Editorial

I recently read Alison Jolly's last book, *Thank You, Madagascar*, which was published shortly after her death and is based on her field diaries and notes (Jolly, 2015). It was a truly fascinating read, and I learned many things about the history of conservation in Madagascar that I didn't know before, particularly about the process of getting the National Environmental Action Plan in place. Even better, I also learned about the lives and careers of some of today's silverbacks in lemur conservation, people who I have known since I started working in Madagascar myself in 2003, many of whom I regard as mentors and friends. It was uplifting to read to what great lengths these people, Malagasy and *vazaha* alike (*vazaha* [noun]: a foreigner), have gone in order to make sure that the most threatened lemur species and their habitats were put under protection. One of these silverbacks of course was Alison Jolly herself, who worked tirelessly on the conservation education component of Madagascar's National Environmental Action Plan and, with the *Ako* series, published an excellent range of children's books with a strong conservation message that are today enjoyed by Malagasy and English-speaking children the world over.

Alison concludes *Thank You, Madagascar* on the following note: "Madagascar is important above all as a test case for any ideal of sustainable peace between humanity and nature. If humanity, Malagasy and outsiders together cannot save Madagascar, what hope is there to save the planet?" So, how well are we doing in terms of saving Madagascar's forests? An as yet unpublished paper by Sébastien Desbureaux and colleagues (Desbureaux *et al.*, 2015) gives a rather bleak assessment. The paper analyses the effectiveness of Madagascar's protected areas with regard to halting deforestation between 2001 and 2012. Among the 138 protected areas in Madagascar, the authors distinguish between the 50 "historic" PAs created between 1927 and 1999, and the 88 "new" protected areas that have been established since 2004. Their sobering conclusion is that in protected areas created before 2000, deforestation was reduced by only 20 % as compared to matched unprotected areas, whilst the early impact of new protected areas was statistically not significant. These figures differ considerably from an assessment by the Office National pour l'Environnement *et al.* (2013), who show annual forest loss as having been 40 % lower in MNP-managed protected areas than in unprotected areas between 2000 and 2005, and 50 % lower between 2005 and 2010. The difference between the two assessments seems to lie in the methodology applied, and in particular in the way that the unprotected control areas were chosen. Both assessments clearly show that there is still a long way to go for making Madagascar's protected area system work for both wildlife and people.

An equally alarming paper was published by Kim Reuter and colleagues last year, on the extent of lemur pet ownership in Madagascar (Reuter *et al.*, 2014). Their study found widespread lemur ownership across a number of taxa, and the authors estimate that more than 28,000 lemurs have been kept as pets within the country since 2010. Despite these gloomy new data I remain optimistic and will not give up as long as there are still forests and lemurs left that we can help protect. After all, we haven't yet lost a single lemur taxon in either the 20th or the 21st century!

In my editorial to Lemur News 17 two years ago I told you about the IUCN Lemur Conservation Strategy 2013–2016 (Schwitzer *et al.*, 2013) that we launched in Tana and Ranomafana in summer 2013. Two years down the line I am happy to report that we have managed to secure the first tranche of funding for some of the most urgent projects of the site-based action plan, in a successful partnership with the IUCN's Save Our Species Fund. I would like to express my thanks in particular to Jean-Christophe Vié, the Director of the SOS Fund, who had the idea for this partnership and has put a lot of energy and enthusiasm into making it work. At the time of writing it looks likely that the SOS Lemurs Special Initiative will be able to issue a second call for proposals already in early 2016.

Traditionally I use this editorial to update the readership of *Lemur News* on the taxonomic changes that have affected lemurs over the past year. Two years ago I reported that the number of lemur taxa had gone up to 105 (101 species) with the description of *Microcebus marohita*, *M. tanosi* and *Cheirogaleus lavasoensis*. Soon after the manuscript of last year's Lemur News (Vol. 18) had been finalised, Lei *et al.* (2014) resurrected *Cheirogaleus thomasi* (Forsyth Major, 1894), a dwarf lemur in the *C. medius* group that occurs in the extreme southeast of Madagascar between Sainte Luce and Petriky. They also identified another four new *Cheirogaleus* species, but did not name them. Earlier this year, Lei *et al.* (2015) described one of the latter, a dwarf lemur from Montagne d'Ambre National Park that belongs in the *C. crossleyi* group, as *Cheirogaleus andysabini*. This brings the total number of described lemur taxa to 107 (103 species), and I am sure there are quite a few more to come.

This volume of Lemur News was kindly supported by the Margot Marsh Biodiversity Foundation.

Christoph Schwitzer

References

Desbureaux, S.; Aubert, S.; Brimont, L.; Karsenty, A.; Lohanivo, A.C.; Rakotondrabe, M.; Razafindraibe, A.H.; Razafiarijoana, J. 2015. The impact of protected areas on deforestation: An exploration of the economic and political channels for Madagascar's rainforests (2001-12). Unpublished paper.

Jolly, A. 2015. Thank You, Madagascar: Conservation Diaries of Alison Jolly. Zed Books, London. 432 pp.

Lei, R.; Frasier, C.L.; McLain, A.T.; Taylor, J.M.; Bailey, C.A.; Engberg, S.E.; Ginter, A.L.; Randriamampionona, R.; Groves, C.P.; Mittermeier, R.A.; Louis Jr, E.E. 2014. Revision of Madagascar's dwarf lemurs (Cheirogaleidae: *Cheirogaleus*): Designation of species, candidate species status and geographic boundaries based on molecular and morphological data. Primate Conservation 28: 9-35.

Lei, R.; McLain, A.T.; Frasier, C.L.; Taylor, J.M.; Bailey, C.A.; Engberg, S.E.; Ginter, A.L.; Nash, S.D.; Randriamampionona, R.; Groves, C.P.; Mittermeier, R.A.; Louis Jr, E.E. 2015. A new species in the genus *Cheirogaleus* (Cheirogaleidae). Primate Conservation 29.

Office National pour l'Environnement (ONE) et al. 2013. Evolution de la Couverture de forêts naturelles à Madagascar 2005-2010. Antananarivo: ONE.

Reuter, K.E.; Gilles, H.; Wills, A.R.; Sewall, B.J. 2014. Live capture and ownership of lemurs in Madagascar: extent and conservation implications. Oryx: doi:10.1017/S003060531 400074X.

Schwitzer, C.; Mittermeier, R.A.; Davies, N.; Johnson, S.; Ratsimbazafy, J.; Razafindramanana, J.; Louis Jr., E.E.; Rajaobelina, S. (eds). 2013. Lemurs of Madagascar: A Strategy for Their Conservation 2013–2016. Bristol, UK: IUCN SSC Primate Specialist Group, Bristol Conservation and Science Foundation, and Conservation International. 185 pp.

News and Announcements

Disney Conservation Hero Jonah Ratsimbazafy

The Houston Zoo is committed to saving species from extinction through strategic partnerships. We seek out local conservation leaders all over the world to enhance their long-term sustainable preservation efforts through partnerships where we offer training, capacity building, funding, marketing, media exposure, conservation networking, and field assistance.

We began a partnership with Jonah Ratsimbazafy in 2012, and began greatly admiring his outstanding commitment and dedication to protecting the biodiversity of Madagascar. Jonah has dedicated his life to protecting highly endangered lemurs and wildlife with GERP (Groupe d'Etude et de Recherche sur les Primates de Madagascar), a primate conservation program he helped establish in 2006. As the President of GERP he works to empower his country to take a strong stand for conservation, directing his Malagasy staff in effective community-based conservation efforts, long-term community buy-in to protect the biodiversity of Madagascar, and scientific research revealing several new species of lemurs. An Associate Professor at the University of Antananarivo, Jonah supervises student research projects, enabling students to tackle current issues in conservation and leads them into careers. Jonah's thorough approach focused on integration has extended to building strong international partnerships and connections with local media and government decision makers to eliminate corruption and encourage proper enforcement of wildlife law in Madagascar, an authority gained from him co-authoring each volume of Conservation International's Lemurs of Madagascar Field Guides and being published with countless studies providing critical data for effective conservation efforts.

We take every opportunity we can to highlight Jonah's outstanding conservation leadership and efforts. To that end, the Houston Zoo nominated Jonah for the highly acclaimed Disney Conservation Hero award recognizing local citizens for their tireless efforts to save wildlife, protect habitats, and educate communities. Each award recipient and their nominating organization will share a $1,500 award from the Disney Wildlife Conservation Fund.

On October 1st 2015, we received notification that Jonah was selected as a 2015 Disney Conservation Hero. The Walt Disney Company said, "We were impressed by your dedication to engage your community in environmental education programs and research projects to protect the rainforests of Madagascar. We applaud your accomplishments and your commitment to the next generation of conservationists!"

The Houston Zoo is proud to work with Jonah Ratsimbazafy, a true conservation hero, and we are elated to see his crucial work highlighted by such a world-renowned organization.

Short Communications

Predation of an adult southern bamboo lemur *Hapalemur meridionalis* by a Dumeril's boa *Acrantophis dumerili*

Timothy M. Eppley[1,2*], Robertin Ravelomanantsoa[3]
[1]Biozentrum Grindel, Department of Animal Ecology and Conservation, University of Hamburg, Hamburg, Germany
[2]Nocturnal Primate Research Group, Department of Social Sciences, Oxford Brookes University, Oxford, United Kingdom
[3]QIT Madagascar Minerals, Rio Tinto, Tolagnaro, Madagascar
*Corresponding author: **eppleyti@gmail.com**

The Mandena littoral forest (24°95 S, 46°99 E; located in coastal southeast Madagascar) is a small protected area that consists of 230 ha of fragmented upland littoral forest with seasonally-inundated swamps (Eppley *et al*., 2015a,b). It is within this unique habitat matrix that southern bamboo lemurs (*Hapalemur meridionalis*) are known to feed terrestrially in both the upland forest and swamp, frequently spending multiple hours grazing on various graminoid species (Eppley and Donati, 2009; Eppley *et al*., 2011). These lemurs are medium-sized with a mean ± SE body mass of 1.072 ± 0.107 kg (N = 15), and are characterized as folivores (Eppley *et al*., 2011, 2015b) that exhibit a cathemeral activity pattern (Eppley *et al*., 2015a). While it is suggested that feeding in the terrestrial stratum may be nutritionally beneficial (Eppley *et al*., 2011), this unusual feeding repertoire carries additional predation risks compared to those *Hapalemur* that focus on arboreal resources.

The pressures associated with each stratum likely play a significant selective role in the habitat use and positional behaviour of primates (McGraw and Bshary, 2002). For many lemurs, especially arboreal species, aerial raptors (e.g., *Accipiter henstii, Buteo brachypterus, Polyboroides radiatus*) present possibly the greatest and/or most frequent predation risk (Wright *et al*., 1998; Karpanty, 2006; Karpanty and Wright, 2007). However, some species are able to predate in both arboreal and terrestrial strata. For example, viverrid carnivores such as fossa *Cryptoprocta ferox* (Goodman and Pidgeon, 1999; Sterling and McFadden, 2000) and large snakes, e.g., Madagascar tree boa *Sanzinia madagascariensis* (formerly *Boa manditra*; Goodman *et al*., 1993; Rakotondravony *et al*., 1998), present potential arboreal and terrestrial predatory risks. As is the case with any predation, knowledge of occurrences is often left to chance observation and is very infrequently recorded.

Given the cryptic nature of bamboo lemurs, we expedited the length of time it would take to locate these lemurs with radio-collars. We captured and radio-collared with data-logging tags (ATS, Inc.). These collars collected both continuous activity data and logged skin temperature instantaneously at 15 min intervals. For information on this and the capture/anesthesia/collaring process, please see Eppley *et al*. (2015a). Though our *ad libitum* records consist of multiple predation attempts on *Hapalemur* individuals in both strata, the purpose of this account is to detail our only known successful predation of a southern bamboo lemur individual from one of our four social groups during the study period

(January – December, 2013). On 2nd April 2013, we noticed that an adult female bamboo lemur from group 1 was not with the rest of her group. Occasionally bamboo lemurs will split into sub-parties or venture out on their own (Eppley *et al*., 2015b), and so we continued to stay with the group yet she never returned. The next day, on 3rd April 2013, we tracked the transmitting radio-collar tag of the missing female *Hapalemur* (body mass: 1.15 kg) using radio telemetry. The signal led us to a vast marsh/swamp area within the territory of the group. Instead of discovering the lemur, however, we found a large male Dumeril's boa *Acrantophis dumerili* (155 cm long, 2.95 kg; Fig. 1). Upon manually moving the large boa, we learned that the signal was transmitting from the snake itself. As such, we returned to our camp with the boa and prepared a suitable terrarium for it in hopes that it would pass (i.e., defecate) the transmitter. After approximately two weeks, the boa defecated the radio-transmitting tag, which was still operational. Tag data were retrieved manually via technicians at ATS (Islip, USA), of which the data-logging capabilities indicate that the female lemur became inactive at 09:45 on 10th March 2013 and body temperature shifted to ambient temperature (°C). We thus deduced it was at approximately this time that the female bamboo lemur was captured and ingested by the large *A. dumerili*.

Fig. 1: *Acrantophis dumerili* a month after eating an adult female *Hapalemur meridionalis*.

This account shows that even full-size adult *Hapalemur* may be susceptible to boa predation, while it also highlights the risks that are involved in feeding within the terrestrial stratum.

Acknowledgements

Our work was carried out under the collaboration agreement between the Department of Animal Biology of the University of Antananarivo and the Department of Animal Ecology and Conservation of the University of Hamburg, and QIT Madagascar Minerals (QMM). We thank the Direction du Système des Aires Protégées, and the Ministère de l'Environnement et Forêts of Madagascar for permission to conduct research. Special thanks to Jörg Ganzhorn and Giuseppe Donati for their constant encouragement and guidance, to Jacques Rakotondranary and Tolona Andrianasolo for their logistical assistance, and to Katie Hall for help in the field. We also thank the Environment Team at QMM for their assistance and provision of logistical support on-site and acknowledge their helpful staff, especially Jean-Baptiste Ramanamanjato and Johny Rabenantoandro. We are grateful for the financial (and in-kind) support provided by the American Society of Primatologists, Conservation International, IDEAWILD, Mohamed bin Zayed Species Conservation Fund (Project Number: 11253008), Primate Conservation Inc., and the Primate Society of Great Britain/Knowsley Safari Park.

References

Eppley, T.M.; Donati, G. 2009. Grazing lemurs: exhibition of terrestrial feeding by the southern gentle lemur, *Hapalemur meridionalis*, in the Mandena littoral forest, southeast Madagascar. Lemur News 14: 16-20.

Eppley, T.M.; Verjans, E.; Donati, G. 2011. Coping with low-quality diets: a first account of the feeding ecology of the southern gentle lemur, *Hapalemur meridionalis*, in the Mandena littoral forest, southeast Madagascar. Primates 52: 7-13.

Eppley, T.M.; Ganzhorn, J.U.; Donati, G. 2015a. Cathemerality in a small, folivorous primate: proximate control of diel activity in *Hapalemur meridionalis*. Behavioral Ecology and Sociobiology 69: 991-1002.

Eppley, T.M.; Hall, K.; Donati, G.; Ganzhorn, J.U. 2015b. An unusual case of affiliative association of a female *Lemur catta* in a *Hapalemur meridionalis* social group. Behaviour 152: 1041-1061.

Goodman, S.M.; Pidgeon, M. 1999. Carnivora of the Réserve Naturelle Intégrale d'Andohahela, Madagascar. Fieldiana: Zoology 94: 256-268.

Goodman, S.M.; O'Connor, S.; Langrand, O. 1993. A review of predation on lemurs: implications for the evolution of social behavior in small nocturnal primates. Pp. 51-66. In: P.M. Kappeler; J.U. Ganzhorn (eds.). Lemur social systems and their ecological basis. Plenum Press, New York, USA.

Karpanty, S.M. 2006. Direct and indirect impacts of raptor predation on lemurs in southeastern Madagascar. International Journal of Primatology 27: 239-261.

Karpanty, S.M.; Wright, P.C. 2007. Predation on lemurs in the rainforest of Madagascar by multiple predator species: observations and experiments. Pp. 77-99. In: S.L. Gursky; K.A.I. Nekaris (eds.). Primate anti-predator strategies. Springer, New York, USA.

McGraw, W.S.; Bshary, R. 2002. Association of terrestrial mangabeys (*Cercocebus atys*) with arboreal monkeys: experimental evidence for the effects of reduced ground predator pressure on habitat use. International Journal of Primatology 23: 311-325.

Rakotondravony, D.; Goodman, S.M.; Soarimalala, V. 1998. Predation on *Hapalemur griseus* by *Boa manditra* (Boidae) in the littoral forest of eastern Madagascar. Folia Primatologica 69: 405-408.

Sterling, E.J.; McFadden, K. 2000. Rapid census of lemur population in the Parc National de Marojejy, Madagascar. A floral and faunal inventory of the Parc National de Marojejy, Madagascar: with reference to elevation variation. Fieldiana: Zoology 97: 265-274.

Wright, P.C.; Heckscher, S.K.; Dunham, A.E. 1998. Predation on rain forest prosimians in Ranomafana National Park, Madagascar. Folia Primatologica 69 (Suppl. 1): 401.

A biological survey of Antsahanadraitry forest (Alan'Antanetivy corridor, Manompana) reveals the presence of the hairy-eared dwarf lemur (*Allocebus trichotis*)

Alex Miller[1*], Tantely Ralantoharijaona[2], Chantal Misandeau[3*], Nicole Andriaholinirina Volasoa[2], Harriet Mills[1], Roberta Bencini[1], Lounès Chikhi[4,5,6], Jordi Salmona[4]

[1]School of Animal Biology, The University of Western Australia, 35 Stirling Highway, Crawley 6009, Perth, Western Australia

[2]Université de Mahajanga, Faculté des Sciences, BP 652 401 Mahajanga, Madagascar

[3]Association de Défense de la Forêt d'Ambodiriana Manompana (ADEFA), 3 rue des Cocotiers, Pointe des Châteaux, 97436 Saint Leu, France

[4]Instituto Gulbenkian de Ciência, Rua da Quinta Grande, 6, P-2780-156 Oeiras, Portugal

[5]CNRS, Université Paul Sabatier, ENFA; UMR 5174 EDB (Laboratoire Evolution & Diversité Biologique), 118 route de Narbonne, F-31062 Toulouse, France

[6]Université de Toulouse; UMR 5174 EDB, F-31062 Toulouse, France

*Corresponding author: **alexandra.miller58@gmail.com**

Keywords: *Allocebus trichotis, Varecia variegata*, Alan' Antanetivy forest corridor, Manompana

Abstract

Madagascar is the focus of intense research on its biodiversity but many remote forests and regions still remain poorly studied. This is the case for the Alan'Antanetivy forest corridor and other forests within the region, in north-eastern Madagascar. We surveyed the Antsahanadraitry forest located at the east of this corridor, allocated for timber exploitation under the 'KoloAla Manaompana' forest management plan. We conducted diurnal and nocturnal line transect distance sampling and observed four species of lemur, including the rare hairy eared dwarf lemur (*Allocebus trichotis*) and the critically endangered black and white ruffed lemur (*Varecia variegata*). Our preliminary results call for a larger biodiversity survey of the Alan'Antanetivy forest corridor and the surrounding region, and for additional special management areas to protect threatened lemur species.

Introduction

Madagascar's biodiversity has been the focus of many studies but despite these efforts to describe its biodiversity, some remote forests are still understudied (Goodman and Benstead, 2003; Glaw and Vences, 2007; Moat and Smith, 2007; Mittermeier *et al*., 2010). This is the case for the Alan'Antanetivy forest corridor for which only the flora has been described (Rakotomavo, 2009).

The Alan'Antanetivy forest corridor is among the last large tracts of primary rainforest in north-eastern Madagascar (Green and Sussman 1990; Gehring *et al*., 2010). The 'Alan'Antanetivy' corridor (Moat and Smith 2007), also called "KoloAla Manompana" since its integration into a community-based forest management national programme of the same name, is a large forest tract of approximately 30,000 ha (Rakotomomavo, 2009) connecting Mananara-nord National Park and Ambatovaky Special Reserve (Fig. 1). The KoloAla framework aims to address the goals of poverty alleviation, biodiversity conservation and timber exploitation (Fig. 2). However, the "KoloAla Manompana" has to tackle the deeply rooted tradition of the traditional *tavy* slash and burn agriculture and the high poverty rate. There is a general concern that the 'biodiversity zone' created in the core of the corridor might be insufficient in size and will soon require increased protection efforts to sustain biodiversity conservation in the region (Urech *et al*., 2013). Furthermore, Brown and Yoder (2015) recently identified the north-eastern forest corridor, linking Ambatovaky Special Reserve, Makira Reserve and Masoala Peninsula, and including the Alan'Antanetivy forest corridor, as a major path for the range shift of eastern lemur species under future climate change scenarios.

In June/July 2014 we conducted baseline surveys of the forest of Antsahanadraitry that lies on the eastern edge of the Alan'Antanetivy corridor to document the lemur species present in this area.

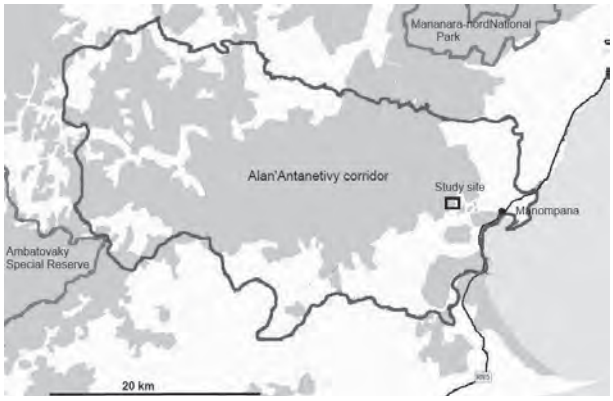

Fig 1.: Map of the survey site. The black square indicates the study site location with transect arrangement indicated. Outlines indicate the border of "KoloAla Manompana" (surrounding the Alan'Antanetivy corridor), and the borders Mananara-nord National Park and Ambatovaky Special Reserve.

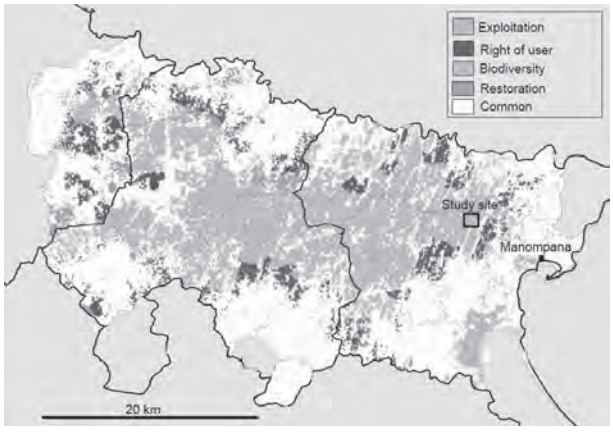

Fig. 2: KoloAla Manompana land partitioning map. Adapted from "Capitalisation de la cartographie participative pour la mise en place des plans de gestion du KoloAla Manompana: Capitalisation de la démarche KoloAla au niveau du corridor forestier de Manompana, Juin 2012".

Methods

Study site

The study site was located at the eastern edge of the Alan'Antanetivy corridor (Fig. 1) at the south east edge of Antsahanadraitry forest (Region Analanjirofo;

16°39'43.46"S, 49°41'09.16"E), a lowland primary rainforest located ~10 km west of the coastal town of Manompana in north-eastern Madagascar. The forest at the study site was mainly composed of primary forest, punctuated in parts by degraded and/or cleared areas.

Line transect census

We conducted both nocturnal and diurnal line-transect distance sampling within Antsahadraitry forest in June and July 2014. Nocturnal surveys were conducted between 18:15 to 21:30 and diurnal surveys between 11:15 to 16:30 along four transects, three of which were located on pre-existing trails, and the fourth was opened for the survey (Fig. 1). The pre-existing trails and the freshly opened transect varied in length from 440-986 m, and were surveyed 1-7 times for a total survey effort of approximately 12km at a slow walking pace (0.5-1.0 km/h) by three researchers. On transect 1 we conducted two diurnal surveys and four nocturnal surveys, on transect 2 one diurnal and six nocturnal surveys, on transect 3 one nocturnal and on transect 4 one diurnal survey. Head-torches were used to spot lemurs, and a spotlight hand-held torch was used to confirm species/genus identification. When an individual was sighted we recorded the species, group size, perpendicular distance from the transect with a Bosch® PLR 50 Digital Laser Rangefinder, height, support tree species, behaviour (feeding, moving or resting) and GPS location (Garmin®Etrex-H GPS, WGS 1984).

Habitat assessment

To assess forest characteristics we recorded at each 10 m interval along surveyed transects and trails: density of small, medium, large trees, and vines (0=absent, 1=few, 2=many, 3=lots); canopy height; forest type (secondary, mature secondary, primary, degraded primary, evidence of cutting or localised fire); digging by humans for tubers or minerals; and proximity of temporary or permanent rivers.

Results

Lemur survey

We observed four different lemur species in Antsahanadraitry forest: the diurnal black-and-white ruffed lemur (*V. varecia*) and three nocturnal species, the hairy-eared dwarf lemur (*Allocebus trichotis*), Gmelin's woolly lemur (*Avahi laniger*), and a yet-to-be-identified mouse-lemur species (*Microcebus* spp; Tab. 1). Additionally, discussions with local residents revealed that there are likely to be at least two species of *Eulemur* present, although no *Eulemur* sp. were sighted during the surveys. The most observed species was *A. laniger* with seventeen individuals sighted in groups of 1-3 individuals.

Fig. 3: Nocturnal photograph of *Allocebus trichotis*. This picture was taken in Antsahanadraitry forest on 23/06/2014 during nocturnal line transect distance sampling survey (Photo A. Miller).

The hairy-eared dwarf lemur (*A. trichotis*) was observed on four occasions during nocturnal surveys at 5-10m heights in the trees and between 18:30 and 20:10 pm (Fig. 3). These sightings confirm the previously suggested distribution of *A. trichotis* (Mittermeier *et al*., 2010) and extend it to the Alan'Antanetivy forest corridor.

We also observed the black-and-white ruffed lemur of the *Varecia variegata subcinta* morphotype (Mittermeier *et al*., 2010), and *V. variegata* calls were frequently heard throughout the forest.

Tab. 1: Observed Lemurs in Antsahanadraitry.

		Transect				Total
		I	II	III	IV	
Transect length		986	520	440	500	-
Diurnal survey #		2	1	1	0	4
Nocturnal survey #		4	6	0	1	11
Family	**Scientific name**	**Number observed**				
Cheirogaleidae	*Allocebus trichotis*	2	2	0	0	4
Cheirogaleidae	*Microcebus simmonsi*	1	4	0	0	5
Indriidae	*Avahi laniger*	8	9	0	0	17
Lemuridae	*Varecia variegata*	1	0	0	0	1

Discussion

Sightings of the rare and elusive hairy-eared dwarf lemur are scarce, with probably no more than a few dozen ever recorded (Mittermeier *et al*., 2010). With four clear observations during our surveys, this new locality of *A. trichotis* could become an important station for research and conservation of this species. Although this species is morphologically prone to confusion with mouse lemurs (*Microcebus*) during nocturnal surveys, its behaviour is relatively easy to discern. The quadrupedal movement is very rapid, more similar to that of a rat than to that of *Microcebus*; *A. trichotis* also freezes when spotted by flash-light beams and this behaviour is sometimes accompanied by head side-to-side or 'head-bob' movement.

We also observed the rare black-and-white ruffed lemur of the *Varecia variagata subcinta* morphotype; however, recent genetic work of Baden *et al.* (2014) suggests that these taxonomic subdivisions may need to be reconsidered.

The five individual mouse lemurs sighted most likely belong to *Microcebus simmonsi* (Mittermeier *et al*., 2010), however genetic and morphological analyses need to be undertaken to confirm the exact species observed. Currently the range of *M. simmonsi* is thought to be restricted to the south of the Ambodiampana River, and to the island of Sainte-Marie, which respectively lie to the south and to the east of the study site (Rasoloarison *et al*., 2013). The presence of *M. simmonsi* in Sainte-Marie (Crowley *et al.,* 2011) suggests that the species present in the corridor is likely to be *M. simmonsi*. This finding would therefore extend the range for this species.

Antsahanadraitry primary forest appears to be only slightly impacted by timber exploitation activities likely, because of its distance from the road (Urech *et al*., 2012). A large proportion of forest between Antsahanadraitry and Manom-

pana has been cleared in the last years and the land is fast-becoming an extended matrix of rice fields with only small patches of forest left in areas too inconvenient for agriculture. Antsahanadraitry forest falls within the KoloAla 'Exploitation zone' (Fig. 2) and it is thus only a matter of time before Antsahanadraitry's precious hardwood is heavily harvested. What is seen as an opportunity for development may become a tragedy for biodiversity. Nevertheless, discussions with locals revealed their enthusiasm for eco-tourism and conservation programs. These attitudes may have been influenced by the nearby association ADEFA (Association de Défense de la Forêt d'Ambodiriana) in Ambodiriana forest where a sustainable community conservation project has been implemented since 1996. The threatened lemurs and tree species recorded in Antsahanadraitry forest would benefit from such conservation activities.

The results obtained in our survey reveal the presence of the rare hairy-eared dwarf lemur (*A. trichotis*) and, pending genetic results confirming the presence of *M. simmonsi*, extend the known range of this species. This warrants an extended biodiversity survey of the Alan'Antanetivy forest corridor, and for a continuous presence of students and researchers. The long-term presence of research and conservation activities has indeed been suggested to have a positive impact on conservation (Schwitzer *et al*., 2014).

Acknowledgements

We thank CAFF/CORE, the "Direction générale de l'Environnement et des Forêts" for giving us permission to conduct this study. Financial support for this study was provided by the School of Animal Biology at The University of Western Australia, the 'Fundação para a Ciência e a Tecnologia' (PTDC/BIA-BEC/100176/2008, PTDC/BIA-BIC/4476/2012 and SFRH/BD/64875/2009), the GDRI Madagascar, the 'Laboratoire d'Excellence' (LABEX) entitled TULIP (ANR-10-LABX-41), and the 'Instituto Gulbenkian de Ciência'. The fieldwork was possible thanks to the support of ADEFA (Association de Défense de la Forêt d'Ambodiriana) and the long term collaboration between LC and the 'Département de Biologie Animale et Ecologie', University of Mahajanga. We also thank Barbara Le Pors, Senta and Arnold for assistance with field support and guiding. This study was made in accordance with the laws of the Countries of Portugal, France, Australia and Madagascar.

References

Baden, A.L; Holmes, S.M; Johnson, S.E; Engberg, S.E; Louis, Jr. E.E; Bradley, B.J. 2014. Species-level view of population structure and gene flow for a critically endangered primate (*Varecia variegata*). Ecology and Evolution 4: 2675-2692.

Brown, J.L.; Yoder, A.D. 2015. Shifting ranges and conservation challenges for lemurs in the face of climate change. Ecology and Evolution 5: 1131-1142.

Crowley, B.E.; Thorén, S.; Rasoazanabary, E.; Vogel, E.R.; Barrett, M.A.; Zohdy, S.; Blanco M.B.; McGoogan C.M.; Arrigo-Nelson S.J.; Irwin M.T.; Wright P.C.; Radespiel U.; Godfrey L.R.; Koch P.L.; Dominy, N.J. 2011. Explaining geographical variation in the isotope composition of mouse lemurs (*Microcebus*). Journal of Biogeography 38: 2106-2121.

Gehring, P. S.; Fanomezana, M. R.; Vences, M. 2010. Filling the gaps-Amphibian and reptile records from lowland rainforests in eastern Madagascar. Salamandra 46: 214-234.

Glaw, F.; Vences, M., 2007. A field guide to the amphibians and reptiles of Madagascar. Vences & Glaw Verlags.

Goodman, S.M.; Benstead, J.P. 2003. Natural history of Madagascar. University of Chicago Press, Chicago.

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

Mittermeier, R.A.; Louis, E.E.; Richardson, M.; Schwitzer, C.; Langrand, O.; Rylands, A.; Hawkins, A.F.A.; Rajaobelina, S.; Ratsimbazafy, J.; Rasoloarison, R.M.; Roos, C.; Kappeler, P.M.; Mackinnon, J., 2010. Lemurs of Madagascar: Third Edition. Conservation International, Washington DC.

Moat, J.; Smith, P.; 2007. Atlas of the Vegetation of Madagascar Vegetation/Atlas de la Vegetation de Madagascar. Kew Publishing, Royal Botanic Gardens Kew.

Rakotomavo, A. 2009. Schéma d'aménagement du site KoloAla Manompana. Report, AIM, Union Européenne, Manompana.

Rasoloarison, R.M.; Weisrock, D.W.; Yoder, A.D.; Rakotondravony, D.; Kappeler, P.M. 2013. Two new species of mouse lemurs (Cheirogaleidae: *Microcebus*) from Eastern Madagascar. International Journal of Primatology 34: 455-469.

Schwitzer, C.; Mittermeier, R.A.; Johnson, S.E.; Donati, G.; Irwin, M.; Peacock, H.; Ratsimbazafy, J.; Razafindramanana., J.; Louis Jr., E. E.; Chikhi, L.; Colquhoun, I.C.; Tinsman, J.; Dolch, R.; LaFleur, M.; Nash, S.; Patel, E.; Randrianambinina, B.; Rasolofoharivelo, T.; Wright, P.C. 2014. Averting lemur extinctions amid Madagascar's political crisis. Science 343: 842-843.

Urech, Z. L., Felber, H. R., Sorg, J.P. 2012. Who wants to conserve remaining forest fragments in the Manompana corridor? Madagascar Conservation and Development 7: 135-143.

Urech, Z. L., Sorg, J. P. 2013. Challenges for community-based forest management in the KoloAla site Manompana. Environmental Management 51: 602-615.

Note sur la présence de *Prolemur simus* à Ranomafana Est, District de Brickaville

J.M. Ralison[1,2]*, J.H. Ratsimbazafy[1], A. Rajaonson[1]

[1]GERP, Lot 34 Cité des Professeurs, Fort-Duchesne, Antananarivo 101, Madagascar

[2]Biotope Madagascar, IIM99 Antsakaviro, Antananarivo 101, Madagascar

*Corresponding author: **jmralison@biotope.fr**

Autrefois considéré comme une espèce éteinte à Madagascar dont la présence dans plusieurs endroits était indiquée par des études de subfossiles, *Prolemur simus* est l'une des espèces de lémuriens les plus rares et les plus menacées (UICN, 2015). Connu à l'époque sous d'autre appellation (notamment *Hapalemur simus*) et révisé taxonomiquement par Groves en 2001, *Prolemur simus* a beaucoup été étudié ces quinze dernières années et redécouvert dans quelques endroits du versant oriental malgache (Delmore *et al*., 2009; McGuire et al., 2009; Rainer *et al*., 2008; Randriahaingo *et al*., 2014; Randrianarimanana *et al*., 2014). Les prospections et études menées par l'équipe de la Fondation Aspinall (TAF), associée avec le Groupe d'Etude et de Recherche sur les Primates de Madagascar (GERP), la Conservation Internationale (CI) et l'Association Mitsinjo, ont déployé le nombre de sites d'observation de l'espèce au sein du Corridor An-

Fig. 1: *Prolemur simus* à Ranomafana Est, District de Brickaville.

Fig. 2: *De forêts de bambous*.

keniheny-Zahamena (CAZ). Cependant, d'autres localités sont encore à explorer.

Après avoir analysé les formations végétales de différentes zones du District de Brickaville par le biais des images satellites, un inventaire rapide de six jours (du 29 Juin au 05 Juillet 2014) a été mené par l'équipe de GERP dans quatre localités apparemment de bon état, à savoir Ambodivoara-Ampasimbe, Ifasina, Ranomafana Est et Maroafo. Le but de ce coup d'œil était de vérifier la potentielle présence de *Prolemur simus* dans des vestiges de forêts où aucune étude n'avait jusqu'ici été faite.

Le principe et la méthode utilisés lors de la prospection ont été basés sur des observations directes des endroits susceptibles d'abriter l'espèce et soutenus par des enquêtes auprès des populations riveraines. Les observations ont été seulement menées dans la matinée. Les informations relatives à la présence de *Prolemur simus* ont toutes été notées, y compris les traces d'alimentation, lors de chaque visite sur terrain.

Parmi les sites visités, *Prolemur simus* a seulement été observé à Ranomafana Est (18°57'07"S/48°49'58"E/100 m), dans un site tout proche de la RN2 et au nord-ouest à 1,5 km à vol d'oiseau de la Commune rurale de Ranomafana Est. Ce groupe se trouve dans une formation secondaire à *Ravenala madagascariensis* (Strelitziaceae) associée à une plantation de girofles (*Syzygium aromaticum* - Myrtaceae), de bambous (*Cathariostachys madagascariensis* - Poaceae), *d'Aframomum* sp. et d'*Eucalyptus*. On note la présence d'un cours d'eau et l'absence de formation forestière aux alentours. Selon les personnes enquêtées, une quinzaine d'individus vit actuellement dans cette propriété privée d'une soixantaine d'hectares. Les individus observés, un peu farouche vis-à-vis de la présence humaine, ont mangé des jeunes fleurs de Ravenala madagascariensis pendant la collecte de données (Fig. 1-2).

Mis à part les perturbations causées par la coupe d'*Eucalyptus* et de grands bambous, la survie de ce groupe de *Prolemur simus* est incertaine à cause de l'isolement du site et du braconnage. *A priori*, des mesures urgentes pour la conservation de ce groupe d'animaux - entre autres la collaboration avec le propriétaire du site, le recrutement des guides locaux pour le suivi écologique du groupe et, dans le cas extrême, la translocation du groupe dans d'autres endroits sûrs, sont jugées nécessaires et primordiale pour sa survie à long terme.

Cette mission a été faite grâce au financement de Houston Zoo que nous tenons à remercier. Nos vives reconnaissances s'adressent également aux autorités locales et aux populations riveraines des endroits visités pour leur accueil chaleureux et leur aide préciluse durant les travaux.

Références

Delmore, K.E.; Keller, M.F.; Louis Jr., E.E.; Johnson, S.E. 2009. Rapid primatological surveys of the Andringitra forest corridors: direct observation of the greater bamboo lemur (*Prolemur simus*). Lemur News 14: 49-52.

Dolch, R.; Fiely, J.L.; Ndriamiary, J.N.; Rafalimandimby, J.; Randriamampionona, R.; Engberg, S.E.; Louis Jr., E.E. 2008. Confirmation of the greater bamboo lemur, *Prolemur simus*, north of the Torotorofotsy wetlands, eastern Madagascar. Lemur News 13: 14-17.

McGuire, S.M.; Bailey, C.A.; Rakotonirina, J.N.; Razanajatovo, R.G.L.; Ranaivoarisoa, J.F., Kimmel, L.M., Louis Jr., E.E. 2009. Population survey of the greater bamboo lemur (*Prolemur simus*) at Kianjavato Classified Forest. Lemur News 14: 41-43.

Groves, C.P. 2001. Primate Taxonomy. Smithsonian Institution Press, Washington DC.

IUCN. 2015. IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 30 July 2015.

Randriahaingo, H.N.T.; Ravaloharimanitra, M.; Randrianarimanana, H.L.L.; Chamberlan, C.; Ratsimbazafy, J.; King, T. 2014. Etude et conservation du grand hapalémur (*Prolemur simus*) aux alentours de la forêt d'Andriantantely. Lemur News 18: 67-72.

Randrianarimanana, L.; Ravaloharimanitra, M; King, T. 2014. Sahanambolena: Un nouveau site pour *Prolemur simus* dans le Corridor d'Ankeniheny-Zahamena, Madagascar. Lemur News 18: 57-61

Supporting the social, economic and environmental aspects of community-based conservation of greater bamboo lemurs, black-and-white ruffed lemurs and indri

Maholy Ravaloharimanitra, H. L. Lucien Randrianarimanana, Hery N. T. Randriahaingo, T. Hasimija Mihaminekena, Tony King

The Aspinall Foundation, BP 7170 Andravoahangy, Antananarivo 101, Madagascar

*Corresponding author: **rrmahooly@gmail.com**

The Aspinall Foundation works in Madagascar to protect endangered lemurs and their habitats, with a particular focus since 2008 in eastern Madagascar on greater bamboo lemurs, black-and-white ruffed lemurs and indri (King and Chamberlan, 2010; King *et al*., 2013). Having identified several priority sites for the conservation of these species through collaborative surveys in and around the Ankeniheny-Zahamena rainforest corridor (Ravaloharimanitra *et al*., 2011), conservation strategies have been developed for many of the sites based on supporting the transfer of management responsibility for the sites to local community associations known as Vondron'Olona Ifotony in Malagasy, or VOIs, and subsequently supporting the VOIs to implement their management contracts (King *et al*., 2013; Ravaloharimanitra *et al*., 2015). Long-term participatory monitoring shows that the greater bamboo lemur populations are increasing across our conservation intervention sites (Mihaminekena *et al*., 2012; Randriahaingo *et al*., 2014).

Between 2011 and 2013 the Foundation supported the creation or renewal of three management transfer agreements (Ravaloharimanitra and King, 2012; King *et al*., 2013), with a fourth completed in 2014, that of the Dimbiazan-jafy VOI in relation to part of the Andriantantely lowland rainforest in the Brickaville District (Ravaloharimanitra *et al*., 2015). Further agreements are in development. Technical and financial supports are provided to these communities before, during and after the signature of the contract with the Ministry responsible for forests, to increase their capacity within the social, economic and environmental aspects of conservation

Fig. 1: Indri notebook distribution.

Fig. 2: Community ginger project.

Fig. 3: Reforestation activities.

(Chamberlan 2012; Chamberlan *et al*., 2013; King *et al*., 2013; Ravaloharimanitra *et al*., 2013, 2015).

During 2014 and 2015 within the social aspect, we have stressed the value of each focal species and their conservation status. In previous years we have distributed to school children and other local people living around our conservation sites a total of approximately 15,000 writing books featuring photos of greater bamboo lemurs or black-and-white ruffed lemurs on the front cover, and other lemurs on the back cover. At the beginning of the 2014-2015 school year we produced another 5,000 writing books, this time featuring indri on the front cover, and distributed them to 15 public primary schools (EPP) and six private primary schools (FKL) surrounding the Ankeniheny-Zahamena rainforest corridor. We also printed and distributed 1,150 calendars to various local authorities, VOI members, parents and schools, providing conservation images and information, and we organised two class trips to Andasibe for primary school children from the Brickaville District (Mangabe EEP 14/11/2014 to 17/11/2014 and Lanonana EEP 23/01/2015 to 26/01/2015), where Association Mitsinjo provided environmental education and forest visits.

For the economic aspect, during 2014 we have emphasized the reciprocal links between biodiversity, human action and wellbeing. We have based our support of livelihood improvement on the motivation of each VOI member to take part voluntarily in conservation activities. According to the requests we received from local communities, the Mamelontsoa VOI of Morarano-Gare commune were provided with funding for cooperative rice storage, a loan to improve rice crops, and the improvement of study conditions for the Nangaranana primary school by providing a metal roof for the new building. In the Brickaville District, the Ainga vao VOI and Dimbiazan-jafy VOI have benefited from the distribution of 725 and 500 kg of ginger seeds respectively.

For the environmental aspect, we have supported the implementation of the local site management plans (PAGS or Plan d'Aménagement et de Gestion Simplifié). Since the end of 2014 our efforts have been concentrated on reforestation activities. In collaboration with Association Mitsinjo from Andasibe, we have trained the four VOIs with completed management transfer contracts, and therefore with their PAGS already approved by the Ministry responsible for forests, in tree nursery management and reforestation. 12,000 seedlings of native species were grown across the four VOI tree nurseries, and they are currently being planted within VOI management zones designated for the recovery of previously deforested areas. Participation of primary school children in the reforestation activities occurred during the celebration of "Journée des écoles" for the Sakalava fokontany and during the World Environment Day celebration for the Mangabe and Lanonana fokontanys.

Acknowledgements

We thank the government of Madagascar, in particular the Ministry of the Environment, Ecology, Sea and Forests, our partner organisations including Association Mitsinjo, GERP and Conservation International, and all the local people, communities and authorities with whom we work in and around the Ankeniheny-Zahamena corridor. Our work in the corridor is funded by The Aspinall Foundation, Association Beauval Nature, and the Mohamed bin Zayed Species Conservation Fund (projects 13256399 and 14258776), to all of whom we are very grateful.

References

Chamberlan, C. 2012. Sauver *Prolemur simus* – 3000 cahiers scolaires "Godroka" distribués autour du CAZ. Lemur News 16: 26.

Chamberlan, C.; Ranaivosoa, L.; Ravaloharimanitra, M.; Randrianarimanana, H.L.; Randriahaingo, H.N.T.; Roullet, D.; King, T. 2013. 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. Lemur News 17: 2-4.

King, T.; Chamberlan, C. 2010. Conserving the Critically Endangered greater bamboo lemur. Oryx 44: 167.

King, T.; Ravaloharimanitra, M.; Randrianarimanana, H.L.L.; Rasolofoharivelo, M.T.; Chamberlan, C. 2013. Community-based conservation of critically endangered lemurs at the

Sakalava and Ranomainty sites within the Ankeniheny-Zahamena rainforest corridor, eastern Madagascar. Lemur News 17: 63-70.
Mihaminekena, T. H.; Ravaloharimanitra, M.; Ranaivosoa, P.; Ratsimbazafy, J.; King, T. 2012. Abondance et conservation de *Prolemur simus* dans les sites de basse altitude de Sahavola et Ambalafary, District de Brickaville. Lemur News 16: 11-15.
Randriahaingo, H.N.T.; Ravaloharimanitra, M.; Randrianarimanana, H.L.; Chamberlan, C.; Ratsimbazafy, J.; King, T. 2014. Etude et conservation de *Prolemur simus* aux alentours de la forêt de basse altitude d'Andriantantely, Madagascar. Lemur News 18: 67-72.
Ravaloharimanitra, M.; King, T. 2012. First community-managed reserve for greater bamboo lemurs inaugurated. Lemur News 16: 26.
Ravaloharimanitra, M.; Ratolojanahary, T.; Rafalimandimby, J.; Rajaonson, A.; Rakotonirina, L.; Rasolofoharivelo, T.; Ndriamiary, J.N.; Andriambololona, J.; Nasoavina, C.; Fanomezantsoa, P.; Rakotoarisoa, J.C.; Ratsimbazafy, J., Dolch, R.; King, T. 2011. Gathering local knowledge in Madagascar results in a major increase in the known range and number of sites for critically endangered greater bamboo lemurs (*Prolemur simus*). International Journal of Primatology 32: 776-792.
Ravaloharimanitra, M.; Ranaivosoa, L.; Mihaminekena, T.H.; Chamberlan, C.; King, T. 2013. Conservation communautaire de *Prolemur simus* à Ambalafary, District de Brickaville, Madagascar. Lemur News 17: 54-57.
Ravaloharimanitra, M.; Randriahaingo, H.N.T.; Ranaivosoa, L. H.; Chamberlan, C.; King, T. 2015. Conservation communautaire de la forêt humide de basse altitude d'Andriantantely, Madagascar. Madagascar Conservation and Development 10(S1): 29-34.

Articles

Lemur population surveys in the Kianjavato region

Sheila M. Holmes[1*], Adam M. Yaney-Keller[2], Daniel V. Rafidimanana[3], Harisoa M. Andrianantenaina[3], Edward E. Louis Jr.[2,4], Steig E. Johnson[1]
[1]University of Calgary, Calgary, AB, Canada
[2]Madagascar Biodiversity Partnership, Antananarivo, Madagascar
[3]Université d'Antananarivo, Antananarivo, Madagascar
[4]Omaha's Henry Doorly Zoo and Aquarium, Omaha, NE, USA
*Corresponding author: **holmess@ucalgary.ca**

Key words: lemur community, conservation, deforestation, nocturnal, diurnal

Abstract
This study serves as the first systematic assessment of lemur populations in the Kianjavato region. Line transects were used to survey populations of lemurs in seven forest fragments, during both night and day. Encounter rates varied across forest fragments, with more disturbed areas having lower encounter rates than areas with ongoing conservation efforts. The presence of two Critically Endangered species in more than one forest fragment is promising for conservation efforts, though the lack of sightings of one reportedly present species, Milne-Edward's Sifaka *Propithecus edwardsi*, indicates possible extirpation from the area. Further surveys will aim to acquire sufficient sightings for accurate population density calculations of all species.

Résumé
Cette étude constitue la première évaluation systématique des populations de lémuriens dans la région de Kianjavato. On a utilisé des transects linéaires pour étudier les populations de lémuriens en sept fragments de la forêt, pendant le jour et la nuit. Les taux d'observation variaient entre les fragments de forêt, avec les zones plus perturbées ayant un plus faible taux que les régions avec des efforts de conservation. La présence de deux espèces en voie de disparition dans plus d'un fragment de la forêt est encourageante pour les efforts de conservation, mais l'absence d'observations d'une espèce remarquée auparavant (*Propithecus edwardsi*) indique la disparition possible de cette espèce dans la zone. D'autres études permettraient d'acquérir des observations suffisantes pour calculer les densités précises de chaque espèce.

Introduction
Recently, the SSC Primate Specialist Group identified 30 priority sites for lemur conservation in Madagascar (Schwitzer *et al*., 2013). One of these sites is the Kianjavato Ahmanson Field Station (KAFS) (Schwitzer *et al*., 2013); it is composed of a network of forest fragments in southeastern Madagascar (Fig. 1). This site is home to two Critically Endangered lemur species, the black and white ruffed lemur *Varecia variegata* and the greater bamboo lemur *Prolemur simus* (IUCN, 2015). There has been ongoing conservation research, outreach, education, and reforestation in the Kianjavato area since 2009, although conservation efforts have been focused on the more centrally located villages, especially those close to the forest of Sangasanga. Short reconnaissance visits were made to the area, including the more distant fragments of Lakia and Simone in 2005 (E. E. Louis Jr., unpublished data). In this study, we aimed to provide a system-wide assessment of the lemur populations across all seven major forest fragments in the Kianjavato area (Fig. 1). We used transect surveys to compare encounter rates of all lemur species across the various fragments.

Methods
We placed 50 line transects (Struhsaker, 1981) of 0.3-0.5 km each throughout the forest fragments, with 4-11 transects per fragment, based on forest area. Transects within a fragment were parallel to one another and a minimum of 250m apart. Only thirty-six of the 50 transects were used for nocturnal surveys due to time and navigation constraints. We surveyed 3-5 transects per day from July 2014 to June 2015 (12 months); we also surveyed 2-4 transects per night from November 2014 to May 2015 (seven months). Given that the forests of Lakia and Simone were more remote, we compressed surveys for those forests into a period of three weeks in April 2015, completing both day and night surveys. Our total survey effort was 358.8 km for diurnal surveys and 99.0 km for nocturnal surveys. Given the comparatively short period in which surveys were performed at Lakia and Simone, we also conducted informal interviews with people living adjacent to these fragments, to determine which lemur species may be present, yet absent from surveys. Interviews consisted of requesting physical and behavioral descriptions of all the lemur species present.
We estimated encounter rates for day and night surveys as the number of individuals of a given species seen per kilometer surveyed in a given forest fragment. We then calculated the mean and standard deviation of encounter rates by fragment, and by species.

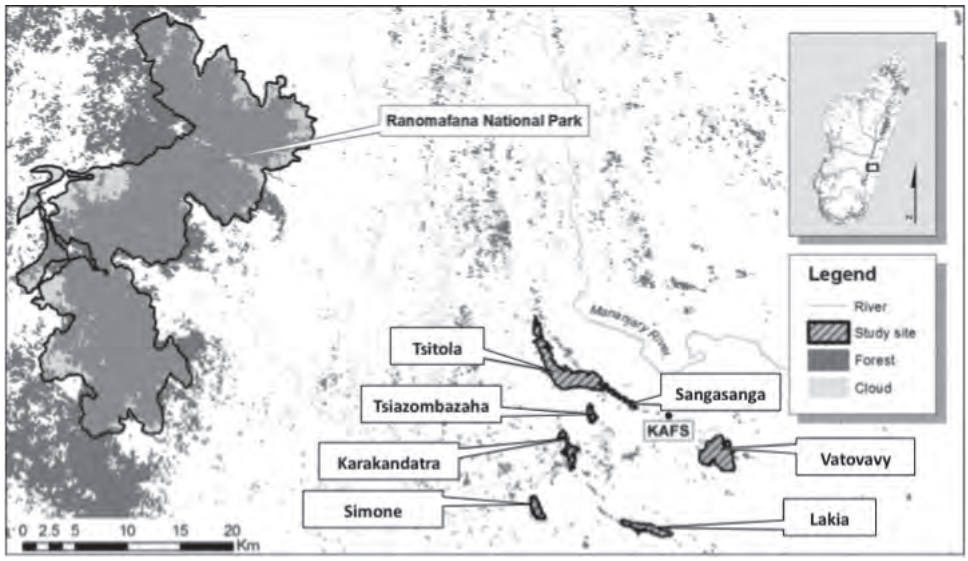

Fig. 1: Map of the study site, with main forest fragments labeled, outlined in black, and filled with grey hatching. Map courtesy of Tracy Wyman.

Results

Encounter rates varied widely across forest fragments (Fig. 2) and species (Fig. 3,4). There was more variation in the encounter rates across sites during day surveys than during night surveys, although the location with the highest diurnal encounter rates (Sangasanga) also had the highest nocturnal encounter rates. Encounter rates for all forest fragments except Sanagsanga were higher at night than during the day. Simone was the only fragment for which day surveys yielded no lemur sightings, though there was only one sighting during the day for Tsiazombazaha.

There was a great deal of variation in encounter rates across species (Fig. 3,4). Jolly's mouse lemur *Microcebus jollyae* had the highest mean encounter rate, and was seen in all six fragments that were surveyed at night, while the aye aye *Daubentonia madagascariensis* and the eastern lesser bamboo lemur *Hapalemur griseus* were only recorded in one forest fragment each (data not shown).

Interviews revealed the possible presence of many additional species that researchers did not observe in Lakia and/or Simone (Tab. 1). Two species of note are *Prolemur simus* and *Propithecus edwardsi*. *P. simus* was described as being present in Lakia, though researchers were unable to locate it despite additional searching of bamboo stands. A group of 5-10 *P. edwardsi* was reported by multiple sources near Simone, though additional searches in the area yielded no signs of this species.

Tab. 1: Lemur species present and potentially present at Lakia and Simone. An "X" represents observation of at least one individual of the species by researchers at the specified site during 2015. A "?" means informal interviews indicated the species was present, but researchers did not observe it. Blank squares indicate that the species was neither observed, nor mentioned in interviews at the site in 2015.

Lemur species	Lakia	Simone
Avahi peyrierasi	X	
Daubentonia madagascariensis	?	
Microcebus jollyae	X	X
Eulemur rubriventer	?	X
Eulemur rufifrons	X	?[a]
Hapalemur griseus	?	X
Prolemur simus	?	
Propithecus edwardsi		?
Varecia variegata	X	X[a]

[a]Interviews specified three *E. rufifrons* and one *V. variegata* typically observed together by locals, though only the *V. variegata* individual was observed by researchers.

Discussion

All eight species listed as present by the IUCN SSC Primate Specialist Group (Schwitzer *et al.,* 2013), with the addition of *Cheirogaleus major*, were observed during surveys in the Kianjavato region. The only species that has been reportedly sighted in the area but not confirmed by researchers is *Propithecus edwardsi*. Many people have informally communicated to researchers that *P. edwardsi* has been present at the site in recent years. This species, present in nearby Ranomafana National Park (Schwitzer *et al*., 2013), has been reported in Tsitola as recently as 2009 (E.E. Louis Jr. pers obs.), and was repeatedly reported in interviews for this study as being present in the area of the Simone forest. However, despite additional searches of the forest fragments, *P. edwardsi* has yet to be confirmed at this site. If future surveys do not yield sightings of this species, it could be an indication of a recent extirpation of this species from the study site.

On the other hand, both of the Critically Endangered species, *Varecia variegata* and *Prolemur simus*, were present in at least two forest fragments each. In fact, the relatively high encounter rate of *V. variegata* compared to other species may indicate a possible resilience of this species to deforestation in this area. This is encouraging for conservation efforts.

In general, the lowest mean encounter rates at the site corresponded with the fragments with the most anthropogenic disturbance. In particular, Lakia, Tsiazombazaha, and Simone had very few diurnal lemurs, while Sangasanga, the fragment with the longest history of conservation outreach and education, had by far the highest mean encounter rate of all the forest fragments. This suggests that conservation efforts at this site may have had a positive impact on lemur populations, even in only the last six years. Conservation efforts have centered on Sangasanga forest since 2009, and have expanded to include villages near Vatovavy and Tsitola forests more recently. Tsiazombazaha is the most degraded of the nearby forest fragments (D. Rafidimanana, pers obs.), and the recent expedition to Lakia and Simone, where conservation action has yet to begin, revealed many signs of forest degradation and active logging (A. Yaney-Keller, pers obs.). While we cannot rule out alternative causes for the current patterns, future conservation efforts should be expanded to include these more remote areas.

Variation in encounter rates across species may be due to natural variation, but may also be attributed to the cryp-

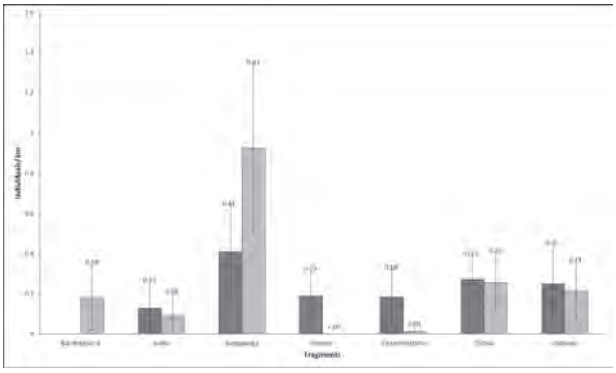

Fig. 2: Mean and standard deviation of lemur encounter rates across seven forest fragments during day and night surveys. Day surveys (light grey bars) were performed over a period of 12 months, and night surveys (dark grey bars) were performed over a period of seven months. The exceptions were for Lakia and Simone, which were both surveyed over a period of three weeks in April 2015. Error bars represent standard deviation. No night surveys were performed at Karakandatra.

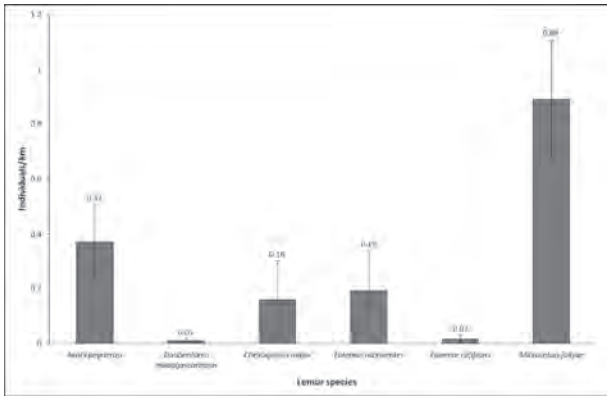

Fig. 3: Mean encounter rates for night-active species during nocturnal surveys. Columns represent the mean encounter rate of each species at night, across all forest fragments. Error bars denote standard deviation.

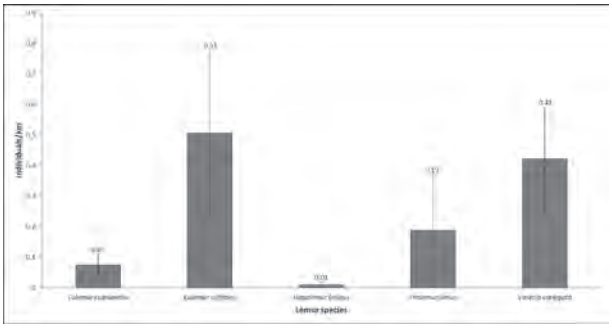

Fig. 4: Mean encounter rates for day-active species during diurnal surveys. Columns represent the mean encounter rate of each species during the day, across all forest fragments. Error bars denote standard deviation.

tic appearance and behavior of some species, for example *Daubentonia madagascariensis*. While this species was only observed in one forest fragment during surveys, individuals are known to be present, or have been present in the past, in at least three additional fragments (E.E. Louis, unpublished data). We will continue surveys in this area in order to obtain sufficient data to accurately calculate population densities for each species, and to facilitate comparisons to other sites in the region and across Madagascar (e.g., Irwin *et al*., 2005).

Acknowledgements

We are grateful to the Government of Madagascar for permission to conduct research. We thank all of the technicians who assisted in data collection, and the communities surrounding the forests for supporting our surveys. This project received funding from Conservation International's Primate Action Fund, Primate Conservation, Inc., the University of Calgary, and the Natural Sciences and Engineering Research Council of Canada (NSERC).

References

Irwin, M.T.; Johnson, S.E.; Wright, P.C. 2005. The state of lemur conservation in south-eastern Madagascar: Population and habitat assessments for diurnal and cathemeral lemurs using surveys, satellite imagery and GIS. Oryx 39: 204-218.

Schwitzer, C.; Mittermeier, R.A.; Davies, N.; Johnson, S.; Ratsimbazafy, J.; Razafindramanana, J.; Louis Jr., E.E., Rajaobelina S. 2013. Lemurs of Madagascar: A strategy for their conservation 2013-2016. IUCN SSC Primate Specialist Group, Bristol Conservation and Science Foundation, and Conservation International. 185 pp.

Struhsaker, T.T. 1981. Census methods for estimating densities. Techniques for the study of primate population ecology. National Academy Press, Washington, DC, USA.

IUCN. 2015. IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 30 July 2015.

Reniala Lemur Rescue Center for Ring-tailed Lemurs in Madagascar

Marni LaFleur[1,2*], Tara Clarke[2,3], Lea Giraud[4], Ibrahim Antho Jacky Youssouf[2,5], Lisa Gould[2,6], Maurice Adiba[4]

[1]University of California San Diego, Department of Anthropology, La Jolla, California

[2]Lemur Love, Inc. USA 501(c)(3)

[3]Duke University, Department of Evolutionary Anthropology, Durham, North Carolina

[4]Reniala Lemur Rescue Center, Madagascar

[5]Universiteé de Toliara, Département de Sciences Biologie, Toliara, Madagascar

[6]University of Victoria, Department of Anthropology, Victoria, Canada

*Corresponding author: **marni.lafleur@gmail.com**

Overview

The Reniala Lemur Rescue Center (LRC) is the only facility in Madagascar caring for ring-tailed lemurs (*Lemur catta*), now classified as an Endangered species (Andriaholinirina *et al.,* 2014), and often trafficked as part of the illegal pet or bushmeat trades. The LRC was established in 2011, after the Ministry of Water and Forests (MEF) began confiscating privately held ring-tailed lemurs, without a long-term plan for their care. Since 2011 the MEF has continued to confiscate ring-tailed lemurs. The LRC facility is located in the Reniala Botanical Reserve; approximately 6 km^2 of spiny forest habitat in south western Madagascar. This area is part of the natural range of ring-tailed lemurs, although local lemur populations were extirpated sometime in the late 1990s, likely due to hunting pressure and/or habitat destruction or degradation. The LRC aims to function as a temporary facility for displaced ring-tailed lemurs, as our ultimate goal is to release these animals back into their natural habitat;

although some individual lemurs are not suitable for reintroduction, and to date an appropriate release location has not been identified.

Origin

Ring-tailed lemurs are flexible animals that reside in a plethora of habitats in south and south-western Madagascar (see Gould, 2006). They are semi-terrestrial, group living primates that exhibit strict female dominance (Jolly, 1966). Ring-tailed lemurs live in social groups that range, 5-25 animals, depending upon location and environmental factors (see Jolly *et al*., 2002; Gould *et al*., 2003). In terms of diet, *L. catta* are classified as an opportunistic generalist (Sauther, 1994) and a frugivore/folivore (Gould, 2006; Simmen *et al*., 2006), and can survive in highly degraded landscapes (Cameron and Gould, 2013). Male lemurs disperse from their social group upon sexual reproduction (3-4 years of age) and every 3-4 years thereafter, for the duration of their lives. Female lemurs do not migrate *per se*, but matrilines may be aggressively evicted from their natal groups and thus be forced to find new territory. Because of their general ecological flexibility and robust nature, ring-tailed lemurs can survive in captivity, whereas other lemur species cannot (e.g. folivorous lemurs such as *Indri indri* and most *Propithecus* species; Junge *et al*., 2009). This may make ring-tailed lemurs a more attractive target for live-capture and sale.

Since there are no known instances of captive breeding of ring-lemurs in southern Madagascar, all captive individuals were likely wild-caught. Once captured, infant lemurs may then be sold to individuals or businesses (for less than the equivalent of $2 USD), and primarily serve as a lure for tourists (Schwitzer *et al*., 2013). Animals either may be used as photo props, wherein tourists pay a small amount of money to have their photo taken with the lemurs (in Anakao 2015: between 30 cents and 3 USD, M. LaFleur and T. Clarke, pers obs.), or are kept in hotels where tourists can see and photograph the animals (Goodman, 1993).

Pet lemurs may also be kept as a back-up protein source in times of food instability (Zinner *et al*., 2001), although this has yet to be confirmed for ring-tailed lemurs. Informants suggest that wild-caught ring-tailed lemurs are killed and smoked in south-western forests, so that meat can be transported and sold in and around Toliara (Sauther *et al*., 2013). Guides and local people report hunting ring-tailed lemurs either currently, where animals still persist (e.g., Zombitse-Vohibasia National Park), or previously, before animals were locally extirpated (e.g., Mangily). Consuming ring-tailed lemurs is traditionally *fady* (taboo) to some Malagasy ethnic groups (Mahafaly, Tanalana) (see Loudon *et al.,* 2006), but accepted by others (Vezo, Anosy), and may be an increasingly preferred by young transient workers, for example, who may be less bound to social tradition and have more disposable income (see Sauther *et al*., 2013). Due to the clandestine nature of capture and sale of lemurs, and ring-tailed lemurs in particular, information on the animals' origins or rates of capture are largely unknown (Reuter *et al*., 2015).

Most people that keep pet lemurs are aware that it is illegal (Reuter *et al.,* 2015). Prior to 2011, the practice was largely tolerated or inconsistently enforced by authorities in and around Madagascar's southwest (see Reuter *et al*., 2015). In 2011, the MEF began confiscating illegally held ring-tailed lemurs in the Toliara region. Since the MEF does not have facilities to care for animals, a care center for ring-tailed lemurs was urgently needed as confiscated animals were living in small garbage bin-type containers near offices (Fig. 1). Maurice Adiba, the LRC's founder, secured initial funds, veterinary guidance and technical advice from Touroparc Conservation <www.touroparc.com>, a zoological society in France. Since their original investment, Touroparc Conservation has continued to support the LRC. Other financial and practical supports have come from Lemur Love, Inc. <www.lemurlove.org>, Zoo Sanary <www.zoaparc.com>, dotation fund "La passerelle", Little Rock Zoo <www.littlerockzoo.com>, the Brigitte Bardot Foundation <www.fondationbrigittebardot.fr>, and several private donors.

The LRC is located 25 km north of Toliara in the Mangily region of Ifaty (Fig. 2). The land is privately owned and has an established botanical and ornithological reserve. Tours are offered daily and in addition to native plant species, visitors can see a plethora of birds including the area endemic ground roller (*Uratelornis chimaera*), spider tortoise (*Pyxis arachnoides*), radiated tortoises (*Astrochelys radiata*), mouse lemurs (*Microcebus griseorufus*), and other reptiles, insects and arachnids. Reniala Botanical Reserve provides permanent employment for eleven staff (Dame Gertude, general manager; Dabe, Vonjy, Bebe, Clovis, tour guides; Mariette, receptionist; Zarline, Pauline, Esparence, housekeepers; Ariste, cook; Olivier and Zanga, Reserve guards). Additionally, the NGO Reniala for the Lemur Rescue Center employs two staff (Mbola Versene, LRC Manager and Environnemental manager; Edson, lemur keeper).

As of July 2015, there are 26 ring-tailed lemurs at the LRC, and three more individuals in the process of being transferred from MEF to the LRC. Several more privately held ring-tailed lemurs have been identified in Ambola (one individual), Anakao (at least eight individuals), Tolanaro (one ring-tailed lemur along with one Hapalemur), and Tsinjorike (three individuals), and the LRC hopes to secure funds for the transfer and care of these individuals at the Center in future. The general protocol for intake of animals includes a Ministry agent in Toliara contacting the person(s) keeping a

Fig 1: Ring-tailed lemurs living in a small cage after being confiscated by the MEF.

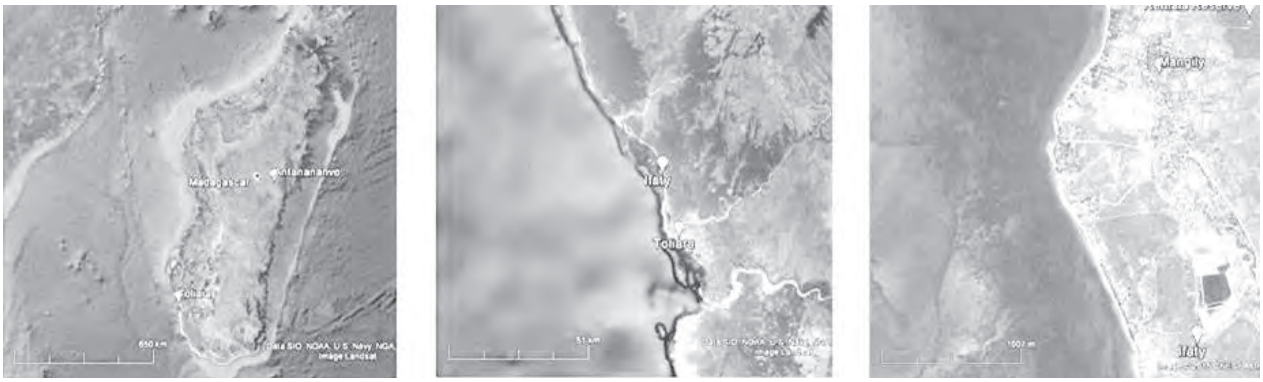

Fig 2: Google Earth Satellite images of Madagascar showing the cities of Antananarivo and Toliara (left), Toliara and Ifaty (middle), and Ifaty, Mangily, and Reniala Reserve (right).

lemur or lemurs, and presenting the person with the choice of either surrendering the animal or paying an exorbitant fine (approximately $1000 USD) to keep the animal. Confiscated animals are then held at the MEF office in Toliara until they can be transferred to the LRC. Prior to transfer, the LRC must have the animals checked by a veterinarian and pay all seizure-related expenses incurred by Ministry officials. Physical transportation and associated costs are also the responsibility of the LRC. Permissions to hold and transfer ring-tailed lemurs have been granted by the same governmental entity, the MEF.

Lemur behaviour and care at the LRC

As wild-caught captive lemurs mature, they become difficult to manage and are often kept in highly unsuitable conditions, such as small filthy cages, or tethered to short ropes (Reuter *et al*., 2015). However, one of the lemurs (Lola) at the LRC was relatively well-cared for (though the type of captivity was still species inappropriate) and even traveled to Antananarivo on at least three separate occasions (via Air Madagascar, with permission of MEF) to receive veterinary care (Fig. 3).

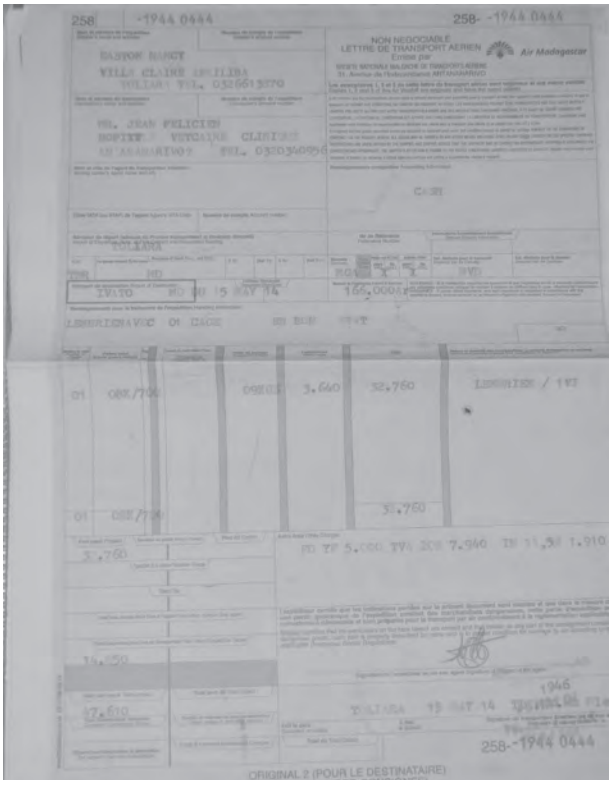

Fig 3: Air Madagascar ticket for Lola the ring-tailed lemur.

Pet ring-tailed lemurs are sometimes kept singly, in pairs, or in small groups of up to four individuals, with members of other lemur species, and may also befriend other species of animals, such as village cats (pers. obs.). Some captive ring-tailed lemurs become extremely aggressive towards humans and may lunge at or bite people, although this is not always the case. Aggressive behaviours are obviously problematic and not conducive to pet animals in a village setting.

Once residing at the LRC animals are initially housed alone or with the animal they came in with, before being introduced to others. One large (~19 animals) and several small (2-5 animals) social groups have been established. Ideally new animals can be integrated into the large social group, but not all individuals possess the normal repertoire of species-appropriate social behaviours necessary to live with other ring-tailed lemurs, or they may not be tolerated by the group for reasons unknown.

Original lemur enclosures at the LRC included eight smaller units (2 x 2 x 2 m), which can be either continuous or sectioned off, and a large (6 x 6 x 10 m) adjoining aviary-type enclosure (Fig. 4). The frames of these enclosures were constructed of wood, and these frames suffered severe damage from cyclone activity and termites. In 2015, the LRC built two new larger enclosures (10 x 6.5 x 20 m) with a metal frame (Fig. 5) and funded by Virgin Unite and the Brigitte Bardot Foundation, which is expected to withstand environmental pressure for significantly longer than the aforementioned wood-framed structures. A veterinary treatment room funded by the Brigitte Bardot Foundation will be built at the end of July 2015.

Since the large original enclosure has been damaged (cyclone activity, termites), about half of the large group members can escape and are semi-free ranging. These animals stay close to the enclosure (< 200 m), and always return for meals and at night. When outside of the enclosure, the lemurs forage in trees nearby and monitor the area where the animals' keeper (Edson) prepares their food. Contact between the LRC lemurs and humans is not allowed, with the exception of Edson, who enters cages for husbandry and feeding purposes. Tourists regularly visit the Reniala Botanical Reserve (approximately 4000 to 6000 per year) and tour guides explain that these animals have been rescued and are being rehabilitated.

Five of the ring-tailed lemurs present at the LRC were born in the facility in 2011 and 2012. Adult females are now given injections of Depo-Provera (150mg/ml concentration; 5 mg/

Fig 4: Original LRC enclosures that were built in 2011. Small cages are in the foreground and the large enclosure is in the background.

kg body weight) to prevent reproduction. This contraception is administered by a veterinarian five times annually, once every 40 days commencing in mid to late April. Contraceptives are administered to prevent births as the LRC could not otherwise manage to care for all of the potential offspring that would be born annually.

Animals are fed on several small platforms twice daily, at approximately 8 am and 5 pm. The bulk of their diet consists of mixed fruits (tomato, cucumber, melon, mango, etc.) and vegetables (carrot, potato, etc.), and the content varies according to local availability. Additionally, three times per week a charrette (zebu cart) collects branches from trees out of the reserve boundaries that are known ring-tailed lemur plant foods. These natural foods provide a form of enrichment, are a source of nutrition, and allow the ring-tailed lemurs to become accustomed to natural foods. Other food enrichment is provided on alternating days, also three times per week, and consists of hiding foods in coconut or baobab fruit shells, in decaying wood, or inside of plastic bottles.

Many of these captive ring-tailed lemurs exhibit stereotypy or other abnormal behaviors. Stereotypic behaviors include pacing, circling or other repetitive motions, and in the case of one female lemur (Laurence) abnormal repeated opening/closing of her jaw. Animals that are semi-free ranging do not appear to exhibit stereotypy, although it is not known if this is because they are able to escape at will, because many of them are young (animals born at the facility), or perhaps because they have had less traumatic histories. The majority of the daily stress felt by the ring-tailed lemurs appears to be in relation to food provisioning. Animals become agitated near feeding time, watch vigilantly for signs of their keeper, and many exhibit stereotypic pacing or movements while waiting

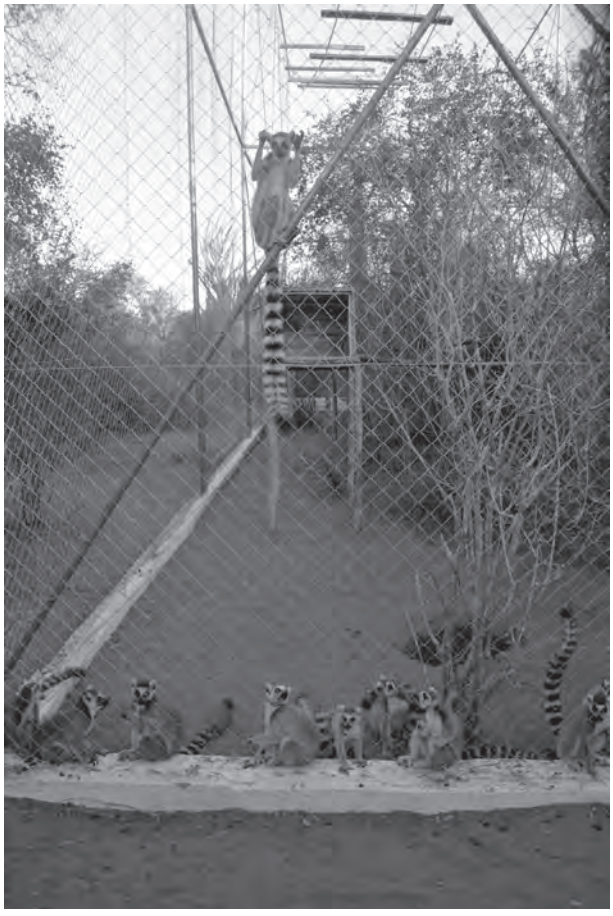

Fig 5: New LRC enclosure built in 2015.

Fig 6: Ring-tailed lemur feeding frenzy at the LRC.

Fig 7: Camera trap photo of lemur nighttime activity at the LRC.

Fig 8: Amandine recovering after having her femoral fracture set.

for food. Furthermore, animals become frenzied at feeding time (Fig. 6) and dominant individuals can be very aggressive. Ring-tailed lemurs at the LRC are active during both the day and at night (Fig. 7), as has been documented in wild populations (Donati *et al*., 2013; LaFleur *et al.,* 2014). Sleeping boxes exist within the enclosure, and although the animals do use these, they also sleep in trees or on the ground. Terrestrial predators are present: camera traps have shown feral cats, and many dogs frequent this territory. There is no evidence for the presence of fossa. The lemurs respond appropriately to aerial predators (alarm call and jump down) and terrestrial predators (alarm call and jump up), however we are unsure if sleeping on the ground at night makes them more susceptible to predation once released, but this is a possibility.

Four ring-tailed lemurs died while under the care of the LRC, and one suffered a broken bone. Although no necropsies were performed on the lemurs that died (a veterinarian was not available), the circumstances surrounding the deaths will be briefly described here. One animal ("Frisquette") was extremely obese (>3kg) and died during transit to the LRC. The second ("Fred") experienced recurring seizures and was found drowned in the groups' water basin. The third ("Thirsty") was noted as being ill and consuming little before dying. The last lemur ("Leona") was regarded as extremely thin and without adipose tissue after death although it is not known why she was in this condition. In addition to these, one lemur ("Amandine") suffered a fractured femur of unknown cause. Amandine was taken to a veterinarian in Toliara, her leg was set, and she has since recovered (Fig. 8).

Reintroduction and Future Considerations

We have considered several options for release sites, but to date a suitable location has not been identified. Important considerations include: species appropriate habitat type, proximity to humans, re-capture or hunting threat, and presence of existing ring-tailed lemur populations. With the exception of the St. Luce area (a littoral rain forest), ring-tailed lemurs occur in dry habitats of south and southwestern Madagascar. These habitats are thus most appropriate for potential release sites. Extremely remote release locations are impractical (e.g. Tsimanampetsotse) given that animals will need to be provisioned following release, and individually monitored for a minimum of one year, according the IUCN guidelines (IUCN/SSC, 2013). Despite the practicality of being near human settlements, for provisioning and monitoring, such proximity may prove dangerous for the lemurs, as habituated animals could easily be taken by poachers. For example, we have reports of ring-tailed lemur infants being taken from Tsimanampetsotse. Areas of particular concern for re-capture and hunting of ring-tailed lemurs include those to the north of Toliara, such as Mangily where the LRC is located, and in the southeast of Madagascar including regions of Petriky, Andohahela, Fort-Dauphin (see LaFleur, 2014).

Reintroduction of captive ring-tailed lemurs into forests that have existing ring-tailed lemur populations runs the additional risk of disease transmission. There are forests in southwestern Madagascar which have suitable habitat yet are devoid of ring-tailed lemurs, which would evade possible transfer of disease; however these forested areas are likely without ring-tailed lemurs because of over-hunting, which may indicate that released lemurs could be hunted as well. Thus, cultural acceptance of hunting and/or eating ring-tailed lemurs may also threaten the successful reintroduction of these animals. Aforementioned complications aside, stereotypy and abnormal behaviors exhibited by the Reniala ring-tailed lemurs suggest that staged releases are within their long-term best interest; wild captured ring-tailed lemurs appear to be intolerant to all but very large and naturalistic enclosures. As such, we will continue to search for suitable locations.

Community relations will be essential during the reintroduction process. Ideally, a community or village would become stewards for these animals and share a vested interest in their survival. Education is important both for Malagasy and *vazaha* (foreigners), regarding laws and protection of animals, and the detriment caused by wild-capture to individual ring-tailed lemurs, and the impact of capture on the future of ring-tailed lemur survival. Finally, consistent enforcement of law is necessary to curtail exploitation of ring-tailed lemurs.

The LRC and Reniala Botanical Reserve have been working with local people to increase environmental awareness, improve livelihoods and maintain the flow of information regarding our activities. These include teaching village children about reforestation and care of native plants in a small nursery, viewings (5 separate occasions) of the Malagasy dubbed version of "Madagascar: Land of heat and dust" (BBC 1 release 2010), maintenance of a honey bee colony and training local women to harvest and sell honey, surveys of peoples' attitudes about food and non-food animals, and tours of the LRC with explanations as to why we are keeping and caring for ring-tailed lemurs. We plan to design and distribute

posters to hotels and restaurants in Toliara and other tourist destinations (e.g., Anakao, Ifaty) which target tourists and outline how contributing to the pet trade negatively affects the lemurs, in addition to continuing to develop and implement education programs geared towards animal empathy and protecting lemurs.

We welcome suggestions for improving any aspect of the welfare of the ring-tailed lemurs at the LRC and potential locations for their release.

References

Goodman, S.M. 1993. A reconnaissance of Ile Sainte Marie, Madagascar: the status of the forest, avifauna, lemurs and fruit bats. Biological conservation 65: 205-212.

Gould, L.; Sussman, R.W.; Sauther, M.L. 2003. Demographic and Life-History Patterns in a Population of Ring-Tailed Lemurs (*Lemur catta*) at Beza Mahafaly Reserve, Madagascar: A 15-Year Perspective. American Journal of Physical Anthropology 120: 182-194.

Gould, L. 2006. Lemurs: Ecology and Adaptation. Pp. 255-274. In: L. Gould; M.L. Sauther (eds.). *Lemur catta* ecology: What we know and what we need to know. New York, Springer.

IUCN/SSC. 2013. Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0. Gland, Switzerland: IUCN Species Survival Commission.

Andriaholinirina, N.; Baden, A.; Blanco, M.; Chikhi, L.; Cooke, A.; Davies, N.; Dolch, R.; Donati, G.; Ganzhorn, J.; Golden, C.; Groeneveld, L.F.; Hapke, A.; Irwin, M.; Johnson, S.; Kappeler, P.; King, T.; Lewis, R.; Louis, E.E.; Markolf, M.; Mass, V.; Mittermeier, R.A.; Nichols, R.; Patel, E.; Rabarivola, C.J.; Raharivololona, B.; Rajaobelina, S.; Rakotoarisoa, G.; Rakotomanga, B.; Rakotonanahary, J.; Rakotondrainibe, H.; Rakotondratsimba, G.; Rakotondratsimba, M.; Rakotonirina, L.; Ralainasolo, F.B.; Ralison, J.; Ramahaleo, T.; Ranaivoarisoa, J.F.; Randrianahaleo, S.I.; Randrianambinina, B.; Randrianarimanana, L.; Randrianasolo, H.; Randriatahina, G.; Rasamimananana, H.; Rasolofoharivelo, T.; Rasoloharijaona, S.; Ratelolahy, F.; Ratsimbazafy, J.; Ratsimbazafy, N.; Razafindraibe, H.; Razafindramanana, J.; Rowe, N.; Salmona, J.; Seiler, M.; Volampeno, S.; Wright, P.; Youssouf, J.; Zaonarivelo, J.; Zaramody, A. 2014. *Lemur catta*. The IUCN Red List of Threatened Species 2014: e.T11496A62260437. Downloaded on 19 October 2015.

Jolly, A. 1966. Lemur behaviour: a Madagascar field study. Chicago: University of Chicago Press.

Jolly, A.; Dobson, A.; Rasamimanana, H. M.; Walker, J.; O'connor, S.; Solberg, M.; Perel, V. 2002. Demography of *Lemur catta* at Berenty Reserve, Madagascar: effects of troop size, habitat and rainfall. International Journal of Primatology 23: 327-353.

Junge, R.E.; Williams, C.V.; Campbell, J. 2009. Nutrition and behavior of lemurs. Veterinary Clinics of North America: Exotic Animal Practice 12: 339-348.

LaFleur, M. 2014. Another Endangered primate: threats to the survival of ring-tailed lemurs. XXVth Congress of the International Primatological Society, August 11-16, 2014.

Loudon, J.; Sauther, M.L.; Fish, K.D.; Hunter-Ishikawa, M.; Ibrahim, A.J.Y. 2006. One reserve, three primates: applying a holistic approach to understand the interconnections among ring-tailed lemurs (*Lemur catta*), Verreaux's sifaka (*Propithecus verreauxi*), and humans (*Homo sapiens*) at Beza Mahafaly Special Reserve, Madagascar. Ecological and Environmental Anthropology 2: 54-74.

Sauther, M.L. 1994. Eating on the Wild Side. Pp 240-256. In: N.L. Etkin (ed). Wild plant use by pregnant and lactating ring-tailed lemurs, with implications for early hominid foraging. Tucson, University of Arizona Press.

Schwitzer, C.; Mittermeier, R.A.; Davies, N.; Johnson, S.; Ratsimbazafy, J.; Razafindramanana, J.; Louis Jr., E.E., Rajaobelina S. 2013. Lemurs of Madagascar: A strategy for their conservation 2013-2016. IUCN SSC Primate Specialist Group, Bristol Conservation and Science Foundation, and Conservation International. 185 pp.

Simmen, B.; Sauther, M.L.; Soma, T.; Rasamimanana, H.; Sussman, R.W.; Jolly, A.; Tarnaud, L.; Hladik, A. 2006. Plant species fed on by *Lemur catta* in gallery forests of the southern domain of Madagascar. In: A. Jolly; R.W. Sussman; N. Koyama; H. Rasamimanana (eds). Ringtailed Lemur Biology: *Lemur catta* in Madagascar. Springer, New York. pp. 55-68.

Reuter, K.E.; Gilles, H.; Wills, A.R.; Sewall, B.J. 2015. Live capture and ownership of lemurs in Madagascar: extent and conservation implications. Oryx 1-11.

First characterization of the vocal acoustics of Otto's sportive lemur *Lepilemur otto* (Craul *et al*., 2007) with remarks on its abundance

Said Mahaboubi[1], Blanchard Randrianambinina[1], Romule Rakotondravony[1], Marina Scheumann[2], Elke Zimmermann[2], Solofonirina Rasoloharijaona[1*]

[1]Faculty of Science, Technology and Environment, University of Mahajanga, Mahajanga, Madagascar

[2]Institute of Zoology, University of Veterinary Medicine Hannover, Hannover, Germany

*Corresponding author: **solofo_r01@yahoo.fr**

Key words: bioacoustics, abundance, evolution, conservation, sportive lemur

Abstract

Animal vocalizations are an interesting non-invasive bioacoustic tool for the monitoring of cryptic and endangered lemur species such as Otto's sportive lemur (*Lepilemur otto*). To date, information on the biology, ecology, and bioacoustics of this newly described species is lacking. We provide first data on its population density and vocal acoustics in the Inter-river-system II, the Bongolava forest, Sofia region, northwestern Madagascar. Data collection was carried out in three different sites (Marosely, Antsahonjo and Ankarahara) with typical dry deciduous forest. Seven acoustically distinct call types could be recorded. This preliminary vocal repertoire of *L. otto* was similar to the vocal repertoire of *L. edwardsi*, its sister species occurring in the Inter-River-System I. However, there were also tangible differences in some acoustic parameters between the two species. Abundance data imply that this lemur species is highly threatened due to bush fires and the high fragmentation of its habitat. Findings provide the first basis to establish bioacoustic tools for non-invasive assessment of the presence, distribution and monitoring of this species. A more comprehensive study, integrating vocal acoustic data with abundance and chronic stress hormone and population genetic data, is urgently needed to establish management plans for the future protection of this highly endangered sportive lemur species.

Introduction

For many primate species, loud calls (vocalizations which are distinctive and easily localizable against high levels of ambient noise) have been used successfully in studies of adaptation and evolution (e.g., Delgado, 2007; Méndez-Cárdenas and Zimmermann, 2009; Meyer *et al*., 2012; Rasoloharijaona *et al*., 2006), as well as in conservation-related activities (e.g., diagnosing species/subspecies differences: Zimmermann, 1990; Davila Ross and Geissmann, 2007; Méndez-Cárdenas *et al*., 2008). In the last decades loud calls were successfully used in conservation as a non-invasive tool for diagnosing species or subspecies as well as for monitoring the presence and distribution of species or the abundance of populations (e.g., Zimmermann, 1990; Masters, 1991; Gerhardt and Huber, 2002; Remis and Jost Robinson, 2012; also reviewed by Baptista and Gaunt, 1997; Laiolo, 2010). Especially in nocturnal, arboreal lemur species living in dense forest environments, where visual detection as well as visual species discrimination is limited, bioacoustic monitoring will be an important non-invasive tool in species monitoring. This is important to develop conservation strategies of endangered lemur species.

Sportive lemurs (*Lepilemur* spp.) are a nocturnal, arboreal and cryptic lemur species distributed across almost all forested regions on the island Madagascar. They are cat-sized vertical clingers and leapers with powerful hind legs. They live in dispersed pairs (Thalmann and Ganzhorn, 2003; Rasoloharijaona *et al*., 2006) and from some species an elaborate vocal repertoire is known (Rasoloharijaona *et al*., 2006). The different sportive lemur species show only minor differences in pelage colouration and other external characteristics. Thus, their early classification (Petit, 1933; Petter and Petter-Rousseaux, 1960) based on morphological features was disputed, comprehensive cytogenetic approaches and molecular studies identified 26 different sportive lemur species (Mittermeier *et al*., 2010). Otto's sportive lemur (*Lepilemur otto*) is one of the recently described species. Previously *L. otto* was linked to the species *Lepilemur edwardsi*, but molecular genetic data indicated that the two species are separated taxonomic units (Craul *et al*., 2007). Up to date, there is no information available as the biology, ecology and bioacoustics of the Otto's sportive lemur. Thus, in this study we will provide first information on the population density of this species at three different sites in northwestern Madagascar as well as preliminary information on vocal communication. The aim was to assess abundance as well as vocal rates of this species as well as to identify and characterize different call types. These data will provide a first basis to establish bioacoustic tools for non-invasive assessment of species diversity, distribution and monitoring of this species.

Methodology

Study sites

The study took place between July and December 2011 in the typical dry deciduous forest of northwestern Madagascar, the Bongolava forest, Port Bergé district, Sofia region, in northwestern Madagascar (Fig. 1). The three study sites belong to the Inter-River System II (IRS II), between the Mahajamba and Sofia rivers: forest of Antsatratokana/ Marosely (15° 39' 12.1" S –47° 34' 31.2" E, from 28.07.2011 to 19.08.2011, termed Marosely), forest of Antsahonjo/ Antafialatsaka (15° 33' 22.7" S –47° 25' 21.9" E, from 03.11.2011 to 23.11.2011, termed Antsahonjo), and forest of Ankarahara/ Andranomena II (15° 33' 07.0" S –47° 29' 23.9" E, from 25.11. 2011 to 14.12.2011, termed Ankarahara). At all three sites, fires were present and destroyed parts of the forest in 2010.

Assessing population density of sportive lemurs

Nocturnal census observations were carried out between 18:30 and 20:00 at each site according to Rabesandratana *et al.* (2012). At each site, two transects of 1 km were chosen. The observer followed a selected transect of 1 km at a speed an average of 1 to 1.5 km / h^{-1} with dimmed light, using headlamps to identify nocturnal lemurs by light reflection from their eyes. If the animal was seen, another powerful light (Maglite) was used to identify the species. Identification of lemur species was made by visual observation or by listening to loud calls. Nocturnal observations at each transect have been done in total three times. With this method, the average number of individuals counted per kilometer (average calculated per species per site) could be determined by the formula Nme = (N1E / 3) + (N2E / 3) / 2 (Nme: average number of individuals identified by km; N1E: total number of individuals of identified species during the three censuses on the transect 1; N2E: total number of individuals of identified species during the 3 censuses on the transect 2).

Assessing vocal behaviour

At each of the three study sites, observations took place from 06:00 p.m. to 10:00 p.m. during 5 to 7 days per site. First, diurnal observations were conducted to detect the lemurs at their sleeping hole. If lemurs were present, the observer went back to the sleeping hole on the following evening to observe the animals by dimmed light, using headlamps. One focus animal was followed just after leaving the sleeping hole, at the onset of its activity until it was out of sight. Second, if no sleeping hole was found or animals were lost during observation, the observer tried to localize a further animal by the light reflection from their eyes (tapetum lucidum), by their vocalization or by movements in the branches. This animal was then followed until it got out of sight. Vocalizations were recorded using a Sennheiser ME88 directional microphone (Wedemark, Germany; 40– 20,000 Hz frequency range) and a Marantz PMD 660 professional solid-state recorder (Osnabrück, Germany).

Audio recordings were scanned for vocalizations using the software Batsound (FFT size, 512; Hanning window). Based on visual inspection of the sonograms, seven different call types were discriminated and labelled according to previous publications of *L. edwardsi* (Rasoloharijaona *et al*., 2006) as Oooai, Shrill, Bark, Shrill chuckle isolated (SCC), shrill chuckle related (SHCC), High-pitched (HPC) and Squeal (Fig. 2a-f). To assess the call rate, the number of calls per call type per

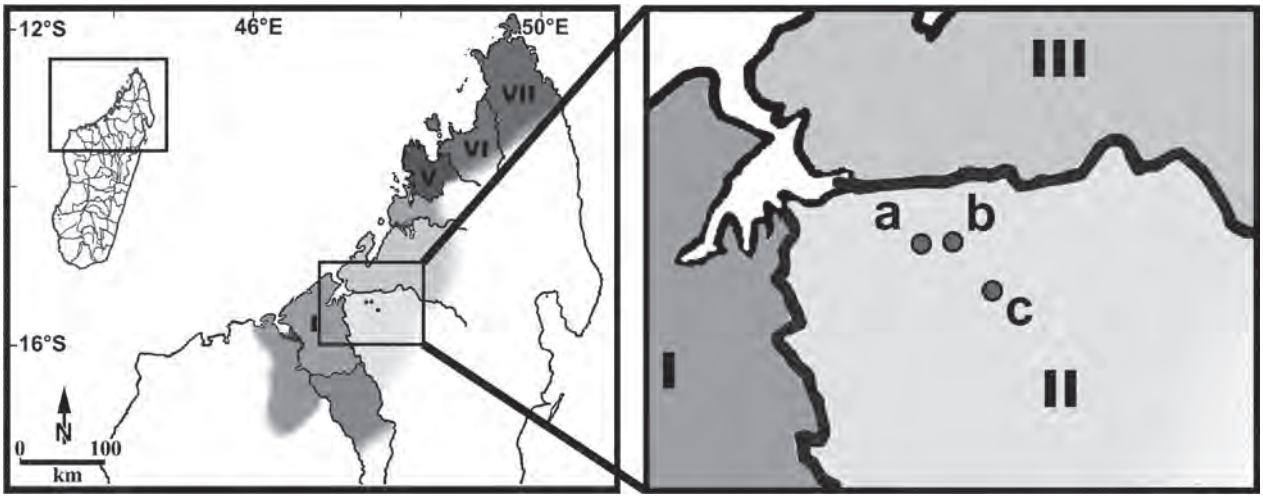

Fig. 1: Map of study site location in the Bongolava forest : (a) Ankarahara, (b) Antsahonjo and (c) Marosely.

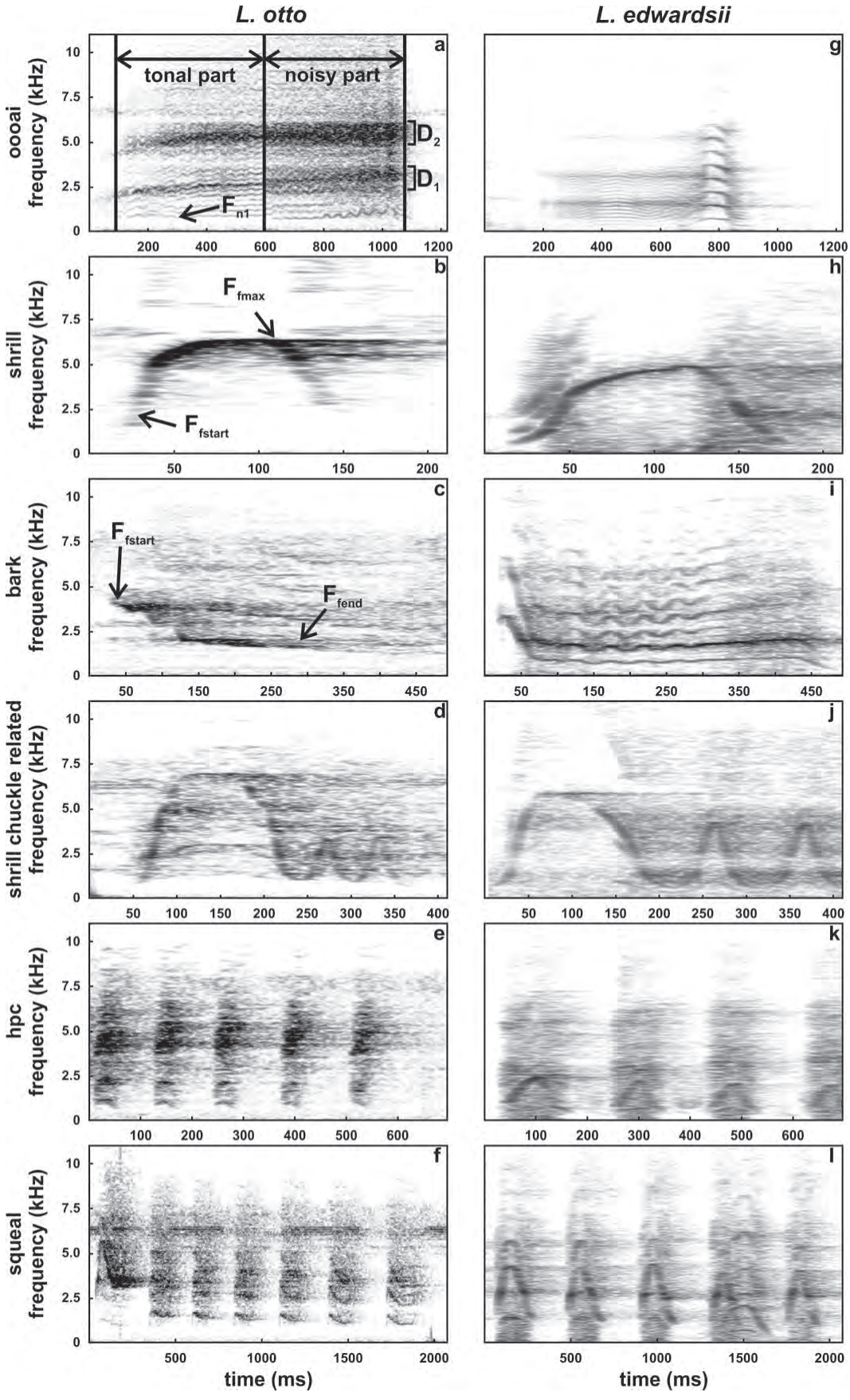

Fig. 2: Sonograms of loud calls in Otto's sportive lemurs; (a) Oooai, (b) Shrill, (c) Bark, (d) Shrill chuckle related, (e) High pitched call, (f) Squeal, and of the Milne Edwards' Sportive lemur: (g) Oooai, (h) Shrill, (i) bark, (j) Shrill chuckle related, (k) High pitched call, (l) Squeal; D1=first dominant frequency band, D2=second dominant frequency, Fn1=first visible frequency peak; Ffstart= First visible frequency at the start of the call, Ffend= Maximum of the first visible frequency contour of the call.

Tab. 1: Definition of measured acoustic parameters.

Parameter	Abbreviation	Call types	Definition
Temporal parameters [ms]			
Total Duration	D_{Total}	Oooai, Shrill, Bark, HPC, Squeal	Duration from the onset to the offset of the call measured in the oscillogram
Duration of tonal part	D_{Tonal}	Oooai	Duration from the onset to the start of the noisy part of the call measured in the sonogram
Duration of noisy part	D_{Noisy}	Oooai	Duration from the start of the noisy part to the offset of the call measured in the sonogram
Spectral parameters [kHz]			
Peak frequency	F_P	HPC, Squeal	Frequency peak with the largest amplitude over the whole call measured in the powerspectrogram
First/second dominant frequency	$F_{D1/2}$	Oooai,	Frequency peak with the largest amplitude within the first or second broad-banded frequency band (see Fig. 2a) measured in the powerspectrogram
First visible frequency peak	F_{fl}	Oooai	First frequency peak measured in the powerspectrogram
First visible frequency at the start of the call	F_{fstart}	Shrill, Bark	First visible frequency at the onset of the call measured in the sonogram
Maximum of the first visible frequency contour of the call	F_{ffmax}	Shrill	Maximum o_f the first visible frequency of the call measured in the sonogram

site per hour (for the first 4 hours) was counted. A call was defined as continued sound element having no sound gap. To characterize the acoustic properties of the call types, temporal and spectral acoustic parameters of call types were manually extracted using Batsound Pro (see Tab. 1 for explanation). Since it was not clear whether the first visible frequency contour reflects the fundamental frequency (e.g., Oooai, where the harmonics were not a multiple of the first harmonic, Fig. 2a), we used the more neutral term first visible frequency in the sonogram to describe tonal calls. Because of strong background noise, only calls of high quality (signal to noise ratio larger than 5 %) were selected for acoustic measurements, which limited the amount of data. Unfortunately, the cryptic morphology and the nocturnal lifestyle limit visual identification of individuals by observers. Thus, the recorded vocalizations could not be reliably assigned to specific individuals. Thus, we calculated the median and interquartile range for each parameter and each call type across all measured high quality calls for a first description of the acoustic characteristics of these vocalizations.

Results

Population density of sportive lemurs within the three sites

Population density varies among study sites and was 3.00 ind./km in Marosely, 2.35 ind./km in Antsahonjo, and 0.56 ind./km in Ankarahara.

Vocal activity within the three sites

In total, we recorded the most vocal events in Ankarahara (76 calls/h) followed by Marosely (25 calls/h) and Antsahonjo (21.25 calls/h; Fig. 3). Most vocal events occurred between 18:00 and 19:00 for all three sites (Ankarahara: 230 out of 304 calls; Marosely: 99 out of 100 calls; Antsahonjo: 73 out of 85 calls), meaning just after the onset of activity.

Acoustic description of loud calls

Based on visual inspection of the sonograms (Fig. 2a-f), 5 tonal call types (Oooai, Shrill, Bark, SCC and SHCC) and 2 noisy calls (HPC and Squeal) could be discriminated. In the following we will present the medians (m) and quartiles (q=25 % quartile – 75 % quartile) for acoustic parameters of each call type.

The Oooai (N=13; Fig. 2a) is a long single call (m=996 ms; q=663-1099 ms) which consist of two parts: a more tonal part at the beginning which transits in a more noisy part at the end. The tonal part was 464 ms long with the first visible frequency at 0.98 kHz (0.89- 1.05 kHz). It contained two broad-banded frequency bands of high energy. The first dominant frequency located at around 2.25 kHz (=m, q=2.05-2.3 kHz) and the second dominant frequency located at 4.86 kHz (=m, q=4.42-5.28 kHz). The noisy part was 493 ms long and also contained the two broad-banded frequency bands with a first and second dominant frequency located at 2.9 kHz (=m, q=2.68-2.97 kHz) and 5.4 kHz (=m, q=5.28-5.49 kHz).

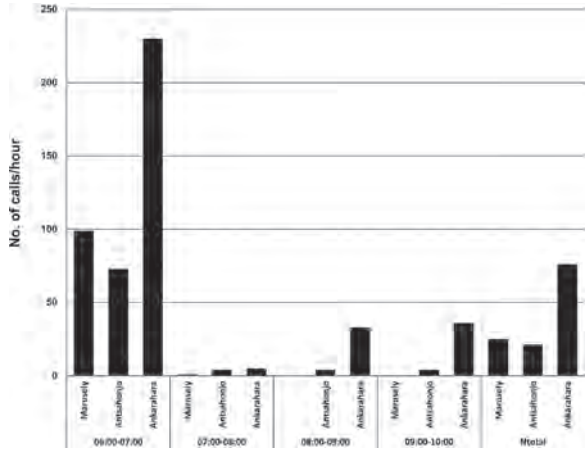

Fig. 3: Vocalization rate within the three sites.

The Shrill (N=26; Fig. 2b) is a tonal call of short duration (m=224ms, q=189-235ms). It has a first visible frequency contour which is inverse U shaped. The first visible frequency starts at 0.9 kHz (=m, q=0.80-0.90 kHz) and increased to 6.7 kHz (=m, q=6.60-6.90 kHz). Due to echo effects it was not possible to reliably measure the first visible frequency contour at the end.

The Bark (N=7; Fig. 2c) is a tonal call of short duration (m=360 ms; q=292-486 ms). It has a first visible frequency at the start of the call of 4.1 kHz (=m, q=3.80-4.30 kHz) which decreased stepwise to 1.00 kHz (=m, q=0.70-1.30 kHz) at the end. Thereby it covers a bandwidth of 3.10 kHz.

The SCC and SHCC (Fig. 2d) calls are tonal calls with a modulated first visible frequency contour. Unfortunately these calls are of low amplitude. Since they did not reach the high quality criterion for acoustic measurements, no

acoustic parameters could be measured but a sonogram is presented in Fig. 2d.

The HPC (N=6 out of 3 series; Fig. 2e) is emitted in series. Some HPC calls within a series can contain a tonal structure. However, the majority of HPC calls within a series were noisy calls of 84 ms (q=45-100 ms) and with a peak frequency of 2.57 kHz (q=2.39-4.21 kHz).

The Squeal (N=6 out of 1 series; Fig. 2f) is a very noisy call emitted in series. It has the shortest duration of 154.5 ms (=m; q=147-164 ms) and a peak frequency of 3.55 kHz (=m; q=3.48-4.04 kHz).

Discussion

Comparing the population density of Otto's sportive lemur between study sites, we found the highest density in the forest of Marosely, followed by Antsahonjo and Ankarahara. This coincides with our observations, that the forest of Marosely was less damaged than the two other sites. In Antsahonjo and Ankarahara, forests are highly fragmented. Rabesandratana *et al.* (2012) found a similar effect of anthropogenic disturbances on the population density of Milne Edward's sportive lemur in the Ankarafantsika National Park.

In contrast to population density, vocal activity of Otto's sportive lemur was higher in Ankarahara than in Marosely and Antsahonjo. This result contradicts our assumption that a high vocalization rate may reflect a high population density. However, this discrepancy might be explained by the fact that in contrast to Marosely and Antsahonjo, observations in Ankarahara took place in November–December, a season characterized by the presence of offspring. Females protect their offspring against males, other females or intruders by emitting a lot of vocalizations to displace them (we captured offspring with mother), which might explain the increased vocal rate in this area despite the low population density. This suggests using vocal activity as a measurement of population density, seasonal dependent differences (e.g. mating or breeding season) have to be taken into account.

For all three sites, vocal activity is highest between 18:00 and 19:00 p.m., suggesting that this time interval may be best to record vocalizations of sportive lemurs in the forest. However, it cannot be excluded that the increase of vocal activity in the early evening is biased by the methodology. Thus, the vocalization rate might be increased by the fact that at sleeping sites, or following lemurs from sleeping sites, the probability to record vocalizations of sportive lemurs was higher than during the rest of the night, where lemurs were less observable or got lost in the dense forest and had to be found again.

Based on the sonograms, seven vocalizations could be distinguished which are in their main acoustic structure similar to call types emitted by *Lepilemur edwardsi* (Fig. 2g-l). Both species are separated by a geographic barrier, the Mahajamba river. Even if statistical tests could not be conducted in this study, when comparing sonograms tangible differences are visible suggesting species-specific differences. Thus, for the shrill, the median of the maximum of the first visible frequency contour (FFmax) was twice higher for *L. otto* (m=6.7, q=6.6-6.9; n=26) than for a comparable sample of *L. edwardsi* (m=3.76, q=3.64-4.82; n=32). For other call types, such as the Oooai, the Squeal, the Bark and the HPC, calls of *L. otto* seems to contain more noisy parts than calls of *L. edwardsi*. However, these differences have to be treated cautiously, since the background noise and therefore the quality of recordings of the calls of *L. otto* was low and may affect especially the tonality of the calls. The resulting low sample size (58 out of 458 recorded calls; 11.9 %) and the missing attribution to single individuals allows only a preliminary description of the acoustic parameter of these call types.

Nevertheless, this study provides first data on vocalizations of *L. otto* and gives some hints on species-specific differences in the acoustic structure of the vocalizations of *L. otto* and *L. edwardsi* supporting genetic analysis. To prove these preliminary results, further studies are needed to increase sample size of high quality vocal recordings using collared individuals for *L. otto* and to compare these data statistically to vocalizations of *L. edwardsi*. Further, a more comprehensive study, integrating vocal acoustic and playback data with abundance and chronic stress hormone and population genetic data is required to establish management plans for the future protection of this highly endangered sportive lemur species.

Acknowledgments

We thank the Malagasy authorities, and in particular the Ministère de l'Environnement et des Forêts for permission to work in Bongolava forest. We are grateful to the Department of Animal Biology of the University of Antananarivo, and the Faculty of Science of the University of Mahajanga. Our thanks also go to the Directeur Régional de l'Environnement et des Forêts and the Head of Conservation International in Sofia region. For help we received in the field, we thank Fatima Salime, Rina Evasoa Mamy, Rakotomanantena Jean Adolphe, Zaankidine Soumaila. We thank SönkeVon Der Berg for technical assistance.

Funding and support for the project have been provided by: Dr. Michael Otto, Deutscher Akademischer Austanschdienst (DAAD) and Stiftung TiHo Hannover.

References

Baptista, LF.; Gaunt, SLL. 1997. Bioacoustics as a tool in conservation studies. Pp. 212-242. In: J.R. Clemmons; R. Buchholz (eds). Behavioral Approaches to Conservation in the Wild. Cambridge Univ. Press, Cambridge.

Craul, M.; Zimmermann, E.; Rasoloharijaona, S.; Randrianambinina, B.; Radespiel, U. 2007. Unexpected species diversity of Malagasy primates (*Lepilemur* spp.) in the same biogeographical zone: a morphological and molecular approach with the description of two new species. BMC Evolutionary Biology 7: 83 (online).

Davila-Ross, M.; Geissmann T. 2007. Call diversity of wild male orangutans: a phylogenetic approach. American Journal of Primatology 69: 305–324.

Delgado, RA. 2006. Sexual selection in the loud calls of male primates: signal content and function. International Journal of Primatology 27: 5-25.

Delgado, RA. 2007. Geographic variation in the long calls of male orangutans (*Pongo* spp). Ethology 113: 487-498.

Gerhardt, H.; Huber, F. 2002. Acoustic Communication in Insects and Anurans. The University of Chicago press book.

Laiolo, P. 2010. The emerging significance of bioacoustics in animal species conservation. Biological Conservation 143: 1635-1645.

Masters, JC. 1991. Loud calls of *Galago crassicaudatus* and *G. garnettii* and their relation to habitat structure. Primates 32:153-167.

Mendez-Cárdenas, M.; Randrianambinina, B.; Rabesandratana, A.; Rasoloharijaona, S.; Zimmermann, E. 2008. Geographic Variation in Loud Calls of Sportive Lemurs (*Lepilemur* ssp.) and Their Implications for Conservation. American Journal of Primatology 70: 828-838.

Mendez-Cardenas, M.G.; Zimmermann, E. 2009. Duetting - a mechanism to strengthen pair bonds in a dispersed pair-living primate (*Lepilemur edwardsi*)? American Journal of Physical Anthropology 139:523–532.

Meyer, D., Hodges, J.K.; Rinaldi, D.; Wijaya, A.; Roos, C.; Hammerschmidt, K. 2012. Acoustic structure of male loud-calls support molecular phylogeny of Sumatran and Javanese leaf monkeys (genus *Presbytis*). BMC Evolutionary Biology 12:16.

Mittermeier, R.A.; Louis Jr, EE.; Richardson, M.; Schwitzer, C.; Langrand, O.; Rylands, A.B.; Hawkins, F.; Rajaobelina, S.; Ratsimbazafy, J.; Rasoloarison, R.; Roos, C.; Kappeler, P.M.; Mackinnon, J.

2010. Lemurs of Madagascar. Third edition. Washington DC Conservation International.
Petit, G. 1933. Le genre *Lepidolemur* et sa répartition géographique. Comptes Rendus de Societe Biogéographie 10:33-37.
Petter, J.J.; Petter-Rousseaux, A. 1960. Remarque sur la systématique du genre *Lepilemur*. Mammalia 24:76-86.
Rabesandratana, A.Z.; Rakotondravony, R.; Zimmermann, E. 2012. Distribution and abundance of Milne Edwards' sportive lemur *Lepilemur edwardsi* in the Ankarafantsika National Park, north western Madagascar. Lemur news 16: 57-59.
Rasoloharijaona, S.; Randrianambinina, B.; Braune, P.; Zimmermann, E. 2006. Loud calling, spacing and cohesiveness in a nocturnal primate, the Milne Edwards' Sportive lemur (*Lepilemur edwardsi*). American Journal of Physical Anthropology 129: 591-600.
Remis, M.J.; Jost Robinson, C.A. 2012. Reductions in primate abundance and diversity in a multiuse protected area: synergistic impacts of hunting and logging in a Congo basin forest. American Journal of Primatology 74: 602-12. doi: 10.1002/ajp.22012.
Thalmann, U.; Ganzhorn, J.U. 2003. *Lepilemur*, sportive lemur. Pp. 1336-1340. In: Goodman SM, Benstead JP (eds). The natural history of Madagascar. University of Chicago Press, Chicago.
Zimmermann, E. 1990. Differentiation of vocalizations on bushbabies (Galaginae, Prosimiae, Primates) and significance for assessing phylogenetic relantionships. Zeitschrift fur Zoologische Systematik und Evolutionsforschung: 217-239.

Inventaire rapide des lémuriens de Maromizaha en vue d'un programme à long-termes de suivi écologique participatif

José-Myriel Ralison[1,2]*, Andry Rajaonson[1], Jonah H. Ratsimbazafy[1]
[1]GERP, Lot 34 Cité des Professeurs, Fort-Duchesne, Antananarivo, 101
[2]Biotope Madagascar, IIM99 Antsakaviro, Antananarivo 101
*Corresponding author: **jmralison@biotope.fr**

Key words: Maromizaha new protected area, forest degradation, lemur surveys, monitoring

Abstract
Lemurs of Madagascar are all endemic species and occupy a wide range of forests around the island. Many lemur species, however, suffer from a range of anthropogenic pressures. The new Maromizaha protected area, located in the District of Moramanga, is home to many lemur species. The creation of scientific databases on the lemur community in the Maromizaha forest is necessary for both the creation of the new protected area and for carrying out the conservation actions that will contribute to the protection of lemurs in the Maromizaha forest. Thus, a rapid survey on the lemur community was carried out in two zones (Ambodipaiso and Analambalo) of this area from 11th to 18th March 2014. The survey used the transect line method, active research and informal interviews. The survey used two transects of 1 km per site. Vegetation structure, pressure and threat analyses were undertaken in order to determine a lemur distribution model. A total of twelve lemur species were found at Maromizaha forest, nine of which are threatened species (*Indri indri*, *Propithecus diadema*, *Varecia variegata*, *Eulemur rubriventer*, *Hapalemur griseus*, *Daubentonia madagascariensis*, *Avahi laniger*, *Microcebus lehilahytsara*, and *Allocebus trichotis*). Lemur species were more diversified at the site with good quality habitat (Ambodipaiso) than the degraded forest (Analambalo). Although Maromizaha lemurs were more diverse compared to the neighbouring humid forests, its lemur community is progressively reducing in number due to anthropogenic pressures, particularly slash-and-burn agriculture and hunting. In fact, the viability of threatened species is exceedingly concerning, and requires a lemur conservation plan such as forest patrol, lemur monitoring and environmental education school programmes.

Résumé
En dépit de leur grande diversité, les lémuriens de Madagascar ne sont pas à l'abri des menaces d'origine anthropique (Schwitzer *et al*., 2013), et plus de 90 % de ces espèces sont en cours d'extinction. Les données issues des inventaires rapides sont un outil nécessaire et primordial dans la définition des actions de conservation et dans l'amélioration des statuts de protection des lémuriens à Madagascar. La forêt de Maromizaha abrite une diversité assez remarquable de lémuriens, aussi bien diurnes que nocturnes (Rakotosaminana *et al*., 2003), dont des espèces menacées et d'autres encore très peu étudiées. Dans le cadre de la mise en place d'un programme de suivi écologique participatif dans la forêt de Maromizaha, afin de suivre le changement de la population des espèces de lémuriens menacées tout en impliquant les villageois, une évaluation de l'état de référence de la communauté lémurienne de deux zones apparemment distinctes a été entreprise du 11 au 18 Mars 2014.

Méthodologie
Située dans le District de Moramanga de la Région Alaotra-Mangoro, la forêt dense humide de moyenne altitude de Maromizaha (Koechlin *et al*. 1974 ; Faramalala, 1995) est délimitée par la route nationale (RN2) au nord, la chaîne de Befody à l'est, la rivière de Maromizaha à l'ouest et la rivière d'Ankazomirahavavy au sud (Fig. 1). Deux sites au sein de cette formation forestière ont été simultanément étudiés dont le premier (Ambodipaiso-JAR) localisé dans la partie sud-ouest de la forêt est caractérisé par des essences régénérées avec un habitat de bonne qualité dont la canopée d'une hauteur moyenne de 10 à 16 m est semi-fermée. Le second site (Analambalo-ARG) situé dans la partie nord-est de la forêt est dominé par desarbres de moyenne et de petite taille. L'habitat de ce site est assez dégradé, marqué par l'ouverture de la canopée située à 10-12 m.
Deux méthodes usuelles aux inventaires de lémuriens ont été adoptées durant l'étude: les lignes de transects-et la recherche active. La méthode des transects est utilisée afin de répertorier la composition de la communauté de lémuriens de chaque site. Cette méthode permet de détecter les espèces de lémuriens soit par observation directe, soit par vocalisations. Deux transects d'une longueur de 1 km chacun ont été dressés dans chaque site d'étude. La session d'observation est fixée de 6 jours et 6 nuits par site. Les inventaires sont faits durant les heures pendant les lémuriens sont les plus actifs, de 06h00 à 10h00 et de 15h30 à 17h30 pour les observations diurnes et de 19h00 à 22h00 pour le sobservations de nuit. Toutes précautions nécessaires aux observations ont été prises en compte. Les vitesses d'observation étaient de 1km/h durant les observations diurnes et 0,6km/h pour les nocturnes. À chaque observation, l'heure du contact, l'espèce, l'effectif, la hauteur approximative de l'animal (hauteur moyenne pour un groupe), l'activité déployée, la distance perpendiculaire au transect (distance moyenne pour le groupe), la position géographique de l'animal (excepté pour *Microcebus*), la hauteur et le DBH de l'arbre et la composition du groupe étaient enregistrés.
Au vu du nombre de jours d'inventaire relativement faible nécessitant un effort d'observation intense, la méthode de recherche active a été adoptée dans l'espoir d'observer

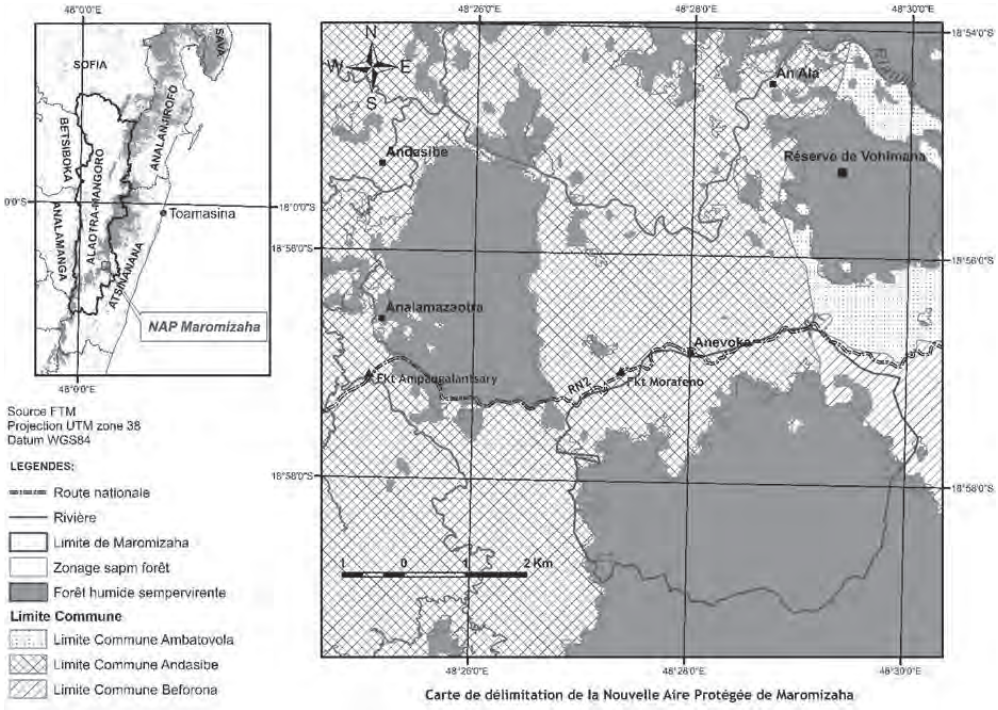

Fig. 1: Localisation de la zone d'étude.

des lémuriens non observés lors des transects. La chance de rencontrer des lémuriens discrets et de trouver des signes de présence augmente en parcourant le maximum de surface possible.

Comme méthodes d'analyse, l'état de chaque population de lémuriens dans chaque site est évalué à partir de leurs densités selon la formule de Whitesides *et al.* (1988). Le test de Kruskall-Wallis (K) est également choisi dans le but de comparer les populations de lémuriens dans les deux zones en admettant qu'une ressemblance de densités de lémuriens s'observe entre ces sites (Ho). L'analyse de diversité par la fonction de Shannon-Wiener (H') et l'équitabilité (J) comparent les indices de diversité de la communauté des lémuriens de ces zones. La fonction de Shannon considère à la fois la densité de chaque espèce et la présence-absence; l'équitabilité est fonction de la diversité; sa valeur élevée indique l'équilibre et l'homogénéité de la répartition des lémuriens. L'indice de similarité de Jaccard permet de comparer la similarité de la forêt de Maromizaha avec les autres forêts situées au nord de la rivière de Mangoro.

Résultats

Un total de onze espèces de lémuriens réparties dans 4 familles ont été recensées dans les deux sites d'étude (Tab. 1). Parmi ces espèces, quatre sont diurnes (*Hapalemur griseus, Varecia variegata, Propithecus diadema, Indri indri*), deux sont cathémérales (*Eulemur rubriventer, Eulemur fulvus*) et cinq sont nocturnes (*Microcebus lehilahytsara, Allocebus trichotis, Cheirogaleus major, Lepilemur mustelinus, Avahi laniger*). Le maximum d'espèces (11) a été observé dans la zone d'Ambodipaiso, tandis que sept espèces ont été inventoriées dans la zone d'Analambalo. Aucune trace de *Daubentonia madagascariensis* n'a été observée ni dans les transects d'étude, ni durant les recherches actives.

Parmi ces espèces, huit sont menacées d'extinction (UICN, 2013), dont trois en danger critique (*Indri indri, Propithecus diadema, Varecia variegata*), et cinq espèces sont vulnérables (*Eulemur rubriventer, Hapalemur griseus, Avahi laniger, Microcebus lehilahytsara, Allocebus trichotis*). Notons que la présence de *Daubentonia madagascariensis* (en danger) dans la forêt de Maromizaha a récemment ét confirmée par d'autres chercheurs. Par ailleurs, la forêt de Maromizaha abrite deux espèces quasi-menacées (*Eulemur fulvus, Lepilemur mustelinus*) et une espèce à données insuffisantes (*Cheirogaleus major*).

La Fig. 2 présente les densités de chaque population de lémuriens dans les deux zones inventoriées.

Tab. 1: Présence-absence des lémuriens dans les deux zones d'étude.

Famille	Espèces	Nom vernaculaire	JAR	ARG	UICN
Cheirogaleidae	*Microcebus lehilahytsara*	antsidi-voalavo	+	+	VU
	Allocebus trichotis	antsidiala	+	+	VU
	Cheirogaleus major	tsitsihy, antsidibe	+	+	DD
Lepilemuridae	*Lepilemur mustelinus*	hataka	+	+	NT
Lemuridae	*Hapalemur griseus*	kotraiky	+	+	VU
	Eulemur fulvus	varika, varika-mavo	+	-	NT
	Eulemur rubriventer	varika mena, barimaso	+	-	VU
	Varecia variegata	varikanda, varitsatsy	+	-	CR
Indriidae	*Avahi laniger*	avahina, fotsiefaka	+	+	VU
	Propithecus diadema	simpona	+	-	CR
	Indri indri	babakoto	+	+	CR
Daubentoniidae	*Daubentonia madagascariensis*	hay-hay	-	-	EN
Total			11	7	

JAR: Ambodipaiso; ARG: Analambalo. CR: En danger critique; EN: En danger; VU: Vulnérable; NT: Presque menace; DD: Données insuffisantes.

En termes d'indice de diversité, les communautés des lémuriens dans les deux zones sont assez similaires (657ind./km^2 pour les 11 espèces d'Ambodipaiso et 634ind./km^2 pour les 7 espèces d'Analambalo). Pourtant, le site Analambalo est dominé par les espèces de Cheirogaleidae dont la densité de *Microcebus lehilahytsara*, *d'Allocebus trichotis* et de *Cheirogaleus major* est élevée.

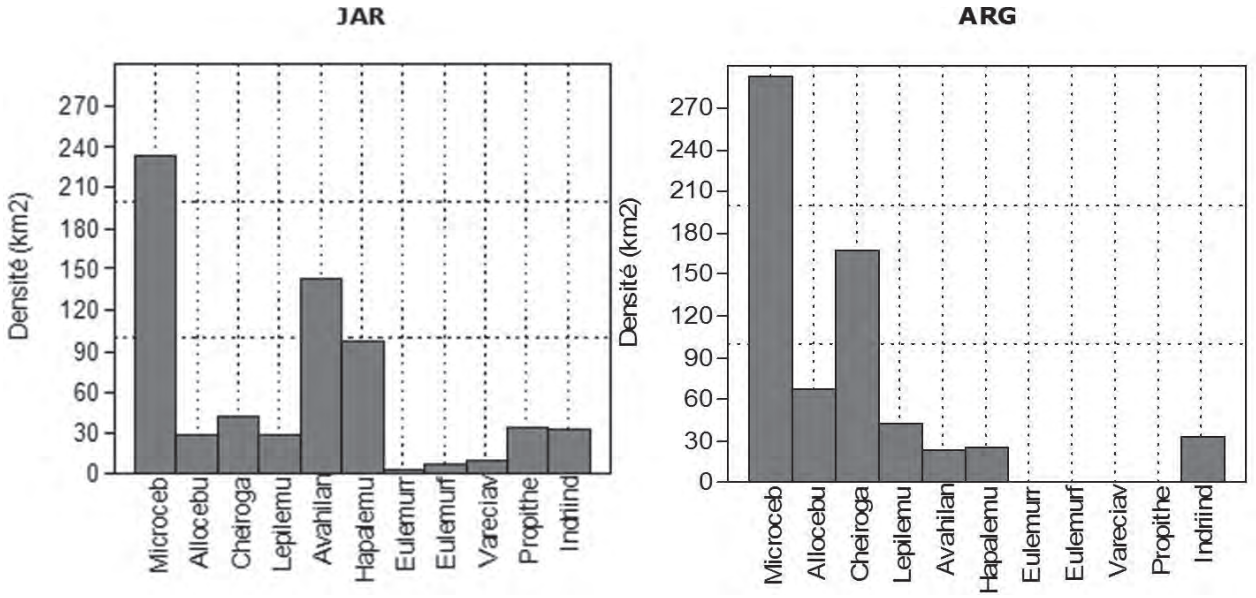

Fig. 2: Histogramme de densités des lémuriens de chaque zone d'étude. JAR: Ambodipaiso; ARG: Analambalo

En termes de densités, la communauté des lémuriens de la forêt de Maromizaha est assez homogène (K=10,0 ; p=0,44; ddl=10) mais les lémuriens d'Ambodipaiso sont beaucoup plus diversifiés (H' = 1,86) par rapport aux lémuriens d'Analambalo (H' = 1,46).

En procédant à la comparaison de diversité de Shannon-Wiener des trois blocs de forêts situées au nord de la rivière de Mangoro (Tab. 2), les lémuriens de Maromizaha (H' = 1,92) sont faiblement diversifiés par rapport aux lémuriens d'Ankerana (H' = 1,98) mais relativement variés par rapport aux lémuriens du Corridor Forestier Analamay-Mantadia-CFAM (H' = 1,77).

Tab. 2: Récapitulation des densités des lémuriens dans trois forêts au nord de Mangoro.

Espèces	Maro-mizaha	CFAM*	Anke-rana*
Microcebus spp.	206	247	139
Allocebus trichotis	35	21	83
Cheirogaleus major	67	0	131
Lepilemur mustelinus	39	99	120
Avahi laniger	63	115	79
Hapalemur griseus	59	44	46
Eulemur rubriventer	3	11	15
Eulemur fulvus	8	17	6
Varecia variegata	8	5	8
Prolemur simus	0	4	0
Propithecus diadema	24	28	8
Indri indri	23	11	12
Daubentonia madagascariensis	0	3	0

* Ralison *et al.* (in prep.)

Le dendrogramme de similarité (Fig. 3) issu de l'analyse de la richesse spécifique et l'indice de similarité de Jaccard permet de distinguer un groupement de Maromizaha, CFAM, Ankerana, Mantadia et Mangabe uni à une distance de 0,50 u.m.e. À l'intérieur de ce groupe se présente (1) la lignée CFAM-Ankerana, et (2) la lignée Mantadia et Maromizaha, liée à une distance de 0,22 u.m.e (lesquels sont quasi-similaires en termes de richesse spécifique). En d'autres termes, les espèces de lémuriens de Maromizaha sont plus proches de Mantadia et du corridor forestier Analamay-Mantadia (CFAM) que des autres blocs forestiers.

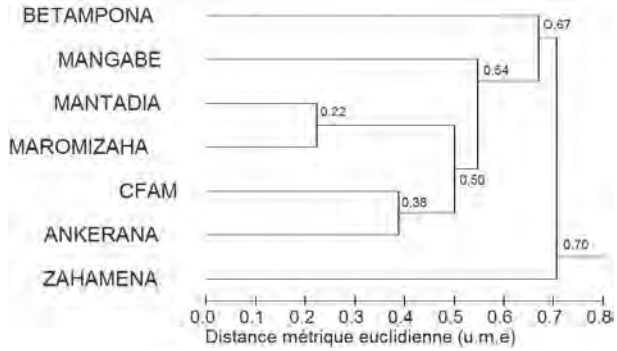

Fig. 3: Dendrogramme de similarité de Jaccard.

Discussion

Les espèces de lémuriens de Maromizaha sont typiques du centre d'endémisme CE2 au nord de la rivière Mangoro et au sud de la rivière Bemarivo (Wilmé *et al.*, 2006). Pourtant, la répartition de ces espèces dans la forêt n'est pas la même. La richesse spécifique élevée dans la zone d'Ambodipaiso est en rapport direct avec la physionomie forestière et la composition floristique de celle-ci où les espèces frugivores telles que *Varecia variegata* et *Propithecus diadema* sont présentes. Cette zone est également marquée par une faible intensité de la chasse. Il est fort probable que le faible nombre d'espèces à Analambalo peut résulter de la fuite des lémuriens vers l'intérieur face aux défrichements, au charbonnage et aux pièges situés dans la bordure de la forêt. La perte d'habitat et la chasse conduisent à l'extinction locale des espèces de lémuriens hautement frugivores comme *Varecia variegata* et *V. rubra* (Rigamonti, 1996; Simons et Lindsay, 1987). L'installation humaine dans les villages périphériques d'Analambalo provoque diverses pressions et constitue une menace majeure pour les lémuriens avec pour conséquence la réduction de la taille des populations. L'inventaire mené à Maromizaha a montré l'importance de la faune lémurienne d'Ambodipaiso. Cette étude rappelle également l'adaptation de *Microcebus* dans le milieu dégradé avec une densité élevée (cas d'Analambalo) favorisée par l'ouverture de la forêt et l'abondance des petits arbres. Enfin, l'étude met en exergue la compétition de deux espèces

nocturnes folivores (*Avahi laniger* et *Lepilemur mustelinus*) exploitant les mêmes sources de nourriture (Ganzhorn, 1989).

Toutefois, quelques hypothèses sur certaines espèces de lémuriens de Maromizaha méritent d'être avancées:

1. La densité de *Varecia variegata* (8 ind./km2) est distinctement comparable à celle d'Ankerana (8 ind./km2) mais nettement plus grande que celle de CFAM(5 ind./km2 ; Ralison *et al.*, in prep). La densité d'*Indri indri* est relativement élevée à Maromizaha (23 ind./km2) par rapport à Ankerana (12 ind./km2) et CFAM (11 ind./km2). L'étude de la végétation faite par Ramanahadray (2009) montre l'abondance des espèces floristiques, à savoir *Uapaca* spp., *Eugenia* spp., *Gaertnera macrostipula*, *Oncostemum elephantipes* et *Diospyros* spp. fréquentées par ces espèces;
2. La rareté d'*Eulemur rubriventer* à Maromizaha (3 ind./km^2) par rapport à Ankerana (15 ind./km2) et Analamay-Mantadia (11 ind./km^2) semble être due à la pression de la chasse. Deux groupes d'*Eulemur rubriventer* d'un maximum de deux individus avec des comportements méfiants ont été recensés. L'absence de l'espèce à Analambalo est probablement due à l'ouverture de la forêt à cause du défrichement intensif et de la coupe sélective;
3. La densité plus élevée d'*Hapalemur griseus* à Maromizaha qu'à Ankerana et Analamay-Mantadia (respectivement 74 ind./km2 et 44 ind./km2) serait partiellement due à l'abondance d'espèces de bambous dans la forêt;
4. La différence de période de travail entre le présent inventaire et l'étude de Randrianambinina et Rasoloharijaona (2006) en saison sèche (Mai-Août) agirait sur la différence de densité de *Lepilemur mustelinus* et *Avahi laniger* dans ce même site;
5. La présence de *Prolemur simus*, mentionné par Rakotosamimanana *et al*. (2003), n'a pasété observée, ni à Ambodipaiso, ni à Analambalo. Par ses exigences particulières en termes d'habitat et d'alimentation (Tan, 1999), il semblerait que *Prolemur simus* n'existe pas à Maromizaha.

La conservation à long et moyen termes des lémuriens de Maromizaha s'effectuerait à travers la mise en œuvre du plan de gestion de conservation des lémuriens. La forêt de Maromizaha subit des pressions humaines (Rakotosamimanana *et al.,* 2003) réduisant la surface de la forêt qui a un impact sur la communauté lémurienne. Face aux différentes pressions anthropiques actuelles, des actions de conservation telles que le suivi écologique participatif des espèces de lémuriens diurnes, la patrouille de la forêt par la population locale, la mise en place des pépinières villageoises, la restauration des parcelles défrichées par des plantes autochtones, la production des essences exotiques pour le besoin en bois de chauffe, le programme d'éducation environnementale au niveau scolaire et l'établissement des projets alternatifs de développement durable pour l'amélioration de l'économie ménagère des riverains doivent être initiées.

Conclusion

L'inventaire des lémuriens dans les deux zones de la forêt de Maromizaha, lequel permet de savoir la richesse de la forêt, est figuré dans les actions de conservation des lémuriens de Maromizaha. L'état de viabilité générale de la communauté lémurienne, particulièrement les lémuriens diurnes, est douteux à cause des pressions anthropiques. Issues des inventaires, la base de données des lémuriens de Maromizaha est mise à jour pour la mise en œuvre du plan de conservation des lémuriens.

Remerciements

Nous adressons notre reconnaissance au Ministère de l'Environnement, de l'Écologie, de la Mer et des Forêts de nous avoir confié la gestion de la forêt de Maromizaha ainsi que l'autorisation de recherche. Ce travail d'inventaire est réalisé grâce à la collaboration fructueuse entre le GERP et Houston Zoo à qui nous adressons nos vifs remerciements pour le financement. Nos sincères salutations sont attribuées aux autorités locales (CIREF, Communes et Fokontany) pour l'acceptation de la réalisation de l'étude et à la population locale (Raiamandreny, guides, cuisiniers, porteurs) pour leur volonté de nous aider pendant la réalisation des travaux de terrain.

Références

Faramalala, M.H. 1995. Formations végétales et domaine forestier national de Madagascar 1:1000000 carte couleur. Conservation International (CI), Directions des Eaux et Forêts (DEF), Centre National de Recherches sur l'Environnement (CNRE) et Foiben-Taosarintanin'i Madagascar (FTM).

Ganzhorn, J.U. 1989. Niche separation of the lemur species in the eastern rainforest of Madagascar. Oecologia 79: 279-286.

IUCN. 2013. IUCN Red List of Threatened Species. <www.iucnredlist.org>.

Koechlin, J.; Guillaumet, J.-L.; Morat P. 1974. Flore et végétation de Madagascar. Vaduz, Cramer.

Rakotosamimanana, B.; Ralaiarison, R.R.; Ralisoamalala, R.C.; Rasolofoharivelo, T.M.; Raharimanantsoa, V.; Randrianarison, R.M.; Rakotondratsimba, J.G.; Rasolofoson, D.R.W.; Rakotonirainy, E.O.; Randriamboavonjy, T.M. 2004. Comment et pourquoi les lémuriens diurnes disparaissent peu à peu dans les forêts d'Ambato et de Maromizaha (région de Moramanga) Madagascar? Lemur News 9: 19-24.

Ramanahadray, S.J. 2009. Étude écologique de différents types de formations végétales de Maromizaha (Corridor biologique Ankeniheny-Zahamena): Schéma d'Aménagement et plan de gestion. Mémoire de DESS en Sciences de l'Environnement. Option Biologie de conservation. Faculté des Sciences, Université d'Antananarivo, p. 62.

Randrianambinina, B. & Rasoloharijaona, S. 2006. Inventaires des lémuriens nocturnes dans la forêt pluviale de Maromizaha (Est de Madagascar). Lemur News 11: 9-11.

Rigamonti, M.M. 1996. Red ruffed lemur (*Varecia variegata rubra*): a rare lemur from the Masoala rain forests. Lemur News 1: 9-11.

Schwitzer, C.; Mittermeier, R.A.; Davies, N.; Johnson, S.; Ratsimbazafy, J.; Razafindramanana, J.; Louis Jr., E.E., Rajaobelina S. 2013. Lemurs of Madagascar: A strategy for their conservation 2013-2016. IUCN SSC Primate Specialist Group, Bristol Conservation and Science Foundation, and Conservation International. 185 pp.

Simons, H.J., Lindsay, N.B.D. 1987. Survey work on ruffed lemurs (*Varecia variegata*) and other primates in the northeastern rain forests of Madagascar. Primate Conservation 8: 88–91.

Tan, C. L. 1999. Group composition, home range size, and diet of three sympatric bamboo lemur species (genus *Hapalemur*) in Ranomafana National Park, Madagascar. International Journal of Primatology 20: 547-566.

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

Wilmé, L.; Goodman, S.M., Ganzhorn, J.U. 2006. Biogeographic evolution of Madagascar's microendemic biota. Science 312: 1063-1065.

Habitat use, diet and sleeping site selection of *Lepilemur tymerlachsoni* in a disturbed forest of Nosy Be: Preliminary observations

Rachel M. Sawyer[1]*, Honaisiford Edwin Mena[2], Giuseppe Donati[1]
[1]Department of Social Sciences, Oxford Brookes University, Oxford, OX3 0UP, UK
[2]Department of Food Nutrition, School of Life Sciences, Shanghai University, Shanghai, 200444, People's Republic of China
*Corresponding author: **rachelsawyer2704@hotmail.com**

Key words: Habitat disturbance, *Lepilemur tymerlachsoni*, Nosy Be, Critically Endangered, sleeping site selection, habitat use

Abstract
The description of many new *Lepilemur* species has left newly recognised species with little or no information available about the most basic aspects of their ecology. This is particularly true of species which have small, isolated populations such as the Critically Endangered *Lepilemur tymerlachsoni* on Nosy Be island. This study aims to provide preliminary observations on this species ecology in a disturbed habitat. We used a combination of daily and nightly focal animal sampling to collect data on habitat use, diet and sleeping site selection. We observed *L. tymerlachsoni* to use four different sleeping sites to varying degrees. We found no significant associations between tree height ($X(6)= 5.386$, $p=0.495$), or substrate type and *L. tymerlachsoni's* "activity type", although there was a strong tendency toward significance for substrate type ($X(4)= 9.185$, $p= 0.057$). We found *L. tymerlachsoni* to be predominantly folivorous, although traces of fruit were found in their faeces. Their diet was made up predominantly of three common tree species which grow in the study forest. *L. tymerlachsoni* are endemic to Nosy Be, where there are very few patches of forest remaining. This species appear to be ecologically flexible, although the presence of lemur traps in the study area is cause for concern. *L. tymerlachsoni* would benefit from long-term monitoring of population dynamics in this study area.

Introduction

The genus *Lepilemur* has experienced one of the largest increases in species numbers across the primate clade in recent years. The current species count stands at 26, more than tripling from just 8 species in 2005 (Groves, 2005; Andriaholinirina *et al*., 2006; Mittermeier *et al*., 2010; Schwitzer *et al*., 2013), but see Tattersall (2007) who cautions against recognising all as full species without more complete data. One consequence of this increase is that for many of the newly recognised species, which previously fell under the umbrella of another species, there is little information available on the most basic aspects of their ecology, behaviour and conservation status (Tattersall, 2007). This is even more concerning when we consider that 94 % of lemur taxa are currently classified within one of the three most threatened categories of the IUCN Red List (Vulnerable, Endangered, Critically Endangered), including 25 of the 26 described *Lepilemur* species (Schwitzer *et al*., 2013; 2014; IUCN, 2014).

The genus *Lepilemur* includes a group of medium-sized (around 900 g), nocturnal and predominantly folivorous lemurs. They are vertical clingers and leapers (VCL), which largely use vertical and angled supports for travel (Warren, 1997; Warren and Crompton, 1997). Their diet consists predominantly of leaves, but is supplemented with fruit, flowers and buds when necessary (Ganzhorn 1988; Ganzhorn 1989; Ganzhorn, 2002; Thalmann, 2007; Dröscher and Kappeler, 2014). As a nocturnal lemur, they are largely inactive throughout the day and have been observed to rest in either dead trees, tree-holes, or a thick density of branches or lianas (Rasoloharijaona *et al*., 2003; Mittermeier *et al*., 2010). Some species of *Lepilemur* are abundant in secondary forest, although the abundance of some species of vertical clingers and leapers have been found to react negatively to habitat disturbance (Ganzhorn; 1989; Herrera *et al*., 2011). In particular, areas which are more heavily logged can incur major energy costs in terms of locomotion and travel if distances between trees are too vast (Ganzhorn, 1993). The recent description of many new *Lepilemur* spp. has left these populations with small distributions, often isolated to one region or even specific areas, making the *in situ* conservation of these populations of paramount importance (Mittermeier *et al*., 2010).

The Nosy Be sportive lemur or Hawks' sportive lemur, *Lepilemur tymerlachsoni*, was described in 2006 (Louis *et al*., 2006). This species is endemic to Nosy Be island and is currently classified as Critically Endangered (B1ab (i,iii,v)) on the IUCN Red List, based on the increasing fragmentation of its habitat and the decline in its population size (Andriaholinirina *et al*., 2014; IUCN, 2014). This pilot study aims to provide preliminary data on the habitat use, diet and sleeping site use of *Lepilemur tymerlachsoni* in an anthropogenically disturbed habitat, to aid the understanding of this species habitat requirements. Specific research questions we aim to address are; 1) does *Lepilemur tymerlachsoni* show a forest height and substrate preference? and 2) what is the dietary composition of *Lepilemur tymerlachsoni* in a disturbed forest? We are hopeful this data will also help to begin a dialogue to plan conservation actions for this highly threatened species.

Methods

Study period and site

The study was carried out over a two-month period throughout July and August of 2011, approximately one mile outside the boundaries of the Lokobe Strict Nature Reserve on Nosy Be Island, Madagascar (S 13 24' 14", E 48 20' 32"). The Lokobe Strict Nature Reserve has the only remaining area of Sambirano primary forest on Nosy Be Island. Sambirano forest acts as a transitional region between the eastern wet and western dry forests, the region is classified as a seasonal moist forest with sub-humid climate (Andreone *et al.,* 2005). The study area is a regenerating secondary forest which was cleared ca. 18 years ago (Frontier-Madagascar, 2013). One area of the forest is used as a vanilla plantation, and parts of the forest understorey have been removed. There are small areas containing cash crops, including bananas and pineapples, and small scale timber extraction for construction materials occurs in this area (Frontier-Madagascar, 2013). Although the majority of the site is secondary forest, there are some remnants of Sambirano forest. The climate of the region is stable, with temperature throughout the year showing only small variability (mean maximum 28 °C and a mean minimum of 23 °C). Rainfall in the region is seasonal with the highest rainfall observed between November and May (Andrews and Birkinshaw, 1998). The cathemeral black lemur (*Eulemur macaco*) and nocturnal Claire's mouse lemur (*Microcebus mamiratra*) are also present at the study site (Mittermeier

et al., 2010). The presence of lemur traps observed within the study site suggests that some hunting of lemurs may take place on a small scale. Potential non-human predators of *Lepilemur tymerlachsoni* present at the site include the Madagascar buzzard (*Buteo brachypteru*), Madagascar harrier hawk (*Polyboroides radiatus*), and the Madagascar ground boa (*Boa madagascariensis*) (personal observation). To date, the presence of the fossa (*Cryptoprocta ferox*) has not been recorded on Nosy Be (Mittermeier *et al*., 2010).

Data collection

In order to characterize the habitat used by *Lepilemur tymerlachsoni*, vegetation surveys were carried out within the study site; four 20 x 20 m plots were measured and marked by flagging and string. The tree species (vernacular name), DBH (cm) and height (m) of all trees with a DBH≥10cm within the plots were recorded (Ganzhorn *et al*., 2003).

Existing trails were walked at the study site both in the day and at night at 06.30 - 09.30 and 18.30 - 21.30, with each time set walked at least four times per week. We collected observational data on habitat use, sleeping site use, and diet on *Lepilemur tymerlachsoni*. Data were collected using focal-animal sampling at one minute intervals for a session of fifteen minutes, or until sight of the individual was lost (Altmann, 1974). After an observation ended the trail was walked further until a different lemur individual was spotted, we applied the same process for each focal lemur. The height in tree (estimated at 1 m increments), substrate type (tree crown, trunk or major branch), and behaviour of the observed individuals were recorded at one minute intervals. Substrate types were defined as follows; 1) "tree trunk" was defined as the central structure of the tree from which branches originate; 2) "major branches" refer to the space between the trunk and tree crown which house the largest branches (Vasey, 2000); 3) "tree crown" refers to the upper layer of the tree which contains smaller emerging branches. Behaviours were recorded in one of three broad categories; resting, feeding, or other active behaviours (excluding feeding). Trails were walked at a slow speed (0.5 - 1 km per hour) as is recommended elsewhere for nocturnal censuses (Nekaris *et al*., 2014). If a lemur was observed feeding, the feeding tree was marked with flagging to be returned to later for identification. If necessary, leaf samples were also collected to identify the tree species, with samples taken to local villagers who were able to provide the vernacular Sakalava name for the species, which was then used to find the family and tree species (Schatz, 2001), with the help of a local Botany student from the l'Université d'Antsiranana, working with Frontier, Madagascar. If individuals were observed resting during the day, the sleeping site type and height (m) were recorded.

Faecal samples were also collected and macroscopically analysed for dietary composition. When a lemur was observed to defecate, their faecal was collected and sealed in a bag and stored for no more than twenty four hours. The faecal sample was weighed and the excess matrix was removed using sampling process of McGrew *et al.* (2009). When the entire excess matrix was removed, initially any seeds were removed and categorised, followed by any fruit pulp, bark, flower parts, buds and stems were removed and recorded.

Data analyses

Behavioural data was grouped into three broad "behavioural activities" for the analyses to allow an assessment of the broad habitat requirements of *Lepilemur tymerlachsoni* for; "nocturnal activity" (data collected during night-time walks, excluding feeding observations), "nocturnal feeding" (any feeding observations recorded during night-time walks) and "diurnal resting" (related to sleeping site choice). Observed heights of focal individuals were pooled into 5m height brackets (0 - 5 m, 6 - 10 m, 11 - 15 m, 15+ m) for the analyses.

Means and standard deviations are displayed for vegetation characteristics and substrate heights used by *Lepilemur*. Simpson's Diversity Index was calculated to assess the overall tree species diversity and richness of the study area (Simpson, 1949). We used the formula:

$$D = \frac{\Sigma n(n-1)}{\Sigma N(N-1)}$$

Where n is the total number of organisms of a particular species and N is the total number of organisms of all species.

Observational sessions (n=145) were analysed to assess the habitat use of the species for broad "behavioural activities". The proportion of observations within specified vertical layers and forest sites were calculated. Pearson chi-square tests (X^2) were used to test for associations between habitat use (substrate height and substrate type) and "activity type" (Dytham, 1999).

Faecal samples (n=23) were analysed for overall dietary trends (McGrew *et al.*, 2009). Percentage occurrence of each broad dietary component, (fruit, leaves, buds, or stems), in the species faecal samples were calculated. Seeds were individually categorised based on the length (mm) and width (mm) of the seed. It was not possible to distinguish species specific differences in leaves, buds and stems remnants found in faecal samples.

All statistical tests were carried out using IBM SPSS Statistics 21.

Results

Habitat characteristics

A total of 367 trees were surveyed, with 25 species of tree recorded in the study area. There were four key tree species which were dominant throughout the study area; *Artocarpus heterophyllus* (3.3 %), *Dypsis madagascariensis* (7.9 %), *Trilepisium madagascariensis* (15 %) and *Cryptocarya* sp. (56.1 %). The mean DBH (cm) of all trees surveyed was 25.1cm (range 10-307 cm; SD = 26.5 cm) while the mean height (m) was 8.04 cm (range 1 - 25 m; SD = 4.4 m). Simpson's Diversity Index for the study site was 0.35.

Habitat and sleeping site use

Lepilemur tymerlachsoni were observed to use a mean height of 7.26 ± 3.13 m during "nocturnal activity" (n=121), ranging between 2 - 18 m, with the majority of individuals (55.3 %) at heights of 6 - 10 m (Fig. 1). They were observed to feed at a mean height of 5.92 ± 1.75 m, ranging from heights of 2 - 8 m (n=13), with the majority of individuals observed to feed also at heights of 6 - 10 m (Fig. 1). They were observed to rest at a mean height of 5.72 ± 3.10 m, ranging from 1 - 10 m, within height classes of 0 - 5 m and 6 - 10 m at the same frequency, and were never observed to rest at heights >10 m (n=10).

In total, three different sleeping site types were observed: 1) tree holes (mean height: 5 m, n=2; Fig. 2a), 2) sleeping amongst dense vegetation in tree crowns (mean height: 8 m, n= 6; Fig. 2b), or 3) sleeping close to the ground on the trunk of *Phoenix reclinata* (mean height: 1.67 m, n= 3; Fig. 2c). One individual was also observed to use the village church in the

daytime to rest (Fig. 2d). No significant associations were found between the "activity type" of *Lepilemur tymerlachsoni* and the height of substrate used; X(6)= 5.386, p=0.495.
During nocturnal activity the animals mainly used tree trunks and major branches, representing >75 % of observations (Fig. 1). They were observed to feed on major branches and tree trunks at a similar frequency (Fig. 1). Tree crowns and trunks were only observed for diurnal resting, with tree crowns the most frequently used sleeping site (Fig. 1). Although not significant, a strong tendency for an association between the "activity type" and the substrate type used was found (X(4)= 9.185, p= 0.057).

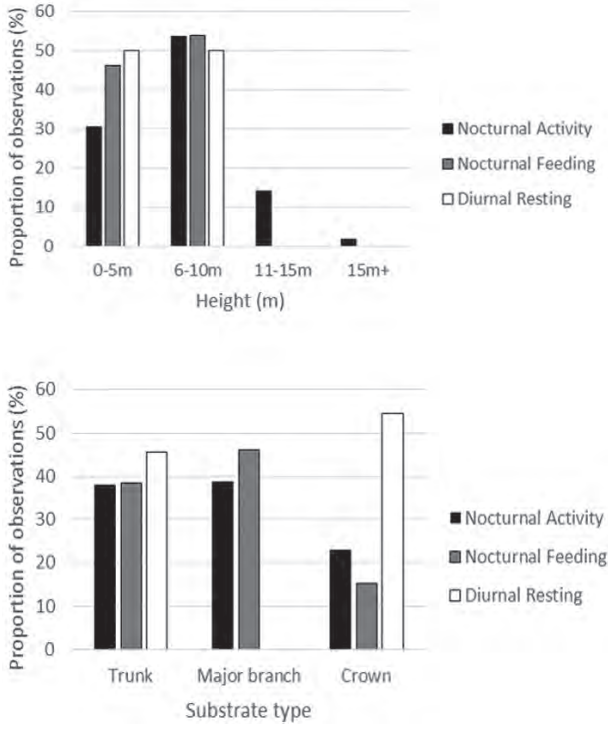

Fig. 1: Histograms showing the proportion of observations of habitat use on *Lepilemur tymerlachsoni*. Substrate heights (upper) and substrate type (lower) used for different "activity types

Diet
Lepilemur tymerlachsoni were observed to feed on the leaves and buds of 6 plant species (n=13). *Cryptocarya* spp., *Artocarpus heterophyllus*, and an unknown species in total made up >75 % of observed feeding observations (Tab. 1).
A total of 23 faecal samples were macroscopically analysed for dietary components (mean weight: 0.65 ± 0.28 g). Leaves were present in 100 % of faecal samples, while evidence of fruit consumption was present in 82.6 % of samples (in the form of seeds, fruit pulp or both). A total of four seed categories were retrieved from the faeces. The seeds ranged in size from 1 x 1 mm to 3 x 2 mm.

Discussion

Lepilemur tymerlachsoni showed a preference for the use of dense vegetation as sleeping sites, demonstrated by the strong association between diurnal resting and tree crowns at our study site. It has been previously reported that *Lepilemur tymerlachsoni*, (previously described as *Lepilemur dorsalis*), on Nosy Be used tree holes in primary forest areas but in secondary forest areas which are lacking in the occurrence of tree holes, they were recorded to use branches for diurnal resting (Andrews *et al*., 1998). Bederu

Fig. 2: Sleeping sites observed to be used by *Lepilemur tymerlachsoni* on Nosy Be; a) tree holes (top left), b) dense vegetation in tree crowns (top right), c) close to the ground on the palm *Phoenix reclinata* (bottom left), and d) one individual was observed to rest in the village church (bottom right).

(2014) did not observe *Lepilemur tymerlachsoni* within Lokobe National Park to use trees with sleeping holes. Elsewhere *Lepilemur mustelinus* were observed to use tree holes most frequently as sleeping sites, with individuals which use dense vegetation sleeping sites using higher vertical layers of the forest than those which use sleeping holes (Rasoloharijaona *et al*., 2008). We observed the same results with *Lepilemur tymerlachsoni*, which used higher vertical forest layers when resting in dense vegetation over tree holes or *Phoenix reclinata*. It would appear regional differences related to sleeping site preferences of Lepilemur species exist; with *Lepilemur edwardsi* observed to prefer tree holes for resting, whereas both *Lepilemur leucopus* and *Lepilemur sahamalazensis* have been observed to use tree holes rarely (Charles-Dominique and Hladik, 1971; Rasoloharijaona *et al*., 2003; Ruperti, 2007). We observed the latter to be true for *Lepilemur tymerlachsoni* also, as we rarely observed them resting in tree holes. This is due to the lack of suitable tree holes for diurnal resting based on the small number of older, larger trees available in the forest (Ruperti, 2007; Seiler *et al*., 2013a). However Seiler *et al.* (2013b) suggested that vegetation clumps can be a "safer" diurnal resting place than tree holes. Sleeping site studies on *Lepilemur sahamalazensis* showed that individuals using tree holes as diurnal resting sites, were observed to exhibit almost three times as much vigilance behaviour as individuals using vegetation clumps, suggesting that individuals using tree holes are under more stress from potential aerial predation (Seiler *et al.,* 2013b). On Nosy Be, aerial raptors are the most significant predation threat to *Lepilemur tymerlachsoni* (Andrews *et al.,* 1998). As we observed most individuals to use dense vegetation as diurnal resting sites, this may represent a risk to their conservation, as it has been suggested that the use of these sleeping sites leaves them vulnerable to human disturbance, and predation by raptors and dogs (Andrews *et al*., 1998). We additionally observed a small number of individuals resting at very close proximity to the ground on the palm species *Phoenix reclinata*, which has sharp spines as its basal leaflets (Figure 3c). This may be an anti-predator strategy as the spines may offer some protection from aerial predators, which have been reported to predate other *Lepilemur* sp. (Rasoloharijaona *et al*., 2008; Seiler *et al.,* 2013b). It is reasonable to assume that boas represent a lower threat than large diurnal raptors for this lemur species.

Tab. 1: Observed plant species and parts consumed by *Lepilemur tymerlachsoni* in this study.

Family	Species	Vernacular name (Sakalava)	English description	Number of individual feeding observations (proportion of observations)	Plant item consumed	
					Leaves	Buds
Anacardiaceae	*Mangifera indica*	Manga	Mango	**2** (10.53 %)	**1**	1
Fabaceae	*Delonix regia*	Hintsakintsana	Small-large tree	**1** (5.26 %)	**1**	-
Fabaceae	*Acacia* sp.	Hazomteva	Shrub-large trees	**1** (5.26 %)	**1**	-
Lauraceae	*Cryptocarya* sp.	Zavoka maro	Small-medium evergreen trees	**7** (36.84 %)	**7**	-
Moraceae	*Artocarpus heterophyllus*	Ampalibe	Jackfruit	**4** (21.05 %)	**4**	-
Unknown	Unknown			**4** (21.05 %)	**4**	-
			Totals	**19**	**18**	**1**

Fig. 3: Lemur traps set up in tree (left) and fallen or removed traps on the ground (right).

Leaves were the plant part most frequently consumed by *Lepilemur tymerlachsoni*, they were the most prominent plant item observed to be consumed and all faecal samples contained traces of leaves. Buds and stems were also identified in the diet of *Lepilemur tymerlachsoni*, and have been observed elsewhere as an important supplementary food item for other *Lepilemur* species (Thalmann, 2001). Although *Lepilemur tymerlachsoni* are specialised folivores, traces of fruits were found in > 80 % of their sampled faecal samples, which would suggest that fruit may play an important role in their diet (Martin, 1990). As the majority of seeds found in the faecal samples appeared to be undamaged, it may also be possible that the species is performing some level of seed dispersal at this site. Fruit has previously been reported in the diet of *Lepilemur mustelinus, Lepilemur ruficaudatus*, and *Lepilemur dorsalis* (now *tymerlachsonorum*), although the low frequencies of fruit reported in the diets of some *Lepilemur* species suggests they are using fruit as a supplementary item (Hladik *et al*., 1980; Ganzhorn, 1988; Andrews *et al*., 1998; Thalmann, 2001; Ganzhorn *et al*., 2004; Dröscher and Kappeler, 2014). Long term studies on *Lepilemur* diet suggest that they prefer more common tree species than other folivorous species, and exhibit a more general diet with some flexibility in the plant parts they consume (Thalmann, 2001). *Lepilemur tymerlachsoni* also exhibit similar dietary patterns to those reported elsewhere, as *Cryptocarya* sp. and *Artocarpus heterophyllus* were two of the most important tree species in their diet, and were also two of the most abundant tree species at the study site. Low presence of fruit in the diet of *Lepilemur edwardsi* in Mahajanga, in contrast with the relatively high frequency of fruit in faecal samples in this study, and observations of frugivory made previously on *Lepilemur tymerlachsoni*, would suggest regional species-specific differences exist in the composition of *Lepilemur* sp. diet (Andrews *et al*., 1998; Thalmann, 2001).

The observed substrate use of *Lepilemur tymerlachsoni* is similar to those reported elsewhere for this genus, likely due to their specialised locomotion (Hladik *et al*., 1980; Warren, 1997; Nash, 1998). *Lepilemur* sp. which live sympatrically with *Avahi* sp. have been observed to use a lower forest level, and large high-angled supports (Warren and Crompton, 1997). We observed *Lepilemur tymerlachsoni* to use a mean height of 7.26 m during nocturnal activity, which is slightly higher than observed in *Lepilemur* sp. which are sympatric with *Avahi* sp. (Warren, 1997; Nash, 1998; Mittermeier *et al*., 2010). On Nosy Be the only other nocturnal species present is *Microcebus mamiratra*, which may potentially explain why *Lepilemur tymerlachsoni* use a slightly wider range of substrate heights. Although we did not specifically collect data on support size and angle, we can make some inferences about the size and angle preferred by *Lepilemur tymerlachsoni* based on the substrate type which they used. *Lepilemur tymerlachsoni* were observed to predominantly use tree trunks and major branches as supports for nocturnal activity, which is unsurprising based on their specialised locomotion, and data available elsewhere on their preference for larger supports at a vertical or angled orientation (Warren, 1997; Warren and Crompton, 1997). This species was observed not to use forest heights >10 m for nocturnal feeding or diurnal resting, and use predominantly major branches and trunks for nocturnal feeding, and trunks and tree crowns for diurnal resting. These habitat choices are likely due to anti-predation strategy, as this species are particularly at risk from aerial predation during daylight hours by raptors (Goodman *et al*., 1993; Schülke and Ostner, 2001; Seiler *et al*., 2013a).

The findings on the habitat use and diet of *Lepilemur tymerlachsoni* we present here, although preliminary and based on a small sample size, provide some of the first data available on this species and its ecology in a disturbed habitat. During our study period, *Lepilemur tymerlachsoni* were observed frequently in the study area and the surrounding area, therefore the species appears to quite abundant in the south-eastern corner of Nosy Be island. This corner is one of the few significant areas of forest cover remaining on Nosy Be. Also we observed evidence of lemur traps in our study area (Fig. 3), which would suggest that hunting of lemurs has, or does occur in this area. The placement of the traps would suggest that *Eulemur macaco* are the main target species, although it is possible that *Lepilemur tymerlachsoni* may also be vulnerable to trapping, as they often rest in exposed areas where they can easily be grabbed by hand by humans. This Critically Endangered sportive lemur would benefit from long term ecological and population monitoring to accurately assess the current status of the species, including a population size estimate. In addition, research pertaining to local human perceptions of the lemur species present in the area and the significance of bush meat hunting to local livelihoods would be of great value to conservation planning for this species, and the overall area.

Acknowledgements
We thank Frontier Madagascar for facilitating the research and all the staff members for providing help and support in the field. We thank the Ministère des Eaux et Forêts, Madagascar for providing the necessary permits.

References
Altmann, J. 1974. Observational Study of Behaviour: Sampling Methods. Behaviour 49: 227-267.
Andreone, F.; Guarino, F. M.; Randrianirina, J. E. 2005. Life history traits, age profile, and conservation of the panther chameleon, *Furcifer pardalis* (Cuvier 1829), at Nosy Be, NW Madagascar. Tropical Zoology 18: 209-225.
Andrews, J. R.; Birkinshaw, C. R. 1998. A Comparison Between the Daytime and Night-Time Diet, Activity and Feeding Height of the Black Lemur, *Eulemur macaco* (Primates: Lemuridae), in Lokobe Forest, Madagascar. Folia Primatologica 69: 175-182.
Andrews, J.; Antilahimena, P.; Birkinshaw, C.R. 1998. Use of a Day Resting Box by a Wild Sportive Lemur, *Lepilemur dorsalis*, on Nosy Be, North-Western Madagascar. Folia Primatologica 69: 18-21.
Andriaholinirina, N.; Fausser, J. L.; Roos, C.; Zinner, D.; Thalmann, U.; Rabarivola, C.; Ravoarimanana, I.; Ganzhorn, J.U.; Meier, B.; Hilgartner, R.; Walter, L.; Zaramody, A.; Langer, C.; Hahn, T.; Zimmermann, E.; Radespiel, U.; Craul, M.; Tomiuk, J.; Tattersall, I.; Rumpler, Y. 2006. Molecular phylogeny and taxonomic revision of the sportive lemurs (*Lepilemur*, Primates). BMC Evolutionary Biology 6: 17.
Andriaholinirina, N.; Baden, A.; Blanco, M.; Chikhi, L.; Cooke, A.; Davies, N.; Dolch, R.; Donati, G.; Ganzhorn, J.; Golden, C.; Groeneveld, L.F.; Hapke, A.; Irwin, M.; Johnson, S.; Kappeler, P.; King, T.; Lewis, R.; Louis, E.E.; Markolf, M.; Mass, V.; Mittermeier, R.A.; Nichols, R.; Patel, E.; Rabarivola, C.J.; Raharivololona, B.; Rajaobelina, S.; Rakotoarisoa, G.; Rakotomanga, B.; Rakotonanahary, J.; Rakotondrainibe, H.; Rakotondratsimba, G.; Rakotondratsimba, M.; Rakotonirina, L.; Ralainasolo, F.B.; Ralison, J.; Ramahaleo, T.; Ranaivoarisoa, J.F.; Randrianahaleo, S.I.; Randrianambinina, B.; Randrianarimanana, L.; Randrianasolo, H.; Randriatahina, G.; Rasamimananana, H.; Rasolofoharivelo, T.; Rasoloharijaona, S.; Ratelolahy, F.; Ratsimbazafy, J.; Ratsimbazafy, N.; Razafindraibe, H.; Razafindramanana, J.; Rowe, N.; Salmona, J.; Seiler, M.; Volampeno, S.; Wright, P.; Youssouf, J.; Zaonarivelo, J.; Zaramody, A. 2014. *Lepilemur tymerlachsoni*. The IUCN Red List of Threatened Species. Version 2014.2. <http://www.iucnredlist.org/>. Downloaded on 28 September 2014.
Bederu, M. 2014. Preliminary data on population and habitat use of *Lepilemur tymerlachsoni* in Lokobe National Park. Lemur News 18: 2-4.
Charles-Dominque, P.; Hladik, C.M. 1971. Le Lepilemur du Sud de Madagascar: écologie, alimentation et vie sociale. Terre et Vie 1: 3-66.
Dröscher, I.; Kappeler, P.M. 2014. Competition for Food in a Solitarily Foraging Folivorous Primate (*Lepilemur leucopus*)? American Journal of Primatology 76: 842-854.
Dytham, C. 1999. Choosing and using statistics: a biologist's guide. Blackwell Science, New York, USA.
Frontier-Madagascar. 2013. Madagascar Forest Research Project, Nosy Be, North West Madagascar: Frontier-Madagascar Environmental Research MGF132 Science Report. Society for Environmental Exploration, UK.
Ganzhorn, J.U. 1988. Food partitioning among Malagasy primates. Oecologica 75: 436-450.
Ganzhorn, J.U. 1989. Niche separation of seven lemur species in the eastern rainforest of Madagascar. Oecologia 79: 279-286.
Ganzhorn, J.U. 1993. Flexibility and constraints of Lepilemur ecology. Pp. 153-165. In J.U. Ganzhorn; P.M Kappeler (eds.) Lemur social systems and their ecological basis. Springer, New York, USA.
Ganzhorn, J.U. 2002. Distribution of a folivorous lemur in relation to seasonally varying food resources: integrating quantitative and qualitative aspects of food characteristics. Oecologia 131: 427-435.
Ganzhorn, J.U.; Jacques Rakotondranary, S.; Ratovonamana, Y.R. 2003. Chapter 3: Habitat description and phenology. Pp. 51-68. In J.M Setchell; D.J. Curtis (eds). Field and Laboratory Methods in Primatology: A Practical Guide. Cambridge University Press, Cambridge, UK.
Ganzhorn, J.U.; Pietsch, T.; Fietz, J.; Gross, S.; Schmid, J.; Steiner, N. 2004. Selection of food and ranging behaviour in a sexually monomorphic folivorous lemur: *Lepilemur ruficaudatus*. Journal of Zoology London 263: 393-399.
Goodman, S. M.; O'Connor S.; Langrand, O. 1993. A review of predation on lemurs: implications for the evolution of social behaviour in small, nocturnal primates. Pp. 51-66. In J.U. Ganzhorn; P.M Kappeler (eds.) Lemur social systems and their ecological basis. Springer, New York, USA.
Groves, C. 2005. Order Primates. Pp.111-184. In: D.E Wilson; D.M Reader (eds). Mammal Species of the World: A Taxonomic and Geographic Reference. Third edition. Johns Hopkins University Press, Baltimore, USA.
Herrera, J. P.; Wright, P. C.; Lauterbur, E.; Ratovonjanahary, L; Taylor, L. L. 2011. The effects of habitat disturbance on lemurs at Ranomafana National Park, Madagascar. International Journal of Primatology 32: 1091-1108.
Hladik, C.M. ; Charles-Dominique, P.; Petter, J.J. 1980. Feeding Strategies of Five Nocturnal Prosimians in the Dry Forest of the West Coast of Madagascar. Pp 41-73. In Charles-Dominique P.; Cooper, H.M.; Hladik, A.; Hladik, C.M.; Pages, E.; Pariente, G.F.; Petter-Rosseaux, A.; Petter, J.J.; Schilling, A. (eds). Nocturnal Malagasy Primates: Ecology, Physiology and Behaviour. Academic Press, New York, USA.
IUCN 2014. The IUCN Red List of Threatened Species. Version 2014.2. <http://www.iucnredlist.org>. Downloaded on 24 September 2014.
Louis, E.E.; Engberg, S.E.; Lei, R.; Geng, H.; Sommer, J.A.; Randriamampionona, R.; Randriamanana, J.C.; Zaonarivelo, J.R.; Andriantompohavana, R.; Randria, G.; Prosper; Ramaromilanto, B.; Rakotoarisoa, G.; Rooney, A.; Brenneman, R.A. 2006. Molecular and morphological analyses of the sportive lemurs (Family Megaladapidae: Genus *Lepilemur*) reveals 11 previously unrecognized species. Texas Tech Univsersity Museum Special Publications SP49: 1-47.
Martin, R.D. 1990. Primate Origins and Evolution: A Phylogenetic Reconstruction. Chapman and Hall, London, UK.
McGrew, W. C.; Marchant, L. F.; Phillips, C. A. 2009. Standardised protocol for primate faecal analysis. Primates 50: 363-366.
Mittermeier, R.A.; Louis Jr, E.E.; Richardson, M.; Schwitzer, C.; Langrand, O.; Rylands, A.B.; Hawkins, F.; Rajaobelina, S.; Ratsimbazafy, J.; Rasoloarison, R.; Roos, C.; Kappeler, P.M.; Mackinnon, J. 2010. Lemurs of Madagascar. Third Edition. Conservation International, Arlington, USA.
Nash, L.T. 1998. Vertical Clingers and Sleepers: Seasonal Influences on the Activities and Substrate Use of *Lepilemur leucopus* at Beza Mahafaly Special Reserve, Madagascar. Folia Primatologica 69: 204-217.
Nekaris, K.A.I.; Pambudi, J.A.A.; Susanto, D.; Ahmad, D.R.; Nijman, V. 2014. Densities, distribution and detectability of a small nocturnal primate (Javan slow loris, *Nycticebus javanicus*) in a montane forest. Endangered Species Research 24: 95-103.
Rasoloharijaona, S.; Rakotosamimanana, B.; Randrianambinina, B.; Zimmermann, E. 2003. Pairspecific usage of sleeping sites and their implications for social organization in a nocturnal Malagasy primate, the Milne Edwards' sportive Lemur (*Lepilemur edwardsi*). American Journal of Physical Anthropology 122: 251-258.
Rasoloharijaona, S.; Randrianambinina, B.; Zimmermann, E. 2008. Sleeping Site Ecology in a Rain-Forest Dwelling Nocturnal Lemur (*Lepilemur mustelinus*): Implications for Sociality and Conservation. American Journal of Primatology 70: 247-253.
Ruperti F.S. 2007. Population density and habitat preferences of the Sahamalaza sportive lemur (*Lepilemur sahamalazensis*) at the Ankarafa Research Site, NW Madagascar. MSc thesis, Oxford Brookes University, Oxford, UK.
Schatz, G. E. 2001. Generic tree flora of Madagascar. Missouri Botanical Gardens, Missouri, USA.
Schülke, O.; Ostner, J. 2001. Predation on Lepilemur by a Harrier Hawk and Implications for Sleeping Site Quality. Lemur News 6: 5.
Schwitzer, C.; Mittermeier, R.A.; Davies, N.; Johnson, S.; Ratsimbazafy, J.; Razafindramanana, J.; Louis Jnr, E.E.; Rajaobelina, S. 2013. Lemurs of Madagascar: A Strategy for Their Conservation 2013-2016. IUCN SSC Primate Specialist Group, Bristol Conservation & Science Foundation, and Conservation International, Bristol, UK.
Schwitzer, C.; Mittermeier, R.; Johnson, S. E.; Donati, G.; Irwin, M., *et al.* 2014. Averting lemur extinctions amid Madagascar's political crisis. Science 343: 842-843.
Seiler, M.; Holderied, M.; Schwitzer, C. 2013a. Effects of Habitat Alteration on Resting Behaviour of the Sahamalaza Sportive Lemur in North West Madagascar. In L.K. Marsh and C.A. Chapman (eds.). Primates in Fragments: Complexity and Resilience, Developments in Primatology: Progress and Prospects. Springer-Verlag, New York.

Seiler, M.; Holderied, M.; Schwitzer, C. 2013b. Effects of Habitat Degradation on Sleeping Site Choice and Use in Sahamalaza Sportive Lemurs (*Lepilemur sahamalazensis*). International Journal of Primatology 34: 260-280.
Simpson, E. H. 1949. Measurement of diversity. Nature 163: 688.
Tattersall, I. 2007. Madagascar's lemurs: cryptic diversity or taxonomic inflation? Evolutionary Anthropology: Issues, News, and Reviews 16: 12-23.
Thalmann, U. 2001. Food Resource Characteristics in Two Nocturnal Lemurs with Different Social Behaviour: *Avahi occidentalis* and *Lepilemur edwardsi*. International Journal of Primatology 22: 287-324.
Thalmann, U. 2007. Behavioral and Ecological Adaptations in Two Small Folivorous Lemurs with Different Social Organization: *Avahi* and *Lepilemur*. Pp 327-352. In: L. Gould; M.L. Sauther. Lemurs: Ecology and Adaptation. Springer, New York, USA.
Vasey, N. 2000. Niche separation in *Varecia variegata rubra* and *Eulemur fulvus albifrons*: I. Interspecific patterns. American Journal of Physical Anthropology 112: 411-431.
Warren, R.D. 1997. Habitat use and support preference of two free-ranging salutatory lemurs (*Lepilemur edwardsi* and *Avahi occidentalis*). Journal of the Zoological Society of London 241: 325-341.
Warren, R. D.; Crompton, R. H. 1997. Locomotor ecology of *Lepilemur edwardsi* and *Avahi occidentalis*. American Journal of Physical Anthropology 104: 471-486.

Ilot M'Bouzi (Mayotte): la conservation d'une population de lémuriens bruns mise en question

Laurent Tarnaud[1*], Brice Lefaux[2]
[1]Chercheur associé, Laboratoire d'Eco-anthropologie et Ethnobiologie (UMR 7206), CNRS-Muséum National d'Histoire Naturelle de Paris, Université Paris 7, France
[2]Parc zoologique et botanique de Mulhouse, France
*Corresponding author: **laurent.tarnaud@free.fr**

Mots clés: lémurien, *Eulemur fulvus*, conservation, Mayotte

Résumé
Parmi les primates non humains, les lémuriens forment le groupe le plus menacé au monde. Plus de 90 % des espèces de ce taxon figurent sur la liste rouge de l'UICN. Tous les lémuriens sont endémiques de Madagascar mais 2 espèces se sont naturalisées depuis de nombreux siècles, dans l'archipel des Comores, dans les iles d'Anjouan et Mohéli (*Eulemur mongoz*) et à Mayotte (*Eulemur fulvus*). Comme à Madagascar, ces îles sont menacées par la dégradation et la fragmentation des habitats forestiers. Dans ce contexte, à Mayotte, de 1997 à 2004, l'association "Terre d'Asile" a transporté sur l'îlot M'Bouzi, qui deviendra réserve naturelle nationale en 2007, 104 lémuriens bruns. Ces individus ont été nourris de rations inadaptées et se sont reproduits pour constituer une population de 718 animaux en 2011 concentrée autour de la zone de nourrissage (environ 3 ha). En 2012, l'arrêt soudain du nourrissage est couplé par la disparition inexpliquée de 300 à 400 individus selon les les acteurs locaux, certains soulignant également un pic de mortalité. Comme le montre l'estimation de la capacité d'accueil de l'îlot, la population des lémuriens bruns de l'îlot Mbouzi pouvait être gérée dans le respect des besoins écologique de l'espèce.

Abstract
Among non human primates, lemurs are the most endangered. More than 90 % of the species are listed on the IUCN Red List. All are endemic to Madagascar but two species are also found naturalised in 3 islands of the Comoros Archipelago: *Eulemur mongoz* in Anjouan and Moheli Islands and *Eulemur fulvus* in Mayotte island. In each of them as in Madagascar, the forests are fragmented and degraded. In this context, in Mayotte, the association "Terre d'Asile" has translocated 104 brown lemurs from 1997 to 2004 to the M'Bouzi Islet, which became the first protected area of Mayotte in 2007. These individuals have been provisioned with inadequate foods (in quantity and quality) and the population has not been properly managed. In 2011, it reached the size of 718 individuals localised on and immediately around the feeding site of 3 ha. In 2012, these lemurs have been stressed by the sudden stop of food provisioning and local actors reported the unexplained disappearance of 300 to 400 individuals as well as a peak of mortality (independent of the disappearance). But, as shown by the estimation of the carrying capacity of the M'Bouzi Islet, this population of lemurs could be managed while respecting the ecology of the species.

Introduction
Il est actuellement recensé 682 espèces et sous espèces de primates dans le monde dont 103 pour la seule île de Madagascar (Schwitzer *et al*., 2013). Les primates malgaches sont parmi les plus menacés au monde du fait de leur endémisme insulaire (Hoffmann *et al*., 2010) qui majore le risque d'extinction d'espèce. 93.9 % des lémuriens sont classés comme menacés dans la liste rouge de l'IUCN (Schwitzer *et al*., 2013). Leur risque d'extinction est corrélé à la disparition de leurs habitats. Deux d'entre eux, très certainement transportées par voie maritime il y a environ un millier d'années par les malgaches de l'éthnie Sakalave, sont présents dans l'archipel des Comores. Le lémurien mongoz *(Eulemur mongoz*) a ainsi colonisé les îles d'Anjouan et de Mohéli tandis que le lémurien brun (*Eulemur fulvus*) se rencontre dans l'ensemble des formations forestières de l'île de Mayotte. Le statut de conservation du lémurien mongoz est critique à Madagascar comme dans les îles d'Anjouan et de Mohéli (UICN, 2014). Louette *et al*. (2004) rapportent que ces animaux ne survivent plus que dans les forêts sommitales des 2 îles volcaniques alors que la superficie de ce type de végétation aurait été réduite par 4 depuis 1950. La situation du lémurien brun de Mayotte est meilleure bien que sa population ait été réduite de moitié depuis 1999 du fait de la disparition de 40 % de la forêt de l'île (Lainé *et al*., 2010). Elle compte ainsi une vingtaine de milliers d'individus dont environ un tiers dans les zones forestières préservées (Tonnabel *et al*., 2011). Déforestation et fragmentation de l'habitat sont les principales causes de la diminution démographique du lémurien brun à Mayotte.
A la fragilisation des populations de lémuriens sauvages à Madagascar font échos des programmes de conservation *in situ,* avec la création d'aires protégées, de parc nationaux, de réserves biologiques privées et publiques permettant de préserver les habitats et la diversité floristique et faunistique; ainsi que la création de programmes *ex situ* avec les institutions élevant les primates en programmes coordonnés dans le monde, tels que les parcs zoologiques européens et les Programmes Européens d'Elevage (EEP). Sur les 82 EEP de primates, 20 concernent des lémuriens ce qui en fait la famille la plus représentée dans la sphère de conservation des parcs (EAZA, 2014). Ces deux types de conservation ne sont pas exclusifs. Selon la Convention sur la Biodiversité (CBD, 1992), la conservation *ex situ* est un complément indispensable de la conservation *in situ* et le rôle des parcs zoologiques est réel pour la préservation à long terme de populations génétiquement diverses (IUCN, "population management guideline" 2012). En outre les

parcs zoologiques participent à la sensibilisation à la protection des lémuriens et à la récolte des fonds pour soutenir des programmes *in situ* via des associations de zoos (Roullet, 2011). Dans les îles d'Anjouan et de Mohéli, les uniques programmes de conservation portent, lorsqu'ils existent, sur les espaces marins. Seul Mayotte, et encore très récemment, a mis en réserve des terres émergées en créant la réserve naturelle nationale de l'îlot M'Bouzi (2007, Fig. 1). Lui précédait le parc préfectoral de Saziley, en partie, propriété du Conservatoire du Littoral et des Rivages Lacustres (1991) et les réserves forestières (1999, réserve administrative sans statut de conservation) gérées par le conseil général et dont les frontières administratives n'ont pu empêcher la déforestation faute de volonté politique et d'une vraie police de l'environnement (Lainé *et al*., 2010). L'habitat forestier est pourtant à protéger efficacement et d'urgence car, au-delà de la préservation de la biodiversité floristique et faunistique (et du lémurien brun), le couvert forestier favorise la formation des nuages et donc le renouvellement des ressources en eau (Matthews *et al*., 2000). La forêt maintient aussi les sols, notamment à Mayotte où le relief est accidenté. Le présent article a pour objectif de rendre compte de l'évolution de la situation des lémuriens bruns sur l'îlot M'Bouzi en insistant sur la nécessité de prendre systématiquement en compte les besoins écologiques des espèces.

Historique de l'introduction et de l'entretien de la population des lémuriens bruns de l'îlot M'Bouzi

C'est dans ce contexte d'absence de programme de conservation et fort du constat du professeur Tattersal s'alarmant du déclin de la population de lémuriens bruns à Mayotte entre 1974 et 1986 (Tattersall, 1989) que l'association française Terre d'Asile (loi 1901) a été créée en 1997 avec pour objet «la Création, l'entretien, le gardiennage et la sauvegarde d'une réserve naturelle pour les lémuriens et autres animaux dits sauvages» (Sigaud, 2007). Terre d'Asile introduisit très rapidement des lémuriens bruns issus du trafic ou recueillis blessés ou maltraités sur l'îlot M'Bouzi depuis

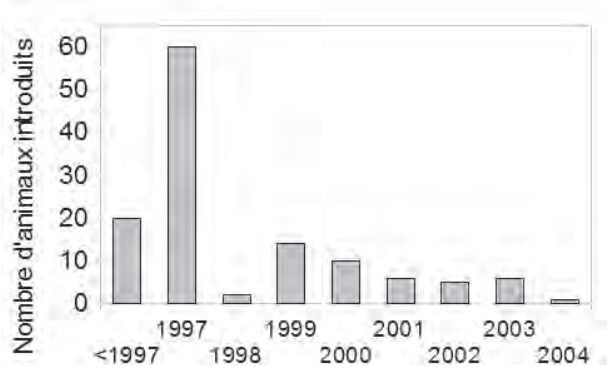

Fig. 2: Nombre d'animaux introduits annuellement par l'association Terre d'Asile entre 1997 et 2004 (données fournies par l'association Terre d'Asile et rapportées dans Sigaud, 2007).

l'île de Grande Terre (Gresse *et al*., 2002, Fig. 1). De 1997 à 2004, 104 animaux, dont 3 lémuriens mongoz (*Eulemur mongoz,* Fig. 2), y ont ainsi été amenés, soignés et nourris par l'association (Fig. 2). Tous ont été relâchés autour des bâtiments d'une ancienne léproserie qui fut occupée de 1936 à 1955 dans une zone d'environ 2 hectares (Sigaud, 2007). Il pré-existait sur l'îlot à la venue de l'association une petite population d'une vingtaine de lémuriens bruns (*Eulemur fulvus*) qui avaient été transférés depuis l'île de Petite Terre par un agriculteur (Mme Gandon, obs. pers.). Terre d'Asile a nourri les lémuriens introduits et leur descendance jusqu'en avril 2012. Leur situation pouvait être comparée à celle d'animaux approvisionnés en nourriture vivant en semi liberté mais concentrés autour des placettes de nourrissage et très faiblement dispersés sur les 82 hectares de l'îlot malgré l'absence de clôture.

Parallèlement à cette implantation, la Direction de l'Agriculture et de la Forêt de Mayotte a initié un projet de réserve naturelle nationale en 1999 qui a abouti en 2007 à la création de la réserve naturelle nationale de l'îlot M'Bouzi avec pour objectif de protéger les reliques de forêt sèche littorale endémique des Comores et les nombreuses espèces de la flore patrimoniale présentes sur l'îlot. Cet espace protégé est géré par l'association des Naturalistes de Mayotte depuis fin 2008. Le décret de création de la réserve ne mentionne pas spécifiquement la présence des lémuriens sur l'îlot. Néanmoins, il permet la création d'une zone d'activité particulière terrestre par arrêté préfectoral où peuvent se dérouler toute activité non directement liées à la gestion ou la valorisation du patrimoine naturel de la RNN. Un arrêté préfectoral signé en 2007 autorisait l'association Terre d'Asile à exploiter l'espace autour de la léproserie. Nous ne traiterons ici que des dimensions écologique, éthologique et conservationniste qu'implique la gestion d'une population de primates et non ses enjeux politiques locaux même s'ils ont pu avoir une incidence sur cette gestion.

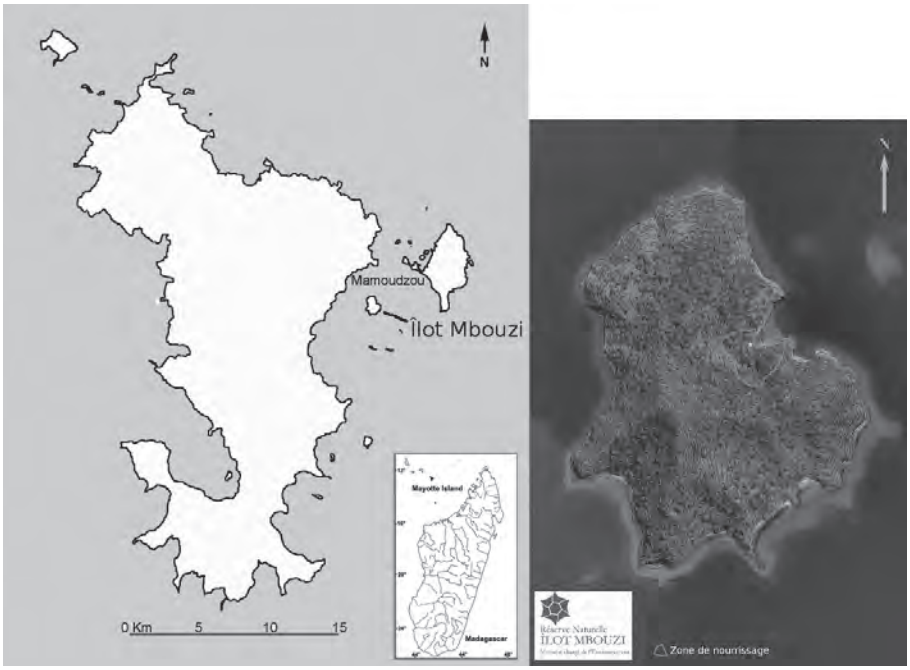

Fig. 1: L'île de Mayotte et la réserve naturelle nationale de l'îlot Mbouzi avec la délimitation de la zone de nourissage des lémuriens autour de la léproserie.

Démographie de la population introduite de lémuriens bruns de l'îlot M'Bouzi

L'estimation de la taille de la population des lémuriens bruns de l'îlot M'Bouzi repose sur plusieurs approches méthodologiques: une identification exhaustive réalisée par l'association Terre d'Asile avec dénombrement du nombre de mâles, de femelles, de naissances et de jeunes ayant atteint l'âge d'un an. Ces chiffres sont partiellement présentés par Sigaud (2007) pour la période 1997-2006 et par Tarnaud (2011) pour la période 2006-2009. En 2010 et 2011, Tarnaud a utilisé 2 autres méthodes de recensement de la population: 1) une méthode de recensement qui se voulait exhaustive par placement d'observateurs à proximité des placettes de nourrissage sur l'ensemble de la zone «léproserie» (2 répétitions par cession de comptage), 2) une méthode de recensement partielle avec extrapolation du taux de fertilité des femelles recensées à l'ensemble de la population (détaillée ci-dessous). Ces deux méthodes ont été employées en avril et octobre 2010 et en avril 2011. Seuls les résultats issus de la seconde méthode, considéré comme plus fiables, sont retenus ici. En 2012, Tarnaud proposa l'emploi d'une autre méthode pour tenir compte de la dispersion des animaux provoquée par l'arrêt du nourrissage. Les animaux étaient recensés le long d'une ligne de comptage parcourue par 5 observateurs espacés de 20 m dans les zones accessibles (absence de fourrés, notamment les fourrés épineux de *Lantana camara*) allant des crêtes sud au plateau (nord). La zone recensée correspondait à la façade est de l'îlot. Les micro-formations forestières (bosquets à manguiers principalement et ravines) pouvant accueillir des lémuriens étaient visitées une à une.

La première méthode consista à répartir 21 à 24 observateurs volontaires (selon le nombre de volontaires disponibles à chaque cession de comptage) dans la zone « léproserie » où étaient distribuées les placettes de nourrissage. Chaque observateur devait dénombrer le nombre de lémuriens adultes visibles dans un espace délimité contenant 1 à 3 placettes d'approvisionnement. Ce comptage s'effectuait toutes les 15 minutes sur signal (sifflet) pendant 3 heures. Les observateurs avaient la possibilité de communiquer entre eux pour éviter les doubles comptages. Toutes les cessions de comptage commençaient en début d'après-midi pour donner le temps aux observateurs de s'habituer à leur "espace" et à la méthode de comptage, et aux lémuriens de s'habituer à la présence des observateurs. Cette méthode devait permettre un comptage exhaustif de la taille de la population de lémuriens, ces derniers venant se nourrir sur les placettes vers la fin de la période de comptage au moment de la distribution de la nourriture. Les horaires de nourrissage avaient été, au préalable, vérifiés auprès de l'association Terre d'Asile. Malheureusement, le nombre d'individus recensés tous les quarts d'heure et entre les 2 cessions de comptage a présenté une très grande variabilité (l'écart maximal enregistré fut de 216 animaux au cours de la même après-midi). Il fut aussi, généralement, impossible de compter les animaux au moment du nourrissage, les horaires théoriques d'alimentation ne coïncidant pas, dans la pratique, aux horaires réels. L'ensemble des animaux ne fut donc presque jamais présent sur la zone de recensement, situation à laquelle s'ajoutait le risque de double comptage.

La seconde méthode dont les résultats ont été retenus pour estimer la taille de la population de lémuriens bruns de l'îlot M'Bouzi s'appuie sur un dénombrement partiel du nombre d'adultes, de jeunes de l'année et de jeunes d'un an révolu et un sexage des individus. Ce dénombrement prenait fin lorsque l'observateur était suivi par des lémuriens en quête de nourriture et dont les déplacements introduisaient le risque d'un double comptage. En avril et octobre 2010, l'extrapolation de la taille de la population a respectivement été effectuée à partir du dénombrement et du sexage de 403 et 456 animaux et de 523 individus en avril 2011. Les comptages ont eu lieu entre 8 et 11 heure du matin. Il a ainsi été possible de déterminer le taux de fertilité des femelles et de survie des jeunes à un an et donc le taux de recrutement de la population (taille de la population de l'année précédente + le nombre de jeunes âgés d'un an). Le nombre de naissances totalisé par l'association Terre d'Asile et communiqué par sa présidente a été utilisé pour estimer la population sur la période 2006-2009. Un taux de mortalité de 2,8 % a été calculé à partir du nombre annuel de cadavres retrouvés par l'association entre 1998 et 2006 (N=40).

La centaine d'animaux introduits par l'association Terre d'Asile à partir de 1997 se sont reproduits et la population de lémuriens bruns comptait en 2006, 448 individus, Sigaud (2007) proposant une fourchette de 415-521 animaux en appliquant une marge d'erreur de 10 % à la comptabilisation de l'association Terre d'Asile. Cette population se répartissait en 30 groupes de 6 à 25 individus. En 2010 et 2011, Tarnaud (2010, 2011) estimait respectivement sa taille à 652 puis 718 lémuriens bruns se distribuant en 39 groupes de 6 à 43 individus (2011, Fig. 3).

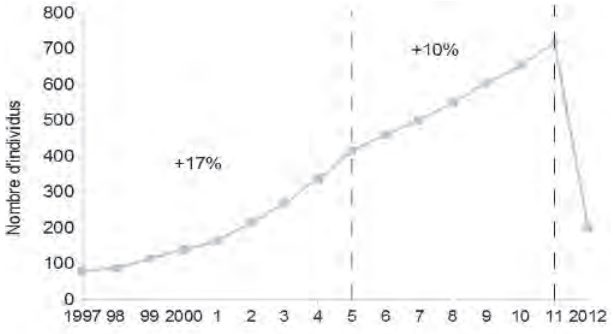

Fig. 3: Croissance démographique de la population de lémuriens de l'îlot M'Bouzi de 1997 à août 2012 (Sigaud, 2007; Tarnaud 2010, 2011).

Depuis 2005, le taux annuel de croissance s'était infléchi, passant de 17 % (2000-2005) à 9,8 % (2006-2011). Il existait toutefois une forte dynamique démographique puisque les jeunes de un à 2 ans correspondaient à 12,3 % de l'effectif total et celui des individus de moins de 10 ans à 75 %. Les femelles de cette espèce sont fertiles jusqu'à la fin de leur vie, leur durée de vie étant estimée à 20 ans en captivité. Sur l'îlot M'Bouzi, la plus vieille femelle était âgée de 18 ans en 2010 (B. Gandon, comm pers.).

Les autres paramètres démographiques sont un sexe ratio en faveur des femelles (1,2 pour une fourchette de 1,15-1,22 entre 2010 et 2011) alors qu'il est proche de 1 en milieu naturel pour l'espèce à Mayotte (Tonnabel *et al*., 2011; Tarnaud et Simmen, 2002). Le taux de fertilité varie entre 0,24 et 0,52 jeune par femelle entre 2007 et 2010 et le taux de survie des jeunes à un an est compris entre 28 et 50 % (Fig. 4). Il est classiquement considéré que les femelles donnent naissance tous les deux ans en milieu naturel et que la moitié des jeunes succombent avant la fin de leur première année de vie (Tattersall, 1977). En 2012, les femelles ont reçu une contraception temporaire par implants hormonaux (Nexplanon®)

Conditions du nourrissage et poids des animaux

Jusqu'en avril 2012, les lémuriens bruns de l'îlot M'Bouzi étaient approvisionnés en nourriture deux fois par jour

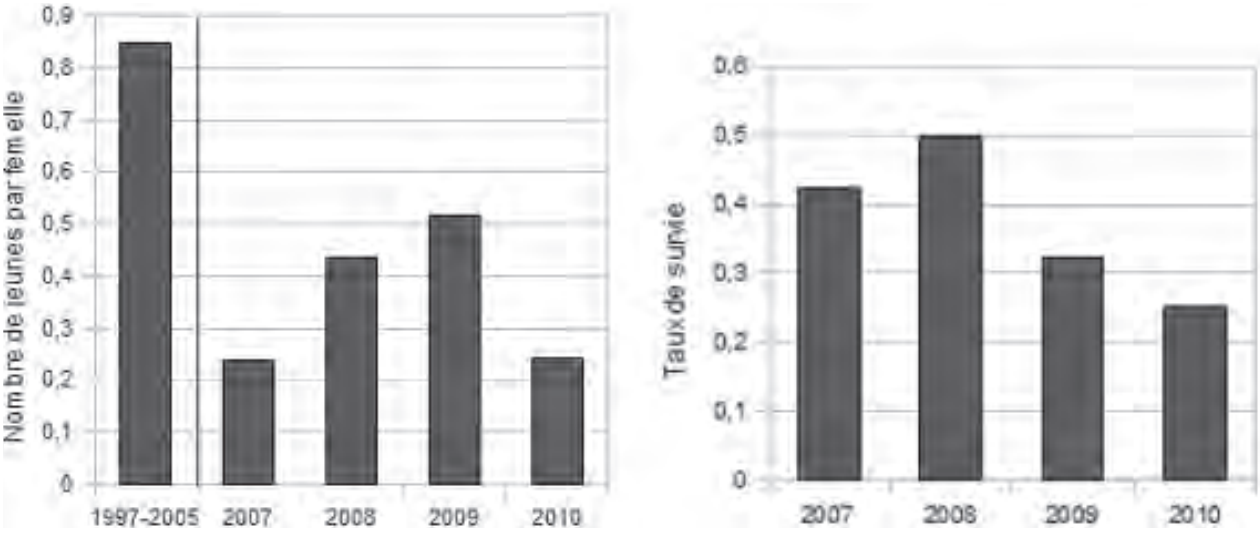

Fig. 4: Taux de fertilité et taux de survie des jeunes à un an sur la période 2007-2010 (Tarnaud, 2010).

(matin/après midi) à des horaires variables selon les années ou les personnes responsables de la distribution. La ration alimentaire était distribuée sur des placettes de nourrissage (Fig. 5) situées dans une zone de 2 à 3 hectares autour de la léproserie et dont le nombre a augmenté avec la taille de la population. On en comptait plus de cinquante en 2011.

Fig. 5: Placette de nourrissage avec une gamelle.

La ration alimentaire distribuée était composé d'une bouillie à base de lait, de riz, de pain et de bananes pouvant être ponctuellement complétée par des fruits de saison. Elle ne correspondait pas à la biologie des animaux dont le régime est frugivore-folivore (Tattersall, 1977; Tarnaud, 2004) ni à leurs besoins caloriques (Tarnaud, 2006) mais répondait à un souci d'économie et à la difficulté de trouver avec régularité et en grande quantité des fruits à Mayotte. Il a ainsi été estimé que les lémuriens vivant en forêt sèche ingéraient respectivement 90 et 160 Kcal par jour en saison sèche et humide alors qu'une ration individuelle journalière sur l'îlot M'Bouzi correspondait à environ 220 Kcal en 2010. L'apport calorique trop important, notamment dû à des aliments riches en glucide aisément métabolisables en graisse chez les primates, et la réduction de l'activité des individus induite par le nourrissage (ci-dessous) se sont traduit par un surpoids moyen de la population des lémuriens de l'îlot M'Bouzi. En 2006, Sigaud (2007), constatait que les individus présentaient un surpoids moyen de +20 % pour les mâles et de +30 % pour les femelles par rapport aux lémuriens sauvages de l'île de Grande Terre (Tab. 1). En 2012, les pesées effectuées lors des captures pour la stérilisation des femelles en vue de leur déplacement par la fondation Brigitte Bardot en centres clôturés, attestaient encore de cette surcharge pondérale chez certains individus (Maecha, Komba na Zoumbe, 2012). Ces pesées attestaient aussi du mauvais état général et de la maigreur de certains animaux provoquée par l'arrêt abrupte du nourrissage (voire ci-dessous) et comme régulièrement constaté par le Dr. Schuller (Schuller, obs pers.). En 2013, les écarts entre les poids moyens minimum et maximum enregistrés étaient moins importants et en meilleur concordance avec les poids attendus pour des animaux non approvisionnés, indiquant une adaptation aux conditions environnementales de l'îlot.

Bilan comportemental et sanitaire

L'approvisionnement en nourriture des lémuriens bruns a provoqué leur concentration artificielle dans un espace réduit de 2 à 3 hectares et, concomitamment, un stress des individus. Les animaux se sont adaptés à cette situation de promiscuité en formant des groupes de grande taille (de 6 à 31 individus). L'augmentation du niveau de stress s'est traduite, entre autre, par une résolution agressive des rencontres intergroupes. Après 4 jours de suivi en octobre 2010 et avril 2011 sur la période de temps 8-17h, Tarnaud (Tarnaud, 2011) a comptabilisé 9 affrontements entre groupes alors qu'il n'avait été le témoin que de 15 rencontres en plus de 1000 heures d'observation dans le Parc Préfectoral de Saziley (Tarnaud, obs pers.), dont seulement 2 s'étaient conclus par une bataille. Les lémuriens arrivant sur un site préféraient attendre le départ du groupe présent plutôt que de l'attaquer. Le nourrissage a aussi eu pour conséquence de réduire le niveau d'activité des animaux. Au cours des 4 jours d'observation pour la fourchette horaire indiquée, les lémuriens de l'îlot M'Bouzi ont présenté, sur la période 8h-17h, un temps d'activité (octobre: 25 %, avril: 20 %) plus réduit que celui des animaux de Saziley (octobre: 45 %, avril: 74 %) étudiés entre 1999 et en 2000 (Tarnaud, obs pers.). La différence respective des taux d'activité des lémuriens entre les mois de ces deux études est statistiquement significative pour le mois d'avril (octobre: t=1,82 ; P=0,09; avril: t=6,78 ; P<0,01). Ces deux sites ont des conditions environnementales comparables et abritent des formations de forêts sèches.

Tab. 1: Poids moyens (kg), poids moyen minimal et maximal des lémuriens de l'îlot M'Bouzi en 2012 et en 2006 et des lémuriens des sites de Saziley, de Poroani et de Grande Terre (d'après, Maecha, Komba na Zoumbe, 2012 et Sigaud, 2007).

Site	Poids moyen		Poids moyen min.		Poids moyen max.		Effectif	
	Mâle	Femelle	Mâle	Femelle	Mâle	Femelle	Mâle	Femelle
M'Bouzi-2013 Mission sanitaire**	1.78	1.82	1.3	1.46	2.4	2.2	26	23
M'Bouzi-2012 (juin)	2	1,9	1,1	0,9	2,9	2,8	68	101
M'Bouzi-2006	2,38	3,10	1,70	2,50	4,30	3,80	16	7
Saziley*	1,99	2,16	1,75	1,80	2,15	2,50	9	7
Poroani	1,93	2,32	1,70	1,95	2,35	2,70	7	6
Grande Terre	1,96	2,20	1,70	1,80	2,35	2,70	18	14

*Saziley: formation végétale de forêts sèche comparable à celle de l'ilot M'Bouzi. **: Mission sanitaire menée pour le compte de la DAF par l'Association Francophone des Vétérinaires de Parc Zoologique AFVPZ (Dr K.Ortiz, Dr B. Quintard et Dr B.Lefaux, comm pers.)

La situation artificielle des lémuriens de l'îlot M'Bouzi s'est aussi traduite par niveau d'infestation par des parasites intestinaux supérieur de 20 % à celui des lémuriens sauvages de Grande Terre en 2005 (Nègre et *al*., 2006). La distribution de nourriture a favorisé la pullulation des rats (Rocamora, 2009; Fig. 6), apportant une pression environnementale supplémentaire sur le milieu. Elle a augmenté les risques de déclaration d'une épizootie qui aurait pu facilement contaminer les lémuriens de Grande Terre vu la proximité de l'îlot M'Bouzi avec l'île de Grande Terre.

Fig. 6: La distribution de la nourriture accessible aux rats a favorisé leur dynamique démographique.

Situation des lémuriens de l'îlot M'Bouzi en 2012

La situation décrite ci-dessus a radicalement évolué en avril 2012 avec l'arrêt du nourrissage des animaux par l'association Terre d'Asile. Un nourrissage ciblé sur les animaux les plus maigres diagnostiqués par le vétérinaire mandaté par la réserve naturelle nationale a été mis en place en juillet 2012 et assuré par l'équipe de la réserve naturelle nationale avec distribution 3 fois par semaine de 75 kg de bananes. Cette action ayant pour but de soulager la souffrance d'animaux dont l'approvisionnement a été abandonné en saison sèche a eu pour conséquence de regrouper sur le site de la léproserie des lémuriens qui avait commencé à se disperser sur l'îlot. Pendant l'été 2012, ces lémuriens semblaient plus maigres que ceux des groupes devenus périphériques. Ce nourrissage ciblé était complété par l'apport hebdomadaire de 120 L d'eau.

En mai 2012, l'association Maecha, Komba na Zoumbe récemment créée a trouvé 63 cadavres en l'espace de 2 semaines (24 individus marqués et 39 autres non marqués, se reporter ci-dessous). Ce nombre n'a pas été validé par le conservateur de la réserve naturelle nationale. Des animaux maigres et non maigres ont été ramassés et un empoisonnement a été soupçonné (Dr. Schuller, comm pers.). Des plaintes dénonçant cette situation ont été déposées par l'ensemble des acteurs locaux et une analyse a été réalisée par le laboratoire Biolytics de l'école vétérinaire de Lyon sans pouvoir incriminer un empoisonnement par raticide comme supposé. L'association Maecha, Komba na Zoumbe a aussi rapporté une diminution, à ce jour encore inexpliquée, du nombre de lémuriens présents sur l'îlot alors qu'elle avait marqué et mis sous contraception 378 lémuriens et observé 60 autres (non marqués) en mai/juin 2012. Ainsi au début de la saison sèche de l'année 2012, la taille de la population de lémuriens de l'îlot M'Bouzi était d'environ 400 animaux contre 700 en avril 2011.

En août 2012, à la demande de la réserve naturelle nationale, un recensement des lémuriens coordonné par Tarnaud a été réalisé. Il a été dénombré 179 animaux (Fig. 7, sont ajoutés 5 animaux signalés concomitamment par l'equipe de la réserve dans la ravine sud-ouest non visitée, soit 184 individus). Ce recensement étant partiel, l'ensemble de l'îlot n'ayant pas été parcouru, la population de lémuriens bruns devait être forte d'environ 200 animaux.

La décroissance singulière de la population de lémuriens bruns de l'îlot M'Bouzi pose la question de la disparition inexpliquée d'environ 300 à 400 individus en tenant compte du pic de mortalité rapporté ci-dessus. Il est à noter que jamais (à l'exception des 63 cadavres) des cadavres en grand nombre n'ont été découvert entre mai 2011 et août 2012 sur l'îlot.

L'année 2012 a aussi été marquée par les réactions provoquées par la proposition soutenue par le CNPN d'euthanasier les lémuriens de l'îlot. La fondation Brigitte Bardot s'était alors engagée à déplacer 300 lémuriens de l'îlot M'Bouzi dans des centres de captivité en Europe. Aujourd'hui, euthanasie comme translocation ne sont plus d'actualité.

Une solution pour les lémuriens de l'îlot M'Bouzi?

A partir d'août 2012, la population des lémuriens bruns de l'îlot M'Bouzi est proche de la capacité d'accueil estimée d'après ses faciès forestiers. Sur les 82 ha de terre émergée, 62 ha sont occupées par des forêts secondaire et de type xérophyle (Viscardi, 2011), faciès forestiers où vivent des lémuriens en Grande Terre. Il a aussi été observé la consommation de 67 aliments différents (34 espèces végétales) sur les 150 connues consommées par les lémuriens en Grande terre (Tarnaud, 2011; Tarnaud *et al*., 2012). Ce premier constat est favorable à la présence de lémuriens «naturalisés» et non approvisionnés par l'homme. Il doit, cependant, être nuancé par le fait que la survie des animaux est fortement contingentée par la disponibilité alimentaire en saison sèche. En effet, les forêts sèches à Mayotte sont caducifoliées. De nombreuses espèces ligneuses et de lianes perdent leurs feuilles. Les fruits sont rares. Ainsi, des 62 ha potentiellement accueillant, seulement 20, correspondant à des faciès végétaux avec des arbres de 5 à 15 m de haut où

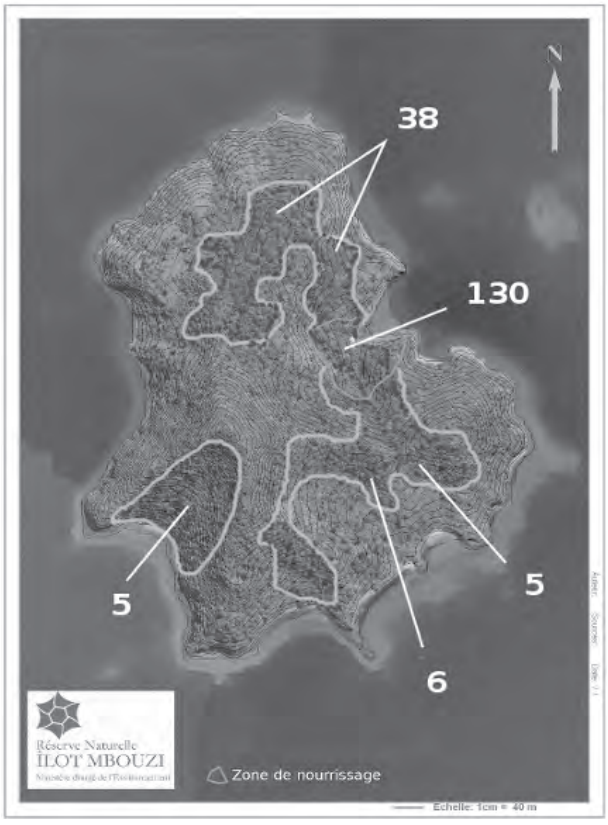

Fig. 7: Distribution des animaux en août 2012 en fonction des zones forestières favorables à la survie des lémuriens en saison humide (tracé vert clair) et en saison sèche (tracé rouge). Le tracé orange correspond à la zone «léproserie». Sont indiqués les 5 animaux signalés dans la ravine sud-ouest et non comptabilisés dans le recensement.

peuvent dormir les animaux présentent un couvert végétal en saison sèche d'après les photographies aériennes infrarouges de la campagne 2008 de l'IGN (IGN, 2008). Il faut y ajouter 25 ha de fourrés pouvant contenir des ressources alimentaires favorables à la survie des animaux pendant l'hiver austral (Fig. 5). Sachant que 10 individus peuvent vivre sur 1,3 à 1,5 ha en forêt sèche (Tarnaud, 2004) et que 15 à 35 ha de forêt sont susceptibles d'accueillir des lémuriens sur l'îlot M'Bouzi, il paraît raisonnable de considérer, selon une approche conservatrice (8 individus pour 1,5 ha), que 80 à 180 individus puissent vivre sur l'îlot sans être approvisionnés par l'homme. En outre, même cette population "réduite" dépasse les capacités d'accueil en captivité dans les parcs zoologiques à la fois en terme de places disponibles et de compétition pour l'espace disponible vis-à-vis des 20 espèces menacées d'extinction, en EEP, et qui ont besoin de voir leur population croître dans ces mêmes parcs si leur translocation était, de nouveau envisagée.

Cette hypothèse raisonnable de capacité d'accueil permet, après bien des années d'une opposition parfois très violente entre les acteurs locaux, de trouver une solution écologiquement pertinente et éthiquement responsable. Elle évite le recours à la manipulation de la faune et à la transformation des équilibres écologiques, manipulations qui sont généralement réalisées avec trop peu de prudence et dans un temps court inadapté alors que l'effort doit être mis sur la protection des habitats. Acceptable en 2012, elle l'était aussi en 2001 alors que la population de lémuriens sur l'îlot M'Bouzi était estimée à 200 individus (Gresse *et al*., 2002). Autoriser l'établissement d'un équilibre de la population de lémuriens bruns de l'îlot M'Bouzi avec l'habitat alors que la taille de la population entre en cohérence avec sa capacité d'accueil sans intervention humaine présente l'avantage évident d'apporter une solution respectant le bien être animal, une première pour cette population longtemps en souffrance. Elle évite aussi toute forme de captivité ou de concentration des animaux et participe à la valorisation de la réserve naturelle. Cette solution suppose que l'îlot M'Bouzi ne soit plus un enjeu politico-médiatique pour les acteurs locaux comme il l'a souvent été.

Références

Andriaholinirina, N., Baden, A., Blanco, M., Chikhi, L., Cooke, A., Davies, N., Dolch, R., Donati, G., Ganzhorn, J., Golden, C., Groeneveld, L.F., Hapke, A., Irwin, M., Johnson, S., Kappeler, P., King, T., Lewis, R., Louis, E.E., Markolf, M., Mass, V., Mittermeier, R.A., Nichols, R., Patel, E., Rabarivola, C.J., Rabarivololona, B., Rajaobelina, S., Rakotoarisoa, G., Rakotomanga, B., Rakotonanahary, J., Rakotondrainibe, H., Rakotondratsimba, G., Rakotondratsimba, M., Rakotonirina, L., Ralainasolo, F.B., Ralison, J., Ramahaleo, T., Ranaivoarisoa, J.F., Randrianahaleo, S.I., Randrianambinina, B., Randrianarimanana, L., Randrianasolo, H., Randriatahina, G., Rasamimananana, H., Rasolofoharivelo, T., Rasoloharijaona, S., Ratelolahy, F., Ratsimbazafy, J., Ratsimbazafy, N., Razafindraibe, H., Razafindramanana, J., Rowe, N., Salmona, J., Seiler, M., Volampeno, S., Wright, P., Youssouf, J., Zaonarivelo, J. & Zaramody, A. 2014. *Eulemur mongoz*. The IUCN Red List of Threatened Species 2014: e.T8202A16117799. Downloaded on 14 September 2015.

Davies, N.; Johnson, S.; Louis. E. E.; Mittermeier, R.A.; Nash, S. D., Rajaobelina, S.; Ratsimbazafy, J.; Razafindramanana, J; Schwitzer, C. 2013 Lemurs of Madagascar: a strategy for their conservation. IUCN Publication, 185 pages.

Gresse, M.; Gandon, B.; Tarnaud, L.; Simmen, B.; Labat, J.N.; Hladik, C.M. 2002. Conservation et introduction de lémuriens sur l'îlot Mbouzy (Mayotte). Revue d'Ecologie (Terre & Vie), 57: 75-82.

Harpet, C. 2011. Relations agriculteurs/lémuriens à Mayotte : Diagnostic, enjeux et préconisation. Report, DAF/SEF, Mamoudzou (Mayotte).

Hoffmann, M. 2010. The Impact of Conservation on the Status of the World's Vertebrates. Science 330: 1503-1509.

Institut de Géographie Nationale. 2008. Campagne de photographies aérienne.

Lainé, G.; Dupuy, S.; Tassin, J.; Sarrailh, J.M. 2010. Etude de la Typologie Forestière de Mayotte: Méthodologie appliquée et nomenclature retenue. Rapport final. ConventionNo. 2009/203776. Report, Montpellier, France.

Louette, M.; Meirte, D.; Jocque, R. 2004. La faune de l'archipel des Comores. Afrotropical Zoology. Edition MRAC, N°293.

Maecha, Komba na Zoumbe. 2012. Contraception des lémurs bruns *(Eulemur fulvus mayottensis)* de la réserve naturelle nationale de l'îlot M'Bouzi – Mayotte. Rapport d'activité, Direction de l'Environnement, de l'Agriculture et du Logement.

Matthews E.; Payne, R.; Rohweder, M.; Murray, S. 2000. Pilot analysis of global ecosystems: Forest ecosystems. World Resources Institute, Washington, DC.

Pérez, I.; Anadón, J.D.; Díaz, M.; Nicola, G.G.; Tella, J.L.; Giménez, A. 2012. What is wrong with current translocations? A review and a decision-making proposal. Frontiers in Ecology and the Environment 10: 494-501.

Rocamora, G. 2009. Dératisation et mise en place d'un protocole de contrôle du Rat noir (*Rattus rattus*) et relevés d'avifaune dans la réserve Naturelle de l'îlot M'bouzi. Rapport de mission Oct-Nov. 09. Les Naturalistes de Mayotte, 44p. Rapport, Association les naturalistes.

Roullet, D. 2011. Rôles des populations captives dans la conservation des lémuriens. Revue de Primatologie. <//primatologie.revues.org/692>. Downloaded on 15 November 2012.

Sigaud, M. 2007. Bilan sanitaire et épidémiologique d'une population semi-captive de lémurs bruns (*Eulemur fulvus*) sur l'îlot M'Bouzi. Disseration de thèse vétérinaire. Maison-Alfort, France.

Tarnaud, L. 2004. Ontogeny of feeding behaviour of *Eulemur fulvus* in the dry forest of Mayotte. International Journal of Primatology, 25: 803-824.

Tarnaud, L. 2006. Cathemerality in the Mayotte brown lemur (*Eulemur fulvus*): Seasonality and food quality. Folia Primatologica 77: 166-177.

Tarnaud, L. 2011. Suivi de la population de lémuriens bruns de l'îlot M'Bouzi. Rapport, Réserve Naturelle Nationale, Massy, France.
Tarnaud, L. 2010. Situation de la population de lémuriens bruns de l'îlot M'Bouzi: outils de gestion et recommandations. Rapport, Réserve Naturelle Nationale, Massy, France.
Tarnaud, L.; Simmen, B. 2002. A major increase of the lemur population of Mayotte since the decline reported in 1987. Oryx 36: 297-300.
Tarnaud, L.; Tattersal, I.; Roeder, J.J., Lefaux, B., Harpet, C.; Langrand, O.; Mittermeier, R.; Tonnabel, J. 2012. Le maki de Mayotte. Univers Maoré 16: 48 pages, Mayotte.
Tattersall, I. 1977. Ecology and behavior of *Lemur fulvus* (Primate, Lemuriformes). Anthropological Papers of the American Museum of Natural History, New York.
Tattersall, I. 1989. The Mayotte lemur: cause for alarm. Primate Conservation 10: 26-27.
Tonabel, J., Tattersall, I.; Simmen, B., Tarnaud, L. 2011. Decline and structural changes in the population and groups of the Mayotte brown lemur (*Eulemur fulvus*). Oryx 45: 608-614.
IUCN/SSC. 2014. Guidelines on the Use of *Ex Situ* Management for Species Conservation. Version 2.0. Gland, Switzerland: IUCN Species Survival Commission, 15p.
Viscardi, G. 2011. Flore et végétation de la Réserve Naturelle Nationale de l'îlot M'bouzi. CBNM / DEAL / Naturalistes de Mayotte. Rapport, Mayotte.

Sex-Specific Height Use Patterns and Implications for Predator Avoidance in Milne-Edwards' Sifaka (*Propithecus edwardsi*), in Ranomafana National Park Madagascar

Danielle Minkus, Summer J. Arrigo-Nelson*
Department of Biological and Environmental Sciences, California University of Pennsylvania, California, PA 15419, USA
*Corresponding author: **arrigonelson@calu.edu**

Key words: lemur, habitat disturbance, maternal behaviour, predator detection, anti-predator behaviour

Abstract
The endangered Milne-Edwards' sifaka (*Propithecus edwardsi*) is a female dominant herbivorous primate that lives in small groups. This species exhibits sex-biased survival patterns with males surviving better as infants and young adults, but females living up to 10 years longer. Differences in survival have been attributed to males engaging in more risky behaviours than females as adults. To determine the relationship between canopy height use and potential predator exposure, data were collected on seven groups of sifakas located within Ranomafana National Park: four groups in disturbed forest and three in undisturbed forest. Each group was followed for five days each month (Jan 02 – May 04), with group scans conducted every 10 minutes to record the height of each individual from the ground. While height use varied significantly between the two sites, males within each site had significantly different patterns of height use than females with infants (DF: p=0.004; PF: p<0.001). Additionally, within the disturbed forest adult females with infants had significantly different height use patterns than females without infants (p=0.012). These differences may be due to differing food distribution patterns or predator avoidance strategies.

Résumé
La sifaka de Milne-Edwards (*Propithecus edwardsi*), est une espèce herbivore en voie de disparition, vivant en petits groupes dominés par des femelles. Cette espèce présente des modèles de survie différents entre mâles et femelles, où les mâles survivent mieux que les nourrissons et les jeunes adultes, mais les femelles vivent jusqu'à 10 ans de plus. Cette différence de survie a été attribué aux omportements plus risqués des mâles une fois l'1âge adulte atteint. Pour déterminer la relation entre l'utilisation de la hauteur de la canopée et l'exposition de prédateurs potentiels, les données ont été collectées sur sept groupes de sifakas situés dans le Parc National de Ranomafana: quatre groupes dans la forêt perturbée, et trois groupes dans la forêt primaire. Chaque groupe a été suivi pendant quatre jours chaque mois (Janvier 02 à Mai 04), avec des scans de groupes menés toutes les 10 minutes pour enregistrer la hauteur de chaque individu du sol. La hauteur absolue utilisée varie entre deux sites encore à chaque site de la hauteur du profil de mâles est significativement différente chez les femelles avec enfants (FD: p=0,004; FP: p<0,001). De plus, dans la forêt perturbée, les femelles adultes avec enfants utilisent un profil de hauteur différent que les femmes sans enfants (p=0,012). Cette différence est probablement due à différents modèles de distribution de nourriture ou de comportement des prédateurs.

Introduction
The endangered Milne-Edwards' sifaka (*Propithecus edwardsi*) is a female dominant herbivororous primate that lives in small groups (typically 3-6 individuals) (Wright *et al*., 1997; Wright, 1998). Both sexes have equal testosterone and aggression levels and adults lack sexual dimorphism (Tecot *et al*., 2013). However, this species appears to exhibit sex-biased survival patterns, with males surviving better as infants and young adults, but females living up to 10 years longer (Morelli *et al*., 2009; Tecot *et al*., 2013). This difference in adult survival has primarily been attributed to males engaging in more risky behaviour (e.g. migration) than females in adulthood (Karpanty, 2003; Morelli *et al*., 2009; Tecot *et al*., 2013).
Another risky behaviour that differs between the sexes is predator exposure (Wright, 1998; Karpanty, 2003). Milne-Edwards' sifakas respond to both aerial and terrestrial predators. Raptors (birds of prey) are considered a potential threat to young sifakas, while the fossa (*Cryptoprocta ferrox*, a medium sized carnivore) is well documented to prey on both adult and juvenile animals (Wright, 1998; Karpanty, 2003). It is estimated that 57 % of the fossa diet consists of lemurs, and that one fossa eats approximately 24 sifakas each year (Wright *et al*., 1997).
In previous studies, males and females have reacted differently to aerial versus terrestrial predators (Wright *et al*., 1997; Wright, 1998; Karpanty, 2003). Males are more vigilant and mob predator models more often than females, especially when infants are present. However females are usually the first to detect aerial predators and give alarm calls. The sexes also behave differently in the absence of predators; for example males will lag over 12 metres behind females during travel and feed at different heights than the rest of the group.
The purpose of this study was to examine whether patterns of canopy height use were affected by previously reported sex differences in predator detection/avoidance behaviour. To look at differences in heights use, we compared the proportion of time that animals spent at different canopy heights between three categories of sifakas: adult males, and adult females with and without dependent offspring. We also examined differences in patterns of height use by social groups living in habitats of varying qualities. We hypothesized that to best detect predators, males would

spend more time higher and lower in the canopy than females, and that females would prefer to occupy the middle of the canopy.

Methods

Data were collected on seven groups of sifakas located within Ranomafana National Park: four groups in disturbed, selectively logged forest (Talatakely - DF) and three in undisturbed, primary rainforest (Valohoaka - PF) (Fig. 1). Each group was followed for five consecutive days each month, from January 2002 to May 2004, with group scans conducted every ten minutes (Altmann, 1974). Among other data taken at each scan (see Arrigo-Nelson, 2006), height from the ground was visually estimated to the nearest meter for every group member.

Data included in this analysis were taken from full day group follows (minimum 6 hours), totaling 348 days (80-98 days per group). Daily patterns of height use were compared between adult males, adult females and adult females with dependent infants using MANOVA and Games-Howell post-hoc tests, by examining the proportion of each day that individuals spent at each height (rounded to the nearest meter). Because of significant differences in forest composition and height use patterns between the undisturbed and disturbed forest habitats, data from our two sites were analyzed separately. All statistical tests were carried out in R (R Core Team, 2014).

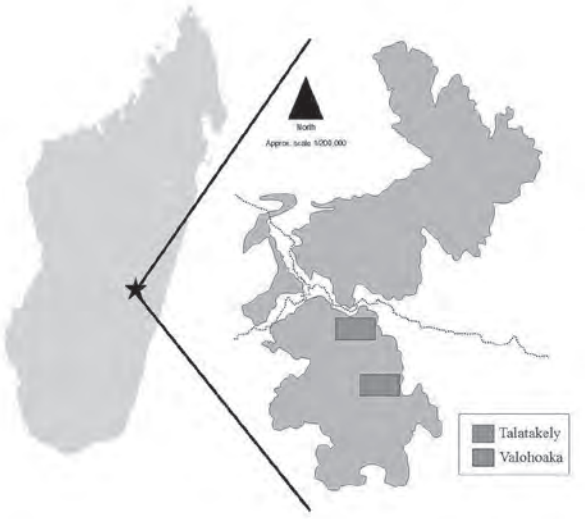

Fig. 1: Map of Ranomafana National Park and study sites: Talatakely (disturbed forest) and Valohoaka (undisturbed forest).

Results

Although similar patterns of height use were seen in both the disturbed and undisturbed forest habitats, the absolute heights used varied greatly between the two sites. Animals in the pristine forest positioned themselves, on average, two metres higher in the canopy than animals in the disturbed forest ($F = 46.9$, $p<0.001$; Fig. 2).

Within each site, males had significantly different patterns of height use than females with infants (DF: $t = 3.17$, $p= 0.004$; PF: $t = 4.8$, $p<0.001$) (Tab. 1,2). Additionally, within the disturbed forest, adult females with infants had significantly different patterns of height use than those without infants ($t = 2.85$, $p=0.012$) (Tab. 1). In the undisturbed forest, females were found to disproportionately make use of the middle of the canopy and males the higher canopy (Fig. 3). On the other hand, in the disturbed forest, males and adult females without infants dominated the middle of the canopy while females with infants spent more time higher and lower than other animals (Fig. 4).

Tab. 1: Disturbed forest (DF) summary.

	N	Mean	Variance		t	DF	p
AFI	14832	11.6	16	**AF:AFI***	2.85	10646	0.012
AF	6399	11.4	22	**AF:AM**	0.38	32401	0.922
AM	19017	11.39	17	**AFI:AM****	3.17	10036	0.004

Tab. 2: Undisturbed forest summary (PF).

	N	Mean	Variance		t	DF	p
AFI	5234	13.56	22	**AF:AFI**	2.1	11690	0.098
AF	7226	13.38	25	**AF:AM**	2.2	10127	0.079
AM	12422	13.21	23	**AFI:AM****	4.8	14664	<0.001

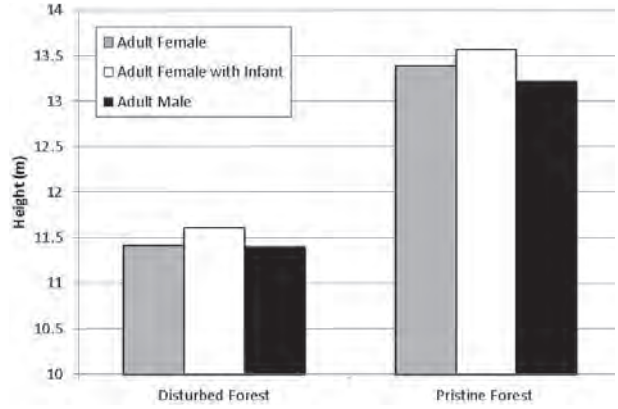

Fig. 2: Between site comparisons of height averages.

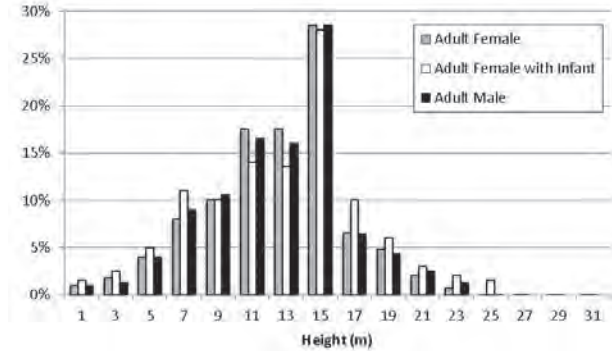

Fig. 3: Undisturbed forest (PF) height use patterns.

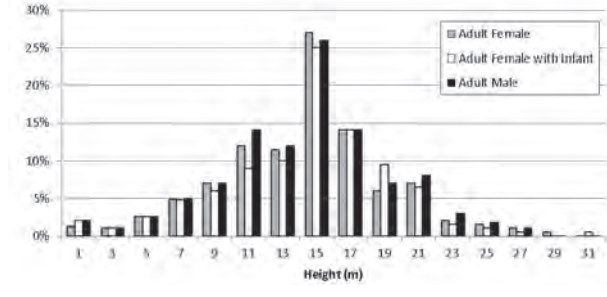

Fig. 4: Disturbed forest (DF) height use patterns.

Discussion

While all animals at both sites use a wide range of canopy heights, several clear patterns existed in the data. Between sites, average canopy height used differed by approximately two metres (Fig. 2). We suggest that two disturbance-related differences may be shaping this pattern. First, given the selective logging and subsequent forest regeneration at the disturbed forest site, food distribution patterns differ widely between the sites (Arrigo-Nelson, 2006), thus shaping sifaka height use. Second, difference in predator population densities between the sites could be leading sifakas to practice different predator defense and or avoidance strategies (Hawkins and Racey, 2008).

Despite the between-site difference, there are several consistent patterns at both sites. All adult sifakas preferred the 14-15 m height range and adult females with infants also spent a disproportionate amount of time in the 16-19 m range, when compared to their group mates (Fig. 3,4). These high canopy heights are likely to give the best vantage point for predator detection, best escape routes from predators and/or the best food resources as has been previously reported for the bamboo lemur (*Hapalemur griseus*), in the same forest, by Grassi (2002). Similar patterns are also seen in species in other forests, including brown spider monkeys (*Ateles hybridus*) (Abondano and Link, 2012).

There was also a noticeable difference in male and female without infant height use patterns between sites. In the disturbed forest, they used the 5-9 m range instead of the 17-21 mrange that they preferred in the pristine forest. This trend is likely due to differences in habitat quality between sites (Arrigo-Nelson, 2006; Herrera *et al*., 2011), with animals without dependent offspring sacrificing predator exposure to gain access to food resources. Future studies on this topic may focus on activity budgets at differing heights to discover if specific activities (e.g., feeding, vigilance, etc.) are more common at specific heights, within each site.

Acknowledgements

We thank Madagascar National Parks for their permission to conduct research, the Madagascar Institute for the Conservation of Tropical Environments and Centre ValBio for their logistical and technical support and Dr. Derek Gray for his statistical assistance. Funding for data collection was provided by J. William Fulbright Program, Margot Marsh Biodiversity Foundation/CI Primate Action Fund, NSF BCS DDIG (No. 0333078), Primate Conservation Incorporated and a Saint Louis Zoo Field Research for Conservation Grant program.

References

Abondano, L.A.; Link, A. 2012. The social behavior of brown spider monkeys (*Ateles hybridus*) in a fragmented forest in Colombia. International Journal of Primatology 33: 769-83.

Arrigo-Nelson, S.J. 2006. The Impact of Habitat Disturbance on the Feeding Ecology of the Milne-Edwards' Sifaka (*Propithecus edwardsi*) in Ranomafana National Park, Madagascar. Dissertation, State University of New York at Stony Brook, New York.

Clarke, E.; Reichard, U.H.; Zuberbühler, K. 2012 The anti-predator behaviour of wild white-handed gibbons (*Hylobates lar*). Behavioral Ecology and Sociobiology 66: 85-96.

Grassi, C. 2002. Sex differences in feeding, height and space use in *Hapalemur griesus*. International Journal of Primatology 23: 677-93.

Hawkins, C.E.; Racey, P.A. 2008. Food habits of an endangered carnivore, *Cryptoprocta ferox*, in the dry deciduous forests of Western Madagascar. Journal of Mammalogy 89: 64-74.

Herrera, J.P.; Wright, P.C.; Lauterbur, E.; Ratovonjanahary, L.; Taylor, L.L. 2011. The effects of habitat disturbance on lemurs at Ranomafana National Park, Madagascar. International Journal of Primatology 32: 1091-108.

Karpanty, S.M. 2003. Behavioral and Ecological Interactions of Raptors and Lemurs in Southeastern Madagascar: A Multiple Predator Approach. Dissertation, State University of New York at Stony Brook, New York.

Morelli, T.-L.; King, S.J.; Pochron, S.T.; Wright, P.C. 2009. The rules of disengagement: Takeovers, infanticide, and dispersal in a rainforest lemur, *Propithecus edwardsi*. Behaviour 146: 499-523.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

Reichard, U.H. 1998. Sleeping sites, sleeping places, and presleep behavior of gibbons (*Hylobates lar*). American Journal of Primatology 46: 35-62.

Tecot, S.R.; Gerber, B.D.; King, S.J.; Verdolin, J.L.; Wright, P.C. 2013. Risky business: Sex differences in mortality and dispersal in a polygynous, monomorphic lemur. Behavioral Ecology 24: 987-96.

Wright, P.C. 1998 Impact of predation risk on the behaviour of *Propithecus diadema edwardsi* in the rainforest of Madagascar. Behaviour 135: 483-512.

Wright, P.C.; Heckscher, K.; Dunham, A.E. 1997. Predation on Milne Edwards' sifaka (*Propithecus diadema edwarsi*) by the fossa (*Cryptoprocta ferrox*) in the rain forest of Southeastern Madagascar. Folia Primatolgica 68: 34-43.

Anthropogenic pressures threatening the black and white ruffed lemur (*Varecia variegata editorum*) in the Analamazaotra Special Reserve, Madagascar

Voahangitiana Rasoamanarivo[1], Brigitte M. Rahariviololona[1], Cynthia L. Frasier[2], Azure Ginter[2], Raoliarivao Andriamandimbisoa[3], Rindra Randriamahefasoa[3], Edward E. Louis Jr.[2,4*]

[1]Département de Paléontologie et d'Anthropologie Biologique, Faculté des Sciences, B.P. 906, Université d'Antananarivo, Madagascar

[2]Bill and Bernice Grewcock Center for Conservation and Research, Department of Conservation Genetics, Omaha's Henry Doorly Zoo and Aquarium, 3701 South 10th Street, Omaha, NE, 68107, USA

[3]Andasibe-Mantadia National Park, Madagascar National Parks, Andasibe, Madagascar

[4]Madagascar Biodiversity Partnership, Lot VO 12Bis A, Manakambahiny, Antananarivo, 102, Madagascar

*Corresponding author: **edlo@omahazoo.com**

Key words: Forest exploitation, lemurs, Madagascar, sustainable alternatives, threats, *Varecia variegata*

Abstract

The southern black and white ruffed lemur (*Varecia variegata editorum*) was extirpated from the Analamazaotra Special Reserve (ASR) in eastern Madagascar by the 1970s. At this time, the infrastructure of the ASR was in development as well as the local enforcement capacity. Since then, this site has become one of the best known ecotourism areas in Madagascar and the management aptitude has improved. Due to this advancement, two *V. variegata editorum* family groups from nearby forests under severe pressure were translocated to the ASR as part of a re-introduction program. They have settled in the lesser visited northeastern portion of the reserve. Black and white ruffed lemurs prefer undisturbed forest habitats; however, this study identified numerous anthropogenic activities that compromise the forest integrity and risk the future of this lemur in the ASR. Field surveys and interviews with residents abutting the ASR recorded multiple forest uses such as logging, collection of

bark for rope making and the production of alcohol. Additionally, people harvest medicinal plants, *Dioscorea ovinala* tubers, and honey from wild swarms. Slash and burn agriculture was also encroaching on the northeastern boundary of the ASR during the study period. In addition to identifying threats, strategies for improving community capacity to generate supplemental income and improve access to food and construction resources to stem extraction from the reserve are described.

Résumé

Le Vari noir-et-blanc de Hill (*Varecia variegata editorum*) s'est localement éteint dans la Réserve Spéciale d'Analamazaotra (RSA), à l'Est de Madagascar, vers les années 1970. A cette époque, l'infrastructure de la Réserve était en développement ainsi que la capacité locale dans l'application des lois en vigueur. Dès lors, ce site est devenu l'une des régions les plus connues en matière d'écotourisme à Madagascar; et l'aptitude dans sa gestion s'est améliorée. Suite à ce perfectionnement, un programme de réintroduction dudit taxon a été développé. Ainsi, deux groupes de *V. variegata editorum*, venant des forêts environnantes sévèrement sous-pression, ont été réintroduits dans la RSA. Ils se sont installés dans la partie Nord-est de la Réserve qui est moins visitée. Cette espèce de lémuriens préfère un habitat non perturbé; néanmoins, de nombreuses activités anthropiques ont été observées dans cette région. Ces pressions pourraient mettre en péril l'intégrité de la forêt et l'avenir de *V. variegata editorum* dans la RSA. Durant les observations directes sur le terrain et les enquêtes menées auprès des villageois, de multiples utilisations de la forêt ont été enregistrées telles que l'abattage de certains arbres, la collecte d'écorce pour la fabrication de corde et la production d'alcool. En outre, les gens récoltent du miel des abeilles sauvages, de *Dioscorea ovinala* et des plantes médicinales. La culture sur brûlis a également empiété sur la partie Nord-est de la Réserve. Des stratégies pour améliorer la capacité de la communauté locale à générer des revenus supplémentaires et à améliorer l'accès à la nourriture et aux ressources de construction pour endiguer l'extraction des produits forestiers de la Réserve sont développées.

Introduction

In 2012, alarming figures came out during the reassessment of the conservation status of lemurs in Madagascar. Approximately 90 % of lemur taxa were threatened; 93 species and subspecies among the 103 identified at the time (Schwitzer *et al*., 2013). Faced with this rapidly declining situation, we wanted to contribute to reducing the risk of extinction of this primate lineage by focusing our work on the Critically Endangered *Varecia variegata editorum* population in the Analamazaotra Special Reserve (ASR) in eastern Madagascar.

The ASR is one of the best known protected biological and ecotourism areas in Madagascar due to its accessibility from the capital city. It is home to many rare endemic and endangered plants and animals. As for lemurs, the ASR harbors seven nocturnal and six diurnal species including *Microcebus rufus, M. lehilahytsara, Cheirogaleus crossleyi, Avahi laniger, Lepilemur mustelinus, Daubentonia madagascariensis, Allocebus trichotis, Hapalemur griseus, Eulemur fulvus, E. rubriventer, Indri indri, Propithecus diadema,* and *Varecia variegata* (Dolch, 2008; Mittermeier *et al*., 2008). For the latter species, there are three recognized subspecies, *V. variegata variegata, subcincta* and *editorum*; only *editorum* is present in the ASR (Mittermeier *et al.,* 2010).

The ASR was created 21st June 1970, by the Decree No. 2278 MAER/SECREF/FOR and it is the 21st Special Reserve in Madagascar (Randriamanantenasoa, 1996). However, the management team of this young protected area was unable to prevent the extirpation of black and white ruffed lemurs by the mid-1970s, predominantly due to bush meat hunting (Day *et al.,* 2009, McGuire *et al.,* 2009). Not only did *V. variegata editorum* become extinct at this site, but also *Propithecus diadema*, another large diurnal species. In contrast to *Indri indri*, neither of the aforementioned lemurs was protected within the cultural belief system around the ASR. The indri is the largest extant lemur that would logically have made it a choice source of bush meat, but hunting this species is locally unacceptable.

By 2006, the ASR was more developed and better prepared to protect its biodiversity at which time two *V. variegata editorum* family groups were translocated, one group of four individuals from the nearby Mantadia National Park (S18°48'57.6"; E048°25'19.9") and a second group of three individuals from the Classified Forest of Anosibe An'ala (S19°14'05.0"; E048°16'18.9"; Day *et al.,* 2009). The *Varecia* at the latter site were heavily hunted and during a recent site visit in 2014 heavy deforestation resulting in the near disappearance of the forest was confirmed (R. Randriamampionana, pers comm.).

Since 2006, the translocated animals have been monitored according to IUCN guidelines for reintroductions and translocations (1998, 2013). Reports from this monitoring effort documented the birth of eight litters of black and white ruffed lemurs in the reserve since the translocation (R. Ramarokoto and R. Randrianindrina, pers comm.). According to Moberg (1985) the non-adaptation of an animal to an environment may cause stress and a failure to reproduce; thus we interpret the population growth of ASR's *V. variegata editorum* as a sign of this subspecies acclimating to its new environment.

Although the translocated population of *V. variegata editorum* at ASR is doing well, numerous illicit activities have recently been observed here during the daily monitoring routine. A significant threat is the traditional practice of slash and burn cultivation or "tavy" (Rajoelison, 2005; Randriamanantenasoa, 2005). This practice completely dismantles the forest, and the loss of natural habitats has been linked to the reduction of biodiversity (Styger *et al*., 2007). Lemurs are among the species likely to be pushed to extinction in Madagascar by tavy as they are territorial, and the available area of their natural habitat is not enough to meet their needs (Mittermeier *et al*., 2004).

Black and white ruffed lemurs are sensitive to habitat disturbance (Mittermeier *et al.* 2008; Balko 1998); thus, the unauthorized anthropogenic activities occurring in the ASR despite its protected status may become a serious threat to *V. variegata editorum* if not addressed. For the well-being of the future of black and white ruffed lemurs in the ASR, an inventory of threats was conducted in 2012 and 2013. The main goal was to collect information on human activities jeopardizing the survival of this taxon in the reserve and identify possible points of intervention via building community capacity to stem future habitat degradation.

Methods

Study site

The ASR is located at S18°48'56.1" and E048°25'11.2" and covers an area of 810 ha (Tattersall and Sussman, 1975; Fig. 1) It is within the protected area of Andasibe-Mantadia, which is part of the Madagascar National Park system in the rural municipality of Andasibe, District Moramanga. It lies about 140 km east of Antananarivo and is bounded to the south by the National Highway N°2 (RN2).

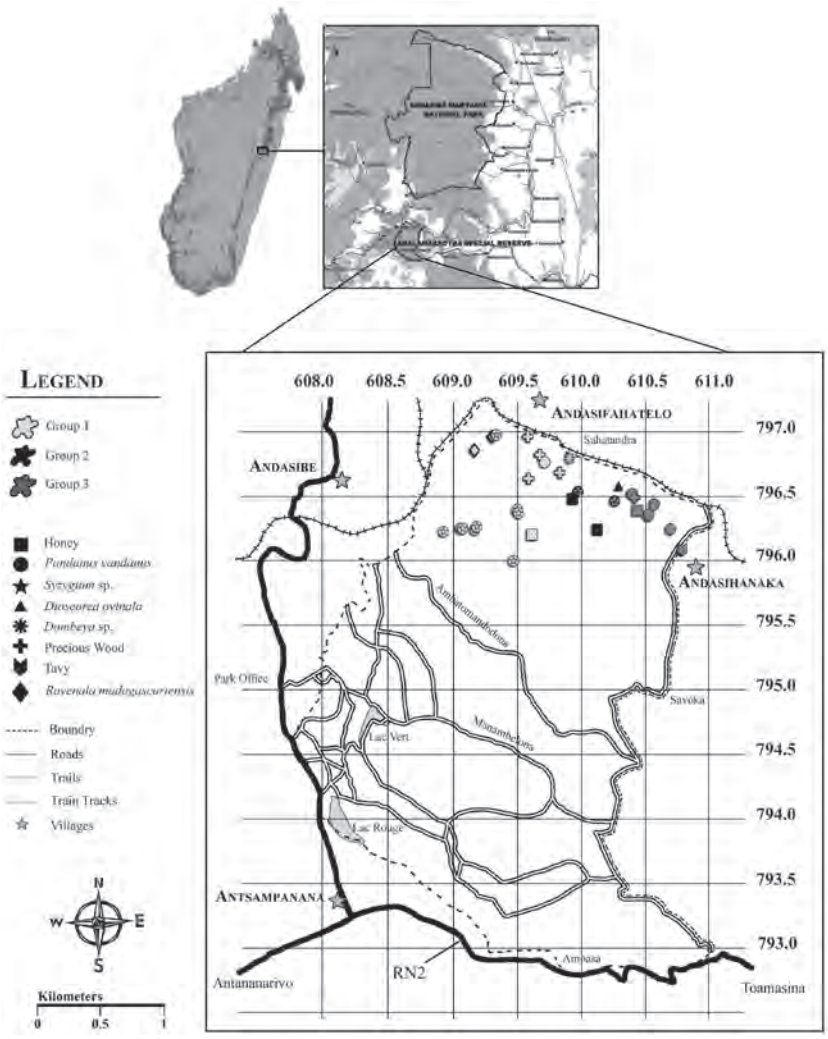

Fig. 1: Map of the study site showing the different anthropogenic pressures within the territories of three *Varecia variegata editorum* social groups in the Analamazaotra Special Reserve.

Within this area are four groups of black and white ruffed lemurs composed of the original translocated individuals and their descendants. Three groups had radio-collared individuals that facilitated monitoring efforts to study their behavioural ecology. The fourth group was not collared during the study period, and so was not depicted on the map of the region, but it is also located in the northern part of the reserve (Fig. 1).

According to Faramalala and Rajeriarison (1999), the ASR is part of the mid-altitude eastern ecofloristic area (850-1100 m). The climax vegetation is represented by wet evergreen forests with an herbaceous undergrowth of the Tambourissa and Weinmannia series. The annual average precipitation of the Andasibe region is 1700 mm with an average temperature of 18°C (MNP, 2009; ANGAP and MINENVEF, 2001).

Identification of threats

Human activities were inventoried along trails in the ASR within the territories of the black and white ruffed lemurs during the cool and warm seasons of 2012 and 2013. These were complemented by semi-structured interviews conducted by the first author in Malagasy in Andasibe, Andasifahatelo and Andasihanaka villages to compile a more comprehensive list of forest uses. Participants were asked open-ended questions on how they use the forest. A combined total of twenty-four representative households were interviewed with ten households in Andasibe, eight in Andasifahatelo, and six in Andasihanaka. Married couples representing the heads of their household were interviewed simultaneously including the Tangalamena, the traditional village authority. Half of the couples were aged 70 years and above and the other half were approximately 30 years old. All had dependents living at home.

Results

Multiple anthropogenic pressures (Figs. 2-6) were identified within the ASR, mostly concentrated near the northern limit of the reserve where the four groups of *V. variegata editorum* live (Fig. 1). It was observed that local people from the towns of Andasibe, Andasifahatelo, and Andasihanaka were

Fig. 2: Slash and burn cultivation on the north eastern boundary of the Analamazaotra Special Reserve, March 2013 (picture by V. Rasoamanarivo).

the most active in forest exploitation. The tavy encroaching on the northeastern boundary of the reserve to expand agricultural lands raised the most concern. Other activities associated with acquiring food were the collection of *Dioscorea ovinala* tubers during the lean season from January until April and again between June and August as well as the consumption of *Ravenala madagascariensis* heartwood.

Fig. 3: Collecting the bark of *Syzygium* sp., known locally as ropandolotra, for alcohol production, February 2013. The trees often die if the trunk is girdled (picture by V. Rasoamanarivo).

Fig. 4: Collecting the leaves of *Pandanus vandanus*, known locally as vakona, for home construction, April 2013 (picture by V. Rasoamanarivo).

Fig. 5: House built with leaves of *Pandanus vandanus*, June 2013 (picture by V. Rasoamanarivo).

Fig. 6: A male sub adult *Varecia variegata editorum* was found dead, probably due to a slingshot wound, in May 2013 (picture by V. Rasoamanarivo).

Multiple plant species were harvested from within the reserve to obtain construction materials with the following species being preferentially felled: *Pandanus vandanus, Ravenala madagascariensis*, and *Syzygium* sp. Additionally, the bark of the latter is used to make a local alcoholic beverage and is frequently harvested such that the trees are girdled and die. People were also seeking additional income generating opportunities as evident from the use of *Dombeya* sp. and *Macaranga madagascariensis* to make rope and the extraction of precious woods to sell. Honey is collected from the ASR during the cool season from May to September, which is directly used for food or sold. Additional uses for forest products were identified in interviews, such as medicinal plant collection, but no direct effects of this were recorded. See Table 1 for a summary of threats identified in the ASR.

Discussion

Madagascar's rural residents rely on forest products to satisfy their daily needs and as a source of income. However, the exploitation of these natural resources in the ASR is threatening local biodiversity. Although the park regulations prevent the harvesting of forest products, it has been observed that once regulations such as these are compromised by a few individuals, others will often follow (Gibson *et al*., 2005). Thus, it is critical to understand the objective of the destructive human activities occurring in the ASR to guide interven-

tion practices and community outreach efforts to curb these behaviors before their more widespread adoption.

Tab. 1: Anthropogenic pressures within the Analamazaotra Special Reserve observed through field work or identified via interviews.

Human Activities	Uses
Recorded by direct observations	
Forest clearing encroaching on reserve boundary	Slash and burn cultivation/*tavy*
Honey collection and related accidental forest fires	Food and supplemental income
Collection of *Dioscorea ovinala* (ovialafotsy) tubers	Food and supplemental income
Felling *Ravenala madagascariensis* (ravinala)	Food (heartwood), home construction (trunks for walls and floors)
Bark collection from *Syzygium* sp. (ropandolotra)	Home construction (walls) and alcohol production
Cutting leaves of *Pandanus vandanus* (vakona)	Home construction (walls and roofs)
Illegal logging of precious woods:	Supplemental income
Dalbergia baroni (voamboana)	
Ocotea sp. (varongy)	
Protorhus ditimena (ditimena)	
Bark collection from *Dombeya* sp. (hafotra)	Supplemental income: rope-making
Recorded by surveys	
Bark collection by felling trees of *Macaranga madagascariensis* (mokaranana)	Rope-making
Medicinal plant collection	Traditional medicine
Xylopia sp. (hazoambo)	
Pauridiantha paucinervis (tsiandrova)	
Ficus pyrifolia (nonokaberavina, nonokamadinidravina)	
Brachylaena sp. (merana)	

Collection of food items was observed in the ASR, but not at the same frequency as the collection of construction materials (Fig. 1). Although, this may suggest that the need for additional food is less pressing, the alarming proximity of *tavy* to the ASR suggests otherwise. *Tavy*, which is part of the agriculture cycle, is widespread in many parts of Madagascar and is one of the main causes of habitat loss and the disappearance of biodiversity (Styger *et al*., 2007). In contrast to selective cutting and extraction of forest products that leave most trees in place, *tavy* results in a barren landscape incapable of supporting arboreal lemur species such as *V. variegata editorum* (Fig. 2). Madagascar National Park offices in Toamasina and Andasibe affirm that the practice of *tavy* must end in order to protect the natural resources of Madagascar.

In interviews, farmers in Andasibe, Toamasina and Brickaville reported that they were aware that *tavy* compromises environmental health, but continue to employ this practice for lack of other opportunities (Hume, 2006). In Andasibe, farmers stated that there was no alternative local work yielding enough money to support their households, no access to education on improved agriculture practices, and they reported that rice will only grow on 'hot' soil (Hume, 2006). Soil is heated by applying fertilizer or burning. As the first option is too expensive, most people resort to *tavy*. *Tavy* is also an important aspect of the traditional culture of eastern Madagascar intertwined with complex spiritual meanings, which must be understood before introducing change (Hume, 2006).

In addition to food production via tavy, people illegally enter the ASR to supplement their diet with forest products. The collection of *Dioscorea ovinala* tubers in the ASR can affect the natural regeneration of the forest as seedlings surrounding these plants are also uprooted. This practice, which leaves large holes that people do not generally refill, constitutes a safety hazard for visitors in this area that is economically dependent on tourism. Forest products have been identified as crucial resources providing micronutrients lacking in staple foods (Vinceti *et al.,* 2008). Vitamin A is an example of a nutrient often missing from diets in developing countries, and home gardens have been successful in alleviating this deficiency (Faber and van Jaarsveld, 2007). We suggest the creation of community gardens rich in crops that complement the nutritional profile of staple foods and may incorporate native species such as *Dioscorea ovinala*. A model community garden has been established near Montagne des Français at the village of Andavakoera. This garden produces a variety of vegetables year round for the village of 125 people as well as excess produce which is sold in Antsiranana

Fig. 7: A model community garden in Andavakaoera, a village near the city of Antsiranana, that provides supplemental food for the residents as well as income through the sale of excess produce. (Picture by E. Louis, Jr.)

We also propose the development of a local honey initiative. Honey was identified as a product that has the potential to contribute to environmentally sustainable economic growth in a market and trade development study by USAID (2004) in Madagascar. The acquisition of honey from wild swarms is generally done using smoke. In 2010, this activity resulted in an accidental fire that burned one to two ha of forest in the territory of *V. variegata editorum*. Responsible bee husbandry could benefit not only participating residents but also promote a greater appreciation of Madagascar's nearly 240 bee species, approximately 90 % of which are endemic (Eardley *et al*., 2009).

In addition to the collection of food products, bark is harvested from certain species of trees. The fruits and leaves of *Syzygium* sp. are consumed by *V. variegata editorum*, but people collect the bark to produce a local alcohol (Fig. 3). During our field observations, most Syzygium sp. trees in the territory of the study animals were subjected to this activity and subsequently exhibited abnormal growth or died. Not only is this a threat to the black and white ruffed lemurs, but may be an imminent danger to the local survival of this tree.

Bark is also collected from two other tree species to make rope, but the harvest was on a smaller scale. It may be possible to sustainably harvest bark from the multiple target tree species for rope production, but collectors would need to be educated to do so without affecting the vascular cambium combined with efforts to identify suitable trees outside the

reserve. Although sustainable bark harvesting may inadvertently support alcohol production, it would alleviate pressure on the most severely impacted tree species in the ASR.

Construction materials are also illegally sourced from the ASR. The vast majority of the houses in Andasihanaka near the northeastern boundary of the reserve are built with *Pandanus vandanus* leaves (Fig. 4,5). A reforestation effort similar to that initiated by Manjaribe *et al.* (2013) may pose a solution to community construction and nutritional needs. This project used a diverse selection of tree species with portions of the reforested lands being enriched with trees appropriate for timber and food production. This project has evolved to include hundreds of people from the villages surrounding the reforestation work and participation was incorporated into the local school curriculum (Kimbrough, 2014). We recommend employing this same community-driven methodology to identify the most utilized tree species and develop a programme that includes their propagation and incorporation in restoration efforts.

Building bridges between Madagascar's educators is also recommended. Many research initiatives and public awareness campaigns are active in Andasibe. However, tavy is still spreading as well as illegal harvesting of forest products. It is time to approach this from a different perspective that may be best outlined by Malagasy educators. Non-governmental organizations and foreign aid bodies could facilitate teacher networking and training workshops such as described by McGuire *et al.* (2013) who brought together educators from rural communes and University of Antananarivo professors and students resulting in the transfer of conservation concepts and empowerment of primary and secondary school teachers.

A difficult, yet necessary, component of forest conservation is enforcement. Gibson *et al.* (2005) found that rule enforcement by local users was significantly correlated to better forest condition and employed the principles of evolutionary game theory to glimpse the inner workings of this phenomenon. It was found that the details of the rules themselves were less important than consistent enforcement. The abundance of anthropogenic pressures near the northern limit of the ASR could be explained by the remoteness of this area relative to the park management offices (Golden *et al.,* 2014). Thus, forest health here is being eroded as forest users extract materials with little consequence.

We encourage the continued grid monitoring of the ASR, while exhorting the need to consistently walk the entire reserve and perform comprehensive threat assessments. Violations of forest use should not be tolerated and extensive efforts should be mounted to promote community buy-in. The current monitoring efforts are a step in the right direction as they are collaborations between MNP agents and Local Committees for Protection. The goal of this partnership is to integrate local people in the conservation of protected areas through co-monitoring and co-management activities.

The development of intervention strategies that target the specific threats identified in this study has the potential to ease pressure on the ASR's population of black and white ruffed lemurs as well as other wildlife relying on shared resources. As stressed by Hume (2006), certain activities are highly ritualized and can be linked to cultural identity, which must be considered in the planning phases of conservation and rural development initiatives. By adopting multi-pronged approaches, the resilience of the people and the forest will be improved.

Acknowledgements

We thank the Ministère de l'Environnement et des Forêts and the Madagascar National Parks for allowing us to conduct this study in the Analamazaotra Special Reserve. Special thanks are particularly addressed to the staff of the Madagascar Biodiversity Partnership. We also thank the staff of the Andasibe-Mantadia National Park: the technical and administrative team and all field assistants (local and MNP guides) for their kind collaboration in carrying out the work on the ground. In addition, we greatly appreciate the generosity of Omaha's Henry Doorly Zoo and Aquarium and The Ahmanson Foundation for their financial support that made this project possible. Thanks to those who reviewed this article for their input and improvements.

References

ANGAP and MINENVEF. 2001. Plan de gestion du Réseau National des Aires Protégées de Madagascar 2001-2006. Publication Ministère de l'Environnement, des Eaux et Forêts, Antananarivo, Madagascar.

Balko, E.A. 1998. A behaviorally plastic response to forest composition and logging disturbance by *Varecia variegata variegata* in Ranomafana National Park Madagascar. Ph.D. thesis, College of Environmental Science and Forestry Syracuse, State University of New York, USA.

Day, S.; Ramarokoto, R.; Sitzmann, B.D.; Randriamboahanginjatovo, R.; Ramanankirija, H.; Ravololonarivo, G.; Louis, E.E. Jr. 2009. Re-introduction of Diademed sifaka (*Propithecus diadema*) and black and white ruffed lemurs (*Varecia variegata editorum*) in Analamazaotra Special Reserve, eastern Madagascar. Lemur News 14: 32-37.

Dolch, R. 2008. Andasibe (Périnet). Pp. 547-559. In: S.M. Goodman (ed). Paysages naturels et biodiversité de Madagascar. The University of Chicago Press, Chicago, USA.

Eardley, C.D.; Gikungu, M.; Schwarz, M.P. 2009. Bee conservation in Sub-Saharan Africa and Madagascar: diversity, status and threats. Apidologie 40: 355-366.

Faber M.; van Jaarsveld, P.J. 2007. The production of provitamin A-rich vegetables in home-gardens as a means of addressing vitamin A deficiency in rural African communities. Journal of the Science of Food and Agriculture 87: 366-377.

Faramalala, M.H.; Rajeriarison, C. 1999. Nomenclature des formations végétales de Madagascar. ANGAP, Antananarivo, Madagascar.

Gibson, C.C.; Williams, J.T.; Ostrom, E. 2005. Local enforcement and better forests. World Development 33: 273-284.

Golden, C.D.; Rabehatonina, J.G.C.; Rakotosoa, A; Moore, M. 2014. Socio-ecological analysis of natural resource use in Betampona Strict Natural Reserve. Madagascar Conservation & Development 9: 83-89.

Hume, D.W. 2006. Swidden agriculture and conservation in eastern Madagascar: stakeholder perspectives and cultural belief systems. Conservation and Society 4: 287-303.

IUCN. 1998. Guidelines for re-introductions. Prepared by the IUCN/SSC Re-introduction Specialist Group. <http://www.iucnsscrsg.org/>.

IUCN. 2013. Guidelines for reintroductions and other conservation translocations. <https://portals.iucn.org/library/sites/library/files/documents/2013-009.pdf>. Downloaded on 5 January 2015.

Kimbrough, L. 2014. Next big idea in forest conservation? Rewards for reforestation. <http://news.mongabay.com/2014/0710-forestinnovation-kimbrough-louis.html>. Downloaded on 23 December 2014.

Manjaribe, C.; Frasier, C.; Bakolimalala R.; Louis, E.E. Jr. 2013. Ecological restoration and reforestation of fragmented forests in Kianjavato, Madagascar. International Journal of Ecology. doi 10.1155/2013/726275.

McGuire, S.; Bailey, C.; Frasier, C. 2013. Conservation Genetics in Action: Protecting Diversity through Innovative Education Programs in Madagascar, one of the world's environment hotspots. Journal of Heredity 104: 591-593.

McGuire, S.M.; Sitzmann, B.D.; Herrington, K.; Day, S.R.; Ramarokoto, R.E.A.F.; Louis, E.E., Jr. 2009. Distribution of a conservation-based activity book at two primary schools near Analamazaotra Special Reserve, Madagascar. Lemur News 14: 38-41.

Mittermeier, R.A.; Ganzhorn, J.U.; Konstant, W.R.; Glander, K.; Tattersall, I.; Groves, C.P.; Rylands, A.B.; Hapke, A.; Ratsimbazafy, J.; Mayor, M.I.; Louis, E.E. Jr.; Rumpler, Y.; Schwitzer, C.; Rasoloarison, R.M. 2008. Lemur diversity in Madagascar. International Journal of Primatology 29: 1607-1656.

Mittermeier, R.A.; Robles G.P.; Hoffman, M.; Brooks, T.; Pilgrim, J.; Mittermeier, C.G.; Lamoreux, J.; da Fonseca, G.A.B. 2004. Hotspots revisited: earth's biologically richest and most endangered terrestrial ecosystems. CEMEX, Agrupacion Sierra Madre, S.C. Mexico.
MNP. 2009. Le Parc National de Mantadia et la Réserve Spéciale d'Analamazaotra. <www.parcs-madagascar.com>. Downloaded on 28 May 2009.
Moberg, G.P. 1985. Influence of stress on reproduction: measure of well-being. Pp. 245-267. In: G.P. Moberg (ed.). Animal Stress. Springer, New York, USA.
Rajoelison, L.G. 2005. Les forêts littorales de la région orientale de Madagascar vestiges à conserver et à valoriser. Ph.D. thesis, Ecole Supérieur Polytechnique, Université Antananarivo, Madagascar.
Randriamanantenasoa, H. 1996. Parc National d'Andasibe-Mantadia- Plan de gestion, Andasibe. Pp. 92, 93.
Randriamanantenasoa, A. 2005. Production d'un outil pratique de terrain pour la gestion d'une aire protégée et le suivi des menaces: application à la Réserve spéciale d'Analamazaotra. Mémoire de fin d'étude en vue de l'obtention du diplôme d'ingénieur de géomètre topographe, Ecole Supérieur Polytechnique, Université d'Antananarivo, Madagascar.
Schwitzer, C.; Mittermeier, R.A.; Davies, N.; Johnson, S.; Ratsimbazafy, J.; Razafindramanana, J.; Louis, Jr., E.E.; Rajaobelina, S. 2013. Lemurs of Madagascar: a strategy for their conservation 2013–2016. Bristol, UK. IUCN SSC Primate Specialist Group, Bristol Conservation, Science Foundation, Conservation International.
Styger, E.; Rakotondramasy, H. M.; Pfeffer, M. J.; Fernandes, E. C. M.; Bates, D.M. 2007. Influence of slash-and-burn farming practices on fallow succession and land degradation in the rainforest region of Madagascar. Agriculture, Ecosystems and Environment 119: 257-269.
Tattersall, I. and Sussman, R.W. 1975. Note on topography, climate, and vegetation of Madagascar. Pp. 13-21. In: I. Tattersall; R.W. Sussman (eds.). Lemur Biology. Plenum Press, New York, USA.
USAID. 2004. Market and Trade Development in Madagascar SOW. <http://egateg.usaidallnet.gov/resources/1194>. Downloaded on 18 September 2014.
Vinceti, B., Ickowitz, A., Powell, B., Kehlenbeck, K., Termote, C., Cogill, B., Hunter, D. 2008. The nutritional role of forest plant foods for rural communities. Pp. 63-96. In: C.J.P. Colfer (ed.). Human health and forests: a global overview of issues, practice and policy. Earthscan, London, UK.

Détermination de quelques aspects de l'écologie de *Daubentonia madagascariensis* (Gmelin, 1788) dans deux forêts malgaches: la Réserve Spéciale de Manombo, Sud-est, et la Forêt de Beanka, Centre-ouest de Madagascar

Rotsinomena T. Andriamisedra[1]*, Megan Aylward[2], Steig E. Johnson[2], Edward E. Louis Jr.[3,4], Brigitte M. Raharivololona[1]*

[1]Département de Paléontologie et d'Anthropologie Biologique, Faculté des Sciences, BP 906, Université d'Antananarivo, Madagascar

[2]Department of Anthropology and Archaeology, University of Calgary, 2500, University Dr NW, Calgary, AB T2N 1N4, Canada

[3]Bill and Bernice Grewcock Center for Conservation and Research, Department of Conservation Genetics, Omaha's Henry Doorly Zoo and Aquarium, 3701 South 10th Street, Omaha, NE, 68107, USA

[4]Madagascar Biodiversity Partnership, Lot VO 12Bis A, Manakambahiny, Antananarivo, 102, Madagascar

*Corresponding authors: **andriamisedrar@gmail.com, raharivololonabrigitte@yahoo.fr**

Mots clés: *Daubentonia madagascariensis*, traces de nourrissage, sélection d'habitat, stratégie d'alimentation, Forêts de Manombo et de Beanka, Madagascar

Résumé

Daubentonia madagascariensis est le plus grand des lémuriens nocturnes. Elle figure parmi les espèces les moins étudiées dans leur milieu naturel. La présente étude contribue davantage à la connaissance de cette espèce, en examinant la sélection de l'habitat par l'animal durant la recherche de nourriture. Cette recherche, principalement basée sur des traces de restes de nourriture, a été menée dans deux forêts: la Réserve Spéciale de Manombo, au Sud-est de Madagascar, durant les mois de Juillet et Août 2014; et la forêt de Beanka, Centre-ouest malgache, pendant les mois de Septembre et Octobre 2014. La présence de traces de nourrissage de l'animal a été considérée comme un indicateur d'utilisation de l'habitat par ce dernier. Ainsi, une description d'habitat a été réalisée aux endroits où ces indices d'activité alimentaire ont été observés et dans des zones où aucune trace n'a été enregistrée. Pour y parvenir, la recherche des traces a été effectuée à l'intérieur de 50 plots botaniques de 20 x 20 m instaurés au hasard le long des transects dans chaque site. Des observations directes sur le terrain, des enquêtes auprès des guides locaux et des agents du site ont été effectuées pour connaitre les pressions qui s'exercent sur l'animal et son écosystème. Les résultats ont montré que la structure des deux forêts diffère largement. Dans chaque forêt, *D. madagascariensis* ne fait pas une sélection d'habitat durant son alimentation. Le cas inverse a été observé en comparant les deux forêts. Dans la RS de Manombo, les zones de nourrissage de l'animal a une densité d'arbres et une diversité floristique plus importantes que celles dans la forêt de Beanka. Mais, dans les deux forêts, ces endroits ont été toujours caractérisés par une canopée ouverte d'une hauteur de 9 et de 10.5 m.

Dans la RS de Manombo, l'Aye-aye à tendance à dénicher les larves dans des troncs d'arbre vivants, à une hauteur beaucoup plus basse (≈ 2 m) que dans la forêt de Beanka où il le fait principalement sur du bois mort à 6 m de hauteur. Cependant, la disponibilité des larves dans ces supports n'ont pas été évaluée. De multiples facteurs écologiques pourraient expliquer les différences quant à l'utilisation de l'habitat par l'animal.

Abstract

Daubentonia madagascariensis is the largest nocturnal lemur. Little is known about foraging behaviour across the range of this species. This study contributes information on the aye-aye by assessing feeding selection based on habitat. This study was carried out in two forests near the extent of the species' range: Manombo Special Reserve in Southeastern Madagascar, during July and August 2014; and Beanka forest, in Central Western Madagascar, during September and October 2014. The presence of feeding signs was used as an indicator of habitat selected for foraging by *D. madagascariensis*. Feeding traces and habitat were surveyed using 50 botanical plots in each forest. Direct field observations, and discussions with local guides and site directors were used to identify threats to the aye-aye in each of the forest ecosystems.

A significant difference in the habitat of the two forests was observed. In each forest, *D. madagascariensis* does not show a habitat preference during its feeding activity. However, the opposite case occurs by comparing the two forests. In the foraging areas of the animal in Manombo SR, the tree density and floristic diversity are greater than in those of Beanka forest; but the canopy is always open with 9 m and 10.5 m height in those parts for both forests.

In Manombo SR foraging of insect larvae occurs at a lower height from the ground than in Beanka. These differences in foraging may be a reflection of the different habitat at the two sites. Additionally more traces were observed in live wood than dead wood in Manombo SR. However, availability of larvae in these substrates was not measured.

Introduction

Madagascar est une île isolée qui a été sujette à de nombreuses vagues d'évolution engendrant un taux d'endémisme élevé en termes de biodiversité (Goodman et Benstead, 2003; Mittermeier *et al.*, 2010; Krause, 2010; Samonds *et al.*, 2012; Goodman et Gautier, 2013). Elle est unique au monde par sa faune et sa flore exceptionnelles. Dans le domaine faunistique, particulièrement les Mammifères, les lémuriens constituent un des atouts majeurs pour l'île du point de vue endémicité (Mittermeier *et al.*, 2010, 2014). Malgré cette richesse naturelle, l'environnement de Madagascar subit continuellement une véritable spirale de dégradation et de nombreuses menaces (ANGAP, 2003; Andriamahazo *et al.*, 2004; Carriere *et al.*, 2005; Schwitzer *et al.*, 2013; Mittermeier *et al.*, 2010, 2014). En 2012, environ 90 % des lémuriens étaient délarés menacés d'extinction, soit 93 espèces et sous-espèces parmi les 103 recensées à l'époque (Schwitzer *et al.*, 2013); et la taille de leurs populations ne cesse de se réduire. Il est impossible de mener des actions de conservation efficace sur un taxon quelconque sans connaitre son mode de vie. Nombreuses sont les études ont déjà été effectuées sur les différents taxons de lémuriens; mais, comparée avec d'autre espèce, l'Aye-aye (*Daubentonia madagascariensis*) figure parmi les moins étudiées à l'état sauvage. Ce fait nous a incité à réaliser cette recherche en essayant de déterminer quelques aspects de l'écologie de *Daubentonia madagascariensis* à partir de ses traces de nourrissage, à savoir: la sélection d'habitat, sa stratégie d'alimentation et les pressions qui s'exercent sur l'animal et son écosystème. Ainsi, l'objectif principal de la présente étude est d'apporter des compléments d'information sur cette espèce de lémurien afin de contribuer à sa pérennisation dans le milieu naturel.

Méthodes

Sites d'étude

Cette recherche a été menée dans deux sites: la Réserve Spéciale de Manombo et la forêt de Beanka, respectivement durant les mois de Juillet et Août 2014 et les mois de Septembre et Octobre 2014. La RS de Manombo se situe dans la partie Sud-est de Madagascar, Région Atsimo Atsinanana (S 23° 02'; E 47°44'). Elle occupe une superficie de 4000 ha (Ralainasolo *et al.*, 2008) (Fig. 1a). La forêt de Beanka se trouve au Centre-ouest de Madagascar, à l'Est de la ville de Maintirano (Fig. 1b). Elle s'étend entre 44° 27' 18,2" et 44° 35' 54,0" de longitude Est et 17° 44' 18.9" et 18° 06' 14.4" de latitude Sud. La forêt recouvre une superficie de 17000 ha et s'étend environ sur 60 km le long de l'axe Nord-Sud (Raherilalao et Goodman, 2013).

Typologie d'habitat

Daubentonia madagascariensis laisse des traces de son activité alimentaire sur certains supports, comme des arbres vivants ou des bois morts et des fruits de *Canarium* spp. Ces traces ne sont que celles de ses incisives après l'extraction des larves et des graines du fruit de *Canarium* spp.

La présente étude s'est principalement basée sur ces traces de nourrissage. La présence de traces a été considérée comme un des indicateurs de l'utilisation de l'habitat par l'animal durant sa recherche de nourriture. Pour savoir si l'animal fait une sélection d'habitat, une description de ce dernier a été effectuée aux endroits où ces indices d'activité alimentaire ont été observés et dans des zones où aucune trace n'a été enregistrée. L'étude de la typologie de l'habitat consiste à décrire la structure verticale et horizontale de la végétation. Pour cela, les caractères botaniques suivants ont été estimés: l'ouverture et la hauteur de la canopée, la densité des arbres et l'indice de diversité floristique ou indice de Shannon-Weaver.

Pour faciliter le travail sur le terrain, des pistes déjà existantes dans chaque site d'étude ont été utilisées. Dans chaque forêt, des pistes mesurant au total 10 km ont été empruntées; et 50 plots botaniques de 20 x 20 m ont été instaurés à chaque intervalle de 200 m le long des pistes. Due à la courte durée de notre projet de recherche, ces plots n'ont pas pu être éparpillés dans toute la forêt. Ils ont été implantés dans une surface de 1200 ha dans la RS de Manombo et 2100 ha dans la forêt de Beanka. Des ratissages sur toute éventuelle présence de traces de l'animal ont été effectués dans les 50 plots. Il est à noter qu'avant la réalisation de cette recherche, nous vious effectué une étude préliminaire sur la reconnaissance

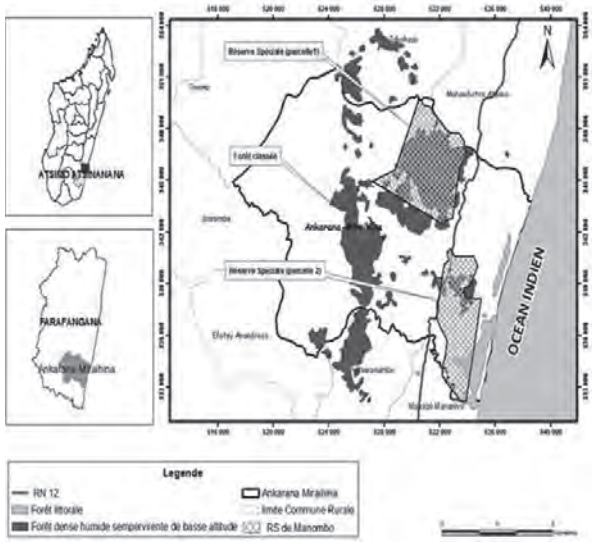

Fig. 1a: Carte de la localisation de la Réserve Spéciale de Manombo (Source: FTM BD 500, modifiée par Andriamisedra, 2015).

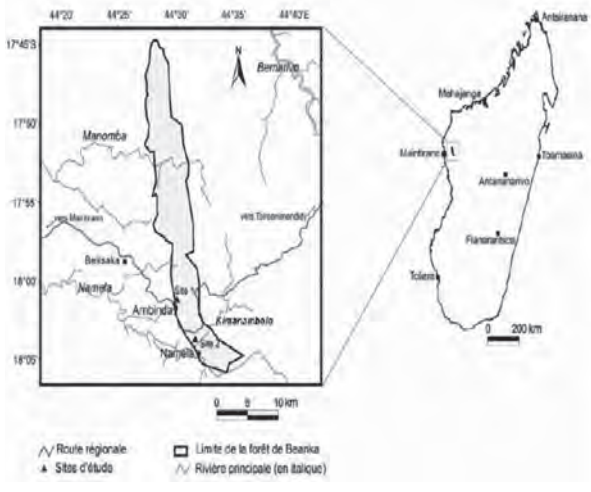

Fig. 1b: Carte de la localisation de la forêt de Beanka (Source: FTM, modifiée par Andriamisedra, 2015).

des traces d'activité alimentaire de l'Aye-aye dans la Forêt Classée de Kianjavato, Sud-est de Madagascar, pour éviter toute erreur dans l'identification de ces dernières.

Ouverture et hauteur de la canopée
L'ouverture de la canopée a été estimée à tous les 5 m du contour de chaque plot botanique, à l'aide d'un tuyau tenu verticalement par la main. Le pourcentage de recouvrement de la végétation est la proportion de la partie ombragée dans le tuyau. Pour estimer le taux de recouvrement, l'échelle de Godron (1983) a été utilisée:

- supérieur à 90 % pour la canopée fermée
- comprise entre 75 et 90 % pour canopée semi-ouverte
- entre 50 et 75 % pour la canopée peu ouverte
- entre 25 et 50 % pour la canopée ouverte
- entre 10 et 25 % pour la canopée très ouverte

La hauteur de la canopée est la hauteur de la majorité des arbres. Elle a été aussi enregistrée à chaque 5 m du contour du plot.

Densité des arbres
La densité des arbres dans un plot est le rapport du nombre total de pieds d'arbre (à DBH ≥ 5 cm) y poussant et la surface du plot.

Indice de diversité floristique
Toutes plantes poussant à l'intérieur de chaque plot botanique ont été aussi inventoriées. L'indice de diversité floristique ou indice de Shannon-Weaver est un indice permettant de mesurer la diversité des espèces végétales. Il correspond à la quantité d'information associée à la collection d'espèces végétales d'une parcelle du plot botanique (Whittaker, 1972; Pielou, 1975; Dajoz, 1996; Frontier et Pichod-vial, 1998). Cet indice est calculé de la façon suivante:

$$H' = -\Sigma \left(\frac{Ni}{N}\right).\log_2\left(\frac{Ni}{N}\right) = -\Sigma pi \log_2 pi$$

Avec
H': indice de diversité floristique; Ni: abondance de l'i-ème espèce; N: abondance numérique totale; pi: fréquence spécifique.

La diversité floristique est forte si la valeur de H' s'approche de 6,8. (Legendre et Legendre, 1984; Frontier et Pichod-vial, 1998).

Stratégie d'alimentation de D. madagascariensis
Dans cette étude, les paramètres étudiés étaient l'état des arbres où les traces d'alimentation avaient été observées (arbre vivant ou bois mort) et la hauteur de ces traces par rapport au sol.

Etude des menaces
Des études sur la pression qui s'exerce sur l'animal et son écosystème ont aussi été effectuées. Pour y parvenir, des observations directes sur le terrain ainsi que des enquêtes auprès des villageois, des guides locaux et des agents du site ont été menées.

Analyses statistiques
Les données ont été traitées et analysées avec le Tableur Excel 2010 et le logiciel SPSS 20.0. Le test de Mann-Whitney a été utilisé pour comparer les caractères botaniques des deux forêts, des lieux de nourrissage de *D. madagascariensis* avec ceux des autres endroits dans chaque forêt, ainsi que les lieux de nourrissage et la hauteur des traces dans les deux sites. Le test de Mann-Whitney est un test de comparaison de la médiane de deux échantillons indépendants. La médiane est la valeur qui sépare la série des données en deux groupes de même effectif.

Résultats

Comparaison de la structure des deux forêts
La comparaison des caractères botaniques étudiés a révélé que la structure de la forêt de la RS de Manombo diffère de celle de Beanka (ouverture de la canopée: U = 51.923; p = 0.000; hauteur de la canopée: U = 9.458; p = 0.004; densité des arbres: U = 57.760; p = 0.000 et indice de diversité floristique: U = 92.160; p = 0.000).
Dans la RS de Manombo, la forêt est caractérisée par une canopée ouverte (valeur de la médiane = 50 %) avec un taux de recouvrement variant de 20 à 75 %; tandis que dans la forêt de Beanka, la canopée est très ouverte (valeur de la médiane = 20 %). Le taux de recouvrement de ce dernier est compris entre 0 à 50 %. La hauteur de la canopée dans la RS de Manombo est beaucoup plus basse que celle de la forêt de Beanka (valeurs respectives des médianes: 8 m et 10 m). La densité des arbres est nettement plus élevée dans la RS de Manombo (6200 individus/ha) que dans la forêt de Beanka (2412.5 individus/ha). La RS de Manombo présente une flore beaucoup plus diversifiée par rapport à la forêt de Beanka (valeurs respectives des médianes: 4.70 et 2.82) (Tab. 1).

Utilisation de l'habitat par Daubentonia madagascariensis *dans chaque forêt*
Dans la RS de Manombo, tous les caractères botaniques étudiés ne présentent aucune différence significative entre les lieux de nourrissage de l'Aye-aye et les autres endroits en dehors (ouverture de la canopée: U = 0.739; p = 0.616; hauteur de la canopée: U = 0.721; p = 0.620; densité des arbres: U = 1.623; p = 0.358 et indice de diversité floristique: U = 0.020; p = 0.832). Dans ces deux habitats, la canopée est ouverte (valeur de la médiane = 50 %) et l'indice de diversité floristique est similaire (valeur de la médiane = 4.70). Une légère différence, statistiquement non significative, a été constatée au niveau de la hauteur de la canopée et la densité des arbres dans ces deux endroits (respectivement, pour la hauteur de la canopée: valeurs des médianes = 9 et 8 m; pour la densité des arbres: valeurs des médianes = 5525 individus/ha et 6500 individus/ha) (Tab. 2).
Le même cas a été aussi observé dans la forêt de Beanka; tous les caractères botaniques ne diffèrent pas aussi entre les lieux de nourrissage de l'Aye-aye et les autres endroits en dehors. Dans ces deux habitats, les canopées sont toujours très ouvertes (U = 1.937; p = 0.332; valeurs respectives des médianes = 22.5 et 15 %). La hauteur de la canopée ne varie pas entre les deux endroits (U = 0.721; p = 0.411; médianes = 10.5 et 10 m). Les densités des arbres sont de 2050 individus / ha dans les lieux de nourrissage de l'animal et de 2425 individus / ha en dehors (U = 0.504; p = 0.745). L'indice de diversité floristique est légèrement semblable dans les deux habitats (U = 0.690; p = 0.656; valeurs respectives des médianes = 2.87 et 3) (Tab. 3).

Comparaison des lieux de nourrissage de l'animal dans les deux sites d'étude
En comparant les lieux de nourrissage de *D. madagascariensis* dans les deux sites, des différences statistiquement significatives ont été observées au niveau de la densité des arbres (U = 8.100; p = 0.006) et l'indice de diversité floristique (U = 14.400; p = 0.000). Dans la RS de Manombo, la

Tab. 1: Tableau récapitulatif des valeurs des caractères botaniques des forêts de la RS de Manombo et de Beanka. Man.: RS de Manombo; Bea.: forêt de Beanka; N: nombre de plot botanique; *: le caractère botanique diffère significativement entre les deux sites d'étude à une valeur de $p<0.05$.

Valeurs	Ouverture de la canopée* (%)		Hauteur de la canopée* (m)		Densité des arbres* (individu/ha)		Indice de diversité floristique*	
	Man. N=50	Bea. N=50	Man. N=50	Bea. N=50	Man. N=50	Bea. N=50	Man. N=50	Bea. N=50
Minimale	20	0	7	0	775	0	3.51	0
Médiane	50	20	8	10	6200	2412.50	4.70	2.82
Maximale	75	50	13	15	11125	6050	6.16	4.02

Tab. 2: Tableau de comparaison des valeurs des caractères botaniques des lieux de nourrissage et des autres lieux en dehors du nourrissage de l'Aye-aye dans la RS de Manombo. LN: lieu de nourrissage de l'animal; Autres: endroits où aucune trace d'alimentation de l'animal n'a été observée; N: nombre de plot botanique.

Valeurs	Ouverture de la canopée (%)		Hauteur de la canopée (m)		Densité des arbres (individu/ha)		Indice de diversité floristique	
	LN N=10	Autres =40	LN N=10	Autres =40	LN N=10	Autres =40	LN N=10	Autres =40
Minimale	25	20	7	7	1425	775	3.93	3.51
Médiane	50	50	9	8	5525	6500	4.70	4.70
Maximale	75	70	12	13	11125	9950	6.16	6.12

Tab. 3: Tableau de comparaison des valeurs des caractères botaniques des lieux de nourrissage et les lieux en dehors du nourrissage de l'Aye-aye dans la forêt de Beanka. LN: lieu de nourrissage de l'animal; Autres: endroits où aucune trace d'alimentation de l'animal n'a été observée; N: nombre de plot botanique.

Valeurs	Ouverture de la canopée (%)		Hauteur de la canopée(m)		Densité des arbres (individu/ha)		Indice de diversité floristique	
	LN N=8	AutresN=42	LN N=8	AutresN=42	LN N=8	AutresN=42	LN N=8	AutresN=42
Minimale	15	0	8	0	1300	0	2.58	0
Médiane	22.5	15	10.50	10	2050	2425	2.87	3.00
Maximale	50	35	13	15	3975	6050	3.66	4.02

Tab. 4: Tableau de comparaison des valeurs des caractères botaniques des lieux de nourrissage *de Daubentonia madagascariensis* dans les deux sites d'étude. Man.: RS de Manombo; Bea.: forêt de Beanka; N: nombre de plot botanique; *: le caractère botanique diffère significativement entre les deux sites d'étude à une valeur de $p<0.05$.

Valeurs	Ouverture de la canopée (%)		Hauteur de la canopée (m)		Densité des arbres* (individu/ha)		Indice de diversité floristique*	
	Man. N=10	Bea. N=8	Man. N=10	Bea. N=8	Man. N=10	Bea. N=8	Man. N=10	Bea. N=8
Minimale	25	15	7	8	1425	1300	3.93	2.58
Médiane	50	22.5	9	10.5	5525	2050	4.70	2.87
Maximale	75	50	12	13	11125	3975	6.16	3.66

zone de nourrissage de cette espèce de lémurien est caractérisée par une densité des arbres beaucoup plus élevée (valeur de la médiane: 5525 individus/ha) que celle dans la forêt de Beanka (valeur de la médiane: 2050 individus/ha). Cette zone présente une flore beaucoup plus diversifiée dans la RS de Manombo que dans la forêt de Beanka (valeurs respectives des médianes: 4.70 et 2.87) (Tab. 4).

L'ouverture et la hauteur de la canopée ne présentent pas une différence significative dans les lieux de nourrissage de l'animal dans les deux forêts (ouverture de la canopée: $U = 3.600$; $p = 0.153$; hauteur de la canopée: $U = 3.600$; $p = 0.153$). Chez ces derniers, la canopée est toujours ouverte (RS de Manombo: valeur de la médiane = 50 %; forêt de Beanka, valeur de la médiane = 22.5 %). Les traces d'activité alimentaire de l'Aye-aye ont été généralement observées sous une canopée d'environ 9 m de hauteur dans la RS de Manombo et de 10.5 m dans la forêt de Beanka (Tab. 4).

Stratégie d'alimentation de l'Aye-aye

Dans la RS de Manombo, la majorité des traces d'activité alimentaire de *D. madagascariensis* a été surtout observée sur des troncs d'arbre vivants que sur du bois mort (respectivement 70 et 30 %). Le cas inverse s'est présenté dans la forêt de Beanka: 63 % des signes enregistrés ont été aperçus sur des bois morts et 37 % sur des troncs d'arbre encore vivants (Fig. 2a). Ces résultats indiquent qu'à Manombo, l'Aye-aye prospecte beaucoup plus les arbres vivants que les bois morts pour s'en procurer des larves d'insecte, et vice versa pour la forêt de Beanka.

La hauteur des traces d'alimentation de l'animal par rapport au sol est significativement différente dans les deux sites ($U = 1$; $p = 0.02$). Dans la RS de Manombo, ces traces se trouvent généralement autour de 2 m par rapport au sol; alors que dans la forêt de Beanka, elles ont été fréquemment observées à une hauteur de 6 m environ (Fig. 2b).

Pressions et menaces

Dans les deux sites d'étude, *D. madagascariensis* est considéré par la population locale comme un animal «porte malheur». De ce fait, les gens le chassent dès qu'ils le voient. Un certains nombre de pressions a également été observé sur l'écosystème de cette espèce de lémurien.

A Manombo, la population riveraine vit en dépendance de la forêt. Malgré le statut d'aire protégée de la Réserve, des actions volontaires de la population locale au détriment de la forêt existent encore, à savoir: la culture sur brulis, la coupe sélective d'arbres pour la construction de maisons, la chasse accrue des lémuriens et des insectivores comme l'espèce *Hemicentetes semispinosus* pour leur viande, et la collecte des produits secondaires comme le miel pour une source de revenu.

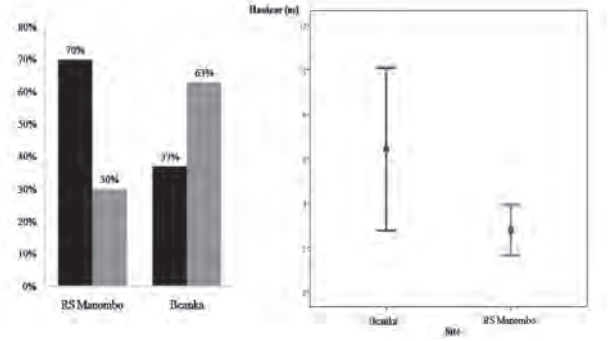

Fig. 2: (a) Proportions des supports marqués par des traces de nourrissage de *Daubentonia madagascariensis* dans la RS de Manombo et dans la forêt de Beanka; (b) hauteurs des traces par rapport au sol.

A Beanka, la forêt est principalement menacée par les feux de brousse volontaires et incontrôlés. Ce fait est dû à l'existence des voleurs de zébus ou "dahalo" qui, pendant leurs actes, doivent effacer les traces de pas des zébus volés par des feux. Outre, les éleveurs brûlent également la forêt pour améliorer le pâturage des bétails. La population de Beanka collecte aussi des produits forestiers comme le miel et certains fruits sauvages, et chasse également les lémuriens pour être simultanément des compléments de nourriture et des sources de revenu.

Discussion

Utilisation de l'habitat par Daubentonia madagascariensis *dans chaque forêt*

Dans la RS de Manombo et dans la forêt de Beanka, notre étude n'a trouvé aucune différence structurelle entre les lieux de nourrissage de *D. madagascariensis* et les autres habitats disponibles. Autrement dit: l'Aye-aye ne montre pas de préférence quant au choix de l'habitat durant sa recherche de nourriture. Cette observation est probablement liée à l'adaptation de cette espèce à une large gamme d'habitat. Beaucoup de chercheurs ont reporté que l'Aye-aye s'adaptait à aux divers types de forêt (Pollock *et al*., 1985; Ganzhorn et Rabesoa, 1986; Iwano et Iwakawa, 1988; Harcourt et Thornback, 1990; Sterling, 1993; Ancrenaz *et al*., 1994; Andriamasimanana, 1994; Rowe, 1996; Garbutt, 1999; Ganzhorn *et al*., 1999). Il peut vivre dans des forêts tropicales primaires et secondaires de l'Est de Madagascar, des forêts secondaires dégradées, des forêts littorales secondaires, des forêts sèches à feuilles caduques, des déserts épineux et même des zones cultivées. Il peut même habiter dans des mangroves et des forêts de broussailles sèches (Tattersall, 1982). Malgré ces observations, Sterling (1993) a constaté que l'Aye-aye vivant à Nosy Mangabe, au Nord-est de Madagascar, montre une préférence en matière de montrait microhabitat. Dans cette forêt et durant son alimentation, l'animal utilise davantage les endroits où poussent des grands arbres (DBH ~ 29 cm), ainsi que des lianes, et où le sous-bois est dense. Dans la présente étude, ces caractères botaniques n'ont pas été évalués à cause de la courte durée de notre période d'étude.

Etude comparative des lieux de nourrissage de l'Aye-aye dans les deux sites

Dans chaque forêt, aucune différence significative n'a été constatée entre les caractères botaniques des zones de nourrissage de l'Aye-aye et ceux des autres endroits en dehors. Par contre, en comparant les deux forêts, l'ouverture et la hauteur de la canopée dans les lieux de nourrissage de l'animal diffèrent avec celles des autres habitats disponibles. Dans la RS de Manombo ainsi que dans la forêt de Beanka, les endroits d'alimentation de l'Aye-aye sont généralement caractérisés par une canopée ouverte de hauteur à peu près identique (9 et 10.5 m). Si les Ayes-ayes sont connus pour être des généralistes quant à l'utilisation de leur habitat, ainsi ces résultats pourraient être liés soit à une certaine préférence, soit à la disponibilité de la nourriture dans ces forêts. Une étude effectuée dans la Forêt Classée de Kianjavato, Sud-est de Madagascar, témoigne d'une préférence de certains aye-ayes dans l'exploitation de leur habitat durant la recherche de nourriture. Les individus étudiés fréquentaient beaucoup plus la forêt dégradée à dominance d'arbres forestiers et la forêt dégradée à dominance de bambous car les larves d'insecte semblaient y êtres abondantes (Solofondranohatra, 2014). Fleagle (2013) a aussi reporté que l'activité alimentaire d'un animal dépend de la disponibilité de sa nourriture dans son habitat.

Inversement, une différence significative a été observée au niveau de la densité des arbres et l'indice de diversité floristique dans les zones de nourrissage de *D. madagascariensis* dans les deux forêts. Comparée à la RS de Manombo, les arbres sont beaucoup plus espacés les uns des autres dans les lieux de nourrissage de l'Aye-aye de Beanka, entrainant une densité des arbres plus faible. Certaines parties de l'habitat de l'animal en sont même dépourvus. La différence floristique est également notable. A Beanka, la végétation pousse sur une formation karstique et n'a que peu d'accès au sol, qui se trouve entre les fractures, engendrant ainsi une rareté des espèces floristiques. Due à la géomorphologie du substrat qui facilite ou non l'installation des plantes, comme la présence du sol ou l'abondance de fissures dans lesquelles les plantes peuvent pousser, la densité des plantes est différente pour les deux sites. Ce fait permet de dire que le type et la quantité de végétation dépendent de la nature du sol (Gautier et Goodman, 2008; Be, 2012; Abassi, 2012; Rakotozafy, 2013). A notre avis, ces certaines différences de la typologie des zones de nourrissage de l'animal entre les deux sites ne sont que le reflet de la différence de la physionomie des deux forêts.

Stratégie d'alimentation de l'animal

Dans la RS de Manombo, beaucoup plus de traces d'alimentation ont été observées sur des troncs d'arbre vivant (70 %) que sur le bois mort (30 %). Le cas inverse s'est présenté dans la forêt de Beanka. Ces observations pourraient être expliquées par la disponibilité de la nourriture de l'animal. Plusieurs auteurs ont reporté que l'activité alimentaire d'un animal dépend aussi de la disponibilité de sa nourriture dans son habitat (e.g. Fleagle, 2013; Solofondranohatra, 2014). Il semble que les larves, parmi les aliments préférés des Ayes-ayes (Petter, 1977; Solofondranohatra, 2014), sont plutôt abondantes dans les troncs d'arbre vivants que dans les bois morts de la RS de Manombo; et le cas contraire à Beanka. Il est aussi fort probable que le bois mort abonde dans la forêt de Beanka, entrainant ainsi l'animal à prospecter davantage ce type de support.

Dans la forêt de Manombo, l'Aye-aye déniche généralement les larves à 2 m du sol; alors qu'à Beanka, il le fait à une hauteur d'environ 6 m. Ces faits semblent être liés à la différence dans l'utilisation de l'habitat par l'animal dans chaque site. La présente étude montre la grande variabilité de *D. madagascariensis* et son adaptabilité aux différentes conditions. C'est probablement la raison pour laquelle cette espèce est la plus répandue des lémuriens.

Pressions et menaces

Dans la RS de Manombo, les pressions, que nous avons observées, avaient déjà été enregistrées par les agents du Madagascar National Parks depuis 2008 (MNP, 2013). Malgré les efforts entrepris par le MNP, les pressions anthropiques exercées sur cette Réserve persistent. De même, la forêt n'est pas à l'abri des catastrophes naturelles telles que les cyclones, les vents forts et les fortes pluies (Ratsimbazafy, 2002). La forêt de Beanka n'est pas non plus protégée de toutes formes de pression. Puisque c'est une forêt sèche, elle est très sensible au feu, et sa régénération est très difficile. Cela entraine un recul de la bordure forestière qui engendre à son tour la diminutin de l'habitat forestier.

Dans les deux sites d'étude, les populations riveraines sont dépendantes de la forêt. Elles nous ont expliqué leur principe de vie qui est: «sans forêt, sans vie». Face à cette situation, nous voudrions suggérer quelques recommandations aux gestionnaires des deux sites telles que: renforcer la protection de la forêt, améliorer sa gestion, connaître les besoins de la population riveraine, envisager des projets d'éducation environnementale, et élaborer des projets de développement en échange de la conservation de la forêt et de sa biodiversité.

Pour conclure, quelques aspects de l'écologie de *Daubentonia madagascariensis* ont pu être déterminés à partir de ses traces d'activité alimentaire. Malgré l'adaptation de cette espèce de lémurien dans différents types d'habitat, elle semble préférer certains endroits durant sa recherche de nourriture. Ce fait est probablement lié à la disponibilité de la nourriture. La structure de la forêt influence aussi l'utilisation de l'habitat par l'animal. Dans les deux sites d'étude, l'espèce exploite différemment l'habitat durant la recherche des larves.

La présente étude pourrait lever l'incertitude sur l'existence ou non de *Daubentonia madagascariensis* dans la Réserve Spéciale de Manombo et dans la forêt de Beanka. Dû au temps limité qui nous a été imparti, l'écologie de cette espèce de lémurien n'a été déduite qu'à partir de ses traces d'activité alimentaire. Parmi nos perspectives, nous souhaitons: mener une étude beaucoup plus approfondie sur l'écologie de cette espèce en se basant sur des suivis d'individus; mettre à jour les données sur son aire de répartition, la taille de sa population et les menaces qui pèsent sur le taxon et son écosystème. Ces informations tendent à contribuer efficacement aux plans d'action de conservation de l'espèce.

Remerciements

Nous adressons nos sincères remerciements au Ministère de l'Environnement, de l'Ecologie, de la Forêt et de la Mer, à Madagascar National Parks (MNP), à Durell Wildlife Conservation Trust (DWCT) ainsi qu'à Biodiversity Conservation Madagascar (BCM) de nous avoir autorisé et aidé à effectuer cette recherche dans la Réserve Spéciale de Manombo et dans la forêt de Beanka. Nos remerciements s'adressent également au Doyen de la Faculté des Sciences et au Chef du Département de Paléontologie et d'Anthropologie Biologique de l'Université d'Antananarivo pour avoir approuvé ce projet de recherche, à Madagascar Biodiversity Partnership (MBP) et tout son personnel pour leur aide technique et logistique. Nos vifs remerciements vont aussi à l'endroit de l'Université de Calgary (Canada), NSERC et Primate Action Fund (PAF) d'avoir soutenu financièrement cette recherche, ainsi qu'aux rapporteurs de ce manuscrit pour leurs critiques et suggestions dans l'amélioration de la version finale.

Références

Abassi, K. 2012. Etude du transfert sol-plante des Radionucléides environnementaux du site Founga, Région Maweni, Grande Comores. Mémoire de DEA en Physique, Université d'Antananarivo.

Ancrenaz, M.; Acrenaz, L. 1994. Field observations of Aye-aye (*Daubentonia madagascariensis*) in Madagascar. Folia Primatologica 62: 22-36.

Andriamahazo, M.; Ebene Onana, C.Y.; Ibrahima, A.; Komena, B.K.; Razafindrandimby, J. 2004. Concilier exploitation des ressources naturelles et protection de la forêt: cas du corridor forestier de Fianarantsoa (Madagascar). Montpellier, Antananarivo, Institut de rechercche et de développement.

Andriamasimanana, M. 1994. Ecoethological study of free-ranging aye-ayes (*Daubentonia madagascariensis*) in Madagascar. Folia Primatologica 62: 37-45.

ANGAP, 2003. Evaluation de l'impact économique des aires protégées. WWF.

Be, F.G. 2012. Ecologie de la végétation relique du littoral oriental entre Tampina et Andovoranto (Région Atsinanana). Mémoire de DEA en Biologie et Ecologie Végétale. Université d'Antananarivo.

Carrière, M.S.; Andrianotahianjanahary, H.; Ranaivoarivelo, N.; Randriamalala, J. 2005. Savoirs et usages des recrus post-agricoles du pays Betsileo: valorisation d'une biodiversité à Madagascar. Vertigo 6.

Dajoz, R. 1996. Précis d'écologie 2ème et 3ème cycles universitaires. Dunod université. Sixième édition. Dunod Paris.

Fleagle, G.J. 2013. Ecology and Biogeography. Primate adaptation and Evolution, Third edition.

Frontier, S.; Pichod-vial, D. 1998. Ecosystèmes: structure, fonctionnement, évolution. Dunod, Paris.

Ganzhorn, J.U.; Rabesoa, J. 1986. The aye-aye (*Daubentonia madagascariensis)* found in eastern rain forest of Madagascar. Folia Primatologica 46: 794.

Ganzhorn, J.U.; Fietz, J.; Rakotovao, E.; Schwab, .D; Zinner, D.; 1999. Lemurs and the regeneration of dry deciduous forest in Madagascar. Conservation Biology 13:794-804.

Garbutt, N. 1999. Mammals of Madagascar. First edition, Yale University.

Gautier, L.; Goodman, S.M. 2008. Classification des communautés floristiques: phytogéographie ou types de végétation. In Goodman S.M. (eds), Paysages naturels et Biodiversité de Madagascar. The University of Chicago Press, Chicago, Illinois, USA.

Godron, M. 1983. Vademecum pour le relevé méthodique de la végétation et du milieu. (Ed). CNRS/CEPE, 151p.

Goodman, S.M.; Benstead J.P. 2003 (eds). The Natural estimates of biotic diversity and endemism for Madagascar. Oryx 39: 73-77.

Goodman, S.M.; Gautier, L. 2013. The importance of field inventories and associated studies to understand biodiversity patterns: The case of the Beanka Forest, Melaky Region, western Madagascar.

Harcourt, C.; Thornback, J. 1990. Lemurs of Madagascar and the Comoros. The IUCN Red Data Book. IUCN. Gland, Switzerland and Cambridge, UK.

Iwano, T.; Iwakawa, C. 1988. Feeding behaviour of the aye-aye (*Daubentonia madagascariensis*) on nuts of ramy (*Canarium madagascariensis*). Folia Primatologica 50: 136-42.

Krause, D.W. 2010. Washed up in Madagascar. Nature. 463: 613-614.

Legendre, L.; Legendre, P. 1984. Ecologie numérique. Deuxième édition, Masson, Paris, Volume III.

Mittermeier, R.A.; Louis, E.E. Jr.; Richardson, M.; Schwitzer, C.; Lagrand, O.; Rylands, A.B.; Hawkins, F.; Rajaobelina, S.; Ratsimbazafy, H.J.; Rasoloarison, M.R.; Roos, C.; Kappeler, P.M.; Mackinnon, J. 2010. Lemurs of Magagascar. Third Edition. Conservation International, Washington, DC, USA.

Mittermeier, R.A.; Louis, E.E. Jr.; Langrand, O.; Schwitzer C.; Gauthier, C.A.; Rylands, A.B.; Rajaobelina, S.; Ratsimbazafy, J.; Rasoloarison, M.R.; Hawkins, F.; Roos, C.; Richardson, M.; Kappeler, P.M. 2014. Lémuriens de Madagascar. Conservation International, Washington, DC, USA.

MNP. 2013. Rapport de l'évaluation des pressions et des menaces dans la Réserve Spéciale de Manombo. MNP Manombo.

Petter, J.J. 1977. The aye-aye. In: Rainier III (Grimaldi) Prince of Monaco; G.H. Bourne (eds.). Primate Conservation. Academic Press, New York.

Pielou, E.C. 1975. Ecological Diversity. New York.

Pollock, J.L.; Constable, I.D.; Mittermeier, R.A.; Ratsirarson, J.; Simons, H. 1985. A note on the diet and feeding behavior of the aye-aye *Daubentonia madagascariensis*.

Raherilalao, M.J.; Goodman, S.M. 2013. Premier aperçu de la diversité des oiseaux de la forêt sèche sur tsingy de Beanka, Région Melaky, Ouest de Madagascar. Malagasy Nature 7: 225-236
Rakotozafy, B.F.L. 2013. Identification et caractérisation écologique de la végétation sur karst de Beanka (Madagascar). Mémoire de DEA. Université d'Antananarivo.
Ralainasolo, F.B.; Ratsimbazafy, J.H.; Stevens, N.J. 2008. Behaviour and diet of Critically Endangered *Eulemur cinereiceps* in Manombo forest, southeast Madagascar. Madagascar conservation and development 3: 38-43.
Ratsimbazafy, H.J. 2002. On the brink of the extinction and process of recovery: Response of Black-and-white ruffed lemur (*Varecia variegata variegata*) to disturbance in Manombo Forest, Madagascar. PhD Dissertation. State University of New York at Stony Brook. Stony Brook, New York.
Rowe, N. 1996. The pictorial guide to the living primates. Pogonias Press, East Hampton, New York.
Samonds, K.E.; Godfrey, L.R.; Ali, G.R.; Goodman, S.M.; Vences, M.; Sutherland, M.R.; Mitchell, T. I.; Krause, D.W. 2012. Spatial and Temporal arrival patterns of Madagascar's vertebrate fauna explained by distance, ocean currents, and ancestor type. Proceedings of the National Academy of Sciences.
Schwitzer, C.; Mittermeier, R.A.; Davies, N.; Johnson, S.E.; Ratsimbazafy, H.J.; Razafindramanana, J.; Louis, E.E. Jr.; Rajaobelina, S. 2013. Lemurs of Madagascar: A Strategy for their Conservation 2013–2016. IUCN/SSC Primate Specialist Group, Bristol Conservation and Science Foundation, and Conservation International, Bristol, UK.
Solofondranohatra, J.S. 2014. Ecoethologie de *Daubentonia madagascariensis* dans la Forêt Classée de Kianjavato, Sud-est de Madagascar. Mémoire de DEA en Primatologie, Université d'Antananarivo.
Sterling, E.J. 1993. Behavioral ecology of the aye-aye (*Daubentonia madagascariensis*) on Nosy Mangabe, Madagascar. PhD thesis, Yale University, New Haven, CT.
Tattersall, I. 1982. The primates of Madagascar. New York: Columbia University Pr. 382p.
Whittaker, R.H.; 1972. Evolution and measurement of species diversity. Taxon, v. 21, p. 213-251.

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.mbzspeciesconservation.org.

Theses completed

Anania, A. 2015. Contextual variation of the vocal signals in *Propithecus diadema* in the wild. Master thesis in Evolution of Animal and Human Behavior, Department of Life Sciences and Systems Biology, University of Torino, Italy. Under the supervision of Prof. Marco Gamba and the co-supervision of Giovanna Bonadonna.
Communication has an important role in triggering and regulating social relations, crucial for survival and fitness. Vocal signals are essential for forestdwelling gregarious species, living in an environment with limited visual contact. The acoustic variation of primate calls is usually investigated to recognize how various factors, such as the context, can affect the structure of a vocalization and the vocal repertoire. Diademed sifaka (*Propithecus diadema*) is a group-living, critically endangered lemur, inhabiting Madagascar rainforests. Knowledge on the vocal communication is still poorly known. The first aim of this study was to provide a preliminary description of *P. diadema's* vocal repertoire using a modern acoustic approach and redefining the terminology of the vocal types. The second purpose was to analyze the usage of the vocal types across different contexts, for a better understanding of the signal function. The final aim was to test the contextual variation of each vocalization. To pursue these aims, we investigated the vocalizations of three habituated

groups of diademed sifaka in the wild, in the Maromizaha primary forest, eastern Madagascar. Between April and August 2014, we collected audio and video recordings and behavioral data with *ad libitum* sampling method. We used the Praat software to generate spectrograms and the program DTWave to calculate the pairwise acoustic dissimilarity between the recorded vocalizations. Using the R-Studio software, we performed the Mantel tests to make a comparison between the acoustic dissimilarity and the contextual occurrence of vocalizations. The visual inspection of spectrograms allowed estimating the vocal repertoire of adult *P. diadema* as being constituted of at least 10 vocal types. We found: ChatterSqueal, Grunt, Hoo, Hum, MMM, Roar, SoftGrunt, Zzuss, Zzuss-Tsk, and Tsk. The results suggested that the Roar is a context-specific alarm call, emitted when raptors are detected. The Hoo serves a cohesion function when an individual loses contact with its group. The Zzuss and the Zzuss-Tsk are long-range multicontext calls, which animals mostly use when they hear a lost mate calling, in case of aerial and terrestrial disturbance, or during vigilance. The MMM appeared a signal of active surveillance on conspecifics, used in various contexts. The most common close-range call, the Hum, showed the same occurrence and a role in affiliation and group coordination during movement. The Chatter-Squeal was uttered during competition. The Soft-Grunt and the Grunt can be used in agonistic contexts, or in case of mild disturbances. The statistical analysis resulted in a highly significant correlation between the acoustic dissimilarity and the context in at least three vocal types (Grunt, SoftGrunt, Zzuss-Tsk), providing the first evidence of context-dependent variants within the vocal types.

Key words: *Propithecus diadema*, sifakas, vocal communication, vocal repertoire, contexts, Maromizaha.

Andriamisedra, T.R. 2015. Détermination de quelques aspects de l'écologie de *Daubentonia madagascariensis* (Gmelin, 1788) dans deux forêts malgaches: la Réserve Spéciale de Manombo, Sud-est, et la Forêt de Beanka, Ouest de Madagascar.

Mémoire de DEA, Option: Paléontologie et Evolution Biologique, Spécialité: Primatologie, Département de Paléontologie et d'Anthropologie Biologique. Faculté des Sciences, Université d'Antananarivo.

Daubentonia madagascariensis est le plus grand des lémuriens nocturnes. Actuellement, les recherches effectuées sur cette espèce sont encore rares. La présente étude contribue davantage à la connaissance de cette espèce, en essayant de comprendre la sélection d'habitat et la stratégie d'alimentation de l'animal à partir de ses traces de nourrissage. Cette recherche a été menée dans deux forêts: la Réserve Spéciale de Manombo, au Sud-est, durant les mois de Juillet et Août 2014; et la forêt de Beanka, à l'Ouest de Madagascar, pendant les mois de Septembre et Octobre 2014. La présence ou l'absence de trace d'alimentation a été considérée comme indicatrice d'utilisation de l'habitat par *D. madagascariensis*. Ainsi, la typologie de l'habitat a été étudiée à travers des caractères botaniques. Pour y parvenir, la recherche des traces a été effectuée à l'intérieur de 50 plots botaniques instaurés au hasard de chaque côté d'un transect dans chaque site. Les résultats ont montré que dans la RS de Manombo, ainsi que dans la forêt de Beanka, les caractères botaniques ne diffèrent pas entre les habitats utilisés et non-utilisés par l'Aye-aye, à l'exception de la hauteur de la canopée. Mais en comparant les deux forêts, une différence significative de la structure de l'habitat de l'animal a été observée, sauf au niveau de la hauteur de la canopée. Dans la RS de Manombo, l'habitat utilisé par l'animal est plus couvert, avec une densité des arbres et une diversité floristique plus importantes que celui dans la forêt de Beanka. L'existence de *Canarium* n'indique pas nécessairement la présence de *D. madagascariensis* dans une forêt. Dans la RS de Manombo, l'Aye-aye déniche plutôt les larves dans des arbres vivants à basse hauteur (≈2 m); tandis que dans la forêt de Beanka, il le fait principalement sur des bois morts à une hauteur plus élevée (≈6 m). La présence de prédateurs et la disponibilité de la nourriture pourraient expliquer ces différences.

Mots-clés: *Daubentonia madagascariensis*, traces d'alimentation, sélection d'habitat, stratégie d'alimentation, Forêts de Manombo et de Beanka, Madagascar.

Rafidiarison, A.R. 2015. Ecologie alimentaire de *Prolemur simus* dans la forêt de Vohiposa, District de Brickaville, Région Atsinanana de Madagascar.

Mémoire de DEA, Option: Paléontologie et Evolution Biologique, Spécialité: Primatologie, Département de Paléontologie et d'Anthropologie Biologique. Faculté des Sciences, Université d'Antananarivo.

Après la récente découverte d'une importante population de *Prolemur simus* dans les forêts environnantes de Brickaville, des études y ont été menées afin d'assurer la survie de cette espèce, qui est classée en danger critique d'extinction. Pour y contribuer, nous avons basé notre recherche sur son écologie alimentaire. Elle a été effectuée durant la saison sèche dans la forêt dégradée de Vohiposa. Deux groupes (groupe I et groupe II) ont été suivis. Plusieurs méthodes ont été adoptées pour pouvoir atteindre les objectifs telles que: le «focal animal sampling» pour déterminer les activités de l'espèce; le suivi phénologique et le «Minimum Convex Polygon» pour estimer la disponibilité de la nourriture dans le territoire des groupes. Les résultats ont montré que *Prolemur simus* consacre plus de la moitié de son temps à se reposer (55,60 %). L'alimentation occupe une proportion de 10,40 % de ses activités. L'espèce se nourrit de trois types de nourriture tels que: des feuilles de *Valiha diffusa*, des moelles de jeunes tiges d'*Afromumum angistifolium* et des fleurs de *Ravenala madagascariensis*. L'animal préfère consommer des feuilles de *Valiha diffusa* (71,70 % de son aliment). Une variation de la composition de l'alimentation des deux groupes a été observée. Les quantités relatives des aliments consommés par *Prolemur simus* sont différentes dans les deux groupes. Durant notre période d'étude, la taille du territoire du groupe I était de 4,04 Ha et celle du groupe II, de 2,43 Ha. *Valiha diffusa*, la principale nourriture de *P. simus*, et *Afromumum angistifolium* sont largement disponibles dans le territoire de chaque groupe, mais des compétitions alimentaires avec d'autres taxons ne sont pas à écarter. Plusieurs facteurs jouent des rôles importants sur l'écologie alimentaire d'une espèce animale tels que: sa physiologie, la saison, la taille et la structure du groupe social, le régime alimentaire, la disponibilité de la nourriture, la compétition, la prédation ainsi que les menaces.

Mots-clés: *Prolemur simus*, bambou, activités, régime alimentaire, Vohiposa, Est de Madagascar.

Randimbiharinirina, R.D. 2015. Activités et modèle de dispersion de *Daubentonia madagascariensis* (Gmelin, 1788) mâle dans la Forêt Classée de Kianjavato, Sud-est de Madagascar. Mémoire de DEA, Option: Paléontologie et Evolution Biologique, Spécialité: Primatologie, Département de Paléontologie et d'Anthropologie Biologique. Faculté des Sciences, Université d'Antananarivo.

Cette étude a été effectuée dans la Forêt Classée de Kianjavato, au Sud-est de Madagascar. Elle a duré un an: d'Octobre 2013 à Octobre 2014. Elle a pour but de compléter les informations sur l'histoire naturelle de *Daubentonia madagascariensis*. Deux individus mâles ont fait l'objet de notre étude. Pour atteindre les objectifs spécifiques, plusieurs méthodes ont été utilisées telles que: la «radio tracking» et le «focal animal sampling» pour déterminer les activités des individus; et la méthode du «Minimum Convex Polygon» pour étudier le modèle de leur dispersion dans leur habitat. Les résultats ont montré que le mâle de *Daubentonia madagascariensis* consacre la majorité de son temps à s'alimenter et à se déplacer. Comparée à d'autres espèces de lémurien, il ne se repose que pendant très peu de temps. Sa nourriture est principalement composée de larves, de graines de *Canarium madagascariensis* et de *Canarium boivinii* et d'insectes. Il complète son régime alimentaire avec du nectar de *Ravenala madagascariensis*. Il montre une préférence significative envers les larves. Les Aye-ayes mâles dénichent ces dernières dans des branches d'arbres partiellement mortes, des arbres morts et dans des troncs de bambou adulte. Pourtant, ils cherchent les insectes dans les fleurs sèches de *Ravenala madagascariensis* et au niveau des branches de *Dypsis linea*. Le territoire des deux individus occupe respectivement une superficie de 974 Ha et de 822 Ha. Ils se chevauchent entre eux; et l'un recouvre presque en totalité celui d'une femelle. Leur territoire semble être délimité par les sources de larves dans la forêt. La dispersion des mâles dans sur leur territoire ne dépend pas uniquement de la répartition spatiale de leur

nourriture. Elle pourrait aussi être liée à d'autres facteurs, comme la recherche d'une femelle.
Mots-clés: lémurien nocturne, *Daubentonia madagascariensis*, écologie, Kianjavato, Sud-est de Madagascar.

Razanamahafaly, O. 2015. Exploitation de la technique du transect linéaire en vue de recensements de lemuriens et des activitées humaines dans les forets de Sahamalaza.
Le Parc National Marin et côtier de Sahamalaza est l'un des Parcs qui renferme des espèces biologiques très étonnantes telles que les lémuriens. Comme toutes les autres aires protégées de Madagascar, ce Parc souffre de la pression anthropomorphique qui engendre la destruction de l'habitat des lémuriens. C'est pour cela que nous avons décidé de faire un recensement de lémuriens et de vérifier l'ampleur des dégats sur les fragments visités. Nous avons réalisé cette étude pendant la saison humide de mi-septembre 2011 à mi-janvier 2012. La méthode d'inventaire standard «transect linéaire» (Whitesides et *al*., 1988; Bennun et *al*. 2002) a été utilisée, ceci nous a permis d'estimer la densité des lémuriens de notre zone d'étude. Nous avons placés 2 transects séparés de 0,3 km au moins dans chaque fragment. Les transects étaient marqués tous les 20 m à l'aide de rubans en plastique (flag) colorés. De plus nous avons relevé tout le long des transects les traces d'activités humaines. Nous avons recensé 4 espèces dans tous les fragments que nous avons visité. Nous avons observé que la richesse spécifique de ce site ne dépend pas de la longueur du transect mais cela a un effet sur le nombre des individus rencontrés. En ce qui concerne les pressions anthropomorphiques, 6 types d'activités ont été relevées, très souvent le long des transects. Quant à la densité, elle voire grandement selon l'espèce. Nous avons constaté qu'il y a un lien entre la densité de lémuriens et la qualité des forêts. Il y a aussi une relation entre le taux d'activités humaines et la distance des fragments par rapport à la station de recherche d'Ankarafa. Enfin, nous avons proposé quelques perspectives pour améliorer la conservation des écosystèmes dans ce Parc.
Mots-clés: Transect linéaire, recensement, évaluation, lémuriens, pressions anthropiques, Parc Sahamalaza