouvements d'individus entre groupes ou des changements de composition des groupes.

Espèces végétales consommées par Prolemur simus

Comme mentionné précédemment, deux espèces de bambou de grande taille sont présentes à Vohibe: *Cathariostachys* cf. *capi-*

tata et *Valiha diffusa*. Selon le Tab. 3, lors de 29 observations directes, *Prolemur simus* a d`avantage consommé *Cathariostachys* cf. *capitata*, avec une fréquence de 82,76 % (Figs. 5, 6). D'autres espèces végétales sont également mangées mais moins souvent, à savoir *Ravenala madagascariensis* (10,34 %; Fig. 7) et *Aframomum* sp. (6,90 %); elles constituent donc une alimentation complémentaire pour ce grand hapalémur. Enfin, nos 59 observations indirectes (traces de nourrissage; Tab. 3) montrent que *Prolemur simus* consomme aussi deux autres espèces de bambou, *Valiha diffusa* et *Cephalostachyum* sp.

Tab. 2: Composition des groupes de *Prolemur simus* observés à Vohibe en décembre 2011 et décembre 2012. *non recensé en 2011

Groupe	Décembre 2011				Décembre 2012			
	Adulte	Juvénile	Nouveau-né	Total	Adulte	Juvénile	Nouveau-né	Total
Groupe I 19,923°S 48,484°E	5	1	1	7	3	1	1	5
Groupe II 19,922°S 48,485°E	5	1	0	6	6	-	2	8
Groupe III 19,925°S 48,487°E	1	0	0	1	2	-	1	3
Groupe IV 19,920°S 48,478°E	5	0	0	5	4	1	-	5
Groupe V* 19,921°S 48,471°E	-	-	-	-	6	-	-	6

Fig. 4: Une femelle *P. simus* allaitante, avec son petit né en novembre 2011, et assise sur un *Dracaena* sp. (Photo: Z.A. Andrianandrasana)

Tab. 3: Fréquence d'observation des espèces végétales consommées par *P. simus*.

Espèce	Nom vernaculaire	Observation directe		Observation indirecte	
		n	Fréquence en %	n	Fréquence en %
Cathariostachys cf. *capitata*	Volohosy	24	82,76	34	57,63
Valiha diffusa	Vologasy	0	0,00	6	10,17
Cephalostachyum sp.	Tsingolovolo	0	0,00	7	11,86
Dypsis sp.	Tsirika	0	0,00	1	1,69
Ravenala madagascariensis	Ravinala	3	10,34	3	5,08
?	Non identifié	0	0,00	1	1,69
cf. *Ravenea* sp.	Nivona	0	0,00	2	3,39
Aframomum sp.	Longoza	2	6,90	5	8,47
	TOTAL	29	100,00	59	100,00

Le Tab. 4 expose quelques caractéristiques des deux espèces de bambous de grande taille observées sur le site. *Cathariostachys* cf. *capitata* présente un diamètre moyen de 5,18 ± 1,83 cm, tandis que celui de *Valiha diffusa* est 4,42 ± 1,43 cm. *Cathariostachys* cf. *capitata* est abondant sur le versant et la crête de la partie orientale de Vohibe. Quant à *Valiha diffusa*, il a beaucoup été observé à l'extérieur de la forêt de Vohibe, mais également à l'intérieur de la partie ouest de Vohibe.

Tab. 4: Caractéristiques des espèces de bambou sur le site d'étude.

	Cathariostachys* cf. *capitata				**Valiha diffusa**			
	Min	Max	Moyenne ± sd	n	Min	Max	Moyenne ± sd	n
Diamètre (cm)	2,4	7,2	5,18 ± 1,83	127	1,7	9,5	4,42 ± 1,43	76
Entre-noeud (cm)	17,4	53,5	36,23 ± 5,47	127	11,8	28,3	20,50 ± 3,74	76
Hauteur (m)	3	26	13,06 ± 5,06	127	2	15	8,93 ± 3,32	76

Espèces de lémuriens sympatriques

L'inventaire par observation directe a révélé que cinq espèces de lémuriens sympatriques de *P. simus* ont été aperçues dans la forêt de Vohibe: *Eulemur fulvus* et *Hapalemur griseus* qui sont des espèces cathémérales, *Avahi* sp., *Cheirogaleus* sp. et *Microcebus* sp. qui sont des espèces nocturnes. En outre, les communautés villageoises ont mentionné que *Propithecus diadema*, *Eulemur rubriventer* et/ou *Lepilemur* sp. étaient présents sur le site auparavant, mais la chasse et l'exploitation abusive des ressources naturelles ont apparemment engendré leur disparition.

Pressions et menaces

La plupart des facteurs menaçant la survie de ce grand hapalémur sont des pressions d'origine anthropique (Tab. 5), et peuvent être regroupés en trois grandes catégories:

La perte d'individus par la chasse: des pièges à lémuriens sont installés toute au long de l'année, principalement sur une ligne de crête dans et/ou à la périphérie de la forêt, sur le passage des lémuriens et autour des *tavy* (champ de culture de riz), sans oublier la présence des prédateurs sur le site (*Cryptoprocta ferox, Sanzinia madagascariensis*);

La perte d'habitat par l'exploitation abusive et la dégradation des ressources naturelles: surtout en cause de défrichement pour la culture sur brûlis ou *tavy* dans et autour de la forêt, et la conversion de l'habitat en champ de culture;

Fig. 5: Une femelle *P. simus* allaitante avec son petit né en novembre 2012 se nourrissant d'une partie molle des jeunes pousses de *Cathariostachys* cf. *capitata*, décembre 2012. (Photo: Z.A. Andrianandrasana)

Fig. 7: Une femelle *P. simus* allaitante avec son petit né en novembre 2012, se nourrissant des fleurs de *Ravenala madagascariensis*, décembre 2012. (Photo: Z.A. Andrianandrasana)

La perturbation d'habitat par la construction d'habitations autour de la forêt, entraînant du bruit et la dispersion des animaux, mais également par le passage des villageois.

En outre, les populations villageoises utilisent les bambous de grande taille, qui constituent la principale source d'alimentation de *Prolemur simus*, pour divers usages locaux:

- Matériels de construction (ex: habitation temporaire et permanente, grenier, escalier, tuyau d'irrigation, poteau de drapeau, etc.);
- Matériaux d'arts et d'instruments musicaux (ex: meubles, panier, guitare, flûte, tambour, bâton de pluie, etc.);

Fig. 6: Trace de nourrissage de *P. simus* sur *Cathariostachys* cf. *capitata* dans la fôret de Vohibe, décembre 2012. (Photo: Z.A. Andrianandrasana)

- Matériels de pêche artisanale (ex: canne à pêche, radeau, rame, nasse, lanterne, ou encore bâton pour perturber les poissons):
- Matériels de chasse (ex: barre d'attache des filets pour pièges à chiroptère);
- Matériels de protection des cultures et élevages;
- Equipement domestique ou ustensile (ex: boîte à sel fin, sucre, café, tabatière, fardeau, vanne, récipients pour la fermentation des alcools locaux, etc.);
- Bois de chauffe.

Tab. 5: Pressions et menaces aperçues sur le site Vohibe. (NB: ++: nombreux; +: moins nombreux; -: néant)

Type	**Année**	
	2011	**2012**
Piège à lémuriens	++	-
Piège à carnivores	++	+
Piège à chiroptères	++	++
Station de construction de fléchettes	++	++
Coupe de bambou	++	++
Culture sur brûlis dans et à la périphérie de la forêt	++	++
Coupe de bois pour la construction d'habitations temporaires et pirogues	++	++
Habitations temporaires dans et autour de la forêt	++	++
Cueillette des produits forestiers (ovy ala et miel)	++	++
Pêche illicite	++	+
Dispersion des zébus	++	++
Dispersion des porcs	++	+
Four à charbon	+	-
Conversion de terre à proximité de la forêt en champ de culture (café, vanille, canne à sucre, haricot, bananier, maïs, ananas)	++	++

Discussion

Dynamique et taille de la population

La recherche des groupes de *Prolemur simus* sur le site de Vohibe reste difficile, notamment en raison du caractère inaccessible ou accidenté du terrain. Cependant, grâce aux efforts de l'équipe d'intervention, le nombre d'individus observés a augmenté. Ainsi, alors qu'en 2011, nous avons identifié quatre groupes totalisant 19 individus, à la fin de cette étude en décembre 2012, nous avons recensé 27 individus répartis en cinq groupes, dont 21 adultes, deux juvéniles et quatre nouveau-nés d'octobre et novembre. Cette augmentation du nombre d'individus observés est due à une croissance démographique des groupes suivis depuis le début de l'étude, mais aussi à la découverte de nouveaux groupes pendant l'étude. Des augmentations similaires sont également constatées sur d'autres sites d'intervention de The Aspinall Foundation (Bonaventure *et al.,* 2012; Lantovololona *et al.,* 2012; Mihaminekena *et al.,* 2012; Randrianarimanana *et al.,* 2012; Ravaloharimanitra *et al.*, 2013).

Ecologie: caractéristiques de l'habitat et régime alimentaire

Deux espèces de bambou de grande taille existent sur le site de Vohibe, avec une répartition restreinte: *Cathariostachys* cf. *capitata* et *Valiha diffusa. Cathariostachys* cf. *capitata* est observé sur le versant et la crête de la partie orientale de Vohibe, alors que *Valiha diffusa* est abondant dans les zones dégradées à *tavy* ou *savoka*. Pendant notre étude *Prolemur simus* a été directement observé consommant préférentiellement les jeunes pousses et feuilles de *Cathariostachys* cf. *capitata,* avec une fréquence de 82,76 %. Cependant, l'espèce a également mangé des jeunes tiges de *Aframomum* sp. et des fleurs de *Ravenala madagascariensis*. Enfin, d'après les traces de nourrissage relevées, *Prolemur simus* a aussi consommé *Valiha diffusa*, ainsi que des fruits de *Dypsis* sp. et de cf. *Ravenea* sp. Nous recommandons une plus longue période de suivi permanente par des chercheurs, afin d'identifier les changements de préférences au cours de l'année, comme constaté au Parc National Ranomafana par Tan (1999).

D'après les récentes études effectuées par The Aspinall Foundation, l'alimentation de *Prolemur simus* présente une variation géographique. Ainsi, dans les sites de basse altitude du District de Brickaville, son alimentation principale est constituée de *Valiha diffusa* (Bonaventure *et al.,* 2012; Lantovololona *et al.,* 2012 ; Mihaminekena *et al.,* 2012), ou *Bambusa vulgaris* et *Valiha diffusa* (Mihaminekena *et al.,* 2012). Par contre, dans les forêts de moyenne altitude faisant partie du Corridor Ankeniheny–Zahamena, l'espèce consomme principalement *Cathariostachys madagascariensis* (Randrianarimanana *et al.,* 2012). Vohibe est le seul site d'intervention de The Aspinall Foundation sur lequel coexistent les deux genres de bambou de grande taille endémiques à Madagascar, *Cathariostachys* et *Valiha*. Une étude plus approfondie du régime alimentaire de *Prolemur simus* sur ce site serait donc très utile pour déterminer les préférences de l'espèce.

Espèces de lémuriens sympatriques

A Vohibe, *Eulemur fulvus* et *Hapalemur griseus*, deux espèces cathémérales, vivent en sympatrie avec *Prolemur simus*. *Varecia variegata*, une espèce menacée d'extinction, était auparavant observée dans la forêt de Vohitrambo, sur la rive opposée de la rivière Nosivolo, mais en a disparu depuis peu (Rajaonson et King, 2013).

Pressions et menaces

La plupart des facteurs menaçant la survie de *P. simus* dans son habitat naturel sont des pressions d'origine anthropique (Ravaloharimanitra *et al.,* 2011, Rakotonirina *et al.,* 2011). En 2011, des pièges à lémuriens ont été trouvés sur le site de Vohibe, sur une ligne de crête dans et à la périphérie de la forêt où passent ces animaux. Des pièges semblables sont toujours régulièrement installés autour des champs de riz afin de protéger les cultures. Ceci suggère donc que la chasse est toujours couramment pratiquée dans la région, à l'aide de pièges mais également de fléchettes. Vohibe n'est pas un cas isolé puisqu'à Ranomainty dans le Corridor Ankeniheny–Zahamena, les nombreux pièges à lémuriens relevés conduisent à la même conclusion (Randrianarimanana *et al.,* 2012).

Les bambous, principale espèce végétale alimentaire de *Prolemur simus*, sont utilisés par les communautés locales à des fins diverses (matériels de construction, artisanaux, de protection des cultures). L'exploitation abusive de ces bambous entraîne une destruction de l'habitat de l'espèce. La culture sur brûlis ou *tavy* constatée sur le site aggrave encore la situation. Ces pratiques provoquent une diminution de l'habitat et des territoires des groupes de *Prolemur simus*; ceci est particulièrement vrai pour les groupes G1, G2 et G3 qui fréquentent la partie orientale de Vohibe. Enfin, la perturbation de l'habitat par le bruit, issu de l'abattage des arbres ou le passage des villageois dans la forêt, engendre une mobilité accrue des groupes de *Prolemur simus* et un certain stress.

Recommandations pour l'élaboration d'une stratégie de conservation

La forêt de Vohibe présente des richesses en flore et faune qui la distinguent d`autres. Les travaux effectués sur le site nous ont permis d'accroître les connaissances sur les conditions nécessaires à la survie de sa population de *Prolemur simus*. Ce grand hapalémur doit faire face aux pressions et menaces pesant sur son environnement, raison pour laquelle nous faisons les recommandations suivantes afin de contribuer à la préservation et la conservation de sa population, des autres espèces animales et de la biodiversité de la région :

- Approfondir les études étho-écologiques sur *Prolemur simus* ;
- Étudier les niveaux d'isolement et de consanguinité éventuelle de cette population, afin de définir les interventions nécessaires à sa viabilité;
- Continuer les campagnes de sensibilisation auprès des communautés locales et au niveau des établissements scolaires publics primaires et secondaires dans la zone d'intervention;
- Créer des microprojets appropriés à la conservation et qui répondent aux besoins des communautés locales.

Remerciements

Nos vifs remerciements sont adressés à toutes les personnes qui ont contribué de près ou de loin à la réalisation de ce travail, et plus particulièrement: le Ministère de l'Environnement et des Forêts, et la Direction Générale des Aires Protégées Madagascar pour l'octroi du permis de recherche; l'Association Française pour la Sauvegarde du Grand Hapalémur (AFSGH) et The Aspinall Foundation pour le financement; The Aspinall Foundation Madagascar et le Groupe d'Etude et de Recherche sur les Primates de Madagascar (GERP) pour la supervision des travaux, l'appui matériel et logistique. Nous tenons aussi à remercier l'ONG Durrell, le Chef cantonnement de la Direction Régionale de l'Environnement et des Forêts de Mahanoro, le Chef de la Circonscription Scolaire de Mahanoro, le Proviseur du Lycée de Mahanoro, les Maires, les autorités locales, les Tangalamena, le Chef de la Zone d'Action Pédagogique d'Ambinanidilana, les Instituteurs des établissements scolaires, les Médecins du Centre de Santé de Base II d'Ambinanidilana et d'Ankazotsifantatra, les patrouilleurs de The Aspinall Foundation, les Communautés Forestières Locales (ou CFL) de Durrell, et les populations villageoises vivant à Vohibe, ainsi que Anjara Bonaventure, Felaniaina Lantovololona, Mohamad Mbaraka, Rose Marie Randrianarison, Maholy Ravaloharimanitra, Delphine Roullet pour leurs étroites collaborations.

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Population density estimates of two endangered nocturnal and sympatric lemur species from the Mariarano Forest, northern Madagascar, using multiple approaches

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Key words: *Lepilemur edwardsi, Avahi occidentalis*, abundance, distance sampling, habitat disturbance

Abstract

A study into the distribution and abundance of *Avahi occidentalis* and *Lepilemur edwardsi*, two endemic and nocturnal species from the northwestern region of Madagascar, was undertaken in the Mariarano Forest in November 2012. The objectives were to establish population size and determine the impact of forest fragmentation on population abundance. Our study showed the initial results of density and population size for both species. We used three methods of distance sampling on a line-transect (Buckland, Müller and Kelker), which differ in the way the effective strip width (ESW) is estimated. The results show optimistic estimates for both populations. The three distance sampling methods provided similar estimates indicating a small difference between the two sympatric lemurs. This difference may be caused by natural effects between species and their habitats (type of habitat, abundance of food, etc.) or by anthropogenic causes such as fragmentation of their habitat and poaching. Forest fragmentation constitutes the heaviest threat to these populations and could lead to their total disappearance if measures of protection are not taken.

Mots-clés: *Lepilemur edwardsi*, *Avahi occidentalis*, abondance, distance sampling, dégradation de l'habitat

Résumé

Une étude sur la distribution et l'abondance de *Avahi occidentalis* et *Lepilemur edwardsi*, deux espèces endémiques de la région Nord-Ouest de Madagascar, a été effectuée dans la forêt de Mariarano, en Novembre 2012. Les objectifs étaient de connaitre les estimations des tailles de chaque population ainsi que les impacts de la destruction de leurs habitats. Nos résultats des estimations des densités sont les premiers connus pour ces deux espèces dans cette zone. Nous avons utilisé la méthode de *Distance Sampling* sur des transectes linéaires. Pour cela, trois méthodes distinctes ont été appliquées au cours des analyses: Buckland, Müller et Kelker. Ces trois méthodes sont basées sur le même principe mais diffèrent dans l'estimation de la distance d'observation efficace (ESW: effective strip width). Les résultats obtenus suite à l'application de ces trois méthodes suggèrent qu'elles sont similaires et montrent une légère différence entre les deux espèces de lémuriens étudiées. Cela peut être dû à des causes naturelles entre espèces, ou entre forêts (type d'habitat, abondance d`éspeces comestible, etc.), ou encore à des causes anthropiques telles que la fragmentation de l'habitat et le

braconnage. La destruction des habitats constitue la menace la plus importante sur ces populations et peuvent entraîner leur disparition totale si des mesures de protections ne soient pas prises.

Introduction

The forest cover of Madagascar continues to deteriorate. The practice of tavy and intensive lumbering are among the most widespread causes of loss to biodiversity in the country (Laurance *et al.,* 2000; Lehmann *et al*., 2006). Such loss is often intensified by the effects of cyclones, which can cause major damage to the forest ecosystem (Rambinintsoa *et al*., 2006; Patel, 2009).

Mariarano Forest, a semi-deciduous forest (typical of the western region of Madagascar), contains some dry and gallery forests. This area does not escape the impact of these deterioration phenomena (Olivieri *et al*., 2005), which makes the forests vulnerable in their present states. Fragmentation affects animal populations on several levels and time scales. Direct invasive causes include increased hunting, logging and burning (Turner, 1996). The impact of these ecological factors threatens biodiversity in different ways; among others, the reduction of plant biomass and an acceleration of the loss of flora and fauna.

Mariarano Forest is home to seven lemur species, of which three are diurnal (*Propithecus coquereli, Eulemur fulvus* and *Eulemur mongoz*) and four are nocturnal (*Microcebus* sp*., Lepilemur edwardsi, Cheirogaleus medius* and *Avahi occidentalis*). The deterioration of their habitat puts these species at risk of extinction, as they struggle to adapt to the abrupt changes (Rambinintsoa *et al*., 2006). In the Mariarano Forest and the surrounding region, they are important not only for the role they play in the regeneration of forest cover (Durbin, 1999; Thalmann, 2006), but also in the development of ecotourism.

Lepilemur edwardsi and *Avahi occidentalis* live in sympatry in the Mariarano Forest (Rambinintsoa *et al*., 2006; Olivieri *et al*., 2005). Both these nocturnal species have comparable body weights and positional behaviors and both are folivorous (Martin *et al*., 1985; Martin, 1990). They are "vertical clinging and leaping" lemurs (Richard and Dewar, 1991), preferring to use vertical supports for travel (Thalmann and Geissmann, 2000; Thalmann, 2001; Rasoloharijaona, 2003). However, the species differ in their social organization. Sportive lemurs (*Lepilemur edwardsi)* are known to live mainly solitarily, whereas woolly lemurs (*Avahi occidentalis*) live in gregarious family groups (Thalmann and Geissmann, 2000; Thalmann, 2001; Rasoloharijaona, 2003). In other areas where the two species are sympatric, such as Ampijoroa in the Ankarafantsika National Park, the species differ in their types of dormitories; *Lepilemur edwardsi* live in holes in trees, whereas *Avahi occidentalis* hide in adjoining branches or in the entanglements of lianas (Warren, 1997; Warren and Crompton, 1997a,b). During our studies, we noted that the two species often hid in entanglements of lianas and foliage. Competition for food acts as a limiting factor on population size (Thalmann, 2001). Line-transect surveys are an important tool for assessing specific presence-absence and density estimates in tropical mammals (Buckland *et al*., 2001; Rodrigues *et al*., 2000). Studies of primate conservation biology and community ecology also widely use density estimates from these surveys (Ganzhorn *et al*., 1999; Jernvall and Wright, 1998; Reed, 1999). Very little information is known about density and population sizes of *Lepilemur edwardsi* and *Avahi occidentalis* in the Mariarano region. Since their forest habitat is highly fragmented (particularly the Analabe and Anosilava forests) and expected to undergo significant changes in the future, rapid surveys are essential to determine conservation priorities for the area.

Methods

Study sites

Our survey was conducted in the Mariarano Forest. This area is a classified forest situated about 80 km northeast of Mahajanga (Olivieri *et al.,* 2005). Administratively, it is located between 15°28'50.0" latitude and 046°41'31.5" longitude and belongs to the District of Mahajanga II in the Region Boeny, Sous-Prefecture Mahajanga II, Commune Rurale Mariarano, Fonkontany Mariarano. This 1,580-ha tract is a semi-deciduous forest (typical of the western region) with some gallery forest (Rambinintsoa *et al*., 2006). It is confined to the east by savannah until the Andranoboka township; to the north by the Mariarano River and the Bay of Mahajamba; to the west by the Canal du Mozambique; and to the south by rice fields, which separate the forest from the Tanambao village (Rambinintsoa *et al.,* 2006).

Line-transect surveys were conducted in three lowland forest fragments: Anosilava, situated 20 km southeast of Mariarano village; Analabe, 5 km to the west of Mariarano; and Ankatsabe, the forest containing the village of Mariarano.

Abundance estimates

At all of the sites, nocturnal lemur populations were surveyed using the line-transect method. In November 2012, six line-transect surveys were conducted in each of the fragments. Transects varied in length (1,000 – 1,500 m) and were walked between 06:00 and 20:00 hrs.

Once an animal was visually detected, one observer noted all the parameters and the second followed the individual, identifying the species using a strong flashlight. Nocturnal

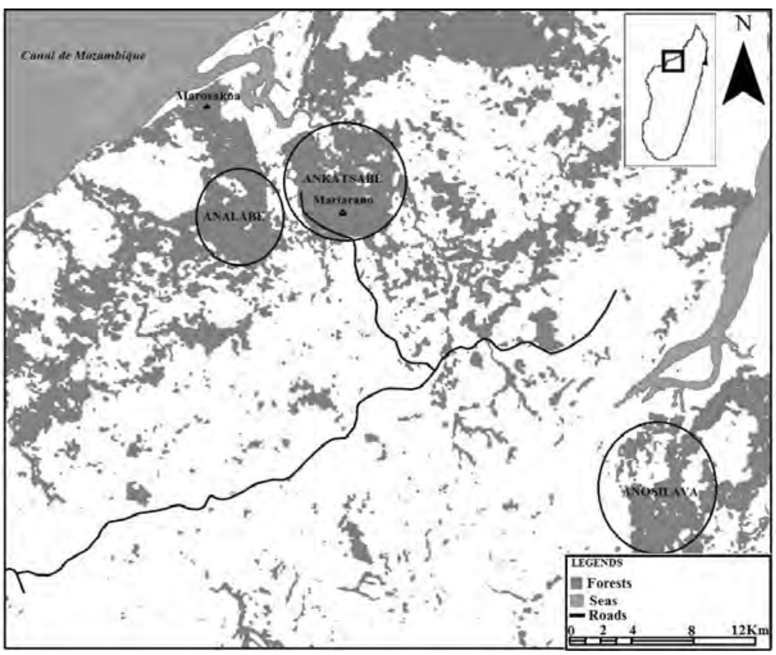

Fig. 1: Study area (map drawn by MTI, reproduction in ArcGis).

species and genera were determined according to their overall size (a means sufficient for discrimination between *Microcebus* sp., *Cheirogaleus* sp., and *Lepilemur* sp./*Avahi* sp.) and their head proportions (relative ear size and protrusion of snout differs between *Lepilemur* sp. and *Avahi* sp.).

Habitat characterization

Habitat characterization allows for the study of the state of the forest and its features. This enables the evaluation of anthropogenic pressures, whilst leaving the virgin forest undisturbed and intact (Fathers and Dolman, 2000). Several parameters were recorded, estimated at 20 to 50 m of the transects: the GPS position; the height of the canopy; and the density of large, medium and small trees. All factors that may be threats to both the forest and the lemurs were noted if they were sighted within a radius of 10 to 20 m of the observer at the considered point.

Density and population size computation

Surveys from line transects were analyzed with three different techniques widely used to estimate density.

These methods differ mostly according to how the effective strip width (ESW) is calculated and can thus be easily compared (Buckland *et al*., 2001; Marshall *et al*., 2008). Indeed, they all use the same principle whereby the final density (*D*) is computed as a simple function of the ESW, the total number of observations (N_t), and the total length of the transects (L_t). The Müller and Kelker methods consider a histogram basis, using the shape of the distribution of observation distances to estimate ESW (Buckland *et al*., 2001; Marshall *et al*., 2008). It consists of inspecting the considered histogram, the perpendicular distance value where the number of individuals falls to 1/3 or more. This value is called commonly FD, "fall-off distance".

$$D = \frac{N_t}{2 \times ESW \times L_t}$$

For Müller's method, the number of observations considered is located before this value, that means ESW = FD. For the Kelker method, all observed animals are considered and determination of the ESW follows the formula: ESW = FD * N_t / N_f. N_t and N_f designate the total number of observations and the number of observations respectively before FD (Lehman, 2006; Randrianambinina *et al*., 2010).
In practice, the evaluation of the density by both the Müller and the Kelker methods is made with the help of the software R (Zeileis *et al*., 2007; Tomases *et al*., 2010). The Buckland method (Buckland *et al*., 2001) is based on the decreasing probability of observing an animal as its distance from the transect increases. Four detection models were tested (uniform, hazard rate, half-normal and negative exponential detection function) and compared using the Akaike Information Criterion (AIC) as recommended by Buckland *et al*. (2001). This method is implemented in the DISTANCE 6.0 program (Quéméré *et al*., 2010; Axel and Maurer, 2011; Meyler *et al*., 2012). We lumped the three fragments for the density calculations since we only had small samples for the Anosilava and Analabe forests.

Evaluation of the population sizes

The determination of total population sizes for every species was made according to the formula: N = A x D, where N = population size; A = area of survey; D = population density.

Results

Survey effort

Our survey effort covered a total area of 25.5 km. The lowland forest fragments of Anosilava and Analabe were completely destroyed by fires, therefore we were only able to establish one transect per forest.

Tab. 1: Number of lemurs observed (by species) in each forest fragment. Nb: Number of individuals, Nb/km: number of observations per kilometer

	Anosilava		Analabe		Ankatsabe		Total
	Nb	Nb/km	Nb	Nb/km	Nb	Nb/km	
Avahi occidentalis	13	2,8	0	0	38	2,3	51
Lepilemur edwardsi	2	0,4	0	0	74	4,48	67
Cheirogaleus medius	0	0	0	0	2	0,12	2
Eulemur mongoz	0	0	0	0	6	0,36	6
Total	15		0		114		129

Density estimates

Seven species of lemur were sighted in the course of this study. However, for the purposes of this research only *Avahi occidentalis* and *Lepilemur edwardsi* were surveyed.

Tab. 2: Density and total population size estimates of *Avahi occidentalis* and *Lepilemur edwardsi*. D=Density; ESW=Effective Strip Width

Species	Method	ESW (m)	Area (km²)	D (ind/km²)	Total
A. occidentalis	Buckland	7	15,8	153,06	2418,34
	Müller	4	15,8	137,25	2168,55
	Kelker	7,2	15,8	137,25	2168,55
L. edwardsi	Buckland	8	15,8	220,23	3479,63
	Müller	5	15,8	203,92	3221,93
	Kelker	7,3	15,8	203,92	3221,93

Tab.1 shows that despite the increased level of destruction of the Anosilava Forest, the highest number of *A. occidentalis* were found here. Contrary to this, the highest quantity of *L. edwardsi* was observed in the Ankatsabe Forest. Neither species was noted during nocturnal observations conducted in the Analabe Forest.
For the Buckland method, the results have been calculated following the truncation of the perpendicular distances to a value of 15 m for *L. edwardsi* and 10 m for A. occidentalis. The uniform model has been chosen for the two species because it presents the small values of AIC. The values of ESW, the density estimates, as well as the total population sizes are presented in Tab. 2.
The use of both the Müller and Kelker methods allows FD to be presented with several values and variations of density following the intervals of perpendicular distances chosen. In the case of our analysis, five intervals of distances (1 m, 2 m, 3 m, 4 m and 5 m) have been proposed and the choice of the graph was made according to the number of repetitions of values of FD in the intervals of distances, and/or to the quality of the graph.
Results from the three methods (Tab. 2) show a light non-meaningful variation of densities calculated between the Buckland and the Müller and Kelker methods. The latter two gave similar density estimates when compared to the Buck-

land method. The density estimates varied between 130 and 155 ind./km² with a population size variance between 2,200 and 2,450 individuals for *Avahi occidentalis* and between 200 and 220 ind./km² with a population size varying between 3,200 and 3,500 individuals for *Lepilemur edwardsi*.

Forest characterization

Anosilava Forest

This area of secondary forest is extremely damaged. During our observations, we noted that all types of lumbering are practiced. Bush fires, grazing fires and a culture of burning land are abundant. Hunting constitutes another pressure threatening the lemur population. We met farmers hunting a *Lepilemur* in its hole for food. Fragmentation is increasing to such an extent that only approximately 100 ha of Lepilemur forest remains. In spite of this deterioration, the forest contains more large trees than elsewhere and is dominated by tamarinds, fig and mango trees. The forest cover is less dense with a very open canopy. Six lemur species were observed; five species were noted during the nocturnal and diurnal observations (*Propithecus coquereli*, *Eulemur fulvus*, *A. occidentalis*, *L. edwardsi* and *Microcebus* sp.), and one was observed outside the transects (*Eulemur mongoz*). According to the villagers, the disappearance of a large part of this forest is very recent; indeed the forest cover had remained largely intact for the last ten years.

Analabe Forest

This fragment is separated from Ankatsabe Forest by the Mariarano River. According to villagers it was once one of the larger forests of the region. The forest cover of this area is very variable and the trees are small. During our observations we noted several signs of deforestation along the line transect and that the culture of land burning is abundant. We did not note any trace of hunting. Last year a bush fire swept the forest and overwhelmed its western part. As a result of this, only a small part of the forest cover remains.

Ankatsabe Forest

The forest around the village of Mariarano is of dry deciduous type. It contains some small trees but its cover is very dense, with very high liana density. Our observations showed little signs of human deforestation for wood-work and wood fire-chambers. We found no trace of hunting. The western part of the forest has been replaced by rice fields and cultures of burnt land.

Discussion

The mean encounter rate per kilometre of the animals was variable according to site and species. We noted that the encounter rate was higher at Anosilava for *Avahi* sp. than at the two other sites. Contrary to this, the encounter rate for *Lepilemur* was the lowest in this forest. One explanation for why this rate of observation of *Avahi* sp. in Anosilava was higher, is that other observations were carried out during day-time hunting periods when lemurs had learnt to be more discreet. *Avahi* sp. is not well known to the villagers, which constitutes an advantage to its survival. Unlike the *Lepilemur*, *Avahi* sp. can sometimes be found in the holes of trees in Anosilava Forest, which makes their capture easier. Contrary to diurnal species such as *Propithecus coquereli* and *Eulemur fulvus* that are often observed in borders of the forests during their activities, *Lepilemur edwardsi* and *A. occidentalis* were more abundant in the interior of the forest (Malcoms, 1994; Lehman *et al*., 2006). These animals sleep during the day, and as a result are at greater risk from hunting due to the ease of their capture. They use habitats inside the forests where access is difficult. They are not generally found in the forest's border, except on occasions when foraging trips take them further afield.

Generally, the density of nocturnal lemurs in these forests was high in spite of the destruction of their habitat. This density varied between 200 and 220 ind/km² for *L. edwardsi* and 130 and 155 ind/km² for *A. occidentalis*. The population density was slightly higher for *L. edwardsi* than for *A. occidentalis*. These differences can be explained in terms of competition between the animals for natural resources, such as access to food and dormitories. In the dry deciduous forest of Ankarafantsika, which contains some big trees with high canopy, these two genera live in sympatry. Competition for dormitories is limited because *L. edwardsi* occupy holes and *Avahi* sp. live in foliage and the entanglements of lianas (Thalmann and Geissmann, 2000; Thalmann, 2000; Warren, 1997; Warren and Crompton, 1997a,b). In the Mariarano Forest (Ankatsabe Forest), the forest cover is dense but the trees are very small and the holes are less marked. The two species were found in foliage and the entanglements of the lianas. Visibility in the habitat is the most influential factor in the census of these primates (Nijman and Menkens, 2005; Mitanis et al., 2000) and could limit the number of lemurs encountered. In spite of these differences of density between the two species, these values are generally higher than the densities observed in the same genera in other areas (Olivieri *et al*., 2005). It proves the importance of ecological interest and eco-tourism in the forest. The results of the forest characterization reveal an intensified destruction of the forest fragments, resulting in an increased number of fragments, and further isolation of reduced forest massifs. It is a negative sign for the lemur communities of Mariarano, because the diversity of lemur species shows a positive correlation with the fragment sizes (Ganzhorn *et al*., 2003). In spite of the higher density, the biggest threat to these species comes from fires. This raised density is found in the Ankatsabé Forest. In the Anosilava and Analabe forests, individuals only occur in parts covered by forest, but a significant part of the forests has been destroyed by fires. Several lemurs and other mammals are killed every day by fires and other forms of destruction (Mittermeier *et al*., 2010; Ramanamanjato, 2000).

Conclusion and recommendations

This survey allowed us to record more information on the density, population sizes, as well as on the greatest threats to the lemurs of Mariarano Forest. Our results are satisfactory as the species seem to be adapted to these broken-up habitats, despite the high degree of fragmentation. Fragmentation and insolation of the habitats constitute important factors for the loss of genetic diversity in the wild populations. To protect the animals distributed in the Anosilava and Analabe forests, a management plan for these forests is necessary. For it to begin, the two forest fragments must be included in the programme. Environmental education activities within the local population and reforestation programmes must be created in order to assure the safeguard of lemur populations as well as their habitats.

Acknowledgements

We wish to thank the Malagasy authorities, and in particular the "Direction Générale des Forêts" for giving us permission to conduct this study. This work benefited from financial support from the "Association Européenne pour l'Etude et la Conservation des Lémuriens (A.E.E.C.L.)". We address our thanks to Dr Brice Lefaux. We address our sincere acknowledegments to the personnel of the "Départment de Biologie Animale et Ecologie, Université de Mahajanga". We thank the personnel of the "Commune Rurale de Mariarano," particularly the mayor and all guides for their aid and assistance during the different missions. Finally, we address our gratitude to Pr Yves Rumpler for the fundamental help in the initial period of the project.

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Conservation communautaire de *Prolemur simus* à Ambalafary, District de Brickaville, Madagascar

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Mots clés: Conservation de la biodiversité, transfert de gestion, COBA, *Prolemur simus*

Résumé
La collaboration entre The Aspinall Foundation et la COBA Ainga Vao de la Commune Rurale de Fanasana Gare a débuté en 2009, lorsque la présence de *Prolemur simus* a été confirmée sur un site de basse altitude dénommé «Ambalafary». Ainsi, un suivi régulier des lémuriens par la population environnante a été mis en place et amélioré au fil des années. Cette dernière a ensuite montré sa volonté d'apporter une réelle contribution à la conservation de l'espèce par la création de la COBA et la requête subséquente d'un transfert de gestion des ressources naturelles, afin que ses actions rentrent dans un cadre légal et normatif. Ce processus a finalement abouti à la signature du contrat de transfert de gestion par la Direction Régionale de l'Environnement et des Forêts de la Région Atsinanana le 4 avril 2012. Depuis, The Aspinall Foundation a appuyé la bonne marche de ce transfert de gestion au travers d'un renforcement des capacités de la COBA, l'amélioration du niveau de vie de ses membres, et l'initiation d'activités de restauration forestière et reboisement.

Abstract
In 2009, following the discovery of the Critically Endangered greater bamboo lemur (*Prolemur simus*) at the low-altitude site of Ambalafary, a collaboration began between The Aspinall Foundation and the Ainga Vao local community association (COBA) of the Fanasana Gare rural commune in the Brickaville District of eastern Madagascar. We immediately initiated community-based lemur monitoring at the site, which has improved over time. The local community expressed a desire to make a real contribution to the conservation of the species through the creation of a COBA. So that their actions were undertaken in a legalised framework, a request was made for the local community to have responsibility for the management of the site's natural resources. This process was finally completed on 4 April 2012 when the Atsinanana Regional Direction for the Environment and Forests signed the management transfer contract. Since then The Aspinall Foundation has supported the implementation of the management contract through capacity building of the COBA, livelihood improvement micro-projects for its members and the initiation of reforestation activities.

Introduction
Prolemur simus, le plus grand lémurien mangeur de bambou, est classé comme en danger critique d'extinction par l'IUCN (2012), et considéré parmi les lémuriens les plus menacés au monde (Wright *et al.*, 2009; Mittermeier *et al.*, 2012). Le site de basse altitude d'Ambalafary, dans le District de Brickaville, figure parmi les sites récemment découverts abritant cette espèce (King et Chamberlan, 2010; Ravaloharimanitra *et al.*, 2011). Pour assurer la survie de la population de *P. simus* à Ambalafary, une stratégie de conservation communautaire a été mise en place quelques mois après sa découverte. Depuis une décennie, Madagascar s'est engagé dans une décentralisation du pouvoir de l'État. Au niveau du secteur forestier, ce désengagement se traduit par le transfert des compétences et responsabilités relatives à la gestion des ressources naturelles aux collectivités locales (Hockley et Andriamarovololona, 2007; Raik, 2007; Marsh, 2012; King *et al.*, 2013). Ce mode de fonctionnement est régi par la loi GELOSE (Gestion Locale Sécurisée) et le décret GCF (Gestion Contractualisée des Forêts). Les processus de transfert de gestion étant assez compliqués et coûteux pour les communautés locales, la plupart d'entre elles sont appuyées par des organisations non-gouvernementales (Raik, 2007; King *et al.*, 2013). Dans le cas d'Ambalafary, The Aspinall Foundation a accepté de collaborer avec l'association communautaire (COBA) Ainga Vao (Ravaloharimanitra et King, 2012).
Par la signature d'un contrat de transfert de gestion en avril 2012, la COBA Ainga Vao est ainsi devenue, pour une durée initiale de 3 ans, le gestionnaire attitré d'Ambalafary, le premier site uniquement et expressément créé pour la conservation de *Prolemur simus* (Ravaloharimanitra et King, 2012). Un programme collaboratif de conservation de *P. simus* a ensuite été mis en place entre The Aspinall Foundation et la COBA, cette dernière assurant un environnement adapté à la conservation de l'espèce, et la première lui apportant les appuis nécessaires à son maintien. Depuis, une augmentation du nombre d'individus a été constatée et le développement d'activités génératrices de revenus a débuté en 2012.
Forte de ses 47 membres, la COBA Ainga Vao est une organisation volontaire constituée d'adultes de tout âge, sans distinction de sexe, religion, classe sociale ou origine. Pour y adhérer, les seules conditions requises sont de résider

dans le Fokontany Mangabe ou Fanasana Gare et d'avoir des activités dans ou autour du site. Elle est rattachée à la Fédération Tsarafaniry, qui regroupe plusieurs COBAs des Communes Rurales d'Anivorano Est, Fanasana Gare, Fetraomby, Lohariandava, Maroseranana, Ambohimanana et Anjahamana, du District de Brickaville, avec l'ambition de coordonner leurs interventions et servir d'interface entre elles, et vis-à-vis des bailleurs éventuels.

Ambalafary (S18,8008° E48,8092°) est situé entre le chef lieu de la Commune Rurale de Fanasana Gare à l'ouest et le Fokontany de Mangabe à l'est, sur la rive nord du fleuve Ivohitra (Fig. 1; Mihaminekena *et al.*, 2012). Le seul accès possible est par traversée du fleuve (120 m de largeur) en pirogue ou radeau, à partir de Fanasana Gare ou de Mangabe. Le site est surtout caractérisé par l'abondance de deux espèces de bambou présentant des chaumes de grand diamètre, *Valiha diffusa* et *Bambusa vulgaris* (Mihaminekena *et al.*, 2012), toutes deux consommés par *P. simus* (Ravaloharimanitra *et al.*, 2011; Mihaminekena *et al.*, 2012), ce qui en fait un lieu de prédilection de l'espèce. Le site abrite un groupe unique de *P. simus*, dont le nombre d'individus n'a cessé d'augmenter: 14 en 2010, 20 en 2011 (Mihaminekena *et al.*, 2012), et 24 en 2012 (The Aspinall Foundation, données non publiées). Le peuplement forestier se résume à une prédominance de «savoka» (habitat secondaire apparaissant après la mise en culture temporaire), composé en grande partie de bambous, arbres fruitiers et quelques ravenalas (*Ravenala madagascariensis*).

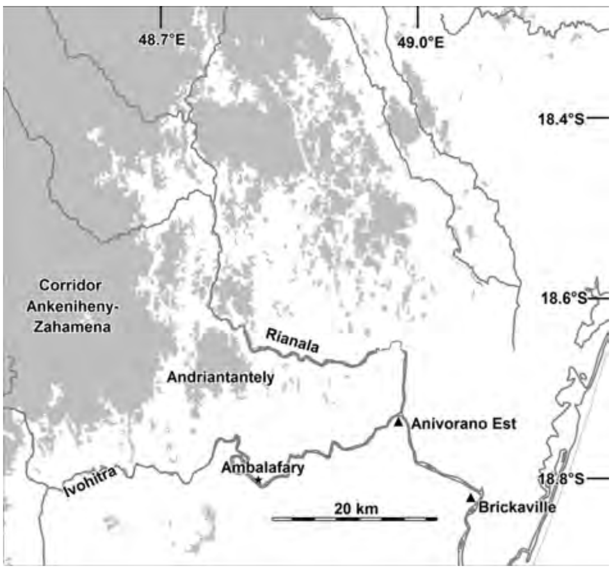

Fig. 1: Localisation du site d'Amabalafary, District de Brickaville, Madagascar.

Cartographie et délimitation du site

La signature du contrat de transfert de gestion n'est pas une finalité en soi, mais une étape dans la responsabilisation de la communauté vivant à proximité des ressources naturelles (King *et al.*, 2013). De ce fait, nous avons d'abord procédé à une cartographie participative des unités de gestion et une matérialisation de leurs limites respectives. Après consultation auprès de la population locale, pour une délimitation sommaire des unités de gestion, une descente sur terrain a permis une levée des points GPS de chaque zonage et de la délimitation, qui a ensuite servi de base à l'élaboration de la carte présentant la délimitation du transfert de gestion.

La surface du transfert de gestion d'Ambalafary est de 129,3 ha; elle est divisée en 4 zones principales, elles-mêmes subdivisées en quelques sous zones (Fig. 2). Ces 4 zones principales sont: (1) la zone de conservation; (2) la zone du droit d'usage; (3) la zone d'utilisation durable, composée des sous zones de reboisement, de restauration forestière et de tampon; (4) la zone d'utilisation et d'occupation contrôlée, composée des sous zone de pâturage, de bas fonds aménageables et de propriétés «privées».

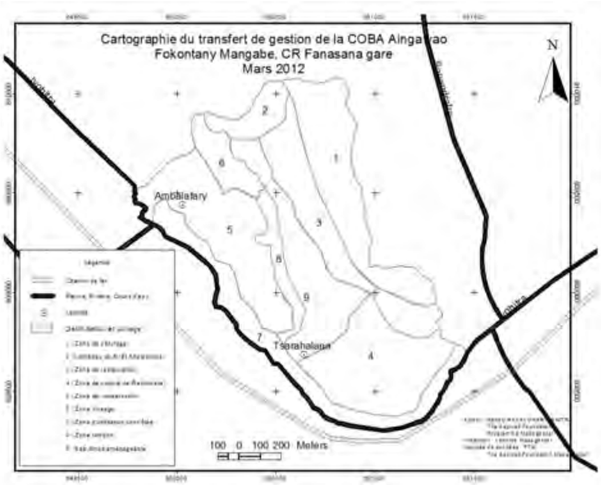

Fig. 2: Délimitation et zonage du site d'Ambalafary, géré par la COBA Ainga Vao. (1: Zone de pâturage; 2: Lambeau de forêt d'Analatsirika; 3: Zone de restauration; 4: Zone de culture de ravintsara; 5: Zone de conservation; 6: Zone d'usage; 7: Zone d'utilisation contrôlée; 8: Zone tampon; 9: Bas-fonds aménageables).

Alternatives aux pressions et menaces

Quelques activités anthropiques ont été identifiées lors de la vérification de l'existence de *Prolemur simus*, et tout au long des activités de suivi (Ravaloharimanitra *et al.*, 2011; Mihaminekena *et al.*, 2012). Ainsi, en 2010, un piège à lémurien a été découvert sur le site. En 2011, les déplacements de *Prolemur simus*, dans sa quête de nourriture, vers une propriété privée connue sous le nom de «Tsarahalana» (S18,80559° E48,82203°), ont semblé constituer une nouvelle menace pour l'espèce (T.H. Mihaminekena, rapport non publié). Cependant, lors de la délimitation, le terrain a été inséré dans la zone de transfert de gestion, rendant ainsi sa conservation plus aisée. Les activités génératrices de revenus ont alors été développées sur base de ces menaces, en utilisant l'arbre à problèmes et les données issues des enquêtes socio-économiques effectuées durant le processus de transfert de gestion.

Depuis quelques années, la culture de ravintsara (*Cinnamomum camphora*, Lauraceae) est en vogue dans le pays en raison des bienfaits de l'huile essentielle qu'on en extrait. Classée parmi les cultures à haute valeur ajoutée, cette espèce végétale suscite un grand intérêt, dont la COBA Ainga Vao est la première bénéficiaire. Le ravintsara représente une filière profitable, tant pour l'environnement en augmentant la surface boisée de la zone, que pour la communauté en améliorant le revenu des ménages qui la composent. En outre, à long terme, le projet pourra contribuer à l'acquisition par la COBA de son autonomie financière. Jusqu'à présent, deux étapes essentielles de la production ont été franchies : la formation théorique sur l'installation et l'entretien des pépinière et plantation (Fig. 3), et une formation pratique sur le terrain (Fig. 4), toutes deux assurées par des membres de la Fédération Tsarafaniry. A l'heure actuelle, les graines ont été semées dans la pépinière et sont en attente de transplantation.

Le principal problème du monde rural malgache est l'insuffisance, voire même l'absence, de liquidités pour les différentes activités agricoles et économiques. Cette absence de liquidités se traduit par une population analphabète et/ou illettrée, des techniques agricoles rudimentaires et sans amélioration conduisant à une production à rendement très bas, et une pression sur les ressources naturelles pour satisfaire les besoins en période de soudure (période de transition entre deux récoltes de riz successives, caractérisée par une insuffisance de nourriture, généralement entre novembre et mars dans nos sites d'intervention). Le gingembre (*Zingiber officinale*, Zingiberaceae) figure également parmi les cultures à haute valeur ajoutée caractérisant la région. Ayant le mérite de ne requérir qu'un faible intrant et un entretien minimal, cette culture a été choisie comme alternative en attendant la période de collecte de feuilles de ravintsara. Chaque membre actif de la COBA a ainsi été doté de cinq kg de semences, et espère récolter 50 kg de gingembre dans un an.

Selon le contrat de transfert de gestion, la COBA a une obligation de reboisement et reforestation, d'autant plus nécessaire que la zone est relativement pauvre en forêt naturelle et plutôt dominée par un savoka à ravenala et bambou. Si les travaux communautaires tels que la mise en place de la pépinière et la préparation du terrain de reboisement sont faciles pour la communauté, l'entretien des jeunes plants, et notamment leur arrosage journalier, est plus problématique car il nécessite une rémunération de la personne responsable, en compensation du temps réduit consacré à ses propres affaires. Un kit d'arrosage fabriqué localement et mis en vente par Innovagri nous a alors permis de solutionner le problème.

Sensibilisation

La connaissance et la prise de conscience de la population locale constituent des éléments-clés de la conservation. Des activités de sensibilisation ont donc été mises en place afin d'inciter les communautés environnantes à intégrer la valeur des richesses qu'elles possèdent. Ainsi, en 2011, The Aspinall Foundation a organisé et financé un voyage d'études pour les élèves de l'EPP Fanasana Gare (Fig. 5), suscitant chez ces enfants un intérêt nouveau pour la nature. Cette action a été renforcée par la distribution de cahiers scolaires, avec *Prolemur simus* en couverture, à tous les écoliers de la zone, pour deux années scolaires successives (2011-2012 et 2012-2013; Fig. 6), et la projection de films documentaires. Les adultes ont, quant à eux, fait l'objet de séances d'informations et communications appropriées, à l'aide de supports audio-visuels tels que posters, calendriers et panneaux d'indications.

Fig. 3: Formation technique pour la plantation de ravintsara. (Photo: Louisette Ravalitera, Fédération Tsarafaniry).

Fig. 4: Formation pratique pour la plantation de ravintsara. (Photo: Louisette Ravalitera, Fédération Tsarafaniry).

Fig. 5: Les élèves de l'EPP Fanasana Gare lors d'un voyage d'études de trois jours à Andasibe, octobre 2011. (Photo: Maholy Ravaloharimanitra)

Fig. 6: La distribution de cahiers scolaires, avec en couverture *P. simus* et d'autres lémuriens, à tous les écoliers de la zone. (Photo: Maholy Ravaloharimanitra)

Conclusions
Un apprentissage de la fonction de gestionnaire est accordé aux communautés locales pour une durée initiale de trois ans. Ensuite, après évaluation de la gestion et l'état des ressources concernées, trois cas de figure se présentent: soit la communauté se voit retirer la gestion, soit elle repasse par une phase d'apprentissage de trois ans, ou elle obtient un accord de transfert valable dix ans. Des améliorations peuvent être apportées en termes d'outils et d'activités.

Les études et activités mises en œuvre au sein du site d'Ambalafary ont montré l'intérêt de la population locale pour la gestion et la conservation de *Prolemur simus* ce qui, avec la contribution des services techniques déconcentrés, a permis l'instauration de règles et lignes directrices pour l'accès aux ressources naturelles. Cependant, malgré la grande motivation dont font preuve les membres de la COBA, des lacunes persistent tant sur le plan technique que financier. Un soutien conséquent et des activités ciblées sont donc requis afin que la COBA acquière les compétences et connaissances nécessaires à une bonne gestion autonome du site.
Enfin, malgré la quasi-absence de menaces pesant sur le site d'Ambalafary (Mihaminekena *et al.*, 2012), des efforts de sensibilisation s'imposent toujours afin de préserver l'état actuel de conservation dont il bénéficie. Si l'amélioration des conditions de vie des communautés locales est un des facteurs favorisant une sensibilisation à la conservation chez les adultes, le développement d'un intérêt pour la nature par des voyages d'études, photos et projections de films documentaires demeure le meilleur moyen d'intervenir auprès des plus jeunes. Outre un renforcement des capacités en matière de gestion des ressources naturelles et de la vie associative, le reflexe de conservation doit être inculqué à chaque personne de la communauté.

Remerciements
Nous adressons nos vifs remerciements à toutes les personnes et institutions publiques ou privées ayant contribué, de loin ou de près, à la réalisation de ce projet, en particulier le Ministère de l'Environnement et des Forêts, qui nous a délivré le permis de recherche et consenti au transfert de gestion du site à la COBA Ainga Vao, par le biais de la Direction Régionale de l'Environnement et des Forêts de la Région Atsinanana. Nous tenons également à remercier vivement les représentants des hiérarchies administratives et traditionnelles locales, en particulier Monsieur le Chef de District de Brickaville et Monsieur le Maire de la Commune Rurale de Fanasana Gare, ainsi que les Présidents des Fokontany de Mangabe et de Fanasana Gare. Enfin, nos vives reconnaissances s'adressent à tous les patrouilleurs locaux pour leurs collaborations et compréhension. Ces activités ont été financées par The Aspinall Foundation dans le cadre du Projet «Sauver *Prolemur simus*».

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Vegetation structure of forest fragments in the southern Sambirano domain, northwest Madagascar

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Key words: forest fragmentation and degradation, vegetation structure, *Lepilemur* density, Sahamalaza Peninsula

Abstract
Globally, the anthropogenic degradation and fragmentation of tropical and subtropical forests is continuing at alarming rates. Madagascar represents an extreme example, with a current rate of forest loss of 1,500 km^2/year resulting in 90 % of the 103 endemic Malagasy lemur species now classified as Critically Endangered, Endangered, or Vulnerable on the IUCN Red List. In this study, we aimed to describe the vegetation structure of the remaining fragments of the Ankarafa Forest on the Sahamalaza Peninsula (part of the southern Sambirano Domain) and identify habitats most suitable for *Lepilemur sahamalazensis*. This would allow monitoring of further habitat destruction, support sophisticated replanting-initiatives, and provide a basis for further studies on habitat preferences of endangered species living in these forests. We found significant differences in forest structure and Lepilemur density between the five studied fragments, namely in tree density, tree height, canopy cover and tree species composition. As the differences in structure were not consistent for all measured variables, we resigned from ranking the fragments according to quality. *Lepilemur* den-

sity ranged between 0.07 and 0.23 ind/ha and was highest in a recently burned fragment of 10 hectare. Despite the index of biodiversity having remained high, the high abundance of mango (*Mangifera indica*) and various bamboo species revealed the impact of the local human population on tree species composition. Differences in species composition between forest fragments suggested a lack of seed exchange between fragments as well as possible differences in soil composition and water supply between fragments. Our results suggest that the forest of the Ankarafa region have been exposed to anthropogenic influences for several decades, leaving forest fragments that all show various degrees of degradation and secondary growth and that are still facing high degrees of habitat destruction. Urgent action is needed to save the unique flora and fauna of the Ankarafa Forest.

Introduction

Globally, the destruction and fragmentation of tropical forest ecosystems is continuing at alarming rates (Gaston, 2005; Myers, 1988; Sussman and Rakotozafy, 1994). Local and global consequences of tropical deforestation, such as decreasing biodiversity, increased carbon emissions, and permanent changes to local hydrology, have been observed (Armstrong *et al.*, 2011). Madagascar represents an extreme example of these trends. Since the arrival of humans some 2,300 years ago, only 10–20 % of the original forest-cover remains in Madagascar (Green and Sussman, 1990). The deforestation rate of Madagascar continues to be enormous, with a reduction of 33 % of primary forest types since the 1970s (Moat and Smith, 2007). The current rate of forest loss is roughly 1,500 km^2 per year, which means that if this rate continues, all primary vegetation of Madagascar will be gone in less than 200 years (Moat and Smith, 2007).

Knowledge about most of Madagascar's highly threatened forest habitats is mostly descriptive, emphasising the urgency to fully understand structure and function of these endangered habitats on an ecosystem level (Blumenfeld-Jones *et al.*, 2006; Ganzhorn, 1995; Sauther, 1998; Sussman and Rakotozafy, 1994). Madagascar is known to have an extraordinary degree of diversity and endemism of flora and fauna (Ganzhorn *et al.*, 2001; Goodman and Benstead, 2003; Myers, 1988). Estimated vascular plant diversity ranges between 10,000–12,000 species (Goodman and Benstead, 2005; Koechlin *et al.*, 1974; Schatz, 2001), and tree and large shrub species have endemism rates of 96 % (Schatz, 2001). Understanding the plant diversity, distribution patterns and structure of different habitats is necessary to reveal the interactions between animals and their environment and hence to establish appropriate conservation measures (Ganzhorn *et al.*, 1997; Reed and Fleagle, 1995; Tomimatsu and Ohara, 2010). As fragmented and degraded habitats constitute a large proportion of many species' remaining habitat, it is critical to know the conservation value of altered habitats (Irwin *et al.*, 2010). The diversity of Madagascar's lemur species is threatened largely by the rapid ongoing forest loss, as most seem to depend on the extent and quality of their typical habitat (Green and Sussman, 1990; Mittermeier *et al.*, 2010). Forest fragmentation is a particular risk to forest-dependent species, as barriers like agricultural savannahs can significantly modify their genetic population structure (Radespiel *et al.*, 1998), especially for small arboreal species that are unable to move between fragments.

Although the ecosystems in western Madagascar are unique in their composition of plant as well as animal species (Sussman *et al.*, 2006), and the dry forests of the south and west in Madagascar are considered to be the most endangered habitats, little research has been conducted on them until now (Dirzo and Sussman, 2002; Janzen, 1988; Smith, 1997; Sussman *et al.*, 2003; Sussman *et al.*, 2006). This is especially true for the remaining forest of the Sahamalaza Peninsula.

The Ankarafa Forest, part of the Sahamalaza-Iles Radama National Park and UNESCO Biosphere Reserve which is located in the Sofia Region in northwestern Madagascar, lies within a transition zone between the Sambirano region in the north and the western dry deciduous forest region in the south, harbouring evergreen forests with tree heights of up to 25 m (Fig. 1). The climate is strongly seasonal, with a cool, dry season from May to October and a hot, rainy season from November to April. The forests in this area include a mixture of plant species typical of the western dry deciduous forest as well as some typical of the Sambirano domain (Birkinshaw, 2004) and represent the habitat of a number of endemic species, including the Critically Endangered lemur species Sahamalaza sportive lemur (*Lepilemur sahamalazensis*) and blue-eyed black lemur (*Eulemur flavifrons*), the Vulnerable northern giant mouse lemur (*Mirza zaza*) and the fat-tailed dwarf lemur (*Cheirogaleus medius*, least concern). The Sahamalaza sportive lemur is probably limited to this degraded area (Olivieri et al., 2007). There are no large connected areas of intact forest left on the Sahamalaza Peninsula, and the remaining fragments all show some degree of anthropogenic disturbance and/or edge effects (Schwitzer *et al.*, 2007a,b). The forests and forest fragments are separated through grassland with shrubs as a consequence of deforestation.

The aim of this study was to quantify the size, diversity and structure of five of the remaining fragments of the Ankarafa Forest in detail, so the results can serve as a basis for future deforestation monitoring, sophisticated replanting actions, as well as for studies on habitat preferences of endangered species living in them. Furthermore we aimed to determine the density of *Lepilemur sahamalazensis*, which was the focus

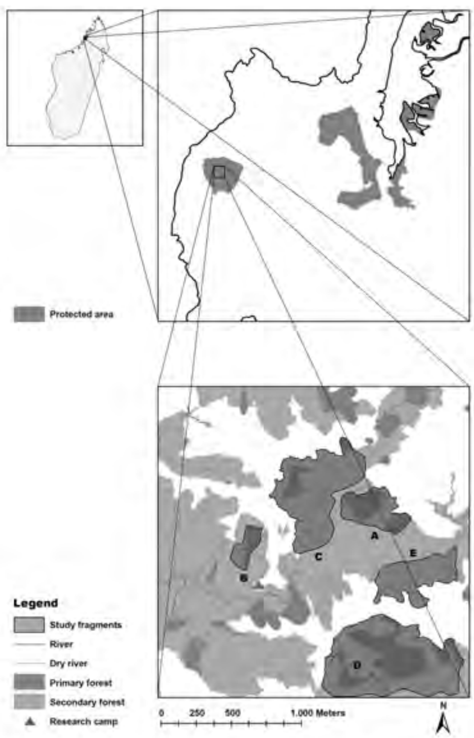

Fig. 1: Habitat map indicating study fragments A–E and the Ankarafa camp in the Ankarafa Forest, Sahamalaza Peninsula, northwestern Madagascar.

species of a PhD study on the influence of habitat degradation on its ecology and behaviour, in relation to forest fragments with varying degradation levels.

Detailed information about endemic lemur species' habitats will be important for the implementation of effective conservation strategies. Based on descriptive information from earlier studies conducted in the Ankarafa Forest (Ruperti, 2007; Schwitzer *et al.*, 2006), we hypothesised that the forest fragments differ significantly in structural variables. We predicted to find variations in tree biodiversity and density, species composition, the extent of canopy cover and different structural variables of small and large trees as well as different numbers of lemurs between the forest fragments. We predicted that *Lepilemur* density would vary between forest fragments, and we predicted that Sahamalaza sportive lemurs would prefer fragments with higher tree density, larger extent of canopy cover, higher tree biodiversity, higher trees and species composition.

Methods

Selection of forest fragments

In the Ankarafa Forest, there are several secondary forest fragments of various degrees of degradation within a 2 km radius of the field station, interspersed with small remnants of primary vegetation separated by grass savannah and mosaics of low to medium-height shrubs (Fig. 1). A previous study showed differences in forest characteristics of 1 ha plots between three fragments as well as within larger fragments and related these differences to past and ongoing anthropogenic disturbance (Ruperti, 2007). We selected three forest fragments based on Ruperti's (2007) work and two additional fragments with confirmed lemur presence (M. Craul, pers. comm.; M. Seiler, pers. obs.). All forest fragments were in the process of regeneration after significant human disturbance to the original forest vegetation over an extended period. We considered them to be at least 35 years old, based on aerial and satellite images and GIS data (Harper *et al.*, 2007), and to exhibit the key characteristics of post-abandonment secondary forest (Chokkalingam and de Jong, 2001).

Forest characterisation

We walked around the edges of every forest fragment in October 2010 with a GPS device (GPS 60; Garmin Ltd., Schaffhausen, Switzerland) to estimate the sizes of the individual fragments. This was done during one day for each fragment. Analyses of the fragment size was conducted via MapSource (version 6.13.7; Garmin Ltd., Schaffhausen, Switzerland).

We characterised the forest structure of five fragments using the point-centred quarter method (Ganzhorn, 2003) during two field seasons (July–October 2009 and April–October 2010). We took a total of 315 sampling points (63 points per fragment) along six transects in each forest fragment. We chose starting points and the direction of transects at random. We located centre-points for the point-centred quarter method every 25 m along the transect line. At each point we measured the distance to the nearest small (5–10 cm diameter at breast height: DBH) and large (> 10 cm DBH) tree for the four geographic directions, identified the trees to species level, measured DBH, bole height and crown diameter and estimated the height. We measured the same parameters for *Bambusa* sp., as this was very abundant in most forest fragments, is a good indicator of degradation and is used by several animal species. This method may overlook rare tree species but we considered it useful as it allowed detailed description of large parts of the forest fragments.

We calculated the density of trees per hectare as $10{,}000/d^2$, where d is the mean distance between the centre point and the nearest large and small tree (example: mean distance of large trees to centre point = 5.24 m. Density per hectare (1 ha = 100 x 100m = 10000 m^2) = $10000/5.24^2$ = 364 trees/hectare; Ganzhorn, 2003). We determined the percentage of canopy cover by taking one photograph at each sampling point. The researcher, standing at the sampling point, tilted the camera (Canon Digital Ixus 70; Canon Inc, Tokyo, Japan) backwards so that the lens (focal length 5.8, focal ratio 2.8) was pointing to the sky. We calculated the percentage of canopy cover using Metalust (Langel, Cologne, Germany), a program that counts the blue pixels and calculates the percentage of blue pixels in relation to the overall amount of pixels in a picture.

We identified trees at least to genus level, using identification guides (Schatz, 2001) and existing tree species identifications carried out by the Département de Flore at Parc Botanique et Zoologique de Tsimbazaza in Antananarivo as part of an earlier study in the same forest fragments (Schwitzer *et al.*, 2007a). We identified 94 % of the large trees in fragment A, 91 % in B, 96 % in C, 96 % in D and 89 % in E. We were able to identify 96 % of small trees in fragment A, 89 % in B, 96 % in C, 94 % in D and 85 % in E. To calculate percentage differences in species composition between forest fragments we used the overall number of species found in two forest fragments and the number of species that were only found in one of the two fragments.

We used Simpson's Index of Diversity to quantify the biodiversity of the fragments and microhabitats:

$$D = 1 - \sum_{i=1}^{S} \frac{n_i(n_i - 1)}{n(n-1)}$$

where n_i = the total number of individuals of a particular species in the sampled fragment/ microhabitat and n = the total number of individuals of all species in the sampled fragment/ microhabitat. The index takes into account the number of species present, as well as the relative abundance of each species. The greater the value, the greater the sample diversity (Simpson, 1949).

Lemur presence

As this study was part of an ecological study on the Sahamalaza sportive lemur (*Lepilemur sahamalazensis*), only the numbers of this lemur species was counted during three successive field seasons between 2009 and 2011. *Lepilemurs* were counted between July and October 2009, April and October 2010, and September and November 2011. As numbers of this species were very low (see result section), the three field guides of the Ankarafa field station were sent out once a week in each of the five forest fragments to search the whole fragment for new sportive lemurs. As the five remaining fragments were sized between 10 and 100 ha, it was possible to search the whole fragment in one day. We were able to identify sportive lemurs individually by fur colouration, face shape and face masks, so we can exclude double counting of animals.

Data analyses

To test for differences in structural habitat characteristics among fragments we used a multivariate analysis of variance (MANOVA). Where differences between fragments were statistically significant, we applied multiple Tukey's honest significance tests (Tukey's HSD) as post-hoc tests. Units of statistical analysis were centre points in case of the habitat description (n = 63 points/forest fragment). The significance level α was chosen as 5 % ($P \leq 0.05$). All statistical tests were carried out using SPSS 19.0 (SPSS Inc., Chicago, USA).

The density of sportive lemurs between the fragments was compared using a non-parametric Kruskal-Wallis ANOVA with Mann-Whitney U as post-hoc test. All statistical tests were carried out using SPSS 19.0 (SPSS Inc., Chicago, USA).

Results

Forest characterisation

The size of the chosen fragments in October 2010 was 22, 10, 30, 100 and 20 ha for fragments A, B, C, D and E, respectively. The five forest fragments studied differed significantly in their characteristics (MANOVA: $F = 4.092$, $P < 0.001$ for large trees; $F = 4.333$, $P < 0.001$ for small trees; Tab. 1).

Fragment A had a high percentage of canopy cover and a high density of small trees, but a low density of large trees compared to other fragments. Fragment B had a low percentage of canopy cover as well as low densities of large and small trees. It harboured the highest large trees, though. Fragment C had a high density of large as well as small trees, large canopy diameters for large and small trees, but large trees with a low height. Fragment D was intermediate in all measured variables to other forest fragments, but crown diameters of large trees were small. Fragment E had a high percentage of canopy cover, high densities of large and small trees, but large trees with a low height and small canopy diameter. There were no significant differences between fragments in the height of small trees, nor in the bole height or DBH of large or small trees (Tukey's HSD after MANOVA, Tab. 1).

Table 1: Overall canopy cover; density, height, DBH, crown diameter, bole height, Simpsons biodiversity index (SBI) of large (> 10 cm DBH) and small (5–10 cm DBH) trees in five forest fragments (median with quartile 1 and quartile 3 provided in brackets) of different degradation levels (n = 63 centre points/fragment). Medians with different superscripts (a, b, c) within a row differ significantly (Tukey's HSD after MANOVA with α = 0.05).

	Fragment A	Fragment B	Fragment C	Fragment D	Fragment E	F (P value)
Canopy cover (%)	85.3^{a} (79.6–90.6)	71.2^{b} (50.7–82.4)	85.3^{ab} (70.7-89.8)	74.6^{ab} (42.5–87.4)	83.1^{a} (70.9–87.5)	9.163 (< 0.001)
Large trees (> 10 cm DBH)						
Density (n ha^{-1})	275^{a} (180-473)	340^{ab} (195-527)	499^{bc} (316-973)	342^{a} (183-626)	529^{c} (338-846)	6.106 (<0.001)
Height (m)	11.3^{ab} (9–14.4)	12.5^{b} (11.2–14.7)	10.3^{a} (7.8–13.6)	11.5^{ab} (9.3–14.5)	11.6^{ab} (9.7–12.4)	3.140 (0.015)
DBH (cm)	16.2 (13.2–21.7)	17.9 (14–23.2)	16.4 (13.8–20.6)	16.6 (14.2–22.4)	16 (14.4–19.7)	1.287 (0.275)
Crown Ø (m)	5.5^{ab} (4.4–8)	5.9^{ab} (4.9–7.3)	6.2^{b} (5.3–9.5)	5.8^{a} (4.8–6.9)	5.6^{a} (4.9–6.5)	3.805 (0.005)
Bole height (m)	4.1 (2.4–5.7)	5 (3.3–6.2)	3.9 (2.2–5.4)	3.8 (2.7–5.4)	4.2 (3.3–5.3)	1.396 (0.235)
SBI	0.8 (0.7–1)	0.8 (0.8–1)	0.8 (0.8–1)	0.8 (0.8–1)	0.8 (0.8–1)	0.059 (0.9)
Small trees (5–10 cm DBH)						
Density (n ha^{-1})	750^{c} (522–1,854)	429^{a} (261–739)	846^{bc} (415–1,433)	470^{ab} (267–810)	872^{c} (384–1,711)	5.725 (<0.001)
Height (m)	7.8^{b} (6.4–9.8)	7.3^{ab} (5.8–8.3)	7.1^{a} (5.3–8.3)	7.4^{ab} (5.5–8.5)	8^{ab} (6.6–9.1)	2.636 (0.034)
DBH (cm)	6.7^{ab} (6–7.3)	6.7^{ab} (6.2–7.4)	6.4^{a} (6–7.2)	6.8^{ab} (6.2–7.3)	6.9^{b} (6.2–7.5)	2.303 (0.058)
Crown Ø (m)	3.1^{a} (2.7–3.7)	3^{a} (2.6–3.4)	3.4^{b} (2.8–4.4)	3.2^{a} (2.8–3.6)	3.1^{a} (2.8–3.7)	7.201 (<0.001)
Bole height (m)	4 (2–5.2)	2.7 (1.7–3.9)	3.5 (1.7–4.5)	3.3 (1.7–4.5)	3.5 (2.5–4.7)	1.081 (0.366)
SBI	0.8 (0.7–1)	0.8 (0.8–1)	1 (0.8–1)	1 (0.8–1)	1 (0.8–1)	1.482 (0.146)

Species composition

The forest fragments differed in their species composition, and only 24 % of all detected tree species were found in all fragments. In fragment B, we found 18 species that were not noted in other fragments, and 12 species were only found in fragment E. Five species were unique to fragment A and D, and three species were endemic to fragment C. The most similar fragments, with 35.8 % difference in species composition, were fragments A–B, A–C and A–E, and the most distinct fragments, with 55.4 % difference were fragments D–E.

For large trees, *Mangifera indica* (Anacardiaceae) and *Grangeria porosa* (Chrysobalanaceae) were dominating large tree species in most described forest fragments (Tab. 2). For small trees, *Sondririna madagascariensis* and *Bambusa* sp. were the dominating small tree species of most fragments (Tab. 2). There seemed to be little correlation between the abundance of large and small tree species. Of a total of 35 tree species that made up the top 10 tree species in all fragments, 14 are missing in at least one fragment. Generally, the most abundant families of trees are Anacardiaceae, Apocynaceae and Moraceae (Tab. 2).

Tab. 2: Percentages of the five most abundant species of large (LT) and small (ST) trees in five forest fragments (A–E). Top five ranks in each category are indicated with subscripts 1 to 5.

Family	Species	Vernacular	A LT/ST	B LT/ST	C LT/ST	D LT/ST	E LT/ST
Anacardiaceae	*Sorindeia madagascariensis*	Sondririny	5^{5} 20^{2}	12^{1} 13^{1}	1 0	10^{2} 17^{1}	0.9 3
Anacardiaceae	*Mangifera indica*	Manga	20^{1} 3	6^{4} 0	20^{1} 4	20^{1} 2	21^{1} 4
Anacardiaceae	*Sclerocarya birrea*	Sakoana	0.8	0 0.5	0.8 9^{2}	0 0	0 0
Apocynaceae	*Tabernaemontana coffeoides*	Hazompiky	0 0.8	0 0	0.8 0	0 4^{5}	0.5 0
Apocynaceae	*Mascarenhasia arborescens*	Gidroa	3 3	1 3	3 0.4	3 5	3^{5} 9^{2}
Burseraceae	*Canarium madagascariensis*	Ramy	8^{3} 3	5 1	1 0	5^{4} 0.8	3 0.5
Chrysobalanaceae	*Grangeria porosa*	Morasiro	2 0.8	9^{3} 6^{5}	9^{3} 0	7^{3} 8^{2}	16^{2} 8^{3}
Clusiaceae	*Harungana madagascariensis*	Harongana	1 5^{4}	2 2	3 0.4	2 2	0.9 2
Clusiaceae	*Garcinia pauciflora*	Taranta	6^{4} 6^{3}	6^{5} 6^{4}	9^{4} 6^{5}	4 4	9^{3} 6^{5}
Combretaceae	*Terminalia perrieri*	Lonjo	3 5	0.5 3	0.8 0	0 4^{5}	1 0
Erythroxylaceae	*Erythroxylum platycladum*	Tapiaka	1 1	2 4	4^{5} 1	0 1	0.9 3
Fabaceae	*Hymenaea verrucosa*	Mandrofo	2 0	0 0	14^{2} 0	0 0	0 0
Lauraceae	*Cryptocarya crassifolia*	Tavolo	0.8 0	0 0.5	0 9^{3}	0 0	0 0
Moraceae	*Ficus tiliaefolia*	Adabo	12^{2} 0.4	0.9 0.9	0.8 4	1 0	2 3
Poaceae	*Bambusa* sp.	Valiha	0 22^{1}	0 10^{2}	0 0	0 7^{3}	0 11^{1}

Family	Species	Vernacular	A LT/ST	B LT/ST	C LT/ST	D LT/ST	E LT/ST
Rhizophoraceae	*Macarisia lanceolata*	Korontsana	2 2	11[2] 6[3]	2 0.8	4 1	2 0
Rubiaceae	*unidentified*	Nofotrakoho	1 0.8	2 3	0.8 7[4]	2 1	0 0
Sapindanceae	*Macphersonia gracilis*	Maroampototro	0 0.4	0 0.5	0 0	0 0.8	3 7[4]
Tiliaceae	*Grewia boinensis*	Selivato	0 0	0 0.5	0.8 0	0 0.8	4[4] 1
Tiliaceae	*Grewia amplifolia*	Sely	3 1	2 0.5	3 0.4	5[5] 3	2 3
Unidentified	Unidentified	Mangarahara	0.4 0	0 0	1 0[1]	0 0	0 0

Lemur presence

The density of Sahamalaza sportive lemurs was generally low in all of the Ankarafa forest fragments. The density of lemurs was found to be different amongst forest fragments after the Kruskal-Wallis ANOVA (P = 0.02). Fragment B had higher densities of sportive lemurs compared to A, C and D (Mann-Whitney U test; A:B P = 0.043; B:C P = 0.046; B:D P = 0.043). In fragment D the density of Sahamalaza sportive lemurs was lower compared to A, B and C (A:D P = 0.043; C:D P = 0.046; B:D P = 0.043). No further differences were found for the densities of sportive lemurs between the fragments, likely due to the very low number of individuals per hectare.

Tab.3: Number of individual Sahamalaza sportive lemurs per hectare with total number of sportive lemurs counted in each fragment during three successive field seasons.

Year	A (22 ha)	B (10 ha)	C (30 ha)	D (100 ha)	E (20 ha)
2009	0.18/ha (4)	0.6/ha (6)	0.17/ha (5)	0.07/ha (7)	N/A
2010	0.14/ha (3)	0.6/ha (6)	0.3/ha (9)	0.11/ha (11)	0.15/ha (3)
2011	0.14/ha (3)	0.5/ha (5)	0.23/ha (7)	0.07/ha (7)	0.1/ha (2)

Besides Sahamalaza sportive lemurs, blue-eyed black lemurs were regularly spotted in all five forest fragments, as were giant mouse lemurs. Fat-tailed dwarf lemurs were found twice each in fragment A and C, and once in fragment B. The low encounter rate is likely to be influenced by the fact that we did only spend the onset of the rainy season and thus the onset of their activity period in Ankarafa. During the dry season, we found three dwarf lemurs resting in tree holes in fragment A and C.

Discussion

We presented a first detailed description of the structure and diversity of Ankarafa's remaining forest fragments. Our results show significant differences in forest structure between the five study fragments. However, these were not consistent for all measured variables. The five fragments differed significantly in density of large and small trees, height of large trees, and canopy cover. Whereas fragments C and D had the highest tree density and A and D had the highest percentage of canopy cover, B (a recently burned forest fragment) contained the tallest trees and had the highest species diversity. The density of sportive lemurs was similarly low for fragments A, C and E. The highest sportive lemur density was found in fragment B and might suggest that this fragment harbours the best habitat for sportive lemurs. Besides higher trees and higher species diversity, tree holes in fragment B had the best quality of all fragments (Seiler *et al*., 2013). It is also possible that the density of Sahamalaza sportive lemurs is higher due to the fact that animals have to share a smaller area after a fire had destroyed large parts of fragment B in 2007. Though it contained the highest tree density, fragment D had the lowest sportive lemur density, supporting the assumption that sportive lemurs might occur in lower densities if a forest fragment is large enough. As the differences in forest structure were not consistent for all measured variables, and reasons for varying *Lepilemur* density remained unclear, we resigned from ranking the fragments according to their quality for the Sahamalaza sportive lemur. To get a better idea of the habitat preferences of the Sahamalaza sportive lemur we decided to describe the habitat structure of confirmed home ranges only for a further part of this study (see Seiler 2012).

Our results do not concur with the results of Ruperti (2007), who described A as the least degraded fragment, followed by B, and found a *Lepilemur* density of 2.8 individuals per hectare. The differences between our results and those of Ruperti (2007) are most likely due to different methods of data collection. Whereas Ruperti measured habitat structure variables and lemur density inside one-hectare plots (one for each fragment), we worked along line-transects that covered a considerably larger area of the respective forest fragments for habitat descriptions, and counted all lemurs we could find during the day during 12 months of fieldwork. According to Ruperti's data, there would be between 28 (B) and 280 individuals (D) in the fragments of Ankarafa forest. Nonetheless, during her study she counted a total of only 14 individuals, suggesting that the real number of individuals was much lower in 2007.

Another factor that may have contributed to the differences is ongoing habitat alteration, which has increased in magnitude since the political crisis in Madagascar in early 2009. Forest and bush fires have been occurring on the Sahamalaza Peninsula on an almost daily basis during recent years, and illegal logging of hardwoods is also common. After several centuries of anthropogenic and subsequent natural degradation, the forests of the Sahamalaza Peninsula seem to be heterogeneous on an increasingly small scale, which makes it difficult to assign entire fragments to existing categories such as primary or secondary forest. During the study period from 2009 to 2011, various observations were made of logging, slash-and-burn agriculture and poaching of the sportive lemurs (Seiler *et al*., 2010; Seiler *et al*., 2012).

Although the index of biodiversity remained high for tree species in all forest fragments, species composition was very different between all forest fragments. The high abundance of tree species like mango and bamboo revealed the impact of the local human population on the structural characteristics of the forests. Tree species without fruits fit for human consumption are selectively logged for firewood or for use as building material, leading to large areas of *de facto* mango monoculture all over the Sahamalaza Peninsula. Bamboo on the other hand thrives on recently logged areas, as it grows very fast. It was thus found in high abundance in most fragments. The high abundance of tree species used by the local human population, as well as our finding that several forest tree species were already absent from some fragments (although the fragments were situated within a radius of only 2 km), suggested that selective logging and slash-and-burn agriculture have been practiced in the area for several decades, with abandoned fields not being given the chance to regrow to become mature secondary forest. The differing species compositions of the studied fragments suggested that some tree species do not disperse beyond the limits of the fragments, probably because important seed dispersers are either absent or unable to cross the non-forest matrix. As frugivorous animal species, especially frugivorous birds (Fleming *et al*., 1987) are rare in Madagascar compared to other tropi-

cal areas, lemurs are considered to act as important seed dispersers (Bollen *et al.*, 2004; Ganzhorn *et al.*, 1999). As most lemur species are unable to cross between forest fragments, fragmentation does not only threaten lemur populations, but also the successful seed dispersal of fruit trees and consequently forest regeneration (Stoner *et al.*, 2007).
The fragmentation of forests is suggested to modify the microclimate, e.g. temperature, humidity and wind, within and around the forest patches, leading to changes in plant composition and structure (Razafindramanana, 2011; Saunders *et al.*, 1991). The differences in species composition in Ankarafas' forest fragments might thus not only be due to selective logging and interrupted seed dispersal, but also due to differences in microclimate. Species composition might also be influenced by soil properties (Laughlin *et al.*, 2007; Weiher, 2003) and groundwater supply (Mertl-Millhollen *et al.*, 2006), which might differ between forest fragments. Whilst swamps and small streams were present in forest fragments A, D and E, even during the dry season, we are not aware of a continuous water supply in fragments B and C. Large differences in species composition were indeed found between fragments C – E and B – E, but also between D – E, two fragments with continuous water supply. Nonetheless, the water supply is higher in fragment E than D due to two swamps in an area of 22 ha, compared to one swamp and one stream in an area of 100 ha in D. An influence of water supply on the species composition is therefore likely. Further studies on soil composition and water availability are needed to assess the influence of these factors on species composition in Ankarafa.
In conclusion, our results suggest that the forests of the Ankarafa region have been exposed to anthropogenic influences for several decades, leaving forest fragments that all show various degrees of degradation and secondary growth and are still facing high degrees of habitat destruction. Urgent action and especially minimising anthropogenic impacts is needed to save the unique flora and fauna of the Ankarafa Forest.

Acknowledgements

We would like to thank Madagascar National Parks (MNP), especially the director of Sahamalaza – Iles Radama National Park, M. Isaia Raymond, for their continuing collaboration. Thank you also to the DGEF and CAFF/CORE for granting us research permits for our work in Sahamalaza, and to Prof. Rabarivola Clément for his ongoing help. Tantely Ralantoharijaona, Bronwen Daniel, Chris Ingold and Sam Gatley, along with all Ankarafa field guides, contributed substantially to the data collection. MS was funded by Bristol Conservation and Science Foundation, Association Européenne pour l'Etude et la Conservation des Lémuriens (AEECL), Conservation International Primate Action Fund, Margot Marsh Biodiversity Foundation, Mohamed bin Zayed Species Conservation Fund, International Primatological Society and Christian-Vogel-Fonds.

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Community-based conservation of critically endangered lemurs at the Sakalava and Ranomainty sites within the Ankeniheny-Zahamena rainforest corridor, eastern Madagascar

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Abstract

The western portion of the Ankeniheny-Zahamena Corridor (CAZ) in eastern Madagascar is one of the only known areas where 4 of the most unique and highly endangered large rainforest lemurs occur sympatrically: greater bamboo lemur (*Prolemur simus*), black-and-white ruffed lemur (*Varecia variegata*), indri (*Indri indri*), and diademed sifaka (*Propithecus diadema*). In this paper we describe the process relating to our facilitation of community-based management for 2 sites containing all 4 species, Sakalava in the Morarano Gare Commune and Ranomainty in the Didy Commune. There are three major phases in facilitating community-based forest management: (1) the legal creation of the community association (COBA); (2) the elaboration of the forest management contract between the COBA and the Environment and Forestry Ministry (MEF); and (3) the support of the COBA to respect the terms of the management contract. We supported 2 COBAs, one of which (Mamelontsoa) had been created prior to our intervention and so required evaluation, contract renewal, and support, the other of which (Ala maitso) was created specifically as a response to the conservation challenges facing a newly-discovered *P. simus* population in an area not covered by any existing community-conservation agreement. Both management contracts were signed during 2012. This has resulted in the delimitation of 5,000 hectares of mid to high altitude rainforest as community-managed conservation zones, containing populations of the 4 focal lemur species. A further 4,500 ha of surrounding areas have been zoned for various activities that will support the protection of the conservation zone, including forest restoration to replace lost forest cover, reforestation to provide wood and other forest products for local needs, and agriculture. The challenge now is therefore to ensure the effective implementation of the management contracts. We have observed that our funding of COBA members to patrol the conservation zones of their respective management areas led to a rapid reduction in hunting pressure on lemur populations, but that reducing habitat destruction is more challenging. Forest clearance, slash-and-burn agriculture, and illegal mining and logging continue to represent threats to the sites. Further support to the COBAs responsible for managing the sites, through education, capacity-building, and micro-project development, remains essential if long-term conservation is to be achieved.

Résumé

La partie ouest du corridor Ankeniheny-Zahamena (CAZ) dans l'Est de Madagascar est l'une des rares zones connues où quatre des grands lémuriens des forêts pluviales les plus menacés vivent en sympatrie: le grand lémurien des bambous *Prolemur simus*, le vari noir et blanc *Varecia variegata*, l`indri *Indri Indri* et le propithèque à diadème *Propithecus diadema*. Dans cet article, nous décrivons le processus relatif à la facilitation de la gestion communautaire de deux sites abritant les quatre espèces, Sakalava dans la Commune de Morarano Gare et Ranomainty dans la Commune de Didy. La facilitation de la gestion communautaire forestière comporte trois phases principales: 1) la création juridique de l'association communautaire (COBA); 2) l'élaboration du contrat de gestion forestière entre la COBA et le Ministère de l'Environnement et des Forêts (MEF); et 3) le soutien de la COBA pour respecter les termes du contrat de gestion. Nous avons appuyé deux COBAs: l'une (Mamelontsoa) avait été créée avant notre intervention et nécessitait donc une évaluation, un renouvellement du contrat et notre soutien; l'autre (Ala maitso) a été spécifiquement créée pour répondre aux défis de la conservation d'une population de *P. simus* récemment découverte dans une zone non couverte par un accord de conservation communautaire existant. Les deux contrats de gestion ont été signés en 2012. Ceci a abouti à la délimitation de 5,000 ha de forêt pluviale de moyenne à haute altitude en zone de conservation gérée par la communauté, abritant des populations des quatre espèces de lémurien focales. 4,500 ha supplémentaires de terrains environnants ont été zonés pour différentes activités contribuant à la protection de la zone de conservation, notamment restauration forestière pour remplacer la perte en couverture forestière, reforestation pour répondre aux besoins locaux en bois et autres produits forestiers, et agriculture. Maintenant, le défi consiste à veiller à la mise en œuvre effective des contrats de gestion. Nous avons constaté que notre financement de membres de COBA pour patrouiller les zones de conservation de leurs domaines de gestion respectifs a conduit à une réduction rapide de la pression de chasse sur les populations de lémuriens, mais que la réduction de la destruction de l'habitat est plus difficile. Le défrichement des forêts, l'agriculture sur brulis, et les exploitations minière et forestière illégales continuent de représenter des menaces pour les sites. Un soutien supplémentaire aux COBAs responsables de la gestion des sites, au travers de l'éducation, du renforcement des capacités et de microprojets de développements, demeure essentiel pour que la conservation à long terme puisse être atteinte.

Introduction

The Ankeniheny-Zahamena corridor (CAZ) is one of the largest remaining continuous rainforests remaining in Madagascar (Fig. 1). The western portion of the CAZ is one of the only known areas where 4 of the most unique and highly endangered large rainforest lemurs occur sympatrically: greater bamboo lemur (*Prolemur simus*), black-and-white ruffed lemur (*Varecia variegata*), indri (*Indri indri*), and diademed sifaka (*Propithecus diadema*) (Randrianarimanana *et al.*, 2012; Figs. 2-5). The first 3 of these species are considered to be amongst the most endangered primates in the world (Mitteremeier *et al.*, 2009, 2012), and are listed in the top 50 most evolutionarily distinct and globally endangered mammals in the world (Collen *et al.*, 2011). Other lemurs occurring in the western CAZ include red-bellied lemur (*Eulemur rubriventer*), brown lemur (*Eulemur fulvus*), eastern bamboo lemur (*Hapalemur griseus*), eastern woolly lemur (*Avahi laniger*), aye-aye (*Daubentonia madagascariensis*), weasel sportive lemur (*Lepilemur mustelinus*), Crossley's dwarf lemur (*Cheirogaleus crossleyi*), and mouse lemur (*Microcebus* sp.) (Randrianarimanana *et al.*, 2012; and unpubl.

Fig. 1: Map of Madagascar showing approximate forest cover (grey), the location of the Ankeniheny-Zahamena Corridor, and the two community-managed sites referred to in this paper (stars).

data). Threats to the survival of lemurs in this area include hunting, slash-and-burn agriculture, and illegal mining and logging (Ravaloharimanitra *et al.*, 2011; Randrianarimanana *et al.*, 2012).

The conservation strategy for the majority of the CAZ is based on ensuring participatory community-based management of the entire boundary of the forest corridor (Ravaloharimanitra *et al.*, 2011). Over 100 local community associations (COBAs) have responsibility for the sustainable management of the boundary zones, grouped into 6 federations to help channel the necessary technical and financial support to the associations. Each COBA requires a contract with the Environment and Forestry Ministry of the government of Madagascar, for the temporary management of specified areas within and surrounding the CAZ, under a legal mechanism created in 2001 known as GCF (*Gestion Communautaire de Forêts*; Community management of forests).

This paper refers to 2 of these COBAs, both located in the western portion of the CAZ (Fig. 1), and supported technically and financially by the UK-based charity, The Aspinall Foundation, due to the recent discovery within their forest sites of *Prolemur simus* (Ravaloharimanitra *et al.*, 2011; Randrianarimanana *et al.*, 2012), a critically endangered lemur which is currently the focus of a collaborative species

Fig. 2: A greater bamboo lemur (*Prolemur simus*) at the Ranomainty site, February 2012. (Photo: L. Randrianarimanana)

Fig. 3: A black-and-white ruffed lemur (*Varecia variegata*) at the Ranomainty site, February 2012. (Photo: L. Randrianarimanana)

Fig. 4: An indri (*Indri indri*) at the Sakalava site, September 2012. (Photo: L. Randrianarimanana)

Fig. 5: A diademed sifaka (*Propithecus diadema*) at the Sakalava site, October 2012. (Photo: L. Randrianarimanana)

survival project (King and Chamberlan, 2010; Rakotonirina *et al.*, 2011). One of the objectives of this *Prolemur simus* conservation project is to ensure effective conservation management of known sites within remaining forest corridors (King and Chamberlan, 2010). Therefore, within the framework of this project, conservation actions focussing on direct threat mitigation were implemented almost immediately following the discovery of *P. simus* at these sites (Ravaloharimanitra *et al.*, 2011), whilst the facilitation of effective community-based conservation has been a longer-term aim (Randrianarimanana *et al.*, 2012). In this paper we will describe the process and perspectives relating to this facilitation for the 2 COBAs, one of which had been created prior to our intervention and so required evaluation, contract renewal, and support, the other of which was created specifically as a response to the conservation challenges facing a newly-discovered *P. simus* population in an area not covered by any existing community-conservation agreement.

Methods

Facilitation of community-based conservation

There are 3 major phases in facilitating community-based forest management within the GCF mechanism: (1) the legal creation of the community association (COBA); (2) the elaboration of the forest management contract between the COBA and the Environment and Forestry Ministry (MEF); and (3) the support of the COBA to respect the terms of the management contract.

Community forest management associations (COBAs)

Several steps are required to create a COBA, with a written document relative to each step comprising the file for the eventual legalisation of the COBA:

- Minutes of the meeting confirming the constitution of the COBA.
- Minutes of the meeting electing the COBA executive committee.
- Minutes of the meeting where the existence of the COBA is accepted by the local population ("Fokonolona").
- A document defining the status of the COBA.
- A document defining the interior rules of the COBA.
- A list of the committee members of the COBA, with a letter from the mayor testifying that the signature of each member has been legally recorded.
- A list of all the members of the COBA.

- The signed register of member presence at a general assembly to validate the documents above relative to the COBA (documents a, d, e, f, g).
- A declaration of the existence of the COBA validated by the local "Fokontany" (the state office representing the lowest level of population organisation, often comprising only a few villages) and signed by the appropriate mayor's office.
- A stamped receipt of all the above documents validated by the appropriate mayor's office.

Community forest management contracts
Once a COBA has been officially recognised by the mayor, the process of applying for and elaborating a forest management contract with the MEF can be started, and again requires several steps:
- A written demand from the COBA to the appropriate regional MEF office (with a copy to the mayor) requesting a forest management contract.
- A preliminary definition of the limits of the site by the COBA and other local people.
- Creation of an evaluation committee presided by the mayor and including appropriate MEF technicians and representatives of the communal advisors.
- A report by the evaluation committee.
- The definitive definition of the site limits, and the zoning of the site for multiple objectives (conservation, sustainable use, controlled occupation and controlled resource use), by MEF technicians accompanied by COBA members, neighbouring community representatives, local authority representatives, and if appropriate supporting organisations.
- The elaboration of a simplified management plan for the site (PAGS).
- The elaboration of the management transfer contract between the MEF and the COBA.
- The elaboration of a traditional community document relative to local community rules (Dina).
- The verification of the morality of the COBA committee members.
- The signature of the management transfer contract, usually during a large community festival organised specially for the occasion.
- An evaluation by the MEF at the mid-point of the management transfer contract.
- An evaluation by the MEF at the expiration of the management transfer contract.

Supporting community associations
In order for a COBA to respect the terms of its management transfer contract with the MEF, and implement the simplified site management plan, most, if not all, require external support, which can be financial, technical, or organisational (capacity building). Some basic tools that are required to help the COBA organise itself correctly include:
- Fixed list of members.
- Notebook for recording member contributions.
- Notebook for recording minutes of meetings.
- Notebook for recording attendance at meetings.
- Notebook for recording attendance at group working parties.
- Notebook for recording ingoing and outgoing letters.
- Notebook for recording patrolling, defendants and application of the Dina.
- Guest book.
- Receipts book and cash outflow order.
- Notebook for recording financial transactions.
- Notebook for recording withdrawal from the controlled resource use zone.
- Notebook for recording member requests.
- Notebook for recording follow-up and renewal of "kijana" (approved locations for keeping zebu cattle inside the forest area).

Results

The two COBAs
We focused our efforts to facilitate effective community-based conservation at 2 sites in the western CAZ, Sakalava and Ranomainty, both of which had been identified as priority sites for the conservation of *Prolemur simus* (Randrianarimanana *et al.*, 2012).
The Sakalava site is located in the Morarano Gare Commune, Moramanga District, and was already the subject of a management transfer agreement between the MEF and an existing COBA named Mamelontsoa, although the previous three-year contract signed in 2006 had expired, and the limits of the forest management zone were not clear (Randrianarimanana *et al.*, 2012). As the COBA already existed, for this site we did not need to facilitate the COBA creation phase, and could start directly with the elaboration of the renewal of the forest management contract phase, described in the next section below.
The Ranomainty site is located 40 km north of Sakalava in the southern limits of the Didy Commune, Ambatondrazaka District, and had no previous community-conservation initiatives or associations, and indeed there was initially some debate as to whether the site was in the Didy or the Fierenana Communes (Randrianarimanana *et al.*, 2012). Our informal investigations within local communities in December 2010 illustrated that the inhabitants of the local village of Ranomainty claimed traditional "ownership" of the site, and were apparently planning to clear it to plant beans. We therefore organised an information and communication mission to Ranomainty village in March 2011, by one of us (HLLR) and an independent socio-organiser, to collect information about the number of people living there, to try to understand local impressions of the project and their plans for the site, and to distribute 20 of our project calendars to the village whilst presenting the aims and results of our work so far. We followed up this informal gathering with a formal mission to the village from 16 to 18 April 2011, involving HLLR, local forestry officials, the Presidents of the local Federations of community associations, and the independent socio-organiser, to discuss the regional forest rules and rights, and to try to agree on a way of officially conserving the *P. simus* habitat. The elder of the village expressed his desire for the community to be made responsible for the conservation of the site, so the discussions focussed primarily on the procedures necessary to create a community-managed zone, and on the current regional rules regarding bush fires which we had identified as one of the main immediate threats to the site.
Given the universal agreement at this meeting to proceed with the facilitation of community-based conservation for the Ranomainty site, we hired a consultant socio-organiser in December 2011 to begin the process of creating the COBA. By March 2012 the COBA had been informally created, with the name of "Ala maitso", meaning "green forest", and its status, internal rules and list of members had been established. The Ala maitso COBA was officially recognised by the mayor of the Didy commune in July 2012.

Elaborating the forest management contract for the Ala maitso COBA, Ranomainty

Having been legally recognised, the Ala maitso COBA could proceed with the application for the management transfer contract. Their official written request was transmitted to the respective MEF representatives for the Alaotra-Mangoro Region (DREF Alaotra-Mangoro) and the District of Ambatondrazaka (CEF Ambatondrazaka) on the 25 July 2012. The participatory delimitation of the zone to be transferred was undertaken from the 19 to 21 August, by representatives of the two MEF offices, the COBA members, the local population, and representatives of the mayor of Didy and of The Aspinall Foundation (Fig. 6). We simultaneously undertook an awareness-raising session regarding the process, and local conservation issues. Further meetings in September illustrated that local understanding of the process was still limited, but progress was made with elaborating the various documents such as the simplified management plan, a draft of which was sent to the DREF Alaotra-Mangoro the following month. At the end of October we undertook another collaborative mission with representatives of the DREF and of the mayor of Didy, to undertake a socio-economic survey and a community education session concerning bush fires and slash-and-burn agriculture.

By mid-November 2012 the process was virtually complete, and in the last week of the month we organised a mission to undertake more capacity-building of COBA members, and to organise the inauguration festival which took place on the 29 November. Participants included the COBA members, other local community members, the mayors of Didy and of Fierenana, and representatives of the DREF and of The Aspinall Foundation. Activities included numerous speeches, showing of an educational film, sharing a meal, and the signing of the management transfer agreement by the president of the COBA and the DREF representative (Figs. 7, 8). We also donated a football to provide the young people with something to do in their spare time instead of hunting lemurs.

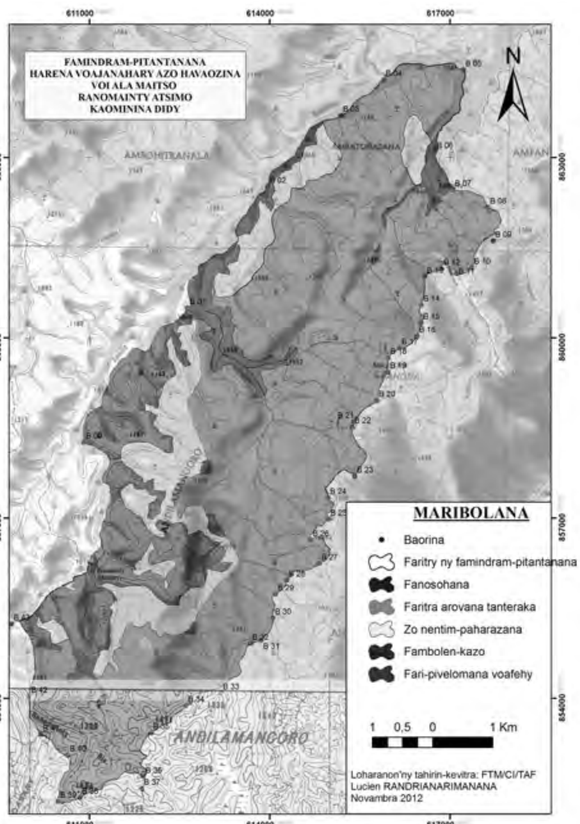


Fig. 6: Map showing the delimitation and zoning of the Ranomainty site for which management responsibility was transferred to the Ala maisto COBA. The conservation zone is the large green area.

Elaborating the forest management contract for the Mamelontsoa COBA, Sakalava

A previous management transfer contract between the MEF and the Mamelontsoa COBA for the Sakalava site had expired, so before being able to renew the contract, the results of the previous contract had to be evaluated. We therefore funded 2 evaluation missions by the regional MEF office (CIREF) in Moramanga, which were undertaken in July and August 2011. Despite identifying some weaknesses within the COBA, the CIREF was generally happy with its management of the forest over the duration of the previous contract, and agreed in principle to renew the agreement.

Figs. 7 and 8: Inauguration ceremony for the signing of the management transfer contract for the Ala maitso COBA, November 2012. (Photos: L. Randrianarimanana)

We therefore organised a subsequent mission from 10 to 19 October 2011, when one of us (HLLR) accompanied the CIREF agents and representatives of the Mamelontsoa COBA to revise and renew the limits and zoning of the management area. The field data collected during this mission was discussed further with the Mamelontsoa COBA in November 2011, and finalised the following month by the GIS specialist from Conservation International (the acting manager of the CAZ protected area) with representatives of the COBA, the CIREF, and The Aspinall Foundation.

With the zoning completed, the CIREF team worked on elaborating the simplified management plan for the site

(PAGS) from January 2012, and we organised a meeting in mid March to help the COBA elaborate the various administrative and technical documents. All the documents were completed in April, and validated and signed by the COBA members in May before being submitted to the tribunal in Moramanga. Once the documents were validated by the tribunal, we worked with the Topography Representation for Moramanga (CIR Topo) to include the management transfer into their maps so that no further change will be made in the future. Following this legalisation of the cartography, the final map (Fig. 9) was presented to the CIREF, and the ceremony for signing the new contract could be organised.

The ceremony was held in Sakalava village on 10 August 2012. In addition to the Mamelontsoa COBA members, attendees included numerous MEF representatives, for Alaotra Mangoro Region, Moramanga Circonscription, and Moramanga District, several state authorities for Alaotra Mangoro Region, representatives of neighbouring communities, and of The Aspinall Foundation. The day included numerous speeches, traditional dancing, sharing of a meal, showing of an educational film, the donation of a football kit, and the signing of the management contract renewal (Figs. 10, 11).

Supporting the COBAs to implement their management contracts

Following the signing of the management contracts with the MEF, for the Mamelontsoa COBA in August 2012 and for the Ala maitso COBA in November 2012, we continued to support both COBAs through capacity-building, particularly with training in organisational and management aspects of operating a community association, and by providing basic materials such as the various notebooks required to correctly document association activities. We financed several information and communication sessions within the 4 villages constituting the Sakalava Fokontany on the Dina for the Mamelontsoa COBA, to ensure that these local community-implemented rules are widely understood, and therefore applicable.

We also provided small-scale infrastructure support, including the donation in December 2012 of irrigation kits to both COBAs for alimenting their respective tree nurseries prior to their reforestation activities planned for early 2013. As there are several organisations working to support rural development activities linked to the management of the Ankeniheny-Zahamena protected area, we will assist the COBAs in applying for relevant support. For example, ANAE with funding from Conservation International has previously granted micro-projects to several COBAs in the region for short-term livelihood improvements, such as the development of winter rice, white beans and maize, and aviculture.

We also support the COBAs by funding members to patrol the conservation zones of their respective management areas, to undertake participatory monitoring of lemur populations in general and greater bamboo lemur groups in particular, and to eliminate or reduce immediate threats to lemurs and their habitat such as illegal hunting or habitat destruction.

Discussion

The signing of a management transfer contract for a local community association signifies the successful completion

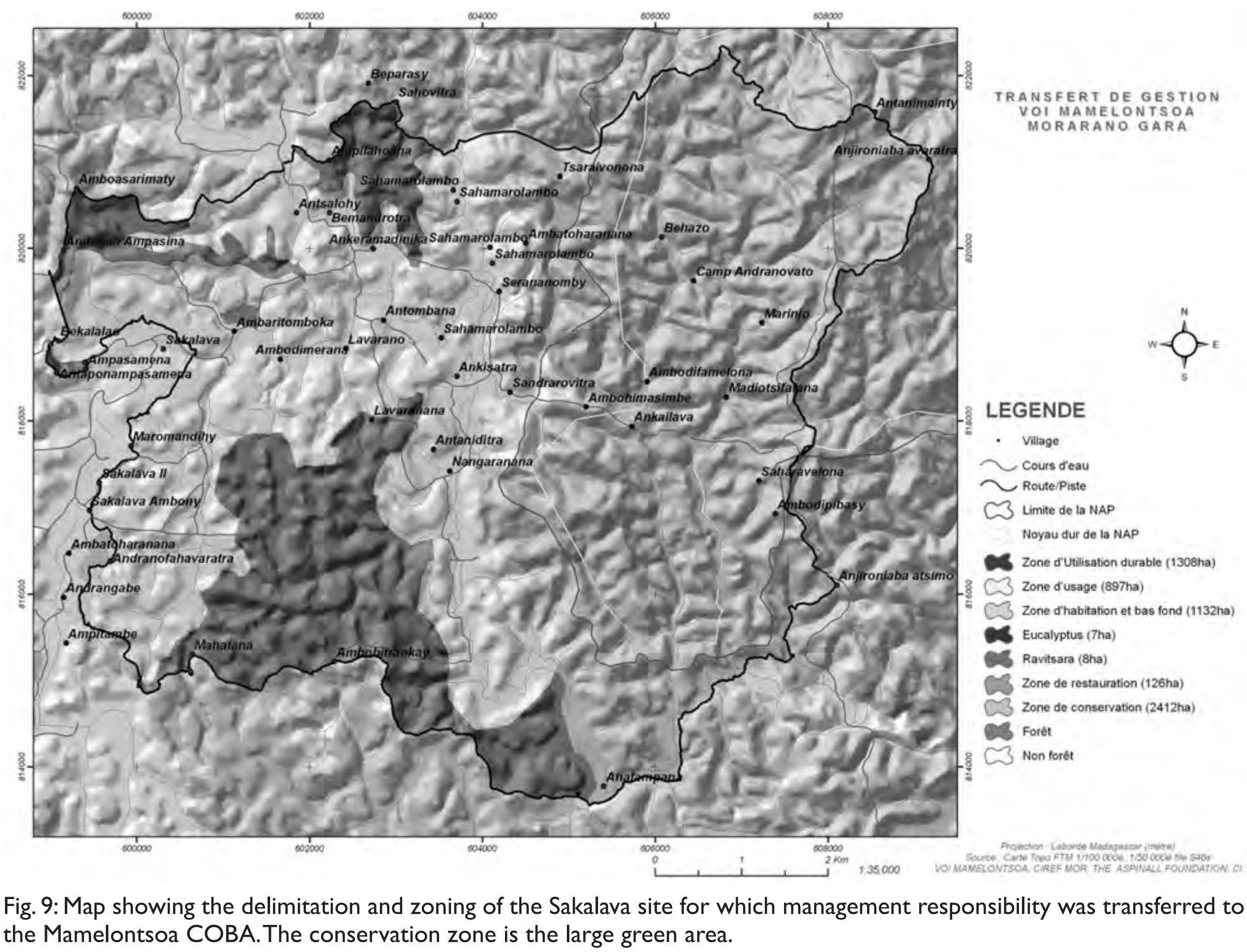
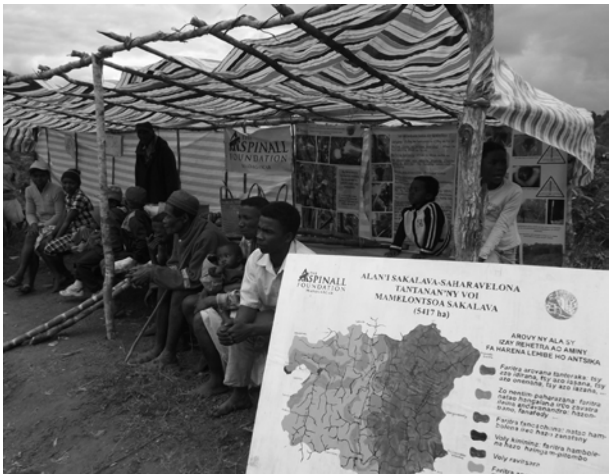


Fig. 9: Map showing the delimitation and zoning of the Sakalava site for which management responsibility was transferred to the Mamelontsoa COBA. The conservation zone is the large green area.



Figs. 10 and 11: Inauguration ceremony for the signing of the renewal of the management transfer contract for the Mamelontsoa COBA, August 2012. (Photos: M. Ravaloharimanitra)

of a long administrative and participatory process, which would probably not be possible without the significant technical and financial support of external non-governmental organisations such as The Aspinall Foundation. However it also signifies the start of the process to realise the underlying objective of the management contracts, that is the conservation of the forest and its biodiversity through community-led actions.

The 2 community-based conservation sites that we have facilitated and supported in the western Ankeniheny-Zahamena Corridor have resulted in the delimitation of 5,000 hectares of mid to high altitude rainforest as community-managed conservation zones (Tab. I), containing populations of some of the most endangered and highest conservation priority primate species in the world, in particular greater bamboo lemur, black-and-white ruffed lemur, indri and diademed sifaka. A further 4,500 ha of surrounding areas have been zoned for various activities that will support the protection of the conservation zone, including forest restoration to replace lost forest cover, reforestation to provide wood and other forest products for local needs, and agriculture (Tab. I). Simplified management plans and annual work plans have been elaborated in a participatory manner which if implemented will assure the conservation of the forests and their lemur populations whilst improving livelihoods of local communities. The challenge now is therefore to ensure the effective implementation of the management contracts.

Tab. I: Zoning of the two sites for which management responsibility was transferred to the Mamelontsoa and Ala maitso community associations.

Zone	Objectives	Area (ha)	
		Mamelontsoa	Ala maitso
Conservation	Conservation of *Prolemur simus* and other species	2,471	2,564
Sustainable use	Forest restoration to increase natural forest cover	1,039	551
	Reforestation to provide for local needs		
Controlled occupation	Habitation	1,131	405
	Agriculture		
	Livestock grazing		
Controlled use	General local resource use	776	548
Total		5,417 ha	4,068 ha

Of the 2 COBAs responsible for these sites, the Mamelontsoa COBA is now fairly competent in the management of their association, and of the natural resources under their management responsibility, while the Ala maitso COBA has only recently been created and is consequently on a steep learning curve. The Ala maitso COBA therefore requires significant capacity-building support over the foreseeable future, whilst the Mamelontsoa COBA will benefit from a more moderate level of capacity-building support. The zoning of the 2 management areas was based on fairly preliminary knowledge of their features, therefore more detailed studies will help clarify the real needs of the local population, the potential management strategies for the areas, and subsequently the revision of the annual work plans. Regular assessments of the state of the forest and its biodiversity will also be necessary to evaluate the impact of the community-based management activities. We have observed that our funding of COBA members to patrol the conservation zones of their respective management areas led to a rapid reduction in hunting pressure on lemur populations, but that reducing habitat destruction is more challenging. Forest clearance, slash-and-burn agriculture, and illegal mining and logging continue to represent threats to the sites. Further support to the COBAs responsible for managing the sites, through education, capacity-building, and micro-project development, remains essential if long-term conservation is to be achieved.

Acknowledgements

We thank the Ministry of the Environment and Forests of the Government of Madagascar, the local authorities and community associations with whom we work, the Mamelontsoa and Ala maitso COBAs, Association Mitsinjo, Conservation International, and Mohamad Mbaraka, Rose Marie Randrianarison and Jonah Ratsimbazafy.

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Taille de la population d'*Avahi laniger* dans la réserve d'Ambodiriana-Manompana, Nord-est de Madagascar

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Mots-clés: Madagascar, *Avahi laniger*, densité, Ambodiriana-Manompana, conservation.

Avahi laniger est le seul lémurien nocturne appartenant à la famille des Indriidae qui habite les forêts humides de l'est de Madagascar (Mittermeier *et al.*, 2010) dont une partie disparaît chaque année (exploitation du bois, pratique du «tavy» ou culture sur brûlis) (Beaucent and Fayolle, 2011; Lehman and Wright, 2000). La fragmentation et la destruction de leur habitat ainsi que la chasse menacent la survie de nombreuses espèces de lémuriens incluant celle de *A. laniger* (Jenkins *et al.*, 2011; Rakotondravony and Rabenandrasana, 2011 ; Anderson, Rowcliffe and Cowlishaw, 2007).

Nous avons réalisé, entre fin Avril et Mai 2012, une étude de densité de la population de *A. laniger* au sein de l'aire protégée de Manompana-Ambodiriana afin d'estimer la taille de la population totale et de déterminer l'impact du projet de conservation menée par l'Association de Défense de la Forêt d'Ambodiriana (ADEFA) qui recherche l'évolution démographique à moyen terme de cette espèce.

Site d'étude: la forêt d'Ambodiriana-Manompana

D'une superficie de 2,25km², la forêt d'Ambodiriana-Manompana (Fig. 1) est située à 7 km du village de Manompana (200km au nord de Tamatave; S16°40'34.7" et E49°42'16.3"). Cette forêt se compose de deux collines séparées par le fleuve Manompana. Cette réserve est essentiellement constituée de forêt primaire non dégradée. Toutefois, il est possible de trouver des patchs de forêt primaire dégradée (exploitation du bois, cyclones) et de savoka (conséquence de la culture sur brûlis). Depuis 1996, l'ADEFA se consacre à la gestion et à l'étude de cette forêt pour en assurer le suivi et la restauration.

Méthodologie: estimation de la densité

La densité de population des avahi a été évaluée en utilisant la méthode de «Line-transect – distance sampling» (Salmona *et al.*, 2013; Viana-Meyler *et al.*, 2012; Marshall *et al.*, 2008; Buckland *et al.*, 2001; Burnham *et al.*, 1980). Six transects (de 70 et 650 mètres de longueur) ont été créés au sein des différentes unités écologiques de la forêt (Fig. 1). Les transects ont été parcourus entre le 30 avril et 18 mai 2012, à des horaires diurnes (8h-16h30) et nocturnes (6h-8h et 16h30-23h), et répétés 6 à 15 fois par une équipe de quatre personnes.

Deux méthodes d'estimation de la densité ont été utilisées. Celles-ci se basent sur le même principe : pour chacune, la densité (D) est égale au nombre total d'observations (NT), divisé par l'aire d'observation (A). L'aire d'observation étant le produit de la longueur totale parcourue (LT) et de la largeur effective d'observation (ESW–Effective Strip Width) qui peut être estimé de différentes manières selon la méthode utilisée (cf Viana-Meyler et al., 2012 pour plus de détails concernant les méthodes). La méthode MPD (Mean Perpendicular Distance, Gates et al., 1968) estime l'ESW en utilisant la moyenne de la distance au transect de toutes les observations. Tandis que la méthode CDS (Conventional Distance Sampling, Buckland et al., 2001), implémentée dans le logiciel DISTANCE 6.0 (Thomas et al., 2010), consiste à ajuster une fonction de détection aux distances perpendiculaires d'observation dans le but d'estimer la largeur effective de comptage (ESW). Quatre fonctions de détection (uniform, negative exponential, half-normal et hazard-rate) ont été testées, et le modèle est choisi en utilisant le critère d'information d'Akaiké (AIC) et le test du χ^2 GOF (Goodness-of-fit) test (Thomas et al., 2010).

Résultats & Discussion

Lors de notre étude, 16,52 km ont été parcourus et 11 groupes d'*A. laniger* ont été observés. La méthode MDP permet d'estimer une densité de 55 individus/km² avec une distance d'observation moyenne de 9,96 mètres. L'aire totale de la réserve étant de 2,25 km², cette méthode suggèrent donc une taille de population totale de 124 individus dans l'ensemble de la réserve.

Tabl. 1: Récapitulatif des données obtenues sur le logiciel Distance 6.0. (ESW: Effective Strip Width; AIC: Akaike Information Criterion)

Modèle	Densité (individus/km²)	Densité int. conf. 95%	ESW (m)	AIC
«Uniform»	25,94	12,260 - 54,897	21,00	66,98
«Negative exponential»	32,71	12,47 - 85,23	11,38	67,31
«Half Normal»	39,17	12,15 - 126,25	10,05	67,66
«Hazard-rate»	40,97	7,18 - 233,86	9,27	68,13

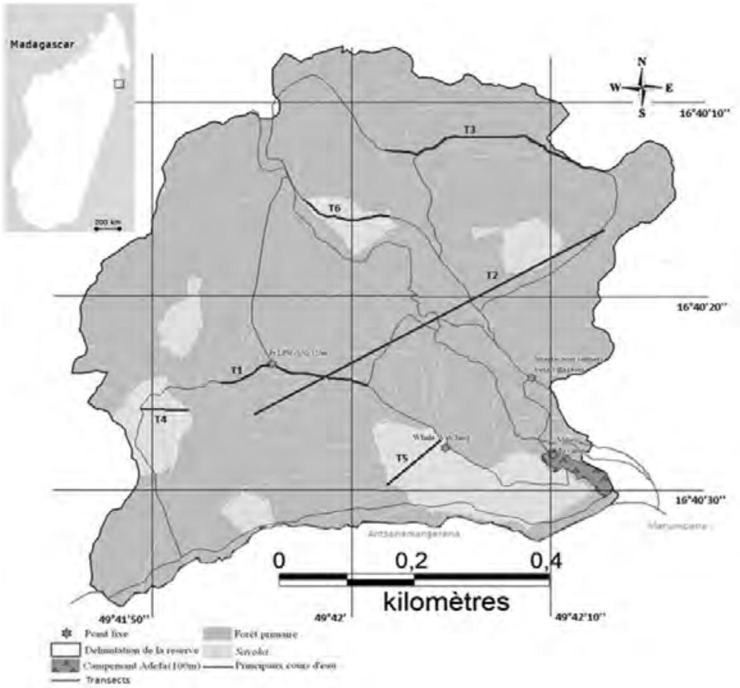

Fig. 1: Site d'étude: la forêt d'Ambodiriana-Manompana. (Source: ADEFA)

Tab. 2: Résumé des densités de population théoriques et observées d'*Avahi laniger* dans la forêt d'Ambodiriana-Manompana lors d'études précédentes et actuelles.

Année de l'étude	Référence	Méthode de calcul utilisée	Densité de population (individus/km²)	Taille de la population de la réserve
2007	Beaucent & Fayolle (2007)	MPD	86	193
2008	Ferrrier & Delacroix (2008)	MPD	58	130
2009	Ebert (2009)	Lors de suivis comportementaux		72 individus observés sur la réserve
2012	This Study	MPD	55	123
2012	This Study	CDS	41	92

Compte tenu du faible nombre d'observations (11), l'AIC et le χ^2 ne permettent pas de distinguer le modèle ajustant le mieux les données (Tab. 1). En conséquence, nous avons choisi par défaut de considérer la fonction de détection fréquemment reportée comme adéquate dans les études de densité chez les Indriidae, c'est-à-dire la fonction hazard-rate (Salmona et al., 2013; Quéméré et al., 2010). En considérant ce modèle, la densité d'Avahi laniger s'élèverait à 41 individus/km² soit environ 92 individus au sein de la réserve avec une ESW d'environ 9 mètres (Tab. 1).

Bien que les méthodes utilisées nécessitent en théorie un minimum de 40 observations pour estimer de manière fiable l'ESW et la densité (Buckland *et al.*, 2001), nos estimations de densité d'*A. laniger* même si elles ne doivent pas être prises à la lettre permettent tout de même d'obtenir une idée du nombre probable d'*A. laniger* au sein de l'aire protégée.

Les estimations obtenues en utilisant la méthode MDP sont supérieures à celles obtenues avec la méthode CDS (Tab. 1). Cela est en accord avec les résultats obtenus sur d'autres espèces et qui suggèrent que la méthode MDP tend à surestimer les densités de population (Viana-Meyler *et al.*, 2012; Richard-Hansen and Niel, 2004; Kun-Rodrigues *et al.*, soumis.). Le faible nombre d'observations et de répétitions de notre étude ne nous permet pas néanmoins de conclure quant à la précision de chacune de ces méthodes, mais l'utilisation de celles-ci nous permet de mieux comparer nos résultats avec ceux des études précédentes.

Les densités de population d'*A. laniger*, reportées dans d'autres régions varient entre 70 et 100 ind/km² (Mittermeier *et al.*, 2010; Garbutt, 2007). Dans la réserve, une étude antérieure de Beaucent et Fayolle (2007) a permis d'estimer une densité d'*A. laniger* de 86 ind/km², tandis que Ferrier et Delacroix (2008) ont estimé une densité de population de 58 ind/km² (Tab. 2). En comparaison notre estimation de 55 ind/km² (méthode MDP) suggère que (i) malgré les faibles nombres d'observations, notre estimation de densité n'est pas invraisemblable, et (ii) la population semble être restée relativement stable entre 2008 et 2012, mais avoir sensiblement décru par rapport à l'étude de Beaucent et Fayolle (2007).

Si le maintien apparent de la population d'*A. laniger* se confirme, ce sera une bonne nouvelle pour l'ADEFA gestionnaire de la réserve. La gestion de la réserve implique un maintien du couvert forestier et une surveillance importante. Ces actions ont donc pu contribuer à une protection relative de l'espèce par rapport à la principale menace directe, la chasse. En effet certaines espèces du genre *Avahi* ont été récemment reportées comme parmi les plus consommées dans l'est de Madagascar (Jenkins *et al.*, 2011). Il serait important de répéter notre étude et d'augmenter l'effort de surveillance des transects à intervalles réguliers afin de permettre un suivi précis de la population et une validation de notre travail.

Remerciements

Nous tenons à remercier L'ADEFA en général, et en particulier M. Grinaud et M. Arnold, M. Augustin Kaloloha, M. Galy et M. Elisé d'Ambodiriana, M. Nono, Mme Liva et M. Willy pour leur aide et leur accueil. Nous remercions aussi la Direction de l'Environnement et des Forêt pour nous avoir accordé l'autorisation de réaliser ce travail de recherche. LC est financé par le "Laboratoire d'Excellence (LABEX)" TULIP (ANR-10-LABX-41) et le project de la Fundação para a Ciência e a Tecnologia (FCT) (ref. PTDC/BIA-BEC/100176/2008). JS est financé par une bourse de thèse de la FCT (ref. SFRH/BD/64875/2009).

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Recensement des lémuriens nocturnes dans la zone de Belemboka-Bombetoka (province de Mahajanga)

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Introduction

Actuellement les habitats naturels des lémuriens nocturnes sont en voie de disparition à cause des activités humaines. Parmi celles-ci, le pâturage, la chasse, le défrichement, la coupe de bois et la collecte des écorces d'arbres pour la fabrication des maisons, du charbon de bois et des pirogues. L'objectif de ce travail est de recueillir des informations sur différentes espèces de lémuriens en capturant et relâchant des individus pour confirmer leur taxonomie, ceci dans le but de rester conforme à la vision de l'ONG FANAMBY et du Zoo de Mulhouse sur la conservation de la zone de Belemboka-Bombetoka. Nous pensons qu'il est utile d'observer les animaux dans les forêts fragmentées, comme celles de Belemboka-Bombetoka, et de préciser les répartitions géographiques des espèces de lémuriens nocturnes. Dans cette étude, nous avons effectué des missions de captures dans des forêts très fragmentées (site d'Antsakanala, site d'Ankamaho).

Matériels et méthodes

Site d'étude

Le site d'étude se trouve au Nord-ouest de Madagascar, plus précisément dans l'embouchure du fleuve Betsiboka (baie de Bombetoka), à 20 km de la ville de Mahajanga, au Sud de Katsepy.

Méthodologies

La méthode utilisée consiste en une capture avec relâche immédiate. La capture était effectuée soit:
- par fusil à air comprimé
- par piège Sherman

Le fusil à air comprimé projette des fléchettes contenant une solution de kétamine (Kétalar, Parke-Davis). Nous avons prélevé un petit fragment de peau ou du sang pour faire les études moléculaires qui ont été menées à l'Institut de Médecine Légale de Strasbourg.
Pour les microcèbes, nous avons utilisé des pièges Sherman en attirant les animaux avec de petites bananes. Du fait de la taille réduite des animaux nous avons prélevé des poils pour faire les analyses moléculaires. Après prélèvement chaque animal a été relâché à l'endroit même de sa capture.

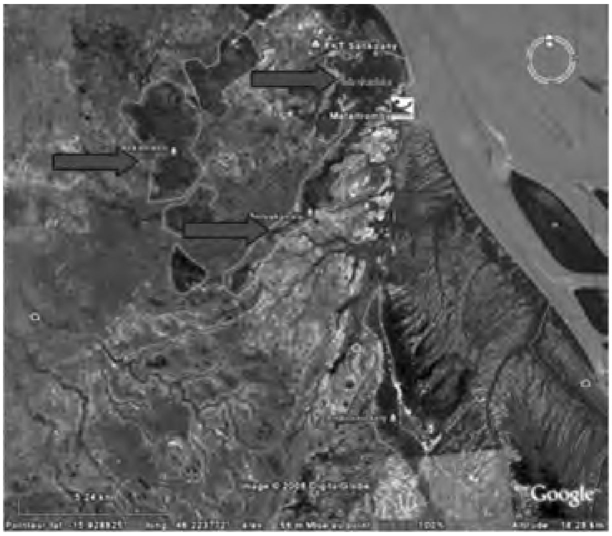

Fig. 1: Carte de la forêt de Belemboka. (Source: ONG FANAMBY)

Extraction des acides nucléiques.
Les acides nucléiques ont été extraits a partir de fragments de tissu (environ un mm^2), de sang (40m l) ou de poils avec le kit Prep filer suivant les instructions du fabricant, puis stockés au congélateur à -30°C.

Etude de la D-loop et du cytochrome b.
Une réaction de polymérase en chaine (PCR: polymerase chain reaction) est employée pour produire un double brin d'ADN correspondant au cytochrome b ou une partie de la D-loop.
Chaque amplification est réalisée en présence de 20 mM tris-Hcl pH 8.4, 50 mM Kcl, 1.5 mM MgCl2 (Gibco BRL), 50m g BSA, 0.5m M de chaque amorce, 1,8 U de Taq DNA polymérase (Perkin Elmer Cetus), 200m M de chaque dNTP (Boehringer Mannheim) et 90 ng de DNA dans un volume de 30m l. Les réactions sont réalisées dans un thermocyler Perkin Elmer Cetus DNA thermocycler 480 de la manière suivante: Pré dénaturation (7 mn à 94°C) puis 10 cycles de dénaturation (30 sec à 94°C), hybridation (45 sec à 54°C), extension (1 mn 30 sec à 72°C), puis 30 cycles de dénaturation (30 sec à 94°C), hybridation (45 sec à 52°C), extension (1 mn 30 sec à 72°C), suivis d'une extension finale (10 mn à 72°C). Les amorces utilisées lors des réactions de PCR pour les microcèbes et les lépilemur sont les suivantes.

D-loop
Dl51: 5'-GCACCCAAAGCTGARRTTCTA-3' (Wyner et *al*., 2000).
Dlpl5: 5'-CCATCGWGATGTCTTATTTAAGRGGAA-3' (Baker et *al*., 1993).

Cytochrome b
AHC223/AHE265
AHC223: 5'-TGACTAATGATATGAAAAACCATCG-3'
AHE265: 5'-TCGTGTAGGAAGAGGAGGTGA-3'
AHE266/AHC226
AHE266: 5'-CGATTCTTCGCACTCCATTT-3'
AHC226: 5'-GGTTGATGCTTCTTCCTTGAG-3'

Après contrôle des produits de PCR sur gel d'agarose à 1.3 %, ceux-ci sont purifiés (NucleoSpinR extract II, Macherey-Nagel) puis séquencés dans le sens 5'-3' et 3'-5' (Taq dye deoxy terminator cycle sequencing kit et séquenceur automatique ABI PRISM 3100).

Les séquences générées sont alignées à l'aide du logiciel Bioedit (Hall, 1999) puis analysées par la méthode de neighbor-joining à l'aide du logiciel MEGA (Tamura et *al.,* 2007).

Résultats
Les captures que nous avons effectuées sont résumées dans le tableau 1. Celles-ci ont été réalisées dans les forêts d'Antsakanala, d'Ankamaho et de Mandakala. Comme on peut le constater sur la Fig.1 ces dernières sont très fragmentées. De manière à déterminer les espèces présentes, une portion de la D-loop et l'ensemble du cytochrome b a été séquencé pour des échantillons des genres *Microcebus* et *Lepilemur* issus de chaque lieu de capture. Des résultats moléculaires, concordants pour la D-loop et le cytochrome b ont été obtenus. La comparaison des séquences avec de séquences d'espèces déterminées répertoriées dans genebank montrent que les lépilemurs capturés dans les forêts d'Antsakanala et d'Ankamaho appartiennent à l'espèce *Lepilemur aeeclis*. Pour les microcèbes, deux espèces ont été retrouvées: *Microcebus murinus* et *Microcebus myoxinus*. *Microcebus murinus* est présent dans les forêts d'Ankamaho et Mandakala, *Microcebus myoxinus* dans celle d'Ankamaho (Fig. 2).

Tab. 1: les nombres et les lieux des espèces capturés Nom de genres

Animaux	Nombre d'animaux capturés	Lieu de capture	Adulte ou jeune	Date
Microcebus sp.	06	Forêt de Mankadala	04 adultes et 02 jeunes	22/08/2009, 23/08/2009
Microcebus sp.	03	Forêt d'Ankamaho	02 adultes et 01 Jeune	28/08/2009
Lepilemur sp.	03	Forêt d'Antsakanala	03 adultes	24/08/2009, 27/08/2009, 30/08/2009
Lepilemur sp.	02	Forêt d'Ankamaho	01 adulte et 01 jeune	29/08/2009

Bien que l'habitat soit perturbé, nous avons pu observer que des microcèbes sont encore présents dans de nombreux fragments de forêt avec souvent une densité de population importante. Il avait déjà été noté que ces derniers peuvent survivre dans des habitats dégradés (Ganzhorn et Schmid, 1998). A l'inverse les lépilemur s'adaptent mal aux habitats dégradés et sont aussi souvent des cibles pour la chasse d'où l'importance de la mise en place de programmes de protection.
De par le manque de financement, les fragments de forêts que nous avons visités avaient été peu étudiés et l'inventaire des lémuriens nocturnes restait imprécis. Dans une étude précédente, *Lepilemur aeeclis* avait été retrouvé à Anjahamena et Mitsinjo (Andriaholinirina et *al*., 2006). Notre inventaire atteste de la présence de ce dernier dans la zone de Belemboka-Bombetoka. Ceci permet d'étendre l'aire de répartition de cette espèce et laisse supposer qu'il existe une continuité de distribution d'Anjahamena à Mataitromby (Belemboka-Bombetoka). De plus, l'existence de *Microcebus myoxinus* dans cette zone confirme la répartition géographique établie par Mittermeier et *al.* (2010).
La sensibilisation des villageois sur les problèmes environnementaux est très différente dans chaque région, néanmoins celle ci est vitale dans la lutte contre la dégradation du milieu naturel. La zone que nous avons étudiée présente une grande richesse tant par la présence de mangrove que par celle de différentes espèces de lémuriens. La pérennité de la zone de Belemboka-Bombetoka qui est accessible par vedette pourrait être assurée par le développement de l'écotourisme.

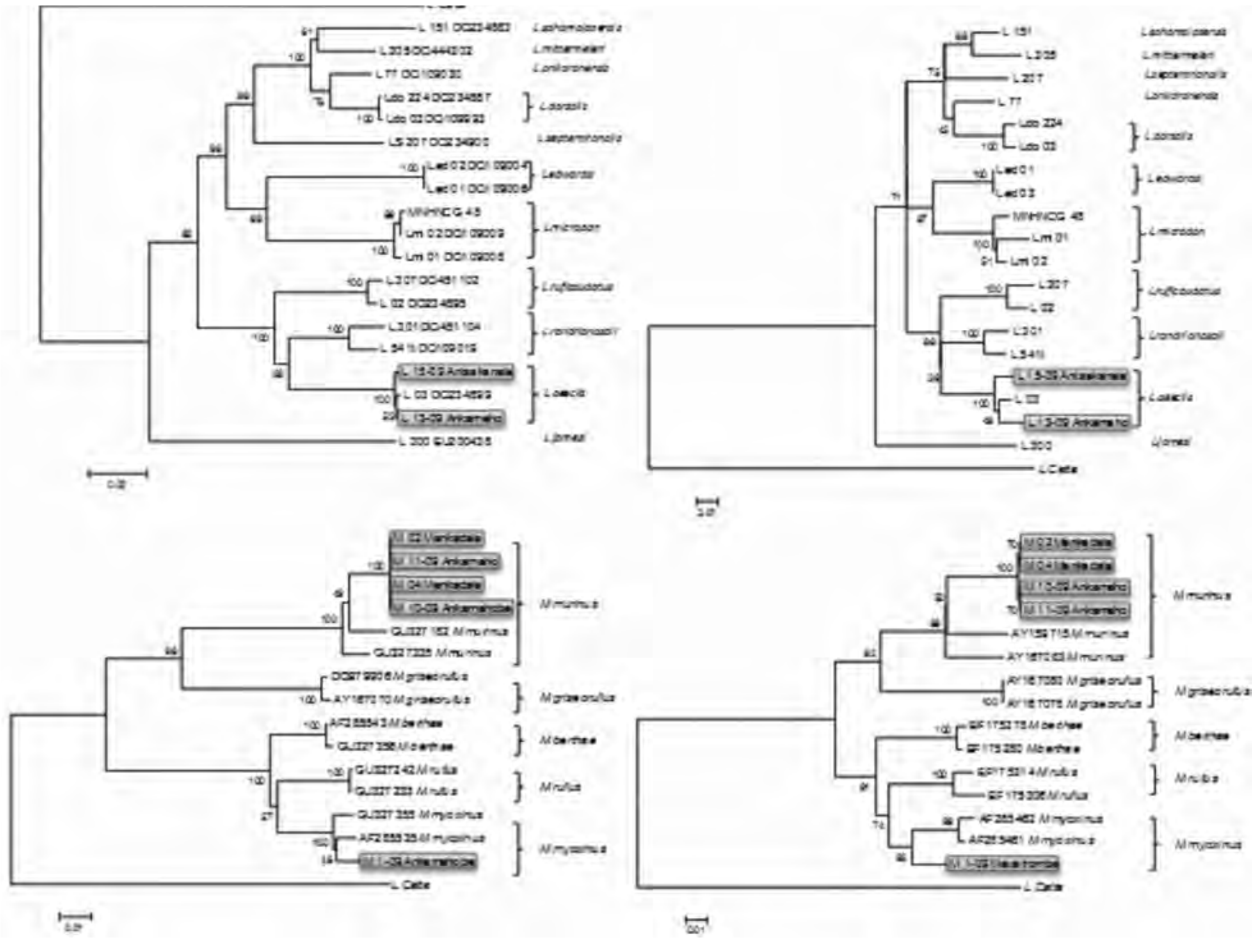

Fig. 2: cladogramme de la répartition des *Lepilemur* (en haut) et des *Microcebus* (en bas) obtenus à partir du cytochrome (gauche) b et D-loop (droite). Les échantillons analysés (sur lignage en couleur) sont comparés à des échantillons d'espèce déterminée.

Remerciements
Nous adressons nos remerciements à toutes les personnes et entités suivantes: la Direction de la valorisation de la Ressource Naturelle à Nanisana -Antananarivo et à Mahajanga pour avoir délivré l'autorisation de capture et les permis de l'exportation (CITES). Ce travail a bénéficié de l'aide financière du Zoo de Mulhouse, de l'Association Européenne pour l'Etude et la Conservation des Lémuriens (AEECL) et l'Unité de recherche EA4438 Physiopathologie et Médecine Translationnelle, Strasbourg. Un spécial remerciement s'adresse également Mr le Dr Daniel Montagnon (Paix à son âme) qui manifestent le signe d'amitié et de collaboration avec nous. Les guides et les villageois de Mataitromby qui ont participé activement à notre travail d'étude. Mr le Président de l'Université de Mahajanga, Mr le Doyen de la Faculté des Sciences de Mahajanga, Mr le chef de Département de Biologie Animale et Ecologie de Mahajanga, les enseignants au sein de l'option Primatologie et évolution de Mahajanga, les personnels de l'ONG FANAMBY de Mataitromby et d'Antananarivo. Merci à vous tous.

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Une synthèse de la campagne 2009-2012 d'exportation du bois de rose malgache

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Introduction
Fin janvier 2009, un membre de Madagascar National Parks donne l'alerte: «ils sont fous! Les coupeurs sont entrés dans le Parc du Marojejy, après avoir menacé les gardes et le directeur. Ils sont en train de couper tout le bois de rose du Parc. C'est un désastre!» Depuis cette date, une équipe de

défenseurs de l'environnement s'est constituée, couvrant tout Madagascar et même au-delà, dans les forêts, les ports et les bureaux de l'Administration centrale. Au fil des mois et des années, tous les renseignements obtenus ont été vérifiés quand c'était possible et notés dans une main courante, mise à jour en permanence et diffusée sur internet sous le titre «*Les Chroniques du bois de rose*».
Certains renseignements fournis par une source unique n'ont pas pu être vérifiés ni prouvés. C'est pour cette raison que la presse a parfois refusé de les diffuser car le sujet est jugé juridiquement trop sensible. Mais l'intérêt des *Chroniques* est de dessiner au fil du temps un tableau d'ensemble parfaitement cohérent. C'est une synthèse de ce tableau qui est proposée ici, analysée sous l'angle du jeu des principaux protagonistes le pouvoir en place, essentiellement la Haute Autorité de Transition (HAT) puisque le Président Ravalomanana a été évincé dès le début de ce dossier; les exportateurs de bois de rose, souvent appelés trafiquants puisque la plupart du temps leur activité est illégale; la communauté internationale, constituée des bailleurs de fond (principalement la Banque Mondiale en l'occurrence), des ONG environnementalistes et de la presse internationale, scientifique ou grand public.
Cette campagne de coupe-exportation de bois de rose a eu lieu entre deux pays: Madagascar et la Chine, les autres pays étant négligeables au regard du tonnage concerné. Celle est concernée essentiellement par la forêt du Masoala et les abords de Mananara-Nord, car le Parc du Marojejy étant mis hors de cause dès août 2009. Selon toute vraisemblance, elle devrait prendre fin au début de 2013, faute de bois restant à exporter. Elle peut être découpée en cinq phases, plus une phase préliminaire.
Phase préliminaire (avant le 26 janvier 2009): la préparation
Si les opérateurs de bois de rose n'ont sans doute pas participé à la préparation des émeutes du Lundi Noir, de nombreux d'éléments laissent à penser qu'ils étaient au courant et qu'ils se sont organisés pour utiliser ces troubles à leur profit.

L'État
Le 26 janvier 2009, le plan «Lundi Noir» se déclenche à l'échelon national. Dans tout le pays, de manière quasi-simultanée, les magasins Magro et Tiko (dont le Président Ravalomanana est le directeur toujours en exercice) sont pillés puis incendiés par des émeutiers recrutés et encadrés à cet effet. Deux jours plus tard, le gouvernement Ravalomanana promulgue l'arrêté interministériel n°003/2009, qui autorise à titre exceptionnel et nominatif l'exportation de bois de rose et d'ébène, au motif de soutenir financièrement 13 opérateurs désignés «en raison de la crise mondiale». La date limite d'exécution est fixée au 30 avril 2009. Et l'application est immédiate, puisque dès le 03 février 2009, le navire *Ultima* (Delmas) embarque 240 tonnes de bois précieux à Vohémar. La campagne de bois de rose a donc été initiée par le gouvernement Ravalomanana, qui a pris ce décret indépendamment des événements du 26 janvier. Il appartiendra au Président Ravalomanana d'expliquer un jour ses raisons, mais on peut les deviner sans peine à l'exposé des motivations publié dans la presse: un lobbysme réussi, puisqu'aucun des 13 opérateurs historiques n'est particulièrement frappé par la crise financière mondiale.

Les trafiquants
Pendant les émeutes de fin janvier, alors que les forces de l'ordre se tiennent soigneusement à l'écart de ces événements, d'autres voyous équipés de 4 x 4 et de camions se précipitent pour saccager les locaux des services des Eau et Forêts : une émeute dans l'émeute. Ils détruisent les bureaux et notamment les archives qui allaient servir pour des procès en cours, arrêtant ainsi les procédures judiciaires faute de preuves. Puis ils font main basse sur les pièces à conviction: des centaines de «*bolabola*» (rondins de bois de rose) saisis par l'Administration disparaissent, emportés par des camions vers les dépôts privés des trafiquants. Ce qui étonne dans cette phase préliminaire, c'est la bonne synchronisation des opérations. Il est frappant de constater la célérité avec laquelle les pillards s'emparent des rondins saisis par les Eau et Forêts. Les camions sont prêts, les manœuvres aussi, l'action est simultanée à Antalaha et à Fénérive et l'ensemble s'enclenche bien. Il est donc peu probable que les crimes aient été improvisés, ce qui signifie qu'elles ont été préméditées. Selon les témoignages connus, les événements du 26 janvier ont été financés par des hommes d'affaires de la capitale, et non par les opérateurs de bois de rose d'Antalaha. Mais il est légitime de penser qu'ils étaient informés de ce qui se tramait et qu'ils ont anticipé les événements: quand l'émeute se déclenche et que les forces de l'ordre se cachent, ils sont prêts à l'action.

La communauté internationale
Durant ces événements, elle observe en silence.

Phase I (26 janvier au 18 avril 2009): la frénésie des trafiquants
Cette phase est marquée par l'anarchie dans les parcs, le désir d'enrichissement massif et rapide des trafiquants et d'une bonne partie de la population valide de la SAVA, ainsi que par l'impuissance de l'Etat. C'est la ruée vers l'or.

L'État
Lorsque la foule des manifestants se fait massacrer le 07 février 2009 à Antananarivo, la confusion s'installe au sommet de l'État. Le président Ravalomanana est contraint de quitter le pouvoir le 17 mars 2009. En avril 2009, le tout nouveau Ministre de l'Environnement rappelle publiquement l'interdiction de couper dans les aires protégées. Mais la nouvelle équipe gouvernementale est débordée, occupée à asseoir son pouvoir sur l'Administration (DREFT 2009, Salava 2009a et 2009b). Le nouveau maître du pays, le Président de la HAT Rajoelina, cherche à contrôler la capitale, puis l'ensemble de la chaîne administrative de l'Etat. Il est plus que temps qu'il prenne les choses en main.

Les trafiquants
Les hommes des villes de la côte nord-est profitent du flottement dans la capitale pour se précipiter dans les Parcs du Marojejy et du Masoala à la recherche de bois de rose. Malgré l'opposition initiale des villageois, vite dispersés par quelques tirs de semonce, les trafiquants emportent des centaines de billes de bois pour les charger dans des camions. La ronde des navires commence, dans le port de Vohémar. Dix rotations exportent plus de 7 000 tonnes de bois précieux en deux mois, sans contrôle ni opposition d'une administration qui ne sait plus qui commande. En forêt, l'ambiance est celle de la ruée vers l'or en Amérique. Alcool, musique, filles et violence accompagnent le dur labeur quotidien des coupeurs, débarrassés de tout contrôle administratif. Les villageois sont de plus en plus nombreux à couper du bois dans le Parc du Marojejy. Le trafic ayant forcément une durée limitée, tout le monde se précipite. Quel que soit le diamètre, tout doit disparaître. On assiste, impuissant, aux «dernières soldes». Le Parc National du Masoala est touché à son tour par la coupe illicite.

La communauté internationale
La première réaction des bailleurs de fonds est de couper les aides financières à Madagascar, dès le coup d'État. Elle se prive ainsi du peu d'influence qu'elle avait. Le 30 mars 2009, les ONG internationales (WWF, WCS, CI) demandent et obtiennent un rendez-vous avec le ministre de l'environne-

ment pour l'alerter sur la situation catastrophique des aires protégées du Nord-est.

Phase II (18 avril au 13 juillet 2009): la mi-temps

Lors de cette phase, la HAT ressent le besoin de calmer le jeu car elle sent qu'elle a perdu la main, d'autant plus que son contrôle sur les régions est mal assuré. Elle préfère geler la situation et faire l'état des lieux.

L'État

Le 18 avril 2009, le nouveau ministre de l'Environnement, des Eau et Forêts ferme le port de Vohémar pour l'exportation du bois de rose. A la mi-mai, 200 conteneurs de bois de rose sont alors bloqués sur les quais de Vohémar. Le Gouvernement se rend compte que les déclarations d'exportation sont fausses.

Les trafiquants

Ils réagissent vite. Ils affrètent un avion pour la capitale où ils sont reçus par des membres de la Haute Autorité de Transition. Tandis que les camions reprennent leurs rotations pour amener les conteneurs de bois au port de Vohémar, la décision de rouvrir le port ne vient pas les conteneurs restent à quai. Pendant cette lutte d'influence, les coupeurs partis d'Antalaha en direction du sud font leur jonction le 21 avril 2009 en plein cœur du Masoala avec leurs homologues partis de Maroantsetra en direction du nord. Les trafiquants pensent que la fermeture de Vohémar n'est qu'une tactique pour faire monter le barème des «commissions». Les armateurs n'envoient plus leurs bateaux à Vohémar, dans le doute (Andriatahina *et al.* 2009).

La communauté internationale

Elle observe en silence, dépassée par la rapidité des événements. En outre, les ONG internationales réalisent leur vulnérabilité. Elles ne peuvent s'opposer frontalement à la HAT sans risquer de se faire expulser du pays, où elles emploient des permanents et où elles ont des programmes en cours. C'est l'opération «silence contre survie». Mais à se taire trop longtemps, elles risquent de perdre les financements de leurs donateurs pour manque de résultats. Cependant, quelques poids lourds des médias internationaux s'intéressent à la situation et montrent les milliers de coupeurs à l'œuvre dans le Parc du Masoala (Rather, 2009).

Phase III (13 juillet au 21 septembre 2009): la négociation

Après l'état des lieux, la HAT est prise entre deux feux: la communauté internationale qui lui reproche discrètement sa façon de prendre le pouvoir autant que la destruction du patrimoine forestier national, et les exportateurs de bois de rose, nouveaux riches, arrogants et soucieux de préserver leur droit de pillage. N'étant pas en position de force, l'État négocie.

L'État

Le 13 juillet 2009, le ministre de l'Environnement signe une lettre adressée à la Direction Régionale des Eau et Forêts et du Tourisme, lui demandant de rechercher des transactions avant jugement sur la base de 72 millions d'ariary par conteneur litigieux, en attente au port de Vohémar. Par défaut, il demande d'engager des poursuites judiciaires, de saisir le bois et de le vendre. Mais d'autres membres de la HAT promettent aux opérateurs qu'ils feront descendre de moitié le montant de «l'amende» et qu'il ne faut pas se précipiter pour la payer. Cependant, un opérateur en a déjà payé l'intégralité... A la fin du mois, le ministre de l'Environnement décide (décision n°338/09/MEF/MI) d'autoriser l'exportation de 25 conteneurs de bois de rose pour chacun des 13 opérateurs du décret 003-2009, contre le paiement d'une «amende» de 72 millions d'ariary par conteneur. Dans la SAVA, la négociation porte partiellement ses fruits : en septembre 2009, cinq trafiquants obtiennent l'accord de transférer leur bois d'Antalaha vers Toamasina, tandis qu'à Maroantsetra, la ministre du Tourisme annonce qu'elle va arrêter le trafic de bois de rose.

Les trafiquants

Ils sont excédés par le montant de «l'amende» du gouvernement. Ils disent «qu'ils n'aideront personne aux prochaines élections. Si le gouvernement est contre eux, pas de problème, ils attendront le suivant.» La négociation doit s'ouvrir. En forêt, la situation est contrastée: le Parc du Marojejy est à peu près calme, faute de bois de rose d'accès facile, mais celui du Masoala est toujours en pleine effervescence. La forêt est presque mise à nu, les animaux s'enfuient et les lémuriens sont chasés (Salava 2009c). Beaucoup de rondins attendent sur les plages ou aux embouchures de rivières, que des bateaux viennent les prendre. De nouveaux villages sont apparus, peuplés de coupeurs, de collecteurs, de vendeurs de détail, de prostituées et de gargotes. Les prix sont élevés, en raison de l'abondance d'argent, de l'affluence des clients et du manque de tout. Les accidents des tireurs de billes et les crimes (bagarres, alcool et vols) sont nombreux, car aucun gendarme n'est visible sur zone. Puis, vers août 2009, la coupe se déplace vers le sud, autour de Maroantsetra et à Mananara (ACMD 2009) où un agent du Parc National de Mananara à les deux pieds brisés par des envoyés des barons du bois de rose d'Antalaha. Il tentait de s'opposer à l'entrée des coupeurs dans le Parc. Ils sont plusieurs centaines à avoir ainsi pénétré dans le Parc, avec des documents officiels revêtus de toutes les signatures. «Les villageois et les responsables locaux auront la tête coupée s'ils continuent de gêner les coupeurs», selon le Cartel d'Antalaha. Dans le Makira, la coupe a atteint un niveau record et presque tout le monde y participe. Fin d`août 2009, les premiers indices apparaissent qui laissent croire que le bois de rose quitte Madagascar par Toamasina. Tous les navires faisant la ligne Antalaha-Toamasina chargent du bois de rose (Salava 2009d). Tandis que les opérateurs touristiques de cette ville reçoivent des menaces de mort de la part des trafiquants de bois de rose, les épouses de hauts fonctionnaires du secteur sont aperçues dans les villages autour du Masoala, en train d'acheter du bois de rose en lieu et place de leurs maris. Toute une économie du bois de rose se met sur pied: la communauté chinoise de la capitale avance la trésorerie pour les acheteurs venus de Chine qui préfinancent les exportations. En retour, ils paieront les importations de friperie depuis la Chine pour ces commerçants. En septembre 2009, dans la capitale, 40 acheteurs chinois font du lobbying pour faire rouvrir le port de Vohémar. Ils ont beaucoup d'argent immobilisé dans ce trafic. Ils tentent en vain de convaincre le Premier ministre, puis ils quittent Madagascar en colère.

La communauté internationale

Elle cherche à faire son unité sur la crise malgache. Elle attend de voir de quel côté la HAT va pencher: l'interdiction de coupe ou l'autorisation. Le Congrès des États-Unis vote le 15 octobre 2009 la résolution H. RES. 839, qui condamnent explicitement la coupe de bois de rose et d'ébène dans les parcs malgaches.

Phase IV (21 novembre 2009 au 24 mars 2010): la reprise des exportations

L'État tente d'imposer le principe du partage de la manne du bois de rose lors de cette période. Il essaie d'encadrer l'activité, puisqu'il ne peut ni ne veut l'interdire car il a besoin de liquidités pour faire tourner la machine administrative. Les taxes du bois de rose y pourvoiront.

L'État

Le 21 septembre 2009, le ministre des Eau et forêts promulgue l'arrêté interministériel n°38244/2009 qui autorise à titre exceptionnel et nominatif l'exportation des 25 conteneurs de bois de rose, d'ébène et de palissandre pour chacun des 13 opérateurs autorisés en janvier dernier, moyennant le paiement de 72 millions d'ariary par conteneur. Le gouvernement négocie âprement avec les trafiquants. Il est prêt à descendre «l'amende» à 60 millions d'ariary par conteneur, alors que les trafiquants en proposent 24. L'autorisation d'exporter prend fin le 30 novembre 2009, lorsque le Premier ministre Eugène Mangalaza décide que l'exploitation, le transport et le commerce de bois précieux sont interdits. Il est aussitôt congédié et son successeur, Camille Vital, change la donnée. Le 21 décembre 2009, par la note n°218-PM/SP.09, le nouveau Premier ministre confirme l'arrêté 38244, mais sans fixer de date butoir cette fois. Les exportations peuvent donc reprendre. Sur le terrain, la Task Force est corrompue: les militaires laissent passer le bois coupé moyennant 200 000 ariary par lot. Ils disent que «c'est une affaire comme une autre et il faut en faire profiter tout le monde». Le Premier ministre prend son bâton de pèlerin et vient à Vohémar à la mi-janvier 2010 pour chercher comment faire partir les 250 conteneurs de bois de rose en attente. En effet, la société maritime Delmas ne veut plus prendre de bois. Un homme d'affaire français va servir d'intermédiaire et convaincre Delmas de reprendre son service. Deux proches conseillers du Président proposent alors un arrangement qui pourrait convenir à presque tout le monde: un troc «bois de rose contre riz» (comme en Irak avec le programme de l'ONU «pétrole contre nourriture»). Ainsi, il n'y aurait pas de taxe à payer. Les exportateurs n'auraient pas leur mot à dire car leur bois serait saisi. Cette fausse bonne idée est vite enterrée. Le 24 mars 2010, le Premier ministre Camille Vital signe un décret (n°2010-141) d'interdiction de toute opération sur le bois de rose.

Les trafiquants

Fin 2009, Maroantsetra regorge de bois de rose. Les billes sont partout: en ville et sur les bas-côtés des pistes. Des camions et des bateaux les déchargent en plein jour. Tous les hommes d'affaires locaux sont impliqués dans ce trafic. Ils vont vendre le bois à Toamasina et reviennent avec toutes sortes de marchandises à vendre sur place, avec la complicité des fonctionnaires. Dans le Masoala, la coupe a lieu devant les rares touristes dans les hôtels. Quelques opérateurs touristiques ont déjà effectué leur reconversion: les vedettes rapides ne transportent plus de touristes, mais du bois de rose. Les quelques irréductibles de Maroantsetra qui défendent la forêt commencent à avoir sérieusement peur. Des menaces de mort sont proférées. Il leur est clairement expliqué que les trafiquants élimineront quiconque les gênera. A Vohémar, les barons du bois de rose échouent à trouver un accord avec le Trésor Public. Comme ils n'ont pas de quoi payer les 72 millions d'ariary d'amende par conteneur, leurs précédents bénéfices étant en sûreté à l'étranger, ils proposent de payer après le départ du bateau, une fois que les acheteurs chinois auront réglé leur facture. Le Trésor Public rejette cet arrangement illégal et tout semble bloqué. Alors, ils tentent d'imposer leurs vues. Le 4 octobre 2009, le *Léa* (Delmas) charge 2 208 tonnes de bois précieux à Vohémar, puis il est bloqué à quai par ordre du ministre des Finances car 66 conteneurs de bois de rose ont été chargés à son bord et les exportateurs n'ont toujours pas acquitté leurs taxes et «amendes». Les exportateurs ont obtenu l'accord du Receveur des Douanes de Vohémar pour ne payer qu'une fois le bateau en mer, ce qui est illégal, d'où la réaction du Ministre. Mais ils réagissent à leur tour: ils ameutent la foule qui attaque le port et menace de tout détruire. Le Capitaine du port autorise alors le *Léa* à lever l'ancre par mesure de sécurité. Mais au lieu de rejoindre Port-Louis (Maurice) comme prévu, le navire est consigné dans les eaux territoriales puis dérouté vers Toamasina. Tout le fret y est déchargé: 78 conteneurs sont en règle et 12 sont sans documents. Après un procès en novembre 2009, le propriétaire des conteneurs sans papiers est acquitté! Le bois prend finalement la mer en juin 2010, à bord du *Terra Bona*, navire de la SEAL. Mais les conteneurs seront alors au nombre de 63 (Ministre des Finances et du Budget 2010). En octobre 2009, il n'y a plus de rondins de bois de rose en attente à l'intérieur du Masoala. Les militaires sont partout, ils arrêtent les villageois (au moins pour 24 heures, jusqu'à ce qu'ils paient quelque chose). Mais leur présence suffit pour vider le Parc de ses coupeurs. La coupe se poursuit dans le Makira, où elle touche surtout des palissandres. Par ailleurs, l'arrêté du 21 septembre 2009 a encouragé la création de beaucoup de sociétés d'exportation de bois de rose, notamment à Antananarivo: elles demandent aux autorités de venir vérifier leurs stocks, lesquels ont été constitués sans autorisation, donc illégalement! La plupart de ces demandes sont acceptées, ce qui légalise l'illégal. Le phénomène bois de rose gagne maintenant la capitale. Les exportations continuent depuis Vohémar: plus de 4 000 tonnes, dont 3 200 partent quelques jours *après* la date limite du 30 novembre 2009. Les trafiquants sont «fous d'argent» et ils acceptent toutes les avances des acheteurs chinois qui passent. Comme il n'y a pas assez de bois en stock, la coupe doit recommencer, même dans les aires protégées. C'est à Ampanihy, entre Ratsianarana et Fampotakely (Masoala) que le trafic est à son maximum: 2 000 à 3 000 personnes y travaillent en permanence. Fin décembre 2009, après la publication de l'arrêté de reprise des exportations du Premier ministre, le Cartel du bois de rose organise une grande fête à Antalaha... Dès le 1er janvier 2010, plus de 1 000 coupeurs reprennent le chemin de la forêt du Masoala, la hache sur l'épaule.

Mais une nouvelle tendance se dessine peu à peu: celle de la concentration du trafic entre les mains de proches du pouvoir. Le 15 novembre 2009, un trafiquant il signale l'arrivée de la mafia chinoise dans le circuit et il s'en inquiète. Elle voudrait que l'un des siens concentre toutes les exportations, en avançant les fonds et gérant les mouvements et les exportations. Et cet homme de l'ombre serait le point focal des acheteurs chinois et l'interlocuteur unique des autorités administratives. Les exportateurs malgaches ne l'entendent pas ainsi, ils se sentent dépossédés de leurs florissantes affaires. En fait, la filière centralisée ne sera pas chinoise, mais malgache, animée par des proches du pouvoir : anciens premiers ministres ou leurs épouses, hommes d'affaires prospères et proches du pouvoir. Près de 200 conteneurs ont déjà quitté ainsi Toamasina.

La communauté internationale

Le 6 octobre 2009, les ONG internationales publient un communiqué condamnant la façon dont le gouvernement malgache gère la crise du bois de rose, tandis que des défenseurs de l'environnement font une publication sur ce sujet à la Conférence Internationale de Rio sur la forêt (Wilmé *et al.* 2009). Début mars 2010, une mission «bois de rose» vient dans la SAVA pour évaluer la situation: la Banque Mondiale, l'Union Européenne, les États-Unis, la Norvège, l'Agence Française de Développement (AFD), accompagnés du directeur général de Madagascar National Parks. La crise environnementale s'internationalise enfin.

Phase V (24 mars 2010 à fin 2012): l'évaporation silencieuse

Après avoir hésité en décembre 2011 sur l'épineuse question de ce qu'il convient de faire des stocks de bois déjà coupés, l'État à décidée que la meilleure solution est de les laisser partir sans bruit. Le conflit va alors se déplacer sur la clé de répartition de la manne: alors que les trafiquants aimeraient conserver leurs 75 % de recette financière (déduction de taxes et des arrangements), des proches du pouvoir vont entrer en concurrence avec eux et mettre en place une filière de contrebande «officielle» avec le bois saisi ou racheté aux trafiquants. C'est l'époque du partage forcé, mais l'Etat est de plus en plus hors-jeu: les impôts ne rentrent plus. En fait, il a été capturé, non par les trafiquants, mais par leurs concurrents en col blanc. Deux filières illégales d'exportation vont ainsi entrer en concurrence: celle des trafiquants, avec la contrebande nocturne depuis les plages de la côte Est ou par les ports du Nord-est, sous fausse déclaration; celle des proches du pouvoir, beaucoup plus massive, au départ de Toamasina, sous fausse déclaration en douane et avec la complicité intéressée ou imposée à l'Administration. Et ce, jusqu'à épuisement des stocks de bois de rose, sans doute réalimentés par des dépôts cachés en forêt et quelques coupes nouvelles.

L'État

En avril 2010, le décret qui instaure un moratoire sur la coupe et l'exportation de bois précieux de Madagascar n'est toujours pas promulgué par le Gouvernement. Son entrée en vigueur fait l'objet d'un marchandage avec les bailleurs de fonds internationaux : tant que l'aide financière n'arrive pas, le décret n'est pas appliqué. Quelques jours plus tard, tout rentre dans l'ordre: le ministre des Eaux et Forêts signe la note d'application. Mais immédiatement, le Premier ministre Camille Vital se rend à Maroantsetra où il ordonne le transfert de tous les dépôts de bois de rose vers Toamasina, en contradiction avec la note signée 48 heures plus tôt par son ministre des Eaux et Forêts, qui interdit tout mouvement de bois de rose (Randriamalala *et al.* 2010). Peu après, en avril 2010, le ministère des Finances et du Budget écrit à l'Association Professionnelle des Banques (lettre n°32/MFB/SG) pour lui demander de bien vouloir rouvrir les comptes en banque des exportateurs de bois de rose, au motif qu'ils sont également dans leur majorité exportateurs de vanille, et que cette clôture de compte allait pénaliser la prochaine campagne de vanille. Pendant un an, la situation est gelée et le bois quitte le pays discrètement, en petites doses. Mis en demeure d'agir par l'UNESCO en juillet 2011, la Présidence de la HAT prend une ordonnance (2011/01) qui durcit considérablement la législation forestière: peine de prison pour les trafiquants, les acheteurs, les coupeurs, les transporteurs et les receleurs de bois de rose, sans possibilité de sursis ni de circonstances atténuantes. Tous les agréments d'exportation sont annulés, ainsi que toute la législation antérieure avec ses contradictions internes. Mais sur le terrain, les choses sont beaucoup plus nuancées. En août 2011, le Ministre des Eaux et Forêts tient une réunion à Sambava en présence des principaux trafiquants de bois de rose. Cette réunion fait suite à l'agitation «populaire» organisée peu avant par le Cartel d'Antalaha pour protester contre l'annonce de la saisie des stocks de bois de rose par le gouvernement. Lors de la réunion, dans la partie à huis clos, le ministre maintient sa fermeté: tous les stocks de bois de rose seront saisis après indemnisation. Mais le ministre ne dit pas s'il envisage de poursuivre en justice les autres détenteurs de bois de rose (ceux dont les papiers ne sont pas en règle). Un jeune trafiquant inconnu menace le ministre: «nous préférons brûler notre bois plutôt que le voir saisi! Et nous brûlerons aussi le Tribunal d'Antalaha!». Alors que Madagascar inscrit ses *Dalbergia* et ses *Diospyros* en annexe III de la CITES (Convention Internationale sur le Commerce d'Espèces Menacées: l'annexe III oblige à certifier que les arbres vendus ont été coupés légalement), le Cartel d'Antalaha continue de défier publiquement l'autorité de l'État. Les éléments de la Task Force participent activement au trafic, les dépôts de bois saisis par l'Administration sont violés, les maires jouant le rôle d'indicateurs. Au début de 2012, les trafiquants affrètent un avion d'Antalaha à la capitale, pour assister à une réunion sur le bois de rose avec les officiels du gouvernement. Le gouvernement leur demande de remettre leur bois pas encore saisi, pour qu'il le vende et l'exporte luimême. Les trafiquants rétorquent qu'ils ont plus de contacts, d'expérience, de savoir-faire, et donc, qu'ils souhaitent exporter eux-mêmes leur bois, quitte à payer plus de taxes. Mais l'accord ne se fait pas. Les trafiquants luttent pour ne pas être écartés des exportations et se faire ainsi déposséder de leur bois. Finalement, le Gouvernement cède puisque le ministre de l'Environnement et des Forêts prend en janvier 2012 l'arrêté 0741/2012 qui, en son article 4, autorise l'exportation du bois «toutes catégories confondues, sous toutes ses formes » (bois brut et bois travaillé). L'autorisation d'exporter est accordée à toute personne physique ou morale qui en fait la demande dans les formes prescrites. Le nombre d'agréments officiels d'exportation explose en effet: à Antalaha, il passe de 20 (avril 2010) à 60 (janvier 2012)! A Sambava, de 5 à 17 et à Antananarivo, de 1 à 7 pour les mêmes dates (Randriamalala 2013). Ce simple arrêté contredit formellement l'ordonnance présidentielle. Lors d'un Conseil des Ministres assez agité, le 22 février 2012, l'arrêté 741/2012 du ministre des Eaux et Forêts est amendé. Le bois de rose et l'ébène sont exclus des exportations. Mais deux jours plus tard, le même ministre rassure les trafiquants, réunis pour la circonstance à l'hôtel Las Palmas à Sambava: «tous vos stocks de bois de rose seront exportés d'ici 3 mois.» Un navire chinois (le *Great Luck*) est pourtant arraisonné au large d'Antalaha par les garde-côtes. Conduit à Tamatave où il est inspecté, il est autorisé à repartir car il est vide. Il venait probablement charger le bois qui vient d'être saisi par l'État. Puis le boutre *Ul Reach* est arraisonné à son tour au large de Mananara. Il est soupçonné de se livrer à la contrebande du bois de rose. Le ministre des Eaux et Forêts devient alors gênant: il perturbe le fonctionnement bien huilé des deux filières d'exportation, mécontentant ainsi les trafiquants-contrebandiers et le fragile équilibre qu'ils ont atteint avec les proches du pouvoir, exportateurs sous fausse déclaration par Toamasina. Il est donc limogé le 13 avril 2012 et fort curieusement, non remplacé. Le Premier ministre est désigné pour assurer l'intérim, ce qu'il ne fera pas. En pleine tempête, le bateau des Eaux et Forêts demeure sans capitaine, jusqu'à ce jour, ce qui semble faire l'affaire de beaucoup de monde. L'action de l'État est toujours aussi peu lisible.

Les trafiquants, filière historique

À la mi-2010, la situation à Mananara-Nord est grave. Le bois de rose est presque épuisé dans le Parc. Des trafiquants se vantent d'être «conseiller spécial du ministre» et osent menacer les Officiers de Police Judiciaire de mutation punitive s'ils tentent de les poursuivre. La coupe et l'acheminement des produits continuent. A Foulpointe, des bateaux viennent régulièrement la nuit devant les plages. Ils jettent des billes de bois de rose dans la mer non loin du rivage et des camions les récupèrent la nuit suivante. Le bois vient de Mananara et doit rejoindre Toamasina. Dans le Masoala, la coupe continue avec la même intensité qu'en 2009. Mais maintenant, on accepte des billes avec des diamètres plus petits et on doit aller au plus profond de la forêt pour les trouver. Ce rythme pourrait se maintenir encore cinq ans, après quoi, il n'y aura plus rien à couper. Comme l'État ne tranche pas assez vite sur le sort des stocks de bois, en avril 2012 les trafiquants manifestent à Antalaha contre la saisie de 3 000 rondins au cœur du Masoala. Ils menacent le Directeur Régional des Eaux et Forêts et réclament le départ de la Force Mixte, chargée de réprimer le trafic. Les trafiquants défient toujours ouvertement l'État. L'embarquement off-shore se poursuit cependant devant le Masoala, pour les opérateurs historiques comme pour les nouveaux-venus dans ce circuit. Un gros navire attend au large, tandis que des coques rapides font la noria depuis les plages, transportant quelques billes de bois de rose à chaque voyage. A l'arrivée des autorités, tout le monde disparaît. A la mi-août 2012, les trafiquants organisent un forum économique à Antsiranana, au cours duquel ils demandent la reprise des exportations (Midi Madagascar 2012). En septembre 2012, il apparaît que les coupes, le transport et l'exportation de bois de rose n'ont jamais cessé dans le Masola et autour de Mananara. La pièce maîtresse du dispositif est une grande barge chinoise (*Peace*) équipée de deux grues, postée devant la baie d'Antongil. Des boutres d'Antalaha, de Mananara, de Maroantsetra lui amènent les billes de bois. Une fois pleine, la barge va transborder sa cargaison vers un bateau plus gros, chinois lui-aussi, ancré au large. D'autres trafiquants utilisent les ports officiels. Ainsi, le 17 septembre 2012, le *Kiara* (CMA-CGM) exporte 3 conteneurs de bois de rose vers Shenzhen, sous une fausse déclaration douanière, au départ du port de Diego.

Les trafiquants, filière «cols blancs»

En août 2010, deux proches du Président se rendent en Chine pour un voyage d'affaire, tandis qu'à Maroantsetra, la disparition des stocks en attente se poursuit en direction de Toamasina. Les petits bateaux débarquent leurs billes de bois de rose de nuit sur les plages autour de la ville. Elles sont rentrées dans des dépôts privés, puis évacuées par la route ou par bateau vers un entrepôt de Toamasina. Son propriétaire est de la famille du Premier ministre. Déjà, en juin 2010, une cargaison illégale de 300 tonnes de bois de rose avait étés saisie par les autorités comoriennes à bord du navire *Soavina III* en provenance de Madagascar. Le 22 juin 2011, six conteneurs de bois de rose en provenance de Toamasina sont découverts à l'Ile Maurice et saisis par la Douane de ce pays. Ils étaient déclarés comme haricots secs, cornes de zébus et produits marins. Puis cinq ou six autres conteneurs de bois de rose sont saisis à Tuléar, après un passage au scanner par les Douanes. Ces échecs internationaux à répétition font désordre et donnent une mauvaise image de la HAT, d'autant plus qu'aucune enquête n'aboutit: la filière réservée aux proches du pouvoir doit mieux s'organiser. En novembre 2011, à Toamasina, la voie rapide se met en place: ordonnée par le sommet de la hiérarchie douanière, elle est réservée aux exportateurs chinois pour l'ilménite, le nickel, le quartz industriel et autres ressources naturelles. Les formalités sont réduites, les conteneurs ne passent pas au scanner. Il suffit donc de bénéficier de complicités dans l'Administration pour pouvoir glisser du bois de rose dans cette filière. Il n'en faut pas plus pour que les acheteurs chinois reviennent à Madagascar. Ils préfinancent leurs commandes de bois de rose à hauteur de 50 %, ce qui signifie qu'ils évaluent faiblement les risques de voir leur bois saisi ou bloqué sur place. Le cours réel du bois de rose monte: de 10 à 12 US$ le kilo, prix FOB au départ de Toamasina en janvier 2012, il est autour de 40 US$ en octobre 2012. Les difficultés à exporter et la pénurie de bois qui commence à se faire sentir font grimper les cours, d'autant plus qu'on évoque un possible embargo chinois sur le bois précieux en 2013. En retour, un phénomène se fait jour: le blanchiment de l'argent du bois de rose. Des masses considérables d'argent sont entre les mains des exportateurs de bois. Ils ne peuvent le déposer en banque sans se faire repérer par le SAMIFIN, l'organisme chargé de lutter contre l'argent sale. Alors ils achètent de la vanille et la stockent. Conséquence: le cours de la vanille monte en flèche. Fin juillet 2012, deux conteneurs de bois de rose sont rapatriés de Malaisie, à la demande des Douanes. Ils font partie d'un lot de 12 qui ont échappé à tout contrôle douanier. L'acheteur chinois et son vendeur ont établi des faux documents, au nom d'une société fictive. Ils ont berné la compagnie maritime, avec la complicité de deux agents des Douanes de Tamatave, qui sont incarcérés. Au moins 4 conteneurs seraient arrivés à Hong Kong, sans espoir de les récupérer. Dans les deux conteneurs récupérés, le bois de rose est déjà connu auprès des Douanes: il a été saisi une première fois, puis confié sous séquestre à l'un des opérateurs «historiques». Ce dernier a le droit de le détenir mais pas de l'exporter, ce qu'il a pourtant fait. Le système est donc poreux.

En novembre 2012, l'un des porte-parole officiels des trafiquants fait un point de situation public. Selon lui, il n'y a presque plus de bois en attente à Vohémar, encore un peu à Sambava, beaucoup à Antalaha et plus du tout dans la Région Analajirofo.

Après vérification, ces affirmations sont vraies. En plus des norias de bateaux depuis les plages vers des bateaux plus gros en attente au large, la majeure partie du bois de SAVA fait mouvement par la route vers la capitale. Les divers barrages de contrôle sont franchis sans difficulté, avec des documents administratifs en règle. Arrivé à destination, le bois est empoté directement dans des conteneurs sous douane, acheminé à Toamasina et embarqué par la filière rapide, sans passer au scanner, grâce aux bons soins d'un transitaire proche du pouvoir. La liquidation du stock en attente est donc imminente, sauf si la coupe continue afin de réalimenter les stocks, maintenant que la filière d'évacuation est bien huilée.

La communauté internationale

la presse internationale continue d'alimenter ses lecteurs sur le sujet, que ce soit la presse scientifique (Barrett *et al.* 2010) ou les journaux à grand tirage (Bearak 2010, Draper 2010). En novembre 2010, l'Environmental Investigation Agency met en ligne une vidéo impliquant le président Rajoelina dans le trafic de bois de rose (Butler 2010). Madagascar est de plus en plus sous le feu des projecteurs, ce qui oblige la communauté internationale à réagir. En juillet 2011, l'UNESCO demande à Madagascar de prendre des mesures pour faire disparaître les stocks de bois de rose. Par sa résolution F7 A10 concernant les Forêts Humides de l'Atsinanana, elle «décide de maintenir les Forêts humides de l'Atsinanana (Madagascar) sur la Liste du patrimoine mondial en péril.» (UNESCO 2011). Le Comité du Patrimoine mondial adopte de son côté la résolution F 35 COM 7A.10 par laquelle il «prie instamment l'Etat partie de prendre des mesures urgentes comme mesures correctives pour arrêter l'exploitation illicite forestière (Comité du patrimoine mondial 2011). La communauté internationale tente de revenir dans le dossier bois de rose lorsqu'en septembre 2012, la Banque Mondiale conclut un accord, toujours inexécuté à ce jour, par lequel elle accorde un prêt de 52 millions de dollars à des ONG et associations environnementales garanties par l'Etat malgache.

Conclusion

Le pillage des ressources forestières dans le Masoala et plus généralement dans les forêts humides de l'Est est documenté depuis 1850 (Randriamalala 2013). De nombreuses vagues de coupe ont eu lieu, sous tous les régimes, la dernière étant survenue dans le Marojejy en 2005-2006 (Patel 2007).

Mais celle de 2009 marque un paroxysme dans les quantités de bois coupé, la rapidité de la coupe et la violence employée par les coupeurs. Dans quelques semaines ou dans quelques mois au plus tard, il n'y aura plus de problème de bois de rose à Madagascar, la ressource ayant disparu, avant que l'écologie des *Dalbergia* ssp. aient pu être vraiment étudiée, ainsi que le dénombrement de ses espèces. Il est possible qu'un jour prochain, le traçage des arbres par leur ADN depuis leur lieu de coupe jusqu'à leur acheteur final soit une réalité (Nielsen *et al.* 2008) et permettra ainsi un meilleur contrôle de la filière, notamment dans les pays où l'État est faible.

Mais durant cette crise, l'État a disparu, ainsi que le respect pour l'environnement que des décennies d'éduction avaient établi dans l'esprit des communautés riveraines des parcs. Constatant le laisser-aller général, les villageois ont été prompts à céder à leurs vieux démons. Quant aux fonctionnaires, qu'ils soient gendarmes chargés d'intercepter les transports de bois, douaniers chargés de vérifier la sincérité des documents d'exportation, magistrats chargés de réprimer les infractions à la loi ou hauts fonctionnaires chargés de mettre un peu d'ordre dans ce capharnaüm réglementaire, certains ont décidé de rester fidèles à l'intérêt général et ils en ont grand mérite. D'autres ont préféré suivre leur intérêt particulier, à l'instar de plusieurs hommes politiques et proches du pouvoir. Ce délitement de l'État mettra d'autant plus de temps à se combler que d'autres menaces, tout aussi lucratives et tentatrices, se font jour dans les forêts : l'exploitation des ressources minérales (pierres précieuses et semi-précieuses), minières ou pétrolières. Que pèsera la protection d'espèces menacées par l'exploitation des sables bitumineux de Bemolanga face aux ressources financières attendues?

Moralement, le terrain est prêt pour un saccage à une échelle encore plus grande. Le bois de rose pourrait bien n'avoir été qu'un avant-goût de ce qui se prépare. Il y a peu, une évaluation estimait à 30 le nombre de lémuriens servis chaque jour dans les restaurants d'une ville moyenne de la côte Est. Si les *fady* (interdit culturel) ne protègent plus les lémuriens, qui protégera les enfants de ce pays? Quel avenir leur est donc réservé?

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Funding and Training

AEECL Small Grants

Since 2009, AEECL awards two small grants of up to €1,000 each year to graduate students, qualified conservationists and/or researchers to study lemurs in their natural habitat. Priority is given to proposals covering conservation-relevant research on those species red-listed as Vulnerable, Endangered, Critically Endangered or Data Deficient by the IUCN. We support original research that helps with establishing conservation action plans for the studied species. Grants are normally given to recent graduates from Malagasy universities to help building local capacity.

We may also, in special circumstances, support studies on Malagasy species other than lemurs if the proposal provides satisfactory information as to how lemurs or the respective habitat/ecosystem as a whole will benefit from the research.

All proposals will be assessed by the Board of Directors of AEECL and/or by external referees. The deadline for applications is February 15th of each year. Successful applicants will be notified by June 1st. More information can be found on the AEECL website, www.aeecl.org.

The Mohamed bin Zayed Species Conservation Fund

Announced at the World Conservation Congress in Barcelona in 2008, The Mohamed bin Zayed Species Conservation Fund is a significant philanthropic endowment established to do the following:

- Provide targeted grants to individual species conservation initiatives;
- Recognize leaders in the field of species conservation; and
- Elevate the importance of species in the broader conservation debate.

The fund's reach is truly global, and its species interest is non-discriminatory. It is open to applications for funding support from conservationists based in all parts of the world, and will potentially support projects focused on any and all kinds of plant and animal species, subject to the approval of an independent evaluation committee.

Details on this important source for species conservation initiatives and research can be found at **http://www.mbz-speciesconservation.org.**

The Primate Action Fund 2013-2014 – Conservation International

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The objective of Conservation International's Primate Action Fund is to contribute to global biodiversity conservation by providing small grants for the conservation of threatened non-human primates and their natural habitats. The maximum award is $5,000. Projects submitted to the foundation are considered if they have one or more of the following characteristics themes: 1) enhancement of scientific understanding/knowledge of the target species/ecosystem; 2) improved protection of a key species, habitat, or reserved area; 3) demonstration of *economic* benefit achieved through conservation of a species and its habitat, as compared to the loss thereof; 4) increased public awareness or educational impact resulting from the project in question; 4) improved local capacity to carry out future conservation efforts through training or practical experience obtained through project participation; and 6) modification of inappropriate policies or legislation that previously led to species or habitat decline. The Primate Action Fund is supported by an annual grant (May/June) from the Margot Marsh Biodiversity Foundation, Virginia. For application guidelines, please contact Anthony B. Rylands at Conservation International, e-mail: **a.rylands@conservation.org**. Applications should be submitted electronically.

The following 11 projects were supported in Madagascar during the 2013–2014 funding cycle, with a total disbursement of US $37,575:

1. Population and Behavioral Assessment of the Northern Sportive Lemur (*Lepilemur septentrionalis*) in the Montagne des Francais region, Northern Madagascar – Mary Dinsmore & Karen B. Strier.
2. Investigating a Possible New Species of *Lepilemur* in Southern Ranomafana National Park, Madagascar – Santiago Cassalett & Patricia Wright.
3. Modelling the Distribution of Folivorous Lemurs Under the Impact of Climate Change: *Lepilemur leucopus* and *L. petteri* – Ellay Stalenberg, Joerg Ganzhon, Wiliam Foley & Hanta Razafindraibe.
4. Remotely Sensed Anthropogenic and Cyclonic Disturbance in Eastern Madagascar Rainforests and Its Impacts on the Distributions of the Greater Bamboo Lemur *Prolemur simus*, Indri *Indri indri*, Black-and-White Ruffed lemur *Varecia variegata*, and Diademed Sifaka *Propithecus diadema* – Erik Olson.
5. The Only Solitary *Lepilemur*?—the Social Organization of the Highly Endangered Sahamalaza Sportive lemur (*Lepilemur sahamalazensis*) in the Sahamalaza – Ile Radama National Park, Madagascar – Isabella Mandl.
6. Examining the Viability of Ring-tailed Lemur (*Lemur catta*) Populations Inhabiting Small Forest Fragments in South-central Madagascar – Liza Gould.
7. Support for the Publication of *Lemurs of Madagascar – A Strategy for Their Conservation 2013–2016* – Christoph Schwitzer.
8. Updating the Knowledge on the Population Dynamics and Behavior of the Black-and-White Ruffed Lemur *Varecia variegata* in Southern Ranomafana National Park, Madagascar – Fanny Cornejo.
9. Field Course "Tropical Ecology: Behavioral Ecology and Conservation Biology of Tropical Vertebrates" – Solofonirina Rasoloharijaona, Romule Rakotondravony, Ute Radespiel & Elke Zimmermann.
10. Adapting Remote Sampling of Biomaterial for Conservation of Canopy-dwelling Primates: A Study with Red Ruffed Lemurs, *Varecia rubra*, on Masoala Peninsula, Madagascar – Monica Mogilwesky & Natalie Vasey.
11. Support for the International Prosimian Congress, Ranomafana, Madagascar, 4th–9th August 2013, "How science and policy can pull prosimians back from the brink of extinction?" – Serge Rajaobelina & Jonah Ratsimbazafy.

News and Announcements

Who pays the price if the goose laying the golden eggs is no longer in Madagascar's forests?

Jonah Ratsimbazafy
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Over the last two decades, I have travelled throughout Madagascar and visited countless forests where lemurs live. I originally visited many of these forests as a student in the early 1990s; I visited other forests simply because I enjoy seeing local lemurs in their natural habitats. I have always found it exciting to see wild lemurs using the habitats as they want and eating the food that they like. What I see now, almost everywhere I go, are forests that look nothing like those I saw 20 years ago. For example, I was recently walking for six hours in a rainforest with my colleagues. We expected to hear the loud calls of the ruffed lemurs and strong melodical songs of the indri. We did not. All we could hear were a few birds singing and insects screaming. All we saw were old campsites with lemur snares surrounding them. Clearly, large-bodied lemurs have been hunted. Do these species even exist in these forests anymore? Ecologists call this "*empty forest syndrome*." I call it sad to visit an empty and very silent forest. In the tourist centers I see the beautiful pictures of the different lemurs who are supposed to be in the forest. These tourists travel for thousands of miles and spend a lot of money to see wild lemurs, but they will not see them anymore. Who will pay the price if there are no more lemurs in Madagascar's forests?

Almost 20% of the world's primates are found in Madagascar; the lemurs are found nowhere else on Earth. With the recent discovery of the two mouse lemurs, Madagascar's 50,000 km^2 of forests are home to 105 species and subspecies of these unique and endemic creatures. Tourists know how special Madagascar and its lemurs are and put a trip to the Eighth Continent on their life list of places to visit. Seeing wild lemurs once in a lifetime is a dream for nature lovers and naturalists around the world. Notably, tourism contributes a substantial amount of resources for Madagascar. If lemurs are no longer in the forests, what incentive do tourists have to visit?

In some forests, like Andasibe/Analamazaotra, Ranomafana, Anjà, and Ankarafantsika, local guides and communities benefit substantially from tourist visits. However, gold and sapphire mining and miners damage the protected forests and hunt lemurs because laws are not respected or reinforced. These activities constantly threaten the survival of Madagascar's flagship species. Local communities will pay a high price for such a loss; if the forests are devoid of lemurs there will be no tourists and the local guides will have no way of supporting their families and communities. Cascade effects of this economic burden will be felt as children are forced to quit school at an early age to help support their families. Over time, the economic impact will affect food security, with serious ethical and political implications. Overall, the loss of lemurs has implications for the entire country, and without efforts to better safeguard this precious national resource, all of Madagascar's residents will ultimately suffer. Indeed, all nature lovers will pay the price if the nation's wealth of 105 lemur species is relegated to the same destiny as their ancestors.

Alison Jolly awarded Honorary Doctorate in Madagascar

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Dr. Alison Jolly has been awarded the "*Honoris causa Doctor*" discerned by the University of Antananarivo, Madagascar. Please join me in congratulating Alison on this achievement.

Duke University Lemur Center initiates new SAVA Region conservation programme

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Duke University Lemur Center has initiated a new conservation program in the SAVA region (Sambava, Antalaha, Vohemar, Andapa) of northeastern Madagascar. Biodiversity is immense in this region with the mountainous reserves Marojejy National Park and Anjanaharibe-Sud Special Reserve protecting over 820 km2 of mainly pristine rainforest. Project goals include environmental education, reforestation, fish farms, and direct collaboration with Madagascar National Parks (Andapa) on a variety of projects. Lemur research with an emphasis on the critically endangered silky sifaka (*Propithecus candidus*) is also an important component of this initiative. View our recent newsletter to learn more about this growing project: **http://connect-technology.net/Clients/SAVA/Sep2012**.

Secrétaire Général du GERP

Rose Marie Randrianarison
GERP, Department of Palaeontology Anthropology, University of Antananarivo, Madagascar, **sissie@gerp-mg.org**

Pr. Jonah Ratsimbazafy a été reconduit de nouveau au poste de Secrétaire Général du GERP (Groupe d'Etude et de Recherche sur les Primates de Madagascar) le 21 décembre 2012, pour un mandat de trois ans (2013 -2015). Toutes nos félicitations!

Theses completed

Ibouroi, M.-T. 2012. Impacts des différents facteurs (naturels et anthropiques) sur la diversité morphologique et estimation de la densité des populations de *Microcebus* (E. Geoffroy, 1828) et *Lepilemur* (E. Geoffroy, 1851) du Nord de Madagascar. Mémoire de Master II, Faculté des Sciences, Option Primatologie et Evolution, Département de Biologie Animale et Ecologie, Université de Mahajanga, Madagascar. Travail réalisé sous la responsabilité de L. Chikhi et C. J. Rabarivola, et co-encadré par J. Salmona.

Cette étude effectuée au cours des mois de juillet à octobre 2010 dans trois fragments forestiers de la région de Loky-Manambato (Bekaraoka, Binara et Solaniampilana) avait pour but d'une part, d'étudier la variabilité morphologique de Microcebus tavaratra entre forêts, et d'autre part, d'estimer les densités et tailles de populations de M. tavaratra et Lepilemur milanoii de la région. Pour l'étude de la densité, nous avons utilisé la méthode de Distance Sampling sur des transects linéaires et en conséquence, seuls deux fragments forestiers ont pu être analysés (Bekaraoka et Solaniampilana). Pour ces deux, deux méthodes distinctes ont été appliquées au cours des analyses (Müller et Buckland). Ces deux méthodes sont basées sur le même principe mais diffèrent dans l'estimation de la distance d'observation efficace (ESW: effective strip width). Pour l'étude morphométrique, nous avons utilisés la technique de capture utilisant des pièges de Sherman et la technique de prise des mensurations morphométriques déjà utilisée par Zimmerman et al. (1998). Nous avons également mené des questionnaires au niveau des populations locales pour connaître les différentes pressions que subissent ces espèces. Les densités obtenues suite à l'application des méthodes de Müller et de Buckland sont similaires, suggérant que des résultats obtenus dans différentes études peuvent probablement être comparés. En revanche nous avons trouvé des résultats assez différents entre les deux espèces de lémuriens étudiées et, pour la même espèce, entre les deux forêts étudiées (Solaniampilana et Bekaraoka). Les données morphométriques suggèrent que les individus *M. tavaratra* de la forêt de Bekaraoka présentent des différences significatives

avec les individus de Binara et Solaniampilana. Les différences morphologiques et de densité observées sont difficiles à interpréter à ce stade car trop peu de fragments forestiers ont pu être étudiés au cours de ce travail. On peut évoquer le rôle de la Manakolana, rivière qui sépare Bekaraoka des deux autres forêts, pour expliquer les résultats de l'analyse morphométrique, ou les types de forêts ou de pression anthropiques pour expliquer la variation des densités. Cependant, à ce stade il nous semble important de réalisés d'autres études similaires dans d'autres fragments, ainsi que des validations dans les mêmes forêts. Pour conclure, les principales perturbations identifiées sont le défrichement, la production de charbon de bois, les exploitations illicites de bois précieux et de bois de construction, la culture sur brûlis, et l'orpaillage.
Mots-clés: Morphométrie, densité, *Microcebus tavaratra*, *Lepilemur milanoii*, Région Loky-Manambato.

Pais, I.G.A. 2011. Genetic diversity in a little known lemur species from the north of Madagascar (*Microcebus tavaratra*). Masters in Conservation Biology, Departamento de Biologia Animal from the Faculdade de Ciência da Universidade de Lisboa (FCUL), Portugal. Under the supervision of L. Chikhi, Laboratoire Evolution et Diversité Biologique, CNRS/UPS, Toulouse, France and Instituto Gulbenkian de Ciência, Lisboa, Portugal.
Species delimitation and population genetic studies can provide information on the evolution of species, as well as their response to natural or anthropogenic pressures. However, for many species these effects have not yet been studied and need further research. This is the case for mouse lemurs (genus *Microcebus*) living in the forests of Daraina. We sequenced the mitochondrial DNA of 72 Microcebus individuals sampled in three forest fragments in order to determine if they are all members of the same species – *M. tavaratra*, previously identified in two individuals from this region. We also wanted to understand how genetic diversity is distributed within and between populations for both mitochondrial and nuclear genes (microsatellites), as the Manankolana river and other natural features in Daraina have shown to play a role in the genetic structure of other lemur species from this and other regions. Finally, we tried to identify genetic clusters despite the limited number of nuclear loci and populations sampled in this study, and determine if these clusters correspond to specific features of the habitat. The results suggest that all individuals belong to the *M. tavaratra* species and that high genetic variation is maintained in populations from Bekaraoka and Solaniampilana. However, the lack of genetic diversity in the Binara forest across all mtDNA loci is surprising. Microsatellite data, showed that the Binara population exhibited similar levels of genetic variability compared to the other sampled locations. Moreover, no clear clustering could be defined at the nuclear level. Despite probably being the most geographically extensive study on *Microcebus* from Daraina, our results suggest that more research should be carried out across the whole region. Studies like this are important for the implementation of appropriate and effective conservation plans for threatened species.

Rakotondrabe, A.R. 2012. Etude du comportement alimentaire et utilisation de l'habitat par *Propithecus coronatus*. Cas de la forêt galerie d'Amboloando (CR Dabolava, District Miandrivazo). Mémoire de DEA en Paléontologie et Evolution Biologique, Biologie Evolutive, Primatologie, Département de Paléontologie et Anthropologie Biologique, Faculté des Sciences, Université d'Antananarivo, Madagascar.
Une étude sur le comportement alimentaire et sur l'utilisation de l'habitat par *Propithecus coronatus* a été réalisée dans la forêt d'Amboloando (CR Dabolava) en mars et avril 2010 afin d'analyser le mode de vie adopté par cette espèce pour survivre dans un habitat très fragmenté. La méthode «Instantaneous sampling» pour un intervalle de 3 minutes et «ad libitum» ont été utilisées durant les observations. Les résultats indiquent la domination du comportement de repos (54.69 %) et de l'alimentation (31.58 %) sur l'activité générale de l'espèce. Particulièrement, pour l'alimentation, malgré la saison de l'étude et l'état de l'habitat, Propithecus coronatus demeure un lémurien folivore. Il consomme des feuilles (62.96 %), des fruits (28.66 %) et une quantité minime des autres parties végétales. Mais la consommation de ces types d'aliments varie avec le sexe et la saison. *Propithecus coronatus* consomme 35 variétés de plantes pour satisfaire son besoin alimentaires, et pour 3 mn, l'espèce fait une moyenne de 20.23 ± 0.14 bouchés lors de l'alimentation. Parmi les différents endroits du site, la zone I est la plus exploitée par l'espèce suite à sa qualité moins dégradée et loin des tapages. A Dabolava, Propithecus coronatus utilise d'avantage le niveau moyen compris entre 5 à 10 m (40.94 %) et le niveau haut 10 à 15 m (22.46 %). Quant à l'utilisation des supports, l'espèce utilise beaucoup plus les branche d'arbres à dimension ≤ 5 cm (48.50 %) et les branches de diamètre compris entre 5 et 10 cm (32.58 %). L'utilisation mensuelle entre les sexes de ces niveaux et diamètres est significativement différent. Comparé aux comportements de *Propithecus diadema* de la RNI de Betampona et de *Propithecus coronatus* de la forêt d'Antrema, le comportement et le mode de vie de Propithecus coronatus de Dabolava présente quelques variations qui résultent probablement de la qualité de l'habitat et de la répartition phytogéographique. Mais des similarités sont aussi observées. En bref, malgré la dégradation de son habitat, *Propithecus coronatus* est contraint de s'adapter à son milieu pour survivre.
Mots clés: *Propithecus coronatus*, lémuriens, activités, nourriture, habitat, Madagascar.
A study into feeding behaviour and habitat utilisation of the crowned sifaka (*Propithecus coronatus*) was carried out at the Amboloando forest (CR Dabolava) in March and April 2010. This study was conducted in order to investigate the way of life adopted by this species within a highly fragmented habitat. Instantaneous sampling at 3 minute intervals and ad-libitum were the behavioural methods used during the study. Results show that the general activity of this species favours a domination of resting (54.69 %) followed by feeding (31.58 %). In spite of the study season and the state of the habitat *Propithecus coronatus* remains a folivorous lemur. It consumed leaves (62.96 %), fruits (28.66 %) and a small quantity of other plant parts. Its consummations vary according to the sex and the season. *Propithecus coronatus* eat 35 varieties of plant to satisfy their energetic needs. Among the different areas of the site, zone I is the most exploited by this species due to its qualities of being less disturbed and far from noise. In Dabolava, crowned sifaka use the middle level of the canopy between 5 to 10 m (40.94 %) and the high level 10 to 15 m (22.46 %). With regards to the support utilisation, this species use more tree branches with a diameter of less than 5 cm (48.50 %) than diameters ranging between 5 to 10 cm (32.58 %). Monthly use of strata and diameters differed significantly between sexes. Compared with the behaviour of the diademed simpona (*Propithecus diadema*) at RNI, Betampona, and *Propithecus coronatus* at Antrema forest, the behaviour and lifestyle of *Propithecus coronatus* in Dabolava show some variation which probably result from their habitat quality and phytogeographical sparsity. On the other hand, some similarities are observed too. In spite of their habitat degradation, *Propithecus coronatus* is forced to adapt to its habitat to survive.
Key words: *Propithecus coronatus*, lemurs, activities, diet, habitat, Madagascar

Ralantoharijaona, T.N. 2012. Application de différentes méthodes d'estimation de la densité, étude de la diversité morphologique et des caractéristiques des dortoirs chez *Lepilemur milanoii* (Louis *et al.*, 2006) dans les fragments forestiers de la région Loky-Manambato au Nord de Madagascar. Mémoire de Master II, option Primatologie et Evolution, Département de Biologie Animale et Ecologie. Faculté des Sciences Université de Mahajanga, Madagascar. Travail réalisé sous la responsabilité de L. Chikhi et C. J. Rabarivola, et co-encadré par J. Salmona.
Ce travail a pour but principal d'estimer la densité des populations de *Lepilemur milanoii* dans différents fragments forestiers de la région Loky-Manambato, d'étudier leur diversité morphologique et les caractéristiques de leurs dortoirs afin de contribuer à leur conservation. La région Loky-Manambato est classée dans le Système des Aires Protégées de Madagascar (SAPM). *L. milanoii* est une espèce de lémurien nocturne confiné à cette région, et sur laquelle existent très peu de données biologiques. Au cours de ce travail, réalisé pendant la saison sèche 2011 (22 juin – 22 octobre), nous avons estimé la densité et la taille (ou abondance) de population de *L. milanoii* en utilisant la méthode de «Distance Sampling», sur transects linéaires, dans six fragments forestiers et réalisé un effort total de 110,16 km. Le résultat de suivi nocturne sur transect linéaire présente 495 observations de lépilemurs. Quatre méthodes d'estimation de la densité (King, Kelker, Müller et Buckland) ont été utiisées pour estimer la densité de *L. milanoii* dans la région de Daraina. Elles sont basées sur le même principe mais diffèrent dans l'estimation de la distance d'observation efficace (ESW: effective strip width). L'application de ces quatre méthodes suggère que la méthode de King tend à produire des estimations plus élevées que les autres méthodes (Kelker, Müller et Buckland)

qui de leur coté produisent des estimations similaires. Par ailleurs, nous avons réalisé une étude morphométrique sur 278 individus dont 118 mâles et 160 femelles. Les données morphologiques suggèrent qu'il existe des différences significatives entre les populations des forêts humides et des forêts sèches pour 11 paramètres parmi les 16 étudiés. Nous avons notamment observé que les mâles ont les oreilles, et les bras plus longs que les femelles, bien que ces dernières soient en moyenne plus lourdes. Nous avons également observé une différence entre les populations situées à l'Est et à l'Ouest de la rivière Manankolana, pour douze des seize paramètres morphologiques étudiés. Une première étude sur les caractéristiques des dortoirs de *L. milanoii* a été réalisée dans douze fragments forestiers. Les résultats suggèrent qu'il n'y a pas de différence sur la plupart des paramètres mesurés tels que la hauteur, l'épaisseur l'ouverture et la profondeur du trou entre les forêts humides et sèches. L'ouverture du trou semble être le seul paramètre qui différencie les dortoirs utilisés par les mâles et femelles.

Mots-clés: *Lepilemur milanoii*, densité et taille de population, distance sampling, morphologie, dortoir

Seiler, M. 2012. The impact of habitat degradation and fragmentation on ecology and behaviour of the Sahamalaza sportive lemur, *Lepilemur sahamalazensis,* in northwest-Madagascar/ L'impact de la degradation et de la fragmentation de l'habitat sur l'écologie et le comportement du lépilémurien de Sahamalaza, *Lepilemur sahamalazensis*, dans le Nord de Madagascar. PhD Dissertation, University of Bristol, UK.

Habitat destruction and fragmentation are the main threats to the lemurs of Madagascar. The extent of impact of habitat alteration on a species is manifold and not clearly predictable without knowing the species' ecology and habitat preferences. This study examined baseline aspects of the ecology and behaviour of the Critically Endangered Sahamalaza sportive lemur (*Lepilemur sahamalazensis*). Study aims were to identify the lemurs' requirements regarding home ranges and sleeping sites, to investigate the influence of habitat degradation on the lemurs' ecology and behaviour, to describe its' vocal repertoire and to develop a non-invasive acoustic tool for rapid species identification. Data collection was conducted in the Ankarafa Forest, Sahamalaza, during three successive field seasons, amounting to twelve months of fieldwork from 2009 to 2011. For habitat descriptions of fragments and microhabitats I used the quarter point sampling method, for home range habitat descriptions a plot-based method. Focal animal sampling was used to create a 24-hour activity budget, and for night follows individuals were radio-tagged. Vocalisations were recorded during night follows using continuous sampling. Playback-experiments with predator calls as well as alarm calls of syntopic bird and lemur species were conducted during the day and with sportive lemur calls during the nocturnal focal animal sampling. The forest structure and tree species composition differed significantly between the five forest fragments, and differences in species composition suggested a lack of seed exchange, indicating that the Ankarafa Forest has been exposed to anthropogenic influences for several decades. Irrespective of the differences in overall structure and habitat parameters of the forest fragments, the microhabitat around sportive lemurs sleeping sites was similar in all measured habitat parameters, as were all measured parameters for the different sleeping trees. The abundance of sleeping sites and feeding tree species was an important factor for home range choice. Tree density was a critical factor for home range and sleeping site choice as a larger amount of canopy cover provided better protection from aerial predators. Results indicate that habitat requirements of the species can still be met by all of the forest fragments, regardless of their differing levels of degradation. The observed lemurs were highly folivorous and fed on 42 different tree species. Insects and fruits were added to the diet occasionally. Individuals had home ranges of 1.4 ha, but used only 0.5 ha of it during one night. They rested for prolonged times during their activity period. Based on low frequencies of social behaviour and the solitary use of sleeping sites, I concluded that the Sahamalaza sportive lemur is a solitary species. I could identify seven loud call classes for the Sahamalaza sportive lemur, most of which were structurally related to call classes described for other sportive lemur species, but differed in frequency and duration. Vocal parameters of the species' loud calls could thus be used for future non-invasive species monitoring and species identification for range boundary studies. The studied lemurs had high levels of active behaviour during the day, and higher diurnal levels of activity in tree hole compared to tree tangle sleeping sites, suggesting a higher predation risk in tree holes. Resting Sahamalaza sportive lemurs recognised predator vocalisations as indicators of increased predation risk, discerned vocalisations of different predators, and employed species-specific anti-predator behaviours. Furthermore, the studied Sahamalaza sportive lemurs were able to use information on predator presence and predator type in referential signals of different surrounding species, thereby taking advantage of the possibility of early predator detection through cross-species communication. This study highlights the need for effective protection of the few remaining intact forest fragments on the Sahamalaza Peninsula with their old trees and high tree diversity, which will be crucial for the long-term survival of the Sahamalaza sportive lemur.

La destruction et la fragmentation de l`habitat naturel des *lémuriens de Madagascar* sont les raisons principales qui menaces leur survie. Cependant, les conséquences de la perte ou de la modification de l'habitat peuvent être variées et sont difficilement prévisibles sans une connaissance approfondie de l'écologie des espèces menacées. La présente étude examine les aspects de base d`écologie et du comportement du lépilémurien de Sahamalaza (*Lepilemur sahamalazensis)*, une espèce en danger critique d'extinction. Les objectifs de cette étude furent d'identifier les besoins du lépilémurien en termes de domaine vital et de sites de sommeil, d'enquêter sur l'influence de la dégradation de l'habitat sur l'écologie et le comportement de l'espèce, de décrire son répertoire vocal et de développer un outil de détection et d'identification acoustique non invasif. La collection des données fut effectuée dans la forêt d'Ankarafa, Sahamalaza, durant trois saisons successives. Au total, cela représente 12 mois dans le terrain repartis entre les années 2009 et 2011. J'ai utilisé une méthode d'échantillonnage quart de point afin de décrire l'habitat à l'échelle du fragment et du microsite. Pour la description des domaines vitaux, j'ai utilisé une méthode basée sur des parcelles. L'échantillonnage d'animaux focaux ainsi que l'utilisation de colliers émetteurs furent employés afin d'établir un budget d'activité sur 24h. Les vocalisations furent enregistrées de façon continue pendant les suivis nocturnes. Des expériences de «playback» comprenant des appels de prédateurs ainsi que des cris d'alarme provenant d'oiseaux et de lémuriens furent effectués durant la journée. La structure et la composition de la forêt différaient de façon significative entre les cinq fragments. Les différences observées en termes de composition suggèrent un manque d'échange de semences, ce qui indique que la forêt d'Ankarafa a été exposée à des influences anthropiques depuis plusieurs décennies. Au-delà de ces différences, le micro-habitat autour des sites de sommeil était comparable à travers tous les aspects considérés. L'abondance de sites de sommeil et la présence d'arbres offrant une source de nourriture étaient des facteurs important dans l'établissement du domaine vital du lépilemurien. La densité d'arbre fut un facteur critique dans le choix du domaine vital et du site de sommeil, sans doute offrant une protection accrue contre les prédateurs aériens. Les résultats de cette étude montrent que les besoins écologiques de l'espèce peuvent encore être satisfaits au sein des fragments de forêt, quoi que soit leurs qualités. Le lépilémurien de Sahamalaza est en grande partie folivore, se nourrissant de près de 42 différentes espèces d'arbre. Insectes et fruits furent occasionnellement ajoutés au régime alimentaire de l'espèce. En moyenne, le domaine vital de cette espèce mesurait 1.4 ha. Cependant, au cours d'une seule nuit un individu ne se servait en moyenne que de 0.5 ha. De longues périodes de repos furent observées durant la phase nocturne. Au vu de la faible occurrence de contacts sociaux et de l'utilisation solitaire de sites de sommeil, je conclus que le lépilémurien de Sahamalaza est une espèce solitaire. Cette étude identifie sept catégories d'appels, la plupart structurellement comparables aux catégories décrites pour les autres espèces de lépilémurien, avec quelques différences en termes de fréquence et de durée. Les paramètres vocaux de cette espèce pourrait donc être utilisés à l'avenir afin d'identifier cette espèce dans le terrain. Les sujets montrèrent un niveau d'activité élevé durant la journée, avec un niveau plus élevé pour les animaux vivant dans des trous d'arbres. Ceci suggère un niveau de prédation plus important pour ces derniers. Les lépilémuriens au repos reconnaissaient les différents appels de prédateurs et montraient des comportements anti-prédateurs propres à chaque type de prédateur. De plus, les sujets semblaient pouvoir utiliser les informations sur les prédateurs émis par d'autres espèces. Cette étude met en évidence le besoin d'une protection efficace des morceaux de forêt qui demeurent intactes sur la péninsule de Sahamalaza. Cette protection jouera un rôle décisif dans la survie a long terme du lépilémurien de Sahamalaza.

Key words: *Lepilemur*, ecology, behaviour, vocal behaviour, habitat degradation and fragmentation, anti-predator behaviour

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Ranaivoarisoa, J.F.; Ramanamahefa, R.; Louis, Jr., E.E.; Brenneman, R.A. 2006. Range extension of Perrier's sifaka, *Propithecus perrieri*, in the Andrafiamena Classified Forest. Lemur News 11: 17-21.

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Book

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LEMUR NEWS VOL. 17, 2013

ISSN 1608-1439

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