LEMUR NEWS

The Newsletter of the Madagascar Section
of the IUCN/SSC Primate Specialist Group

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Front cover: The Endangered golden-crowned sifaka (*Propithecus tattersalli*) at the edge of an area devastated by gold mining activities in the Daraina region of north-eastern Madagascar. © Pete Oxford/naturepl.com

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Editorial

I am writing this Editorial only a couple of days after another attempted (and failed) Coup d'Etat in Madagascar, in which a faction of the army tried to topple the Transition Government. For nearly two years now, since the start of the political crisis in early 2009, the country has not seen a week without demonstrations, tensions between different political parties and attempts from international mediators to get power-sharing agreements signed by all sides. Most donors, governments and multinational organisations alike, have frozen all non-humanitarian aid for Madagascar, which has led to severe funding shortages in the environmental and conservation sector. The political crisis has thus quickly turned into a full-blown environmental crisis, with large-scale illegal logging taking place mainly in eastern Madagascar (Marojejy, Masoala, Makira), and unseen levels of lemur poaching all across the island. To keep people aware of the seriousness of the situation we have decided to run another feature on Madagascar's environmental crisis in this issue of *Lemur News*, with an excellent update on illegal logging by Erik Patel as well as a case study of ongoing threats to lemurs and their habitat in Sahamalaza National Park by Melanie Seiler and colleagues.

The conservation situation of lemurs has also been a big concern in several presentations given at the most recent 23rd Congress of the International Primatological Society in Kyoto, Japan. The talk that I remember best was by *Lemur News* co-editor Jonah Ratsimbazafy, who reminded the audience in a very emotional way that scientists and conservationists working in Madagascar had a moral responsibility to respond to the "cries of the lemurs", as otherwise these would remain unheard by the Malagasy and international community. In the biennial discussion session of "Primates in Peril", the list of the world's top 25 most endangered primates, issued jointly by the IUCN/SSC Primate Specialist Group and IPS, lemurs remained a very high priority and will again make up 20% of the 25 listed species in the next biennium. Sadly, Madagascar thus retains its first place (along with Vietnam) as the country harbouring the highest number of the top 25. It can only be hoped that the political classes of Madagascar come to agree a way out of the current crisis sooner rather than later, as otherwise we run the very serious risk, during the UN Decade of Biodiversity 2011-2020, of losing a substantial proportion of the endemic biodiversity of this amazing megadiversity country.

Alison Jolly with Russ Mittermeier at the IPS Lifetime Achievement Award 2010 ceremony in Kyoto. (Photo: R. Mittermeier)

For a change, on a very positive note, I am thrilled to say that Alison Jolly was awarded the IPS Lifetime Achievement Award for her long-term commitment to lemur conservation and environmental education in Madagascar (see News and Announcements). My two daughters (now 4 and 2 years old) and I particularly enjoy reading Alison's children's book on Bitika, the mouse lemur, as, I am sure, do lots of children in Madagascar and elsewhere in the world.

It is encouraging to see that this volume of *Lemur News* is again full of articles and short reports not only on lemur species red-listed in one of the Threatened categories (VU, EN or CR), but also on Data Deficient nocturnal species such as *Mirza zaza*, *Lepilemur leucopus* and the recently rediscovered *Cheirogaleus sibreei* (see the articles by Rode *et al.*, Fish, and Blanco, respectively). As Johanna Rode and colleagues point out in their short report on *Mirza zaza*, Madagascar is in the unusual situation that 45 % of its primate species are red-listed as Data Deficient, which is a far higher percentage than in any other primate habitat country and mainly derived from the discovery of dozens of cryptic species in the genera *Lepilemur* and *Microcebus* over the last couple of years. Many of those species are only known from their type localities and may in fact be highly endangered. The more research is conducted and published on them, the easier it will become to assign them a conservation status and target them with conservation measures. It will require a concerted effort of the lemur research and conservation community over the next decade or so to to reduce the number of Data Deficient species to a level comparable to other regions (or, ideally, to zero).

Another encouraging development is the frenzy of research and conservation activities now under way for *Prolemur simus* at various locations both south and north of the Mangoro River, reported by Dolch *et al.* as well as Rajaonson *et al.* in this volume. The greater bamboo lemur undoubtedly remains one of the most endangered of Madagascar's lemurs. However, with several additional populations having been discovered over the last two years, workshops having been conducted that have led to a joint-up approach to this species' conservation, and the *ex situ* population having been included as an integral part of conservation efforts, I now think that we stand a real chance of saving *Prolemur simus* from extinction.

As Jörg Ganzhorn announced in his editorial to *Lemur News* 14, I have taken over the coordination of this newsletter from him after the 2009 volume, hence this is now the first volume that I have helped produce (which is my humble excuse for its slightly late publication). Jörg has been involved with *Lemur News* since its inception in 1993, first as a member of its Editorial Board and from volume 3 (1998) as its Editor. I am thus pleased to say that we will not lose his experience and backing, as he has kindly agreed to remain part of the editorial team. Likewise, Jonah Ratsimbazafy and Rodin Rasoloarison, who have been the newsletter's Malagasy coordinators since 2006, and Anne Yoder, who represents the Duke Lemur Center, will carry on as editorial team members, for which I am grateful. I am indebted to Heike Klensang, who has been doing the layout for *Lemur News* now for more than a decade and is still not tired of it, and to Anna Francis, who has designed the beautiful new logo and front cover. Very many thanks also to Stephen D. Nash for the wonderful lemur silhouettes that we printed on the inside back cover.

This volume of *Lemur News* was kindly supported by the Margot Marsh Biodiversity Foundation through Conservation International's Primate Action Fund, and by the WWF Madagascar and West Indian Ocean Programme Office.

I very much look forward to helping to take *Lemur News* into the UN Decade of Biodiversity together with the editorial team and with its base of loyal contributors and readers, and I will do my best to ensure that the newsletter will continue to help promote the conservation of lemurs as it has done for the last 17 years.

Christoph Schwitzer

Feature: Madagascar's Environmental Crisis

Madagascar's illegal logging crisis: an update and discussion of possible solutions

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How sure are you that your favorite rosewood or ebony acoustic guitar was not made from rare, illegally logged trees in Madagascar; an exceptional biodiversity hotspot with desperately little original forest remaining? What is the origin of the wood in the expensive oriental-style rosewood furniture which is heavily advertised for sale on the internet? Unfinished rosewood boards from Madagascar are openly sold even in the United States (www.gilmerwood.com/boards_rosewood-exotic_unique.htm) and the United Kingdom (www.exotichardwoods.co.uk/Woods_List/Madagascar_Rosewood.asp). Can such vendors prove that the rosewood was legally (and ethically) obtained? The answer is usually "no". These can be difficult questions for consumers to answer, but purchasing these products can prolong the ongoing logging crisis in northeastern Madagascar in some of the most unique and biologically diverse forests in the world.

Consumers should be suspicious since none of these rapidly disappearing Madagascan rosewood and ebony species are yet protected under CITES, the Convention on International Trade in Endangered Species. In November of last year, Gibson Guitars, one of the two largest U.S. stringed-instrument companies, came under federal investigation for violating the Lacey Act by allegedly using illegal rosewood from Madagascar which had first been shipped to Germany and then the United States (Michaels, 2009). Most of the illegally logged rosewood in Madagascar is used for the manufacture of furniture in China. Some of this is known to be sold in China as luxurious "Ming Dynasty style" furniture (Global Witness and Environmental Investigation Agency, 2009). Some may well be exported to western countries. China is the world's leading exporter of furniture. According to the Office of the United States Trade Representative, the United States imported 16 billion dollars of Chinese furniture in 2009, making it the USA's fifth largest import from China.

Illegal logging of rosewood (*Dalbergia* spp.) and ebony (*Diospyros* spp.) has emerged as the most severe threat to Madagascar's dwindling northeastern rainforests. In 2009, a year of political upheaval in Madagascar due to an undemocratic change of power, approximately 100,000 of these trees were illegally cut in the UNESCO World Heritage Sites of Masoala National Park, Marojejy National Park, the Makira Conservation Site, and Mananara Biosphere Reserve (also a national park). Needless to say, the wood is extremely valuable. Rosewood can sell for US$5,000 per cubic meter, more than double the price of mahogany. Several hundred million dollars of these precious hardwoods were cut in 2009 in protected areas. The overwhelming majority of these profits are taken by a rosewood mafia of a few dozen organizing individuals, many of whose identities are well known. Few others benefit. Harvesting these extremely heavy hardwoods is a labor intensive activity requiring coordination between local residents who manually cut the trees, but receive little profit (about US$5/day), and a criminal network of exporters, domestic transporters, and corrupt officials who initiate the process and reap most of the enormous profits. This is a "tragedy *with* villains" unlike habitat disturbance from subsistence slash-and-burn agriculture which has been well described as a "tragedy without villains" (Barrett *et al*., 2010; Débois, 2009; Global Witness and Environmental Investigation Agency, 2009; Patel, 2007, 2009; Randriamalala and Liu, in press; Schuurman and Lowry, 2009; Schuurman, 2009; Wilme *et al*., 2009; Wilme *et al*., in press).

Globally, illegal logging results in an estimated US$10 billion lost per year to the economies of timber producing countries (Furones, 2006). In addition to depriving the government of Madagascar of millions of dollars of taxable revenue, illegal logging of this precious wood has decimated tourism in northeastern Madagascar, which had become a growing source of local income. Although selective logging results in less absolute forest loss than clear-cutting, it is often accompanied by substantial peripheral damage such as decreases in genetic diversity and increases in the susceptibility of the impacted areas to burning and bushmeat hunting. Documented long-term ecological consequences of selective logging in Madagascar include invasion of persistent, dominant non-native plant species, impaired faunal habitat, and a diminution of endemic mammalian species richness (Gillies, 1999; Cochrane and Schultze, 1998; Brown and Gurevitch, 2004; Stephenson, 1993). In actual practice, rosewood logging has turned out to be far less "selective" than originally believed. Often rafts made of a lighter species of wood (*Dombeya* spp.) are constructed to float the much more dense rosewood logs down rivers. Approximately five *Dombeya* trees are cut as "raft wood" for every one rosewood tree (Randriamalala and Liu, in press). Tall adult trees of a variety of species, that simply happen to be very close to rosewood trees, must often be cut simply to gain access to cut down a rosewood tree. This has been observed in Marojejy (pers. obs.).

Red ruffed lemurs (*Varecia rubra*) are probably the most negatively impacted lemur since many were hunted by these loggers and this species is known to feed on ebony trees (*Diospyros* spp.) as well as pallisandre (*Dalbergia* spp.) in Masoala (Vasey, pers. comm.). *Varecia rubra* probably also feeds on the fruits and leaves of the logged "raft wood" *Dombeya* spp. trees like *Varecia v. editorium* in Manombo Forest in southeastern Madagascar (Ratsimbazafy, 2007). In Mantadia National Park, *Indri indri* and *Propithecus diadema* consume young leaves of one species of actual rosewood (*Dalbergai baronii*) which is also consumed by Milne-Edwards' sifakas (*Propithecus edwardsi*) in Ranomafana National Park (Powzyk and Mowry, 2003; Arrigo-Nelson, 2007). *Propithecus diadema* at Tsinjoarivo consume the unripe fruit of ebony trees (Irwin, 2006). In Marojejy, silky sifakas (*Propithecus candidus*) not uncommonly feed on the young leaves of pallisandre (*Dalbergia chapelieri*) which is also a preferred sleeping tree (pers. obs.).

When discussing the impacts of precious wood logging, it is important not to forget how damaging all this has been to local communities as well. Local residents have suffered as foreign and domestic elites have corrupted the forest service, leading to losses of sustainable employment in tourism, re-

search, and conservation. In some cases, community life has suddenly changed as gambling, prostitution, and crime have increased in rural communities. Moreover, the risks of local food shortages and nutritional deficiencies mount when farmers abandon subsistence agriculture for temporary, physically dangerous illegal logging work (Global Witness and Environmental Investigation Agency, 2009; Patel, 2007, 2009). Moreover, illegal loggers trample on the beliefs and taboos of local people. In traditional Sakalava culture, ebony is a sacred wood only cut by priests who conduct traditional ceremonies with ebony staffs. The chief of Ankalontany, a Sakalava Malagasy village in the northeast, explained that "Some strangers from outside our village came here. They started cutting ebony and they clearly had no right. We asked for their authorization but they said they didn't have to show us papers. They said they had police clearance and we can't stop them." Laurent Tutu, president of the forest association of Ankalontany, remarked "It hurts us to see our trees cut like this. The forest loses its personality" (Cocks, 2005).

Although illegal logging in Madagascar has received some media attention recently, confusion still remains regarding a number of key facts. The aim of this report is to provide an update (at the time of writing: May 25, 2010), dispel a few myths, discuss some of the possible solutions to this ongoing crisis, and present a comprehensive bibliography of articles, photos, films, and videos related to this topic.

Four myths about illegal logging in Madagascar

Myth #1: "Plenty of Madagascar rosewood is harvested legally…" says Bob Taylor, founder of Taylor Guitars. Quote from Gill, C. (2010). Log Jam. Guitar Aficionado. Spring Issue. P. 68

This is simply not true. A vast amount of published evidence clearly shows that very very little, if any, of the rosewood logging in Madagascar is legal. The overwhelming majority of exported Madagascar rosewood is illegally logged within Masoala National Park and Marojejy National Park (which are part of a UNESCO World Heritage Site) as well as Mananara Biosphere Reserve (also a national park) and the vast Makria Conservation Site (Barrett *et al*., 2010; Débois, 2009; Global Witness and Environmental Investigation Agency, 2009; Patel, 2007, 2009; Randriamalala and Liu, in press; Schuurman and Lowry, 2009; Schuurman, 2009; Wilme *et al*., 2009; Wilme *et al*., in press).

Myth #2: The current ban has stopped illegal logging.

In late March, the government of Madagascar announced a new two to five year ban on export and cutting of ebony and rosewood. The decree #2010-141 officially passed on April 14, 2010. Clearly this was an important and large step forward. However, the decree does not apparently include pallisandre, a precious hardwood in the same genus (*Dalbergia*) as rosewood. Illegal logging of pallisandre has heavily impacted some reserves such as Betampona Natural Reserve (Kett, 2005; Bollen, 2009). At the time of writing (May 25, 2010), there have been no new exports since the recent ban. However, illegal rosewood and ebony logging still continues inside Mananara Biosphere Reserve and the Makira Conservation Site according to reliable anonymous informants. The clearest information has come from Mananara where at least several hundred, recently cut, rosewood logs were observed.

Myth #3: Illegal logging was never a big problem in Madagascar until the recent political crisis.

Illegal logging in Madagascar of rosewood (*Dalbergia* spp.) and ebony (*Diospyros* spp.) did not begin with the culmination of the political crisis in March 2009. A major illegal logging crisis in World Heritage Sites (Masoala National Park and Marojejy National Park) took place during 2004-2005, a time of political stability. The earliest documented case of rosewood logging in Madagascar and foreign export dates to 1902. Foreign exports of Madagascar rosewood occurred at "low" levels (1000 to 5000 tonnes) between 1998 and 2007. In 2008, exports jumped to 13,000 tonnes, and jumped again in 2009 to more than 35,000 tonnes (Botokely, 1902; Randriamalala and Liu, in press; Global Witness and Environmental Investigation Agency, 2009).

Myth #4: There are 43 species of rosewood trees in Madagascar.

Some recent reports had mistakenly made this statement. It is not entirely clear exactly how many rosewood species are found in Madagascar. More botanical research is needed. However, currently, there are believed to be 10 species of rosewood in Madagascar in the genus *Dalbergia* which contains 48 total species. The rosewood species are presumed to be *Dalbergia baronii* [VU], *D. bathiei* [EN], *D. davidii* [EN], *D. louvelii* [EN], *D. mollis* [NT], *D. monticola* [VU], *D. normandii* [EN], *D. purpurascens* [VU], *D. tsiandalana* [EN], *and D. viguieri* [VU] (Barrett *et al*., 2010).

Rosewood stockpile solutions?

Approximately 10,280 tonnes of illegally logged rosewood remain stockpiled in numerous locations in northeastern Madagascar, such as the ports of Vohemar and Antalaha as well as private residences in those cities and Sambava, Ampanifena, Ambohitralalana, and others. Each 150 kg log has an approximate market value of US$1,300 usd. As unfinished logs, the value of the current stockpile is therefore approximately US$90 million. Value increases dramatically, of course, after being constructed, for example, into high-end Ming Dynasty style furniture in China. A single armoire composed of only a few logs can sell for US$20,000 or more. It's a horrid contrast to the annual income in Madagascar (about US$400) or the daily wage provided to loggers (US$5) for the dangerous and physically debilitating work (Randriamalala and Liu, in press; Global Witness and Environmental Investigation Agency, 2009; anonymous local informants).

If the export ban holds (numerous other bans did not), what should be done with these stockpiles? Several ideas have been suggested.

1. The "Forest Counterpart Fund" (Wilme *et al*., 2009) aims to create a conservation and charitable works fund to assist local communities and forests damaged by the illegal logging. The logs are not sold on the open market as in the second proposal below. Rather, philanthropists, conservation organizations, and international aid agencies pay to "adopt" a log. Each log can be "adopted" for its market value (about US$1,300). The logs themselves are given to (carefully selected) local residents who are victims of the illegal logging. The logs would then be carved, engraved, and customized for public display as symbols. If sufficient donors can be found, this proposal offers a win-win solution for Madagascar's forests as well as people.

2. The Moratorium-Conservation-Amnesty-Reforestation (MCAR) program (Butler, 2009). This is essentially a one-off actual sale with conservation benefits. Logs would be auctioned via a transparent market system in which the price and the log code would be recorded, publicly available, and digitally traceable. Funds generated would mainly go towards

conservation programs such as reforestation and forest monitoring. Criminal traders would receive amnesty from prosecution as well as a very small percentage of the funds. An export moratorium would be required. There is always a danger that one-off sales can encourage further logging; a topic which has been extensively debated with respect to confiscated elephant ivory stockpiles. An impressive recent review paper in *Science* (Wasser *et al*., 2010): www.sciencemag.org/cgi/content/short/327/5971/1331) argued that no one-off ivory sales should be approved even if the funds go towards conservation.

3. Destroy the stockpile. This was recently reiterated by Global Witness (GW) and Environmental Investigation Agency (EIA). Andrea Johnson, Director of Forest Campaigns at EIA explained that "To end the cycle of illegal harvest and corruption, the government should take the step of destroying all stocks that are not contained in the latest official inventories…Traders, who are currently stockpiling illegal timber, hoping for another 'exceptional' export authorization, must receive a clear signal that it will be impossible to profit from the illegal trade in the future." Numerous examples can be found from around the world of simple and effective destruction of stockpiles of contraband such as small arms, drugs, and ivory. Destruction also eliminates the not insignificant expense of storing and guarding the items. Burning the rosewood stockpiles would create a lot of pollution, it has been argued, and might be dangerous given the high volume. Other ways of destroying the wood are possible however. The wood could be hacked into tiny unusable pieces. This is already done sometimes by park rangers in Madagascar. This would take a very long time, but would be a fitting punishment of hard labor for members of the rich rosewood mafia! Of course, destruction of the wood, whatever the method, would contribute no money for any conservation or community development funds.

Any of these possibilities are better than what has happened in the past: seized wood was auctioned off to the highest bidder. Foreign export remains a possibility too, despite the ban. French shipping company CMA-CGM Delmas exported rosewood from Madagascar several times in 2009 and 2010.

Long-term solutions?

Thinking long-term, what can be done to prevent another illegal logging crisis in Madagascar?

Some may argue that so little rosewood and ebony remains, logging on this scale could never happen again. However, this had been claimed before 2009 too. More surveys are clearly needed. One hopes that some of the more impenetrable regions of mountainous Marojejy National Park may still have rosewood. But because rosewood tends to be harvested at lower elevations, near rivers (where the largest individuals are found), it is less protected by the physical challenges of the massif than some other tree species. It is encouraging that some *Dalbergia* and *Diospyros* species can form stump sprouts which can grow into a new tree over many many years. Unfortunately, some entire rosewood stumps are removed either to hide evidence of logging or for wood for small, locally made rosewood vases. Rosewood trees are known to be some of the oldest trees in the eastern Malagasy humid forests. They can live to be more than 400 years old, according to local guides. Traders explain that they can be harvested after 50 years (Patel 2007, 2009).

1. CITES

The surest way to reduce the likelihood of another illegal logging crisis in Madagascar, is to list all species in the genera of *Dalbergia* and *Diospyros* on CITES Appendix 1. Currently none of Madagascar's ebony or rosewood species are protected under any appendices within the Convention on International Trade in Endangered Species (CITES). Globally, only one species of rosewood, Brazilian rosewood (*Dalbergia nigra*), is listed under CITES Appendix 1. This is the most stringent category, and prohibits all commercial trade of that wood from the date of listing. This has generally been effective. Guitars in the United States made of Brazilian rosewood are known to have risen in price and are harder to find since Appendix 1 listing. Similarly, Appendix 1 listing of Alerce (*Fitzroya cupressoides*), a heavily logged South American conifer, has significantly reduced logging and trade (Barrett *et al.,* 2010; Keong, 2006).

A few other Brazilian and Central American rosewood species are listed under CITES Appendix 2 and 3. These lower appendices aim to regulate trade, not prohibit it. Just this year, another species of Brazilian rosewood (*Aniba rosaeodora*), exported extensively as fragrant oil, was listed under CITES Appendix 2. Two additional species of Central American rosewood (*D. retusa* and *D. stevensonii*) are listed under Appendix 3. Appendix 2, unlike Appendix 3, does require that the CITES authorities in the export nation determine that the species were legally obtained and that their export will not be detrimental to species survival. There seem to be few cases where Appendix 3 listing was sufficient, except as a means to Appendix 2 or higher listing. The well examined case-studies of big-leaf mahogany (*Swietenia macrophylla*) and ramin (*Gonystylus* spp.) both began as Appendix 3 species (which only requires unilateral listing by a habitat country) and were later voted in as Appendix 2 species by the CITES parties (Keong, 2006).

To what degree can CITES regulations be implemented and enforced? The need for more officially trained import inspectors has been suggested numerous times. The agency chosen as the CITES management authority should be free of corruption and have experience in forest management. Insufficient trained staff has also hindered the ability of export authorities to determine whether an Appendix 2 species was legally obtained and non-detrimental to species survival. Range countries often require assistance in this respect. An unusually good example comes from Indonesia where biological data for ramin has been used in non-detriment findings to examine sustainability. Missing "certificates of origin" have been a problem for some Appendix 3 species. While ramin and big-leaf mahogany were listed on Appendix 3, the required 'certificates of origin' were not consistently issued by exporting nations; while importing countries were not always diligent about confirming that shipments arrived with such certificates (Blundell, 2007; Keong, 2006).

2. Independent forest monitoring (IFM)

In addition to CITES, actual improvements in forest monitoring on the ground are needed. A new system called independent forest monitoring (IFM) may be needed in order stop illegal logging, monitor implementation of REDD (Reducing Emissions from Deforestation and Forest Destruction) programs, restore the confidence of international donors, and ultimately to save Madagascar's precious forests as well as attain social justice for Madagascar's impoverished population. IFM has been defined as "the use of an independent third party that, by agreement with state authorities, provides an assessment of legal compliance, and observation of and guidance on official forest law enforcement systems" p. 18 (Global Witness, 2005). IFM is similar in principle to unbiased international election observers. Local and international expertise is utilized, and monitoring teams operate

independently but with the consent of the host government. Independent forest monitors are strictly observers, law enforcement remains the responsibility of local officials and governments.

Of course other nations have been faced with similar forest monitoring problems. IFM has already been used successfully in several African and Central American nations seeking to improve the effectiveness of their forest monitoring. Since it was first introduced in 1999, IFM has been established in Cameroon, Cambodia, and Honduras. Smaller scale feasibility and pilot studies have been conducted in Ghana, Peru, Mozambique, Republic of Congo, Tanzania, and Democratic Republic of Congo. In Cambodia and Cameroon, donor countries have been the impetus behind IFM. Though in Honduras, the incentive for IFM was domestic, and hosted by the Honduran Commission for Human Rights (CONADEH). Furones (2006) and Young (2007) review the results of IFM in these nations, and consider them to be "broadly positive". Specific examples of the impact of IFM in these nations include: documentation of hundreds of forest crimes, cancellation of logging concessions, moratoriums on logging and timber transport, and creation of new "forest crimes monitoring units" in the forestry administrations. In some cases, IFM has earned money for these governments by identifying violations which led to large fines against logging companies and individuals breaching the law and forest management regulations.

3. Update IUCN Red List assessments

The approximately 10 Madagascar rosewood species listed above have not had their official conservation status evaluated by the IUCN since 1998. At that time, all were threatened except for *D. mollis*. Five of the ten were already classified as 'endangered' then. Given the extreme logging since that time, it is likely that their Red List categories should be reassessed (IUCN, 2010).

4. UNESCO World Heritage Sites "in danger"

The majority of the illegally logged rosewood in Madagascar comes from two UNESCO World Heritage Sites: Masoala National Park and Marojejy National Park. Why have Masoala and Marojejy not been placed on the World Heritage Sites "In Danger" List? After all, 2010 is the United Nations "International Year of Biodiversity". Nine national parks and seven other protected natural areas are currently on this danger list, mainly for extensive anthropogenic disturbance such as poaching, logging, and war. The extent of the logging damage in Masoala National Park, in particular, over the past 5 years, must rival that of some of the other national parks "in danger". Placing a site on the UNESCO "danger list" is not utter de-listing. It is a reversible process meant to draw attention to and attract possible resources which can alleviate the crisis. There are specific funds that can become available if a site is placed on the danger list. One can only speculate that the reasons for no change in status may well be political and practical. Perhaps it complicates matters that eight national parks (which include these two) comprise the single Atsinanana World Heritage Site Complex. Perhaps there are fears of triggering an even greater loss of tourism. Whatever the reasons may be, it is odd that UNESCO has not been more vocal or active in its support of these two national parks which are the biodiversity jewels of the Atsinanana World Heritage Site Complex (IUCN, 2007).

5. DNA fingerprinting

DNA fingerprinting has recently been used on confiscated ivory to determine which populations of African elephants were slaughtered. Similar genetic techniques would be of great assistance in determining which populations of Madagascar rosewood are being logged the most, and in identifying species. DNA testing has already been used to track timber, but not yet in Madagascar. One of the biggest methodological challenges is extracting DNA from the heartwood of dead tree trunks (e.g., rosewood stockpiles), which consist of dead cells with partly degraded DNA. In living trees, it is a routine process to obtain DNA from the cambium just beneath the bark or leaves or buds. Nevertheless, several new techniques have successfully extracted DNA from dry wood of ramin (*Gonystylus* spp.) and other woods including 1000 year old beech (*Fagus* spp.) (Nielson and Kjaer, 2008).

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Photographer Toby Smith:
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Photographer Chris Maluszynsk:
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Rosewood logging films

Dan Rather Reports: Treasure Island. Episode 437. A detailed investigation of the impact of the recent political crisis in Madagascar on the unique biodiversity of this island continent. Filmed in high-definition, active rosewood logging camps are shown. The impact of such habitat disturbance on the silky sifaka and the World Heritage Sites of Marojejy NP and Masoala NP are discussed. The debates surrounding the Ambatovy nickel mine adjacent to Andasibe-Mantadia NP are also discussed. The mine may be endangering one of the rarest animals on earth, the greater bamboo lemur (*Prolemur simus*) which is being protected there by the NGO Mitsinjo. Aired on HD-NET cable television November 2009. Purchasable and downloadable on I-Tunes in the United States. DVDs can be purchased online:
hdnet-store.stores.yahoo.net/danrare437.html
Sample Clip 1:
www.facebook.com/video/video.php?v= 600388589544
Sample Clip 2: **www.youtube.com/watch?v= dEi-yRlJ-mk**

Carte Blanche: Madagascar (Part 1 and Part 2). Two short films examining illegal rosewood logging in Madagascar and the impact on the critically endangered silky sifaka. They were produced by Neil Shaw and commissioned and funded by Carte Blanche which is one of the most respected television news programs in the Southern Hemisphere. Aired on South African Television in April, 2010, and streams freely online here:
Carte Blanche: Madagascar Part 1:
beta.mnet.co.za/carteblanche/Article.aspx?Id= 3919&ShowId=1
Carte Blanche: Madagascar Part 2:
beta.mnet.co.za/mnetvideo/browseVideo.aspx?vid=25570

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Rosewood logging videos

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www.youtube.com/watch?v=FzWNPHBRrAc
Madagascar Rainforest Massacre (French):
www.youtube.com/watch?v=KtjmFWpGNKs&feature=related
Madagascar Rainforest Massacre (Malagasy):
www.youtube.com/watch?v=rHYYhhLHeQw&feature=related

Global Witness – Environmental Investigation Agency - Illegal logging in Madagascar – Part 1
www.youtube.com/watch?v=T1hPviSbRcU
Global Witness – Environmental Investigation Agency - Illegal logging in Madagascar – Part 2
www.youtube.com/watch?v=LBtsNBpWW0E
Global Witness – Environmental Investigation Agency - Illegal logging in Madagascar – Part 3
www.youtube.com/watch?v=payUUJed0dc
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Ongoing threats to lemurs and their habitat inside the Sahamalaza - Iles Radama National Park

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The Sahamalaza - Iles Radama National Park, officially inaugurated in July 2007 and managed by Madagascar National Parks (MNP), includes both marine and terrestrial ecosystems and is the first park that was created under the "Programme Environnemental III" of the Malagasy government and the World Bank. In addition to the few remaining forest fragments of the Southern Sambirano ecoregion, the park is home to extensive mangrove forests, which harbour their own highly endangered fauna, and also includes offshore coral reefs. In 2003, researchers from the Cologne Zoo, funded by AEECL, undertook an expedition to Sahamalaza to explore the opportunities for the establishment of a permanent field station in order to study and protect the Critically Endangered blue-eyed black lemur (*Eulemur flavifrons*) and its habitat. In 2004 and 2005, the field station in the Ankarafa Forest became reality (Schwitzer *et al*., 2006), and it has since been used by both European and Malagasy scientists as a basis for research on *E. flavifrons* and other lemur species, especially the Sahamalaza sportive lemur (*Lepilemur sahamalazensis*) and the northern giant mouse lemur (*Mirza zaza*), occurring on the Sahamalaza Peninsula (Schwitzer and Randriatahina, 2009).
Sahamalaza - Iles Radama National Park lies within a transition zone between the Sambirano region in the north and the western dry deciduous forest region in the south, harbouring semi-humid forests with tree heights of up to 30m (Schwitzer *et al*., 2006). The forests include a mixture of plant species typical of both domains (Birkinshaw, 2004), and the remaining primary and secondary forest fragments vary in their degree of degradation. There are no larger connected areas of intact primary forest left on the Sahamalaza Peninsula, and the remaining fragments all show some degree of anthropogenic disturbance and/or edge effects (Schwitzer *et al*., 2007). The forests and forest fragments are separated by grass savannah and shrubs. Sahamalaza is the only protected area that harbours the blue-eyed black lemur, the Sahamalaza sportive lemur and the northern giant mouse lemur. Other lemur species in the park include the aye-aye (*Daubentonia madagascariensis*), the western bamboo lemur (*Hapalemur occidentalis*), and an as yet unidentified species of dwarf lemur (*Cheirogaleus* spec.).
The remaining forest of the Sahamalaza Peninsula and its unique fauna are in grave danger of disappearing. The habitat is already extremely degraded, nonetheless bush fires and tree-felling are activities that are routinely pursued and accepted within the local society (Ruperti *et al*., 2008). During the first field season of a study on the impact of habitat degradation and fragmentation on the ecology and behaviour of the Sahamalaza Peninsula sportive lemur (*Lepilemur sahamalazensis*), conducted by MS in 2009, local people from the villages surrounding the protected area were found logging trees in the already small forest fragments almost on a daily basis. Logging activities mainly occurred in forest fragments where no researchers had been present in previous years. During walks through different forest fragments, in addition to large numbers of logged trees, two places where trees were processed for further use were found. Trees were felled mainly in the early morning hours, on the one hand because of the high temperatures later in the day, on the other hand probably because of the assumption that the researchers started observing animals later in the day and therefore would not realise the illegal logging activities. Nonetheless, trees were sometimes also felled in the afternoons. Because locals immediately fled when becoming aware of researchers' presence, we believe that the presence of researchers and/or field guides, park authorities or park rangers is a crucial factor in stopping illegal logging in the remaining fragments. For the next field season (2010) we therefore plan to expand the observations of *Lepilemur* to other, not yet used forest fragments to help prevent their destruction. Of course this cannot be a long-term solution to this problem. The presence of park rangers and further environmental education of the local people will thus be extremely important to save the Sahamalaza forests from further degradation.
About five times between August and October 2009, fires occurred near the Ankarafa field station, three times in the savannah and twice in the forest itself. After having extin-

Fig. 1: *Lepilemur sahamalazensis* poached and roasted by locals in Sahamalaza - Iles Radama National Park".

guished these fires it became obvious that they had all started right beside the fire breaks that are frequently used as paths by people on their way between villages. The Ankarafa field guides, all of them locals from the surrounding villages, assumed that the fires were set by villagers to show their dissatisfaction with the recently established national park that prohibits the use of the forests for collecting building material for their dwellings. As we followed the smoke that was coming from another fire, we found an area inside one of the core zones of the national park that was inhabited by a young couple. They harvested a rice field and regularly burned undergrowth around it. Additionally, they kept cattle and goats and had built 2 houses at this site, one for the cattle and one for themselves. As we talked to them, they claimed that they were allowed to stay on this site and that MNP had sold this part of the forest to them. They affirmed that, if they set fire on this site, they would keep an eye on it and would prevent the fire from expanding into the forest. Unfortunately this was not the case, however, as we later observed a fire around this site without anyone near it. Overall, it seemed that there were various people living inside the national park on permits given to them by what they claimed to have been MNP agents; we were told that there was a map of the park showing all the "excluded" areas available for housing and agriculture, which could be seen in the village of Marovato. If that was indeed the case (we did not have the opportunity to verify the information), it would be a massive problem for protecting Sahamalaza's unique wildlife and forests. If people claiming to be MNP staff illegally sold permits for activities inside the national park, the destruction of the small forest fragments will continue rapidly.

Another big problem comes with cattle; every day zebu cattle were observed in all forest fragments and on the savannah in Ankarafa, as people from nearby villages let their cattle roam freely. The abundance of zebu themselves and their excrements indicated that they frequently used the forest fragments as grazing grounds, especially those with remaining primary forest parts. When zebu were grazing in the forest rather than on the savannah, their movements were accompanied by crashing and breaking sounds; they were undoubtedly hindering the growth of many saplings, if not eating them. This is an additional threat to the forest fragments, and furthermore, the abundance of the excrements of local zebu has been found to negatively correlate with the density of *L. sahamalazensis* (Ruperti, 2007). Additionally, the introduced bush pig is responsible for considerable habitat destruction due to digging up large areas, thus hindering the growth of saplings. Unfortunately, the bush pig is reproducing wildly as it is regarded as fady (taboo) by the local people and therefore not hunted.

Not only the activities of local people seem to be a threat to the endangered wildlife on the Sahamalaza Peninsula. One of the Ankarafa field guides encountered a foreigner, probably a resident living in Madagascar (since he spoke Malagasy fluently), with a 4x4 car and two local guides about 1 km from the researchers' camp. These people had set up a tent and told the Ankarafa field guide that they were visiting all villages on the Sahamalaza Peninsula to look for fish. As we checked their camp site the next day, the three men were gone, but signs of a fire, logged branches and feathers of a harrier hawk were found, indicating that they had caught and killed this endangered bird of prey. We wrote a report about this event and handed it over, together with feathers of the bird, to MNP in Maromandia. However, as long as there are no signs, borders or fences indicating the national park area and its restrictions, these problems will continue.

The ongoing political crisis is a further big concern that hinders the effective protection not only of the biodiversity of the Sahamalaza Peninsula, but of Madagascar and its national parks system as a whole. Only 10 years ago, Madagascar was notorious for its environmental degradation and deforestation, but that began to change in 2003 when then President Marc Ravalomanana, working with international conservation organizations and local groups, set aside 10 % of the country's surface area as national parks and started supporting ecotourism, which slowed deforestation and helped to safeguard biodiversity. After the political events in early 2009 that saw the ousting of the President and the installation of a transitional government, the majority of donor funds, which provided half the government's annual budget, have been withdrawn, leading to major funding gaps that have affected protected areas and their management. There currently is almost no money to employ park rangers or to implement other measures to protect the forests inside Madagascar's national parks, and forest degradation is going on without noticeable resistance from the relevant authorities. Despite the political crisis that affects most of the social and environmental activities of numerous NGOs, AEECL is still carrying out its research activities and support to the villagers surrounding the Sahamalaza - Iles Radama National Park. Since the establishment of the protected area in 2007, AEECL has been conducting, besides its research programme, different projects that aim to reduce the excessive environmental exploitation inside and around the park. As the major activity of the local population surrounding the Sahamalaza Peninsula National Park is rice-growing, every year AEECL organizes a rice-growing training course and rice-growing competition, using modern techniques in order to increase yield per ha and to decrease the use of slash and burn agriculture. To stop the ongoing overexploitation of the environment, environmental education is another important part of AEECL´s work. As many villages in Sahamalaza are unable to pay teachers, AEECL subsidizes teachers' salaries to ensure the primary education of the local children. Additionally, leaflets about the Sahamalaza biodiversity and its importance are distributed. They inform and educate villagers about the importance of lemurs and other species for their forest ecosystem. To minimise bush fires and to protect the forest against uncontrolled fires, AEECL organizes firebreak programs around the Ankarafa Forest, close to the research camp, where during three days, hundreds of local people remove the grasses on a 7m wide strip around the forest fragments. Furthermore, several reforestation campaigns have been conducted, where villagers, including many teachers and their pupils, have planted trees around their villages with the help of AEECL.

Because of all the factors described here, the protection of Sahamalaza's unique flora and fauna continues to be a major challenge that has to be faced by the local human population with the help of Madagascar National Parks and foreign partners. Two essential parts of AEECL's efforts to help meeting this challenge are to stimulate further scientific study of endangered lemurs and other wildlife at its research station in the Ankarafa Forest, especially by Malagasy students, and to enable the local human population around the Sahamalaza - Iles Radama National Park to sustainably use their natural resources.

Acknowledgements

We would like to thank Madagascar National Parks (MNP), especially the director of Sahamalaza - Iles Radama National Park, M. ISAIA Raymond, for their continuing collaboration.

Thank you also to the DGEF and CAFF/CORE for granting us research permits for our work in Sahamalaza, and to Prof. RABARIVOLA Clément for his ongoing help. Tantely Ralantoharijaona and Bronwen Daniel, along with all Ankarafa field guides, contributed substantially to fighting forest fires and other environmental threats in Ankarafa in 2009. MS was funded by Bristol Conservation and Science Foundation, AEECL, Conservation International Primate Action Fund, Margot Marsh Biodiversity Foundation, Mohamed bin Zayed Species Conservation Fund, International Primatological Society and Christian-Vogel-Fonds.

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News and Announcements

Madagascar conservationist wins international environmental prize

Mr Rabary Desiré has been awarded the 2010 Seacology Prize (**www.seacology.org/prize/index.htm**) for his his tireless efforts to further forest conservation in northeastern Madagascar. Mr Desiré will receive the US$10,000 Prize on October 7, 2010 at a ceremony in Berkeley, California.

Rabary Desiré is recognized by many as a major conservation leader in northeastern Madagascar, and is a highly-sought-after research and eco-tourism guide. With the money he makes from guiding, he buys forested land in order to protect it. Years of work have finally culminated in the establishment of his own small private nature reserve called Antanetiambo (**antanetiambo.marojejy.com/Intro_e.htm**), which means "on the high hill". It is perhaps the only reserve in northern Madagascar that has been entirely created from start to finish by a single local resident.

According to Mr Desiré, "I am very happy to receive this award and I feel very lucky for myself and Madagascar. After many years of hard work and political instability, finally we are having some local conservation success. I plan to use these funds for such projects as reforestation, developing tourist

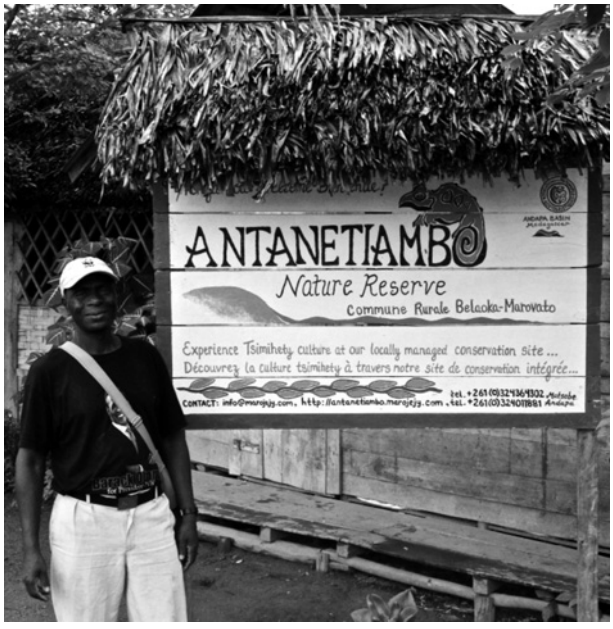

Fig. 1: Rabary Desiré next to the sign for the Antanetiambo Nature Reserve he created.

infrastructure and purchasing the land around Antanetiambo Nature Reserve to increase the size of the reserve and the amount of protected land in this region. This award will help preserve the precious biodiversity and high endemism of Madagascar, as well as fight the ongoing battle against massive deforestation and possible extinction of many beloved species... Thanks Seacology for giving me this prize. The whole region will never forget it."

Read the full press release:
www.seacology.org/news/display.cfm?id=4238

Célébration du quinzième anniversaire du GERP (1994-2009)

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Quinze ans se sont écoulés depuis la création, en 1994, de la Société de Primatologie malgache ou Groupe d'Etude et de Recherche sur les Primates de Madagascar (GERP). Elle fut fondée par dix Primatologues dont le Professeur Berthe Rakotosamimanana qui occupait à la fois le poste de Secrétaire Général du GERP et le Co-éditeur de la revue Lemur News jusqu'à sa disparition en 2005. De son vivant, elle désirait ardemment passer le flambeau au Docteur Jonah Ratsimbazafy pour le poste de Secrétaire Général du GERP qui, en 2006, a été mandaté à l'unanimité par les membres nationaux et internationaux du GERP au titre de Leader du GERP.

L'Association compte aujourd'hui 169 membres et 20 d'entre eux sont de nationalité étrangère. La multidisciplinarité des membres du groupe (Primatologues, Anthropologues, Paléontologues, Ornithologues, Herpétologues, Spécialistes de Micromammifères et Mammifères, Parasitologistes, Botanistes, Géographes, Vétérinaires, Agro-forestiers, Biochimis-

tes, Dessinateur, Financiers) apporte une importante potentialité dans l'accomplissement de la mission du GERP: transférer les compétences nécessaires à la préservation de la biodiversité pour les générations futures. Par ailleurs, les actions du GERP comprennent également la formation des pépinières de Primatologues, la mise en œuvre du plan de conservation des lémuriens, la contribution à l'amélioration des activités génératrices de revenu des communautés de base liées à la conservation, sans oublier l'éducation environnementale de la population cible.
En 2007, l'attribution par le GERP du nom de *Microcebus macarthurii* à une nouvelle espèce découverte dans la forêt de Makira représentait un témoignage de reconnaissance au dévouement de la Fondation MacArthur. De plus, le GERP a depuis 2008 officiellement été mandaté par le MEFT/DGEF/DSAP comme Gestionnaire de la forêt de Maromizaha, pour que cette dernière devienne une Nouvelle Aire Protégée (NAP). Plus récemment encore, en février 2010, le prix "lifetime" décerné par l'IPS a été attribué à un membre scientifique du GERP en la personne du Docteur Alison Jolly.
A l'occasion de son quinzième anniversaire, le GERP aura l'honneur d'organiser une conférence scientifique sur les lémuriens, à Antananarivo en novembre 2010.

Conservation International's Primate Action Fund: Projects funded March 2009 to March 2010

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Conservation International's Primate Action Fund awards small grants (up to $5,000) to support projects and initiatives promoting the conservation of primates worldwide, focusing on Critically Endangered and Endangered species in their natural habitats (and most especially those included in the biennial listing of the World's 25 Most Endangered Primates). Projects should contribute to at least one of the following themes: (1) enhancement of scientific understanding/knowledge of the target species/ecosystem; (2) improved protection of a key species, habitat, or a reserved area; (3) demonstration of economic benefits achieved through conservation of a species and its habitat, as compared to its loss; (4) increased public awareness or educational impact resulting from the project in question; (5) improved local capacity to carry out future conservation efforts through training or practical experience obtained through project participation; and (6) modification of inappropriate policies or legislation that previously led to species or habitat decline. Awards are given most frequently for population and distribution surveys, and ecological and behavioral studies pertinent to conservation initiatives for threatened species. Grants are also given that support genetic and taxonomic studies, publications, workshops for action plans and suchlike, and primate field courses. Some awards are given to help primate habitat-country primatologists attend the biennial congresses of the International Primatological Society. The fund does not support participation in academic courses.
The Primate Action Fund comes from an annual award to Conservation International, Arlington, Virginia, USA, made by the Margot Marsh Biodiversity Foundation. It is managed jointly by Ms Ella Outlaw and Dr Anthony B. Rylands, both of CI's Office of the President. Guidelines for application can be obtained by writing to Anthony Rylands (see Funding and Training section in this issue).
Five grants were awarded to benefit lemur conservation in the March 2009 – March 2010 funding cycle. They were as follows: (1) Halting politically-induced deforestation in the short term to preserve the unique primate community of Tsinjoarivo, eastern central Madagascar–Mitchell T. Irwin, Fanomezantsoa, Jean-Luc Raharison and Marina Blanco; (2) Rapid survey and assessment of the northern sportive lemur, *Lepilemur septentrionalis*, in the Sahafary Region, Madagascar–Edward Louis Jr, Jean
Ranaivoarisoa, John Zaonarivelo and Steig Johnson; (3) Support for the publication of the IUCN/SSC Primate Specialist Group newsletter and journal *Lemur News*, volume 14–Jörg U. Ganzhorn and Christoph Schwitzer; (4) Student training course "Field Methods in the Study of Primate Behavior and Ecology", Kirindy forest, 2010–Melanie Dammhahn, Peter M. Kappeler, Claudia Fichtel, Cornelia Kraus and Rodin Rasoloarison; and (5) Comparison of habitat requirements of the Data Deficient northern giant mouse lemur (*Mirza zaza*) in two differently degraded habitats, in Sahamalaza, northwestern Madagascar–Johanna Rode and Christoph Schwitzer.

International Technical Meeting on *Prolemur simus*, 26-28 January 2010, Antananarivo, Madagascar

The greater bamboo lemur *Prolemur simus* has long been considered to be one of the rarest primate species in the world. Up to 2007 only 60 individuals were known from the wild, and another 22 were in captivity (Wright *et al.*, 2008; Primate Conservation 23: 5-17). Once widespread across Madagascar, more recent confirmed sightings were exclusively from south-eastern Madagascar, which led to the assumption that the species was extinct on the rest of the island. In 2008, Dolch *et al.* (Lemur News 13: 14-17) rediscovered *P. simus* in the Torotorofotsy wetlands, north of the Mangoro River. Since then, several extensive surveys have been conducted north and south of the Mangoro, and evidence of greater bamboo lemurs was found at several sites in the Ankeniheny-Zahamena Corridor, in the central region of the eastern rainforest (King and Chamberlan, 2010; Oryx 44: 167).
In the context of developing a conservation action plan for the greater bamboo lemur, the Madagascar Fauna group organised, from 26-28 January 2010 at the motel d'Antananarivo, Anosy, an international technical meeting with the theme "Conservation of the critically endangered greater bamboo lemur *Prolemur simus*: What we know now, what we need to know and potential conservation strategies". Several members of the PSG contributed to this.
The objectives of the meeting were 1) to share information about the current situation of the various groups/populations of *Prolemur simus* in the wild and in captivity; 2) to discuss the threats, the solutions and the conservation strategies for three groups - north of the Mangoro River (Torotorofotsy and the Ankeniheny-Zahamena corridor CAZ), south of the Mangoro River (south-east and the Fandriana-Vondrozo corridor COFFAV), and in captivity (Madagascar and Europe); and 3) to make a plan, short to long term, to move towards a conservation action plan for the species.
With 28 participants, the meeting was well attended. Presentations were given by researchers studying *P. simus* in the wild and in captivity, representatives from the Ambatovy, Madagascar National Parks, the University of Antananarivo and

conservation NGOs. While other potential *P. simus* sites still need to be explored, results from the most recent surveys suggest the total estimated size of the known population is between 221-346 individuals**.** Another 20 individuals are housed in one Malagasy (Parc Ivoloina Zoo) and several European zoos and and managed under the umbrella of an EEP.

The following recommendations for the conservation of *P. simus* came out of the meeting:

- We need to achieve official/formal protection for all currently known *P. simus* habitat (using whatever status is appropriate to the site);
- Animals of the northern and southern populations (wild or captive) should not be mixed until the taxonomic situation is clarified;
- Faecal samples should be collected from all sites using a standard protocol (meeting participants agree to collaborate to achieve this);
- When animals are caught/immobilised the opportunity should be used to maximise the collection of samples;
- Bamboo plot data should be collected from all sites using a standard protocol (meeting participants agree to collaborate to achieve this);
- A health screening protocol should be applied whenever the opportunity arises;
- Sites in the Ankeniheny-Zahamena Corridor (CAZ) recently shown to harbour *P. simus* should be evaluated by 2011 at the latest to assess population size;
- Maromiza and Lakato need to be evaluated for the presence of *P. simus*, and protected to ensure connectivity;
- We agree that assuring connectivity between Torotorofotsy and CAZ is a high priority, and that the area needs an integrated conservation plan involving all stakeholders – CI to drive the process under supervision of the Alaotra-Mangoro Forestry Commission;
- It is important to make *P. simus* a priority (conservation target) for the CAZ;
- Improved communication using a mailing list will be established, the "*Prolemur* Conservation Working Group";
- There are other sites that need to be surveyed for *P. simus* (a list of sites has already been identified);
- Maximising connectivity between *P. simus* sites is important;
- Local communities should be directly involved in *P. simus* conservation wherever possible;
- In case of a crisis scenario involving potential translocation, a technical strategy is needed consistent with IUCN guidelines;
- The EEP-Ivoloina exchange of *P. simus* is important to strengthen the global captive population;
- For the time being, it is not recommended that additional wild *P. simus* be added to the global captive programme, except in emergency;
- In the case of emergency, we recommend that animals go to PBZT if upgraded facilities have been installed; if not then they should go to Ivoloina;
- Based on the development of the global captive programme, integrated (metapopulation) management of *P. simus* should be considered;
- Another technical meeting should be held in January 2011.

The workshop was financially and technically supported by the Madagascar Fauna Group with additional contributions from Conservation International Madagascar.

Lemur presentations at the 23rd Congress of the International Primatological Society, Kyoto, Japan

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The 23rd Congress of the International Primatological Society (IPS) was held in Kyoto (Yoshida Main Campus), Japan on 12th-18th September, 2010. This congress brought together more than 1,000 delegates from 56 countries. Twenty-eight talks and three posters were presented on lemur studies during that congress.

I am also pleased to share with you the good news that the winner of the 2010 IPS Lifetime Award is Professor Alison Jolly who is an active member of GERP (Groupe d'Etude et de Recherche sur les Primates de Madagascar). The lemur lady, Prof. Jolly, has devoted her life to the conservation of the world's primates. Education is one of the main activities that she never stops to discuss, as she found that the only chance to save the endangered lemurs of Madagascar is to provide the Malagasy children with tools enabling them to learn and love the creatures that exist in their backyards.

I hope that even more lemur researchers will present the results of their work at the 24th IPS Congress in Mexico.

Short Communications

Preliminary conservation status assessment for the Data Deficient northern giant mouse lemur *Mirza zaza*

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Madagascar is one of the world's most important biodiversity hotspots, underpinned by its large proportion of endemic species and high rates of deforestation. During the last decade, species diversity of Madagascar's endemic lemurs has increased dramatically due to new discoveries and taxonomic revisions. This has resulted in the unusual situation of 45 % of all Malagasy primate species being Red-Listed as Data Deficient (DD) by the IUCN. This is by far the highest such figure for any primate habitat country (by comparison, 13 % of all primates and 15 % of all mammals are Red-Listed as DD). The lack of species-specific knowledge makes it impossible to design effective conservation measures targeting these taxa. To help assign a conservation status to the DD northern giant mouse lemur *Mirza zaza*, described in 2005 due to distinctive features in morphology, behaviour and genetics (Kappeler *et al.*, 2005; Primate Report, 71, 3-26), we examined space requirements and group size of this small nocturnal lemur species during a three-month study (May-July 2010) and extrapolated our results to the taxon's area of

occupancy in order to estimate the size of its remaining population.

Mirza zaza lives in dry forests of north-western Madagascar, one of the fastest declining habitats of the island, with a decrease in forest cover of 40 % from 1975 to 2000. The area of occurrence of the species is limited by the Maeverano River in the south and the Mahavavy River in the north. Combining forest cover data collected by the Madagascar Vegetation Mapping Project (**www.vegmad.org**) with data on group home range size and group size calculated from our study and additional literature, we calculated minimum and maximum estimates of total remaining population size. Since data for the Madagascar Vegetation Mapping Project were collected several years ago, we lowered the estimate of total available habitat according to the estimated annual rate of decline. Habitat decline may have accelerated since the onset of the political crisis in Madagascar in early 2009, which is not yet reflected in our estimates. Since a previous survey failed to detect *Mirza zaza* in several regions within the species' area of occurrence, we applied different estimates of the percentage of suitable habitat actually inhabited by the species. Our calculations yielded the following estimates:

- Maximum estimate: The total area covered in dry forest within the area of occupancy of *M. zaza* is approximately 1,650 km^2. Assuming an occupancy of 80 %, group home ranges of 2 ha and group size of 4 individuals there would be max. 177,500 animals left in total.
- Minimum estimate: In order to reflect the long-term survival of the species in a very fragmented area, only fragments ≤ 1 km^2 and smaller fragments closer than 500 m to other, larger fragments (total area: 955 km^2) were considered. We chose 1 km^2 to allow a minimum viable population of 250 animals. If only 30 % of the habitat is inhabited, animals use group home ranges of 4 ha and live in groups of on average 2.3 animals, this leads to an estimate of 16,500 individuals left.

Mirza zaza should be assessed as Vulnerable (VU B2ab) since its area of occupancy in both estimates is lower than 2,000 km^2. With several sites within the species' distribution area found to be unoccupied, the remaining habitat being extremely fragmented with the smallest fragments unsuitable to support a viable population, and habitat vanishing quickly, *M. zaza* may become Endangered (EN B2ab) in the near future if its area of occupancy shrinks below 500 km^2.

Our preliminary conservation status assessment used the best available data for *Mirza zaza*. More accurate estimates will be possible if more data become available, especially on percentage of occupancy. This method might be applied to other DD lemur species in order to gain initial assessments of their conservation status.

An observation of the hairy-eared dwarf lemur, *Allocebus trichotis*, in the Lakato region, eastern Madagascar

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Although a few decades ago the hairy-eared dwarf lemur (*Allocebus trichotis*) was considered "unquestionably the rarest of surviving lemurs" (Tattersall, 1982, p. 131), more recent field work has found this species to be widely distributed across portions of the eastern humid forests of Madagascar (e.g., Meier and Albignac, 1991; Rakotoarison, 1998; Schütz and Goodman, 1998; Goodman and Raselimanana, 2002). Since more than a decade, there have been numerous records of this species from the central portion of the eastern humid forests, and information is now available on aspects of its ecology and natural history (e.g. Rakotoarison *et al*., 1997; Garbutt, 2000; Biebouw, 2009; Ralison, 2010). Here we add an additional record from the region of Lakato, an area from where this species had not been previously recorded.

From 22-28 October 2010 we were part of a research group that conducted a biological inventory of a forest block in the Lakato area and in the southern portion of the Zahamena-Ankeniheny forest corridor. The specific study site was centered at the following locality, which served as the base camp for all inventory activities: Province de Toamasina, Alaotra-Mangoro Region, 14.5 km SW of Andasibe (Périnet) village, Ampasipotsy-Anivonimaro/Ambalafary Forest, 19°02'38"S, 48°20'55"E, 995 m elevation.

During a nocturnal survey on 28 October 2010, the first author observed and photographed an individual of *A. trichotis*. The animal appeared not to be accompanied by any conspecifics. The distinctive ear-tufts, characteristic of *Allocebus*, were clearly visible (Fig. 1). The lemur was observed at 21h58 and for about five minutes. The site was in partially disturbed lower montane forest, about 200 m away from the research camp and within a few meters of the dirt road connecting the RN 2 (connecting Antananarivo-Toamasina) and the village of Lakato. The animal was not particularly active and rested in the upper portion of a 4 m tall tree. As it was photographed, including the use of flash, the individual remained largely stationary, until it finally turned and moved off into another tree and into dense vegetation.

During the course of nocturnal observations of forest animals within the study site, this was the only observation of *A. trichotis*. Each night numerous individuals of *Microcebus* cf.

Fig. 1: Photo of *Allocebus trichotis* taken during the night of 28 October 2010 in a forest block approximately halfway between the turn-off of RN 2 and the village of Lakato. The ear-tufts of this animal, diagnostic of this species, are readily visible in the photo.

lehilahytsara were observed in close proximity. Although *A. trichotis* is now known to have a broad distribution across a good portion of the eastern humid forests, from lowland to montane forests (up to about 1,000 m), it occurs in low densities (Mittermeier *et al*., 2006). This factor might account for its absence in other forested sites surveyed within the Zahamena-Ankeniheny forest corridor (e.g., Schmid *et al*., 1999; Randrianabinina and Rasoloharijaona, 2006). However, continued surveying efforts at these sites will probably result in the finding that it occurs across the forest corridor.

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When big lemurs swallow up small ones: Coquerel's dwarf lemur as a predator of grey mouse lemurs and endemic rodents

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Predation has probably played a major role in the evolutionary history of lemurs, and specifically affects small nocturnal lemurs, which are heavily predated upon by a wide range of vertebrates, including carnivores (e.g., viverrid or domestic carnivores), birds (e.g. raptors, owls) or reptiles (e.g. *Boidae*) (Goodman, 2003). In contrast, lemur predation by other lemur species appears exceptional and highly opportunistic, with one observed case of predation of an infant *Lemur catta* by *Eulemur fulvus* (Pitts, 1995). However, such events might occur more regularly in other lemur species. Two indirect lines of evidence suggest that Coquerel's dwarf lemur (*Mirza coquereli*) predates on closely related smaller mouse lemurs (*Microcebus* sp.) (Kappeler and Rasoloarison, 2003). The first report is based on events where the partially eaten carcass of a gray mouse lemur (*M. murinus*) was found together with a live *M. coquereli* in a trap (Goodman, 2003). The second observation consists of an experimental confrontation of *M. murinus* with *M. coquereli*, both being kept in separate cages that were temporarily placed next to each other. In most experiments, mouse lemurs started alarm-calling at the Coquerel's dwarf lemur and moved around in their cage in an agitated fashion (Fichtel, 2009). Here, we present the first direct evidence of predation by wild *M. coquereli* upon gray mouse lemurs and endemic rodents (western tuft-tailed rats, *Elliurus myoxinus*).

Study animals, study site and methods
Coquerel's dwarf lemurs (300 g; mean home range size: 4 ha) occur in the western lowland forests and gray mouse lemurs (60 g; mean home range size: 1.5 ha) can be found in most remaining forests in southern and western Madagascar (Kappeler and Rasoloarison, 2003; Rasoloarison *et al*., 2000). Both species share several features. Both are nocturnal and omnivorous solitary foragers. They mainly feed on primary resources (fruits, gum, flowers, young leaves), insect secretions, small invertebrates and occasionally vertebrates (chameleons and lizards). Their diet displays seasonal fluctuation, as well as interspecific variation (Goodman, 1993, 2003), and the Coquerel's dwarf lemur is reported to be slightly more carnivorous than the gray mouse lemur (Petter *et al*., 1977). In captivity, both species have been observed eating young rodents (Petter *et al*., 1977) although this has never been reported in the wild. Both species occur sympatrically in central western Madagascar with western tuft-tailed rats, a nocturnal, frugi- and granivorous and partially arboreal rodent (average body mass: 66 g) (Carleton, 2003).
All following observations were made in the Forêt de Kirindy, a 12,500 ha forestry concession of the C.N.F.E.R.E.F. (formerly C.F.P.F.) Morondava. This dry deciduous forest is situated 60 km northeast of Morondava (44°39´E, 20°03´S). The predation of the western tufted-tail rat was witnessed during a focal observation of a Coquerel's dwarf lemur which was equipped with a radio collar (Biotrack TW3). The observed mouse lemurs were similarly equipped with radio collars (Holohil Systems Ltd., BD-2C, 1.8 g), permitting behavioural observations of focal animals.

Results and discussion
The first observation reports the predation of a western tuft-tailed rat by an adult male *M. coquereli* in November 2006 (Fig. 1). The Coquerel's dwarf lemur was found sitting on the ground at 20h17, feeding on a tufted-tail rat, and changed its position only to climb-up the vegetation from 1-3 m height and to recover the carcass when it fell to the ground. It devoured the whole carcass, including (cracked) bones. After finishing eating, the *M. coquereli* groomed its face and hands.

Fig. 1: An adult Coquerel's dwarf lemur (*Mirza coquereli*) in the Foret de Kirindy, Madagascar.

The second observation reports an unsuccessful attack on an adult female gray mouse lemur (55 g, approx. age: 1 year and 9 months) by a Coquerel's dwarf lemur in October 2009. At 21h24, the mouse lemur had been foraging high up in the vegetation (between 6 and 15 m) for at least 10 minutes, licking sugary insect secretions off leaves, when a *M. coquereli*, adult size, was spotted at the same height, about 10m from the focal subject, slowly and silently moving towards the mouse lemur. Marking brief and frequent pauses in an apparently easy progression into the canopy, its whole attitude strongly recalled the hunting cat, with a low head and a flexible body, apparently entirely focused on its prey. In less than 30 seconds, the *Mirza* was within 5 m of the mouse lemur, who kept feeding in the same location. While the *Mirza* approached within 2 m, the mouse lemur suddenly disappeared in an eclipse, quickly fleeing among the top and tiniest branches, and jumping from one slim branch to the next. The Coquerel's dwarf lemur did not try to chase it. After 2 minutes out of sight, the mouse lemur was retrieved quietly feeding on tree exudates, 25 m away from its previous localization in its fleeing direction, and 15 m away from a frequently used sleeping site. Less than 10 minutes later, the female was joined by a related female and both entered the tree hole together (21h37).

Finally, an adult Coquerel's dwarf lemur was observed feeding on a young male gray mouse lemur (body mass: 37 g; approx. age: 2-3 months) in June 2010. The predation was recorded at 22h10, about two hours after behavioural data had been collected from the predated mouse lemur, which at the time showed no signs of injuries and displayed normal behaviour. The body of the gray mouse lemur was almost complete when the observer spotted the *M. coquereli* feeding on it, suggesting that the mouse lemur was killed shortly before. The Coquerel's dwarf lemur was sitting with its prey in a tree of about 10m height, which stood 25 m away from the position where the grey mouse lemur was last spotted alive. It took about one hour to finish the entire carcass, interrupted by occasional vigilance scans of the surroundings.

The frequency of such events is probably relatively low, and all reported observations happened during, or at the end of, the dry season in Kirindy. It is thus possible that predation pressure by *M. coquereli* increases at times of food scarcity, when alternative resources like fruits and invertebrates are rare or absent. However, it is also important to note that most observations took place during the dry season, when vegetation density is low in this dry, deciduous forest. This means that the timing of events reported here might simply reflect study methods. Nevertheless, this suit of anecdotal observations represents the first direct and unambiguous evidence for predation by the Coquerel's dwarf lemur upon small nocturnal lemurs, as well as other mammals. Predation among other primate species is relatively rare. So far, only chimpanzees, orangutans, baboons, blue monkeys and capuchins have been observed preying upon other primates (Fichtel, in press). Our report provides evidence for the first case where a lemur species might commonly predate upon other lemurs.

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Collective mobbing of a boa by a group of red-fronted lemurs (*Eulemur fulvus rufus*)

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Key words: red-fronted lemurs, boa, predation, mobbing, anti-predator behaviour

Introduction

Collective anti-predator behaviour is one of the principal advantages of group-living (for mammals, e.g., Janzen, 1970; van Schaik, 1983). It can be broadly divided into two strategies and tactics employed before and after predator encounters (Caro, 2005; Rahlfs and Fichtel, 2010; Fichtel, in press). While the former include predator-sensitive foraging and increased vigilance, mobbing occurs in several mammal species after detecting a predator (e.g., Tamura, 1989). Why animals engage in mobbing and who benefits from it in which way remains an unresolved question in animal behaviour (for reviews see Curio *et al.*, 1978; Shields, 1984). Until today, published field observations of group-living lemurs mobbing a predator are rare (summarised in Scheumann *et al.*, 2007). Regarding snakes, only three interactions have been described so far (Colquhoun, 1993; Rakotondravony, 1998; Burney, 2002). Here, we report a prolonged mobbing display against a Madagascar ground boa (*Acrantophis madagascariensis*) by a group of red-fronted lemurs (*Eulemur fulvus rufus*) in Kirindy Forest. Observations like this may help to elucidate fundamental mechanisms of collective anti-predator behaviour by contributing to a pool of data on mobbing by particular pairs of prey and predators.

Observations

The event was observed during regular behavioural observations of red-fronted lemurs in Kirindy Forest, 60 km north of Morondava. It was the only snake-lemur interaction observed during the entire study period from November 2007 to April 2010, in which four lemur groups were followed daily by one or two observers, respectively (> 4,000 h of observation data). Red-fronted lemurs live in multi-male, multi-female groups of 5-12 individuals (Pereira and Kappeler, 1997; Wimmer and Kappeler, 2002). The study group (B) that encountered the boa included 9 individually marked animals at the time (2 adult females, 5 adult males, 1 juvenile male, 1 male infant).

On March 1, 2010, at 7.19 h, sudden alarm calls of several red-fronted lemurs were heard in the study area known as CS7. Six individuals (2 adult females, 2 adult males, 1 juvenile male, 1 male infant) could be identified after approaching the group to within 10 m. Three of them (2 adult females, 1 adult male) emitted "Woofs" and "Huvvs", vocalisations typically uttered during predator encounters (Fichtel and Kappeler, 2002). The 5 individuals surrounded an approximately 2 m long Madagascar ground boa (Fig. 1) that was lying motionless on the ground. The lemurs sat at a height of 1-2 m, each about 3 m away from the snake, wagging their tails vigorously, except the infant that kept a distance of 5 m during the entire event and did not display any vocalisations or tail-wagging. During the next 4 min, one of the adult males approached the front end of the boa twice, getting as close as 1-2 m. After 5 min, he left the scene. During this time, one of the adult females also approached the snake up to within 2 m. When the male left, the second female started to quickly circuit the boa for 4 min, maintaining a distance of 2-3 m. After 14 min of several approaches and continuous alarm calls by 3-5 individuals, the boa moved for the first time, heading slowly away. The remaining adult male approached the moving snake also within 2 m; also at its front end. About 1 min later, the boa had moved 15 m away, and the lemurs left in the opposite direction, still uttering grunts continuously. Once the boa was out of sight, the mobbing stopped and the lemurs` behaviour returned to baseline levels.

Fig. 1: Madagascar ground boa in Kirindy. (Photo: Lennart Pyritz)

Discussion

The mobbing reaction of the group was strong and prolonged and included most of the group members. This is similar to the behaviour of a black lemur (*Eulemur macaco macaco*) group encountering a Madagascar boa at Ambato Massif, where the group mobbed the snake for 15-20 min, and some individuals approached it as close as 1 m before finally leaving the location (Colquhoun, 1993). It is also noteworthy that females and males mobbed and approached the snake in equal measure as observed in a number of other species (e.g., Tamura, 1989; Ferrari and Ferrari, 1990; Tello *et al.,* 2002). The infant maintained a larger distance to the boa and did not engage in the mobbing displays, however. Similar infant behaviour has also been reported for other primates (e.g., Ferrari and Ferrari, 1990) and might be due to a higher susceptibility to an attack due to smaller body size or a lack of innate experience regarding predator encounters and mobbing strategies (Curio *et al.*, 1978; Fichtel, in press).

The strong mobbing reaction of the lemurs might be explained by the hunting strategy of the snake. Boas are ambush hunters that usually abandon an attack as soon as they have been detected (Montgomery and Rand, 1978; Slip and Shine, 1988). Therefore, it seems beneficial for prey animals to signal the ambush hunter quickly and distinctly that it has been detected. As boas do not pursue their prey after an unsuccessful attack, it is also unsurprising that the lemurs' behaviour returned to baseline levels of anxiety shortly after departing the site of the predator encounter. In contrast, groups of red-fronted lemurs showed increased vigilance behaviour for at least 30-60 min after encountering a fossa (*Cryptoprocta ferox*; pers. comm. Jean-Pierre Tolojanahary and pers. observation by LP), which is probably due to the higher agility and climbing abilities of the largest mammalian carnivore. Furthermore, fossas have been observed to hunt cooperatively and pursue prey up to 45 min (Lührs and Dammhahn, 2009).

There are no quantitative data on predation rates of lemurs by snakes in Kirindy, only opportunistic observations (e.g., Schülke, 2001; Eberle and Kappeler, 2008) that are biased by several factors, however. The low observation rate of boa-lemur interactions could be due to the reptiles` nocturnal lifestyle (Raxworthy, 2003), so that most of the attacks would occur at night when no or only few observers are working in the forest. Furthermore, boas at Kirindy are only active during the rainy season from January to April, when observations are often limited by dense foliage and frequent rainfalls.

Five of the six individuals taking part in the mobbing were related (1 adult female and her 4 offspring from the last 4 years), while it is currently unknown whether the second adult male sired one of the two youngest group members. However, due to the small number of detailed observations of predator encounters it remains impossible to identify the ultimate causes of collective mobbing (kin defence/parental care, self-/group defence or cultural transmission of enemy recognition; Curio *et al.,* 1978) in this species for the time being.

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Response of two nocturnal lemurs (*Microcebus murinus* and *Lepilemur leucopus*) to a potential boiidae (*Sanzinia madagascariensis*) predator

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Primates display an array of responses to predators, and differences in these responses were once thought to exist based on activity pattern. Solitary foraging, cryptic coloration, and cryptic movements to remain hidden from predators were considered anti-predator adaptations among nocturnal primates while diurnal primates used large group size to enhance their ability to detect and defend against predators, give alarm calls to warn conspecifics of the presence of a predator, and flee from predators (Hill and Dunbar, 1998; Isbell, 1994; Stanford, 2002). As research into nocturnal primate behavior expanded, results revealed that, like diurnal primates, nocturnal primates display a range of anti-predator behaviors upon encountering a predator (Fichtel, 2007). Nocturnal primates vary in the type of response (mobbing, alarm calling), height in the canopy, proximity to other individuals, and vigilance levels in the presence of different predators (Fichtel, 2007; Gursky, 2002, 2003, 2005, 2006; Schuemann *et al.*, 2007; Schulke, 2001). In particular, mobbing behaviors are well- documented in tarsiers (*Tarsius* sp.), mouse lemurs (*Microcebus* spp.), and fork-marked lemurs (*Phaner furcifer*) (Gursky, 2007; Eberle and Kappeler, 2008; Schulke, 2001). Mobbing includes close approach, touching, sniffing, and pouncing on the predator (Gursky, 2007). Interspecies mobbing of a predator occurs as well. Fork-marked lemurs and coquerel's dwarf lemurs (*Mirza coquereli*) together mobbed a snake (*Boa manditra*) (Schulke, 2001).
Several hypotheses have been put forth to explain the evolution of mobbing behavior (Eberle and Kappeler, 2008): 1) by-product mutualism in which individuals defend others in the process of defending themselves, 2) reciprocity where animals obtain higher fitness by cooperating with others, and 3) kin selection whereby animals cooperate when they share common genes. A fourth hypothesis known as perception advertisement was developed as an explanation for the evolution of alarm calling and other mobbing behaviors in birds (Curio *et al.*, 1978; Zuberbuhler *et al.*, 1999) but has been extended to account for the presence of mobbing behaviors in primates (Gursky, 2005). According to this hypothesis, alarm calling and mobbing are signals to the predator that the element of surprise has been lost. Snakes, leopards, and other animals that hunt by crypticity and rely on the element of surprise to capture prey are common recipients of alarm calling and mobbing. Research on both diurnal and nocturnal primates suggests that alarm calling and mobbing by these primates results in predators leaving an area (Zuberbuhler *et al.*, 1999; Gursky, 2006). Here I report the divergent responses of two species of nocturnal primates (*Microcebus murinus* and *Lepilemur leucopus*) to the same potential predator- a nocturnal boiidae snake (*Sanzinia madagascariensis*) and discuss implications for the above hypotheses based on these observations.

Methods

The observations reported here were made in the Ankoba gallery forest of Berenty Private Reserve in southern Madagascar. The encounters between the snake and primates were observed in the course of a six month study investigating the ecology of *Microcebus murinus*. During this study, trails within the reserve were walked to locate unhabituated mouse lemurs. When encountered, the time at which the encounter began, height, location, and activity of the mouse lemur were recorded continuously until the mouse lemur was out of sight for more than five minutes. The time, height, and activity of potential predators were also noted when they were encountered, but predators were not followed unless they were within proximity to a primate.

Results

While conducting walks to locate mouse lemurs in May 2009, a sportive lemur alarm call at 20:52 alerted me to the pres-

ence of a boiidae snake later identified as *Sanzinia madagascariensis*. I saw two white-footed sportive lemurs (*Lepilemur leucopus*), one located at 4m height and the other at 5m height in a tree over the trail. The sportive lemurs were barking and looking at the snake. The snake was moving at approximately 4 m high in a tree and was attempting to cross a gap and move into a tree nearer to the tree in which the sportive lemurs were located. The attempt was unsuccessful as the snake slipped and almost fell out of the thin, terminal branches. The snake then moved down to 3.5 m height and began crossing the canopy gap along thicker branches. The sportive lemurs continued to alarm bark at the snake until 21:02 when the snake turned away from the gap in the canopy and began moving lower down in the tree and away from the sportive lemurs. The sportive lemur alarm calling ended by 21:04 when the snake had traveled down the tree trunk to 3m in height. The sportive lemur lowest in the tree continued to watch the snake while the other sportive lemur moved to 8m height in its tree and began feeding.

At 21:15, I was preparing to leave the area when I noticed a mouse lemur at 0.5 m in the same tree as the snake. The snake was at 3 m height in the tree and moving down the main trunk of the tree. The mouse lemur looked at me as it walked up the main trunk of the tree in the direction of the snake. The snake faced the mouse lemur, but the mouse lemur did not appear to notice the snake as it alternated looking in my direction with looking around its immediate area while foraging for insects. The mouse lemur continued to move up the tree until it was within 0.25 m of the snake where it paused and looked intently at the spot where the snake was located and then jumped backwards away from the snake. The mouse lemur then began moving around the tree at the same height (3 m) as the snake, jumping to terminal branches, and running along main branches while pausing to look at the snake. The mouse lemur's movements took it from 1m to only a few cms in distance from the snake. The mouse lemur continued this pattern of running and pausing to examine the snake for 7 mins. The mouse lemur then began foraging for insects in a neighboring tree at 3-4 m height and within 1-2 m of the snake. While foraging, the mouse lemur would pause to look in the direction of the snake which remained motionless. The mouse lemur foraged in this manner for 4 mins until a sportive lemur alarm called. Prior to the alarm call, the mouse lemur was foraging approximately 1m from the snake and the snake began moving down the tree trunk. At the sound of the sportive lemur alarm call, the mouse lemur jumped to 2 m distance from the snake and paused in its foraging to watch the snake. The snake remained motionless. A minute later the sportive lemurs alarm called again. The snake began moving down the trunk of the tree again and the mouse lemur moved to forage insects in trees that were approximately 3-5 m from the snake and at 5m height. After 5 mins of foraging at this increased distance from the snake, the mouse lemur moved back into the tree where it was initially observed and foraged within 1m of the snake for 2 mins. The mouse lemur then moved close to the snake coming within less than 1m of the boa and running and jumping around the snake while pausing to watch it while standing bipedally. After 3 mins of remaining motionless while the mouse lemur ran, jumped and watched the snake, the snake began moving back up into the dense crown of the tree. The mouse lemur continued running and jumping around the snake and watching it at a distance of 0,5-1 m away as the snake moved into the crown of the tree. 8 mins later, the mouse lemur began foraging insects at 3-4 m height in the canopy and within 0,5-1 m from the snake with occasional glances in the direction of the snake. The mouse lemur then moved further away from the snake and foraged insects at 5m in height and approximately 5 m distance from the snake. At 21:46 the mouse lemur was out of sight and did not return by 21:51 when I left and continued the mouse lemur walk. A return visit to the location at 10:05 for species identification of the species revealed the presence of no mouse lemurs or *Lepilemur* in the vicinity.

Discussion

Eberle and Kappeler (2008) describe the successful mobbing of a *Sanzinia madagascariensis* by two female and one male mouse lemur (*Microcebus murinus*). The mobbing caused the snake to release a captured male mouse lemur. Subsequent genetic analysis revealed that the mobbing females were related to the attempted victim (Eberle and Kappeler, 2008). Additional encounters between mouse lemurs and snakes without captured prey did not elicit mobbing behaviors from the mouse lemurs (Eberle and Kappeler, 2008). Instead, the mouse lemurs sat approximately 2 m from the snake and watched it. (Eberle and Kappeler, 2008). The mobbing of the snake by relatives of a captured mouse lemur and the lack of mobbing behaviors by solitary mouse lemurs in Eberle and Kappeler's study support the kin selection hypothesis for the evolution of mobbing behaviors. However, the solitary mouse lemur observed in this study displayed mobbing-like behaviors in the absence of kin or other individuals. Additionally, under experimental conditions, solitary mouse lemurs monitored model snakes and even locomoted towards the model predators (Rahlfs and Fichtel, 2010). The presence of mobbing-like behaviors in solitary animals lends support to the by-product mutualism hypothesis. Mouse lemurs may display mobbing-like behaviors as an individual strategy and then when larger numbers of mouse lemurs contact a predator, the appearance of a group-defense strategy may result from multiple individuals pursuing the same strategy.

The observations here also lend support to the perception advertisement hypothesis. The mouse lemur may have benefited by displaying mobbing behaviors toward the snake to let the snake know that it was being monitored and would not surprise the lone mouse lemur as it foraged. However, a prediction of the perception-advertisement hypothesis is that cryptic predators should flee when faced with alarm calls and mobbing as they cannot surprise prey in their vicinity. The alarm calling by the sportive lemurs and the mobbing-like behaviors of the mouse lemur observed in this study did not cause the snake to flee. Instead, the snake remained in the area while both the sportive lemurs and mouse lemur left the area. Size of the mobbing and alarm-calling group may be important. Tarsiers were more likely to retreat first if their mobbing group consisted of four or fewer individuals (Gursky, 2007). The small group sizes here may have not caused the predator to flee, but may have served as an adequate warning that it had lost the element of surprise and should not expend energy in an attack.

Of particular interest in these observations was the opportunity to view the responses of two different nocturnal primate species to the same predator. Such observations are infrequent in the literature. Schulke (2001) observed *Phaner* and dwarf lemur (*Mirza coquereli*) together mobbed *Boa manditra*. In the case of the sportive and mouse lemurs, neither showed the same behavioral response to the *Sanzinia madagascariensis*. The pair of *Lepilemurs* maintained a larger distance between themselves and the snake than did the mouse lemur. The mouse lemur did not vocalize in the vicinity of the snake, however, the sportive lemurs vocalized during their encounter with the snake. Mouse lemurs seldom respond to predator models with alarm calls in experimental

conditions (Rahlfs and Fichtel, 2010). Nocturnal primates and other mammals may not rely on alarm calls as an anti-predator strategy (Rahlfs and Fichtel, 2010) because early detection of predators at night is more difficult and solitary foraging may limit the usefulness of this strategy. The sportive lemurs however did alarm call in the presence of the snake. Alarm calls in nocturnal primates may function as a deterrent to the predator or to recruit conspecifics in defense against the predator (Rahlfs and Fichtel, 2010). The exact function of the sportive lemur alarm calls in this study cannot be determined, but they do reveal a need for future studies to examine potential variation in alarm call behaviors between nocturnal species. Given variation in body size, diet, and sociality in nocturnal primates, we might expect variation in anti-predator behaviors such as alarm calling among nocturnal species.

The possibility exists that the mouse lemur may have recognized the alarm calls of the sportive lemur because it increased its distance from the snake, ceased foraging, and monitored the snake following an alarm call. Recognition of the alarm calls of other species has been documented for birds, small mammals, and primates including diurnal lemurs (Fichtel, 2004; Rainey *et al*., 2004; Shriner, 1998). However, the suggestion that mouse lemurs recognize sportive lemur alarm calls needs to be further investigated with field experiments. The ability of nocturnal primate species to recognize the alarm calls of other sympatric species would be beneficial to animals that frequently forage away from conspecifics.

The few encounters documented between nocturnal primates and their predators describe a range of anti-predator responses that vary depending on the type of predator, proximity of conspecifics, and available vegetative cover. Such flexibility is interesting because nocturnal primates- especially mouse lemurs- are often used as living models for the ancestral primate. The anti-predator behaviors of nocturnal primates such as mouse lemurs may reflect the primitive primate or even primitive mammal condition (Stanford, 2002). The range of anti-predator behavior described for nocturnal primates in this and other studies implies that the flexibility in anti-predator behaviors observed in primates have a more ancient origin than originally suspected or that mouse lemurs and sportive lemurs have developed divergent anti-predator behaviors that may not have been present in early mammals and primates. Wider use of experiments to explore the differing conditions which elicit variable responses to predators within and between nocturnal species will be necessary to develop a more complete understanding of ancestral versus derived anti-predator behaviors. Additionally, comparative research exploring variation in anti-predator behaviors in other nocturnal mammal species will be needed.

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Effective predation defence in *Cheirogaleus medius*

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Besides one's own death, the predation of offspring is the most severe loss of fitness possible. In species that invest significantly in their offspring it is therefore natural that this "expensive" offspring should be guarded to avoid predation. Nonetheless, and particularly in small animals, it is uncertain whether an adult can effectively defend its offspring when it is attacked by a larger predator.

The fat-tailed dwarf lemur (*Cheirogaleus medius*) is a small (130 g), strictly nocturnal primate that occurs in the dry, deciduous woodlands of western Madagascar, and lives in social monogamous small family groups consisting of a reproductive male-female pair and their offspring from one or more breeding seasons. Males and females maintain lifelong pair bonds and usually separate only when one partner dies (Fietz, 1999; Müller, 1999; Fietz and Dausmann, 2003). The

diet of *C. medius* consists mainly of fruits and varying proportions of arthropods depending on the season (Fietz and Ganzhorn, 1999). *C. medius* is unique among primates because it spends seven months hibernating during the cooler dry-season of the southern winter (April to October), when food and water availability are low (Petter, 1978; Hladik *et al.*, 1980; Dausmann *et al.,* 2004). When resting during the day and when hibernating, the dwarf lemurs occupy tree hollows either alone or with members of the family group (Dausmann *et al.,* 2005). In the wild, female *C. medius* usually give birth to twins and in most cases reproduction only takes place every second year (Fietz and Dausmann, 2006). *C. medius* only reproduce after delayed emigration from their family and successful occupation of their own territory (thus in their third year at the earliest; Fietz *et al.,* 2000). In addition, their life span is restricted by their size and is usually between 4 and 11 years for territory holders, and so opportunities to reproduce are limited (for most animals between one and three). Therefore, every young is a costly and valuable investment. Avoiding predation of their young should therefore be a critical part of parental care.

Predators of *C. medius* include raptors (Madagascar harrier hawk *Polyboroides radiatus*, Madagascar buzzard *Buteo brachypterus*, Madagascar long-eared owl *Asio madagascariensis*), mammals (Fossa *Cryptoprocta ferox*, Narrow-striped mongooses *Mungodictis decemlineata*), and snakes (Madagascar Ground Boa *Acrantophis madagascariensis*, Madagascar Tree Boa *Sanzinia madagascariensis*, Malagasy Cat-eyed Snake *Madagascarophis colubrinus*) (Dausmann, submitted). The choice of an appropriately sized tree hollow in which to give birth can reduce attacks from many of these predators with the exception of snakes which are able to enter any hollow that can be used by *C. medius*.

C. medius leave their tree hollows at sunset to forage alone but both sexes defend their shared territory. After the birth of their offspring, both parents take turns in guarding the young in the tree hollow throughout the night, while the other one forages. As the young get older, the proportion of time that parents spend guarding them gradually declines (Fietz and Dausmann, 2003). At the age of about two weeks, both parents leave the hollow and return only occasionally. During this time, the young are particularly vulnerable to predation, since they are unguarded. Later, the young accompany the parents during their nightly excursions.

In this note, I want to describe evidence that adult *C. medius* can repel larger predators and therefore guarding or at least remaining within hearing range of the tree hollow is an effective measure against predation of their offspring. I report an observation in which a snake (*Madagascarophis colubrinus*) tried to attack two *C. medius* young within a tree hollow but was successfully repelled by the mother.

Our observation occurred in the Kirindy C.F.P.F. forest, a dry deciduous forest near the west coast of Madagascar (60 km north east of Morondava) during a focal animal survey of a female *C. medius* on January 31st. For a more detailed description of the area see Ganzhorn and Sorg (1996).

The female was a mother of two young aged two weeks. The male of the pair was also being observed. The female left the tree hollow after sunset at 18:57 hours and the male followed at 19:01 hours. The two young were left alone in the hollow within a dead tree (Malagasy name: Mapingo). The entrance of the hollow was 3 m above ground. The female started her regular patrol of the territory border, but suddenly abandoned the patrol at 19:29 hours when about 80 m from the hollow. She returned quickly to the hollow in almost a straight line. On approach to the hollow, it was clear that the two young who had been left alone within the hollow were making loud and constant distress calls. On a branch of the same tree at a height of about 1.5 m above ground was a large *M. colubrinus* (> 1 m length) eying the hollow. Even though this crepuscular or nocturnal snake is mainly terrestrial, scansorial behaviour is possible. The female approached the snake to within a few centimetres and actively attacked it, and the snake responded by striking towards the female. Both the adult female and the juvenile *C. medius* were loudly vocalizing constantly. After three min, the female seized the tail of the snake with both hands and bit it about 10 cm from the end. The snake tried to drop to the ground, but remained dangling in the female's teeth. After 10 s of wriggling and repeated attempts to strike the female the snake fell to the ground and moved away quickly. The female descended to about 1 m, observed the ground for a few minutes and then spent 15 min agitatedly observing the surroundings at a height of about 3 m and inspecting the tree hollow containing the young, who were still loudly vocalizing. For the next 3.5 hours the female was moving rapidly around within the territory, which is very unusual for a *C. medius*, frequently returning and checking the tree hollow with the young. She finally carried leaves into a new tree hollow about 50 m away and separately carried both young to the new tree hollow. She did not return to sleep in the original tree hole for the next two months, even though it had been used frequently prior to this encounter. It seems puzzling that the male of the pair did not come to help during the attack. Since the male was followed simultaneously we know that at the time of the attack he was less than 20 m from the tree hollow, and clearly within hearing range of the distress calls. He returned about 30 min after the attack where he met the female and groomed her while she and the young continued making distress calls. Since reproduction in this species is a fairly rare event even including extra pair copulations, the possibility of siring offspring is restricted, and the male should have been highly motivated to defend his young in order to increase his fitness. Considering the high (obligate) paternal investment in guarding the young and the life-long pair bond, *C. medius* have a surprisingly high rate (ca 40 %) of extra pair young (Fietz *et al.*, 2000; Schwensow *et al.*, 2007). It is thought that the male cannot discriminate between intra pair and extra pair young and therefore cares for any offspring of his pair-partner, so as not to jeopardize the survival of his own young. Alternatively, paternal care of extra pair young could be an indicator for male quality or simply a tactic to maintain his bond with the female and so securing future mating possibilities in such a long-lasting relationship (Fietz and Dausmann, 2003). Genetic analyses showed that the male ("social father") of our observation was indeed only the genetic father of one offspring, but not the other (Schwensow *et al.*, 2007). However, even if he was able to distinguish kin from non-kin, he should still have defended the tree hollow in order to protect his one own offspring. Interestingly, in the weeks before these observations, the male and the female had always spent the daily resting period together in the same tree hollow. However, the day after the predation attempt they slept apart, the male in the old, and the female together with the offspring in the new tree hollow. We cannot judge whether the male was unable to find the female in the new tree hollow, whether he chose to rest in the old hollow, or was prevented from entering the new tree hollow.

Conclusion

Clearly, the surveillance of offspring either directly within the tree hollow (additionally offering thermoregulatory advan-

tages simultaneously; Fietz and Dausmann, 2003), or by staying within hearing range, does offer protection from attack by at least some predators even in this small species of primate.

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Lepilemur feeding observations from Northern Madagascar

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Lepilemur ankaranensis is the most northerly distributed member of the genus *Lepilemur*, with a range that extends south from Montagne d'Ambre National Park (Mittermeier *et al.*, 2008). The behaviour and ecology of *Lepilemur* is poorly understood (Ratsirarson *et al.*, 1987); this report summarises some preliminary observations of *L. ankaranensis*.
Observations took place in a forest fragment (09°23.6E, 46°07.3'S) 70km south of Antsiranana (Diego Suarez), near the town of Anivorano, west of the Route Nationale 6. The site is situated approximately 4 km south of the Mt. d'Ambre Park limit (Fig. 1). The area is heavily degraded, with only pockets of secondary dry deciduous forest remaining.

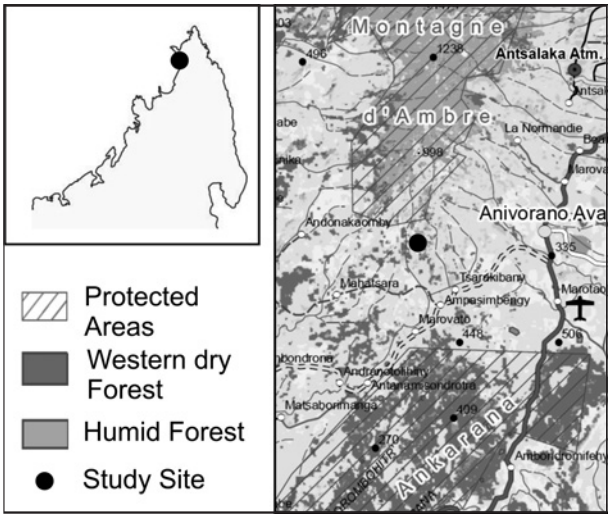

Fig. 1: Study site in northern Madagascar.

Casual feeding observations of *L. ankaranensis* took place from August 2009 to March 2010 (excluding the month of December). Observations were made in the first hour after sun set, with animals located using a flashlight. They were then followed, and any feeding bouts were recorded, with the plant species and food item noted. During this time, 32 % of all observations were of *L. ankaranensis* feeding on fruits, whereas all other observations were of leaf feeding. Five plant families were utilized for their fruits during the study: Moraceae, Verbenaceae, Rubiaceae, Pittosporaceae, and one that was not identified.
As *Lepilemur* are thought to be predominantly folivorous (Ganzhorn *et al.*, 2004; Thalmann and Ganzhorn, 2003), this proportion of fruit consumption seems to be high as compared to other *Lepilemur* species. For example, Thalmann (2001) found that during their study of *L. edwardsi,* only 0.3 % of 229 feeding bouts were feeding on fruits.
Also during this study, *L. ankaranensis* was observed feeding on fruits with both *Eulemur coronatus* and *Eulemur sanfordi* in the same tree, also feeding on the same fruit, with no signs of aggression shown between any of the animals. A second study took place in June 2010, six dusk-till-dawn follows were carried out on consecutive nights, for a total of 64.3 hours. Again, animals were located at dusk with a flashlight and followed until they returned to their sleeping sites in the

morning. During this time, 175 feeding observations were recorded, and no fruit was consumed. During this second study, a focal animal was observed to be chased out of a feeding tree by a female *E. coronatus*. The female *E. coronatus* then began eating the unripe fruits of the tree. It thus seems that during times of fruit abundance *L. ankaranensis* utilize fruits as a food resource along with several other lemur species occurring in the area. However, when food resources were not abundant in the dry season, only leaves were eaten and interspecific competition appears to be higher.

On several occasions during this second study, leaf stems were snapped from trees and white tree exudates were consumed. Latex exudates are thought to be a toxic defence mechanism and therefore usually avoided by primates (Glander, 1994), but latex feeding by *Colobus* spp. has also been observed (Mckey, 1978). Other lemur species, such as *Phaner furcifer* (Petter *et al.*, 1975; Petter, 1978; Thalmann, 2006) and *Mirza coquereli* (Hladik, 1979), are also known to feed on tree exudates. A review of the literature on exudate feeding in primates by Coimbra-Filho and Mittermeier (1977) suggested that tree exudates, in addition to simple sugars, protein, and minerals, may also provide a source of calcium. However, the latter authors also suggested that for most primates exudate feeding was rare and of little nutritional importance. This short report highlighted some behaviors of *Lepilemur ankaranensis*, a relatively poorly studied member of the *Lepilemur* genus. Further field work is required to examine in detail the previously discussed observations and to improve our knowledge of this species.

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Hypotheses on ecological interactions between the aye-aye (*Daubentonia madagascariensis*) and microhylid frogs of the genus *Platypelis* in Tsaratanana bamboo forest

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The aye-aye (*Daubentonia madagascariensis*) is the most distinctive of all lemurs. It is the only known living species of the Daubentoniidae (Simon and Meyer, 2001). The hands of the aye-aye are highly specialised, with long and slender third fingers that are used for precise grooming, mainly at face level, to get food into the mouth with rapid movements, and to tap on the bark of tree trunks to detect insect larvae or other arthropods (Goix, 1993). When an aye-aye locates a cavity, it will anchor the upper incisors into the wood and then gnaw away at the wood with the lower incisors to make a pit (Erickson, 1995a, 1994). This unique manner of foraging for arthropods leaves traces of biting on the wood cover which are often used to ascertain the presence of the species even without an actual sighting (Duckworth, 1993 and own observations of one of us, ER). During a recent herpetological inventory on the Tsaratanana massif in northern Madagascar, we noticed bamboo holes that were possibly caused or enlarged by foraging aye-aye, and we observed frogs living inside these cavities. Here we report these observations and posit a number of hypotheses on the possible ecological interactions among these species, with the goal of stimulating further studies.

During a herpetological inventory in Tsaratanana (the highest mountain massif of Madagascar, which rises up to 2876 m above sea level) one of us (AR) carried out an ecological study on frogs of the genus *Platypelis* (Mycrohylidae: Cophylinae), from the 9th to the 22nd of June 2010. Specifically, we worked in a mountain forest bordering the temporary pond locally called Matsabory Maiky (S 14°09'04.09"- E 48°57' 26.06" – 2,066 m elevation) - corresponding to campsite 2 on the trail from Mangindrano to the Maromokotro peak. The observed *Platypelis* occupy a specific microhabitat: the species live and breed inside the bamboo internodes which contain water and are accessible through small external holes. These frogs have endotrophic development: their non-feeding tadpoles develop inside the water retained in the tree holes and bamboo internodes. Based on a comparison with type material and DNA barcoding, we ascertained that the encountered *Platypelis* belong to two species described from

the Tsaratanana massif: *P. tsaratananaensis* (most common) and the much larger *P. alticola* (more rare). Detailed data on the ecology and reproductive biology of these frogs will be published elsewhere. Approximately 754 bamboo trunks, at five different study sites, were inspected around the campsite. These sites each had four plots of 10 x 10 m areas. Out of the 754 trunks, we discovered in 162 of them, a total number of 204 internode segments; small rounded holes that were most probably made by insects like *Dinoderus minutus* (Delobel and Tran, 1993). According to these authors, *Dinoderus minutus* deposit eggs in bamboo internodes in which their larvae develop (Fig. 1d).

At one of the sites (ca. 600 m east of the pond), we discovered some bamboo stems with remarkably different kinds of holes which allowed access to the hollow cavity of the internodes. Parts of the bamboo had been damaged in an irregular way. This appeared similar to what has already been described as typical damage caused by the gnawing activity of the aye-aye, whereby a freshly ripped-back piece is still attached and solid (Duckworth, 1993) (Fig. 1a-b).

On 20 of the 281 bamboo trunks at this study site, we found similar damages, with a total of 71 holes which were more or less oval and measured 5.2-29.7 mm vertically and 1.5-8.2 mm horizontally. The diameter measurements of the non-damaged bamboo trunks were 5.3-54.2 mm, and those with holes were 5.3-48.9 mm. On several bamboo trunks we observed such holes in various internodes (1-6 m above the ground), and some internodes had an upper and a lower hole. Most importantly for the hypotheses drawn below, on some of the trunks without holes, we observed clear traces of gnawing that probably represent the upper and lower incisors of the aye-aye (Fig. 1b). According to our observations, 80 % of all the holes found in the study site were caused by the activity of insects, and 20 % by the aye-aye.

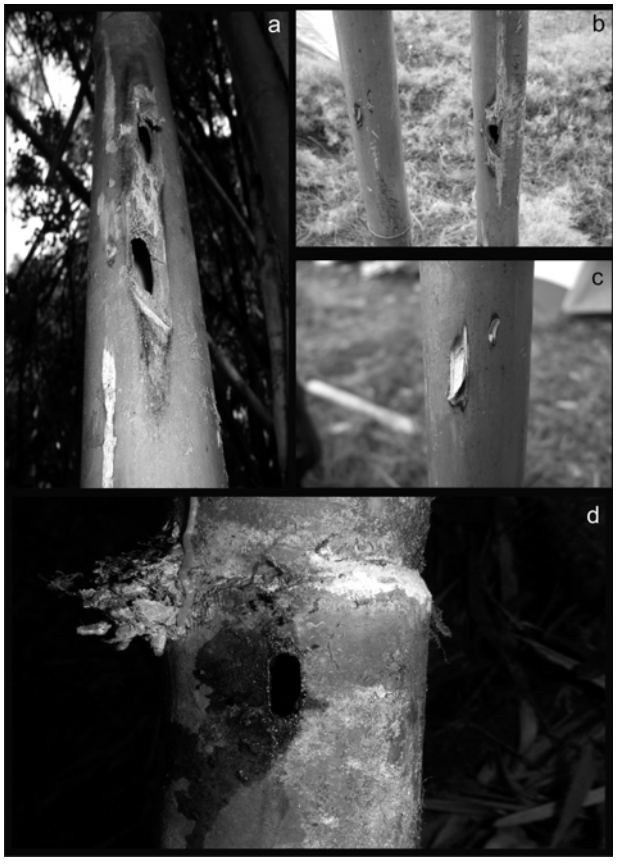

Fig. 1: Traces of animals on the trunks of bamboo at the study site: (a) bamboo internode segment with an upper and a lower node attributed to the aye-aye; (b) segments of two bamboo trunks with a hole attributed to the aye-aye on the right and bite traces on the left; (c) traces attributed to aye-aye upper and lower incisors on a "virgin" bamboo trunk segment; (d) typical regular-shaped hole in a bamboo segment attributed to insects.

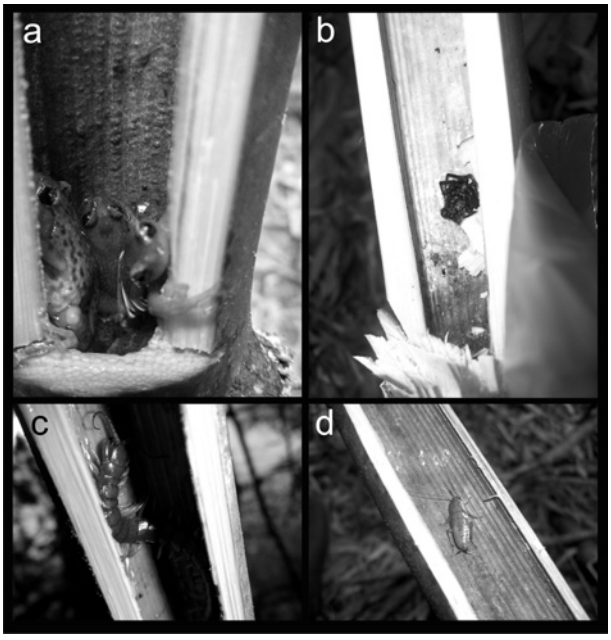

Fig. 2: Animals observed within bamboo segments: (a) frogs: various specimens of *Platypelis tsaratananaensis* in one segment; (b) spider; (c) myriapod; (d) insect (cockroach).

Bamboo internodes accessible by both kinds of holes were populated by *Platypelis* frogs as well as a variety of insects, spiders and centipedes (Fig. 2). At the study site where the bite traces ascribed to the aye-aye were discovered, the altogether 282 holes (putatively made by insects) contained: 61 *Platypelis* distributed in 24 different holes, 12 insects in 8 different holes, and 2 myriapods in 2 holes. In the 71 holes ascribed to the activity of the aye-aye, we observed 30 *Platypelis* in 11 holes, 4 insects in 3 holes, and 0 centipedes.

Based on these observations, we posit the following (partly alternative) hypotheses which require verification and further study:

(1) We are confident that the observed marks at one of our study sites, similar to those noted by Duckworth (1993), are indeed caused by the activity of the aye-aye. Fresh bamboo stems are externally smooth and very strong, and it seems unlikely that any other mammal or even a bird could cause such damage. However, the possibility that these holes may be made by rats (such as *Rattus rattus* (which we collected at Matsobory Maiky), or *Brachytarsomys*) needs to be excluded by direct observations.

(2) We assume that the aye-aye will typically search for bamboo internodes which already have small holes made by insects. This is because in such internodes there is a high likelihood of finding prey. In addition to insect larvae and other arthropods, tree-hole breeding frogs like *Platypelis* may also be consumed. In areas with high bamboo density, these frogs may constitute an import part of the aye-aye diet. If proven, this fact - that aye-ayes may eat frogs in addition to invertebrates - would be an interesting discovery in terms of Primatology.

(3) Alternatively, the aye-aye may also gnaw holes into previously untouched bamboo segments. The bite traces we en-

countered in such "virgin" internodes support this hypothesis. Reasons for this might either be a search for drinking water, or the search and detection of insect larvae which develop inside these internodes and which have not yet made a hole to emerge.
(4) As a fourth and highly speculative hypothesis, the aye-aye may gnaw holes into "virgin" bamboo segments (or increase the size of pre-existing holes) as part of a long-term feeding strategy in which such holes are produced to make the bamboo segment suitable for colonization by arthropods and frogs. This would enable the aye-aye to "harvest" its food during a subsequent visit to the site several days later. Obviously, such a foresighted feeding strategy in a basal primate would be of extreme interest, but we are aware that alternative and more probable explanations exist.
Detailed testing of these hypotheses will require long-term observations in an area of dense growth of large bamboo, probably including the deployment of a large number of camera traps and possibly hair traps to obtain evidence of aye-aye activity. Carrying out such studies at the site in Matsabory Maiky is difficult. It should be noted that the Tsaratanana massif is difficult to access. However, alternative sites, e.g. at Marojejy (Duckworth, 1993) might contain a large population of *Platypelis* (albeit other species) as well, and could be surveyed more systematically.

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Discovery of crowned sifaka (*Propithecus coronatus*) in Dabolava, Miandrivazo, Menabe Region

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The crowned sifaka *Propithecus coronatus* was until recently regarded as one of four subspecies of *P. verreauxi*, family Indridae, which occur throughout western and southern Madagascar (Muller *et al*., 2000; Mittermeier *et al*., 1994; Tattersall, 1986; Wilmé and Callmander, 2006). Recent taxonomic revisions (Mittermeier *et al*., 2008) have promoted all four subspecies to full species status (Mittermeier *et al*., 2006). However, there is considerable debate about the validity of *P. coronatus*, and especially its relationship with *P. deckeni* (Mittermeier *et al*., 2008), due to the physical similarities and close geographical distributions of these taxa, including apparent sympatry at some sites (e.g. Tattersall, 1986; Curtis *et al*., 1998; Muller *et al*., 2000; Groves, 2001; Thalmann *et al*., 2002).
P. coronatus was previously assigned to the IUCN conservation rating "Critically Endangered", but has since been moved into the "Endangered" category; nevertheless, the distribution range and the ecology of this species are not yet well understood (IUCN, 2008). Crowned sifakas are diurnal, and their habitat is characterised by dry deciduous forests and mangroves (Petter and Andriatsarafara, 1987). They live in groups of two to eight individuals, with home ranges from 1.2–1.5 ha. They feed mainly on buds, green fruits and mature leaves (Muller, 1997). It is known that they reproduce seasonally, with females giving birth every 2-3 years (Curtis *et al*., 1998; Mittermeier *et al*., 2006). Compared to other lemurs, their reproduction rate is very slow, making recovery of small populations even more problematic.
The newly discovered crowned sifaka population is situated at Amboloando (UTM WGS 84, N 7822351 E 580189) in the Commune of Dabolava in central Madagascar, and is the most southerly record of the species. Amboloando lies about 4 km from Dabolava village, and 40 km to the southeast of Miandrivazo. Amboloando comprises 7 ha of dry semi-deciduous, secondary forest that exhibits the characteristics of riverine forests, consisting of deciduous as well as evergreen trees such as *Acacia* sp., *Nastus* sp. and *Macaranga* sp. The altitude is about 600 m above sea level, and the area is characterized by a clearly defined wet and dry season. The sifaka population is composed of a single group, which constituted six adults and one juvenile when first discovered in June 2009 (Razafindramanana, 2009). One of the adult males disappeared later in the year, presumed dead, leaving six individuals remaining. The animals appear to be classic *P. coronatus* (Fig. 1), but some individuals show pelage colour variation, with dark fur on their back and arms (Fig. 2). Behavioural studies of the group are underway, and a preliminary community-based conservation program has been established at the site, involving several organisations including GERP, The Aspinall Foundation, SAHA and Pan-African Mining Madagascar. Forests in Amboloando and the surrounding area are heavily degraded. Different factors threaten the survival of this species in Madagascar: in contrast to the other sites such as Anjamena (Muller, 2000), hunting does not occur in Amboloando, partly due to the sifaka being regarded as holy by the local people. Therefore, other threats such as habitat destruction through slash-and-burn agriculture to make way for pasture for livestock, charcoal production, and mining exploitation affect the sifaka group.
Surveys in the vicinity of Dabolava suggest that this is the only group of *P. coronatus* remaining in that area, despite local people claiming that other groups were present between 5 and 10 years ago. Therefore, it appears that habitat destruc-

Fig. 1: Crowned sifaka in the Amboloando Forest (top).
Fig. 2: Crowned sifaka with dark colour on its arms (right).

The Mahajilo is a tributary of the Tsiribihina River, which is considered to represent the north-western limit of *P. verreauxi* (Mittermeier *et al.,* 2006). *P. coronatus* is therefore unlikely to be found much further south or south-west than Dabolava. Only 80 km south-west of Dabolava, a population of *P. verreauxi* is known from Ambatolahy (SAHA, 2009), which lies within the Ambararata/Londa protected area complex (Fig. 3). Another tributary of the Mahajilo, the Mania River, lies between Ambatolahy and Dabolava and may therefore represent the distributional limit of *P. coronatus* and *P. verreauxi* in the south of Madagascar. A conservation programme and restoration of the remaining habitat with the local people are needed to save this population of *P. coronatus*.

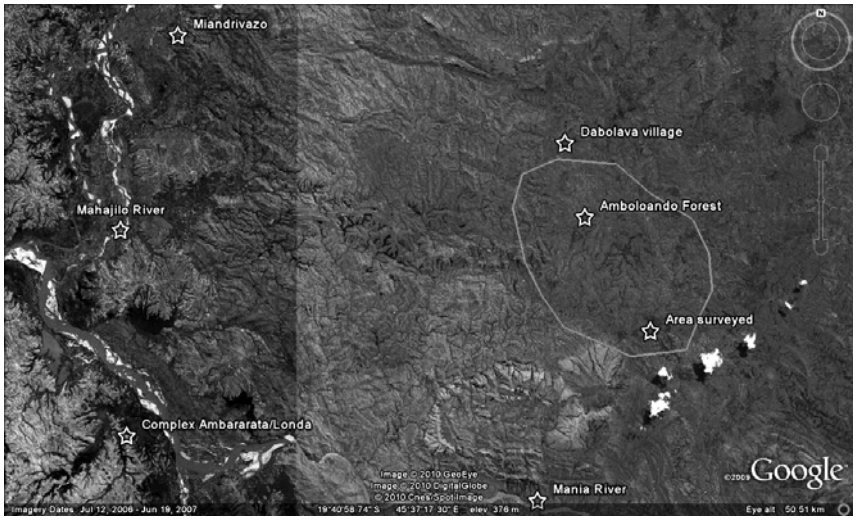

Fig. 3: Map showing the area of discovery and survey in Dabolava.

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tion for local livelihoods has resulted in the almost complete extirpation of crowned sifaka in the area, probably due to a combination of habitat loss and food scarcity.

Some studies describe the range of *P. coronatus* as broadly restricted to the region between the rivers Betsiboka and Mahavavy (Muller *et al.*, 2000; Wilmé and Callmander, 2006), with a population density of 173 individuals/km² at Anjamena (Muller, 2000). In an analysis of the distribution of lemurs in central western Madagascar, Thalman and Rakotoarison (1994) suggested that the faunal region bounded by the Betsiboka, the central highlands, the river Tsiribihina and the Mozambique Channel can be divided into four sub regions. These sub regions are separated by the three rivers: Mahavavy, Manambaho and Manambolo, but are interconnected with the Bongolava Massif. The discovery of a crowned sifaka population in Dabolava, which is located in the south of the central highlands sub region, confirms the hypothesis that the historical range of this species might spread along the central highlands of Madagascar. The record of a group of crowned sifaka in Andranotonga, slightly north of the Mahajilo River, was cited by Tattersall (1986). The present report appears to be the first location of *P. coronatus* to the south of this river.

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Inferences about the distant past in Madagascar

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From Etienne de Flacourt (1658), the following is an English translation, from the original French, of an entry in his book "Histoire de la Grande Isle Madagascar:"
"Tretretretre or Tratratratra. It is a large animal like a calf of two years old, with a round head and the face of a man: the fore feet are like those of a monkey (or ape), and the hind feet also. It has curly (or frizzy) hair, a short tail and ears like those of a man. It resembles the "Tanacht" described by Ambroise Paré. It can be seen near the pond of the Lipomami [tribe] and in that region is where it can be found. It is a highly solitary animal, the people of that country have a great fear of it and flee from it as it also does from them." From this context, it is not clear whether Flacourt actually had seen this animal.
It is well known that in Madagascar village people tend to name lemurs after the sounds they make, following a sort of onomatopoeic pattern for animal names such as occurs in the case of the cuckoo bird in English. For instance, the ground predator alarm call of species of genus *Propithecus* is a loud "si-i-fak!" cry and so the name of this animal in the Malagasy language is "Sifaka". The mouse lemur makes a chittering alarm call and has the name "T'sit-sihy". The *Avahi,* a nocturnal lemur, has one call that sounds like the word "avahi!" In the case of Flacourt's animal the name Tretretretre or Tratratratra is definitely onomatopoeic and sounds like an alarm bark–it is not unlike the bark alarm call of the southeastern Madagascan lemur *Propithecus edwardsi*, or that of another lemur related to it, *Indri indri*, or even the alarm bark of the chimpanzee.
Hence, I have often considered this term, or name, to be a "fossil" sound and it seems likely that it would have been a replication, by members of the Lipomami tribe of the alarm call of this giant lemur when they told Flacourt about the animal. The location of the Lipomami region in southeastern Madagascar is known today (Tattersall, 1982). Thus Flacourt's name for the animal may be the only known "fossil" sound. There are frequent references by various scientists all agreeing that Flacourt must have been describing, in the above passage, one of the giant extinct lemurs; but which one? All lemurs have hands and feet like those of monkeys, but wavy hair is more restricted–mainly to members of the Indriid group or taxonomic family [this family includes only species of the extant genera *Propithecus, Indri,* and *Avahi*] and incidentally they all have rounded ears–like those of a man. One large giant extinct lemur of the south and southwest of the island is known as *Palaeopropithecus ingens* and taxonomists generally agree that genus *Palaeopropithecus* is related to the family Indriidae (Orlando *et al*., 2008), where curly or frizzy hair occurs. A number of scientists have speculated that Flacourt's Tretretretre lemur belonged to the genus *Megaladapis* (Tattersall, 1982; Mittermeier *et al*., 1994), which also occurs as fossils from the southern part of the island, but species of this genus have a large snout and could never be described as having a round head. Moreover, the distal ends of the nasal bones in species of this genus are elongated and expanded and, in life, there must have been an expanded or bulbous nose or even a trunk. Hence, one could never say that the creature had "a face of a man." Differing from *Megaladapis, Palaeopropithecus ingens* does have a rounded human-like head with forward directed eyes and a small face. In addition to all these other features, the living species *Indri indri* or babacoot, is the only lemur that has a short tail. In addition to this, the most complete skeleton of *Palaeopropithecus*, recovered by a Duke expedition in 1983, and the only associated skeleton of this animal ever found includes a sacrum that diminishes posteriorly and could only hold a very small and short tail. In opposition to all these conclusions, it can be said that *Palaeopropithecus ingens* could not possibly be construed to have been the size of a calf of two years in age–nor, in fact, would any of the extinct giant lemurs have been that large. Nevertheless, it is well known that exaggeration surrounds stories about such little known animals, and also Malagasy cattle tend to be small. For these reasons it would appear that the Tretretretre was a *Palaeopropithecus* species–a conclusion also implied by Godfrey and Jungers (2002). A year later these authors reconfirm the same position (Godfrey and Jungers, 2003).
Between 1994 and the year 2003 teams from the Duke Lemur Center excavated fossils at two caves called Akomaka and Ankilitelo in southwestern Madagascar on the Mikoboka Plateau north of Tulear. This region is Madagascar's most extensive and stratigraphically thickest calcareous plateau. Discoveries made at both of these caves show that the southwestern part of the island was inhabited comparatively recently by several giant lemurs including *Palaeopropithecus ingens* and *Megaladapis edwardsi*. More importantly, these species lived relatively recently (Godfrey and Jungers, 2002), as evidenced by radiocarbon dating based on specimens from Ankilitelo (*Megaladapis* at 630 ± 50 years B.P. and *Palaeopropithecus,* 510 ± 80 years B.P. The latter of these dates (calculated in 1996) ranged from 1406 to 1566 years AD and falls into historic times. These are relatively recent ages, not so far from the date of Flacourt's observation of the Tretretretre which could have been at any time after he was named Governor of Ft. Dauphin Madagascar in 1648; approximately 350 years ago. A more recent date determined in 2008 on a *Cryptoprocta* bone from Ankilitelo gives a similar age to that of the *Palaeopropithecus*, estimated as between 1408 and 1488 (Simons, 1997; Muldoon *et al*., 2009; Muldoon and Simons, 2007). This suggests that the small mammals accumulated more or less contemporaneously with the giant lemurs. [The cave name, Ankilitelo, means "at the three kili (tamarind) trees" but no such trees grow there now. Mala-

Fig. 1: *Harpagophytum grandidieri* burr or "hitchhiker" from southern Madagascar. These barbs are approximately 9.5 cm across.

gasy caves can be named for a nearby settlement or village. At present there is no nearby hamlet with such a name but in the past there could have been. Kili trees often grow in villages there.]

At this point another speculation can be introduced. Pastoral grass burning has reduced present day forests on the Mahafaly Plateau, north of Tulear, to the ridges of hills and many present day plant species occurring in them must be the same as those of 500-1000 years ago. The remaining forests near Ankilitelo represent both spiny thicket and succulent woodland regions and examples of the dry deciduous forest are nearby (Simons, 1997; Muldoon *et al*., 2009). In general, grass burning in that region, near the Ankilitelo cave, is arrested from spreading by outcrops of limestone on the slopes of hills. In addition, it would appear that surviving forests on hilltops of the Ankilitelo region remain as they were a few hundred years ago. The surface finds of small mammals in Ankilitelo (34 species) do reflect those of a few hundred years ago–when the giant lemurs existed and when the cave was serving as a natural trap–these environmental conditions were similar to those of the present. The fauna suggests that, perhaps, the region then was slightly more humid, and definitely the forests of the region have undergone fragmentation (Simons, 1997; Muldoon and Simons, 2007). Each such natural trap cave serves as a window in time because, as the solution cavities open mainly from below, the fauna that fall in will only begin to collect when there is a surface opening. More dates are being determined for fossils from Ankilitelo but the window concerned here did not open long enough ago that the 34 small mammal species are different from those now extant in the region or relatively nearby. The commonest giant lemur at Ankilitelo is the awkwardly constructed *Palaeopropithecus* that presumably could not support itself on all fours on the ground. Once having fallen to earth it would have been restricted to swimming, sloth-like motions and this perhaps explains why so many *P. ingens* fell into the pit. Also, Godfrey and Jungers (2003) report a Malagasy tradition (p. 258) that an "ogre with the body of an animal but the face of a human" could be made helpless on smooth rock surfaces. Such clumsiness of the sloth-like *Palaeopropithecus* would account both for its abundance in Ankilitelo and its presumed inabilities on the ground. Whatever the pelage of this animal was like, or indeed that of any of the giant lemurs, their fur could not have resisted picking up burrs and other hitchhikers from the southwestern forests as has been noted with modern lemurs (personal observations of Michelle Sauther). A present day student of behavior, Sauther, has observed individual *Lemur catta* that had become entangled with the large seeds of what is often called *Uncarina grandidieri*–but more properly, because of an earlier date of description, this species should be assigned to genus *Harpagophytum*–meaning "snatcher plant". This plant of southwestern Madagascar has amazing "hitchhikers" about 2.5 to 3 inches across each of which has 30/35 protruding spines approximately 1.5 inches long (see Fig. 1). Each of these spines is, in turn, tipped by 4 recurving fishhook-like projections. This huge seed pod is something that it seems would only have evolved to be transported by a much larger animal than any now extant on the Island–presumably a giant lemur like species of such southern genera as *Palaeopropithecus, Megaladapis,* or *Archaeolemur* or even transportation by the elephant bird (see below).

Modern botanists report that the pasty pollen of this plant is spread by pollen-eating beetles, who, after feeding on pollen from the anthers, get it all over themselves and when covered by pollen fly from flower to flower where pollen is transmitted from them to the stigma. This sort of pollination may be the principal fertilization process, but lemur transport of these seed burrs does occur today (personal observations of Michelle Sauther), and must have also done so in the past. Working at the Beza Mahfaly Special Reserve, in southwestern Madagascar, Sauther has seen *Lemur catta* individuals with *Harphagophytum* burrs stuck on the face, feet, and tail. However, she has not seen them attached to *Propithecus verreauxi;* a second larger, diurnal lemur species which occurs at Beza but is more arboreal than *L. catta*. These dry seed pods would naturally attach to the skin, not necessarily fur, of any passing animals and be carried while attached until its spines were broken enough for the seed to drop off. It was recently suggested that dispersal of these seed pods might have been carried out primarily by the extinct elephant birds of Madagascar (Midgley and Illing, 2009). The authors presenting this view argue that the mature fruit more often accumulate on the ground as "trample burrs" and so are more likely to stick to the feet of these extinct giant ratites than to fur of arboreal animals. I suspect, however, that the giant lemurs did not always stay high up in trees but were often on or near to the ground. The mature terminal hooks of the *Harpagophytum* (*Uncarina*) burr have evolved so as to attach to any extremity, not necessarily fur. Also it is of interest that these plants are often called the "Mouse-trap tree" or "Grapple tree". These species belong in the sesame family (Pedaliaceae) and typically constitute shrubs or small trees. It is told that Malagasy people sometimes collect and put together bunches of these seeds and place cheese or other attractants at the center of the bunch. They then use this device to trap rats and mice: Hence, the origin of the common name.

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Husbandry guidelines for mouse lemurs at Paris Zoo

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There are two species of mouse lemur in captivity in Europe: the grey mouse lemur, *Microcebus murinus*, and the Goodman's mouse lemur, *Microcebus lehilahytsara* (Pes, 2009). The European captive population of grey mouse lemurs was established at the end of the 1960s and is now composed of 165 individuals (778.77.10; Pes, 2009), distributed in 29 institutions. The population of this species is of unknown origin. According to recent morphological measurements (Pes, 2009) and preliminary results of mtDNA studies (Roos, 2008, in Pes, 2009), this population can be divided into two pure lineages: one composed of pure breed animals from the region of Vohimena (SW Madagascar), and the other of pure breed animals from the region of Mandena (SE Madagascar). A third lineage is composed of hybrids between the two pure lineages (Pes, 2009).

The European captive population of Goodman's mouse lemurs was established in 2005 and is currently composed of 62 individuals (33.29; Pes, 2009) distributed in two institutions. The first animals were imported from the area of Andasibé, Madagascar. They were recognized as a new species when they arrived in Europe (Rübel, pers. comm.).

The Parc Zoologique de Paris has a success story with the grey mouse lemurs. The most important group arrived in December 1990 and was composed of 79 individuals. The origin of the animals that arrived in the 1980s is unknown. According to the analysis of the European captive population (conducted by Tomas Pes for the ESB), the animals coming from Paris appear to be hybrids between the two pure lineages described above (Pes, pers. comm.).

The first births occurred in 1991 only a few months after the arrival of the first animals. During the period of 1991 to 2004, when the last grey mouse lemurs eventually left the zoo after the closing of the nocturnal area, there had been a total of 224 successful births (young surviving longer than two months), with an 86.5 % birth success rate. 1994 was the most prolific year with 56 successful births. The colony of grey mouse lemurs in Paris occasionally reached more than 150 individuals.

Before 2001, we didn't know much about the animals, especially the composition of the groups. Eleven females were the founders of the colony in Paris. Since the identity of the fathers was not recorded, the filiations were only built from the females. Potentially, 28 males could have been the founders of the colony.

Before 2002, most of the females lived alone in small cages and were introduced to males (of various group sizes) only during the few days of oestrus. The females were kept isolated again afterwards. The young were separated from their mothers just after their weaning to join a young animals group.

In 2002 we decided to implement some changes in the management of the colony in order to improve the wellbeing of the animals: to increase the space available to them, to rearrange the enclosures according to the wild habitat of the animals, to carry out enclosure enrichment, and to re-constitute the groups to make them more similar to the ones observed in the wild. The following husbandry guidelines were established according to the new management of the colony set up in 2002.

Only single sex groups could be seen by the public. The breeding groups were kept in a separated building. Moreover, from 2002 onwards, we limited the number of births (around 10 per year) in order to be able to keep all the animals in good conditions (and no longer in small cages as had been done in the past).

Facility standards

1. Enclosure

Size: The enclosure should have a minimum total floor size of 4 m^2 with a minimum height of 2 m for both male and female groups. For a mother with her young, the enclosure can be smaller during the first month. After this period, the young start to explore their environment and need more space.

Temperature: 20°C (18-22° C). Not below 18° C. Below this temperature, the animals enter torpor. Torpor can also be provoked by intense stress such as prolonged capture of an animal.

Inside Humidity: 50-70 %.

Lighting and photoperiod: Similar to that found in Madagascar or Europe but the photoperiod must vary during the year for breeding.

Furniture: Dense environment with thin branches and leaves. The animals need to have many places to hide from people and also from each other when they live in groups, especially when the animals are unrelated.

Nest box (see Fig. 1):

- Size: 12x12x12 cm
- Entry diameter: 5 cm
- It's very important to provide one nest box per animal, in different places, even if they sleep together. This allows them to be alone if they want to be.

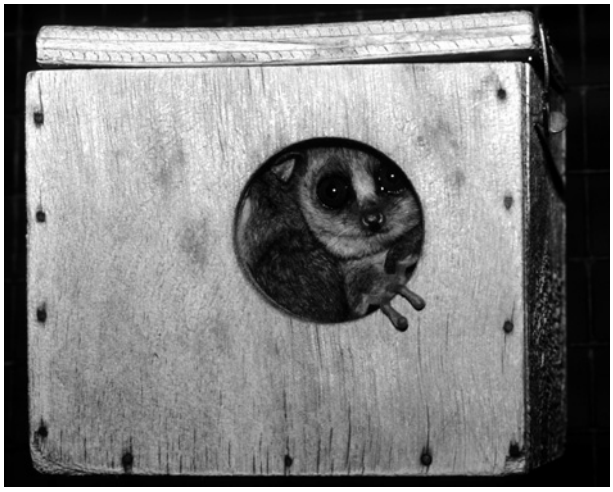

Fig. 1: Grey mouse lemurs (*Microcebus murinus*) in nest box at Paris Zoo. (Photo: F.-G. Grandin, MNHN)

2. Feeding and watering
Two feeding spots are needed if there are more than two adults in the group. Additional feeding spots are required according to the size of the group. If there are not enough nest boxes or feeding spots, the animals can be very aggressive towards one another, sometimes causing serious wounds, mostly to the tail. One water bottle per enclosure is sufficient.

Diet for 1 animal/day:
Monday: 1 tea-spoon of gruel* + 3 folivorous pellets
Tuesday: 1/8 of apple + 2 slices of carrot + 3 folivorous pellets
Wednesday: 1/8 of apple + 1/8 of pear + 3 folivorous pellets
Thursday: 1 tea-spoon of gruel* + 3 folivorous pellets
Friday: 1/8 of apple + 2 slices of carrot + 3 folivorous pellets
Saturday: 1 tea-spoon of gruel* + 3 folivorous pellets
Sunday: 1 slice of banana + 1/8 of mango + 5 mealworms + 3 folivorous pellets
*Gruel composition: folivorous pellet powder + milk powder + baby cereals + yolks + cottage-cheese + juice of squeezed oranges + vitamins (every Monday).
For overweight animals (weight >100 g): from Tuesday to Saturday we provide only 2 slices of carrot and 3 folivorous pellets. No change for Sunday and Monday.
For underweight animals (weight <70 g): we add 5 mealworms and one piece (~2 cm^2) of gingerbread every day in the diet.
It is important to give more food to lactating females. If they don't have enough food, they will eat their young: we add 5 mealworms and one piece (~2 cm^2) of gingerbread every day in the diet.

Social grouping
During the non-breeding season, we separate males from females.

Male groups: the best groups are composed of individuals of the same litter. If the males are unrelated, it is important to know the dominance relations between them in order to determine which one will be the breeding male (probably the dominant one). From 2002, studies of the hierarchy in the male groups were systematically conducted to allow us to determine the young's fathers. The male groups are composed of 2 to 5 individuals (Fig. 2). Note that we managed to keep a group of up to 10 males together as a non-breeding group.
Female groups: they are only composed of related females (mother-daughter-sister). The female groups are composed of 2 to 4 individuals. But more important groups can be maintained in more spacious enclosures. Note that it was impossible to keep unrelated females together for more than one breeding season. These groups are very unstable and the females can be very aggressive towards one another. Moreover, the old unrelated females are very anti-social and do not tolerate each other.
The breeding groups are established in March, before the beginning of the breeding season. The best way to do this is to introduce the females of a same group to the males' enclosure.

Reproduction
Oestrus observation: When the females are with the males, it is important to check their vulvas regularly in order to follow the oestrus evolution (vulva opened 2-3 days every month during the breeding season; until 3 oestrus per breeding season). If a female does not develop a second oestrus (probable pregnancy, length: 2 months), she is removed from the breeding group and kept alone until her young are weaned. The females, even if they are related, can be very aggressive to one another during this period. At the end of the oestrus most females develop a white cap on their vulva. The females can have a baby from 8 months old. This means that they can have their first oestrus at 6 months. It is better to remove females from a breeding situation after 6 years, but it is important to keep them in related female groups.
The size of the male's testes increases at the time of oestrus. Except for the oestrus period, testes are usually almost invisible.

Fig. 2: Group of male grey mouse lemurs (*Microcebus murinus*) at Paris Zoo. (Photo: F.-G. Grandin, MNHN)

Parturition observation: The nest boxes are checked every day for several days before the parturition. Before opening a nest box, we softly tap on it: it allows the female to exit without having a baby hanging on to her nipples (between 1-3 young). The nest box is opened every day for several days after the parturition, to check if the young are still alive (but we don't touch them of course!). The births can occur from March to October but most of them appeared from April to June in Paris where we follow the Malagasy photoperiod.
Splitting of the young: It is better to wait 4-5 months after the parturition before doing any changes in the mother-young group (even if the young are weaned at 2 months). Then, the daughter(s) stay with their mother and all are introduced back into the female group that they originated from before the breeding season. The young male(s) are separated from their mother and sister(s). If there is only 1 male, he is introduced to a group of males of the same age. If there are several brothers, they stay together and compose a new male group.

Enrichment
In Paris, a study showed that the females use feeding enrichments more often than the males. This could be explained by the ecology and behaviour of this species; by the fact that the

females may be more interested in food during the breeding season than the males which, in turn, may be more interested in the females (Roullet, 1998).
The enrichment made with a branch covered in fruit juice was the most used by the animals: This is a branch (diameter of around 5 cm, length of 30-40 cm) in which two trenches are dug along its length. The branch is fixed onto the mesh roof. We apply the fruit juice in the trenches with a brush (Roullet, 1998). The animals spend their time licking the juice out of the branch as they would do with sap in wild (Martin, 1973).

Mixed-species exhibits
Paris Zoo experienced 2 successful combinations: with ayes-ayes (*Daubentonia madagascariensis*) and greater tenrecs (*Tenrec ecaudatus*). We tried to put the mouse lemurs in with slow lorises (*Nycticebus coucang*), but without success: wounds were observed on the mouse lemurs' tails, so they were removed from the exhibit.

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Articles

Diurnal lemur density in the national park parcel Ivontaka Nord, UNESCO Biosphere Reserve of Mananara-Nord

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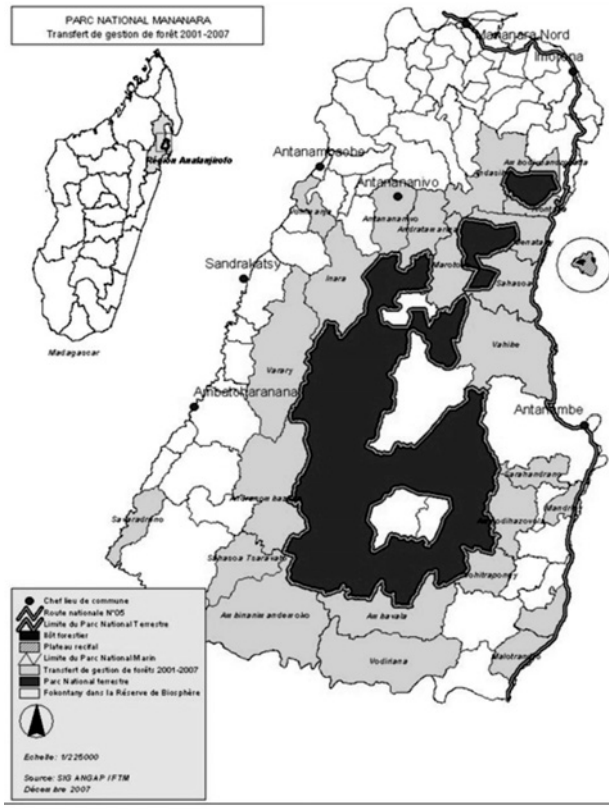
Abstract
Here I present a recent diurnal lemur density study performed in the Biosphere Reserve of Mananara Nord, conducted between the dates of November 9 and 22, 2008 in Ivontaka Nord; part of Mananara-Nord National Park. Densities were calculated using transect walks, and other information was gathered through interviews with local people and national park staff. The density of *Eulemur fulvus albifrons* appears to be over twice that recorded in other areas (Table 1), while the density of *Varecia variegata variegata* appears to be low, perhaps due to the latter's preference for undisturbed habitat and past problems with overhunting. In addition, *Eulemur rubriventer* was found to inhabit the park, though its range was previously thought not to extend east into the biosphere. Having been, in the past, under strong pressures from local inhabitants, Ivontaka Nord represents a disturbed low altitude rainforest; however this report shows that the lemur populations within the parcel may be recovering.

Introduction

Background
The Biosphere Reserve of Mananara-Nord was created in 1989. It is one of 533 UNESCO (the United Nations Educational, Scientific, and Cultural Organization) Biospheres around the world. The Biosphere Reserve of Mananara Nord covers 144,000 ha, with 23,000 ha being devoted to a terrestrial park, and another 1,000 ha to a marine park. The terrestrial national park is split into three separate parcels. Going from north to south these parcels are: Ivontaka Nord, Ivontaka Sud, and Verezanantsoro. The parcel of Ivontaka Nord covers an area of only 827 ha. This is small compared to the other two parcels; Ivontaka Sud and Verezanantsoro, which are 1,300 ha and 20,685 ha respectively (Fig. 1). These parcels are connected by forest sections that are not protected by the national park system (ANGAP, 2005).



Carte illustrant les transferts de gestion de forêts aux Communauté de Base (COBA) Dans la Réserve de Biosphère de Mananara-Nord

Fig. 1: National Park of Mananara-Nord. Three parcels in dark shade, going from north to south: Ivontaka Nord (where this survey was carried out), Ivontaka Sud, Verezanantsoro. Source: MNP.

Threats
It is estimated that approximately 1.9 to 2.2 % of the primary forest within the biosphere is cleared every year, usually for rice cultivation through *tavy* (slash and burn agriculture) (ANGAP, 2005). Besides just destroying necessary habitat, this deforestation further splits already extremely fragmented sections of primary forest. Another concern is illegal (and legal) selective extraction. The population within the biosphere relies on wood for constructing their houses and fuel for cooking. In the villages most cooking is done over an open flame using collected wood. The wood does not simply go to the villages on the periphery of a forest, but is also collected for sale in urban centers and areas farther away from the forest.

Another large concern in the biosphere has to do with poaching. Until recently, hunting was thought to not be of great concern in Madagascar, being far below the menace caused by deforestation (Goodman *et al*., 2003); however, that is quickly proving incorrect. Unlike in other areas of the country where eating lemurs is considered *fady* (taboo), the Betsimisaraka ethnic group that makes up the majority of inhabitants within the biosphere reserve is only known to have *fady* related to the eating of *Indri indri,* and even this taboo has been shown not to be universal (Mittermeier *et al*., 2006). In the area people have classically used *laly* (traditional lemur traps) and firearms in order to hunt lemurs for consumption (ANGAP, 2005). Lemurs within the reserve have been a traditional source of protein for villagers whose diets are based on the staple rice.

Site

The field camp was situated within the town of Ambodivoandrozana approximately 17 km south of Mananara Nord. The village is inaccessible by vehicle but rests less than 2 km from the national park parcel of Ivontaka Nord. Between the town and the national park lies another forest managed by the COBA (*communaute de base*) for conservation and local subsistence needs. This forest is split into three zones; Beantohiravina (21.7 ha), Betsingiala (11.52 ha), and Ambahinkarabo (41.06 ha). These zones are separated by areas of agricultural land and secondary forest. A Gestion Contractualisée des forêts (GCF) in 2005 transferred certain management and use rights to the local community. It is mostly low altitude primary growth rainforest, intermixed with zones of *savoka* (secondary growth). The parcel of Ivontaka Nord is made up of both primary forest and disturbed habitat. From past species inventories, it was believed that two diurnal lemur species (*Eulemur albifrons* and *Varecia v. variegata*) and multiple nocturnal species, including *Microcebus rufus, Lepilemur mustelinus, Avahi laniger, and Daubentonia madagascariensis* among others inhabited this national park.

Methods

A survey of diurnal lemur species was conducted in the low altitude (between 250 and 300 m above sea level) rainforest in the national park of Ivotaka Nord and adjoining community-managed forest (GCF). The survey was conducted from November 9-22, 2008. Within the national park parcel, a preestablished 2 km transect set up by ANGAP was followed, in addition to other transects along preexisting paths throughout the two forests. Additional permanent transects were not established because of time constraints and the desire to limit the impact on the habitat. Instead, distance was measured by walking at a constant pace along preexisting paths (approximately 900 m per hour). This pace was calculated using the 2 km transect, and variation in speed was used to create a range for densities. The total of 17 transects were walked, ranging from 600-2,500 m in length, with a total distance walked of approximately 30 km.

For each transect the date, start and end time, weather, and location were recorded. When a lemur was spotted, the species was noted along with the group size, time of day, distance on transect, distance from path, habitat type, and the GPS coordinates. Density was then calculated by the number of individual lemurs/area. Area was based on the total length of transects walked multiplied by double the average perpendicular distance of lemur from the path (Whitesides *et al*., 1988; Norscia *et al*., 2006). Common methods for this type of primate study include using a 50 % criterion for falloff distance based on histograms (Whitesides *et al*., 1988; Johnson and Overdorff, 1999; Erhart and Overdorff, 2008) or the program DISTANCE (Quemere *et al*., 2010). However, given time constraints it was not possible to collect an adequate amount of data to perform these tests. Based on earlier studies on similar species in similar habitats we used a falloff distance of 20 m (Irwin, 2001). In addition to transect walks, interviews were conducted with employees of the ANGAP office of Mananara Nord and local people of the town of Ambodivoandrozana. Within the village, the interviews were done with prominent members of the community including members of Slow Food (an agriculture movement within the biosphere) and the COBA.

Results

The observed population density for *Eulemur albifrons* was 46.13 ± 2.32 individuals/km^2 within the park (Tab. 1). The average group size observed was 7 individuals. Multiple groups were observed with females carrying babies on their back, and overall this species was found in a variety of different habitats, both dense and sparse primary forest, and even on the edge of secondary growth. Through a combination of data collected in the forest and interviews with local people, we found that though *Eulemur albifrons* frequents multiple habitats, even leaving the forest to eat crops, they mainly rest within the National Park.

Two other diurnal lemur species were observed within the parcel, *Varecia variegata variegata* and *Eulemur rubriventer. V. v. variegata* was observed to have a density of 1.06 ± 0.02 individuals/km^2 (Tab. 1). This species was only observed on one occasion and only one individual was seen. According to the local guide and vice president of the COBA, eight individuals of this species exist within the parcel, a group of five and a group of three (F. Frejes, personal communication). This implies a density of 0.97 individuals/km^2. From traces observed on the ground (eaten fruit) and calls heard, it seems clear that this lemur spends the majority of its time within the limits of the parcel as it prefers deep valleys with tall trees; a habitat not found in the more disrupted community managed forest.

Tab. 1: Density of diurnal lemurs within the parcel of Ivontaka Nord. Densities were calculated of the three species observed within the parcel, *Eulemur albifrons, Eulemur rubriventer,* and *Varecia v. variegata.* A 50 % falloff distance was used for perpendicular distances over 20 m (Whitesides *et al*., 1988; Irwin *et al.,* 2000) Error bars represent the error in pace of transect walked and error in observation of animals from path.

Species	Number of individuals encountered	Number of groups encountered	Calculated density (individuals/km^2)
Eulemur albifrons	31	5	46.13 ± 2.32
Eulemur rubriventer	3	1	6.40 ± 0.38
Varecia v. variegata	1	1	1.06 ± 0.02

Eulemur rubriventer, being a species believed to live west of the biosphere in higher altitude rainforest, was thus not on the initial list of lemurs to be found in the area. From the one sighting of three individuals in a dense part of the primary forest, the calculated density is 6.40 ± 0.38 individuals/km^2 for the parcel (Tab. 1). No sightings were made of this individual outside of the parcel, and as its eating habits closely mirror that of *E. albifrons*, it was not possible to tell the difference between traces found on the ground.

Discussion

The parcel of Ivontaka Nord is considered to be an example of disturbed primary forest. Anthropogenic effects are much stronger in Ivontaka Nord than in other parcels, because it is the smallest of the three, and the closest to the town of Mananara. Before the creation of the national park, the area of Ivontaka Nord was frequently used as a place to grow crops through *tavy*, harvest wood for construction and cooking, and hunt lemurs. For these reasons, the lemur population of the parcel was at one time diminished to the point of localized extinction of the critically endangered *Varecia v. variegata,* in addition to the localized extinctions of *Indri indri* and *Hapalemur griseus* (J. Betsiahilika, personal communication). Yet, because it is connected through a corridor of community managed forest to the less disturbed parcel of Ivontaka Sud (Fig. 1), in 2002, *V. v. variegata* migrated into the GCF corridor between Ivontaka Sud and Ivontaka Nord, and in 2005 these lemurs could again be found within the parcel. However, the species of *Indri indri* and *Hapalemur griseus* are not believed to currently inhabit the parcel, though they can be found in the other two parcels within the biosphere (J. Betsiahilika, personal communication).

Within the parcel, there was convincing evidence to suggest that the lemurs might be recovering even more than previously known. During the two weeks of transects, *Eulemur rubriventer* was observed within the parcel, even though its recorded range ends west of the biosphere reserve. In addition, traces of the distinct eating habits (shredding the stems of tall plants whilst stripping off foliage) of *Hapalemur griseus* were found within the *savoka*. Additionally, there were reports of *Indri indri* spending time in the corridor between Ivontaka Sud and Ivontaka Nord (J. Betsiahilika, personal communication).

Through field observations, *E. albifrons* was found to have a population twice that found in other areas such as Masoala (Mittermeier *et al*., 2006). They frequent both the parcel and community forest. During the season in which this study took place, when most of the fruit within the parcel is not yet ripe, many *Eulemur albifrons* were reported by local villagers to be exiting the parcel in search of other cultivated fruits like lychee and banana. *V. v. variegata* on the other hand appeared to not leave the protected parcel. It is possible that they adapt their feeding habits based on the season and thus do not eat cultivated fruits (Ratsimbazafy, 2002).

The observed density of *V. v. variegata* was not congruent with the report of the local guide (F. Frejes, personal communication). This species, like *Eulemur rubriventer*, was observed on only one occasion. Because of time constraints, surveys had to be conducted over a two week period and with only the use of one field team. For more complete and definitive findings, a survey needs to be done over a longer period of time, possibly across different seasons. Also, it would be beneficial to conduct the same type of study after dark. Finally, it would be helpful to determine lemur densities in the other two parcels, and the community managed forests in-between.

Conclusion

It is currently of the utmost importance to make sure that the integrity of forested sections outside the realm of the parcel remains protected. These areas represent a buffer between the fragile low altitude rainforest and an ever expanding human population. The corridor formed by these community-managed forests, between the three national park parcels, is a priority area. It has already been shown to provide a bridge to facilitate migration between the three parcels, which is critical in a country where forest fragmentation is proving detrimental to the gene flow of lemurs (Louis *et al*., 2006).

Through the work of the biosphere reserve, significant steps have already been taken to encourage conservation. Both government officials and villagers appear to be working together to promote a healthy ecosystem. Already with the promotion of crops such as vanilla, cloves, and coffee, as an alternative to other more environmentally negative livelihoods, villagers say they have seen an improvement both in their lives and the forest health (Desana and Berger, personal communication). However, people have needs; the agricultural inhabitants of these rural areas need both to grow their food and to have wood and other materials for performing everyday tasks. It is possible to improve both the lives of the people in the area and decrease their negative impact on their environment through simple strategies such as rice intensification and promoting more efficient cooking methods. Maybe then populations of *Indri indri*, *Hapalemur griseus*, and *Propithecus diadema*, all species that at one time inhabited the area, will return to the parcel of Ivontaka Nord.

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Distribution of *Prolemur simus* north of the Mangoro-Nosivolo River – how far north do we really have to look?

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Introduction

While the Mangoro-Nosivolo river system is a recognized biogeographical divide for several lemur species (Goodman and Ganzhorn, 2004), this pattern does not hold for the Greater Bamboo Lemur (*Prolemur simus*). Findings from numerous subfossil sites indicate that the historical distribution of *P. simus,* now one of the rarest Malagasy primates (Wright *et al.,* 2008, 2009), once encompassed most of Madagascar (Godfrey and Vuillaume-Randriamanantena, 1986). During the last 150 years, documented sightings of the species became more and more scarce and by the middle of the last century it was already feared extinct (e.g. Napier and Napier, 1967).

More recent discoveries came solely from southeastern Madagascar (Petter *et al.*, 1977; Meier and Rumpler, 1987), which led to the unspoken assumption that *P. simus* had been extirpated from the rest of the island. Despite the fact that the last collected specimen of *P. simus* had come from Mananara in 1876 (Godfrey and Vuillaume-Randriamanantena, 1986), not a single individual had been found north of the Mangoro river for more than 130 years, before Dolch *et al.* (2004, 2008) rediscovered the species in Torotorofotsy, in the commune of Andasibe.

In order to investigate further into the distribution and abundance of *P. simus* north of the Mangoro, several extensive surveys have recently been, and are currently being, conducted (King and Chamberlan, 2010). As preliminary results of these surveys are trickling in, accounts of *P. simus* from inhabitants of these regions also multiply rapidly and await verification.

We do not aspire to anticipate survey results, but we believe that summarizing our current knowledge of *P. simus* north of the Mangoro is crucial for the planning of future surveys and conservation strategies.

Methods

We gathered and compiled information on *P. simus* north of the Mangoro deduced from our own research, from reports that villagers brought to our attention, and from anecdotal evidence in existing literature. The ten localities from where information was available included (from south to north) the Marolambo area, the Brickaville area, the western parts of the Ankeniheny-Zahamena Corridor (CAZ), Zahamena, the Soanierana-Ivongo area, Ambatovaky, Marotandrano, Mananara, Makira, and Marojejy (Fig. 1).

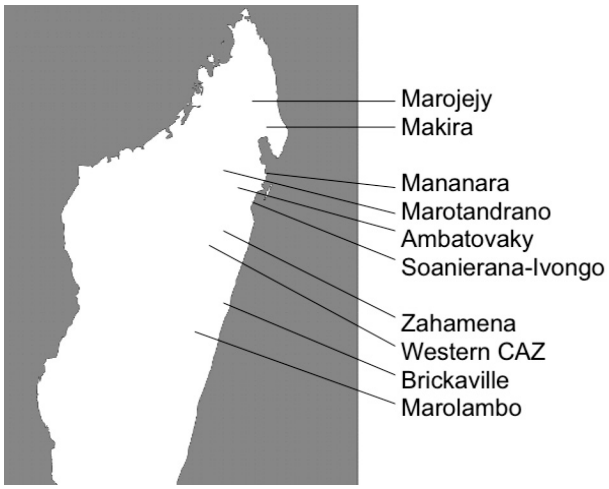

Fig. 1: Localities from where information on *P. simus* was collected.

Results

Results of our compilation are summarized in Tab. 1. Of all localities north of the Mangoro examined, two (Brickaville and western CAZ) have steadfast records of *P. simus* based on independently confirmed sightings. One locality (Soanierana-Ivongo) has a record based on a single observation, whereas for four others (Marolambo, Zahamena, Ambatovaky, Makira) evidence is only based on reports of villagers. The final three (Marotandrano, Mananara, Marojejy) do not have any records. Details are given below.

Tab. 1: Potential localities for *P. simus* north of the Nosivolo-Mangoro.

Region	evidence based on
Marolambo area	reports by villagers
Brickaville area	sightings, confirmed
Western CAZ	sightings, confirmed
Zahamena	reports by villagers
Soanierana-Ivongo area	sightings, unconfirmed
Ambatovaky	reports by villagers
Marotandrano	(no evidence)
Mananara	(mo evidence)
Makira	reports by villagers
Marojejy	(no evidence)

Marolambo area. A hotspot of endemic fish species richness, the Nosivolo and lower Mangoro rivers have recently received increased attention by researchers and conservationists alike. While working in this area, we received several accounts of villagers on *P. simus* from 2006-2009. Reports claiming the occurrence of *P. simus* come from 4 communes along the Nosivolo-Mangoro river, and focus (from west to east) on Ambohimilanja, Betampona, Marolambo and Ambinanidilana. In order to verify these accounts, a preliminary survey is currently being conducted within The Aspinall Foundation's "Saving *Prolemur simus*" project (Ratsimbazafy, 2010).

Brickaville area. A similar survey has already been conducted for the Brickaville area. A total of 6 sites in isolated fragments in the communes (from west to east) of Fanasana, Anivorano and Fetraomby have been found containing *P. simus*. Details are given by Ravaloharimanitra *et al.* (2010).

Western CAZ. In the course of the same survey, 12 sites in the western parts of the Ankeniheny-Zahamena corridor have been found containing *P. simus* (Ravaloharimanitra *et al*., 2010). These findings follow earlier reports from villagers that had claimed its presence (e.g. Schmid and Alonso, 2005). The communes where *P. simus* has been confirmed include (from south to north) Andasibe, Morarano-Gare, Fierenana, and Didy.

Zahamena. Ganzhorn (2004) states that a report of the presence of *P. simus* in the PN Zahamena was brought to his attention in 1995, but that it "was questioned and eventually withdrawn". Information on a possible occurrence of *P. simus* in Zahamena, obviously derived from that report, is mentioned in Godfrey *et al.* (1997).

Soanierana-Ivongo area. In their little noticed bulletin, the Association de Défense de la forêt d'Ambodiriana report that trainee Coralie Ebert, while studying the woolly lemurs (*Avahi laniger*) of this forest, claims to have observed an individual of *Prolemur simus* (ADEFA, 2009). An earlier lemur survey of the area (Beaucent and Fayolle, 2008) has not yielded evidence of *P. simus*. The forêt d'Ambodiriana lies just 30 km to the north of Soanierana-Ivongo, a region where, according to Mittermeier *et al.* (2006), *halogodro* and *bokombolobe* are still used as local names for *P. simus*.

Ambatovaky. Ambatovaky is an area that has received only little attention due to its difficult accessibility. In the early 1990s, a lemur survey was conducted by Evans *et al.* (1993-1994). They did not find tangible evidence for *P. simus*, but state that "local people indicated that there existed until recently a lemur which fed on giant bamboo along the Sandrangato and/or Marimbona rivers, known as *alakoto* or *halokoto*".

Marotandrano. Lying to the northwest of Ambatovaky, Marotandrano has even received less attention than the former. A lemur survey by Ralison (2006) did not indicate presence of *P. simus*.

Mananara. The last specimen of *P. simus* to be collected from north of the Nosivolo-Mangoro river came from an area close to Mananara (Godfrey and Vuillaume-Randriamanantena, 1986). Although the exact collection locality can not be traced (due to unsuited transcription of its name by the collector J. P. Audebert), the assumption that *P. simus* may still occur in the forests around Mananara was still put forward by Nicoll and Langrand (1989). No evidence for *P. simus* in Mananara has been produced since.

Makira. Being Madagascar's largest continuous rainforest (317,000 ha), lemur surveys in Makira are not easy to conduct. Two years of intensive surveys by Rasolofoson *et al.* (2007) and Ratelolahy and Raivoarisoa (2007) have not uncovered any evidence of *P. simus*. Similarly, during seven years of relying on trusting relationships with hunters, Golden (2009) has not come across *P. simus* among the 23 mammal species hunted for consumption throughout southern, western, northern, and eastern Makira. However, villagers living adjacent to the newly discovered Antohaka Lava forest at the edge of northeastern Makira (20 km south of Andrakata on Marojejy's southeastern border) have reported recent sightings of a large bamboo lemur with ear tufts known locally as *bokombolobe*. Unfortunately, several months of systematic lemur surveying of the Antohaka Lava forest between August and December 2009 did not confirm these reports, despite an exceptional primate diversity documented inthat area (Patel, 2009).

Marojejy. A lemur survey by Sterling and McFadden (2000) found no evidence of *P. simus*. Alleged observations of bamboo lemurs other than *Hapalemur griseus* by tourists may be attributed to the possible presence of *H. occidentalis*, rather than *P. simus* (R. Mittermeier, pers. comm.). Moreover, during nine years of research on *Propithecus candidus* in Marojejy, no local reports or sightings of *P. simus* have been received (Patel, 2009).

Discussion

Despite the scarcity of information, growing evidence supports that *P. simus* may still be widespread in Madagascar north of the Mangoro river. Since the species occupies large home ranges (Dolch *et al*., unpubl. data), appears to travel at night due to possible cathemerality (Santini-Palka, 1994), is cryptic, and often silent when unhabituated, it is conceivable that it has been overlooked in the past. However, because the *P. simus* vocal repertoire is distinct and extensive (Bergey and Patel, 2008) and its feeding traces on giant bamboo (*Cathariostachys madagascariensis*) are unmistakable, attention to such indirect evidence of *P. simus* presence should be focused upon in all surveys.

The report from Makira, if confirmed, is especially interesting, since the northernmost former record for the species (other than from subfossils) comes from Antongil Bay (Schwarz, 1931).

Our experience shows that accounts of villagers are mostly reliable, and that people usually have a good sense of what animal species do or do not occur in their vicinity. Therefore, integrating local people is crucial for further studies into *Prolemur* distribution. Logically, collaboration with local people is one conservation recommendation given by the Prolemur Conservation Working Group (Madagascar Fauna Group, 2010).

Based on information compiled, we tentatively conclude that *P. simus* is still more widespread than previously thought. Without sufficient data, given persisting threats to the habitats in which it occurs and our incomplete understanding of habitat requirements for the species, we do not dare say that a larger distribution area contributes in any way to relieving the species from extinction pressure. Unfortunately, *P. simus* still has to be considered one of the most threatened primates in the world.

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Enquête préliminaire de la distribution des lémuriens de bambou dans et autour du Corridor forestier Fandriana-Vondrozo, Madagascar

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Introduction

Le Grand Hapalémur (*Prolemur simus*) mangeur de bambou, est classé comme étant "gravement menacé CR" sur la liste rouge de l'Union Internationale pour la Conservation de la Nature (UICN, 2009). Il est aussi l'une des quatre espèces de Madagascar faisant partie des 25 primates considérés comme les plus menacés au monde (Mittermeier *et al.*, 2007, 2009). Des individus capturés dans les années 1800 venaient d'une région plus étendue, ce qui laisse supposer que son habitat a diminué. Les sites de subfossiles avec des squelettes identiques à celui de *P. simus* sont nombreux, impliquant une distribution encore plus vaste à une époque très ancienne (Godfrey et Vuillaume-Randriamanantena, 1986; Godfrey *et al.*, 2004).

Actuellement, la distribution géographique de l'espèce semble très étroite. On pense que *P. simus* est seulement présent dans quelques fragments de forêt tropicale humide près de la côte Est de Madagascar (Mittermeier *et al.*, 2006 ; Dolch *et al.*, 2008; Wright *et al.*, 2008). Wright *et al.* (2008) résume la crise

actuelle de l'espèce: sur les 70 localités étudiées, la présence de *P. simus* est confirmée seulement sur 11 d'entre elles, à une altitude comprise entre 121 et 1600 m.

La plupart des sites connus abritant *P. simus* se trouvent dans ou autour du Corridor Fandriana-Vondrozo, dans le Sud-Est du pays (Andriaholinirina *et al.*, 2003; Meier et Rumpler, 1987; Sterling et Ramaroson, 1996; Wright *et al.*, 1987, 2008; Mittermeier *et al.*, 2009). Deux autres espèces de lémuriens de bambou vivant dans le corridor, *Hapalemur aureus* et *H. griseus*, sont aussi menacées (Mittermeier *et al.*, 2006; IUCN, 2009). Notons que *P. simus* est le plus grand des lémuriens de bambou, avec un pelage gris brun (comme *H. griseus*). Il se distingue facilement des deux autres espèces par des touffes de poils blancs sur les oreilles. Sa face est aussi plus allongée, et on le trouve souvent au sol, alors que les autres espèces y sont rarement (Wright *et al.*, 1987). Selon l'étude de Tan (1999) à Ranomafana, le régime alimentaire de *P. simus* est constitué à 95 % d'une seule espèce de bambou *Cathariostachys* sp. (ou *volohosy* dans le dialecte local malgache), 3 % d'autres espèces de bambous et de graminées, 0,5 % de fruits et 1,5 % d'autres éléments (principalement de la terre et des champignons).

La présente étude a été organisée dans le cadre du Projet Varibolomavo proposé par The Aspinall Foundation (TAF). Ce projet veut mettre en place des actions rapides, efficaces et collaboratives pour sauver *Prolemur simus*. Plus précisément, le deuxième objectif du projet est d'organiser une étude de la distribution et de l'abondance de *P. simus* (TAF, 2008, 2009; King and Chamberlan, 2010). Par conséquent, le but de cette étude était de contribuer à réaliser ces objectifs, dans et autour du corridor Fandriana-Vondrozo, par a) la récolte des connaissances indigènes locales sur les distributions des lémuriens; et b) la recherche des signes de présence des lémuriens de bambou. Nous présentons ici un résumé des résultats de l'étude, exposés de façon plus détaillée par Ratolojanahary *et al.* (2009).

Méthodes

Entre les 27 novembre 2008 et 25 mai 2009, nous avons enquêté dans 14 zones situées dans et autour du Corridor Fandriana-Vondrozo (Tab. 1, Fig. 1). Pour chaque commune, des entretiens avec les autorités locales ont eu lieu. Des collaborations avec ces personnes ont permis d'organiser les réunions villageoises pour mener les enquêtes participatives, à l'aide de photos des espèces de lémuriens supposées coexister dans ce couloir forestier (*Prolemur simus*, *Hapalemur aureus*, *H. griseus*, *Eulemur rufus*, *E. rubriventer*, *Propithecus edwardsi*, *Varecia variegata editorum, Microcebus rufus, Cheirogaleus major*, *Avahi laniger*, *Lepilemur microdon*, *Daubentonia madagascariensis*). Les appellations locales des différentes espèces connues par les communautés villageoises ont été relevées lors de chaque enquête. De plus, nous avons utilisé la méthode de cartographie participative (Jones *et al.*, 2005) durant la réunion dans les communes de Mahazoarivo, landraina, Sahamadio et Evato. Suite aux résultats des enquêtes villageoises, nous avons visité des forêts et sites intéressants dans la région, toujours accompagnés par un guide local et des agents de recherche du Centre ValBio de Ranomafana. Nous nous arrêtions tous les 25 mètres pour relever la localisation des bambous et des espèces de lémuriens, ainsi que les signes de présence de ces dernières.

La présence des espèces de lémuriens était révélée soit par l'observation directe (animal vu), soit par l'observation indirecte (signes de nourrissage, excréments ou vocalisation). La recherche des signes de nourrissage des lémuriens de bambou était faite dans les zones de bambous, et les signes

Tab. 1: Les zones visitées pendant l'enquête.

Zone	Sites visités	Dates
Zones situées dans le corridor forestier		
Ambendrana	1	27-28 nov 2008
Amindrabe	1	29 nov - 1 déc 2008
Ambodiara	1	11-13 déc 2008
Antarehimamy	1	14-16 déc 2008
Antaranjaha	4	29 jan - 6 fév 2009 (dont Tsianivoho et Ambolomadinika)
Manambolo	1	9-11 mai 2009
Zones situées autour du corridor forestier		
Mananjary	4	14-16 jan 2009
Sahalanona	9	17-23 jan 2009
Manakara	1	25 jan 2009
Mahazoarivo	2	18-19 mai 2009 (dont Ifasy)
landraina	1	21 mai 2009
Sahamadio	1	22-23 mai 2009
Evato	0	24-25 mai 2009
Mahafasa	0	25 mai 2009
14 zones	**27 sites**	**27 nov 2008 - 25 mai 2009**

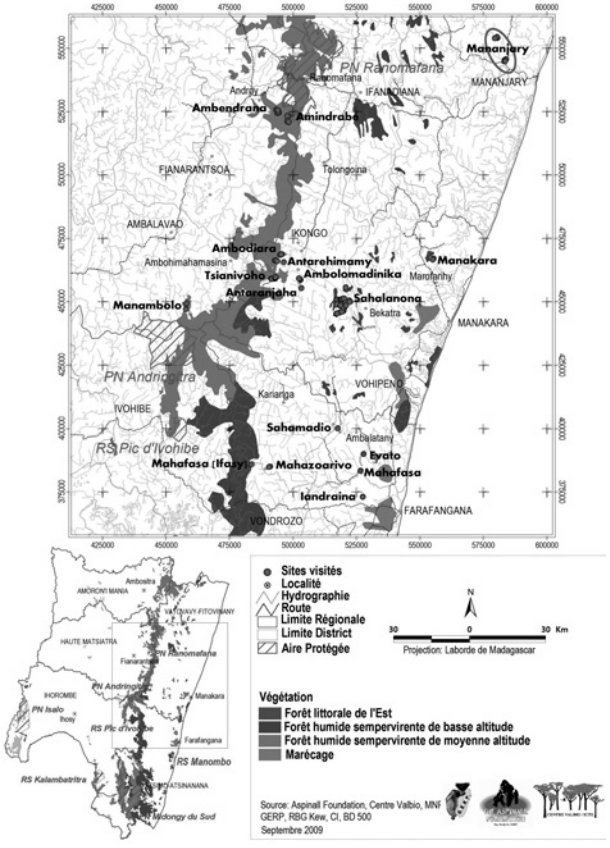

Fig. 1: Les sites visités lors de l'enquête dans et autour du Corridor forestier Fandriana-Vondrozo.

étaient examinés précautionneusement afin d'identifier l'espèce qui en était responsable. *Prolemur simus* préfère surtout les bambous de grand diamètre, et les parties de bambou privilégiées varient avec les saisons. Entre juillet et novembre, *P. simus* consomme principalement la moelle tendre de bambou géant (Tan, 1999), après avoir ouvert la tige en deux et l'avoir déchirée en petits morceaux (Wright *et al.*, 1987). Ainsi, l'échantillon à rechercher devrait être des tiges déchirées sans ou avec peu de moelle. Par contre, entre novembre et avril, il se concentre sur les jeunes pousses (Tan, 1999), donc les échantillons devraient être des bouts de jeunes pousses de bambou géant. Avec de l'expérience, il est égale-

ment possible de distinguer les signes laissés sur les feuilles de bambou. *P. simus* se nourrit des jeunes feuilles matures et ne consomme pas la partie tranchante de la feuille. Par contre, *Hapalemur aureus* et *H. griseus* consomment uniquement la base de la feuille, *H. aureus* déchirant la gaine de chaume à l'aide de ses dents avant de manger les branches.

Résultats et Interprétations

Espèces de lémuriens recensées

Les populations locales ont souvent des noms vernaculaires distincts pour les différentes espèces de lémuriens. En outre, nous avons remarqué qu'ils ne pouvaient pas toujours identifier les espèces sur les photos, alors qu'ils pouvaient les reconnaître dans la nature. Les informations récoltées lors des enquêtes villageoises doivent donc être utilisées avec précaution et sont toujours à vérifier sur le terrain. Durant les vérifications, nous n'avons trouvé qu'un seul site présentant des signes de nourrissage de *Prolemur simus* (Tab. 2). Par contre, nous avons effectué 39 observations (directes et indirectes) de *Hapalemur griseus*, dans 10 des 12 zones visitées (Tab. 2), et huit observations (indirectes) de *H. aureus* (Tab. 3). Toutes ces observations ont été faites dans les zones situées au sein du corridor forestier, mais aucune dans ses alentours (Tab. 2). Cette espèce a laissé des signes de nourrissage et émis des cris. La présence de huit autres espèces de lémuriens a également été constatée (Tab. 2). L'une d'entre elles, *Varecia variegata editorum*, est une sous-espèce gravement menacée selon l'UICN (2009), et les détails de toutes les observations de cette espèce sont présentés dans le Tab. 4.

Résultats par zone située dans le corridor forestier de Fandriana-Vondrozo

Ambendrana: Le village d'Ambendrana (S21°22'44.9" E 047° 18'31.0", altitude 1121 m) est placé sous l'autorité de la commune rurale d'Androy et situé à une vingtaine de kilomètres au sud du Parc National de Ranomafana. Ce village est entouré de rizières localisées tout autour du corridor. La forêt d'Ambendrana a une superficie de 1.496 hectares et est gérée par la communauté de base depuis 2003. Au cours de l'enquête, les villageois n'ont reconnu que 3 espèces de lémuriens des 12 présentées sur les photos, notamment l'espèce *Hapalemur griseus*. D'après nos observations, la forêt d'Ambendrana est perturbée. Cependant, nous avons pu localiser quelques groupes de lémuriens, dont un groupe de *H. griseus*, et des signes de nourrissage.

Amindrabe: La forêt d'Amindrabe a une superficie de 5.800 hectares et est également gérée par la communauté de base depuis 2003. Cette forêt est située à 5,7 km du village d'Ambendrana. Le Fokontany Amindrabe (S21° 23'14.8" E047°21' 46.4", altitude 1096 m) fait également partie de la commune rurale d'Androy et comprend plusieurs villages. Durant l'enquête, les villageois ont reconnu 5 espèces de lémuriens, dont *H. griseus*. Pendant l'expédition dans le site d'Amindrabe, deux anciens signes de nourrissage (vieux d'environ un an d'après nos constatations) de *P. simus* ont été trouvés sur le tronc d'une espèce de bambou localement appelé Volotsangana (S21°24' 22.5", E047°23'07.2", altitude 1055 m). Nous avons également trouvé deux groupes de *H. griseus*, des *Propithecus edwardsi* et des signes d'alimentation de *Daubentonia madagascariensis*, attestant de la grande diversité de ce site en espèces de lémuriens.

Ambodiara: Le Fokontany d'Ambodiara (S21°54'41.3", E047°23'29.2, altitude 346 m) existe depuis 1910 et est composé de 8 villages. Le village d'Ambodiara est situé à 5,9 km, c'est-à-dire à environ 3 heures de marche à l'ouest d'Ikongo. Au cours de l'enquête, les villageois ont reconnu 9 espèces de lémuriens, dont *Hapalemur aureus, H. griseus* et également *Prolemur simus*. D'après nos observations, la forêt d'Ambodiara est perturbée. Nous n'avons pas trouvé *P. simus* sur ce site, mais nous avons constaté la présence de *Cathariostachys* sp. Par contre, *Varecia variegata editorum* abonde dans cette localité, et nous avons trouvé des signes de nourrissage de *H. aureus* et *H. griseus*.

Antarehimamy: Situé dans le district d'Ikongo, le village d'Antarehimamy (S21° 55'59.2", E047°22'17.6", altitude 410 m) se situe à 3,16 km au Nord-Est d'Ambodiara et à 9,01 km à l'ouest de la commune rurale d'Ikongo. Lors de l'enquête, les villa-

Tab. 2: Espèces de lémuriens rencontrées dans chaque zone.

Zone	*Hapalemur griseus*	*Hapalemur aureus*	*Prolemur simus*	*Autres espèces*
Zones situées dans le corridor forestier				
Ambendrana	vu & signes	signe		*E rubriventer* (vu) *Microcebus* sp. (nid)
Amindrabe	vu & signes	signe	signe (environ 1 an)	*P. edwardsi* (vu et entendu) *D. madagascariensis* (signes)
Ambodiara	signes	signes		*V. variegata* (entendu)
Antarehimamy	signes	signes		*V. variegata* (entendu)
Antaranjaha	signes	signes & entendus		*V. variegata* (entendu) *E. rufus* (vu)
Manambolo		signes		*E. rufus* (vu) *E. rubriventer* (vu)
Zones situées autour du corridor forestier				
Sahalanona	vus & signes			*M. rufus* et *A. laniger* à vendre
Mananjary	vus & signes			*Microcebus* sp. (nid) *Cheirogaleus* sp. (signes)
Manakara				*E. rufus* (vu) *A. laniger* (vu)
Mahazoarivo	vus			
Iandraina	signes			
Sahamadio	signes			

Tab. 3: Observations de *Hapalemur aureus* faites pendant l'étude.

Zone	Remarque	Latitude	Longitude	Altitude (m)
Ambendrana	signe de nourrissage	S 21° 22' 22.7"	E 047° 20' 46.5"	1182
Amindrabe	signe de nourrissage	S 21° 24' 13.1"	E 047° 22' 47.7"	1070
Ambodiara	signe de nourrissage	S 21° 53' 27.0"	E 047° 21' 18.9"	825
Antarehimamy	signe de nourrissage	S 21° 54' 47.5"	E 047° 20' 38.4"	1074
Antaranjaha	signe de nourrissage	S 21° 58' 20.3"	E 047° 20' 16.7"	828
Antaranjaha	entendu des cris	S 21° 58' 25.3"	E 047° 20' 17.7"	783
Antaranjaha	signe de nourrissage	S 21° 58' 39.1"	E 047° 19' 43.8"	786
Manambolo	signes de nourrissage	S 22° 04' 06.2"	E 046° 59' 27.5"	1238

Tab. 4: Observations de *Varecia variegata* faites pendant l'étude.

Zone	Remarque	Latitude	Longitude	Altitude (m)
Ambodiara	entendu des cris	S 21° 53' 17.4"	E 047° 21' 42.3"	500
Ambodiara	entendu des cris	S 21° 53' 17.7"	E 047° 21' 34.5"	825
Antarehimamy	entendu des cris	S 21° 55' 00.4"	E 047° 22' 10.3"	489
Antaranjaha	entendu des cris	S 21° 58' 23.6"	E 047° 20' 15.4"	828
Antaranjaha	entendu des cris	S 21° 58' 31.5"	E 047° 20' 13.6"	743

geois ont reconnu 7 espèces de lémuriens, mais aucun lémurien de bambou. Néanmoins, nous avons trouvé des signes de nourrissage de *Hapalemur aureus* et *H. griseus*. Nous avons également remarqué l'abondance de *Varecia variegata editorum* sur le site.

Antaranjaha/Ambolomadinika/Tsianivoho: Située dans le district d'Ikongo, la commune d'Ambolomadinika gère 12 Fokontany, dont Antaranjaha et Tsianivoho. Le Fokontany Antaranjaha (S21°59'42.3", E047°25'40.2") est situé à 3,7 km au Sud-Ouest d'Ambolomadinika. Dans ce site, les villageois n'ont pas reconnu de lémuriens de bambou. Cependant, des cris de *Hapalemur aureus* ont été entendus dans la forêt à 150 m environ de notre campement, c'est-à-dire à Ankazondrano. A Marofototra, situé à 30 minutes du Fokontany d'Antaranjaha, toutes les jeunes pousses de bambou *Cathariostachys* sp. étaient coupées. Ce sont des signes de nourrissage de *H. griseus*. De plus, un villageois a confirmé avoir trouvé un groupe de *H. griseus* comprenant 12 individus à cet endroit. Nous avons également entendu des cris de *Varecia variegata editorum*, vu un groupe de *Eulemur rufus*, et trouvé un piège à lémuriens dans la forêt. Dans la commune rurale d'Ambolomadinika, on remarque beaucoup de zones agricoles déboisées. Malheureusement, les lémuriens de bambou sont menacés à cause de la coupe massive de bambous dans ces zones et la chasse pratiquée par les habitants de la Commune.

Manambolo: Située dans la région de Fianarantsoa, la forêt de Manambolo (S22°04'06.2", E046°59'27.5", 1238 m) se trouve dans le Fokontany de Morafeno, commune rurale de Sendrisoa. La gestion de la forêt est assurée par le FI.TE.MA (FIkambanan'ny TEraky MAnambolo) et concerne cinq villages: Mandamako, Mahavita, Ambinda, Ankazobe, Ampidira. La survie de la population locale dépend largement de l'agriculture, l'élevage et la production du rhum traditionnel. Cependant, la culture sur brûlis est encore pratiquée sur la lisière forestière. Lors de l'enquête, les villageois ont reconnu 4 espèces de lémuriens, dont *Hapalemur griseus* et *H. aureus*. La vérification en forêt nous a révélé des signes de nourrissage de *H. aureus*, et nous avons vu directement *Eulemur rufus* et *E. rubriventer*.

Résultats par zone située autour du corridor forestier de Fandriana-Vondrozo

Mananjary: Notre campement à Tsararivotra (S21°10'41.8", E048°13'19.6", altitude 39 m) était situé à 23 km au nord-ouest de la ville de Mananjary. Le site de Tsararivotra est inclus dans le Fokontany de Volomborona Asakatara et fait partie de la commune de Morafeno Mananjary. Nous n'avons trouvé que *Hapalemur griseus*, *Cheirogaleus major* et *Microcebus rufus* dans cette zone.

Sahalanona: La commune de Sahalanona fait partie du District d'Ikongo et inclut 9 Fokontany (Sahalanona, Mahaly, etc.). La population est composée d'agriculteurs, d'éleveurs et de pêcheurs. Le village de Sahalanona (S22°03'19.2" E047°37' 12.2", altitude 129 m) existe depuis environ 300 ans. Malgré l'abondante présence de bambous, dont le bambou géant *Cathariostachys* sp., nous n'avons trouvé que *Hapalemur griseus* dans cette zone. Cette espèce est menacée par la chasse que pratiquent les villageois. D'autres espèces de lémuriens sont également en danger car elles sont aussi chassées et vendues par les villageois, notamment *Avahi laniger* (chassé pour l'alimentation et l'usage domestique) et *Microcebus rufus* (dont le prix est de 5.000 Ariary par individu).

Manakara: Le village d'Ambila se trouve à 17 km au nord de Manakara. Le Fokontany Ambila fait partie de la commune d'Ambila (S22°00'11.6", E047°58'19.9") de la région de Manakara. Notre observation a été effectuée directement dans la forêt de Tsiazombazaha située à 10 km du village d'Ambila. L'enquête n'a pas eu lieu dans ce site car il n'y avait plus de village (principalement notre cible) autour de la forêt. Cette forêt est gérée par la communauté de base du Fokontany d'Ambila. A cet endroit, nous n'avons pas trouvé de bambou, et avons trouvé seulement deux espèces de lémuriens, *Avahi laniger* et *Eulemur rufus,* après vérification dans la forêt.

Mahazoarivo/Ifasy: Située dans la région de Farafangana, la commune de Mahazoarivo (S22°39'49.0", E047°18'42.4", 222 m) fait partie du corridor forestier, et la population pratique l'agriculture et l'élevage. L'exploitation des ressources minières, surtout des pierres précieuses, représente une source de revenus importante pour la population. Lors de l'enquête, les villageois n'ont reconnu que deux espèces de lémuriens, *Hapalemur griseus* et *Microcebus rufus*. Nous avons visité deux forêts dans cette commune, à Mitimboto (Fokontany de Mahazoarivo) et Ifasy ou Mahafasy (Fokontany Mahatsara) où deux groupes de *H. griseus* ont été vus sur chaque site. A Ifasy (S22°39'13.0", E47°14'56.1"), des individus de *H. griseus* de très grande taille ont été localisés, similaires à *Prolemur simus*, mais l'absence des touffes de poils blancs sur les oreilles nous a permis de faire la distinction. Nous avons également remarqué que le nom local de *H. griseus* était différent à Mitimbato et Ifasy, respectivement Varibolo madinika et Varibolo vaventy.

Iandraina: Le Fokontany d'Iandraina fait partie de la commune Rurale de Vohimasy. Il se situe à 15 km au nord-ouest de Farafangana. La forêt de Befoza et celle d'Ambolosy (S22°46'07.0", E047°41'07.0", 53 m) se trouvent dans ce fokontany. Les populations sont constituées principalement d'agriculteurs et d'éleveurs. La pratique des cultures vivrières constitue l'activité principale. Contrairement aux autres sites que nous avons visités dans le sud de la zone d'étude, nous avons trouvé une population de *Cathariostachys* sp. à Ambolosy.

Sahamadio: Située dans la région de Farafangana, cette zone est plus ou moins enclavée (absence d'infrastructure routière) et même la circulation et le transport de produits locaux s'effectuent toujours par pirogue. La commune rurale de Sahamadio (S22°31'13.4", E047°35'02.8", altitude 27 m) dépend beaucoup de l'agriculture. L'existence de signes de nourrissage dans la forêt de Sahamadio nous a permis d'établir que *Hapalemur griseus*, localement appelé "varibolo" y est présent. L'enquête effectuée au niveau de la commune rurale d'Ambalatany a également confirmé la présence de lémuriens de bambou de grande taille dans la forêt d'Ambalakazaha.

Evato: Dans la commune d'Evato (S 22°36'42", E 047°41'20"), dans la région de Farafangana, le développement des différentes infrastructures est remarquable, citons comme exemple les hôpitaux, écoles, marchés et routes en bon état. Un bloc de forêt primaire se trouve à Iaboloha dans cette commune. Notre enquête nous a donné des informations sur la présence de plusieurs espèces de lémuriens dans cette forêt. Ce site mérite donc d`être visité pour une prochaine vérification.

Mahafasa: Dans cette zone située également dans la région de Farafangana, ce qui reste de forêt primaire est en général la forêt de bambou, un endroit où se trouvent des tombeaux. Etant donné la situation actuelle de sécurité, nous n'avons pas obtenu la permission de visiter cette forêt sacrée de bambou. Cette dernière recouvre une grande surface, environ 3 km de longueur et jusqu'à 100 m de largeur, et pourrait être importante en tant qu'habitat de lémuriens.

Discussion

La série d'expéditions menée le long du Corridor forestier Fandriana - Vondrozo nous a permis d'évaluer provisoirement la répartition des lémuriens de bambou. Concernant *Prolemur simus*, un seul signe de nourrissage a été identifié, et ce signe remontait à un an, confirmant les résultats des études précédentes qui indiquent que l'espèce a une distribution fragmentée dans la région (Wright *et al.*, 2008). Pour *Hapalemur aureus* (espèce menacée EN), la découverte de l'évidence de sa présence sur six zones, toutes dans le corridor forestier, est encourageante car cela implique une large distribution dans celui-ci, bien que l'espèce ne semble pas exister en-dehors. *Hapalemur griseus* (espèce vulnérable VU) a été trouvé dans presque toutes les zones visitées, dans le corridor forestier mais également dans des zones éloignées de ce dernier.

La menace principale pour les espèces de bambou dans la région du corridor Fandriana-Vondrozo est la destruction des habitats naturels et leur conversion en champs de culture. Cette technique est appelée "agriculture sur brûlis". Par conséquent, cette pression entraîne la raréfaction et même la disparition des espèces autochtones de bambous. Malgré la présence de bambous à l'intérieur du corridor, la persistance de la pratique du tavy, les coupes de bambous en permanence et surtout la chasse aux lémuriens mettent en péril la survie des espèces de lémuriens. En outre, la taille de la forêt du Corridor Fandriana-Vondrozo est petite par rapport aux autres corridors forestiers du pays. Sa largeur est très réduite surtout dans sa partie sud, et sur la photo aérienne, la voûte forestière apparaît très ouverte. Tous ces facteurs menacent la viabilité des populations de lémuriens vivant dans le corridor, et tout particulièrement les espèces présentant une distribution fragmentée telles que *P. simus*.

Actuellement, beaucoup de lémuriens sont chassés et vendus par les villageois (exemple: Sahalanona, Antaranjaha). Les forêts de bambous sont fragmentées et isolées les unes des autres, ce qui laisse à penser que ces lémuriens de bambou sont réellement en danger. En outre, les utilisations des bambous dans la région sont nombreuses. La population locale utilise les différentes espèces de bambou suivant leur taille pour la construction des maisons, particulièrement pour les toitures, les murs, et des clôtures. Les bambous servent également à fabriquer du matériel pour les usages quotidiens, parmi lesquels les paniers à fruits, volailles, écrevisses et anguilles. Enfin, ils permettent de transporter des bagages. Aussi, les espèces de bambous de plus grand diamètre sont utilisées comme récipient pour transporter de l'eau. La conséquence négative de l'utilisation des bambous est minime par rapport à la destruction des habitats. Exemple: le Corridor d'Ampitsinjovabe (site d'Antarehimamy) est une bonne localité pour trouver *H. griseus*, *H. aureus* et *V. variegata editorum*, mais ces trois espèces sont menacées à cause de la chasse et des coupes sélectives de bois pratiquées par les habitants résidant autour du corridor.

Pour la conservation de *Prolemur simus*, il faudrait accroître la taille des aires protégées en y incluant les forêts de bambous, et restaurer les fragments d'habitats isolés au sein d'un paysage agricole déboisé, afin d'équilibrer la valence écologique, c'est-à-dire la zone supportable pour l'espèce (en pratiquant une reforestation de bambou). Cependant, d'une façon générale, il y a un besoin immédiat de sensibilisation, pour conscientiser la population aux problèmes de coupe de bambous, de tavy et de chasse des lémuriens, afin d'assurer la survie d'espèces de lémuriens dans et autour du Corridor Fandriana-Vondrozo. Finalement, les sites d'Ambodiara, Mahazoarivo (Alafady, Ranomena), Ambalakazaha et Mahafasa sont recommandés pour une nouvelle vérification de la présence ou non des lémuriens de bambou. En effet, la population locale semble être convaincue d'avoir trouvé *P. simus* à ces endroits.

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Effect of red ruffed lemur gut passage on the germination of native rainforest plant species

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Key words: seed dispersal, germination success, *Varecia rubra*, primate, corridor restoration, Masoala

Abstract

Like much of Madagascar's remaining rainforest, the forest of Masoala National Park is facing severe threats from deforestation and fragmentation. The remaining fragmented areas are connected by degraded corridors which are important for biological exchange. Frugivorous animals such as lemurs may have an important role in the restoration of such degraded areas through seed dispersal. Unfortunately, no studies have been carried out before concerning the role lemurs play in the restoration of the largest corridor in Masoala, Ambatoledama. This study explores the effect of seed passage inside the gut of the frugivorous red-ruffed lemur (*Varecia rubra*) on the germination of some native tropical plants with the aim to understand the capacity of *V. rubra* to help in the restoration of the Ambatoledama corridor. We planted seeds of nine plant species that we collected from *V. rubra*'s fresh feces in a nursery to compare with seeds that we extracted manually from corresponding fruits. The germination of seeds was monitored each month after planting them. Results showed that defecated seeds had overall a significantly higher germination rate than non-passed seeds. Thus, lemur ingestion of seeds has the capacity to improve seed germination of several species and some plants require the physiological treatment inside the gut to germinate. Results suggested that restoration projects in the area including the Ambatoledama corridor should take into account the important role *Varecia rubra* plays in the regeneration of the forest and corridor. Management actions that increase movement and protection of animals moving into and out of the corridor will be important for the long term success of the project.

Introduction

The rainforest of the Masoala Peninsula suffers greatly from loss and fragmentation caused by the human population living around the area. The forest is subdivided into different fragments, connected by corridors of degraded habitat which are Ambatoledama, Analambolo and Ilampy (Holloway, 1997). Corridors are vital for enabling gene flow and dispersal of wildlife among habitat fragments (Mech and Hallett, 2001). The largest of these is the Ambatoledama corridor, which connects two large parcels of the forest (Fig. 1). The restoration of this corridor is critical for safeguarding wildlife populations in the fragments and for preserving gene flow between fragments (Mech and Hallett, 2001; Haddad *et al*., 2003). To restore this degraded corridor, it is necessary to plant native trees or to encourage zoochory (biological dispersal of seeds through animal defecation) (Duncan and Chapman, 2002; Neilan *et al*., 2006). Since 1997, Madagascar National Parks (MNP) and the Wildlife Conservation Society (WCS) have established a restoration project in the Ambatoledama corridor by planting native fruiting trees (Holloway, 1997) with the aim of attracting frugivorous vertebrates which will in turn carry seeds into the degraded parts of the forest and into forest clearings. Unfortunately, no studies have previously been carried out to shed light on the importance of frugivorous animals, especially lemurs, in the reforestation of the Ambatoledama corridor. Unlike the majority of tropical forests, the diversity of the frugivorous bird community in Madagascar is impoverished, and therefore primates are the principal dispersers of its tropical trees (Goodman, 1997; Dew and Wright, 1998; Ganzhorn *et al*., 1999; Bleher and Böhning-Gaese, 2001). Ten lemur species are indentified as living in the Masoala Forest (Mittermeier *et al.,* 2006); one of which (*Varecia rubra*) is endemic to this region and has Endangered status (IUCN, 2008), and can be found in both the corridor habitat and adjacent forest fragments (Razakamaharavo *et al.,* 2010). Previous studies demonstrated that *Varecia variegata* is an effective disperser in the southeastern rainforests (Dew and Wright, 1998). However, we know very little about the potential role of *V. rubra* for regeneration and restoration of the corridor habitat in Ambatoledama.

In this study, we explored the germination success of seeds defecated by *Varecia rubra* in order to understand their capacity for seed dispersal and potential impact on the restoration of the degraded rainforest corridor at Ambatoledama. Our objective was to shed light on the role of this species in forest regeneration. Understanding their influence on tree germination is particularly important given the threatened status of this species. This paper tested the hypothesis that gut passage of seeds by *Varecia rubra* facilitates seed germination. Our prediction was that lemur-gut-passed seeds have a higher germination rate than non-passed seeds because of the physiological treatment affecting the seed coat inside the gut.

Materials and methods

Field site

This study was carried out at the Ambatoledama corridor (S15°27' E050°01') on the north-eastern part of the Masoala Peninsula. Ambatoledama connects Masoala National Park with Makira National Forest to the West. Its forest has undergone significant deforestation but restoration projects have augmented Ambatoledama such that it now forms a 1 km wide corridor of secondary forest (Hekkala *et al*., 2007; Razakamaharavo *et al*., 2010). It consists of a dense evergreen rainforest with an altitude ranging from 300 to 700 m. The forest is mostly characterized by the presence of tree species of the Pandanacea, Ebenaceae, Clusiaceae, Euphorbiaceae, Sapotaceae and Rubiaceae families (Martinez, unpublished).

Study species

Varecia rubra belongs to the family Lemuridae (Gray, 1821) and is one of two species recognized within the genus (Mittermeier *et al*., 2006). *V. rubra* is only found on the Masoala peninsula and it is classified by the World Conservation Union (IUCN) as Endangered (IUCN, 2008). *V. rubra* is a large-sized diurnal species with a body length ranging from 43 to 57 cm (Vasey, 2003) and has a typically frugivorous diet (Rigamonti, 1993; Vasey, 1997). They currently inhabit both the corridor habitat and the adjacent protected areas (Razakamaharavo *et al*., 2010) and are thus potentially important for regeneration of the corridor habitat.

Field experiment

Focal animals were followed for 3-5 days per week from dawn to dusk (from 0600 hours to 1800 hours) to collect fresh fecal samples (Dew and Wright, 1998; Kaplin and Moermond, 1998; Stevenson, 2000; Poulsen *et al*., 2001; Link and Di Fiore, 2006). Each fecal sample was washed and filtered through a 1-mm sieve (Stevenson, 2000). Seeds were extracted and then identified with the help of local research guides and an expert local botanist familiar with the Masoala flora.

We planted gut-passed seeds and control seeds that were extracted manually from fruits in an outdoor nursery adjacent to the corridor at Ambatoledama. The nursery consisted of two "flower beds" of 11.2 m²: one for defecated seeds and the other one for non-passed seeds. Following methods used by the conservation agents of MNP in Ambatoledama, a sunshade of 80 cm height, composed of Longoza leaves (*Afromomum angustifolium*) was placed above each flower bed to imitate the closed canopy of the forest. Also, the soil of the nursery was mixed with fertile soil from cultivated field. Seeds were placed in the soil mixture and covered by 1 mm-thick river sand to keep a constant temperature.

An equal number of seeds were planted within each species per treatment. However, the numbers varied between species depending on how many seeds were collected from lemur feces. The germination of seeds was assessed each month after planting.

Data analysis

We performed a paired t-test to test for differences between the germination rate of lemur-gut-passed and non-passed seeds, an ANOVA analysis to test if the two factors (seed species and treatment) had effects on the germination rate of the seeds and to determine whether there was interaction between these factors. We analyzed the germination of each species in order to assess the influence by lemur gut passage, with Pearson test using contingency tables, which was adjusted with Bonferroni correction for multiple comparisons (Sokal and Rohlf, 1995).

Results

In total, 268 fresh fecal samples from three individuals of red-ruffed lemur were collected during 58 days of observation. The fecal samples contained fleshy fruit parts, stalks, leaves, soil and fecal liquid. 95.52 % of these contained seeds, to some of which fleshy fruit parts were still attached. 906 seeds of more than 1mm size were extracted. A majority of them were intact with minor scarification. They represented 34 different plant species that belong to 15 Families. Based on our collected sample, the most common seed species found in lemur defecations were the nine species we chose to study here (Tab. 1). In the nursery, we planted a total of 390 defecated seeds and compared them with 398 non-passed seeds.

Lemur-gut-passed seeds had significantly higher germination rates overall than non-passed seeds ($t=3.284$, $df=8$, $p=0.011$). Passed seeds had a germination rate of 64.61 %, whereas non-passed seeds had a rate of 39.69 %. For each species, seeds that had been defecated had a higher germination rate than non-passed seeds, except for Tsilaitra (Tab. 1). This pattern was driven primarily by four species, including Antaivaratra, Matahobaratra, Tsilaitra, and Vongobe species.

In a two factor analysis of variance for seed germination, there was a significant interaction between the species of seeds and their treatment (passed or non-passed) ($F= 4.2004$, $p<0.0001$). When the analysis was repeated excluding the interaction, seed germination differed significantly both between seed species ($F=23.268$, $p<0.0001$) and between their origins ($F= 58.706$, $p<0.0001$). For some species, gut passage might only be important for dispersal away

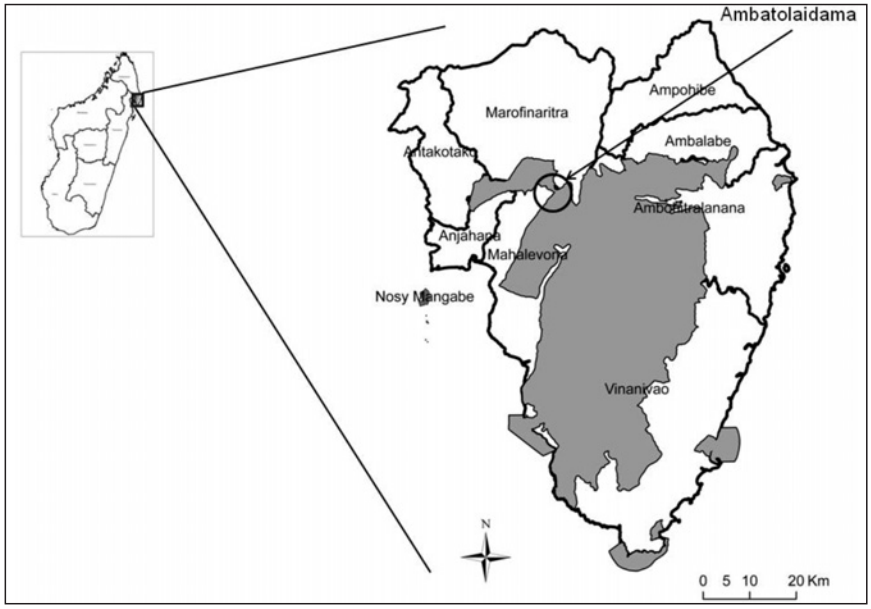

Fig. 1: Location of the Ambatoledama corridor.

Tab. 1: List of species studied with their germination rate. Sample sizes are represented in brackets. The star on p-values corresponds to their significance (Pearson test) after a Bonferroni correction for multiple tests.

#	Malagasy name	Scientific name	Family	Germination rate		Pearson test	
				gut-passed seeds	non-passed seeds	Chi-square	P-value
1	Antaivaratra	*Potameia* sp.	Lauraceae	41.67 (n = 48)	17.86 (n = 56)	7.139	0.0075*
2	Hazondrononо	*Sideroxylon*	Sapotaceae	80.00 (n = 10)	60.00 (n = 10)	0.952	0.3291
3	Karaka	*Pandanus*	Pandanaceae	40.00 (n = 20)	15.00 (n = 20)	3.135	0.0766
4	Matahobaratra	*Garcinia* sp.	Clusiaceae	58.06 (n = 31)	00.00 (n = 31)	25.364	<0.0001*
5	Rotro Beravina	*Eugenia* sp.	Myrtaceae	60.61 (n = 33)	42.42 (n = 33)	2.184	0.1394
6	Tavolo madinidravina	*Cryptocarya* sp.	Lauraceae	51.25 (n = 80)	26.25 (n = 80)	1.043	0.307
7	Tsilaitra	*Norhonia* sp.	Oleaceae	91.67 (n = 12)	100.0 (n = 12)	10.533	0.0012*
8	Vapakafotsy	*Uapaca silvestris*	Euphorbiaceae	75.00 (n = 56)	25.00 (n = 56)	1.17	0.2795
9	Vongobe	*Garcinia verrucosa*	Clusiaceae	84.00 (n = 100)	78.00 (n = 100)	28	<0.0001*

from the parent tree; for others, it is also important for their germination success. The difference of germination rate within each species showed that for four species, the germination rate of defecated-seeds was higher than for non-passed seeds (Tab. 1).

Discussion

As we predicted, our results showed that lemur-gut-passed seeds had a higher germination rate than non-passed seeds. Based on our collected fecal samples, our study confirmed that *V. rubra* has a mainly frugivorous diet. The nine species (Tab. 1) studied here represented the most common species in *V. rubra*'s diet during the humid hot season. Its frugivorous diet and passing of intact seeds suggest that *V. rubra* is predisposed to be a beneficial seed disperser. Frugivorous animals are, in general, categorized into three classes (Kaplin and Moermond, 1998; Bollen *et al.*, 2004; Gosper *et al.*, 2005): (1) seed dispersers which have the capacity to carry seeds from one place to another, (2) those who drop seeds under the parent tree without ingesting them, and (3) seed predators which digest seeds. Our results showed that *V. rubra* may be an effective seed disperser of several tropical rainforest plants in the Ambadoledama corridor through endozoochory. The passage of seeds in *V. rubra*'s gut improved the germination of several species in this study (Chapman and Chapman, 1996; Poulsen *et al.*, 2001). It appears that some plant taxa in particular, require a chemical scarification process inside the lemur gut to acquire a high level of germination capacity, like the majority of vertebrate-dispersed plants (McKey, 1975; Dew and Wright, 1998), as they may not be able to germinate without the removal of their aril by a frugivore (Howe, 1986). Moreover, the plant species making up the majority of the diet appeared to be primarily large-sized seeds (10-30 mm; Razafindratsima and Martinez, unpublished data), and are therefore difficult to swallow by frugivorous birds.

As a seed vector, *V. rubra* may play an important role in maintaining forest diversity by affecting the spatial distribution and dynamics of plants (Bleher and Böhning-Gaese, 2001; Clark *et al.*, 2001; Brodie *et al.*, 2009). Endozoochory by this species is an important strategy for the plant to increase its fitness because seeds can minimize the time they spend in the embryogenesis phase (Dew and Wright, 1998), which is likely to reduce the rate of seed predation by rodents and other granivores (Wehncke and Dalling, 2005). Also, it helps plants to avoid disproportionate seed and seedling mortality near the parent, and to be deposited in a microhabitat suitable for their establishment and growth (Howe and Smallwood, 1982).

The results presented here suggest that *V. rubra* may be vital to corridor restoration, which is important for maintaining the biotic exchange between the forested blocks of the Masoala Peninsula. Ambatoledama is vulnerable and currently facing significant fragmentation (Dokolahy, 2005; Razakamaharavo *et al.*, 2010). Thus, the existence of such dispersers in this site is likely to be very important for quickly facilitating seed dissemination. A potential loss of the floral diversity will occur if this lemur species goes extinct or moves into other forest blocks. Recent increases in both bushmeat hunting for lemurs and tree poaching in the area (Hatchwell, 1999; Barrett and Ratsimbazafy, 2009; Golden, 2009; Into, 2009; Schuurman and Lowry, 2009) may have dire consequences for forest regeneration and future habitat restoration efforts. Loss of the floral diversity and change in community structure of the vegetation is expected to occur in the absence of these lemurs which may be critical for dispersal of many larger-seeded species. Decline or loss of this species may also limit successful forest regeneration and habitat restoration of the corridor. Thus the conservation of *V. rubra* is likely to be key for an effective restoration program at Ambatoledama.

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Feeding ecology of the crowned sifaka (*Propithecus coronatus*) in a coastal dry forest in northwest Madagascar (SFUM, Antrema)

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The crowned sifaka (*Propithecus coronatus*; Milne-Edwards, 1871) inhabits dry forests, riparian forests and mangroves of northwest Madagascar. Originally believed to occur in a restricted area between the Mahavavy River in the southwest (where it overlaps with *P. deckenii*) and the Betsiboka River in the northeast (which separates it from *P. coquereli*), sightings west of the Mahavavy River and along the Bongolava Massif suggest that the distribution of this medium-sized species is wider (Tattersall, 1986; Thalmann *et al*., 2002). The distribution and the taxonomic status of crowned sifakas have long been debated, but the combination of morphological and biogeographic evidence supports considering it as a valid species (Thalmann *et al*., 2002; Mittermeier *et al*., 2006; Groves and Helgen, 2007; Mittermeier *et al*., 2008). Considered as Endangered (A2 c,d) by the IUCN (2010), populations of crowned sifakas were estimated not to exceed 1,000 individuals in the wild. However, recently discovered populations in restricted fragmented forests extend the species'

distribution range farther towards the Southwest. A "Bio-cultural Project" was therefore initiated at Antrema (a site located in the Mahajanga region) in 2000 to promote sustainable management (Gauthier *et al*., 2001). The project aims at preserving a coastal environment in which crowned sifakas occur in high densities while allowing villagers, mainly fishermen, to use natural products of the environment with parsimony and to benefit from technical and economical help. The project also aims at promoting local socio-cultural rules and a way of life that tends to respect the forest environment, including useful plants and several sympatric lemur species (*Propithecus coronatus*, *Eulemur fulvus*, *Eulemur mongoz*, *Lepilemur* sp., *Microcebus murinus*). The site contains three of the Northwest's typical ecosystems (dry semi-deciduous forest, mangrove swamp, savanna), which suffer moderate anthropogenic pressure (Gauthier *et al*., 2001). Owing to local beliefs, especially the sacred ("*masina*") nature of sifakas, the Sakalava community plays a central role in this conservation process (Harpet *et al*., 2000, 2008). In this context, a few studies started investigating the behavior in relation to habitat and food supply of the lemur species of Antrema (Gauthier *et al*., 1999; Razafimahefa, 2001; Ramanikirahina, 2004). However, a detailed analysis of the feeding ecology and population densities of *P. coronatus* is still lacking. We present here preliminary data on the plant species composition of the white-sand coastal forest inhabited by a dense population of sifakas (among other prosimian species) and on the feeding ecology of sifaka groups censused since 2008.

Methods

Study site

The Antrema station is a coastal area of 12,300 ha located on the left riverside of the Betsiboka estuary, northwestern Madagascar (15°42'-15°50'S, 46°-46°15'E; Gauthier *et al*., 2001). The region undergoes a distinct dry season of 7 months from April to October. The mean annual rainfall (n = 9 years) in the Mahajanga region is 1,410 mm (with a peak in January-February), with irregular rainfall during the dry season. With an annual mean of 27° C, temperature is highest in October and lowest between June and August (Airport of Mahajanga, 2000-2009).

Although the Antrema area has been traditionally protected by the local Sakalava beliefs, forest areas where studies are conducted are fragmented. After two first surveys in November 2007 and April-May 2008, we decided to establish the study site at Badrala (15°45.665'S, 46°12.300'E). With about 24 ha just behind the littoral dune, this non-sacred forest site offers suitable conditions to study the socioecology of sifakas and the dynamics of a dry forest in Madagascar. The forest there is partly split by a sandy open dune that sifaka groups can cross easily. Tree logging occurs at low intensity (with few selected species for defined use, e.g. for boats or coffins) and small trees are sporadically cut for fences and house building. We studied floristic composition by inventorying trees along four North/South-oriented line transects, 10 m-wide each, that were roughly perpendicular to the sea front. Within this 0.73 ha, we tagged each tree ≥ 10 cm diameter at breast height (DBH) with plastic labels, recorded their DBH, the number of stems and their vernacular name. Likewise, we counted woody lianas and herbaceous vines ≥ 1 m high within eight 10 x 10 m (800 m²) plots regularly spaced along the transects. Plant species were sampled and dried for later botanical identification.

Sifaka population density

In order to locate and identify groups of *P. coronatus* in Badrala, we initially mapped groups encountered during repeated transect walks. We drew individuals' facial masks for each of the followed groups, noted their sex from visual inspection of the genitalia and other external characteristics (cysts, scars, damaged ears, fur colour), and took pictures. Knowledge gained progressively of groups and individuals allowed us to provide a preliminary estimate of population density for the Badrala site.

Behavioral data collection

We collected behavioral data during 4 periods (06 to 21 July 2008; 11 November to 12 December 2008; 05 April to 06 June 2009; 17 October to 22 November 2009). Most groups were already accustomed to the sporadic presence of local people. Once we could observe animals at close distances, we followed each group successively over 2 to 5-day periods, from 06:30 to 18:30 hours.

We used the instantaneous scan-sampling method (Altmann, 1974) to study group activity budget. Every 5 minutes, we recorded the individuals' activity using one of the following categories: resting (immobile, with eyes open or closed), moving (more than 0.5 m), foraging (searching for a food item), feeding (processing or chewing a food item), social activity (displaying agonistic and affiliation behaviors with other individuals) and other miscellaneous behaviors. We noted the plant part and species eaten by individuals.

Besides recording activity budgets, we determined diet from mouthful counts converted into weight of ingested matter (Hladik, 1977) for 2 periods: April-June 2009 and October-November 2009. We estimated food intake in focal individuals that were followed continuously for 30 minutes each. Observations were alternated across males and females (excluding juveniles) within groups.

Results

Forest composition

Plant families occurring at Badrala are presented separately for trees and lianas/vines in Fig. 1. To date, 91 tree and liana or vine species have been identified at least at the family level, and taxonomic identification of 15 more putative species is still in progress. The 5 richest families in terms of the number of species are Fabaceae, Sapindaceae, Ebenaceae, Euphorbiaceae and Apocynaceae. The most dominant tree species are *Strychnos decussata*, *Vitex beraviensis*, *Mimusops occidentalis*, *Baudouinia fluggeiformis* and *Macphersonia gracilis* that represent almost one third of total basal area and tagged trees. *Combretum coccineum*, *Hypoestes* sp., *Landolphia perrieri* and *Reissantia* sp. accounted for more than one third of the lianas and vines.

Density of trees inventoried on the 4 transects (n=486) corresponds to 666 inds. ha^{-1} with a total basal area of 14.5 m² ha^{-1}. We found a high density of woody lianas and herbaceous vines in the 800m² plots (n=373).

Sifaka population density and group composition

Groups at Badrala have 1-3 breeding adult males, 1-4 breeding adult females, and 1-4 immature offspring. We encountered between 15 and 20 groups at this site. Based on current recognition of individuals within these groups, a minimum estimate of 300 inds. km² was calculated. Mean size of focal groups was 4.3 ± 1.8 individuals (n=16).

Diet and activity pattern

Sifakas consumed at least 60 plant species from 32 families. Tab. 1 lists major food species eaten. During the dry season, 14 plant species represented 75 % of the diet whereas only 7 species were the main food resource in the wet season.

Tab. 1: Food species accounting for 50 and 75 % of the diet of *Propithecus coronatus* during the dry season and the wet season. Eaten plant species are listed in decreasing order and their abundance in transects and plots (see text) is indicated.

Family	Species	Vernacular name	Items	Abundance (%)		
Dry season						
Lamiaceae	*Vitex beraviensis*	Mojiro	*yl*	10,7		
Fabaceae	*Baudouinia fluggeiformis*	Manjakabentany	*yl ml*	*4.7*		
Sapotaceae	*Mimusops occidentalis*	Natofotsy	*yl stems*	*3.9*		
Anacardiaceae	*Operculicarya gummifera*	Atokonjo	*ml buds*	*3.5*	50 %	
Sapindaceae	*Majidea zanguebarica*	Tsipopoka	*yl ml fl*	*2.3*		
Oleaceae	*Noronhia boinensis*	Tsilaitra beravina	*yl*	*1.9*		
Moraceae	*Trilepisium occidentalis*	Kililo	*ml*	*1.2*		
Sphaerosepalaceae	*Rhopalocarpus lucidus*	Hazondringitra	*yl fr*	*1.0*		
Melastomataceae	*Warneckea* sp.	Voatrotrokoala	*yl*	*0.6*		75 %
Burseraceae	*Commiphora* sp.	Arofy	*fr buds*	*0.4*		
Fabaceae	*Bussea perrieri*	Morango	*ml*	*0.2*		
Olacaceae	*Olax dissitiflora*	Ambiotsy	*ml*	*0.2*		
Moraceae	*Ficus pyrifolia*	Nonika	*fr*			
Unidentified	-	RR80	*ml*			
Wet season						
Anacardiaceae	*Abrahamia deflexa*	Motsovavy	*yl fl*	3,1		
Anacardiaceae	*Abrahamia* sp.	Manavodrevo	*buds yl fl*	*1.2*		
Fabaceae	*Chadsia flammea*	Fanamohazo	*buds yl fl*	*0.8*	*50 %*	
Sapotaceae	*Capurodendron gracilifolium*	Natoboay	*buds yl fr*	*0.2*		
Apocynaceae	*Landolphia perrieri*	Vahipira	*yl*	*6.8*		*75 %*
Combretaceae	*Terminalia* sp.	Taly	*buds yl*	*3.1*		
Anacardiaceae	*Operculicarya gummifera*	Atokonjo	*yl*	*3.5*		

yl: young leaves; ml: mature leaves; fl: flowers; fr: fuits

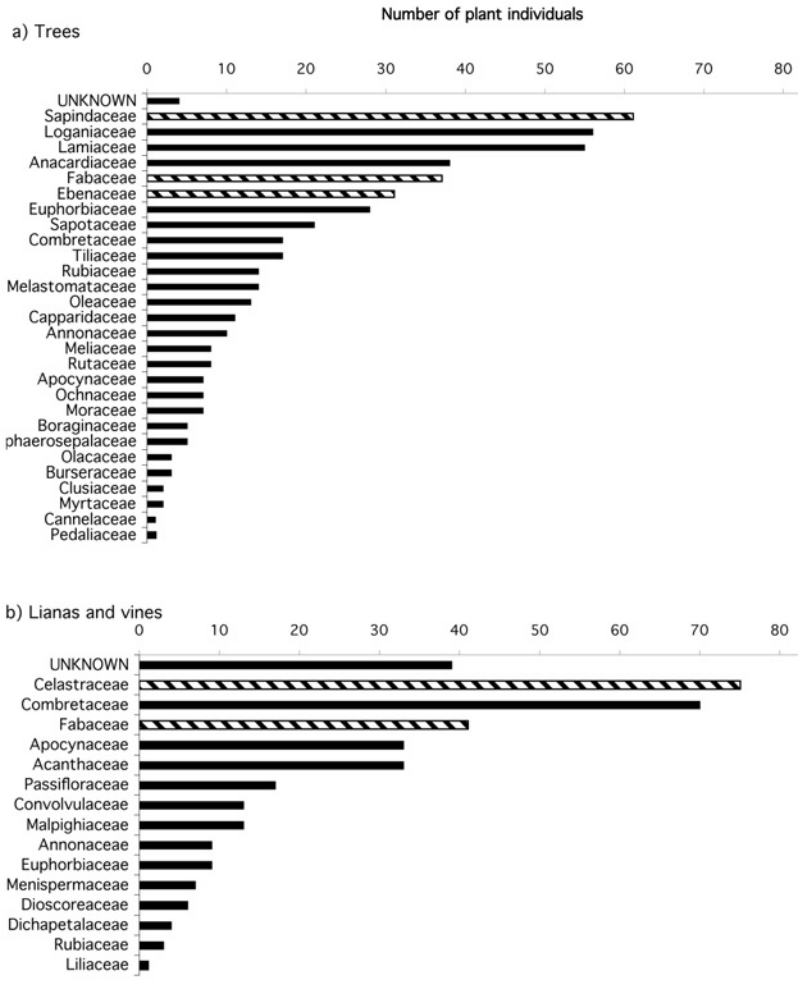

Fig. 1: Abundance of plant families plotted in decreasing number of individuals among a) trees with DBH>10cm (based on transects; 0.73 ha) and b) woody lianas and herbaceous vines >1 m height (based on plots; 0.08 ha). Striped bars refer to the plant families with the highest number of species.

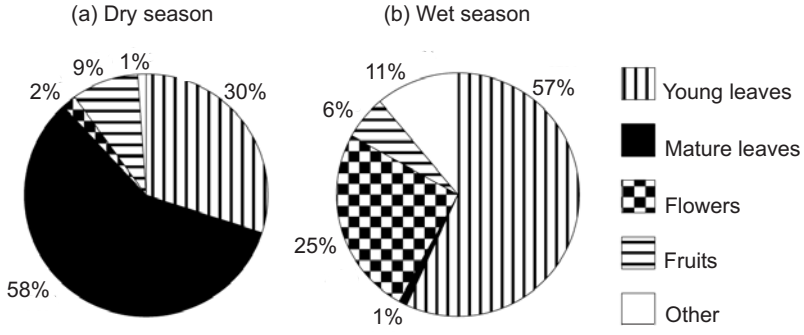

Fig. 2: Food categories in the diet of *Propithecus coronatus* during the dry season (a) and the wet season (b).

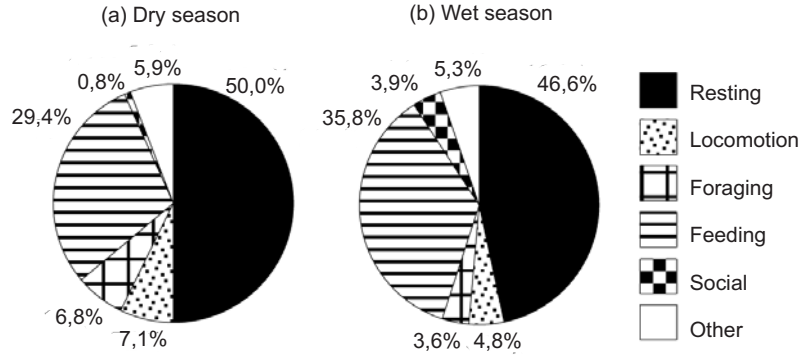

Fig. 3: Activity budget of *Propithecus coronatus* during the dry season (a) and the wet season (b).

Sifakas were highly folivorous during both seasons, supplementing their diet with flowers, fruits, vegetative buds, and sometimes young stems (Fig. 2). They consumed more mature leaves and fruits in the dry season and more flowers in the wet season.

The activity budget of the sifakas is presented in Fig. 3. Although 'resting' predominated throughout the study, individuals rested more in the dry season than in the wet season. Inversely, they travelled less and engaged in feeding activities more often during the wet season.

Discussion

The sifaka density was found to be high in the dry forest of Antrema, with a minimum estimate far above the 173 inds. km^2 found in the riparian forest of Anjamena (Muller *et al*., 2000) or for other sifaka species in dry or wet forests (O'Connor, 1988; Ganzhorn, 1992). This high density might be related to some peculiar characteristics of the forest in terms of food quantity and/or food quality available to this prosimian species. However, tree basal area was not particularly high compared with other dry forests in Madagascar and Mayotte (Hladik, 1980; Simmen *et al*., 2005). It is not yet clear also whether high density is related to a putative low predation pressure. To our knowledge, no sightings or traces of viverrid carnivores have been reported; large raptors and boas would be the only predators that could affect the demography of the Antrema sifaka population (Garbutt, 2007; Sinclair and Legrand, 2008).

As regards their feeding behavior, crowned sifakas fed primarily on leaves from a few tree, liana and vine species, and supplemented their diet with a wide range of secondary items as commonly occurs in other *Propithecus* species (Meyers and Wright, 1993; Simmen *et al*., 2003; Lehman and Mayor, 2004; Irwin, 2008). Although this species remained folivorous during our study, its diet changed with seasons. Young leaves were the preferred food type in the early wet season, while mature leaves were the dominant one in the beginning of the dry season. In addition, *P. coronatus* ate a higher proportion of liana and vine parts during the wet season. Crowned sifakas also followed the typical activity pattern of other sifaka species (Norscia *et al*., 2006; Patel, 2006; Charrier *et al*., 2007), spending most of their time resting and devoting a substantial amount of time to feeding activities and locomotion. Activity budget nevertheless changed with seasons. It is generally suggested that the cool dry season represents a period of food scarcity for animals, which they compensate for by reducing their energy expenditure, travelling less and resting more. In a recent joint research project, the content of litter traps regularly distributed along the transects was collected and weighted every two weeks throughout one year. It was found that plant species could be grouped according to their temporal pattern of leaf loss (Ranaivoson *et al*., 2010; see also Razakanirina, 2010). Several trees, lianas and vines lost their leaves more or less regularly throughout the dry season while others were characterized by delayed leaf loss or on the contrary by precocious leaf fall. One consequence is that leaves are available throughout the year, although as different sets of species varying in quantity, diversity, and presumably, nutritional quality. This at least could explain why sifakas are able to increase the diversity of consumed plants (and adopt a more opportunistic strategy) during the dry season, a period normally described by the scarcity of food resources.

Future work on seasonal variations in the diet's nutritional and chemical content will allow us to examine the role of qualitative aspects in food choices (Moss, 1991; Dearing *et al*., 2000) and further examine potential differences between genders with regard to the importance of energy conservation for female sifakas (Wright, 1999; Charrier *et al*., 2007).

Conclusion

Better knowledge of the ecology and the villagers' social perception of this flagship species may contribute to conservation of other diurnal lemurs, by incorporating the villagers' symbolic perception of their natural environment. Investigating the interactions between this species and plants of the coastal dry forest ecosystem will undoubtedly result in better conservation decisions for Antrema. From an evolutionary ecology standpoint, the studies we have planned for the next years at Antrema will also contribute to better identify the selective pressures that have been driving the evolution of prosimian typical life-history traits such as reproductive synchronization or dominance-based feeding priority of females over males in gregarious species (Wright, 1999; Dewar and Richard, 2007).

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Effet de la dégradation de l'habitat sur la consommation alimentaire d'*Eulemur rubriventer* dans deux sites: Talatakely et Vatoharanana, du Parc National de Ranomafana

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Mots clés: *Eulemur rubriventer*, dégradation, habitat, consommation alimentaire, Ranomafana, Madagascar

Introduction

La grande île est potentiellement riche en matière de biodiversité et est par conséquent renommée pour sa remarquable richesse écologique, biologique et génétique (Ganzhorn *et al.*, 2001). Cette richesse qui est gravement menacée par la diminution et la destruction immuables des habitats naturels de nombreuses espèces fait de Madagascar un des huit "hotspots" les plus considérés de notre planète (Ganzhorn *et al.*, 2001).

A l'échelle mondiale, la menace la plus grave pour la population des primates est la destruction et la dégradation de leur habitat, notamment les forêts tropicales qui hébergent aujourd'hui environ 90 % des primates non humains du monde (Mittermeier et *al.*, 2006, 2010). Les lémuriens malgaches ne font pas exception à cette constatation. La dégradation des forêts affecte la biologie générale des lémuriens car non seulement elles leur fournissent des abris et de la nourriture, mais aussi elles servent de supports à la locomotion et aux différentes activités de ces animaux (Razafimahazo, 2001).

Selon Randriatahina en 2001, la fragmentation de l'habitat affecte en premier lieu la distribution et la dispersion de la nourriture. Certains facteurs influencent le rythme d'activité et le budget-temps des primates: il s'agit surtout des facteurs écologiques majeurs tels que la structure de l'habitat, le type d'alimentation (Zaonarivelo, 1999). Par ailleurs, Dunbar (1988) affirme que les primates pourraient augmenter leur déplacement journalier pour trouver de la nourriture ou inversement en vue d'économiser leur énergie.

Notre présent travail est axé sur la corrélation entre l'habitat et l'alimentation des lémuriens. Les lémuriformes montrent un degré de variabilité en ce qui concerne la spécialisation aux régimes alimentaires. La plupart d'entre-eux (les Lémuridés, les Mégaladapidés, les Indridés) se spécialisent au régime végétarien. Cependant, la proportion de feuilles, de fleurs, et de fruits consommés varie suivant les espèces et sous-espèces, d'une région à une autre, et de saison en saison (Richard, 1978). Selon Zaonarivelo (1999), des facteurs écologiques influencent les comportements des lémuriens et la perturbation de leur habitat affecte leur organisation sociale et l'exploitation des ressources alimentaires.

En tenant compte de toutes ces observations, nous avons effectué une étude concernant l'effet de la dégradation de l'habitat sur la consommation alimentaire d'*Eulemur rubriventer* dans deux sites: Talatakely et Vatoharanana du Parc National de Ranomafana, dans la province de Fianarantsoa.

Il y a lieu de souligner qu'*Eulemur rubriventer*, une espèce hautement frugivore (Overdorff, 1993), dispose d'une haute importance écologique car elle participe activement à la dispersion des graines dans la région du Sud-Est de Madagascar, en particulier dans le Parc National de Ranomafana. A cet égard, bien que l'animal soit encore classé dans la catégorie vulnérable selon la liste rouge de l'UICN (Mittermeier *et al.*, 1994, 2006, 2010), il a besoin d' une action de conservation.

C'est la raison pour laquelle le parc national de Ranomafana a été choisi comme notre station de recherche car par rapport aux autres régions de l'île, les lémurs à ventre roux y sont les plus répandus (Mittermeier *et al.*, 2006); et leur habitat présente un degré variable de dégradation.

Compte tenu de cette variation du degré de dégradation et de perturbation du milieu de vie d'*Eulemur rubriventer* dans le Parc National de Ranomafana, nous pouvons avancer une hypothèse selon laquelle la consommation alimentaire n'est pas statistiquement différente entre celle de Vatoharanana et celle de Talatakely.

Ce projet a été réalisé dans le cadre de la collaboration interdépartementale entre l'Université d'Antananarivo, l'ICTE/MICET, le MNP et l'Université de Texas. Ainsi, le présent travail qui vise en la conservation des lémurs à ventre roux a comme objectifs d'inventorier les différentes espèces de plantes consommées par *Eulemur rubriventer*, de comparer le régime alimentaire adopté dans chaque site d'étude, de déterminer les caractéristiques des plantes consommées dans les deux sites d'études à dégradations différentes.

Site d'études

Le parc National de Ranomafana se trouve dans le Sud Est de Madagascar. Sa superficie est de 41.600 ha. Ce parc se localise au Nord-Est de Fianarantsoa, à 70 km à l'Ouest de l'Océan Indien et à 400 km d'Antananarivo. Il est situé entre 47°18' à 47°37' Est de longitude et 21°2' à 21°25' Sud de latitude. La température moyenne annuelle est de l'ordre de 21°C selon Turk en 1995. Quant à la pluviosité, Overdorff a affirmé en 1996 que la pluie y est saisonnière avec une précipitation moyenne de 2000 mm. Deux sites ont été choisis pour effectuer notre travail de recherche. Il s'agit de:

Talatakely: milieu perturbé et plus dégradé. Il est situé à environ 10 mn de marche de la poste de garde et de contrôle du Parc d'Ambodiamontana. Ce site de 1020 m d'altitude (Brady *et al.*, 1996), est caractérisé par une visite fréquente de touristes. Notons également que, à cause des abattages intensifs des arbres par les bûcherons (Kremen, 1992), la forêt de Talatakely se trouve fortement dégradée.

Vatoharanana: un milieu moins perturbé et moins dégradé. Cet endroit est à 1090 m d'altitude et se trouve à 2 heures de marche de Talatakely. Ce champ de forêt était exploité par les bûcherons il y a 25 ans (Brady *et al.*, 1996). Mais, la dégradation était moins intense que celle de Talatakely (Kremen, 1992). La visite des touristes dans cette station d'études est également moins fréquente. Vatoharanana est donc un site moins perturbé par rapport à Talatakely.

Les deux stations de recherche sont représentées dans la figure 1.

Espèces étudiées

Afin de répondre à toutes nos questions, une espèce hautement frugivore, qui participe activement à la dispersion des graines (Overdorff, 1993), a fait l'objet de notre étude. Il s'agit du Lémur à ventre roux ou *Eulemur rubriventer*. Généralement, cette espèce de taille moyenne vit en petit groupe de 2

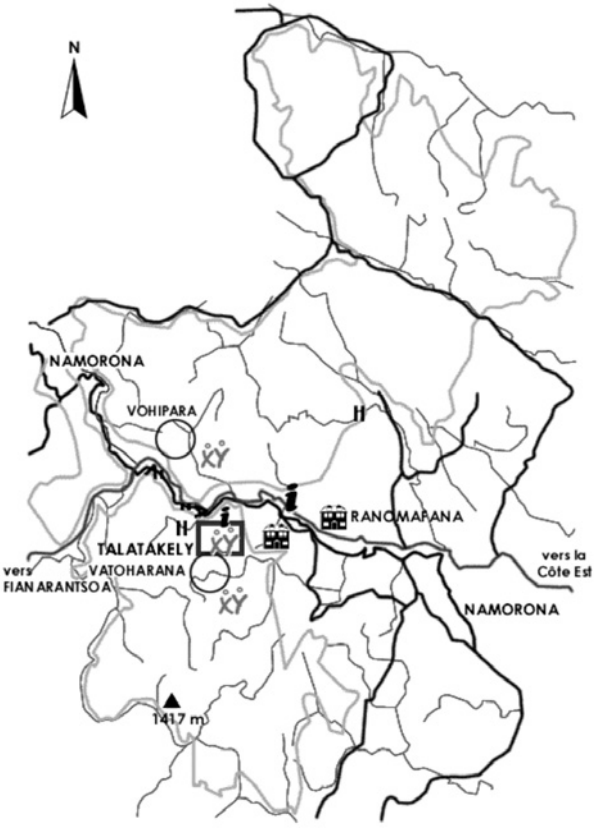

Fig. 1: Localisation des deux sites d'études dans le Parc National de Ranomafana.

à 5 individus. Elle consomme également des feuilles, des fleurs, de la terre, des mille-pattes. Selon Overdorff (1996), l'animal mange beaucoup plus de fruits et moins de feuilles. *Eulemur rubriventer* présente un dimorphisme sexuel au niveau de la morphologie. En effet, le ventre des femelles est clair; tandis que la poitrine et la partie inférieure du corps du mâle sont visiblement colorées en marron roux. Le mâle diffère également de la femelle par la présence de tâche blanche sur le coin interne des yeux (Dague et Petter, 1988). En ce qui concerne notre étude, nous avons suivi cinq groupes de lémurs à ventre roux dont trois à Talatakely et deux à Vatoharanana.

Suivi écologique

Le suivi écologique proprement dit était précédé de la familiarisation de tous les groupes d'études. A ce propos, durant cinq mois d'études sur terrain, du mois de décembre 2003 au mois d'avril 2004, la fréquence d'observation était de cinq jours par semaine. L'observation s'étale de sept à douze heures dans la matinée et de treize à quinze heures dans l'après midi. Au total, l'équipe a suivi cinq groupes pour les sites de Talatakely et de Vatoharanana, pendant 588 heures 45 minutes et 54 secondes.

La méthode d'enregistrement continu de données a été adoptée. Elle nous donne des informations plus fiables et plus pratiques par rapport à une méthode d'enregistrement instantané (Martin et Bateson, 1986). En outre, nous avons collecté les données sur l'alimentation en suivant la méthode de "focal animal sampling" (Altmann, 1974). Durant ces observations, nous avons enregistré les informations suivantes:

Site d'études: Talatakely ou Vatoharanana;

- Groupe d'étude;
- Focal animal;
- Date de l'observation;
- Heure d'observation (Début et fin);
- Temps dépensé (Début et fin) à la consommation alimentaire et aux autres activités;
- Nom de chaque espèce consommée (plantes ou autres);
- Parties consommées des plantes: fruit, feuille, fleur;
- Etat des parties comsommées (fruit immature ou mûr, jeune feuille, feuille mature, fleur ouverte ou fermée);
- Piste la plus proche.

Analyses statistiques

Test de similarité entre deux échantillons

Ce test sert à vérifier la similarité entre le régime alimentaire adopté par les lémurs à ventre roux de Talatakely et celui de Vatoharanana. Il se base sur la valeur du coefficient de Jaccard (Brower *et al.*, 1990). Ce coefficient est donné par la formule suivante:

$$CC = \frac{C}{S_1 + S_2 - C}$$

CC: Coefficient de Jaccard

S_1: Effectif d'espèces végétales, animales et autres dans le régime de l'espèce de Talatakely (E_T);

S_2: Effectif d'espèces végétales, animales et autres dans le régime d'*Eulemur rubriventer* de Vatoharanana (E_V);

C: Effectif d'espèces végétales, animales et autres communes (E_T et E_V)

Par souci de conformité, nous avons adopté les échelles suivantes:

0-40 %: faible similarité entre les deux régimes;
40-60 %: similarité moyenne entre les deux régimes;
60-80 %: grande similarité entre les deux régimes;
80-100 %: forte similarité entre les deux régimes.

Test de Chi-deux:

Cette méthode sert à comparer la durée moyenne journalière (en minute) consacrée à la consommation alimentaire des lémurs à ventre roux de Talatakely et de Vatoharanana. A cet effet, les variables utilisées sont les durées moyennes journalières dépensées à la consommation des fruits, des feuilles, des fleurs et autres (sol, eau, champignon, insectes,…); et ce dans des intervalles de temps bien déterminés; c'-est-à-dire, entre 7 et 8h, 8 et 9h, 9 et 10h, 10 et 11h, 11 et 12h, 13 et 14h et finalement entre 14 et 15h. Plus précisément, elle nous permet de vérifier si la différence entre la consommation de ces aliments est statistiquement significative ou non dans les deux milieux.

Résultats

Temps dédié à l'activité alimentaire

Fig. 2 montre l'allure générale de la durée moyenne journalière en ce qui concerne la consommation alimentaire générale des lémurs à ventre roux du milieu plus dégradé de Talatakely et celle du site moins dégradé de Vatoharanana. Selon cette figure, la prise de nourriture débute entre 7 et 8h. Concernant le site de Talatakely, elle dessine un pic entre 9 et 10h. Cette activité diminue jusqu'à 12h, puis remonte pour atteindre le maximum vers 14 à 15h. Quant à l'*Eulemur rubriventer* de Vatoharanana, le pic de l'alimentation se situe entre 8 et 9h. La courbe diminue jusqu'à 12h environ. Ensuite, une légère remontée de l'activité est constatée jusqu'à 15h envi-

ron. L'hypothèse nulle est acceptée car l'analyse statistique (χ^2= 9,95 ;avec ddl=6, et p>0,05) indique une différence non significative concernant la prise de la nourriture entre chaque intervalle de temps.

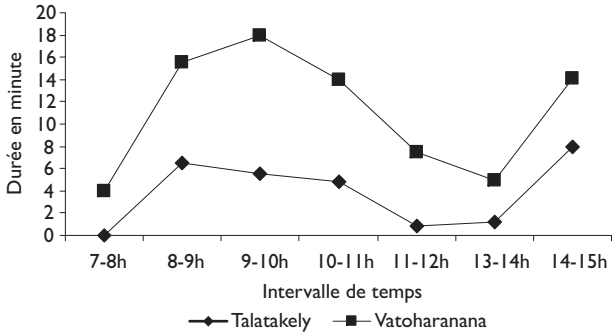

Fig. 2: Temps consacré à la consommation alimentaire pour *Eulemur rubriventer* dans les deux sites d'étude: Talatakely et Vatoharanana.

Similarité entre les régimes alimentaires d'Eulemur rubriventer du site dégradé de Talatakely et de celui de la station moins dégradée de Vatoharanana

L'inventaire des espèces consommées par les lémurs à ventre roux dans les deux sites nous a permis de calculer le coefficient de Jaccard afin de tester s'il existe ou non une similarité de régimes dans les deux milieux. Nous avons recensé 52 espèces de plantes qui sont utilisées comme source de leur nourriture pour le site de Talatakely. En revanche, 60 espèces sont inventoriées dans le site de Vatoharanana. Il est à noter que 35 d'entre elles sont à la fois consommées à Talatakely et à Vatoharanana. La liste des espèces végétales utilisées par ces animaux comme source de leur nourriture (avec la durée de consommation correspondante) est résumée dans le tableau récapitulatif suivant.

Tab. 1: Liste des espèces végétales consommées (61) par *Eulemur rubriventer*, avec la durée de consommation correspondante, dans les deux sites d'étude.

						Durée (en mn)	
Nom malagasy	**Genre**	**Famille**	**Fr**	**Fe**	**Fl**	**Tala**	**Vato**
Ramy	*Canarium madagascariensis*	Burseraceae	+				+
Kalafambakaka	*Oncostemum* sp.	Myrsinaceae	+	+	+	23,57	242,55
Vakoana	*Pandanus* sp.	Pandanaceae	+		+	+	21,40
Nonoka	*Ficus* sp.	Moraceae	+			24,02	269,75
Vahimberana	*Strongylodon c raveniae*	Fabaceae			+	2,03	189,72
Voara	*Ficus* sp.	Moraceae	+			70,08	39,45
Voara rano	*Ficus botryoides*	Moraceae	+	+		23,13	36,15
Sandramy	*Protorhus* sp.	Anacardiaceae	+				17,08
Voandavenona			+			12,70	87,63
Famakilela	*Ficus* sp.	Moraceae	+	+		3,65	7,55
Tavolo malady	*Cryptocarya acuminata*	Lauraceae	+			98,32	
Vahitamboro	*Danais* sp.	Rubiaceae	+	+		19,10	12,97
Mahanoro	*Streblus dimepate*	Moraceae	+			62,58	
Tsirika	*Pandanus* sp.	Pandanaceae	+			38,00	1,67
Rotra	*Syzygium* sp.	Myrtaceae	+			27,28	
Apana	*Ficus* sp.	Moraceae	+			8,070	135,15
Sira	*Neodypsis* sp.	Arecaceae	+			36,30	21,47
Rotra mena	*Syzygium* sp.	Myrtaceae	+			9,020	17,32
Fandramanana	*Aphloia theaeformis*	Flacourtiaceae	+			127,82	
Velatra spécial	*Ruellia* sp.	Acanthaceae		+		68,68	27,05
Faritraty	*Memecylon* sp.	Melastomataceae	+			16,83	101,57
Maranitratoraka	*Vernonia* sp.	Asteraceae		+			68,40
Vahivoraka	*Mendoncia avani*	Mendonciaceae	+		+		169,48
Fatsikahitra	*Alberta humblotii*	Rubiaceae	+	+		9,03	425,63
Albizia	*Albizia chinensis*	Leguminosae	+				29,67
Rotra fotsy	*Syzygium* sp.	Myrtaceae	+				30,97
Tongoalahy	*Bakerella* sp.	Loranthaceae	+		+	3,25	25,68
Kalafana spécial	*Oncostemum botryoides*	Myrsinaceae	+	+	+	7,67	130,45
Hafipotsy	*Grewia* sp.	Tiliaceae	+				35,92
Fanalamangidy							+
Vavaporetaka	*Melanophylla crenata*	Melanophyllaceae	+			26,05	16,58
Kaboka	*Voacanga* sp.	Apocynaceae	+			86,73	66,30
Sandramy fotsy	*Protorhus* sp.	Anacardiaceae	+				20,32
Apaliala	*Treculia africana*	Moraceae	+				14,85
Ramandriona	*Dilobeia thouarsii*	Proteaceae	+			7,15	15,28
Andriambo. lamena		Menispermaceae	+			138,73	
Bararata	*Gaertnera* sp.	Rubiaceae	+			26,75	11,62
Nato jabo	*Mammea vatoensis*	Clusiaceae	+				69,60
Tavilona	*Vernonia* sp.	Asteraceae		+			4,07
Malanimanta	*Apodytes thouvenotii*	Icacinaceae	+				3,52
Voantsosoka			+				45,08
Lambinanala	*Nuxia* sp.	Loganiaceae	+				17,88
Rahiaka	*Chrysophyllum boivinianum*	Sapotaceae	+			6,30	663,50
Amontana	*Ficus lutea*	Moraceae	+			22,42	
Goavy	*Psidium cattleianum*	Myrtaceae	+			589,02	
Fanorafa		Euphorbiaceae	+				173,10
Kimba spécial	*Symphonia* sp.	Clusiaceae		+			3,23
Veso	*Terminalia tetranora*	Combretaceae		+			2,02
Vahirano	*Cissus* sp.	Vitaceae	+			15,73	104,17
Fohaninasity	*Psychotria* sp.	Rubiaceae	+				260,93
Rohindambo	*Smilax anceps*	Smilacaceae	+				5,67
Sary	*Potameia chartacea*	Lauraceae		+			36,60
Kalamasina	*Embelia madagascariensis*	Myrsinaceae		+			10,43
Ambora	*Tambourissa thouvenotii*	Monimiaceae		+			10,85
Harongana	*Harungana madagascariensis*	Clusiaceae	+				21,45
Nato spécial	*Sideroxylon* sp.	Sapotaceae	+				1,82
Holatra		Champignon				+	
Amboralahy	*Decarydendron helenae*	Monimiaceae		+			10,33
Sandramy Mena	*Protorhus* sp.	Anacardiaceae	+				1,50
Inconnue						1,37	8,82
Champignon							6,60

Tala = site de Talatakely; Vato = site de Vatoharanana; Fr = fruits; Fe = feuilles ; Fl = fleurs.; *: consommé

Le calcul du coefficient de Jaccard offre une valeur de 0,45; soit 45 %. Il en découle que le régime alimentaire d'*Eulemur rubriventer* des deux sites présente une similarité moyenne. Aussi, la différence entre le régime d'*Eulemur rubriventer* des deux milieux peut être révélée par la constatation de la durée consacrée à la consommation de chaque catégorie alimentaire telle que les fruits, les fleurs, les feuilles et bien d'autres (Cf. Tab. 2 et Fig. 2).

En se basant sur ce tableau récapitulatif (Tab. 2) et sur la Fig. 2, nous constatons que dans le milieu dégradé de Talatakely, la consommation des fruits s'avère très importante par rapport à celle du milieu moins dégradé de Vatoharanana. De plus en comparant avec l'espèce du site de Talatakely, celle de

la station de Vatoharanana comble beaucoup plus sa nourriture avec des fleurs, des feuilles, et d'autres types d'aliments.

Tab. 2: Comparaison de la consommation journalière de chaque catégorie alimentaire d'*Eulemur rubriventer* dans les deux sites durant la période d'observation (en minute).

Sites	Fruit	Fleur	Feuille	Autres
Talatakely	80,80	0,52	4,54	0,12
Vatoharanana	72,58	8,32	11,16	1,63

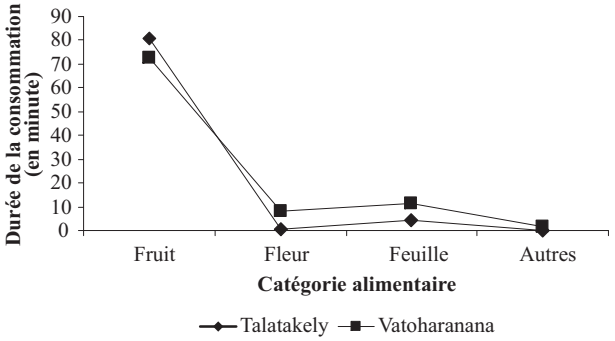

Fig. 3: Allure de la consommation journalière de chaque catégorie alimentaire d'*Eulemur rubriventer* dans les deux sites durant la période d'observation.

Discussion

Eulemur rubriventer est un lémurien hautement frugivore. Mais la proportion des fruits qu'il consomme varie suivant le degré de perturbation, de dégradation, de l'altitude du milieu, ainsi que de la saison. Notons également que la consommation des différentes catégories alimentaires dépend de la disponibilité des ressources alimentaires (Rasolofonirina, 2001). Lors de notre étude, nous constatons que dans le milieu dégradé de Talatakely, la consommation des fruits s'avère très importante que dans le milieu moins dégradé de Vatoharanana. De plus, en comparant avec l'espèce du site de Talatakely, celle de la station de Vatoharanana comble beaucoup plus sa nourriture avec des fleurs, des feuilles, et d'autres types d'aliments. Ceci est dû certainement à la saison cyclonique durant laquelle le vent est violent. Comme le site de Vatoharanana est beaucoup plus élevé par rapport à Talatakely, il s'avère logique qu'il est beaucoup plus affecté par ce vent violent. En effet, les fruits deviennent rares car beaucoup d'entre eux tombent par terre. Selon Zaonarivelo (1999), pendant la période de crise, *Varecia variegata variegata* augmente le taux de folivorie même si les feuilles sont des aliments de compensation. Cette stratégie adoptée par l'animal lors de la période de crise est également observée chez d'autres espèces de lémuriens de la forêt dense humide (Ganzhorn, 1988) entre-autres l'*Eulemur rubriventer*, le *Eulemur mongoz* qui se nourrissent de fleurs en plus des fruits et des feuilles durant la période de floraison (Sussman, 1975). Par ailleurs, Garbutt (1999) argumente que les fruits constituent la majeure partie de l'alimentation d'*Eulemur rubriventer*. Mais quand ils ne sont pas disponibles, les feuilles et les fleurs sont aussi consommées (Rasolofonirina, 2001). Notons à la même occasion que les primates adoptent différentes stratégies pour affronter le manque de nourriture de base (le fruit pour notre cas) soit en augmentant le temps de la recherche de nourriture en se déplaçant beaucoup, soit en acceptant de consommer des aliments de basse qualité (Zaonarivelo, 1999).

Par rapport au milieu dégradé, l'abondance des fruits dans le milieu moins dégradé est évidente. Mais en tenant compte de l'étude phénologique mensuelle des plantes recensées, ce n'est pas toujours le cas; car plusieurs facteurs pourraient agir sur ce milieu. Ainsi le climat, en particulier la pluviosité et le cyclone, influence la qualité et la quantité de la nourriture disponible (Dajoz, 1985). En effet, durant la période cyclonique, l'altitude de la station joue un rôle important sur les arbres à semences. Autrement dit, plus l'altitude d'un milieu est élevée, plus le vent agit directement sur les arbres et plus les fruits tombent. Par conséquent, les arbres portent moins de fruits. L'animal est obligé de se rabattre sur d'autres catégories alimentaires comme les feuilles, les fleurs, les champignons, les insectes pour pouvoir combler l'insuffisance de nourriture de base. Ce cas se rencontre dans le site de Vatoharanana qui est considéré comme milieu moins dégradé et qui est situé à une altitude plus élevée (1090 m) par rapport au site dégradé de Talatakely qui se trouve à une altitude de 1020 m (Brady *et al*, 1996). Concernant le site de Talatakely, la dispersion des fruits dans l'espace est insuffisante à cause de la dégradation de ce milieu. Ainsi, au lieu de combler sa nourriture par d'autres types d'aliments, il est contraint à se déplacer loin afin de consommer de la nourriture de haute qualité qui lui apporte beaucoup plus d'énergie comme le glucide, le lipide et les protéines (Zaonarivelo, 1999).

Finalement, en se basant sur les données phénologiques, nous avons constaté que la consommation de chaque catégorie alimentaire varie suivant leur disponibilité mensuelle dans chaque mileu. Au mois de décembre, par exemple, l'*Eulemur rubriventer* de Vatoharanana consomme beaucoup plus de fleurs que de fruits par rapport à celui de Talatakely car pendant ce mois, les fleurs y sont disponibles. Remarquons également que l'espèce de la station de Talatakely ne consomme que des fruits durant la fructification de l'espèce introduite de goyave (*Psidium cattleianum*). Ce type de fruit est très apprécié par l'animal.

Le régime alimentaire d'*Eulemur rubriventer* est moyennement similaire dans les deux milieux étudiés.

Cependant, quelques espèces de plantes consommées par l'animal sont propres à chaque site. L'espèce introduite de goyave *Psidium cattleianum* se rencontre uniquement à Talatakely. Notons que l'introduction de cette espèce marque la dégradation de cette station. Par contre, l'animal de Vatoharanana a l'opportunité de consommer, par exemple, l'espèce *Mammae vatoensis* qui est endémique à ce site. Cette similarité moyenne entre les deux régimes implique que la dégradation du site de Talatakely n'est pas encore poussée à l'extrême (Randriamahaleo, 2005). En effet, il est classé parmi les sites moyennement dégradés. Selon Tam-Alkis (1997), le site de Talatakely est séparé de Vatoharanana par une barrière biogéographique (rivière Fompohonona). Il paraît que la dispersion des graines de part et d'autre de cette rivière est empêchée. Voilà pourquoi certaines espèces de plantes, utilisées comme source alimentaire, caractérisent uniquement l'un de ces sites. Par conséquent son régime varie suivant le site.

Conclusion

Cette étude nous a permis de fournir plus d'informations sur la relation entre la dégradation de l'habitat d'*Eulemur rubriventer* et sa consommation alimentaire. L'investigation révèle une similarité moyenne entre le régime alimentaire adopté par l'animal de Talatakely et celui de Vatoharanana. L'espèce semble être principalement frugivore quelque soit le site. Cependant, la proportion de consommation varie suivant le milieu. A Talatakely, par exemple, ce lémur à ventre roux se

nourrit beaucoup plus de fruits par rapport à celui de Vatoharanana où il comble sa nourriture avec des fleurs, des feuilles, et bien d'autres catégories alimentaires. Ceci est dû sans doute au passage des deux cyclones (Elita et Gafilo) dans la région durant la période d'étude. En fait, Vatoharanana se trouve à une altitude très élevée par rapport à Talatakely. En effet, les vents violents agissent directement sur les arbres fruitiers, conduisant ainsi l'insuffisance des fruits. Aussi, la consommation de *Psidium cattleianum* (Myrtaceae), qui est une espèce introduite propre à Talatakely semble être très importante dans ce milieu. Par contre, *Chrysophillum boivinianum* s'avère être la plus appréciée par l'animal de Vatoharanana. Toutes ces constatations nous conduisent à dire que la consommation alimentaire d'*Eulemur rubriventer* paraît être conditionnée par la disponibilité de la nourriture dans chacun des sites visités et par l'état de l'habitat.

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Observations of terrestrial latrine behaviour by the southern gentle lemur *Hapalemur meridionalis* in the Mandena littoral forest, southeast Madagascar

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Key words: southern gentle lemur, *Hapalemur meridionalis*, defecation, latrines, Mandena

Latrine behaviour is defined as the non-random selection of a specific defecation site, and although it is rarely described in primates it is well known among other mammalian species as a form of olfactory communication (Irwin *et al*., 2004). Olfactory compounds, which convey chemical signals, are transmitted via scent-producing skin gland secretions, saliva, and/or waste products (Epple, 1986). Olfaction signals may be advantageous as they are not limited spatially and temporally, allowing individuals of a predominately visual communication

to receive signals when distant from the source (Schilling, 1979; Irwin *et al*., 2004). Olfactory signals may transmit information pertaining to environmental familiarisation (Schilling, 1979), reproductive behaviour and condition (Epple, 1986), territorial demarcation (Mertl-Milhollen, 1979), and inter- or intra-group spacing (Schilling, 1979; Epple, 1986).

Previous literature has discussed latrines by varying in location (arboreal, terrestrial, or subterranean), and being further analysed by volume of faeces and spatial distribution (Schilling, 1980; Boonstra *et al*., 1996; Irwin *et al*., 2004; Pouvelle *et al*., 2009). This behaviour appears to be well studied within other mammals but for primates, especially strepsirhines, latrine use is only sparsely mentioned within much broader scope research (Irwin *et al*., 2004). In this report we present our observations of this peculiar behaviour exhibited by the southern gentle lemur, *Hapalemur meridionalis*, a threatened primate that occurs in southeast Madagascar. We will use our observations to review the hypotheses offered thus far to explain latrine use, i.e. advertisement of sexual cycle, predation avoidance, intra- group and inter-group spacing in the context of the fragmented littoral forest.

Methods

This research was conducted from May to July 2008, on the southern gentle lemur within the Mandena littoral forest (24°95'S 46°99'E), a coastal forest in southeast Madagascar. The littoral forest is among the most endangered ecosystems in Madagascar (Bollen and Donati, 2006) and Mandena is a protected conservation zone encompassing 230 hectares of fragmented and partially degraded littoral forest interspersed with marsh and swamp. Three groups of *H. meridionalis* (mean = 5.7 ind/group) were habituated and followed daily from dawn to dusk with 62 hours of observation recorded (Eppley and Donati, in press). These lemurs are of particular interest, as they do not subsist exclusively on bamboo like the majority of their congeners. Rather, the southern gentle lemur exhibits a dietary predilection for terrestrial (turf) grasses while displaying a unique grazing behaviour (Eppley and Donati, in press). Although the main research being conducted focused on the feeding ecology of these animals, opportunistic observations of latrine behaviour were collected *ad libitum*. In addition to habitat characteristics and GPS waypoints taken at the feeding and resting sites of three groups, latrine locations were also recorded. Spatial analyses were carried out with ArcMap version 9.3, with the outermost feeding and resting site waypoints for each group being used to create the minimum polygon for their respective ranging areas.

Results

On three separate occasions an entire group of foraging *H. meridionalis* were witnessed descending to the ground and defecating in succession either near or under a high-rooted tree of different species. Latrine bouts were recorded *ad libitum* on a single occasion for Group B (four individuals) and twice for Group C (seven individuals). Observations took place within the forest fragment, and were never witnessed in open canopy areas. The three occurrences of this terrestrial latrine behaviour were observed shortly after individuals had awoken from a midday resting bout (between 11:00 and 14:00) at distances approx. 20 m from the resting site. The three locations where the latrine behaviour was exhibited are shown in Figure 1. Little overlap between the ranging areas of the three groups was observed with 0.92 ha (7.74 %) calculated to exist between groups A and B, 0.18 ha (1.68 %) between groups A and C, and 0.06 ha (0.73 %) between groups B and C. After an individual had defecated, they ascended three to four meters and continued feeding. Subsequently, the group followed an order of sequential defecation, where by one conspecific would defecate and the next would rapidly follow. The individuals remaining at an elevated height always appeared vigilant, scanning the surrounding area and sometimes continuing to forage, while the conspecific was on the ground. Upon inspection of two of the defecation sites, accumulations of hardened faecal matter were identified. Dissimilarly, the third site consisted of only fresh faeces with no sign of old faecal matter.

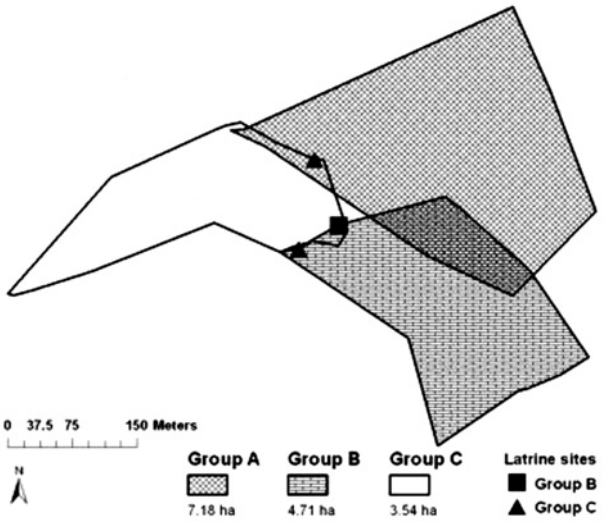

Fig. 1: Ranging areas of the three observed *H. meridionalis* groups within the northeast corner of the Mandena littoral forest. The three latrine sites were observed within the territorial boundary buffer zones of Groups A & C and B & C.

Discussion

Among primates, latrine behaviour has been recorded (Table 1) in *Alouatta seniculus* (Gilbert, 1997; Feeley, 2005; Neves *et al*., 2009; Pouvelle *et al*., 2009), *Ateles geoffroyi* (Notman *et al*., 2009), as well as the strepsirhines: *Cheirogaleus major*, *C. medius*, *Lepilemur leucopus* (Charles-Dominique and Hladik, 1971; Russell, 1977), *L. microdon*, *L. ruficaudatus*, *Hapalemur aureus*, *H. griseus*, *Prolemur simus*, and *Lemur catta* (Irwin *et al*., 2004). With the exception of Neotropical primates, however, minimal research has been conducted to understand its function within primates and latrine utilisation is often a matter of debate. In Ranomafana National Park, for example, *H. griseus* have been observed to occasionally use the same resting/sleeping sites and since they often defecate very soon after they wake up (Tan, pers. comm.), an accumulation of faecal material under these trees may appear inadvertently latrine-like (Notman *et al*., 2009; Pouvelle *et al*., 2009). Thus, latrine use by *H. griseus* may be anecdotal within this population.

Irwin *et al.* (2004) presented four non-mutually exclusive hypotheses for the possible adaptive function of primate latrines: 1) advertisement of sexual cycle, 2) predation avoidance, 3) intra-group spacing, 4) and inter-group spacing.

The conveyance of scent-marks is well known to advertise sexual activity and receptivity (Asa, 2008). If this holds true for *H. meridionalis*, latrines should be used more frequently during the breeding seasons. It has been reported that *H. griseus* mate between June and July, experiencing a gestation length of approximately 137 days (Tan, 2006). Though our research potentially overlapped with the mating season, we made no observations of mating during the study period.

Thus, we had no possibilities to compare the mating season with pre- or post-mating periods, as the hypothesis testing would require. However, since two of the latrines at Mandena appeared to be utilized long-term, similar to the findings of Irwin *et al.* (2004), we conclude that the advertisement of sexual receptivity is unlikely the sole function of lemur latrines.

Tab. 1: Observed primates that have exhibited terrestrial latrine behaviour. Adapted from Irwin *et al.* (2004).

Species	Localities	References
Hapalemur meridionalis	Mandena Conservation Zone	This study
Hapalemur griseus	Analamazaotra Special Reserve	Irwin *et al.* (2004)
Prolemur simus	Ranomafana National Park	P. Wright (in Irwin *et al.*, 2004)
Lemur catta	Isalo National Park	J. Jernvall and P. Wright (in Irwin *et al.*, 2004)
Lepilemur leucopus	Beza Mahafaly Special Reserve	L. Nash (in Irwin *et al.*, 2004)
Lepilemur microdon	Manombo Special Reserve	J. Ratsimbazafy (in Irwin *et al.*, 2004)
Lepilemur sp. (*?microdon*)	Kalambatritra Special Reserve	Irwin *et al.* (2004)
Lepilemur ruficaudatus	Kirindy Forest	J.U. Ganzhorn (in Irwin *et al.*, 2004)
Ateles geoffroyi	Runaway Creek Nature Preserve, Belize	Notman *et al.* (2009)
Alouatta seniculus	Nouragues Reserve, French Guiana	Pouvelle *et al.* (2009)

Gentle lemurs have a particularly effective predator avoidance strategy including camouflage from cryptic pelage, rapid flight behaviour, and potential cathemeral activity pattern (Mutschler *et al.*, 1999; Curtis *et al.*, 2006; Tan, 2006). Several potential predators of *Hapalemur* exist in the littoral forest. There have been documented cases of fossa *Cryptoprocta ferox* preying on *H. griseus* (Goodman and Pidgeon, 1999; Sterling and McFadden, 2000). The Madagascar tree boa *Sanzinia madagascariensis* (= *Boa manditra*) also prey on *Hapalemur* spp. (Goodman *et al.*, 1993; Rakotandravany *et al.*, 1998), and several aerial predators (Madagascar harrier hawk *Polyboroides radiatus*, Frances's sparrowhawk *Accipiter francesii*, Henst's goshawk *Accipiter henstii*, common barn owl *Tyto alba*, and the Madagascar long-eared owl *Asio madagascariensis*) represent a threat to medium-sized lemurs (Goodman *et al.*, 1993; Wright, 1997; Karpanty and Goodman 1999). In fact, the concealment of *Hapalemur* faeces under large high-rooted trees may theoretically act as a safeguard against predation by impairing the ability of a predator to detect the prey population (Boonstra *et al.*, 1996; Irwin *et al.*, 2004). Although these observations are in accord with the anti-predator idea, single faecal deposits were also detected at indiscriminate locations. Thus, more data are necessary to test the hypothesis of latrine behaviour as an anti-predator strategy.

Intra-group spacing has also been suggested to advertise proximal resource use and assist in inter-individual spacing (Kruuk, 1992). In accord with Irwin *et al.* (2004), however, it is unlikely that *Hapalemur* latrine behaviour is used for intra-group spacing, as they live in cohesive family units.

The territorial demarcation hypothesis suggests that scent-marks are placed around home range boundaries to act as a delineation of the territory, i.e. inter-group spacing (Mertl-Millhollen, 1979; Lewis, 2005). In fact, it is evident from our observations that *H. meridionalis* chose defecation sites in the narrow areas of overlap with neighbouring conspecifics groups (Fig. 1). If this adaptive function holds true, latrine behaviour might be even more common in areas of dense population (Irwin *et al.*, 2004), such as the forest fragments of Mandena (Eppley and Donati, in press).

Although the exhibition of preferred, non-random defecation sites is most likely multifactorial, latrines in Mandena appear to best fulfil the function of inter-group spacing. Therefore, latrines may be a low-energy behavioural response to the ecological challenge of defending resources with minimal rates of agonism (Irwin *et al.*, 2004). In the future, more quantitative studies should focus on seasonal and spatial exhibition of latrine use to verify whether this behaviour is intrinsically linked to territorial delineation and resource defence in lemurs.

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Conservation des lémuriens via la protection de leurs habitats et le développement communautaire dans les corridors de Betaolana et Tsaratanana-Betaolana, région de SAVA

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Contextes

Ecologique:
Madagascar est connu pour sa haute valeur en biodiversité. Sa flore et sa faune ont une valeur d'endémicité très élevée (au dessus de 80 %) due entre autres à son insularité. Madagascar est donc plus riche en espèces endémiques comparées à d'autres continents du monde. Le microclimat de l'île a permis que d'une région à une autre, la flore et la faune constituent une richesse spectaculaire à part.
Pour la partie Nord de Madagascar, la flore luxuriante, avec des espèces endémiques du genre Dalbergia, est encore à découvrir. Le WWF a travaillé dans la région de SAVA pour la mise en place de deux Aires Protégées (AP), Parc National de Marojejy et Réserve Spéciale d'Anjanaharibe Sud, actuellement sous gestion du Madagascar National Parks. Pour le WWF, la conservation du flux génétique implique le maintien et la restauration de la connectivité écologique. Ce maintien peut être le plus important paramètre le long des pentes altitudinales car cette connectivité est actuellement très rare au sein de l'écorégion de l'Est. De plus, il peut constituer un refuge pour la biodiversité vu les changements du climat (Erdmann *et al*., 2005).
Eu égard aux efforts déjà investis dans la protection des deux AP (Parc de Marojejy et de la Réserve Spéciale d'Anjanaharibe Sud), le WWF a continué ses efforts de conservations dans les deux corridors forestiers (Betaolana et Tsaratanana-Betaolana). Dans ces localités, les espèces endémiques sont aussi très remarquables comme le palmier *Marojejya insignis* et la fougère *Asplenium marojyense*. La forêt dense et humide de cette partie de l'île abrite une multitude de faune à découvrir et à protéger.
La forêt occupe encore 35,60 % de la région de SAVA (données images satellites de 2000), ce taux est élevé par rapport à d'autres régions de Madagascar. La richesse en biodiversité de cette zone est démontrée par de nombreuses études, sur la flore et sur la faune, conduites dans cette zone.
Pour ces deux corridors Betaolana et Tsaratanana-Betaolana, les inventaires effectués par Rajaonson et Rakotonirina (2007) pour le WWF ont montré l'existence de 10 espèces de lémuriens pour le corridor Betaolana, et de sept espèces pour le corridor Tsaratanana Betaolana, 84 espèces d'oiseaux pour l'ensemble des deux corridors. En comparaison avec les inventaires des lémuriens effectués par Goodman *et al*. (2003), la région d'Andapa, incluant les AP de Marojejy et d'Anjanaharibe-Sud et le corridor forestier de Betaolana, possèdent une richesse spécifique en communautés de lémuriens et tient une place importante en biodiversité à Madagascar. La synthèse des études déjà effectuées dans la zone a recensé 12 espèces de lémuriens dont: *Microcebus rufus, Cheirogaleus major*, *Allocebus trichotis*, *Phaner furcifer*, *Avahi laniger*, *Lepilemur mustelinus*, *Daubentonia madagascariensis*, *Hapalemur griseus griseus*, *Eulemur rubriventer*, *Eulemur fulvus*

albifrons, *Propithecus candidus*, *Indri indri*. Parmi ces espèces citées, celles non rencontrées dans les deux corridors sont: *Indri indri* et *Phaner furcifer* (pour les deux corridors Betaolana et Tsaratanana-Betaolana) et *Allocebus trichotis* pour le corridor Tsaratanana Betaolana).

Parmi les espèces de lémuriens, le Simpona (*Propithecus candidus*) est une des 25 espèces de primates les plus menacées dans le monde (Mittermeier *et al.*, 2005), d'où l'intérêt de se focaliser sur sa conservation. Certains auteurs (Petter *et al*., 1979; Tattersall, 1982) pensent que l'habitat du Simpona pourrait éventuellement s'étendre vers le Sud jusqu'aux forêts de la péninsule de Masoala. Il est par contre prouvé que le versant Ouest de Anjanaharibe-Sud, actuellement sans statut de protection, héberge une population importante de Simpona. La population de Simpona de la région Andapa et donc mondiale est estimée à une valeur comprise entre 100-1000 individus (Mittermeier *et al*., 1994). Des inventaires effectués par le WWF vers la fin 2006 ont relevé que le Simpona se rencontre aussi vers le Nord du Corridor de Betaolana en allant vers le Nord Ouest du côté du massif de Tsaratanana.

Social et économique:

Les deux corridors forestiers, Betaolana et Tsaratanana Betaolana, couvrent approximativement une superficie respective de 16 500 ha et de 130 900 ha et sont très riches en forêt. En se référant aux délimitations sur la carte 1, les deux corridors renferment encore jusqu'à 90 % de forêts. Situées sur des sols ferralitiques, les forêts des deux corridors sont localisées entre les altitudes 850 et 1600 m pour Betaolana et 800 à 2280 m d'altitude pour Tsaratanana-Betaolana. Les deux corridors jouissent encore du climat humide de la région de SAVA.

Les deux corridors appartiennent aux districts d'Andapa (pour le Corridor de Betaolana) et de Bealanana (pour le corridor de Tsaratanana-Betaolana). Les populations des communes locales vivant à la périphérie de ces corridors sont estimées, en 2009, à 72 521 pour le corridor Betaolana et à 41 333 pour le corridor Tsaratanana-Betaolana (à partir des données d'INSTAT 1993).

Dans la région de SAVA, les forêts dans les deux corridors Betaolana et Tsaratanana Betaolana font partie des domaines forestiers de l'Etat. Ils n'ont de ce fait pas de statuts particuliers (Garreau et Manantsara, 2003). Toutefois, le WWF, connaissant l'importance de la flore et la faune dans cette zone, a mis en œuvre de 2005 à 2008 deux projets spécifiques pour la conservation des lémuriens et de leurs habitats dans la région de SAVA. Dans le cadre des projets mis en œuvre par le WWF qui se sont succédés dans la région de SAVA, celui-ci a travaillé avec les populations locales pour mettre ces deux corridors sous statuts de Nouvelles Aires Protégées. Pour le Corridor Betaolana, huit communautés de bases ayant reçu des contrats de transferts de gestion des lots de forêts ont déjà déposé leur manifestation d'intérêt dans ce sens en 2008. Les différentes étapes et procédures à respecter suivent actuellement normalement leur cours.

Cet article, eu égard à tous les acquis dans le cadre des projets du WWF, est une capitalisation des expériences de WWF Madagascar pour les projets de conservation des lémuriens et de leurs habitats dans le Nord de Madagascar. L'un des deux projets est connu sous son appellation courte, projet Simpona. Son but est en effet de mettre en exergue cette espèce phare bien qu'elle ne soit pas la seule à être protégée dans le cadre des projets du WWF.

Approche de conservation

Les sites des deux projets

La région de SAVA se trouve dans l'ex Province d'Antsiranana au Nord de Madagascar. Les deux projets du WWF dans cette localité ont été conduits dans deux corridors forestiers entre les Aires Protégées Tsaratanana (Réserve Naturelle Intégrale), Marojejy (Parc National) et Anjanaharibe Sud (Réserve Spéciale). La carte suivante montre la situation générale de ces localités.

Les objectifs de conservation

A partir de la connaissance des richesses de cette localité, des pressions et menaces sur les espèces cibles, la finalité des deux projets était de freiner l'utilisation irrationnelle de la forêt tout en construisant un environnement où les populations locales pourront vivre en harmonie avec la nature. Découlant de cette finalité, les objectifs des deux projets ont été de: 1) Mieux connaître le niveau de menace sur les lémuriens et sur leurs habitats; 2) Elaborer des scénario de zonages et de gestion; 3) Conscientiser et éduquer les communautés locales concernant les menaces et la protection des lémuriens; 4) Initier de nouveaux transferts de gestion des forêts auprès des communautés locales de base (sur la partie Ouest du Corridor de Betaolana); 5) Protéger et/ou restaurer les habitats des lémuriens; 6) Renforcer la protection des lémuriens par l'extension et la création de nouvelles aires protégées; 7) Vulgariser et promouvoir les produits de substitution des principaux produits forestiers; 8) Procéder au suivi d'évaluation des méthodes et procédures de gestion internes des associations des forêts; 9) Restaurer les terrains défrichés de la périphérie du corridor. En bref, les deux projets essaient de renforcer les conditions requises pour la conservation à long terme de la biodiversité via la conservation des fonctions écologiques des deux corridors (Betaolana et Tsaratanana-Betaolana) de manière participative.

Diagnostic participatif: Mieux connaitre pour mieux protéger

Cartographie

A partir des connaissances issues de la littérature, une cartographie simplifiée basée sur des cartes topographiques (échelles 1/100 000) et des interprétations des images satellites 2000 a été élaborée. L'objectif est de partir des limites des forêts à partir de ces images pour délimiter des zones où les inventaires forestiers vont être réalisés. De même, de par cette technique, des zonages forestiers et des cartes d'occupation des sols sont élaborés. Le zonage forestier se base sur les états de dégradations des forêts. Les unités semblables ont été groupées dans une même catégorie définie pour un objectif spécifique (conservation, enrichissement / restauration, droit d'usage).

Inventaire des lémuriens par des primatologues

Pour mieux intégrer les populations locales dans l'importance de la conservation des lémuriens, elles ont été invitées à participer aux inventaires des lémuriens. Leur connaissance de base, combinée aux connaissances scientifiques de deux primatologues recrutés ont été pour renforcer les acquis dans le cadre de la littérature. Cette approche a aussi permis d'élaborer des documents de base pour le suivi des lémuriens et de choisir des espèces pour la restauration forestière.

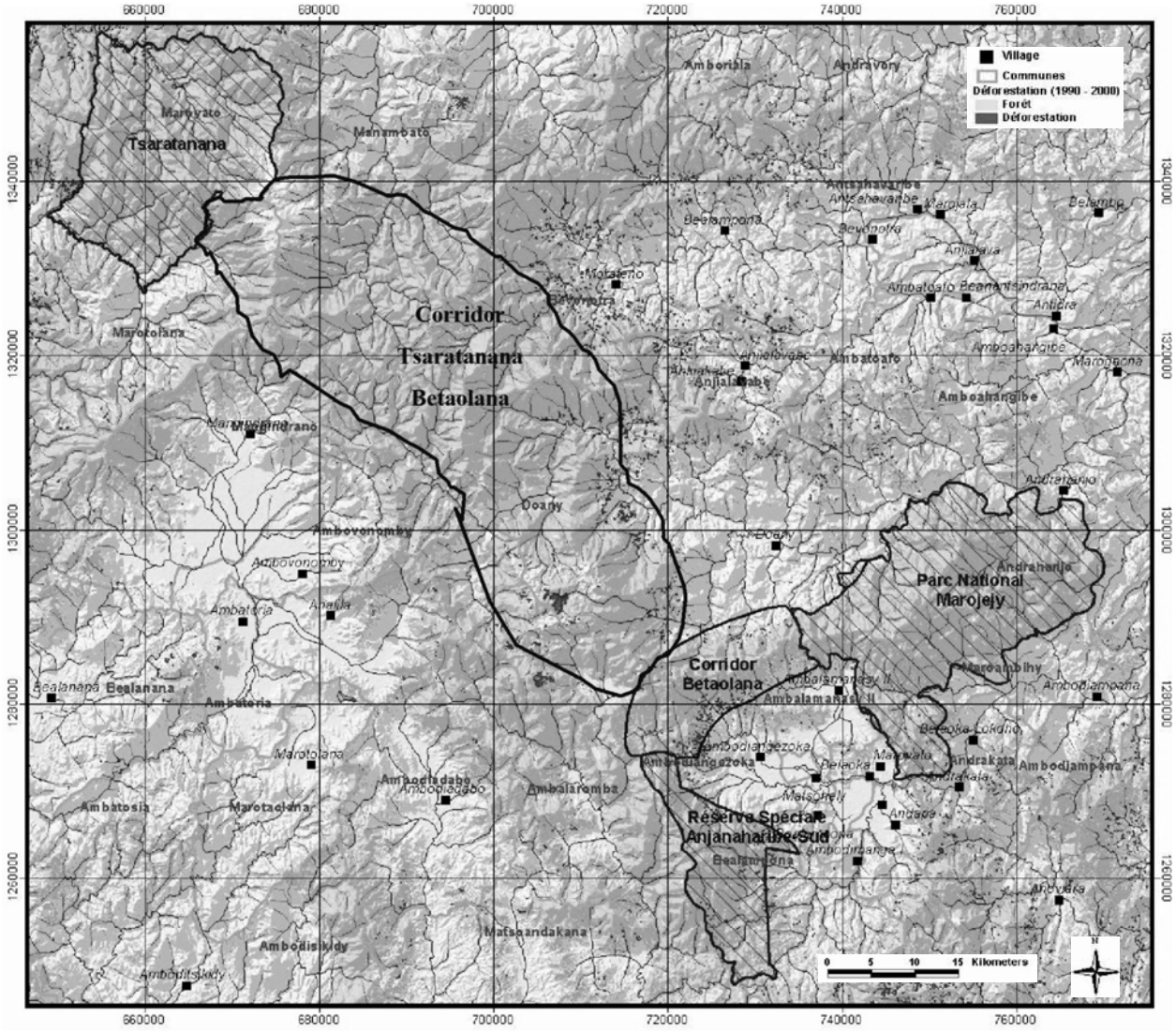

Fig. 1: Carte de localisation générale des sites.

Etudes des pressions et menaces sur les lémuriens et leurs habitats

Les études sur les pressions et menaces ont été conduites selon des enquêtes informelles et formelles et selon des observations directes. Les enquêtes informelles servent à la fois à gagner la confiance des populations locales et à recueillir le maximum d'informations. Les enquêtes formelles sont utilisées par les consultants primatologues pour une meilleure représentativité des réponses. Les membres de l'équipe de WWF, à mesure de l'avancement de la conduite des activités dans le cadre des deux projets, ne cessent de faire des recoupements entre toutes les réponses obtenues.

La participation des membres des communautés de base est indispensable dans les deux types d'enquêtes pour qu'ils se sentent responsables et pour confronter les réponses au fur et à mesure que des biais sont observés. Les méthodes classiques de recherches participatives utilisées sont du genre MARP: Méthode Accélérée de Recherche Participative et PALM: Participatory Learning Methods ou Méthode d'apprentissage Participatives. Les membres de l'équipe du WWF ont reçu auparavant des formations sur ces méthodes. Dans le cadre de leur travail, ces méthodes sont conduites lors des premières approches au sein d'une nouvelle communauté demandant à gérer une ressource naturelle dans leur terroir.

Responsabilisation sous forme de transfert de gestion

Inventaire forestier et zonage

Dans chaque localité de travail avec une communauté, des inventaires forestiers ont été conduits. La finalité est de connaitre les potentialités des différents types de forêts en produits forestiers ligneux et non ligneux. Une uniformisation des méthodes de relevés a été réalisée. A partir des cartes de zonages élaborées, les inventaires ont été concentrés dans les zones de conservations et des droits d'usage. Des parcelles imbriquées sont définies. Elles ont des surfaces de 100 x 100 m pour des diamètres de 1,30 m (dhp) supérieur ou égal à 30 cm; deux parcelles de 25 x 25 m pour les arbres de dhp compris entre 10 cm à 30 cm; et deux parcelles de 5 x 5 m. Les dimensions de ces parcelles peuvent varier en fonction du relief (si le terrain est trop accidenté, la réduction des dimensions est préconisée) et leur nombre varié. Mais quelques soient les variantes, une moyenne de un hectare par type de forêt est requise pour les gros diamètres.

Elaboration de plan d'aménagement

En vue de l'obtention des contrats de transfert de gestion des forêts auprès du Ministère des forêts, chaque communauté devrait établir des plans d'aménagement des forêts.

Les plans d'aménagement suivent les directives proposées par la Direction Générale des forêts. Le WWF, pour l'élaboration de ces plans, a surtout veillé à ce que les prélèvements respectent le principe de la durabilité à savoir: ne prélever que le volume correspondant aux accroissements moyens annuels. Pour un meilleur équilibre entre les besoins des populations locales, des reboisements en espèces introduites sont aussi proposés dans ces plans d'aménagement, mais dans des parcelles en dehors des forêts naturelles.

Appropriation sous forme de contrôle

L'approche d'appropriation sous forme de contrôle a aussi été développée pour atteindre les objectifs des deux projets. Elle consiste à encourager les membres des communautés à l'établissement de parcelles d'observation en forêt en se basant sur les pistes existantes et sur les signes visibles de pressions (coupe, pièges). Des représentants dynamiques au sein de chaque communauté sont ainsi élus et font des visites (contrôles) régulières, parfois inattendues, en forêts. Ces visites sont organisées pour observer la biodiversité (floraison des plantes, augmentation du nombre des groupes de lémuriens observés, passage d'un oiseau ou autre type d'animal faisant la particularité de leur forêt etc.) et pour constater si des pressions sur les lémuriens et la forêt sont encore présentes. Ces membres notent leurs observations dans des cahiers réservés pour ces observations et tout autre évènement qu'ils jugent importants (rencontre avec d'autres personnes, etc.).

Mesures d'accompagnement

Le WWF défini les mesures d'accompagnement de toute activité développée pour contribuer à l'amélioration des conditions de vie des populations locales. Ces activités doivent à la fois réduire les pressions sur la biodiversité en générale et sur les cibles de conservation en particulier (forêt naturelle et lémurien) et compenser les efforts de conservations entrepris. L'approche consiste d'abord à analyser les résultats de toutes les études préalables aux transferts de gestion des forêts. A partir de ces analyses, les potentialités de chaque terroir (à partir des cartes d'occupation des sols et des rendements obtenus pour chaque spéculation engagée) dans lesquels vivent les communautés sont dégagées. Les mesures à développer cherchent ainsi à augmenter les sources de revenus des paysans et à améliorer leur alimentation pour une meilleure santé.

Résultats et discussions

Inventaires forestiers et zonages

Au total, 14 inventaires forestiers (correspondants au nombre de transfert de gestion des forêts) ont été effectués dans la région de SAVA. La potentialité des forêts est variable. Le nombre des arbres de dhp > 30 varie de 200 à 400/ha. Au total, 200 espèces de plantes (ligneuses et non ligneuses) sont inventoriées. D'un site à l'autre, le nombre des espèces ligneuses inventoriées varie de 45 à 87.

Les espèces les plus fréquemment rencontrées sont: *Tambourissa religiosa*, *Weinmannia rutembergii*, *Zantoxyllon mananarense*, *Chrysophyllum boivinianum*, *Canarium madagascariensis*, *Symphonia fasciculata*, *Diospyros aff.ambilensis*, *Macaranga decaryana*, *Erythroxylum sphaeranthum*, *Brachylaena merana*, *Syzygium emirnense*, *Uapacca densiflora*, *Ocotea cymosa*…

En fonction de l'éloignement des forêts par rapport aux villages, leur état de dégradation diffère. Cette observation a permis de faire trois grande classifications: forêt naturelle plus ou moins intacte, classée à protéger ou à conserver (formant donc le noyau dur); forêt partiellement dégradée, localisée encore en plein cœur de la forêt, classée comme forêt à restaurer; forêt naturelle à faible potentialité, due à un degré d'écrémage localisée à la périphérie des lisières, classée comme zone de cantonnement de droit d'usage.

Transfert de gestion des forêts

Le WWF a pu mettre en place dans le cadre de ces deux projets 14 transferts de gestion. Pour chaque communauté, la surface totale des forêts dans ces transferts varie de 300 à 5000 ha (dépendant du taux de couverture forestière dans le territoire de chaque village d'appartenance de la communauté). Les zonages des forêts sont décrits précédemment. En principe, les contrats sont établis pour trois ans. Ensuite une évaluation devra se faire par le Service Forestier en partenariat avec les communes d'appartenance des communautés gestionnaires des forêts. Etablis à partir de 2007, certains contrats nécessitent ainsi une évaluation à partir de cette année ou au plus tard en début de l'année prochaine.

Au total, les 14 transferts de gestion des forêts ont permis de sécuriser sous la gestion des COBA, 27 000 ha de forêts. Ces forêts incluent tous les types de forêts à différents usages définis auparavant (conservation, restauration, droit d'usage).

Les valeurs de la restauration pour le WWF sont présentées dans son document de la vision de la biodiversité (Erdmann *et al*., 2005) qui a défini 40 aires comme Aires Prioritaires de conservation de par leur valeur en biodiversité. Les études sur leur état de dégradation ont relevé aussi que 23 de ces aires auront probablement besoin d'importante restauration (< 20 % de forêt), si elles doivent entièrement concourir à la conservation de la biodiversité. Dans tous les sites de transferts de gestion des forêts, le WWF met ainsi l'accent sur l'importance de la restauration. Les communautés avec l'encadrement du WWF, des observations sur terrain et des inventaires effectués définissent ainsi des zones de restauration dont la superficie varie d'une communauté à une autre. Les espèces utilisées pour ces restaurations des forêts dégradées sont essentiellement des essences autochtones. Leur choix est justifié par leur emplacement (héliophile pour les zones très ouverts et/ou périphérie de la forêt; nomade pour les zones sous couvert des espèces héliophiles) ou par leur utilisation (construction, nourriture des lémuriens).

Suivis et contrôles

Le WWF, pour faciliter l'uniformisation des suivis et contrôle en matière des lémuriens, a élaboré un livret sur les lémuriens avec la photo des espèces et une description sommaire des espèces. L'idée de départ était d'exploiter ces livrets peu avant la fin des projets pour les analyser. Il a pourtant été constaté que les représentants des communautés n'ont pas utilisé les livrets, mais les a bien classés dans leur valise. Leur explication est que le livret (en couleur) est trop beau pour être amené et abimé en forêt à cause de l'humidité. Néanmoins, les suivis et contrôles ont été effectivement effectués par les communautés. De plus, les données ont été stockées soit dans des cahiers à part, soit dans leur tête.

Dans le cadre des suivis et contrôles instaurés de manière participative, des suivis et contrôles à part doivent aussi être faits par les organismes techniques d'appuis des communautés. En effet, à travers les expériences de l'élaboration du livret, il a été constaté que les instructions et formations n'ont pas été suivies correctement. Les agents des deux projets, ne se sont donc rendus compte qu'un peu tardivement de la nécessité de faire aussi des suivis et contrôles rapprochés.

Table 1: Caractéristiques des localités d'observation des lémuriens.

Localités	Andrakengy	Andasipiro	Ambodivoara	Ambodimandresy
Période d'observation	20 Novembre - 3 Décembre 2006	6 Décembre - 17 Décembre 2006	19 Novembre - 3 Décembre 2006	5 Décembre - 17 Décembre 2006
Coordonnées géographiques	S 14° 18' 53.4" E 049< 16' 38.3"	S 14° 12' 10.0" E 049< 22' 34.8"	S 14° 32' 05.0" E 049< 26' 42.1"	S 14° 32' 05.0" E 049< 30' 21.1"

Les suivis et contrôles effectués par les paysans ont quand même permis de localiser des sites d'observations de l'espèce *Propithecus candidus* (Simpona). Patel, en échangeant les données avec l'équipe des projets du WWF a publié en 2009 que l'espèce *Propithecus candidus* est aussi rencontrée dans le Corridor de Betaolana et de Tsaratanana-Betaolana. Quelques caractéristiques des localités où les inventaires ont été effectués et où cette espèce a été observée sont synthétisées dans le tableau 1.

Les alternatives aux pressions et menaces

Les pressions sont définies comme étant les activités causant des impacts négatifs aussi bien sur les forêts que sur les lémuriens. Ces activités peuvent être légales ou illégales. Par contre, les menaces sont des activités pouvant apparaître dans le futur et pouvant avoir des impacts négatifs sur les cibles (dans le cadre de ce projet les cibles sont les lémuriens et leur habitat).

Les analyses, effectuées dans le cadre de ces deux projets ont montré que les pressions et les menaces sur les cibles sont principalement constituées de: la déforestation causée essentiellement par les cultures sur brûlis, la dégradation des forêts engendrée par les prélvements diverses (bois de construction ou autre matériels pour la construction tels que les lianes et les bambous, cueillette de miel), la chasse moderne et le piège traditionnel. La déforestation tue à la fois les lémuriens et détruit leur habitat. Il en est de même des pièges traditionnels mais à un degré moindre.

Pour arrêter les pressions sur les forêts, les deux projets du WWF ont donc analysé les activités pouvant remplacer celles formant une pression et constituant une menace dans le futur. En bref les activités développées sont: l'amélioration de l'exploitation de l'espace par l'agroforesterie; la promotion des cultures maraichères, l'amélioration des cultures de riz sur les bas fonds étroits par les Systèmes de Riziculture Améliorés (SRA), la promotion des briques pour la construction des maisons et le reboisement des espèces à croissance rapide; l'apiculture, la pisciculture et l'amélioration de l'élevage des volailles.

Elaboration d'une stratégie régionale pour la conservation des lémuriens

Les principales cibles de conservations des deux projets sont la forêt humide et les lémuriens. A part les transferts de gestion, les deux projets ont aussi été conduits pour éduquer, informer et sensibiliser les populations locales (partant des élèves dans les écoles primaires aux écoles secondaires mais aussi l'ensemble des populations concernées dans les communes).

Pour la sauvegarde des lémuriens, les engagements des parties prenantes sont recherchés à travers l'élaboration et la mise en œuvre d'une stratégie régionale pour la conservation des lémuriens. Dans cette stratégie, les activités de chaque partie sont définies de manière à minimiser les dépenses monétaires afin de les rendre réalisables.

Pour une meilleure intégration ou engagement de chaque entité, une Association des Amis des lémuriens a été créée. Cette association est mise en réseau via un site web aux amoureux des lémuriens dans le monde. La vision a été développée pour le long terme. Toutefois, le WWF s'est rendu comte qu'avec l'isolement de chaque localité, les réponses instantanées et directes des membres aux intéressés via le site web sont très limités et précaires. En effet, pour se connecter, les élèves doivent aller à Andapa; et même si certains élèves d'Andapa sont concernés, le reflexe avec cette haute technologie nécessite encore un encadrement rapproché pour être efficace.

Pour mieux unir les efforts, une Union Régionale des Associations de gestion des forêts, appelée aussi "Gestion Unie du Corridor de Betaolana" a aussi été créé. Malgré les efforts investis pour créer cette Union, elle est restée au stade de constitution (dépôt de dossier) au moment où les phases des deux projets sont terminées. Toutefois, elle est engagée et sera reprise dans les autres projets du WWF dans cette localité. Il est donc souligné ici l'importance des encadrements par des organismes promoteurs dans le long terme ou du moins à moyen terme pour obtenir de meilleurs impacts dans les phases du projet.

Les parties prenantes définies dans ce document sont composées par les partenaires techniques et les autres organismes et/ou associations travaillant dans les domaines de l'environnement, les communautés de base, les organes de décentralisation et de déconcentration de l'Etat (les régions, les communes, les districts et les Fokontany).

Conclusions

La capitalisation des deux projets du WWF dans le Nord a permis de comprendre les efforts encore à fournir dans le cadre de la conservation des lémuriens et de leur habitat. Les deux projets conduits dans la région de SAVA sont complémentaires, ceci a permis une uniformisation des approches techniques et scientifiques. Les deux projets ont enrichis les données sur la diversité de la zone en flore et en faune. Ils ont pu se réaliser de manière participative. En effet, ils ont été très bien accueillis par les populations locales du fait que ces projets étaient majoritairement axés sur les activités de développement pour atteindre leurs objectifs de conservation.

En conclusion, les défis à lancer doivent se concentrer sur deux aspects.

Aspect technique: des études plus poussées sur la flore et la faune sont à conduire. En effet, les découvertes à faire sont encore immenses vu l'étendue du massif forestier.

Aspect développement: des activités sont engagées et n'en sont qu'au début de leur mise en œuvre. Il serait nécessaire dans le futur de faire des évaluations de ces projets en termes d'impact sur la conservation des habitats et des lémuriens ainsi que sur l'amélioration des conditions de vie de la population locale.

Ces deux projets ne sont pas des projets de recherches. Toutefois, ils ont pu être enrichis par les interventions des scientifiques consultants d'une part et des équipes du WWF d'autre part.

Remerciements

Nos vifs remerciements s'adressent aux bailleurs qui ont financés les projets du WWF Madagascar dans la région de SAVA. Ils ont permis de conduire à la fois des études scientifiques et des activités de développement. Ces bailleurs sont: WWF Allemagne, WWF Suède et la Conservation Internationale. Bien qu'à faible volume en terme de fonds, nous tenons aussi à remercier le WWF Danemark pour des fonds spécifiquement alloués à l'élaboration des support de com-

munication (poster, teeshirt, banderoles etc.) pour une meilleure compréhension des aspects de la conservation auprès des paysans en particulier et des parties prenantes en général.

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Genetic diversity in ten Indri (*Indri indri*) populations compared to other lemur species

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Genetic diversity is considered by most to be the key to long term survival and the maintenance of the evolutionary trajectory of a species. Genetic variation at loci under selection gives the species as a whole the mechanisms with which to respond or adapt to environmental changes. Lemurs in general are poorly studied with respect to establishing baseline parameter estimates for genetic diversity. Only limited population genetics studies exist on the genera *Propithecus*, *Avahi, Varecia*, *Eulemur*, *Microcebus*, and *Mirza* (Tab. 1). To date, the genus *Indri* is depauperate of population genetic data that would help better understand the genetic diversity harbored in its populations.

Tab. 1: Lemur studies using multilocus microsatellite suites to estimate genetic diversity as observed (HO) and expected (HE) heterozygosity levels.

Species	Populations	Samples	Loci	HO	HE	Reference
Indri indri	2	20	20	0.654	0.766	Zaonarivelo *et al.*, 2007b
Propithecus deckeni	2	20	14*	0.790	0.851	Lei *et al.,* 2008a
P. deckeni	1	10	18*	0.776	0.776	Lei *et al.*, 2008b
P. coquereli	1	25	20	0.635	0.771	Rakotoarisoa *et al.*, 2006a
P. candidus	2	18	17*	0.648	0.614	McGuire *et al.,* 2009
P. coronatus	1	10	18*	0.771	0.774	Lei *et al.*, 2008b
P. diadema	2	20	13*	0.818	0.814	Ramarokoto *et al.*, 2008
P. edwardsi	2	20	12*	0.681	0.618	Bailey *et al.,* 2009
P. verreauxi	3	30	13	0.670	0.712	Rakotoarisoa *et al.*, 2006b
P. tattersalli	2	20	16*	0.673	0.683	Razafindrakoto *et al.*, 2008
P. tattersalli	**3	75	13	0.699	0.682	Quéméré *et al.,* 2009
P. tattersalli	9	224	13	0.690	0.660	Quéméré *et al.*, 2010
Avahi laniger	5	37	22	0.640	0.838	Andriantompohavana *et al.*, 2004
A. occidentalis	1	7	22	0.514	0.586	Andriantompohavana *et al.*, 2004
Varecia rubra	2	32	15	0.616	0.618	Razakamaharavo *et al.*, 2010
V. variegata variegata	4	35	25	0.337	0.506	Louis *et al.,* 2005
Eulemur cinereiceps	2	21	16*	0.598	0.641	Tokiniaina *et al.,* 2009
E. collaris	4	40	10*	0.617	0.576	Ranaivoarisoa *et al.*, 2010
E. sanfordi	5	54	11*	0.562	0.567	Ramanamahefa *et al.*, 2010a
E. coronatus	6	80	11*	0.636	0.673	Ramanamahefa *et al.*, 2010b
E. rubriventer	2	12	20	0.531	0.643	Andriantompohavana *et al.,* 2007
Lemur catta	1	24	7*	0.837	0.838	Zaonarivelo *et al.,* 2006
Microcebus ravelobensis	8	205	7	0.615	0.605	Olivieri *et al.,* 2007
M. ravelobensis	12	187	8	0.708	0.734	Radespiel *et al.,* 2008
M. bongolensis	3	45	8	0.557	0.565	Olivieri *et al.*, 2008
M. danfossi	7	78	8	0.628	0.662	Olivieri *et al.*, 2008
Mirza coquereli	***1	69	7	0.712	0.799	Markolf *et al.*, 2008

* Heterozygosity averages calculated using loci with null allele frequency estimates less than 0.10.
** Estimated over genetic clusters, not actual populations
*** Samples taken from 1993-2006.

The Indri (*Indri indri*, Gmelin, 1788), or Babakoto as it is known in most of eastern Madagascar, is the largest extant lemur (Powzyk and Thalmann, 2003). Indri are primarily mid-level forest folivores preferentially feeding on immature leaves and somewhat also on mature leaf matter, flowers, fruits, seeds and even bark when necessary (Britt *et al.*, 2002). The Babakoto is currently threatened by the rapid reduction

of forest cover and fragmentation of suitable habitat (Harper *et al*., 2007) which limits the species' density and range (Glessner and Britt, 2005). Although protected, the Babakoto is also threatened by subsistence hunting pressure and bush meat trade (Golden, 2005). Designated as Endangered according to the IUCN Red List of Threatened Species (IUCN, 2008), *I. indri* is currently split into two subspecies, *Indri indri indri* (Gmelin, 1788) and *Indri i. variegatus* (Gray, 1872). Here, we present population genetic parameter estimates from populations along the entire range of the species analyzed from nuclear microsatellite multilocus genotypes.

Methods

Samples were collected from 106 Indri from 10 sites across the geographical range of the species (Fig. 1). From north to south, the forests represented in the collection were Anjanaharibe-Sud Special Reserve, Marotandrano Special Reserve, Ambatovaky Special Reserve, Zahamena Special Reserve and National Park, Betampona Nature Reserve, Anjozorobe Regional Forest Reserve, Mantadia National Park, Analamazoatra Special Reserve (Andasibe), Maromizaha Classified Forest, and Anosibe an'ala Classified Forest. The elevations of the sampling sites ranged from lowland forests (Anosibe An'ala, 125 m asl) to highland forests (Anjozorobe, 1358 m asl).

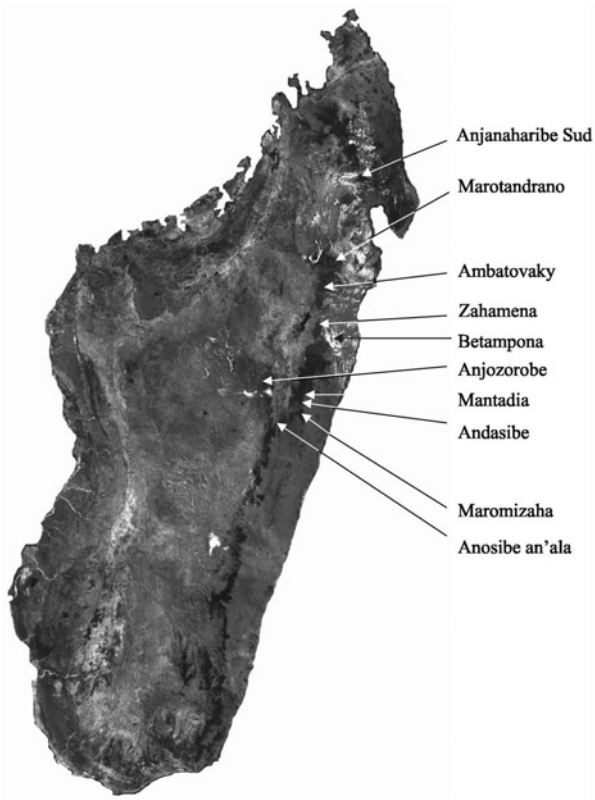

Fig. 1: Map of Madagascar indicating the study areas.

Immobilization and collection

All lemurs investigated in this study were free-ranging and were immobilized with a CO_2 powered DAN-INJECT (Brrkop, Denmark) Model JM rifle propelling Pneu-Darts (Williamsport, PA) loaded with 10 mg/kg estimated body weight of Telazol® (Fort Dodge). We recorded the location (within 6 m accuracy) of all of the immobilized lemurs using a global positioning system (GPS) device. Each individual was transported back to the base camp where complete morphometric data were taken (Zaonarivelo *et al*., 2007a). Whole blood (1.0 cc per kilogram) from the femoral artery and 2.0 mm skin biopsies from the ear pinnae were collected from each sedated lemur (Junge and Louis, 2002). A Home Again® (Home Again Pet Recovery Service, East Syracuse, NY) microchip was placed subcutaneously between the scapulae of each lemur to positively identify individuals re-captured during any future immobilizations. Following data and sample collection, an injection of lactated Ringer's solution was administered subcutaneously to support maintenance requirements and to dissipate the effect of the Telazol®. Animals were monitored for three hours post recovery then released according to the capture GPS coordinates.

Data generation

Ear punches were dissected into quarters and DNA was extracted using standard PCI/Chloroform procedures (Sambrook *et al*., 1989). Approximately 50 ng of genomic DNA was used for each PCR reaction. Multilocus genotypes were generated from a suite of 20 Indri-specific microsatellite loci as described in Zaonarivelo *et al.* (2007b). The genotype file was checked for typographical errors, scoring errors, stutter bands and allele dropout with Micro-Checker (van Oosterhout *et al*., 2004) and Microsatellite Analyser (MSA; Dieringer and Schlötterer, 2002). We used CERVUS (version 2.0, Marshall *et al*., 1998; Slate *et al*., 2000) to identify loci with excessive null allele frequency estimates ($nf > 0.10$) and to estimate polymorphic information content of the loci. Moderate ($0.05 < nf < 0.20$) and high ($0.20 < nf$) null allele frequencies can have significant effects on population genetics parameter estimates (Chapuis and Estoup, 2007). The process of redesigning primer pairs is both costly and time consuming; therefore, we opted to delete problematic loci from the data set. We deleted eight loci with moderate null allele frequencies ($nf > 0.1$) to reduce the bias from misclassification of null heterozygotes as homozygotes (Callen *et al*., 1993; Hoffman and Amos, 2005) and to control the variance of parameter estimates (Chapuis and Estoup, 2007). The accepted loci were verified for independence of linkage disequilibrium (with Bonferroni-adjusted P-values) in FSTAT (Goudet, 1995, 2001).

Hardy-Weinberg exact tests (Guo and Thompson, 1992) were performed by locus and population in Genepop (version 4.0, Raymond and Rousset, 1995). Initially, we used the default settings for the MCMC estimation of HWE then increased the batch size from 100 to 250 to reduce the standard error of the *P*-value to below 0.01. Genetic diversity was measured as observed heterozygosity (HO) and expected heterozygosity (HE). In addition, the number of effective migrants was estimated globally and pair-wise using the private allele method. We used FSTAT to calculate the total number of alleles (k), mean number of alleles (MNA), and rarefacted allelic richness (AR; Leberg, 2002) by locus and population. Allelic richness estimates the allelic diversity in a data set based on the population with the fewest number of individuals contributing genotypes by locus. This is an unbiased comparison of allelic diversity since populations with more contributors provide a greater opportunity to capture more alleles from lower frequency occurrences. Wright's *F*-statistics were estimated in FSTAT for within population similarity (*FIS*) and between population differences (*FST*) according to Weir and Cockerham (1984).

The effective population sizes were estimated with the linkage disequilibrium (LD) option in NeEstimator (Peel *et al.*, 2004; Hill, 1981; Waples, 1991). We tested all populations having met the minimum statistical threshold required (n = 20 genes or 10 individuals) for the presence of bottleneck events using Bottleneck (version 2.0, Cornuet and Luikart,

1996; Luikart *et al*., 1998; Piry *et al*., 1999) under the Infinite Alleles Model (IAM; Kimura and Crow, 1964), the Stepwise Mutation Model (SMM; Ohta and Kimura, 1973), and the Two Phase Model (TPM; di Rienzo *et al*., 1995). We varied the proportion of the single step contribution to the TPM to identify the $P < 0.05$ threshold of significance. The program identifies populations with an excess of heterozygosity relative to mutation-drift equilibrium which is indicative of a reduction in the effective population size (Maruyama and Fuerst, 1985). An estimate of relationships among all individuals sampled at each forest was done in SPAGeDi (Hardy and Vekemans, 2002), then compared to a simulation of known pedigreed individuals. The analysis was performed to calculate the relationship coefficients described in Queller and Goodnight (1989) in the absence of spatial data.

Results

Genetic diversity as mean number of alleles ranged from 6.08-8.92 per population. Using the rarefacted allelic richness, the range lowered to 5.87-7.67. The expected heterozygosity ranged from 0.77-0.86 ($P > 0.05$; Fig. 2) with an average of 0.81, while the observed heterozygosity ranged from 0.65-0.84 ($P < 0.05$; Fig. 3) with an average of 0.74. The number of effective breeders in the sampled populations averaged between 12.6 and 39.6 per population (Tab. 2).

Results from Bottleneck showed that none of the 10 populations deviated from a mutation-drift equilibrium under the SMM. Three populations, Anjanaharibe Sud, Ambatovaky and Anjozorobe did not show evidence of population bottleneck under the IAM either. The rest of the populations were significant for bottleneck events under the IAM and varying proportions of single step contributions under the TPM.

The frequencies of the relationship coefficients estimated using SPAGeDi were overlaid upon a simulation generated from known pedigreed data so that each of the population's relative distribution of relationships could be compared with parent offspring, full sibling, half sibling and unrelated relationship coefficient distributions (Fig. 4). The data indicated that the sampling was from individuals that were somewhat related more than the unrelated individuals in the reference simulation. Inbreeding can also be due to background relatedness where an increased allelic identity by descent is a result from bottleneck events in the population's history. Relationship coefficient distributions support the assumption that the individuals sampled were often from family groups. All of these sources may potentially be due to the effects of habitat fragmentation which is certainly the case in the Anosibe an'ala population where the habitat is so fragmented that although multiple family groups were encountered, they were found in isolated forest fragments.

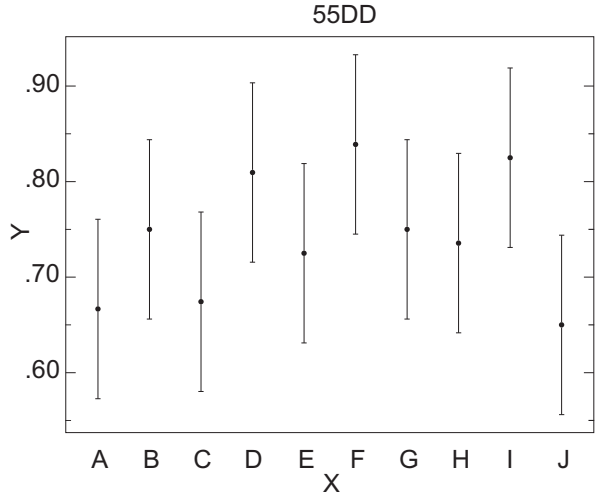

Fig. 2: Ranges of expected heterozygosities with 95 % confidence intervals: A) Anjanaharibe Sud; B) Marotandrano; C) Ambatovaky; D) Zahamena; E) Betampona; F) Anjozorobe; G) Mantadia; H) Andasibe; I) Maromizaha; J) Anosibe an'ala.

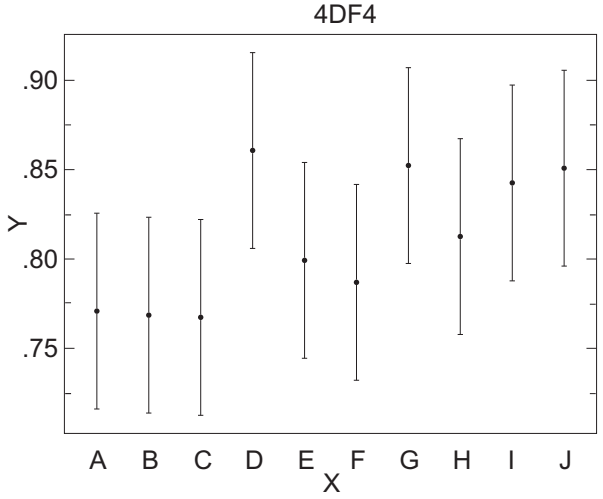

Fig. 3: Ranges of observed heterozygosities with 95 % confidence intervals: A) Anjanaharibe Sud; B) Marotandrano; C) Ambatovaky; D) Zahamena; E) Betampona; F) Anjozorobe; G) Mantadia; H) Andasibe; I) Maromizaha; J) Anosibe an'ala.

Tab. 2: Population genetic parameter estimates for 10 populations comprised of n samples each derived from 12 microsatellite loci for number of alleles (k), the mean number of alleles (MNA), allelic richness (AR), probability of satisfying Hardy-Weinberg Equilibrium (HWE), observed (HO) and expected (HE) heterozygosities, inbreeding estimate (*FIS*), the number of effective breeders (*Neb*) estimated with the linkage disequilibrium method and 95 % confidence interval, and results from the Bottleneck test under the infinite allele model (IAM) and the two phased model (TPM) with proportion of multistep mutations contributing to the $P < 0.05$ significance level.

	n	k	MNA	AR	HWE	HO	HE	*FIS*	*Neb*	95% CI	IAM	TPM
ANJ	10	80	6.67	6.41	*	0.67	0.77	0.135	23.0	16.2-37.8	NS	NS
TAND	10	73	6.08	5.87	NS	0.75	0.77	0.024	21.9	15.1-36.9	**	70
VAK	11	76	6.33	5.92	NS	0.69	0.77	0.121	20.1	14.7-30.4	NS	NS
ZAH	14	107	8.92	7.65	NS	0.81	0.86	0.060	39.6	28.8-61.3	**	10
BET	10	79	6.58	6.37	**	0.73	0.80	0.093	18.3	13.5-27.1	**	20
ANJZ	10	83	6.92	6.70	NS	0.84	0.79	-0.066	20.9	15.1-32.5	NS	NS
TAD	10	96	8.00	7.67	NS	0.75	0.85	0.120	20.1	15.3-28.3	**	70
DASI	11	81	6.75	6.40	NS	0.73	0.81	0.095	12.6	10.2-16.2	**	5
MIZA	10	89	7.42	7.17	NS	0.83	0.84	0.021	15.9	12.4-21.3	**	5
ANOSIBE	10	92	7.67	7.38	*	0.65	0.85	*0.236	28.8	19.9-49.3	**	NS

* $P < 0.05$, ** $P < 0.001$; Anjanaharibe-Sud(ANJ), Marotandrano (TAND), Ambatovaky (VAK), Zahamena (ZAH), Betampona (BET), Anjozorobe (ANJZ), Mantadia (TAD), Andasibe (DASI). Maromizaha (MIZA), Anosibe an'ala (ANOSIBE).

Discussion

Of the 10 Indri populations sampled, six (Anjanaharibe Sud, Ambatovaky, Zahamena, Betampona, Mantadia, and Anosibe an'ala) deviated from HWE with an excess of homozygotes. Considering inbreeding as potential cause, five of the populations (Anjanaharibe Sud, Ambatovaky, Betampona, Mantadia, and Andasibe) had relatively high *FIS* and one (Anosibe an'ala) had

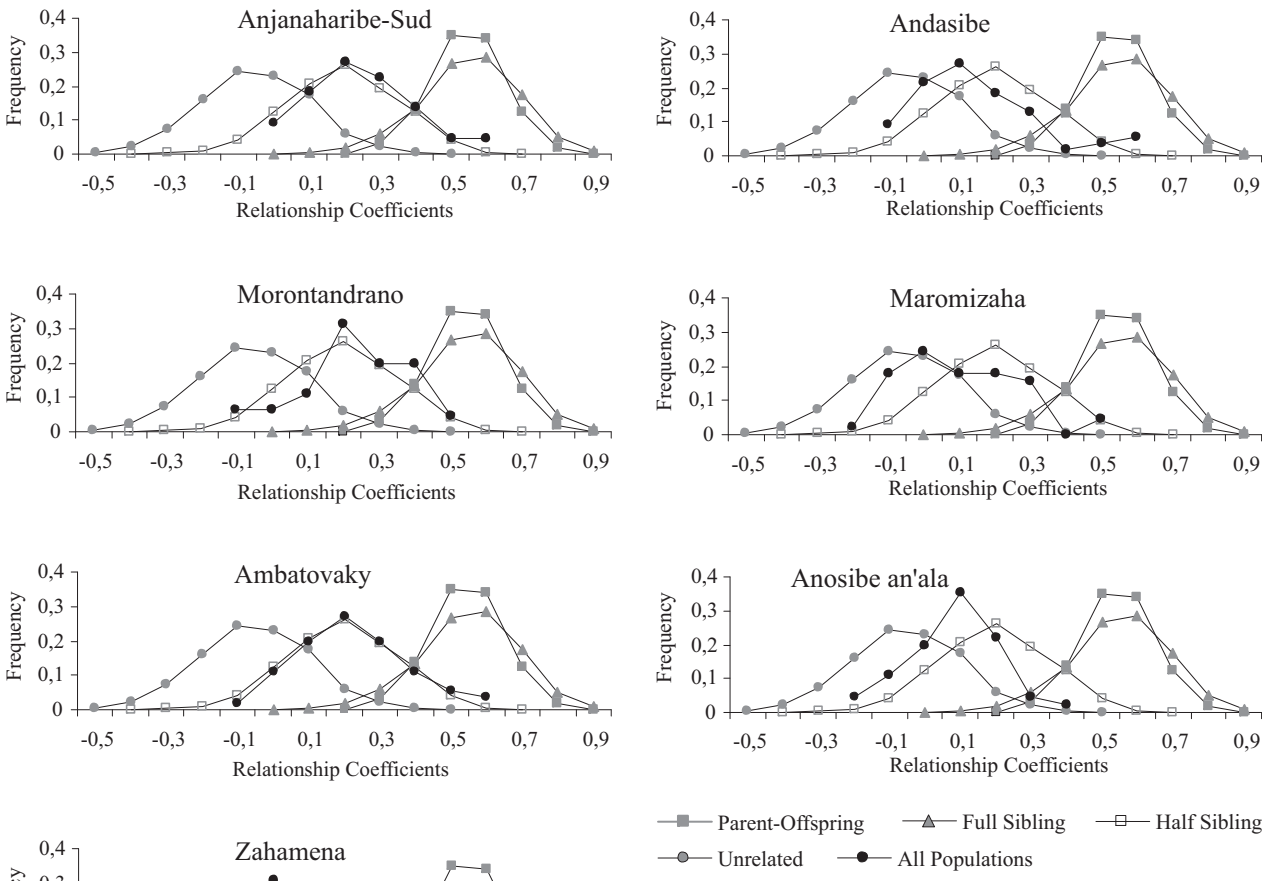

Fig. 4: Distributions of relationship coefficients estimated in each population overlaid on a simulation of 10,000 known genotypes and pedigreed relationships (Queller and Goodnight, 1989).

a significantly high *FIS* estimate. Considering relationship among the samples as one manner of capturing inbreeding, all populations show some degree of relationship above what would be expected if the sampled individuals were unrelated. This is not surprising since samples were collected as found and this could include individuals that are members of a family group which is supported by the relationship coefficient distributions in Fig. 2.

All populations demonstrated some degree of recent reduction in the effective population sizes. The bottlenecks did not appear to have been a single global event as different populations showed differing degrees to which the bottlenecks were detected. Using Lawler's (2008) 4**Neb**generations, the bottlenecks detected would have had an expected window of occurrence of up to 250 to 800 years ago, within the timeframe of human encroachment. Hence, we postulate that among other things, anthropogenic disturbances, whether habitat destruction or subsistence hunting, may have influenced the demographic reduction that we detected in the bottleneck test. These baseline values could be useful in long-term or future studies to determine genetic health trends over time under various forest or habitat conditions.

Genetic diversity is considered to be the most important factor in determining the genetic health of a species or population. Among the lemurs, there is little information in the literature that addresses the genetic diversity estimations for multiple populations of a given species. Ranaivoarisoa *et al.* (2010) found the observed heterozygosity in three of four *Eulemur collaris* populations to be higher than the expected heterozygosity. In *E. coronatus*, Ramanamahefa *et al.* (2010a)

found the expected heterozygosity to be higher in five out of six populations, one comparison was significantly higher ($P < 0.01$). In *E. sanfordi*, Ramanamahefa *et al.* (2010b) found that in all populations sampled, the observed heterozygosities were higher than the expected heterozygosities. Lastly, Quéméré *et al.* (2009), found that their study estimated the expected heterozygosity level for several populations of *P. tattersalli* to be higher than the estimate found by Razafindrakoto *et al.* (2008) using a different marker suite in different populations. Other studies (included in Tab. 2) have estimated heterozygosity levels for one or two populations of various lemur species in recent years. While these estimates provide some general sense of genetic diversity, they are not standardized (e.g. not the same markers were used in each study) so the estimates are contingent on the polymorphic information content and amplification quality in each independent study. What we do see is a relative trend that the observed heterozygosities are in general lower, but usually not significantly, than the expected heterozygosities under the assumptions of HWE.

In this study on *I. indri*, we found the differences among the *HO* estimates to differ but not significantly and the differences among the *HE* estimates to differ with low significance ($P < 0.05$). The average estimates for heterozygosity, thus genetic diversity, were in the upper range of those found in limited population studies on other lemur species. These estimate trends provide the basis for future and integrative studies where multiple species might be considered in sympatric zones to investigate the overall genetic health of the biodiversity and to better understand the effects that humans may be having on the evolutionary potential of lemurs.

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Verreaux's sifaka fur condition in the spiny forest of southern Androy

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Résumé

Les conditions du pelage des animaux peuvent représenter un moyen fiable et un indicateur non invasif pour comprendre l'état de santé d'une population et distinguer des segments différents de la même population. En 2008 nous avons effectué un recensement de sifaka (*Propithecus verreauxi*) dans les forêts riveraines de la réserve de Berenty (foret galerie et de transition de Malaza et forêt secondaire aux

espèces allochtones de Ankoba) et dans six portions de forêt épineuse qui sont inclues dans le domaine privé de Berenty. Nous avons relevé l'état du pelage des animaux selon trois conditions: fourrure intègre (niveau 1), fourrure faiblement endommagée (ponctuée par des petites zones, sans pelage, couvrant moins de 30 % du corps; niveau 2), fourrure fortement endommagée (pelage manquant sur une surface supérieure à 30 %; niveau 3). Nous avons aperçu seulement quatre sifaka au niveau de pelage 3 et, par conséquence, nous avons pu évaluer statistiquement les différences seulement entre les niveaux de pelage 1 et 2, en comparant forêt épineuse et les forêts riveraines, soi au niveau des groups d'animaux (n= 41) soi au niveau des zones recensée (n= 9). Même si avons détecté un nombre significativement plus haut de sifaka avec la fourrure faiblement endommagée dans le domaine épineuse, la nature et surtout l'entité du dommage indiquent que les conditions du pelage n'arrivent pas vraiment à différentier des segments distincts dans la population de sifaka de Berenty.

Introduction

An index of coat condition can be a non-invasive tool for tracking health and stress at the population level (Jolly, 2009a). In fact, pelage growth can be directly influenced by the proximate stimulus of light (acting through neuro-endocrine pathways), by the nutritional status, and indirectly by temperature and behavior (Ling, 1970). Two main functions of fur are a) insulation, which allows conservation of body heat, thus reducing energy expenditure and food requirements; and b) shielding, which protects day-active mammals from excessive heat load from solar radiation (Scott *et al*., 2001; Kenagy and Pearson, 2000).

Here, we considered coat condition of *Propithecus verreauxi* (Verreaux's sifaka) as a possible indicator of the "health status" of animals in different habitats and investigated whether it could provide information on possible population stress in the poorly investigated spiny forest of south Madagascar.

The dry spiny forest of southern Madagascar is a thorny environment, both metaphorically and literally speaking. Listed as one of the 200 most important ecological regions in the world, it harbors the highest level of plant endemism in Madagascar (Elmqvist *et al*., 2007). In spite of its importance, the spiny forest is underrepresented in terms of protection and conservation programs (Fenn, 2003; Ganzhorn *et al*., 2003; Seddon *et al*., 2000). To fill, at least in part, this gap, we investigated sifaka fur condition in different spiny forest parcels inside the Berenty Estate (Androy region, south Madagascar) and compared it with sifaka inhabiting the riverine forest areas inside the Berenty Reserve, a habitat much richer in staple food for lemurs.

Methods

Study site, survey technique, and fur condition evaluation

In March-April 2008, a comprehensive sifaka survey was conducted in the Berenty Estate, covering 134 ha of spiny forest and 60 ha of non-spiny forest areas. The Berenty Estate is located in the semi-arid Androy Region (rainfall averages less than 500 mm per year). The spiny forest is usually 3 to 6 m in height with dwarf and xerophyte plants, and emerging trees of the Family Didieraceae that may reach more than 10 m in height, such as the keystone species *Allouadia procera* (Elmqvist *et al*., 2007). We performed the survey in all accessible spiny forest parcels (sacred areas, used as a cemetery, cannot be accessed by anyone except for local family clans) and in three riverine areas of the Berenty Reserve (on the Mandrare river), comprising a northern section (occupied by the 40 ha secondary forest of Ankoba dominated by the exotic legume species *Pithecellobium dulce*; S 24.99°; E 46.29°) and a southern section (Malaza: S 25.01°; E 46,31°) (Fig. 1 shows study locations). Inside Malaza we considered the 7 ha gallery forest (dominated by tamarinds; *Tamarindus indica*) and the front-transitional forest (13 ha) (Jolly *et al*., 2006). In all the areas considered in this study, logging and hunting are prohibited, and the fossa (*Cryptoprocta ferox*) is absent.

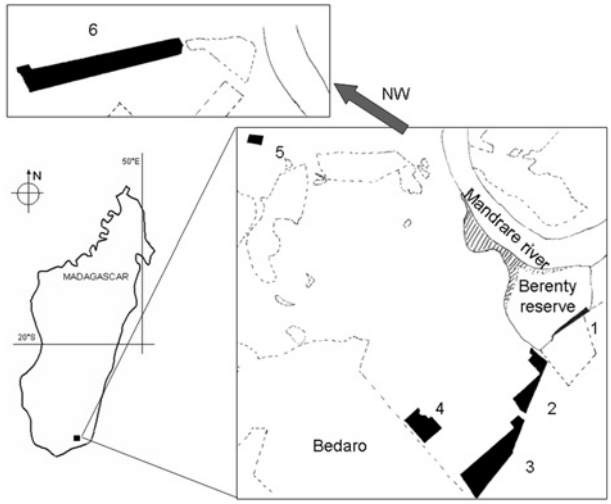

Fig. 1: Study site location: Berenty reserve (solid outline; white area: scrub; diagonal lines: Ankoba and Malaza riverine forests) and spiny forest fragments (black areas): 1 = Spiny Malaza; 2 = Spiny Reserve 1; 3 = Spiny Reserve 2; 4 = West Rapily; 5 = Fragment X; 6 = Anjapolo, about 13 km north-west of Berenty. Dashed outlines include degraded spiny and/or scrub areas. The rest of the territory (white) is covered by pasture and sisal fields. (Map based on Google Earth satellite view).

We performed the survey via walking, at a speed of about 1 km/h, along preexisting trails and through forest paths chosen *ad hoc* to have visibility of at least 50 m to the right and left (to avoid pseudoreplication we followed Norscia and Palagi, 2008).

During the census we evaluated the fur condition of each individual lemur. We scored coat condition on a 3-point scale: coat undamaged, with fur fully covering the body (level 1); ruffled coat, with fur punctuated by small areas of reduced/missing fur (on less than 30 % of the body, especially on elbows and/or knees; level 2); patchy coat, usually with black skin areas clearly visible due to reduced/missing fur (on more than 30 % of the body, especially on elbows/knees, external sides of forearms and thighs, fingers and toes; level 3) (Fig. 3).

Statistics

We performed the analyses at group or at forest site level. Owing to the small sample size (n<10 for forest sites) or deviation from normality (when n$10, in the analyses per group; Kolmogorov-Smirnov, p<0.05), we applied non-parametric tests (Siegel and Castellan, 1988) and considered exact p-values according to Mundry and Fischer (1998).

Results

In total we counted 183 sifaka adults and 25 infants (less than 1 y old, not included in the analyses). In the riverine forest areas we counted 81 adult males and 57 adult females whereas in the spiny forest we counted 45 individuals and were able to sex 21 adult males and 19 adult females. Overall, we observed level 3 fur condition only in four subjects (two

in the spiny and two in the non-spiny forest areas). Thus, we considered only level 1 (undamaged coat) and 2 (moderately missing fur) for the analyses and found that the proportion of individuals with level-1 fur was significantly higher in the non-spiny than in the spiny areas both in the analysis per forest site (Exact Mann-Whitney U test, $n_{non\text{-}spiny}=3$, $n_{spiny}=6$, $Z=-2.35$, $p=0.024$) (Fig. 2) and in the analysis per group (Mann-Whitney U test, $n_{non\text{-}spiny}=31$, $n_{spiny}=11$, $Z=-3.26$, $p=0.001$).

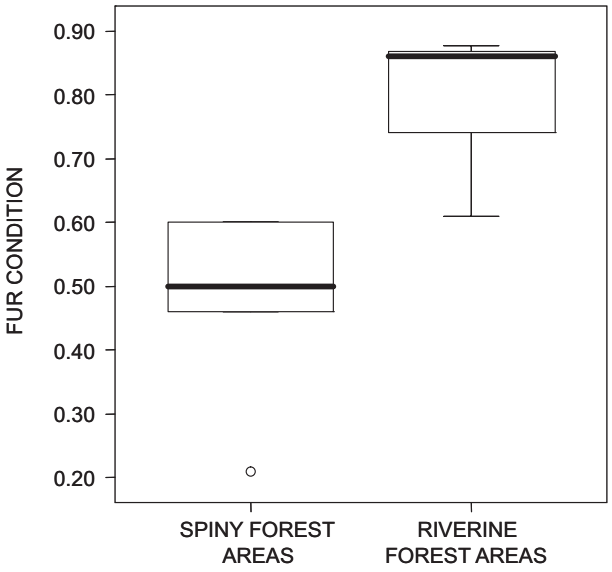

Fig. 2: Difference in fur condition (proportion of individuals showing level-1 fur) between the spiny and riverine forest areas. The difference is significant ($p<0.05$). Black lines: median; box: 25-75%; whiskers: non-outlier range.

Discussion

Monitoring coat condition in an apparently healthy population can yield a baseline of data for climate changes (being influenced by climatic factors such as temperature and amount of solar radiation) and eventual pathology, and reveal differences between population segments, and in forest fragments can track progressive degradation or improvement over time (Jolly, 2009a).

For the sifaka, we found that fur condition was better in the riverine forest areas than in the spiny forest domain (Fig. 2), reflecting the fact that riverine forest areas are richer than spiny forest areas in terms of staple food for lemurs. However, the comparison had to be restricted to individuals with full coat and moderately missing fur (level 1 and 2, respectively) because only four sifaka showed fur in truly bad condition (level 3; Fig. 3 shows the worst fur - and animal - condition observed in the forest).

In the *Lemur catta* of Berenty, serious fur loss was due to the alopecia syndrome, associated with the consumption of the toxic plant *Leucaena leucocephala* (Jolly, 2009b). Although consumed also by *P. verreauxi* in the past (Simmen *et al*., 2003), *L. leucocephala* was not present in the spiny forest and removed from Berenty when this study was performed (H Rambeloarivony, pers. comm.).

Lemurs in the non-spiny forest domain are characterized by a good nutritional status (due to accessibility of protein-rich food) (Jolly *et al.,* 2006), which positively reflects on pelage. The sifaka of the spiny forest, which is characterized by an entirely open canopy, are exposed to high temperatures and need to save energy, and this situation positively influences pelage growth as well. Although different in nature, these two pressures (food availability and heavy exposure to light) both

Fig. 3: Sifaka male (probably old and/or sick) in the spiny forest showing fur in very bad condition (level 3). (Photo: Ivan Norscia)

act positively on pelage, probably dampening the differences in fur conditions between spiny and non-spiny forest sifaka. Considering the type of coat "damage" in the spiny forest (ruffled fur and/or missing/reduced fur in small areas), the most likely and obvious correlate is the "unfriendly" vegetation, forming an open canopy that oblige the sifaka to travel through (and hide in) the thorny undergrowth.

Whilst sifaka density plummets when moving away from the riverine to the spiny forest areas, following the sharp gradient generated by water availability decrease (Norscia and Palagi, 2010), it seems that fur condition can only slightly differentiate sifaka segments of population inhabiting riverine forests and adjacent or close spiny forest areas.

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Rediscovery of Sibree's dwarf lemur in the fragmented forests of Tsinjoarivo, central-eastern Madagascar

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The recent genetic confirmation of a rare dwarf lemur species, *C. sibreei*, at Tsinjoarivo is bitter-sweet. The excitement of reporting the first known living population of this species is tainted by conservation concerns, as the forest fragment in which Sibree's dwarf lemurs were captured is highly disturbed and targeted for illicit logging. This species, like many others inhabiting rapidly degrading forests, faces the serious threat of extinction.

Taxonomic background of the genus, first field discovery, and subsequent recognition of *C. sibreei*

During the 19th century, the small nocturnal lemurs of Madagascar were clumped in a chaotic array of species and genera. For most of the 20th century, however, dwarf lemurs (*Cheirogaleus*) were classified in only two species: the eastern *C. major* and the western *C. medius* (Schwarz, 1931). Around the turn of the century, Groves (2000) conducted a taxonomic revision of the genus on the basis of morphological analysis of museum specimens and increased the species number to seven: *C. medius*, *C. adipicaudatus*, *C. major*, *C. ravus*, *C. crossleyi*, *C. minusculus* and *C. sibreei*. This last species, in fact, had been originally described by the Swiss naturalist Forsyth Major in 1896 during one of his expeditions to Madagascar (Forsyth Major, 1896). He had named it *Chirogale sibreei* in honor of fellow naturalist James Sibree, who had spent more than fifty years in Madagascar and had written extensively about its people, fauna, flora and geology. Forsyth Major published measurements of an individual "obtained from the neighbourhood of Ankeramadinika," a locality vaguely described by its discoverer as "one day's journey to the east of Antananarivo", but in fact a well-known village at the time, located in the central high plateau on the road that connected Antananarivo to Mahatsara on the east coast (Capitaine "X", 1901). In his taxonomic revision, Groves (2000) included as *Cheirogaleus sibreei* not only the holotype from Ankeramadinika (currently housed at the Natural History Museum in London) but also three additional specimens (3 skins and 1 skull), two of which came from Ampasindava, northwestern Madagascar, and one from an unclear provenance (Imerina, which refers to a region of the central highlands around Antananarivo).

The taxonomic shrinkage of *Cheirogaleus*

The increase in the number of species within the genus *Cheirogaleus* was not surprising because dwarf lemurs occupy a wide variety of habitats in Madagascar, and their close relatives, the mouse lemurs (*Microcebus*), had undergone a taxonomic explosion of their own with more than 10 species described during the past 15 years (Louis *et al*., 2008; Olivieri *et al*., 2007; Radespiel *et al*., 2008). However, Groves' 2000 revision of dwarf lemur taxonomy did not escape criticism, not least of which had to do with the criteria that he used to define species, the lack of reliable locality information from museum specimens, and the absence of on-the-ground surveys to assess geographic boundaries and variation among species (Blanco *et al*., 2009; Tattersall, 2007). A recent and more comprehensive revision of dwarf lemur taxonomy was carried out by Groeneveld and colleagues, who compiled genetic and morphometric data from field as well as museum specimens from a variety of localities across Madagascar, including some of the specimens studied by Groves (Groeneveld *et al.,* 2009; 2011). This research showed overall consistency between morphological and genetic data in recognizing only three *Cheirogaleus* species: *C. medius*, *C. major* and *C. crossleyi*. Individuals that previously had been assigned to *C. adipicaudatus* fell within the *C. medius* clade, and those named as *C. ravus* grouped with *C. major*. Results were inconclusive for *C. minusculus* and *C. sibreei* because holotype specimens were not available for sampling and their genetic affiliation could not be determined. Genetic data from one of the *C. sibreei* museum specimens from Ampasindava linked this specimen to *C. medius*. Nevertheless, the *C. sibreei* holotype from Ankeramadinika was larger and did not group morphologically with other *C. medius*. This suggested that the individuals from Ampasindava may have been misclassified by Groves as *C. sibreei* (Groeneveld *et al.,* 2010). The status of this species remained equivocal.

Second field discovery of *C. sibreei*, at last

The story of a dwarf lemur named "May" told by Mitchell Irwin (2002) turned out to be rather prophetic. Irwin's research team rescued this dwarf lemur badly burned in a

human-induced fire nearby Andasivodihazo, one of the forest fragments at Tsinjoarivo (Fig. 1). At the time, "May" was believed to be, as were all eastern rainforest dwarf lemurs, *C. major*. Unfortunately, this female could not fully recover and died soon after the salvage, but her skeletal remains were carefully preserved and stored at the University of Antananarivo by Irwin's team. Seven years later this specimen came to play a key role in our morphological analysis of dwarf lemurs at Tsinjoarivo.

Fig. 1: Map showing Tsinjoarivo and other localities associated with Sibree's dwarf lemurs; see text for details.

In 2006, with the logistic help of Mitchell Irwin and Jean-Luc Raharison, I began a survey of nocturnal lemurs at Tsinjoarivo. My assistants and I successfully trapped dwarf lemurs at two study sites: in one of the forest fragments (Andasivodihazo, 19°41'15"S, 47°46'25"E, 1660 m) and within continuous forest (Vatateza, 19°43'15"S, 47°51'25"E, 1396 m) (Blanco *et al.,* 2009). Even to an inexperienced eye, fragment dwarf lemurs looked different from continuous forest individuals, in that they were overall smaller, with grayer fur, marked eye rings and significantly larger female genitalia (Fig. 2). Our morphological and dental analyses determined that of all the species described by Groves, *C. sibreei* was the most similar to forest fragment dwarf lemurs (Blanco *et al.,* 2009). (Hopefully, sampling of *C. sibreei*'s holotype will be allowed in the near future to definitely determine whether or not there is a genetic match between this specimen and fragment dwarf lemurs from Tsinjoarivo.) Recent genetic analyses have confirmed not only that dwarf lemurs from Andasivodihazo constitute a different clade (and therefore an independent phylogenetic lineage), but also that the fragment dwarf lemur species had branched off first and was ancestral to the other dwarf lemur species (Groeneveld *et al*., 2010). To date, no other living population of *C. sibreei* has been reported in the wild and more intensive surveys around the Tsinjoarivo area (including possibly remaining forests nearby Ankeramadinika, ~100 km from Tsinjoarivo) are warranted to assess geographic boundaries and population density.

Fig. 2: Sibree's dwarf lemur captured at Andasivodihazo, one of the forest fragments at Tsinjoarivo.

Conservation concerns

The genetic confirmation of three clades corresponding to *C. medius*, *C. major* and *C. crossleyi*, each of which has broad geographic distributions, implied that dwarf lemurs might be less threatened than previously thought (Groeneveld *et al*., 2009). However, the situation for *C. sibreei* is radically different. Tsinjoarivo's unique geographic setting, continuous with the central plateau on the west and the steep escarpment of rainforest in the east, may harbor a unique array of animal communities. To date, *C. sibreei* has been captured in sympatry with *C. crossleyi* at one forest fragment, Andasivodihazo, and at one intermediate location, Ankadivory. Both of these areas are subjected to illicit logging and heavy deforestation (Fig. 3). Furthermore, these forest sites are located towards Tsinjoarivo's western boundary which reaches some of the highest altitudes (up to ~1650 m) known in eastern

Fig. 3: Example of logging near Ankadivory, one of the forest sites where Sibree's dwarf lemurs were captured.

rainforests in Madagascar. So far, only *C. crossleyi* has been captured at Vatateza, a lower altitude site located within continuous and less disturbed forest. Virtually everything has to be learned about the "ancestral" *C. sibreei*, including how to prevent its extinction through habitat loss. Concerted efforts by organizations such as Sadabe (**www.sadabe.org**) are instrumental in raising awareness of endangered species and promoting research and educational programs in the Tsinjoarivo area.

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Funding and Training

AEECL Small Grants

Since 2009, AEECL awards two small grants of up to € 1,000 each year to graduate students, qualified conservationists and/or researchers to study lemurs in their natural habitat. Priority is given to proposals covering conservation-relevant research on those species red-listed as Vulnerable, Endangered, Critically Endangered or Data Deficient by the IUCN.

We support original research that helps with establishing conservation action plans for the studied species. Grants are normally given to recent graduates from Malagasy universities to help building local capacity.

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

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

The Mohamed bin Zayed Species Conservation Fund

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

Provide targeted grants to individual species conservation initiatives;

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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 new source for species conservation initiatives and research can be found at
www.mbzspeciesconservation.org

CI Primate Action Fund

The principal objective of Conservation International's Primate Action Fund is to contribute to global biodiversity conservation by providing strategically targeted, catalytic support for the conservation of endangered nonhuman primates and their natural habitats.
Projects submitted to the foundation should have one or more of the following characteristics:

- A focus on critically endangered and endangered nonhuman primates (and most especially those included in the biennial listing of the World's 25 Most Endangered Primates) living in their natural habitats;
- Location in areas of high overall biodiversity and under great threat (e.g., "threatened hotspots", "megadiversity" countries) - to ensure maximum multiplier effect for each project;
- Direction and management by nationals from the tropical countries, to help increase local capacity for implementing biodiversity conservation;
- The ability to strengthen international networks of field-based primate specialists and enhance their capacity to be successful conservationists; and
- Projects that result in publication of information on endangered primate species in a format that is useful both to experts and the general public.

CONSERVATION INTERNATIONAL

Applications for support are considered throughout the year with no deadlines for submittal. Proposals should be sent by electronic mail to:
Anthony B. Rylands, Primate Action Fund, Conservation International, 2011 Crystal Drive, Suite 500, Arlington, VA 22202, USA, **a.rylands@conservation.org**

Recent Publications

Lemurs of Madagascar, 3rd edition, by Russell A. Mittermeier, Edward E. Louis Jr., Matthew Richardson, Christoph Schwitzer, Olivier Langrand, Anthony B. Rylands, Frank Hawkins, Serge Rajaobelina, Jonah Ratsimbazafy, Rodin Rasoloarison, Christian Roos, Peter M. Kappeler and James Mackinnon. Illustrated by Stephen D. Nash. Conservation International, Tropical Field Guide Series, Arlington, VA, 2010. 762 pp. ISBN: 978-1-934151-23-5. US$55.00.

In 2006, Madagascar was making significant progress towards conservation by expanding the protection of its natural treasures. At the same time, the second edition of Conservation International's Tropical Field Guide Series, *Lemurs of Madagascar*, had just come off the press, a full twelve years after its much-celebrated predecessor. A lot has changed in four years. Political and economic instability has imperiled both the Malagasy people and their unique wildlife. Conservation has taken drastic steps backwards as the desperation of the masses and greed of a few elites and international profiteers has exacerbated the conflict between the domains of humans and wildlife. CI has answered the call to action by releasing a new third edition of its lemur field guide, dwarfing previous editions in both size and its depth of research and detail. With nearly 1,100 references to support it–up from approximately 500 references in the second edition–the third edition stands as more than just a complete compendium of our knowledge about lemurs, but the perfect guide for appreciating the history, diversity, uniqueness, and pure beauty of our strepsirrhine cousins.
According to CI's Jill Lucena, from early 2009, the 13 authors and dozens of contributors have worked tirelessly on the third edition, dedicating thousands of hours towards its production. Authors Matthew Richardson and Anthony B. Rylands, as well as illustrator Stephen D. Nash and graphic designer Paula K. Rylands, labored exclusively on the project for nine months. The end result is a field guide that will leave other academic fields envious! This new volume is 247 pages longer than the previous edition, with 767 pages of carefully organized maps, photos, and colorful illustrations, in addition to all the details lemur enthusiasts and researchers have come to expect from this book. The content is so rich that the book's dimensions have increased from 7.5" x 4.5" x 1" to slightly more than 9.25" x 6.25" x 1.25" just to accommodate everything. And herein lies what may be the only problem with this new edition. Reviews of the previous two editions had lavished praise for not only the content and scope, but also the portability of the books. Although it will fit comfortably in a backpack, it will add more weight and consume more space than its predecessors. But given the content, that may be a small price to pay.

The layout of the book has not changed much since the last edition. An enthralling chapter on Madagascar's ancient geological history has been added, providing tantalizing details about the mysteries of Madagascar's ancient past, while a few familiar chapters and appendices have been reordered. Each lemur family has now been assigned its own chapter. The section entitled "How to Use This Field Guide" still walks new readers through the layout of the book. The "Quick Visual Reference" and colored tabs facilitate speedy navigation and help to satiate an ecotourists' spontaneous hunger for specific information. The "Lemur Life-list" returns in a more readable table format to help ecotourists record their first sightings of the numerous lemur species. Even the maps of the island have been revamped and are easier to read in this larger format.
Introductory chapters discuss ancient geology, lemur origins, the extinct subfossil (giant) lemurs, the history of lemur re-

search, and lemur conservation. Each chapter contains significant updates from the second edition. The ancient geology of Madagascar is covered in meticulous detail, while the theories of lemur origins are explored in depth, leaving both reader and researcher alike desperate for more definitive answers. The chapter on the extinct subfossil lemurs is beautifully illustrated with new peer-reviewed artwork from award-winning illustrator Stephen D. Nash, and has new details about their biology and extinction. The history of lemur research and discovery expands greatly upon the work from the last half century–a topic greatly underrepresented in the previous edition. Additionally, the chapter is loaded with newly added artwork from the 1700s and 1800s. The lemur conservation chapter provides a critical update on the newest emerging threats faced by lemurs and their habitat, namely the logging of precious hardwoods and bushmeat hunting. Additional detail is also provided about other important threats that received little mention previously, such as invasive species, cattle-raising, and mining.

The bulk of the book details the description, geographic range, natural history, conservation status, and best locations to observe each of the 101 species and subspecies of lemur. (This total is up from the 71 taxa detailed in the second edition, yet the authors note that upcoming research may reveal as many as 110 to 125 lemur taxa!) Each species section sports a portrait photo, detailed range map, and other photos to enrich the lavish textual content. Once again, the third edition sets itself apart from the previous editions with its encyclopedic coverage of details from the lemur research literature. Species, such as the silky sifaka (*Propithecus candidus*), are discussed in significantly greater detail, bringing everyone from bright-eyed ecotourists to veteran lemur researcher up to speed on the latest findings.

The second edition of *Lemurs of Madagascar* sold out quickly, leaving shelves empty as early as February 2008. The third edition is poised to do the same. With a print run of 10,000 copies, nearly two-thirds are already spoken for according to Jill Lucena. To help promote conservation education in Madagascar, CI is generously donating 3,000 copies to its partner in the field, NGO Fanamby. CI hopes that the remaining copies will spark the public's interest in Madagascar's ecological gems and spur a new wave of ecotourism to bolster conservation efforts.

Once again, CI has provided an invaluable tool for a diverse audience, which includes ecotourists, Malagasy tour guides, students, lemur researchers, and lemur enthusiasts. Although larger and not quite as portable as its predecessors, the increased size of the third edition hosts a wealth of enhanced encyclopedic detail, new and stunning artwork by Stephen D. Nash, and additional color photos and illustrations. With a copy of this printing in hand, the only things missing are a backpack full of supplies and an airline ticket to Madagascar. So what are you waiting for?

Alex Dunkel

Theses Completed

Blanco, M.B. 2010. Reproductive biology of mouse and dwarf lemurs of eastern Madagascar, with an emphasis on brown mouse lemurs (*Microcebus rufus*) at Ranomafana National Park, a southeastern rainforest. PhD Dissertation. University of Massachusetts, Amherst.

This dissertation investigates reproductive schedules of brown mouse lemurs at Ranomafana, using intensive trapping techniques. The reproductive condition of female mouse lemurs was recorded on the basis of vaginal morphology, vaginal smears, body mass gain profiles and nipple development. Testis size was measured in males throughout the reproductive season. The timing of the first seasonal estrus was determined in frequently captured females over multiple years and it showed individual periodicities close to 365 days, consistent with endogenous regulation and entrainment by photoperiod. The timing of estrus did not correlate with female age or body mass. Males showed testicular regression during the rainy season, although there was high inter-individual variation in testes size at any given point during the reproductive season. Furthermore, some individuals completed testicular regression earlier than others. Implications for polyestry are discussed.

For comparative purposes, mouse lemurs were also trapped at two study sites in the Tsinjoarivo area: one in a forest fragment and the other within continuous forest. These forests are higher in altitude than the main study area at Ranomafana. Trapping success for mouse lemurs was lower at Tsinjoarivo than Ranomafana. Albeit preliminary, data from Tsinjoarivo suggest that females have lower reproductive success than do females at Ranomafana. Nevertheless, mouse lemurs in the Tsinjoarivo forest fragment did not appear to be in "poorer" condition than those in the continuous forest. It had been reported in the literature that western gray mouse lemurs captured in secondary forests have lower body masses and lower recapture rates than those captured in primary forest; in fact, the opposite was true of the mouse lemurs at Tsinjoarivo.

I additionally collected data on a larger member of the family Cheirogaleidae, the dwarf lemurs (*Cheirogaleus*), which live in sympatry with *Microcebus* at Ranomafana and Tsinjoarivo. I analyzed the patterns of growth, development and reproduction in *Cheirogaleus* and *Microcebus* and compared dwarf and mouse lemurs to other similarly-sized prosimians which do not undergo torpor or hibernation. These comparisons draw attention to the unusual reproductive and metabolic strategies employed by cheirogaleids to cope with Madagascar's unpredictable environments, which ultimately define their very unique life histories.

Key words: *Cheirogal*eus, Madagascar, *Microcebus*, Mouse lemurs, Rainforest, Ranomafana, Reproduction, Tsinjoarivo.

Bonaventure, R.T.A.R. 2010. Ecologie et comportement de *Propithecus verreauxi* dans les zones d'extension de la Réserve Spéciale de Bezà Mahafaly. Engineer in agronomy, option Eaux et forêts. Eaux et forêts, Ecole Supérieure des Sciences Agronomiques de l'Université d'Antananarivo (ESSA), Madagascar.

The population of *Propithecus verreauxi* in the special reserve of Bezà Mahafaly is one of the conservation targets of the site which is the subject of a long-term follow. Natural destruction of their habitat and the pressure of hunting which is exerted on this species outside of the current reserve are the origin of the sifakas' decline. With the park extension project under way, furthering the knowledge on behavior and ecology of *Propithecus verreauxi* in disturbed areas outside the current reserve is essential for decision-making regarding conservation measures for this species. Thus, a study of behavior and ecology of the sifakas was carried out in the extension area of the special reserve of Bezà Mahafaly in gallery and transition forest at the end of the dry period. The study was centered on 3 focal groups including one in the gallery forest and two in the transition forest. The method of focal animal sampling was chosen to study their behavior. A floristic inventory according to the Gentry method, which includes transects of 2 x 50 m, was carried out to study the habitat. On the whole, 120h of observations of sifaka behavior were carried out and 12 transects were walked. In disturbed areas, the sifakas still consumed preferred plants. This resulted in a high intake of 2 or 3 easily digestible plant species while at the same time a large variety of other species was consumed. Thus, the disturbance of the sites did not influence food intake of the sifakas. Moreover,

it was the group of sifakas in the gallery forest which was the most affected by resource scarcity in the dry period, necessitating a priorisation of the sifaka groups in this forest formation in the extension of the reserve. In addition, the availability of nutritional resources influenced spacial dispersion of group members as well as group size. With the current park extension project different access restrictions will be implemented, having as an objective the conservation of the sifaka groups as well as other conservation targets outside of the current reserve, while introducing a range of alternative income-generating activities and sustainable resource management practices for the local communities.
Key words: Lemur, *Propithecus verreauxi,* Ecology, Behavior, Conservation, Special reserve, BezB Mahafaly, Madagascar.

Delmore, K. 2009. Maintenance of stability in the Andringitra brown lemur hybrid zone. M.A. thesis, University of Calgary, Calgary, Alberta, Canada.
Two models of hybrid zone stability have been proposed: 1) the tension zone model, which predicts that intrinsic selection acts against hybrids but is counteracted by dispersal of parentals into the zone and 2) the bounded superiority model, which predicts that exogenous selection favours hybrids within transitional habitats and parentals outside the zone. I used morphological, genetic and ecological data to evaluate these models in a stable hybrid zone between Eulemur rufifrons and E. cinereiceps in southeastern Madagascar. This zone appears to conform to the bounded superiority model: it was relatively wide and composed mostly of hybrids that were equally as fit as parentals. Gene flow between parental and hybrid populations was also limited, clines in multiple characters were non-coincident and significant ecological correlates were identified. Results suggest that hybridization can serve as an important evolutionary force and need not always be considered a conservation risk for endangered taxa.

Hobinjatovo, T. 2009. Etude morphométrique et génétique de conservation d'*Eulemur cinereiceps* (Milne-Edwards et Grandidier, 1890) dans les forêts de Mahabo, de Manombo et de Vevembe, Madagascar. Mémoire de DEA en Biologie, Ecologie et Conservation Animale, Département de Biologie Animale, Faculté des Sciences, Université d'Antananarivo.
Cette étude a pour but, d'une part, de connaître et de comparer la morphométrie d'*Eulemur cinereiceps* de la forêt de Mahabo, de Manombo et de Vevembe - Madagascar, ainsi donc de voir le degré du dimorphisme sexuel et d'autre part, d'établir des données de bases génétiques pour avoir de plus amples informations en vue de la conservation de cette espèce en danger critique. La descente sur le terrain et la collecte des données ont été effectuées pendant deux semaines du mois de mai 2006 et le travail au laboratoire pour l'étude génétique a été fait du mois de Février au mois de Mai 2007. Ce lémurien pése en moyenne 2,04 kg avec une longueur moyenne de la couronne de la tête de 10,84 cm, celle du corps de 33,31 cm et est doté d'une queue de 50,44 cm. La comparaison de la morphométrie des individus des sites d'étude, par le test U de Mann-Whitney montre que le Lémurien à Collier Blanc de Vevembe est de plus grande taille que ceux des 2 autres sites. La différence de taille entre le mâle et la femelle n'est pas significative. Chez cette espèce, le dimorphisme sexuel est très marqué concernant la couleur du pelage et la dimension de la canine supérieure, considérable chez le mâle. Le testicule droit du mâle est plus long, large et volumineux que le gauche. 14 marqueurs génétiques polymorphiques ont été sélectionnés pour effectuer le génotypage par l'utilisation de la technologie moléculaire et à l'aide de la réaction en chaîne polymérasique. Les programmes de Cervus, GenePop, Fstat, Structure et Bottleneck ont été utilisés pour déterminer la structure et la nature génétique de la population d'*Eulemur cinereiceps*. Ces analyses ont permis de déterminer que la valeur de la diversité des gènes des populations est pareille et modérée, oscillant autour de 57 % ; la divergence génétique est comprise entre 0,05 à 0,15 et est qualifiée de modérée; la richesse allélique varie de 2,928 à 3,632; une migration entre la population de Mahabo et de Vevembe, d'une part et celle de Manombo et de Vevembe d'autre part, a été identifiée; un certain degré de consanguinité a été constaté à Mahabo. La population de Manombo subit un goulot démographique et aucune structure distincte ni sous - structure n'a été observée au sein des populations de ces 3 sites. Même si cette espèce est en danger critique, sa santé génétique est modérée. Elle pourrait être bonne si les solutions adéquates sur la conservation génétique étaient appliquées. Dans le cas contraire, elle deviendrait désastreuse. La prise immédiate de mesures de conservation efficientes est donc nécessaire afin de préserver les populations pures d'*E. cinereiceps* et de protéger ses habitats.
Mots-clés: *Eulemur cinericeps,* Mahabo, Manombo, Vevembe, Madagascar, Morphométrie, Mensuration, Génétique, Population, Conservation.

Ingraldi, C. 2010. Forest fragmentation and edge effects on eight sympatric lemur species in southeast Madagascar. M.A. thesis, University of Calgary, Calgary, Alberta, Canada.
Extensive slash-and-burn agriculture in southeastern Madagascar has led to the fragmentation of forests in this region, creating a constricted available habitat area and increasing the proportion of forest edge. I investigated the response to forest fragmentation and edge effects in eight lemur species through comparisons of species density and diversity between fragments, as well as correlation analyses including population distribution patterns, ecological variables, and distance from forest edge. I also include a more detailed focus on the behavioural response of *Eulemur cinereiceps*. Results were highly varied, with no species showing strong aversion to forest edge but with higher overall densities in larger, more connected fragments. *Eulemur cinereiceps* spent significantly more time near the forest edge while resting, but edge did not affect feeding patterns or food availability. These results suggest that conservation management should focus on maintaining large, complex fragments and improving connectivity through forest corridors.

Mihaminekena, T.H. 2010. Etude de la relation entre la dégradation de l'habitat et les activités de *Propithecus edwardsi* du Parc National de Ranomafana Ifanadiana, Madagascar. Mémoire de DEA en Paléontologie et évolution biologique, Biologie Evolutive, Primatologie, Département de Paléontologie et d'Anthropologie biologique, Faculté des Sciences, Université d'Antananarivo.
Une étude sur le comportement et l'habitat de *Propithecus edwardsi* a été réalisée dans le Parc National de Ranomafana. Elle a été réalisée dans trois sites ayant chacun un degré de perturbation inégal: Talatakely (fortement perturbé); Sakaroa (moyennement perturbé) et Valohoaka (non perturbé). Sa finalité est d'analyser le type de comportement biologique adopté par l'espèce en réponse à la dégradation de son habitat et de le comparer entre les trois sites. La méthode adoptée est celle décrite par Altmann en 1974 qui consiste à déterminer l'activité du focal animal toutes les dix minutes et celle de tous les groupes toutes les cinq minutes. Pour toutes les activités, sauf le déplacement, la différence est toujours significative pour les trois sites. Le repos est plus élevé dans le site intact (36.6%) par rapport à l'alimentation. Inversement le repos est moins fréquent (28.9 %) que l'alimentation (53.6 %) dans le site fortement perturbé. La fréquence des activités de l'espèce dans le site moyennement perturbé est toujours comprise entre les deux sites perturbés et non perturbés. Pour ses activités, l'espèce utilise certains niveaux de strates, spécialement ceux compris entre 10 et 15 et 15 et 20 m. Néanmoins, l'espèce habitant le site intact se place à un niveau plus haut que celle de la forêt perturbée. Les grands arbres sont plus abondants à Valohoaka qu'à Sakaroa et à Talatakely: respectivement la hauteur varie de 10.80, 9.53 et 9.47 m; celui du DHP est de 13.59 cm; 12.17 et 11.09 cm. Les épaisseurs de la couronne sont respectivement 4.42, 4.28 et 3.91 m. Les parties de plantes

consommées pour chaque site sont significativement très différentes. La corrélation entre la consommation de jeunes feuilles et les activités exercées est toujours positive et significative quel que soit le site. Les femelles choisissent un niveau plus haut des arbres que les mâles à Valohoaka et à Talatakely par contre à Sakaroa c'est l'inverse. La cohésion du groupe est plus observée dans le site intact par rapport à celui dégradé. Bref, la perturbation influe les activités générales et la structure de l'habitat de *Propithecus edwardsi*.
Mots-clés: *Propithecus edwardsi*, Lémuriens, Degré de perturbation, Habitat, Activités, Parc National de Ranomafana, Madagascar.

Polowinsky, S.Y. 2009. Nutrition of captive Sclater's lemurs (*Eulemur macaco flavifrons* GRAY, 1867) and crowned lemurs (*Eulemur coronatus* GRAY, 1842), with special emphasis on the problem of obesity. PhD dissertation, Biology and Geography, University of Duisburg-Essen, Germany.
This study was concerned with the obesity problem of blue-eyed black lemurs and crowned lemurs in captivity. Its aims were to optimize the species' diet in captivity by combining data obtained from individuals kept at different European zoos as well as from wild blue-eyed black lemurs to gain a better understanding of the ecological and nutritional needs of *Eulemur macaco flavifrons* in order to prevent individuals from becoming obese and to assist planned conservation measures.
The captive part of the study was conducted in two European zoos: Cologne Zoo (Germany) and Parc Zoologique et Botanique de Mulhouse, Sud-Alsace (France). A long-term study with one group of blue-eyed black lemurs (1.3) and one group of crowned lemurs (1.2) was carried out at Cologne Zoo. In addition, three groups of blue-eyed black lemurs (2.1; 1.1; 1.1) and three groups of crowed lemurs (2.2; 2.1; 3.2) were studied at Mulhouse Zoo. The body weight development of captive individuals was registered and compared to body weight data of wild individuals. The obesity rate in captivity was recorded. An obese animal was identified as one weighing more than two standard deviations over the mean wild weight. Moreover, nutrient and energy intake of *Eulemur macaco flavifrons* and *Eulemur coronatus* at Cologne Zoo and Mulhouse Zoo were registered. In addition, digestibility trials were conducted. Samples of feeds and faeces were analyzed using Weende analysis and detergent analysis. In Madagascar, four groups of *Eulemur macaco flavifrons* in two forest fragments, one mainly primary forest and the other predominantly secondary forest, were observed. Samples of plants utilized by free-ranging blue-eyed black lemurs were collected. They were botanically classified and analyzed using Weende analysis and detergent analysis.
The mean body weights of *Eulemur macaco flavifrons* as well as *Eulemur coronatus* in captivity were significantly higher than the mean body weight of free-ranging individuals. 100 % of the *Eulemur macaco flavifrons* sample and 33.3 % of the *Eulemur coronatus* sample were obese. Significant body weight differences were found between the groups studied at Cologne Zoo and Mulhouse Zoo, which could be explained by different feeding regimes. Comparing the diet of free-ranging blue-eyed black lemurs to the zoo diets that were based mainly on fruits and vegetables at Cologne Zoo and Mulhouse Zoo, considerable differences were found with respect to NDF, ADF, ADL and crude protein content, whereas ash and crude lipid content varied only slightly. The NFC and energy content in the zoo diets were almost twice as high as those in the diet of wild blue-eyed black lemurs. The high NFC, crude protein and metabolizable energy content and low fibre content of the zoo diets as compared to the wild diet, combined with a relatively high apparent digestibility of ~80 % for *Eulemur macaco flavifrons* and ~84 % for *Eulemur coronatus*, respectively, and in combination with lemurs' typically low basal metabolic rates, all clearly contribute to the obesity problem of captive *Eulemur macaco flavifrons*.
The presented data of food consumed by *Eulemur macaco flavifrons* in captivity and in the wild reveals elementary differences concerning nutrient and energy composition. Although a bright variety of fruits and vegetables could protect animals in captivity from stereotypic behaviour, a systematic reassessment of the zoo diet is suggested: increasing fibre content and decreasing energy density by feeding vegetables, and whenever possible, fresh plant material in appropriate quantities instead of energy-rich fruits, gruel or commercial feeds. Although the utilization of the food fibre content by a generalist frugivore like *Eulemur macaco flavifrons* or *Eulemur coronatus* is limited, fibre content plays an important role in the maintenance of physiological health. A zoo diet corresponding to the natural requirements of lemurs guarantees an optimization of breeding programmes and presents a valuable and necessary contribution to the preservation of these highly endangered species.
Key words: *Eulemur macaco flavifrons*, *Eulemur coronatus*, Nutrition, Digestibility, Obesity, Captivity, Energy intake.

Rafaliarison R.R. 2010. Activité générale du *Prolemur simus*: transition saison sèche - saison de pluies et activité de la femelle avant et après mise bas dans le Parc National Ranomafana. Département de Paléontologie et d'Anthropologie Biologique, Université d'Antananarivo, Madagascar.
Cette étude a été réalisée dans la parcelle 3 du parc national Ranomafana qui abrite le seul groupe du parc. Elle nous aidera à mieux comprendre les variations de l'activité générale du *Prolemur simus* pendant la transition de la saison sèche à la saison de pluie ainsi que la variation de l'activité de la femelle avant et après mise bas. Les résultats ont montré que le *Prolemur simus* a dépensé la moitié de leur temps à l'alimentation suivi du repos. Les variations de la fréquence de l'activité sont en relation avec la partie consommée (tige, moelle ou jeunes pousses), la disponibilité alimentaire, la température et la pluie ainsi que la disponibilité en eau. La strate la plus utilisée est comprise entre 0 à 5 m. La présence d'un nouveau né a une influence sur l'activité et la proximité des individus du groupe. Pour la femelle, il y a une diminution de la fréquence de l'alimentation après la mise bas. Il y a aussi une augmentation très marquée de la fréquence du repos après la mise bas. Le juvénile s'éloigne de la femelle après mise bas tandis que le mâle reste toujours près de la femelle.
Mots clés: *Prolemur simus,* Activités, Mise bas, Parc National Ranomafana, Madagascar.
This study was carried out in Parcel 3 of Ranomafana National Park, where the only group of *Prolemur simus* within the park is present. It concerns the variation in the general activities of *P. simus* during the transition from the dry season to the rainy season as well as the activity of the female before and after giving birth. The results showed that *P. simus* spent half of their time feeding, followed by resting. The variation in frequency of activities was related to the consumed plant parts (trunk, culm pith or bamboo shoot), availability of food, temperature, rain and the availability of water. The most frequently used forest stratum was between 0 and 5 m of height. The presence of the new-born had an influence on the activity and the spacing of the individuals in the group. For the female, there was a reduction of the frequency of feeding after giving birth. There was also a very marked increase in the frequency of resting after birth. The juvenile stayed away from the female after she had given birth, but the male always remained close to the female.
Key words: *Prolemur simus*, Activity, New born, Ranomafana National Park, Madagascar.

Raharivololona, B.M. 2010. Intestinal parasite infection of the gray mouse lemur (*Microcebus murinus*, J.F. Miller, 1777) in the south-eastern littoral forest of Madagascar. PhD Dissertation, Hamburg University, Hamburg, Germany.
Madagascar's plants and animals belong to one of the most unique and threatened biotas of the world. Lemurs are the flagship species associated with the biological crisis of the island and notably vulnerable to habitat degradation. While most studies on the effect of habitat destruction on species survival have focused on population reduction and forest degradation, indirect effects, such as altered parasite loads have received little attention. Parasitologi-

cal studies have concentrated on large primates, such as apes and monkeys. This is probably due to epidemiological interest in apes, which are genetically closer to humans and are known to be a reservoir of certain pests and diseases fatal to humans. Prosimians' gastrointestinal parasites are less studied.

The goal of this project was to assess and describe the gastrointestinal parasites of the lemur species *Microcebus murinus* (Family Cheirogaleidae), also known as the gray mouse lemur, from the littoral forest fragments of Mandena in extreme southeastern Madagascar. In addition, I wanted to evaluate the utility of determining gastrointestinal parasite loads based on fecal samples. From April 2003 to October 2005, 427 fecal samples obtained from169 different individuals of *M. murinus* from five forest fragments were analyzed to assess the parasite species richness of this animal based on parasite egg morphology. Three individuals of *M. murinus* were also sacrified in order to look for adult worms for identification and confirmation of parasite species, and to localize their gastrointestinal parasites in the digestive tract. Screening all fecal samples by using the modified technique of the McMaster flotation, I noted that *M. murinus* harbored at least nine different intestinal parasites, which included 1) six Nemathelminthes: a member of the family Ascarididae, one species of the family Subuluridae represented by the genus *Subulura*, an unidentified *Strongylida*, a species of the genus *Trichuris* (Trichuridae), two species of the family Oxyuridae: the first belongs to the genus *Lemuricola* and the second is still unidentified; 2) two Plathelminthes: two cestodes of the genus *Hymenolepis* (Hymenolepididae); 3) one Protozoa: belonging to the order Coccidia.

These gastrointesinal parasites of *M. murinus* from Mandena have not been previously described from this primate. The cestode infection deserves special attention, as these parasites have not been previously reprted from lemurs. Adult worms of *Trichuris* species were found in the caecum, as well as *Lemuricola* worms in the caecum and large intestine. *Subulura* worms were more abundant in the caecum than in the small and large intestine. A large number of *Subulura* larvae were observed in the caecum. As exemplified by the data on *Subulura* sp. worms in the digestive tract of *M. murinus*, the number of nematode parasite eggs and larvae found in the feces are correlated with the intensity of infection in the digestive tract.

To assess effects of forest fragmentation and degradation, fecal samples from the first captureof 169 individuals of *Microcebus murinus* living in five littoral forest fragments were analyzed for gastrointestinal parasites. The fragments differed in size and forest quality. In good quality forest blocks, lemurs from a smaller fragment had higher prevalences and intensities of infection of gastrointestinal nematodes and protozoans than animals from a larger forest fragment. In larger forest blocks, excretion of eggs from Ascarididae and tapeworms was higher in a degraded forest fragment than in a better quality forest fragment. This situation was reversed in small forest fragments with fewer eggs of *Subulura* nematodes and protozoans shed by lemurs in the degraded fragment than by lemurs from the good quality fragment. The analyses are hampered by the fact that only one forest fragment was available per type of treatment. Keeping this limitation in mind, the results are consistent with other studies and indicate that forest degradation and fragmentation have marked effects on the level of parasitism of Madagascar's lemurs.

To assess seasonal effects on the excretion of gastrointestinal parasites I screened fecal samples from *M. murinus* caught during monthly trapping sessions for eggs and larvae of intestinal parasites. Parasite excretions changed seasonally when analyzed at the level of individual hosts. The number of parasite species and the abundance of parasite eggs and larvae in *Microcebus* feces were higher during the hot season than the cold season. Reduced parasite excretion during the cold season could be due to environmental factors or due to the ability of *M. murinus* to enter torpor and hibernation during the cold season which might lead to reduced metabolism of intestinal parasites and results in reduced shedding of parasite eggs. No such seasonal variation was found on the level of the lemur population when the analyses were based on samples of unknown origin.

The study revealed noticeable effects of forest fragmentation on parasite loads as measured via the excretion of parasites. The disadvantageous consequences of increased parasite infections on the health of these animals is due to changes in habitat conditions and is a factor that needs to receive more attention when developing conservation plans.

Key words: *Microcebus murinus*, Parasites, Habitat degradation, Fragmentation, Forest quality, *Hymenolepis*.

Randrianarimanana, H.L. 2009. Etude comparative de l'alimentation et du comportement des deux espèces sympatriques d'Indriidés : *Propitecus diadema* et *Indri indri* dans le Réserve Naturelle Intégrale n°1 de Betampona (Tamatave). Mémoire de DEA en Paléontologie et évolution biologique, Biologie Evolutive, Primatologie, Département de Paléontologie et d'Anthropologie biologique, Faculté des Sciences, Université d'Antananarivo.

Des études comportementales et nutritionnelles des deux espèces sympatriques d'Indriidés (*Propithecus diadema* et *Indri indri*) ont été réalisées pendant les mois de mars, avril, juin et juillet 2008 dans la Réserve Naturelle Intégrale numéro un de Betampona (Tamatave). Les données comportementales et nutritionnelles, la hauteur fréquentée et la nature des supports et des coordonnées géographiques ont été enregistrés toutes les 10 minutes. Des analyses statistiques ont été réalisées pour étudier comment ces deux plus grands lémuriens partagent leurs nourritures et habitats. Même si les deux espèces ont la même fréquence d'alimentation et sont toutes deux considérées folivores, *Propithecus diadema* consomme un peu plus de fruit qu'*Indri indri* (respectivement 33,6 et 9,4 %) et utilise beaucoup plus d'espèces végétales comme source de nourriture. *Propithecus diadema* fréquente des hauteurs beaucoup plus basses qu'*Indri indri* durant ses activités (8,3071et 10,208 m). De plus, cette dernière espèce utilise beaucoup de petits supports (respectivement 3,80 et 5,38 cm) et peu inclinés (40,32° et 47,79°). *Propithecus diadema* se déplace beaucoup tandis qu'*Indri indri* se repose davantage. Malgré le chevauchement de leur territoire, ces deux espèces montrent une séparation de leur niche écologique.

Mots-clés: *Propithecus diadema*, *Indri indri*, Alimentation, Comportement, Comparaison.

Razafindratsima, O.H. 2009. Rôle écologique de *Varecia rubra* et d'*Eulemur albifrons* dans le Corridor Ambatolaidama du Parc National Masoala. Mémoire de DEA en Biologie, Ecologie et Conservation Animale, Département de Biologie Animale, Faculté des Sciences, Université d'Antananarivo.

Une étude a été effectuée sur deux espèces de lémuriens sympatriques dans les forêts tropicales humides du corridor Ambatolaidama du Parc National Masoala - *Varecia rubra* (Geoffroy, 1812) et *Eulemur albifrons* (Geoffroy, 1796). Le but est d'étudier les rôles écologiques de ces espèces dans la reforestation du corridor en tant que disséminatrices de graines. Ceci afin de mettre en évidence leur importance au niveau de ce site et par conséquent, d'élaborer une stratégie de conservation. Un groupe d'*E. albifrons* et trois groupes de *V. rubra* ont été suivis. Trois femelles de *V. rubra,* choisies comme animaux focaux, ont été munies de colliers à radio émetteur. Ces espèces ont fait l'objet de suivis quotidiens, de novembre 2006 à janvier 2007, afin de collecter des informations sur leur régime alimentaire et leur défécation. Pour *E. albifrons,* aucune donnée sur son alimentation n'a été obtenue de part la difficulté de son suivi dû à l'absence de collier. Les fèces collectées sont analysées afin d'en extraire des graines qui ont été, ensuite, inventoriées, mesurées et identifiées. La viabilité de ces graines a été étudiée par un test d'immersion dans l'eau, puis par la mise en terre dans une pépinière des graines défequées comparées avec celles extraites manuellement des fruits. Afin de comprendre le devenir de ces graines après leur dépôt, une étude de l'habitat où

les fèces ont été déposées a été réalisée. Les résultats de cette étude ont démontré que *V. rubra* a une frugivore élevée (86.1 %). Aussi, ces deux espèces participent activement à la dissémination des graines de la majorité des espèces végétales du corridor, avec 16 graines par jour disséminées par *V. rubra* représentées par 34 espèces végétales appartenant à 15 familles, et 10 graines par jour pour *E. albifrons* réparties dans 8 familles avec 11 espèces. De plus, après leur passage au niveau du tube digestif de ces animaux, les graines sont viables (x = 107,283, ddl = 2, p = 0,0001) et ont une germination plus élevée que les graines témoin (x = 55,680, ddl = 1, p = 0,0001). Très peu d'entre elles ont subi des dommages (seulement de 3,8 % et 0,7 % respectivement pour les graines déféquées par *V. rubra* et *E. albifons)*. L'étude de l'habitat démontre une réussite de germination malgré une forte pente. Ces deux espèces de lémuriens sont donc d'importantes disséminatrices de graines de la forêt humide du corridor Ambatolaidama. Elles jouent un rôle important dans le maintien de l'équilibre écologique et contribuent à la reforestation du corridor.

Mots-clés: *Varecia rubra, Eulemur albifrons,* Primates, Régime alimentaire, Dispersion des graines, Parc National Masoala, Corridor, Ambatolaidama, Madagascar.

Razakanirina H. 2010. Suivi phénologique global et statut de conservation de 4 espèces végétales *(Strychnos decussata, Diospyros ferrea, Gardenia decaryi* et *Capurodendron gracilifolium)* consommées par *Propithecus verreauxi coronatus* dans la forêt de Badrala (Antrema - Région Boeny). Mémoire de DEA en Biologie et Ecologie Végétale, option Ecologie végétale, Département de Biologie et Ecologie Végétale, Faculté des Sciences, Université d'Antananarivo.

La Station Forestière à Usage Multiple d'Antrema constitue un des habitats de *Propithecus verreauxi coronatus*. Dans cette région, ces Lémuriens sont vénérés comme étant les représentants des ancêtres des "Sakalava". Cette culture leur offre donc un haut niveau de protection mais est- ce que la forêt peut leur fournir la nourriture dont ils ont besoin?

Des études sur la phénologie et une évaluation du statut de conservation des quelques espèces consommées par ce lémurien ont été réalisées dans la forêt sèche sur dune de Badrala (partie Nord de la station), afin de faire ressortir les différents types phénologiques et la saisonnalité des différentes phénophases des arbres de cette forêt. Trois (3) plots de 2000 m ont été montés dans la forêt et dans chaque plot, tous les arbres à DHP > $10 cm sont numérotés et des paniers collecteurs de litières sont installés suivant un transect de 200 m. La phénologie des arbres a été suivie pendant une année grâce à des observations directes de chaque individu et à l'analyse des litières qui sont collectées tous les 15 jours. La période de floraison maximale des espèces se produit au début de la saison humide, avant l'apparition des feuilles et la défeuillaison est assez importante au milieu de la saison sèche. *Strychnos decussata, Diospyros ferrea, Gardenia decaryi* et *Capurodendron gracilifolium* sont classées en danger d'extinction (EN). Ainsi, des mesures de conservation sont à entreprendre afin de protéger ces espèces et les habitats de ce lémurien.

Mots-clés: Suivi phénologique, Statut de conservation, Plantes consommées, *Propithecus verreauxi coronatus*, forêt sèche, Badrala, Station Forestière à Usage Multiple d'Antrema, Madagascar.

Rued, A.C. 2009. Social structure and female foraging strategies in white-collared lemurs (*Eulemur cinereiceps*). M.A. thesis, University of Calgary, Calgary, Alberta, Canada.

This thesis examines the nature of male-female affiliation in *Eulemur cinereiceps*, specifically whether it consists of special relationships or a central male social structure. A special relationship includes an unrelated male and female adult who preferentially associate and affiliate with each other over all other individuals within the group. I also examine the flexibility of female foraging strategies in response to changes in resource availability and energy requirements. I tested the resource defence hypothesis, which proposes that reproductive females form special relationships with males to improve foraging success and offset the energetic costs of reproduction. Data were collected on two small groups in Mahabo forest, on the southeastern coast of Madagascar. Analysis of social structure data suggested central male structure when resources were scarce and central female structure during the period of relative resource abundance. The resource defence hypothesis was not supported by foraging data.

Solomon, S.K. 2010. Living on the edge: a preliminary dry season study of crowned lemur (*Eulemur coronatus*, Gray 1842) and Sanford's lemur (*E. sanfordi*, Archbold 1932), responses to anthropogenic habitat changes in northern Madagascar. M.A., Anthropology (Environment & Sustainability), University of Western Ontario, London, Canada.

Habitat fragmentation through anthropogenic disturbance is a significant threat to primates in all biogeographic areas. Recent research has shown that primates have non-patterned responses to this disturbance and that general models of changing primate behaviour are not effective conservation tools. Previous research on primates in fragments is concentrated in the Neotropics demonstrating a need to investigate species-specific responses in other areas of the world. This study examined two sympatric lemur species, the crowned lemur (*Eulemur coronatus*) and Sanford's brown lemur (*Eulemur sanfordi*) and their responses to anthropogenic habitat fragmentation in northern Madagascar. Although habitat generalists, Sanford's lemur was extirpated at the study site while crowned lemur density was low but viable; they were restricted to forest fragments on the periphery and top of limestone massifs. Conservation initiatives in these fragments are reliant on preserving fruit trees located in the remaining forest flatlands and the commitment of a community conservation group.

Key words: Northern Madagascar, Crowned lemur, Sanford's brown lemur, Forest fragmentation, Edge effects, Lemur density, Community conservation, Dry season, Deciduous forest.

Guidelines for authors

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Journal article

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

Book chapter

Ganzhorn, J.U. 1994. Les lémuriens. Pp. 70-72. In: S.M. Goodman; O. Langrand (eds.). Inventaire biologique; Forêt de Zombitse. Recherches pour le Développement, Série Sciences Biologiques, n° Spécial. Centre d'Information et de Documentation Scientifique et Technique, Antananarivo, Madagascar.

Book

Mittermeier, R.A.; Konstant, W.R.; Hawkins, A.F.; Louis, E.E.; Langrand, O.; Ratsimbazafy, H.J.; Rasoloarison, M.R.; Ganzhorn, J.U.; Rajaobelina, S.; Tattersall, I.; Meyers, D.M. 2006. Lemurs of Madagascar. Second edition. Conservation International, Washington, DC, USA.

Thesis

Freed, B.Z. 1996. Co-occurrence among crowned lemurs (*Lemur coronatus*) and Sanford's lemur (*Lemur fulvus sanfordi*) of Madagascar. Ph.D. thesis, Washington University, St. Louis, USA.

Website

IUCN. 2008. IUCN Red List of Threatened Species. <www.iucnredlist.org>. Downloaded on 21 April 2009.

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Drawing by Stephen D. Nash

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