LEMUR NEWS

The Newsletter of the Madagascar Section of the I.U.C.N./S.S.C. Primate Specialist Group

NUMBER 14, December 2009

CONSERVATION INTERNATIONAL

MARGOT MARSH BIODIVERSITY FOUNDATION

WWF

DPZ Deutsches Primatenzentrum

SPECIES SURVIVAL COMMISSION

UHH Universität Hamburg

Cover photo: Processing of a rosewood stockpile in Antalaha (photo anonymous)..

LEMUR NEWS

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

PSG Chairman: Russel A. Mittermeier
PSG Deputy Chairman: Anthony B. Rylands

Editors
Jörg U. Ganzhorn
Ken Glander
Jonah Ratsimbazafy
Rodin M. Rasoloarison
Michael Schwibbe
Anne Yoder

Assistant Editors
Anja Ganzhorn
Rose Marie Randrianarison

Layout
Heike Klensang

Number of copies: 1000

ISSN 1608-1439

Addresses for contributions
Jörg U. Ganzhorn
Abt. Tierökologie und Naturschutz
Universität Hamburgl
Martin-Luther-King-Platz 3
20146 Hamburg
Germany
E-mail: ganzhorn@zoologie.uni-hamburg.de

Jonah Ratsimbazafy, Rodin M. Rasoloarison,
Rose Marie Randrianarison
GERP
34, Cité des Professeurs, Fort Duchesne
Antananarivo (101)
Madagascar
E-mail: gerp@wanadoo.mg

Lemur News online
Volumes 3 -present are available online at
www.dpz.eu

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

EDITORIAL

It has been a sad time since the last issue of lemur News has been released.

Ando Ratovonirina died tragically on February 7, 2009. Ando was a journalist with a strong background in ecology and conservation. He had only recently completed his journalism studies and had been working for Radio et Télévision Analamanga for three months. Previously he was a photographer for the "La Gazette de la Grande Ile" and used to write for the "Tophos" news agency under the pseudonym of Hathor. With his tragic death we lost a promising young colleague who had the potential to promote conservation beyond the academic arena. But more than a colleague we mourn the death of a human being, friend and son.

Ando Ratovonirina

Madame Olga Ramilijaona, Professeur Titulaire at the Faculté des Sciences of the University of Antananarivo, died on January 6, 2010. Madame Olga had been in charge of the Department of Zoology and of its doctoral program. She was instrumental in developing the curriculum of the department and to promote students in close collaboration with her colleagues in Antananarivo and her international collaborators. Madame Olga also headed the fauna group within the CITES. She has passed away long before her time had come. We mourn her untimely death.

Olga Ramilijaona

Ando Ratovonirina and Olga Ramilijaona worked towards a society characterized by high standards in their respective field. We will do whatever we can to continue and extend their legacies.

For the last 12 years, Lemur News has been edited by a team of dedicated Malagasy and non-Malagasy "lemur people" brought together by Conservation International. I enjoyed these years and the stimulating interaction with people with first information from the field. But now I feel that it is time to pass the newsletter on to the next generation so that we can take advantage of fresh enthusiasm and new approaches. Christoph Schwitzer from Bristol Zoo has agreed to take on the responsibility as the international coordinator. Christoph is placed nicely at the interface of zoos, education, conservation and field research. Christoph Schwitzer received his PhD in Zoology from the University of Cologne, where he studied the nutritional ecology of lemurs. He was part of the primatological research group at Cologne Zoo before becoming program coordinator for the *Association Européenne pour l'Etude et la Conservation des Lémuriens* (AEECL) in Madagascar, where he established a field research and conservation programme. Since 2006 Christoph is head of research at Bristol Zoo Gardens, and since 2007 he is also executive secretary of AEECL. His main research interests are the behavior and ecology of primates in human-altered habitats, and the nutritional ecology of frugivorous mammals.

On a personal note, I would like to thank all our collaborators and contributors for their excellent work during the last few years. In particular I would like to thank the Margot Marsh Biodiversity Foundation, the Primate Action Fund, CI and WWF for their support over the years.

Misaotra betsaka
Jörg Ganzhorn

COVER STORY:
A tragedy with villains: Severe resurgence of selective rosewood logging in Marojejy National Park leads to temporary park closure

Erik R. Patel
Cornell University, 211 Uris Hall, Ithaca, NY 14850,
erp8@cornell.edu

The Marojejy website (www.marojejy.com/) summarizes the reasons for the closure: "The closure was deemed necessary by park management due to the lawlessness that has descended over the SAVA region during this time of political unrest in Madagascar, and the resultant looting and destruction which is currently occurring within the park. In particular, gangs of armed men (led primarily by foreign profiteers in conjunction with the rich local mafia) are plundering the rainforests of Marojejy for the extremely valuable rosewood that grows there". The logging is now known to have occurred within the central eastern and north-eastern sectors of the park that have road access to Sambava (Mandena, Andratamarina, Andrahanjo) (pers. comm., Herve Bakarizafy, Marojejy National Park Director). These are approximately the same regions where illegal rosewood logging occurred in Marojejy in 2005 (Patel, 2007: Fig. 1).

The goal of this report is to provide a detailed summary of these recent events which represent the greatest conservation threat Marojejy has ever faced. The natural history and conservation status of Madagascar's precious hardwoods will also be reviewed. This extreme case study illustrates how unsustainable manual selective logging can have severe accessory effects including loss of tourism, creation of numerous new large trails, an increase in bushmeat hunting, and destruction of a likely food species of the silky sifaka (*Propithecus candidus*). A few rosewood (*Dalbergia louveli*) tress have been found within the habitat of the main silky sifaka study group at Camp 2 (Marojejia) of Marojejy (pers. obs.; pers. comm.: Mosesy Madiomanana, Marojejy N.P. Chief Guide; Rabary Desire, Marojejy N.P., former Chief Guide) and informal observations suggest that they occasionally eat leaves of the rosewood tree (Tohonkasina Jacques Harson (Jackson), Marojejy N.P. re-

search guide). Milne-edwards' sifakas do eat the leaves of pallisandre (*Dalbergia baroni*) in Ranomafana National Park (Arrigo-Nelson, 2007). Diademed sifakas (*Propithecus diadema*) consume leaves of this genus as well (Irwin, 2006).

Illegal logging of precious wood, such as rosewood and ebony, has emerged as one of the most severe threats to Madagascar's northeastern rainforests. Thousands of logs, worth millions of dollars, have recently been confiscated at ports of Vohémar, Antalaha, and Toamasina. Most of these logs were harvested from the two largest protected areas in the region, Masoala National Park and Marojejy National Park (Fig. 1, cover picture). Harvesting these extremely heavy and valuable hardwoods is a labor intensive activity requiring coordination between local residents who manually cut the trees, but receive little profit, 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" (Jolly *et al*., 1984). There are about 18 major rosewood exporters or "rosewood barons" in Antalaha for whom thousands of local residents inadvertently work for (pers. com.: Bematana Martin, Antalaha rosewood dealer and exporter). The impacts of such selective logging include violating local taboos as well as ecological consequences such as increased likelihood of fire, invasive species, impaired habitat, and loss in genetic diversity. Recommendations include listing *D. louveli* under CITES Appendix III, increasing the involvement of the judicial system, no future authorizations for the gathering or exporting of precious wood, reforestation, and extensive police monitoring along strategic roadways (reviewed in Patel, 2007).

Fig. 1: Four km from Marojejy National Park, illegally logged rosewood being transferred from the Manantenina River to ground transport in broad daylight. Photo Credit: Anonymous

Conservation Status of Rosewood and Ebony

Three species of endemic rosewood, members of the family Leguminosae (Febaceae), are found within Marojejy National Park predominantly near large rivers at low elevations: *Dalbergia baronii*, *D. madagascariensis*, and *D. louveli*. IUCN Red List categories were assigned in 2003, but require updating following extensive logging in recent years. Listed as "vulnerable", *D. baronii* and *D. madagascariensis* were seldom found within 5 km of a protected area, and the authors note that large specimens are rare due to overexploitation. Even rarer, *D. louveli* is classified as "endangered" since no trees whatsoever were found within 5 km of a protected area, and "populations of this rare rosewood are now severely fragmented, and it is selectively felled for the export market" (Labat and Moat 2003). The wood of *D. baronii* and *D. louveli* is lustrous deep red and referred to as "rosewood" or "bois de rose" in French or locally in Malagasy as "Andramena" which translates to "trunk-red". *D. madagascariensis* is one example of palisandre, a precious *Dalbergia* hardwood without the vibrant red coloration (Du Puy, 2002).

All three tree species provide precious hardwood and are believed to be harvested mainly for furniture construction overseas (particularly China), and only occasionally used in Madagascar for artistic carvings and vases for sale to tourists (Fig. 2). Expensive rosewood guitars and other musical instruments made from rosewood are popular around the world, including in the United States (Du Puy, 2002). However, it is not clear at this time, what exactly happens to Madagascan rosewood after it arrives to China. Chinese importers are said to prefer unprocessed whole rosewood logs (pers. com.: Bematana Martin, Antalaha rosewood dealer and exporter).

Fig. 2: Rosewood carving shop in Antalaha which makes 20 to 30 rosewood vases each day, and more than 5,000 since 2005 when they began this business. They report a continuous supply of rosewood scrap pieces since 2005.

Masoala National Park contains both ebony and rosewood. Remarkably, more than 25 species of ebony (*Diospyros*) are found on the Masoala peninsula, a number of which have commercial value. The park was designed to leave sufficient forest outside the reserve to permit selective logging of precious hardwoods. However, rampant timber extraction has left very few of these trees outside park boundaries. Park managers at Masoala have long reported that trying to stop illegal logging in the park is a constant battle (Rubel *et al*., 2003; Razafindramiadana, 2009). Ebony and rosewood logging has been documented as the second of four principal direct threats to Masoala biodiversity (Kremen *et al*., 1999). According to forest surveys by the Masoala National Park staff, 70 % of locally logged rosewood occurs within Masoala National Park (Rasarely *et al*., 2005).

Rosewood Logging In Marojejy National Park: 2004-2005

Soon after cyclone Gafilo struck the SAVA (Sambava, Andapa, Vohémar, Antalaha) region of northeastern Madagascar in March 2004, the Ministry for the Environment, Water, and Forests (MINENVEF) issued tem-

porary permits, valid only until the end of March, only for the collection of wood that had been toppled by recent cyclones outside of protected areas. However, these restrictions were difficult to enforce because of the remote locations of the wood and because MINENVEF agents are seldom in the field. Sylvain Velomera, former Director of Marojejy National Park, questions the justification for these initial temporary permits: "It's only a justification to allow cutting of rosewood, since cyclones do not blow over rosewood, only papaya and coconut and other small vulnerable trees, not rosewood" (pers. comm.).

During this time of economic stress, post - cyclone with the price of vanilla very low, exporters encouraged local farmers to harvest rosewood, palisandre, and ebonies anywhere they could find it, including protected areas. Numerous reports of illegal precious wood logging ensued (Raoel, 2005; Rasarely *et al*., 2005). In response, a regional decree (n° 001 2005 REG / SAV) was issued on March 25, 2005 mobilizing inspection brigades and prohibiting the traffic and transport of rosewood and ebony. Subsequently, 106 persons were arrested in northeastern Madagascar in 2005 for illegal harvesting or transport of precious wood (Rasarely *et al*., 2005). At Marojejy alone, in 2005 over 20 separate incidents of illegal rosewood logging are known to have occurred (Sylvain Velomora, former Director of Marojejy National Park, pers. comm.; Wul Frank, Conservation Agent, Marojejy National Park, pers. comm.). On June 1, 2005 Malagasy police confiscated 165 tons (4,884 logs) of ebony and 340 tons (2,630 logs) of rosewood from two major ports in the northeast of Madagascar, Vohémar and Antalaha (Raoel, 2005). More recently, in January 2007, 14 large crates of rosewood valued at about 1.5 million dollars were apprehended in Vohémar. Also, in June 2007, 800 pieces of hidden rosewood were confiscated from the premises of a prominent Antalaha businessman (Nivo, 2007). The wood was apparently on its way to Singapore or China which is the world's largest consumer of tropical wood (Musa, 2007). SAVA regional head Paulin explained that "We do not know the companies nor the people (involved), but we can see from the documents obtained by customs officials that (it) is destined for China" (Cocks, 2005).

Rosewood Logging In Marojejy National Park: 2009

Like the crisis in 2004-2005, the current crisis began with the repeal of legislation prohibiting exportation of precious wood during a time of economic stress. Dr. Frank Hawkins, Conservation International's vice-president for Africa, explains that "In two previous periods of unrest (1991 and 2001), turn-a-quick-buck harvesting is exactly what had happened, with rosewood and the big-headed turtle (now critically endangered) among the prime targets." (Cressey, 2009).

On January 19, 2009 the government passed legislation permitting the export of an estimated 500,000 logs of precious hardwood that had already been illegally logged and stockpiled at ports of Antalaha and Vohémar. Numerous logs were also hidden underground and secretly submerged underwater. Similar to the previous crisis, little monitoring was established to prevent newly logged wood from being exported as well. In fact, radio announcements were made proclaiming rosewood logging was now legal in SAVA. On January 27, widespread looting and riots occurred across Madagascar. Two weeks later, the Ministry for the Environment, Water, and Forests (MINENVEF) in Antalaha (adjacent to Ocean Momo Hotel where a lot of rosewood tables and arts are on display) was actually robbed of their entire stockpile (estimated as 500 metric tons) of confiscated rosewood (**www.mongabay.com** March 23, 2009; **www.marojejy.com** March 20, 2009; **www.marojejy.com** April 10, 2009; Razafindramiadana, 2009)! The "guardians" (a local family) of the Antalaha MINENVEF report that 3000 people stormed the compound removing 10 truckloads of rosewood, but leaving behind hundreds of logs of less valuable pallisandre. Several large buildings in the compound were also completely destroyed during the mass robbery (Ratiana Zaquiline and Henry Dede, pers. comm.).

The value of such stock piles are staggering. In Vohemar and Antalaha, high quality rosewood is purchased by the Chinese exporters for $5 to $6 USD per kilogram, but in some cases $10 to $11 USD per kilogram. For example, a typical two meter rosewood log weighing 150 kg may be sold in Madagascar for $900 USD (Fig. 3). Once finished as an armoire in China, using several logs, the retail value can exceed $30,000 USD. By comparison, local people are only paid between $1,5 to $2,5 USD per day for finding, cutting, and dragging the enormous tree pieces. A single 25 meter tall mature rosewood tree may be 400 years old. Considerable variability exists in regeneration rates of cut *Dalbergia* stumps. Further research is necessary, however a preliminary study by WMF suggests that many rosewood stumps do not regenerate (GW-EIA 2009, WWF 2009, pers. com.: Mosesy Madiomanana, Marojejy N.P. Chief Guide; Rabary Desire, Marojejy N.P., former Chief Guide; Eric, Marojejy Park Agent Mandena; Bematana Martin, Antalaha rosewood dealer and exporter).

The MINENVEF Antalaha rosewood theft occurred two weeks after the first massive anti-Ravalomanana protests in the capital in which the state-owned TV and radio station were burned, and dozens of people killed. Ten days earlier the cyclone "Eric" struck the east coast, followed by even more severe "Fanele" two days later on

Fig. 3: Confiscated 2 m long rosewood log or "bola bola" weighing approximately 150 kg and worth approximately $900 USD in Madagascar. As a finished armoire in China using several logs, the retail value can exceed $30,000 USD. Individuals pictured are park agents, Sambava police, a local politician, and representatives from the Department of Water and Forest.
Photo Credit: Erik R. Patel

the west coast. Extensive damage and flooding across the island affected more than 60,000 people and left more than 4,000 homeless. With thousands of jobs recently lost, many development organizations concurred that "Madagascar is facing an evolving humanitarian crisis of proportions unprecedented in its history" (IRIN News, April 23). To make matters worse, the cyclone season is the lowest tourism season and corresponds to the "lean season" when food stores run low before the harvests in May and June. Around this time in January, foreign exporters, collaborating with local vanilla businessman, arrived in Vohemar and Antalaha. In some cases, armed guards were observed with these foreign exporters (**www.mongabay.com** March 23, 2009; **www.marojejy.com** March 20; 2009; **www.marojejy.com** April 10, 2009; Razafindramiadana, 2009).

As the political crisis worsened in Antananarivo, the environmental crisis spiraled out of control all over the country. Many park rangers were reported to have left their posts because of safety concerns. Thousands of people went to Masoala and Marojejy to harvest rosewood (Braun, 2009; **www.marojejy.com** March 20, 2009). On March 17, former President Ravalomanana assigned all government powers to a military council loyal to himself headed by Vice-Admiral Hyppolite Ramaroson. The very next day, the military handed over the executive power that was given to it by Ravalomanana to the new "High Transitional Authority", headed by former Antananarivo Mayor (and DJ), Rajoelina (BBC, 2009). On March 20, Marojejy National Park was closed to tourism by the park director who had been threatened with violence (burning of his house) by the growing "rosewood mafia" (**www.mongabay.com** March 23, 2009; **www.marojejy.com** March 20, 2009; pers. com.: Mosesy Madiomanana, Marojejy N.P. Chief Guide; Rabary Desire, Marojejy N.P., former Chief Guide; Eric, Marojejy Park Agent Mandena).

Why It Was Necessary To Close Marojejy National Park

It was necessary to close Marojejy National Park because of the lawlessness resulting from a large immigration of people (some of them armed) to Mandena, the closest village to the park entrance. This is part of the tourist zone. Approximately 1500 people from dozens of villages surrounding Marojejy entered the village of Mandena adjacent to the park entrance. Additionally, 80 to 90 % of the local residents of Mandena (population size about 2000), including 12 of the 13 local police or "cartier mobile" also entered the park in order to log rosewood. The leaders were several dozen armed professional criminals working for rosewood boss' in Antalaha. Several park agents were threatened with violence. Similar events occurred in regions further north, particularly near villages Andratamarina and Andrahanjo. Unfortunately, less is known about what exactly occurred in those areas (**www.mongabay.com** March 23, 2009; **www.marojejy.com** March 20, 2009; pers. com.: Mosesy Madiomanana, Marojejy N.P. Chief Guide; Rabary Desire, Marojejy N.P., former Chief Guide; Eric, Marojejy Park Agent Mandena).

Numerous reports of rampant open logging ensued. An anonymous source explained that "the villagers are afraid of the authorities (ANGAP/WWF) so they aren't cutting trees directly. Instead, they look for the good trees and then guide the logging teams to the trees. The slaughter has progressed to the industrial stage. The newly completed road from the park entrance to the Sambava-Andapa highway is actually stained red from all the logs that have been dragged along it." The very structure of society is being changed. Another anonymous source reported that: "At night, some loot the [rosewood] stockpiles of others. Every night now the village bars are filled with rowdy traders and transporters bragging about the money they have acquired, until the early hours of the morning, especially on weekends. The attitudes of the people have changed; they have become aggressive and without pity, they speak of their success to show off in front of others. All this without really considering the consequences of their actions, the risks, regulations, etc…"

Marojejy National Park Re-Opens After 40 Days

Relative calm returned to Marojejy N.P. soon after the arrival of gendarme from Antananarivo who were replaced by gendarme from Sambava once the situation stabilized. Currently, 16 gendarme from Sambava are stationed in three main regions where illegal logging occurred: 4 in Mandena, 6 in Andratamarina, and 6 in Andrahanjo. A new Ad Hoc Committee has been created to address Marojejy's rosewood crisis and involves representatives from various NGOs, national police, local police, park staff, and local politicians (pers. comm., Herve Bakarizafy, Marojejy National Park Director; Eric, Marojejy Park Agent Mandena). Although, the tourist region around Mandena and park entrance appears calm, less is known about the more remote regions of the park near Andratamarina and Andrahanjo.

Collateral Damage

Selective logging of precious wood in Madagascar, such as rosewood, is known to be accompanied by increases in fire and hunting (IUCN, 2006; Mittermeier *et al*., 2006). During the five weeks when thousands of people entered Marojejy, reports of bushmeat hunting increased, particularly for eels, crayfish, and small mammals as well as lemurs (Eric, Marojejy Park Agent Mandena). Some small trees were also cut for fuelwood and various cooking sites adjacent to the new rosewood trails inside Marojejy were found. At least 10 km of new trails have been created between the park entrance and Camp 1 (Mantella) within the tourist zone (pers. obs.; pers. com.: Mosesy Madiomanana, Marojejy N.P. Chief Guide; Rabary Desire, Marojejy N.P., former Chief Guide). I was shocked by the extensive network of large new trails, no doubt many of which have not been found yet (pers. obs.). Loss of tourism is another clear negative consequence.

International Conservation Organizations Sound The Alarm

Many international conservation organizations working in Madagascar have recently concurred that the precious hardwood logging in the north-east has reached unprecedented levels. In an unprecedented sign of concern, on March 27, 2009 13 conservation groups working in Madagascar issued a joint public statement with the United Nations Educational, Scientific and Cultural Organization (UNESCO) condemning the severe increase in environmental devastation at Marojejy and Masoala National Parks (UNESCO News, April 3, 2009). Marojejy and Masoala were inaugurated a part of a World Heritage Site cluster just 2 years ago. At the time of their inauguration, the extent of illegal

rosewood and ebony logging was minimized, and considered only a minor threat (IUCN, 2007). On April 8, the International Union for Conservation of Nature (IUCN) issued a similar statement emphasizing these two national parks and called "on governmental authorities and all Malagasy citizens to do all they can to stop those illegal and potentially irreversible activities which threaten the future of Madagascar's heritage" (IUCN Madagascar Statement, April 8, 2009).

Conclusions

The extensive illegal selective logging described in this report challenges the traditional notion that large-scale commercial logging has not really yet occurred in Madagascar's rainforests. However, the manual selective logging described in this report is not as severe as the mechanized clear-cutting of entire tracts of forests as in South East Asia (IUCN, 2007; Mittermeier *et al*., 2006). Given that bushmeat hunting, harvesting of other forest products, new roads into the parks, and entire park closures are now known to accompany precious hardwood logging in Marojejy and Masoala, it may be worth re-evaluating whether "Highly selective small scale logging of precious woods such as rosewood and ebony …may not have a serious ecological impact overall…" (IUCN, 2007, p. 6).

A little good news has recently arrived. All of the tourist bungalows in Marojejy remain intact and the main silky sifaka study group at Camp 2 (Marojejia) has seven of the eight group members who were there in December 2008. A sub-adult 4 year old disappeared from the group between February and April. He may have emigrated, been predated by the fossa, or in some way impacted by the crisis in Marojejy during this time (e.g. hunted). During recent observations of this group (May 8 to May 11, 2009), they did not appear unusually vigilant or "fearful" and seldom emitted alarm calls towards human observers (pers. obs.).

Acknowledgements

This article would not have been possible without the contributions of many anonymous supporters of conservation at Marojejy National Park who have often risked their own safety.

References

Arrigo-Nelson, S.J. 2007. The impact of habitat disturbance on the feeding ecology of the Milne-Edwards' sifaka (*Propithecus edwardsi*) in Ranomafana National Park, Madagascar. Ph.D. Dissertation, New York: Stony Brook University, Stony Brook.

BBC. 2009. Timeline: Madagascar. April 1. http://news.bbc.co.uk/2/hi/africa/country_profiles/1832645.stm

Braun, D. 2009. Lemurs, rare forests, threatened by Madagascar strife. NatGeo News Watch. March 23. http://blogs.nationalgeographic.com/blogs/news/chiefeditor/2009/03/lemurs-threatened-by-madagascar-strife.html

Cocks, T. 2005. Loggers cut madagascan rainforest with impunity. Reuters. July 4.

Cressey, D. 2009. Conservationists see trouble in Madagascar conflict. The Great Beyond Blog. March 20. http://blogs.nature.com/news/thegreatbeyond/2009/03/conservationists_see_trouble_i.html

Du Puy, D.J. 2002. The Leguminosae of Madagascar. Royal Botanic Gardens, Kew, UK.

Garreau, J.M.; Manantsara, A. 2003. The protected-area complex of the Parc National de Marojejy and the Reserve Speciale d'Anjanaharibe- Sud. Pp. 1451-1458. In: S.M. Goodman, J.P. Benstead (eds.). The Natural History of Madagascar, University of Chicago Press, Chicago, USA.

Goodman, S.M. 2000. Description of the Parc National de Marojejy, Madagascar, and the 1996 Biological Inventory of the Reserve. Field. Zool. 97: 1-18.

GW-EIA -Global Witness and Emnvironmental Investigation Agency- (2009). Investigation into the illegal felling, transport and export of precious wood in SAVA Region Madagascar. Unpublished report to the Government of Madagascar. www.globalwitness.org/media_library_detail.php/887/en/field_ investgation_into_illegal_ logging_in_madaga.

Humbert, H. 1955. Une merveille de la Nature à Madagascar. Première exploration botanique du massif du Marojejy et de ses satellites. Mémoires de l'Institut Scientific de Madagascar, série b, 6: 1-210.

Irwin, M.T. 2006. Ecological Impacts of Forest Fragmentation on Diademed Sifakas (*Propithecus diadema*) at Tsinjoarivo, Eastern Madagascar: Implications for Conservation in Fragmented Landscapes. Ph.D. Dissertation, New York: Stony Brook University, Stony Brook.

IRIN News. 2009. Madagascar: Political events upstage humanitarian crisis. April 23.

IUCN. 2007. World heritage nomination. IUCN technical evaluation. Rainforests of the Atsinanana (Madagascar). IUCN Evaluation Report. ID No. 1257.

IUCN News. 2009. Statement on Madagascar. April 8. http://cms.iucn.org/news_events/?uNewsID=2995

Jolly, A.; Jolly, R. 1984. Malagasy economics and conservation: A tragedy without villains. Pp. 211-218. In: J.E. Treherne (ed.). Key Environments: Madagascar, Pergamon Press, Oxford, UK.

Kremen, C.; Cameron, A.; Moilanen, A.; Phillips, S.J.; Thomas, C.D.; Beentje, H.; Dransfield, J.; Fisher, B.L.; Glaw, F.; Good, T.C.; Harper, G.J.; Hijmans, R.J.; Lees, D.C.; Louis Jr., E.; Nussbaum, R.A.; Raxworthy, C.J.; Razafimpahanana, A.; Schatz, G.E.; Vences, M.; Vieites, D.R.; Wright, P.C.; Zjhra, M.L. 2008. Aligning conservation priorities across taxa in Madagascar with high-resolution planning tools. Science 320: 222-226.

Kremen, C.; Razafimahatratra, V.; Guillery, R.P.; Rakotomalala, J.; Weiss, A.; Ratsisompatrarivo, J.S. 1999. Designing the Masoala National Park in Madagascar based on biological and socioeconomic data. Cons. Biol. 13: 1055-1068.

Labat, J.N.; Moat, J. 2003. Leguminosae (Fabaceae). Pp. 346-373. In: S.M. Goodman, J.P. Benstead (eds.). The Natural History of Madagascar, University of Chicago Press, Chicago, USA.

Marojejy.com News Update. 2009. March 20. www.marojejy.com/Breves_e.htm#Mar09

Marojejy.com News Update. 2009. April 10. www.marojejy.com/Crise_e.htm

Mittermeier, R.A.; Konstant, W.R.; Hawkins, F.; Louis, E.E.; Langrand, O.; Ratsimbazafy, J.; Rasoloarison, R.; Ganzhorn, J.U.; Rajaobelina, S.; Tattersall, I. 2006. Lemurs of Madagascar, second edition. Cons Int, Washington DC, USA

Mongabay.com. 2009. Scramble to log Madagascar's valuable rainforest trees in midst of crisis. March 23. http://news.mongabay.com/2009/0323-madagascar.html

Musa, T. 2007. Chinese demand drives global deforestation. Reuters. June 10.

Nivo, T.A. 2007. Bois de rose: 800 isa no tratra tao amin'ny mpandraharaha iray. Madagascar Tribune. June 22.

Patel, E.R. 2007. Logging of rare rosewood and palisandre (*Dalbergia* spp.) within Marojejy National Park,

Madagascar. Madagascar Conservation and Development 2: 11-16.
Raoel, 2005. Trafic illicite de bois précieux. Madagascar Tribune. June 1.
Rasarely, E.; Ramiandrarivo, L.; Bettencourt, S.; Bidani, B.; Rajaonson, B.; Rambeloarisoa, G. 2005. Mission report in the SAVA of November 21 to 24, 2005. World Bank Document.
Razafindramiadana, L. 2009. Abus dans l'exportation de bois. L'Express de Madagascar. Edition n° 4217. January 24.
Rubel, A.; Hatchwell, M.; Mackinnon, J.; Ketterer, P. 2003. Masoala – L'oeil de la Forêt. Zoo Zurich.
US AID. 2005. Madagascar Annual Report FY 2005. June 16.
UNESCO News. 2009. World Heritage rainforests in Madagascar threatened by illegal logging and trafficking of precious wood. April 3.
http://whc.unesco.org/en/news/500
WWF -World Wildlife Fund- (2009). Towars sustainable management of hardwood species in Madagascar: Evaluation of the stock of rosewood (*Dalbergia* spp.) in the Andapa and Menabe regions. May 11, 2010, retrieved from www.madagascar.panda.org/ourwork/cssp/speciesprojects/rosewood/

Masoala – The Eye of the Forest massively threatened by illegal lumbering

Zurich, August 28, 2009 - Zurich Zoo is terribly concerned about current developments at Masoala National Park in the North East of Madagascar. According to a report published by its most important partners in Madagascar in the sectors ecology and finances, approx. 4,000 persons are currently lingering illegally in the National Park and felling precious rosewoods or poaching protected animals unhindered. The leaders of these groups of illegal woodcutters do not even shy away from threatening the local population and the staff of the National Park with weapons. Various international nature conservation organizations, the representatives of embassies of several countries, the World Bank, and the KfW Development Bank are working together intensively in order to assist the interim government of Madagascar in coming to terms with this crisis. Global Witness and the Environment Investigative Agency are currently investigating the circumstances in the individual national parks. The UNESCO has also been alerted. Every day, new horrific news about the extent of the illegal felling of trees and the hunting of lemurs in Masoala National Park as well as other national parks and protected forests in Madagascar reach Zurich Zoo. Following the overthrowing of the government in March of this year and the corresponding distress to Madagascar's civil society, the transitional government lost control of the natural resources in the national parks and reservations. The unarmed rangers of the National Park authorities are threatened, intimidated, and attacked and forced to watch, dismayed, as the nature reserves are plundered. According to the report of the union of international partners in the field of ecology (Cercle de Concertation des Partenaires Techniques et Financiers du Secteur Environnement, CCPTF) published on August 6, 2009, it must be assumed that towards 4,000 persons are illegally camping in Masoala National Park and felling precious rosewoods there unhindered. Every day, hundreds of trees are felled and illegally removed by overland or sea route. The leaders of these wood felling troupes do not hesitate to threaten with arms, the local population attempting to protect the forests. The woodcutters also hunt and uninhibitedly shoot down lemurs in order to procure meat for food or to be sold to restaurants as delicacies. Madagascar and Masoala are on the point of losing their unique natural heritage in only very short time and of returning to times of impoverished forests, erosion, and poverty. The rosewood barons and their allies are the only ones to profit from the current raiding of the treasures of the rainforest. Forests thus plundered always lead to an impoverishment of the local population as a consequence of erosion, the rivers filling with mud and the corals of the sea being covered with sediment. In a cry for help to the public published in a Madagascan daily paper, citizens as well as the Association of Tourism Entrepreneurs of Maroantsetra–Masoala, the GOTMM, have pleaded for aid to prevent the potential of sustainable tourism being sacrificed to a short-lived rosewood inebriation: "Au nom des habitants de Maroantsetra, riverains du Parc national de Masoala et Makira, qui croient aux potentialités infinies, aux atouts immenses que constitue un Partimoine naturel aussi exeptionnel et qui veulent jouer la carte tourisme nature pour le développement économique de la région. Aidez-nous!"* Zurich Zoo is greatly concerned about the current developments and the threat of destruction of sustainable tourism and the improved protection of Masoala National Park that have been demanded since 2003. In particular in these difficult times, Masoala National Park and the park authorities of Madagascar National Park require every possible form of international support. Zurich Zoo is in close contact with its local partners, the Wildlife Conservation Society (WCS), Masoala National Park, and the Swiss Ambassador to Madagascar. WCS cooperates closely with other international nature conservation organizations such as the WWF and Conservation International. The World Bank, the KfW Development Bank, the United Nations Programm for Developpement (UNDP), and the US Agency for International Development (USAID) are all endeavoring to support the Madagascan interim government in dealing with the current crisis in the country's national parks and reservations. The UNESCO has been alerted as to the situation in Masoala National Park that was declared a UNESCO World Heritage site in 2007. Currently, upon request of the Madagascan National Park authorities, the Global Witness and Environment Investigative Agency (EIA), two internationally active and politically independent NPOs, are investigating the situations in the individual national parks. The corresponding report with suggestions of measures to be taken is expected to be published in the next few days. It remains to be hoped that the culprits be held responsible for their actions as soon as possible. Zurich Zoo attaches great importance to providing continued support and assistance to Masoala National Park and the population in the surrounding areas. In particular during such difficult times, it is important to ensure that projects underway may continue to progress. The plundering of the national parks will inevitably lead to an impoverishment of the local population. The park's natural resources are the future capital of the Madagascan society.

*) *In the name of the inhabitants of Maroantsetra, Masoala and Makira National Parks who believe in the infinite potential and value of this extraordinary natural heritage, we wish to foster the development of sustainable tourism in order to ensure the economic development of this region. Help us!*
For further information, please contact: Dr. Alex Rübel, Director Zurich Zoo or Dr. Martin Bauert, Curator Nature Conservation Projects and Botany, Tel. 044 254 2500, **medien@zoo.ch**, **www.zoo.ch**
Text and photos can be downloaded from the following site: **www.zoo.ch/medien**

Fonds de contre-partie sylvestres. Les forêts de Madagascar, blessées, peuvent effacer leurs dettes pour sauver leur avenir, avec le soutien des citoyens de Madagascar

Lucienne Wilmé[1], Derek Schuurman[2], Porter P. Lowry II[3,4]
[1]Missouri Botanical Garden, Madagascar Research and Conservation Program, Antananarivo, Madagascar
[2]London, UK
[3]Missouri Botanical Garden, St. Louis, Missouri, USA
[4]Département Systématique et Evolution, Muséum National d'Histoire Naturelle, Paris, France

Exportation de bois précieux
Les troubles politiques ont démarré à Madagascar le 25 janvier 2009, et un arrêté autorisant l'exportation de bois précieux a été signé trois jours plus tard. Les premières exportations massives de bois précieux ont eut lieu dès le mois d'avril 2009 (Débois, 2009) en ouvrant la voie à la plus importante exploitation illégale de bois jamais perpétrée dans les parcs et réserves du nord-est, plus particulièrement les parcs du Marojejy, Masoala et Makira (Schuurman et Lowry, 2009, Wilmé *et al*., 2009).
Après les premières expéditions massives en direction de la Chine, l'exploitation intensive se poursuit dans les parcs du nord-est avec des milliers de bûcherons qui organisent des véritables campements forestiers dans les parcs de Masoala et Makira. Le dernier bateau chargé de bois précieux quittera le port de Vohemar le 3 décembre et l'année se termine avec un triste record: 24,560 tonnes de bois précieux exportés (Wilmé *et al*., 2009). Au moment où ces lignes partent sous les presses, aucun nouveau conteneur n'a été exporté de Madagascar et les compagnies maritimes ainsi que les banques semblent reculer devant ce trafic organisé sur lequel le Samifin (Service de renseignement Financier – Financial Intelligence Unit) enquête (Anonyme, 2009).

Constitution de stocks: les menaces actuelles et futures
Si depuis plus de huit semaines, les bois n'ont plus été exportés, l'exploitation dans les parcs se poursuit et les stocks ne cessent de grossir. Ils étaient d'au moins 15,700 tonnes à la fin de l'année 2009. De telles quantités ont été accumulées dans le seul dessein de les exporter tôt ou tard; la pratique est ancienne et les cyclones ont même été incriminés ces dernières années pour justifier et légaliser de telles exportations (Schuurman et Lowry, 2009). Aujourd'hui l'exploitation se poursuit à grande échelle, les stocks continuent de grossir par la motivation de ces acteurs qui cherchent l'exportation des bois bruts en profitant du contexte mondial de la course effrénée et aveugle à l'extraction des ressources naturelles, et plus particulièrement pour leur expédition en Chine (Canby *et al*., 2008). Car les 1137 conteneurs exportés en 2009 auraient été vendus à plus de 200 millions de dollars US (Wilmé *et al*., 2009) et la situation qui prévaut au début de l'année 2010, avec des stocks importants bloqués provisoirement et la poursuite de l'exploitation, constitue la pire menace qui pèse sur les forêts du nord-est de Madagascar et les bois précieux restants.

Liquidation des stocks ?
Il est évident que les négociants organisent et spéculent sur l'exportation des stocks de bois précieux actuels ainsi que sur ceux qui restent sur pied dans les forêts malgaches, et tant qu'une mesure dissuasive efficace n'aura pas été adoptée par une gouvernance rigoureuse, l'exploitation illégale de bois précieux se poursuivra jusqu'a total épuisement des ressources. Ces arbres centenaires ont été exploités dans l'illégalité et devraient, conformément au code forestier, être saisis par les autorités compétentes, mais le problème ne sera que reporté. Dans le passé, à des échelles bien moindres, les bois saisis étaient alors estampillés et vendus aux enchères (Stasse, 2002), de sorte que les nouveaux acquéreurs (qui peuvent être les anciens) essayeront de nouveau d'exporter ces bois en ajoutant de nouveau une pression sur la forêt.
L'autre solution qui est la destruction des stocks peut être assimilée à une alternative radicale mais présente l'avantage de réduire à néant la pression sur les autorités pour procéder aux exportations et devrait permettre de réduire, voir de mettre un terme, à l'exploitation de ces bois précieux. Cependant, une destruction par le feu de ces stocks, comme cela a pu être fait pour l'ivoire en Afrique constitue une source de pollution importante sans oublier que le volume de bois concerné est tel que l'opération est non seulement dangereuse mais qu'elle pourrait aussi être délicate à maîtriser.
L'utilisation de ces bois dans un artisanat local pourrait être envisagée pour permettre de maintenir les bois sur le territoire et valoriser ces ressources par leur transformation. Cependant, de tels volumes ne pourraient jamais être absorbés par l'artisanat local, en même temps que la conservation des stocks pendant plusieurs décennies serait problématique et bien trop dangereuse. Par ailleurs, le développement à court terme de l'artisanat qui emploie des bois précieux constituerait une menace de taille pour le futur de cette activité car la ressource serait de nouveau convoitée.

Le fonds de contrepartie sylvestre
La valeur marchande des bois d'ébène, de palissandre et de bois de rose qui constituent actuellement les stocks est vraisemblablement supérieure à 100 millions de dollars. Si cette manne pouvait financer des œuvres caritatives pour compenser les dommages subis par les victimes de l'exploitation illégale de bois précieux, les stocks restants pourraient redresser quelques méfaits opérés par l'exploitation.
Un rondin de bois précieux, aussi dénommé '*bolabola*', a un poids moyen de 130 kg (Stasse, 2002) pour une

valeur à l'exportation de l'ordre de US$ 1,300. Ce rondin pourrait être cédé virtuellement en contrepartie d'un fonds sylvestre pour un montant à définir mais qui sera au moins égal à US$ 1,300. Le *bolabola* ainsi cédé serait alors transporté vers le bénéficiaire de l'œuvre qui sera aussi doté d'un financement à hauteur du fonds sylvestre pour son fonctionnement. Le récipiendaire, parmi les victimes de l'exploitation illégale, identifiées par les études écologiques et sociales, veillera à personnaliser les *bolabola*, à les sculpter ou les graver par exemple. Ils seront alors exhibés à la périphérie des parcs et des réserves, dans les villages, centres d'éducation et de santé et deviendront le symbole d'une transformation réfléchie aussi bien qu'un souvenir du viol perpétré en 2009 et 2010 sur les forêts avoisinantes.

Ainsi, avec l'aide extérieure et la volonté intérieure, ces forêts pourraient effacer leurs dettes et entamer leurs siècles de convalescence.

Bibliographie

Anonymous 2009. Trafic de bois de rose. Soupçons de blanchiment d'argent. Tribune 31 octobre 2009.

Canby, K.; Hewitt, J.; Bailey, L.; Katsigris, E.; Xiufang, S. 2008. Forest products trade between China and Africa: An analysis of imports and exports. Forest Trends and Global Timber 2008: i-x, 1-36.

Débois, R. 2009. La fièvre de l'or rouge saigne la forêt malgache. Univers Maoré 13: 8-15.

Schuurman, D.; Lowry II, P.P. 2009. The Madagascar rosewood massacre. Madagascar Conservation and Development 4: 98-102.

Stasse, A. 2002. La Filière Bois de Rose. Région d'Antalaha – Nord-est de Madagascar. Unpublished Master's thesis, Université de Montpellier, France.

Wilmé, L.; Schuurman, D.; Lowry II, P.P.; Raven, P.H. 2009. Precious trees pay off – but who pays? An Update. Document prepared for the COP15, Copenhagen Meeting, 7-15 December 2009. **www.illegal-logging.info/uploads/PosterrosewoodUpdate09Dec2009.pdf**

A forest counterpart fund: Madagascar's wounded forests can erase the debt owed to them while securing their future, with support from the citizens of Madagascar

Lucienne Wilmé[1], Derek Schuurman[2], Porter P. Lowry II[3,4]

[1]Missouri Botanical Garden, Madagascar Research and Conservation Program, Antananarivo, Madagascar

[2]London, UK

[3]Missouri Botanical Garden, St. Louis, Missouri, USA

[4]Département Systématique et Évolution, Muséum National d'Histoire Naturelle, Paris, France

Export of precious wood

Political turmoil began in Madagascar on 25 January 2009, and a decree authorizing the export of precious timber was signed three days later. The first massive exports of precious timber occurred as early as April 2009 (Débois, 2009), paving the way for the largest wave of illegal logging ever perpetrated within the parks and reserves of north-eastern Madagascar, particularly in Marojejy, Masoala and Makira parks (Schuurman and Lowry, 2009, Wilmé *et al*., 2009).

After the initial shipments of huge amounts of precious timber to China, intensive illicit exploitation continued in protected areas in the northeast, with thousands of loggers operating out of veritable forest camps, mostly within Masoala and Makira. The most recent ship laden with illegally sourced precious timber left the port of Vohemar on 3 December 2009, and the year closed with an alarming and tragic record: 24560 tons of illegally-sourced precious timber was exported from the country (Wilmé *et al.*, 2009). At the time this note goes to press, no additional containers have been exported from Madagascar; shipping companies and banks appear to be having second thoughts regarding this organized trafficking, which is being investigated by Samifin (the Financial Intelligence Unit; Anonymous, 2009).

Buildup of timber stocks: current and future threats

While no wood has been exported for eight weeks, logging in protected sites continues unabated and stocks are continuously increasing. Existing stocks were estimated to be at least 15,700 tons at the end of 2009. Such quantities of valuable hardwoods are being built up for the sole purpose of being exported sooner or later, a practice that has been carried out for decades, with cyclones even having been implicated in recent years to justify and 'legalize' such exports (Schuurman and Lowry, 2009). Large scale logging continues today and stocks grow, driven by players who seek to export wood and profit from a global context with its mad, blind race to extract natural resources, especially for export to China (Canby *et al*., 2008). The 1137 containers of timber known to have been exported in 2009 are thought to have sold for over 200 million U.S. dollars (Wilmé *et al*., 2009), and the situation in early 2010, with large, temporarily frozen stocks coupled with continued illegal logging, constitutes the worst imaginable threat to what remains of north-eastern Madagascar's rainforests.

Liquidation of stocks?

It is clear that timber traders are organizing and speculating on the future export of the current timber stocks as well as on what remains in Madagascar's forests. Until effective and dissuasive measures are adopted by a rigorous governing authority, the illegal exploitation of precious woods will continue until total extirpation of the targeted resources. These centuries old trees have all been sourced illegally and should, in accordance with the Forestry Act, be seized by the appropriate authorities. However, that would only postpone the problem. In the past, on a much smaller scale, wood seized was stamped and sold at auctions (Stasse, 2002), such that new owners (who may have been the same as the previous owners) would again attempt to export the wood, once again adding pressure on forests.

Another solution, the destruction of stocks, can be seen as a radical alternative but has the advantage of completely alleviating pressure on the authorities to proceed with exports and it would also help to reduce, or even stop, the exploitation of precious timber. However, destruction of these stocks by fire - as has been done for ivory in Africa - constitutes a large source of pollution. Also, the volume of timber involved is such that the process would not only be dangerous but would also be complicated to control.

The use of wood for local crafts could be envisioned as a way to retain the timber in Madagascar and to add value to these resources through their transformation. However, such large volumes are too vast to be absorbed by the local crafts community, and protection of these stocks for several decades would be problematic and far too dangerous. Moreover, the short-term development of the crafts industry that utilizes precious woods could become a major threat to the future of this activity because the resources would once again become highly sought after.

The forest counterpart fund

The market value of current stocks of ebony and rosewood likely exceeds 100 million dollars. If this windfall could be used to fund charitable works to compensate for the damages and losses inflicted on the victims of the illegal exploitation of precious woods, the remaining stocks could offset some of the negative consequences of the illegal exploitation.

A log of precious wood, known locally as a '*bolabola*', weighs on average 130 kg (Stasse, 2002) and has an export value of ca. $US 1,300. Ownership of these logs could be sold (for an amount at least equal to $US 1,300) and the revenue placed in a forest fund. Each *bolabola* donated in this manner would then be transported to a beneficiary, who would also receive operating funds. The recipients, selected from among the victims of the illegal logging, as identified by ecological and social studies, would ensure that the *bolabola* are customized, for example by carving or engraving them. The logs would then be exhibited near the edges of parks and reserves, in villages, education and health centers, thus becoming symbols of the thoughtful use of these ill-gotten resources, while also serving as a reminder of a the rape perpetrated on the nearby forest in 2009 and 2010.

With help from outside Madagascar and commitment from within the country, these forests could thus erase the debt owed to them and begin the many centuries of healing that will be required.

References

Anonymous 2009. Trafic de bois de rose. Soupçons de blanchiment d'argent. Tribune 31 octobre 2009.

Canby, K.; Hewitt, J.; Bailey, L.; Katsigris, E.; Xiufang, S. 2008. Forest products trade between China and Africa: An analysis of imports and exports. Forest Trends and Global Timber 2008: i-x, 1-36.

Débois, R. 2009. La fièvre de l'or rouge saigne la forLt malgache. Univers Maoré 13: 8-15.

Schuurman, D.; Lowry II, P.P. 2009. The Madagascar rosewood massacre. Madagascar Conservation and Development 4: 98-102.

Stasse, A. 2002. La Filiére Bois de Rose. Région d'Antalaha – Nord-est de Madagascar. Unpublished Master's thesis, Université de Montpellier, France.

Wilmé, L.; Schuurman, D.; Lowry II, P.P.; Raven, P.H. 2009. Precious trees pay off – but who pays? An Update. Document prepared for the COP15, Copenhagen Meeting, 7-15 December 2009. **www.illegal-logging.info/uploads/PosterrosewoodUpdate09Dec2009.pdf**

COMMUNIQUÉ DE PRESSE

Trafic de bois precieux a Madagascar Les partenaires internationaux rappellent les enjeux

Antananarivo le 10 mars 2010 – Les bailleurs de fonds impliqués dans le financement de la conservation de la biodiversité è Madagascar suivent avec attention la situation de l'environnement dans les régions forestiéres du pays. Une équipe de partenaires techniques et financiers et de représentations diplomatiques présentes à Madagascar a donc effectué une mission d'information dans la région SAVA du 7 au 9 mars 2010 afin de mieux comprendre l'ampleur actuelle de l'exploitation illicite de bois précieux. Ont participé à cette mission les Ambassadeurs des Etats-Unis, de la Norvège, et de l'Union européenne; ainsi que le Country manager de la Banque mondiale et le Directeur de l'Agence française de développement. Cette équipe était accompagnée par le Directeur général de Madagascar National Parks (MNP, ex-Angap) et le Directeur de l'Administration Générale du Territoire de la région SAVA.

Ces partenaires attachent un intérêt particulier à la question de la lutte contre les abus en matière d'exploitation forestière pour deux raisons. D'une part, du fait de l'importance des sommes engagées depuis des années par leurs institutions dans les secteurs de la gouvernance forestière et la protection de la biodiversité. D'autre part, parce que l'exploitation et l'exportation illégales de bois précieux non travaillé (bois de rose, palissandre, ébène) cause préjudice aux engagements que Madagascar a pris dans le cadre de plusieurs Conventions internationales: La Convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction (CITES), ratifiée par Madagascar en 1975; la Convention sur la diversité biologique ratifiée en 1995; l'inscription en 2007 des Forêts humides de l'Atsinanana (dont font partie les Parcs de Masoala et Marojejy, entre autres) dans la liste du Patrimoine Mondial établie par l'UNESCO; et les dispositions des accords de dons signés avec la Banque mondiale et le Fonds mondial pour l'environnement (GEF/FEM) dans le cadre de l'appui à la troisième phase du Programme environnemental.

Par ailleurs, l'exploitation illégale du bois précieux représente une perte irréversible pour le capital naturel et collectif de Madagascar, et affecte d'autres activités économiques (dont notamment le tourisme), ainsi que l'image de Madagascar.

Les principaux aspects du trafic ont pu être abordés au cours de cette mission d'information. Outre les réunions de travail avec le Chef de région, puis avec les opérateurs, l'équipe s'est rendue au Port de Vohémar pour discuter avec les responsables de la Task force et les divers services concernés (douanes, direction des eaux et forêts). Un survol par hélicoptère de la zone, accompagné de visites dans trois villages limitrophes du parc de Masoala, a pu permettre de prendre la mesure concrète du problème, mais aussi de discuter avec les villageois de la problématique socio-économique du trafic au niveau des communautés. Les informations recueillies lors des contacts au cours de la mission font état de la présence de plusieurs centaines de bucherons à l'intérieur du parc national, et l'équivalent de plus de mille containers de bois déjà abattu.

Les membres de la communauté internationale signataires de ce communiqué regrettent que les coupes illégales de bois précieux continuent et que la situation soit loin d'être maitrisée, plusieurs mois après la restitution en Novembre 2009 du rapport commandé par les autorités malgaches auprès de Global Witness. En attendant que toutes les parties concernées par ce sujet aient une meilleure compréhension de la situation et des moyens à mettre en place pour y remédier, les partenaires sous-signataires recommandent un arrêt du système d'exceptions répétées, qui favorise une spirale négative. En effet, il semble que les acteurs impliqués dans les trafics escomptent la prochaine mesure d'exception qui leur permettrait de régulariser leurs réserves acquises de manière illicites, ce qui les encourage dans l'attente à constituer des nouveaux stocks. Nos institutions sont par ailleurs disposées à discuter avec les services techniques compétents des solutions possibles à ce complexe problème.

News and Announcements

GERP

Notre collègue Jonah Ratsimbazafy a été élu comme Sécretaire Général du GERP le 17 mai 2009. Félicitations Jonah!

The Zoo and Conservation Medicine Club (ZCMC)

The Zoo and Conservation Medicine Club (ZCMC) organized it's 1st workshop between the 18 and the 21st of May 2009. This 4 days workshop aimed at giving an extra training to veterinary students and a platform for professionals of conservation to meet and discuss on some wild animals conservation issues in Madagascar.
The Zoo and Conservation Medicine Club (ZCMC) was created in May 2008 at the the Veterinary School of the University of Antananarivo (DESMV) in partnership with Madagascar Fauna Group (MFG). Despite Madagascar's extremely rich biodiversity, no malagasy veterinarian is currently specialized in zoological and wildlife medicine. The Zoo and Conservation Medicine Club is now composed by 18 veterinary students from various classes and two graduated veterinarians who now work with Madagascar's endangered species. The club activities are diverse and include among others, lectures, conferences, debates, hands-on training, internships/preceptorships and workshops. In November 2008, the ZCMC applied for and obtained a grant from the Chicago Zoological Society- Brookfield Zoo for the development of the club. Thanks to this funding, the club organized training/workshop at the Ivoloina Zoological Park with the participation of multiple speakers from different countries, different studies and specialities all related to the conservation of endangered species in Madagascar. The workshop was organized on a 4 day basis with a full day of lectures, a full day of hands-on practice and a day of research presentations including students research projects. The workshop also provided an invaluable opportunity for professionals from different fields to meet, share experiences and discuss about wild animals conservation issues in Madagascar.
Fidisoa Rasambainarivo, Madagascar Fauna Group, BP 442 Morafeno Toamasina 501, Madagascar,
f.rasambainarivo@gmail.com

Conservation International: Webpage and Publications

The CI webpage that informs of its publications and how to order them has been recently updated at:
www.conservation.org/publications/Pages/default.aspx

Primates in Peril: The World's 25 Most Endangered Primates 2008-2010

The media launch for the list of the World's 25 Most Endangered Primates 2008-2010 was on Thursday 18th February 2009. It was kindly hosted and organized by the Bristol, Clifton and West of England Zoological Society (the Bristol Zoo Gardens), in Bristol, UK, thanks to Jo Gipps (Director of Bristol Zoo Gardens, and Chair of the Conservation and Sustainability Committee of the World Association of Zoos and Aquariums- WAZA), Christoph Schwitzer and J. Bryan Carroll (both of the Bristol Conservation and Science Foundation). The report is published on the PSG website as Mittermeier, R.A., Wallis, J., Rylands, A.B., Ganzhorn, J.U., Oates, J.F., Williamson, E.A., Palacios, E., Heymann, E.W., Kierulff, M.C. M., Long Yongcheng, Supriatna, J., Roos, C., Walker, S., Cortés-Ortiz, L. and Schwitzer, C. 2009. *Primates in Peril: The World's 25 Most Endangered Primates 2008-2010*. IUCN/SSC Primate Specialist Group, International Primatological Society (IPS), and Conservation International, Arlington, VA. 84pp.

Le Parc Botanique et Zoologique de Tsimbazaza

est en train de publier "*Les nouvelles du Parc Botanique et Zoologique de Tsimbazaza* (*PBZT*)" regulièrement. Nos felicitations!

The First Marsh Award for Excellence in Primate Conservation

The Margot Marsh Biodiversity Foundation is pleased to announce the presentation of the first Marsh Award for Excellence in Primate Conservation, which will be given to Tilo Nadler, founder and director of Vietnam's Endangered Primate Rescue Center. Mr. Nadler has been selected to receive this $10,000 award in recognition of his dedicated effort to save some of the world's rarest and most critically endangered primates.

The Margot Marsh Biodiversity Foundation was created in honor of the late Margot Marsh, who lived in La Jolla, California and contributed very generously to wildlife conservation efforts during her lifetime. She was especially interested in programs that helped to ensure the survival of threatened primate populations. Since the Foundation was established in the mid-1990s, it has provided more than $5 million to hundreds of primate conservation projects worldwide. In serves as a fitting legacy for Margot, helping to preserve a number of critically endangered species and fostering the careers of many young and talented primate specialists.

By establishing Vietnam's Endangered Primate Rescue Center at Cuc Phuong National Park, Tilo Nadler is attempting to save several species whose populations are measured in the low thousands or even the low hundreds and dozens of individuals, such as douc, Delacour's and golden-headed langurs. The Rescue Center serves as a refuge for animals confiscated from the illegal trade, as well as a captive breeding center that is now beginning to produce animals for reintroduction projects. In addition to maintaining this facility and supervising its staff of Vietnamese biologists and caretakers, Tilo has also launched numerous field surveys to determine the conservation status of little-known species, as well as contributed to genetic studies that better define Vietnam's unique primate fauna. In large part because of his efforts, the attention of the international conservation community is now squarely focused on the endangered primates of that country.

The Margot Marsh Biodiversity Foundation has present Mr. Nadler with this special award in August 2008 at the 22nd Congress of the International Primatological Society in Edinburgh, Scotland.

AEECL: Update of activities

Christoph Schwitzer[1]*, Guy H. Randriatahina[2]
[1]Bristol Conservation and Science Foundation, Bristol Zoo Gardens, Clifton, Bristol BS8 3HA, UK
[2]Association Européenne pour l'Etude et la Conservation des Lémuriens (AEECL), Lot: IVH 169 N Ambohimanandray, Ambohimanarina, Antananarivo 101, Madagascar
*Corresponding author: secretary@aeecl.org

The Association Européenne pour l'Etude et la Conservation des Lémuriens (AEECL) is a consortium of European zoological gardens and universities who have joined forces to carry out conservation and research projects for Madagascar's highly endangered lemurs. The non-governmental organisation was founded by the zoological gardens of Mulhouse, Cologne and Saarbrücken and the University of Strasbourg, and is based in Mulhouse, France. Today we have more than 25 member institutions from all over Europe. Lernould (2002) has written about the work of AEECL in this journal seven years ago. This article provides an update on our current activities and introduces the new AEECL Small Grants scheme (see "Funding and Training").

As our priority, AEECL has been working on the creation of a reserve for the blue-eyed black lemur (*Eulemur flavifrons*), one of Madagascar's rarest lemur species, since a number of years (Fig. 1). The new Sahamalaza - Iles Radama National Park was officially inaugurated in July 2007. The charming lemur with its blue eyes is also the logo of the consortium. The member zoos have furthermore initiated captive propagation programmes for the blue-eyed black lemur as well as for the crowned lemur (*Eulemur coronatus*) and the red-bellied lemur (*Eulemur rubriventer*) within the framework of the European Association of Zoos and Aquaria (EAZA). These programmes aim to establish self-sustaining captive populations of the respective species, which can serve both as models to learn more about the species' biology as well as reserve populations for possible future reintroduction projects (e.g. Moisson and Prieur, 2008).

Fig. 1: *Eulemur flavifrons* female.

A blue-eyed flagship species

The Sclater's or blue-eyed black lemur is, besides man, one of the very few species of primate that have blue eyes. These animals occur almost exclusively on the Sahamalaza Peninsula, a very remote area in northwest Madagascar. Sahamalaza lies within a transition zone between the Sambirano evergreen forest region in the north and the western dry deciduous forest region in the south. Called the southern Sambirano, this area harbours semi-humid evergreen forests with tree heights of up to 30 m. The lemur species living in Sahamalaza are threatened by hunting and forest destruction. Blue-eyed black lemurs were assessed Critically Endangered (CR A2cd) at the most recent IUCN Red List assessment, based on an 80 % population reduction during the last 25 years. The same probably applies to the Sahamalaza sportive lemur (*Lepilemur sahamalazensis*), a recently described species from the Sahamalaza Peninsula that has not yet been assessed. The Sahamalaza region has been in AEECL's focus of scientific and conservation interest since 1988. The blue-eyed black lemur, endemic to this part of Madagascar, has been selected as the flagship species for all con-

servation efforts concerning the region. For many years AEECL, in close collaboration with the Malagasy protected areas authority MNP (formerly ANGAP) and the Wildlife Conservation Society (WCS), has been working towards the implementation of a national protected area on the Sahamalaza Peninsula. Our first goal was reached in 2001, when UNESCO declared Sahamalaza a biosphere reserve. The region was finally declared a National Park in June 2007, altogether comprising 260 km^2 of forests, coral reefs and mangroves in its core zones.

AEECL and WCS, with the involvement of representatives of local communities from the Sahamalaza Peninsula and representatives of several environmental institutions, have implemented a community-based natural resource management programme in Sahamalaza in December 2000. Two objectives of this programme were identified: to maintain and strengthen natural processes and the condition of terrestrial and marine ecosystems; and to improve natural resource use techniques in order to improve the standard of living of the local human populations.

AEECL's research programme

AEECL has established a research and conservation programme in the Ankarafa Forest, probably the largest continuous area of blue-eyed black lemur habitat still remaining (Randriatahina and Rabarivola, 2004). A small research camp serves as a base for research work on the conservation ecology of Sahamalaza's lemurs, and for conservation measures in Sahamalaza. Our research in Sahamalaza and elsewhere in Madagascar aims at increasing the scientific understanding of endangered lemurs through the study of impacts of habitat degradation and fragmentation on their ecology and behaviour (Schwitzer *et al*., 2006, 2007a, b). Moreover, the speciation and distribution areas of different lemur taxa are investigated in order to be able to assign a conservation status to those species and to implement effective conservation measures. Researchers, financed by AEECL, have been working on the taxonomy of lemur genera such as the bamboo lemurs (*Hapalemur*; e.g. Fausser *et al*., 2002; Rumpler *et al*., 2002), the sportive lemurs (*Lepilemur*; e.g. Ravaoarimanana *et al*., 2001) and the sifakas (*Propithecus*) and are helping to clarify their systematics using cytogenetic methods. We are also conducting research on captive lemurs in the AEECL member zoos, aimed at optimising animal welfare and breeding success of the lemur species in our care (e.g. De Michelis *et al*., 1999; Polowinsky *et al*., in press).

Acknowledgements

We would like to thank Madagascar National Parks (MNP), especially the director of Sahamalaza 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. We are grateful to all university institutes and researchers who have been collaborating with us, both in Madagascar and abroad.

References

De Michelis, S.; Di Trani, C.M.P.; Moisson, P. 1999. Preliminary results on the behavioural development of three new-born lemurs (*Eulemur rubriventer*, *Eulemur macaco flavifrons*) at Mulhouse Zoo. (Abstr.). Folia Primatol.70(4): 215-216.

Fausser, J.L.; Prosper, P.; Donati, G.; Ramanamanjato, J.-B.; Rumpler, Y. 2002. Phylogenetic relationships between *Hapalemur* species and subspecies based on mitochondrial DNA sequences. BMC Evol. Biol. 2: 4.

Lernould, J.-M. 2002. Un programme international de recherche et de conservation pour le lémur aux yeux turquoise (*Eulemur macaco flavifrons*). Lemur News 7: 30-33.

Moisson, P.; Prieur, C. 2008. European studbook for Sclater's lemur (*Eulemur macaco flavifrons*), n°5. Parc Zoologique et Botanique, Mulhouse. 25pp.

Polowinsky, S.Y.; Schwitzer, C. In press. Nutritional ecology of the blue-eyed black lemur (*Eulemur flavifrons*): Integrating *in situ* and *ex situ* research to assist the conservation of a critically endangered species. In: M. Clauss *et al*. (eds.). Zoo Animal Nutrition Vol. IV, Filander Verlag, Fuerth, D.

Randriatahina, G.H.; Rabarivola, J.C. 2004. Inventaire des lémuriens dans la partie nord-ouest de Madagascar et distribution d'*Eulemur macaco flavifrons*. Lemur News 9: 7-9.

Ravaoarimanana, B.; Fausser, J.L.; Rumpler, Y. 2001. Genetic comparaison of wild populations of *Lepilemur septentrionalis* and *Lepilemur dorsalis* using RAPD markers. Primates 42: 221-231.

Rumpler, Y.; Prosper, P.; Hauwy, M.; Rabarivola, C.; Rakotoarisoa, G.; Dutrillaux, B. 2002. Chromosomal evolution of the *Hapalemur griseus* subspecies (Malagasy Prosimian), including a new chromosomal polymorphic cytotype. Chromosome Research 10: 145-153.

Schwitzer, C.; Schwitzer, N.; Randriatahina, G.H.; Rabarivola, C.; Kaumanns, W. 2006. "Programme Sahamalaza": New perspectives for the *in situ* and *ex situ* study and conservation of the blue-eyed black lemur (*Eulemur macaco flavifrons*) in a fragmented habitat. Pp. 135-149. In: C. Schwitzer, S. Brandt, O. Ramilijaona, M. Rakotomalala Razanahoera, D. Ackermand, T. Razakamanana , J.U. Ganzhorn (eds.). Proceedings of the German-Malagasy Research Cooperation in Life and Earth Sciences. Concept Verlag, Berlin, D.

Schwitzer, N.; Randriatahina, G.H.; Kaumanns, W.; Hoffmeister, D.; Schwitzer, C. 2007. Habitat utilization of blue-eyed black lemurs, *Eulemur macaco flavifrons* (Gray, 1867), in primary and altered forest fragments. Primate Conservation 22: 79-87.

Schwitzer, N.; Kaumanns, W.; Seitz, P.C.; Schwitzer, C. 2007. Cathemeral activity patterns of the blue-eyed black lemur *Eulemur macaco flavifrons* in intact and degraded forest fragments. Endangered Species Research 3: 239-247.

ARTICLES

Rapid lemur survey in northern Menabe

Melanie Dammhahn[1]*, Livia Schäffler[1], Claudia Fichtel[1], Peter M. Kappeler[1,2]
[1]Abteilung Verhaltensökologie and Soziobiologie, Deutsches Primatenzentrum, Kellnerweg 4, 37077 Göttingen, Germany
[2]Abteilung Soziobiologie and Anthropologie, Universität Göttingen, Berliner Straße 28, 37073 Göttingen, Germany
*Corresponding author: mdammha@gwdg.de

Keywords: *Microcebus*, *Lepilemur*, distribution, northern Menabe, conservation

The region of the Menabe Central includes the area surrounding Morondava from the sea to the foothills of the central highlands and contains one of the largest remaining tracts of dry deciduous forests in Madagascar. This region covers 125.000 ha and includes eight communities of the districts of Morondava and Belo sur Tsiribihina. A scientific workshop by Conservation International identified it as one of the two areas of highest conservation priority in Madagascar. In March 2006 the Malagasy government declared to establish a protected area in the Menabe Central. In collaboration with local, national and international NGOs and agencies, the Malagasy government has thereby cleared the way for a conservation programme that includes protection of the habitat of four flagships species (including *Microcebus berthae*), reforestation programs and the development of management plans for sustainable use of the forest and ecotourism. In order to contribute to an effective protection of the dry deciduous forests of Menabe, specific additional monitoring programs are required (see also Mittermeier *et al*., 1992, Ganzhorn *et al*., 1997). In an effort to contribute to such activities, we implemented a monitoring project to survey lemur populations in northern Menabe, which is not part of the protected area yet.

The central western region of Madagascar, bordered by the rivers Tsiribihina in the south and Manambolo in the north (Fig. 1) was never extensively surveyed for lemurs. In a brief survey conducted in 1993 on both banks of the Manambolo River, Thalmann and Rakotoarison (1994) reported first data on lemur distribution in central western Menabe. South of the Manambolo, they detected 10 lemur species, either by direct observations, by vocalizations or via tracks. Identification was unambiguous for *Propithecus v. coronatus*, *Eulemur fulvus rufus*, *Mirza coquereli*, *Cheirogaleus medius*, and *Microcebus murinus*. *Phaner furcifer* and *Hapalemur griseus occidentalis* were recognized by vocalizations only. The presences of *Daubentonia madagascariensis* was based on gnawing and bite marks only. Referring to the morphology of a single individual, the authors could not exclude *C. major* to be present. *Lepilemur* could not be identified to species level. Based on a rapid survey, Sterling (1998) reported the presence of *Eulemur fulvus rufus* and four nocturnal species as well as signs of *Daubentonia madagascariensis* from a forest south of the Manambolo river, west of Amboalimena and east of Ankevo.

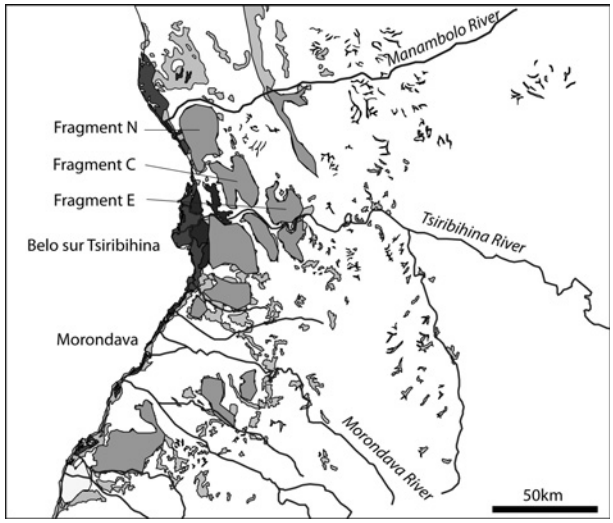

Fig. 1: The survey area in central western Madagascar between the rivers Tsiribihina in the south and Manambolo in the north. Remaining forest fragments in dark, the three visited forest blocks are indicated by arrows.

In a recent taxonomic revision of the genus *Lepilemur*, Andriaholinirina *et al.* (2006) assigned samples from this area to a new species *L. randrianasoli*, which differs from *L. ruficaudatus* in karyotype, being slightly smaller, and having a narrower and longer head (Andriaholinirina *et al*., 2006). Currently, the distribution of the species is restricted to the type locality (central fragment) and the Reserve Naturelle Intégrale Tsingy de Bemaraha with the Tsiribihina River being the southern limit. Thus, the species is most likely locally endemic with a very limited distribution. The narrow distribution of *L. randrianasoli*, paired with ongoing habitat loss in the area, indicates the species' high conservation priority, but details on geographic boundaries and its distribution are currently lacking.

Local people also reported the presence of a small mouse lemur, which was later identified as *M. myoxinus*; its presence was confirmed for the south of the Manambolo River in Amboalimena forest and near Belo sur Tsiribihina (Rasoloarison *et al*., 2000). To the north, the occurrence of *M. myoxinus* was reported from the northern bank of the Manambolo River (Thalmann and Rakotoarison, 1994), the Tsingy de Bemaraha National Park and Strict Nature Reserve (Rakotoarison *et al*., 1993, Rasoloarison *et al*., 2000), the Andranomanitsy Forest (Ralison, 2007), the Tsingy de Namoroka (Rasoloarison *et al*., 2000), and up to Baly Bay Area (Hawkins *et al*., 1998). Beyond the river Mahavavy, there is evidence for the presence of other mouse lemur species (Olivieri *et al*., 2005). The southern limit of the species is most likely the Tsiribihina River, because the area south of the river is inhabited by another locally endemic species, *M. berthae*, whereas the presence of *M. myoxinus* can be excluded (D. Zinner and L. Schäffler, unpubl. data). Few data on the distribution of *M. myoxinus* in northern Menabe are available and it remains unclear whether *M. myoxinus* and *M. murinus* occur sympatrically in that area.

The aim of this rapid survey was to provide detailed information on lemur species diversity as well as species boundaries and distribution of *Microcebus myoxinus* and the newly described *Lepilemur randrianasoli* in the three remaining fragments located between the rivers Tsiribihina and Manambolo (Fig. 1). This information is urgently required for an accurate assessment of the species' population size and conservation status.

Methods

We surveyed lemur populations in three fragments north of the Tsiribihina between 01. and 14.10.2007 (Fig. 1). In each fragment, we established transects of 1 km and used two census methods: nocturnal transect walks (all species) and line trapping (*M. berthae*, *M. murinus*, *M. myoxinus*, *C. medius*, *M. coquereli*). Furthermore, all occurrences of lemur species during explorations of the area, also outside of the predetermined transects were noted and included in presence-absence analyses. In total, we established two transects in each fragment N, C and E; due to security problems, fragment C was only surveyed and no trap-line was established.

Each transect was slowly walked (1 km/h) twice at night (6:30-9:30 h pm) by a pair of trained observers. An attempt was made to identify every sighted individual to species level, to estimate distance from the transect line and to determine the position on the transect via GPS. Additionally, we recorded all species-specific vocalizations as indicators of a given species presence. Trap-lines were established along each transect and consisted of 41 small Sherman live traps, one every 25 m, and 21 large Sherman live traps, one every 50 m. Traps were set for 3 consecutive nights and baited at dusk and checked and closed in the early morning. Additionally, an attempt was made to locate sleeping sites of sportive lemurs, where they could be captured by hand. All captured animals were briefly restrained and immobilized with Ketanest 100, identified to species level, sexed, aged (juvenile/adult), weighted and a set of standard morphological measurements were taken. Furthermore, tissue samples in form of small (2 - 3 mm^2) ear biopsies on both sides were taken for later DNA extraction and genetic analyses. All animals were released at the site of capture shortly before dusk at the same day.

Results

The forest of the eastern fragment (transects E1, E2) in the vicinity of the ephemeral Lac Hima was heavily degraded with numerous signs of fresh slash and burn activities, which resulted in a disrupted canopy. The northern fragment (transects N1, N2) showed signs of an uncontrolled forest fire from 2002/2003 but was only slightly degraded in other parts, still containing *Commiphora* trees.

In total we confirmed the presence of 6 species in the northern, eastern and central fragments, respectively (Table 1). Whereas, *M. murinus*, *M. coquereli*, *C. medius*, *P. pallescens* and *L. cf. randrianasoli* were found in each of the fragments, the presence of *M. cf. myoxinus* could only be confirmed in the northern and eastern fragment. Only one small group of *E. rufus* was sighted in the central fragment and the species was absent in the northern and eastern fragments. Diurnal *P. deckenii* could not be encountered anywhere during the survey. In interviews, however, villagers reported the presence of the two larger lemur species in very remote forest areas and they declared to hunt both species occasionally. *M. murinus* and *M. cf. myoxinus* co-occurred at 3 of the 6 transects and were seen partly at close distances (< 150 m) during nocturnal transect walks.

Table 1: Results of lemur surveys in northern Menabe.

Species	Transect					
	E1	E2	N1	N2	C1*	C2*
Microcebus myoxinus	s	x	x			s
Microcebus cf. myoxinus			x	x		
Microcebus murinus	x		s	x		
Cheirogaleus medius	s		x		s	
Mirza coquereli	s	s	s	v	v	v
Phaner pallescens	v	v	v	v	v	s
Lepilemur cf. randrianasoli	s			s	s	
Propithecus deckenii						
Eulemur rufus					s	

x = capture, s = sighting, v = vocalization, *Transects C1 and C2 were only surveyed and no trap-line was established

In total we caught seven *Microcebus* individuals, three of which could be clearly identified as *M. murinus* (Fig. 2), one resembled *M. myoxinus* as described by Rasoloarison *et al*. 2000 (Fig. 2) and three individuals were slightly more gracile than the *M. myoxinus* individual (Fig. 2) and had a more pointed nose, as is typical for *M. berthae*. They differed, however, clearly from *M. murinus* in having a reddish colouration and being smaller in body weight and several morphometric traits. For this report, we include all *Microcebus* differing from *M. murinus* in *M. cf. myoxinus* and await further genetic analyses for final species determination.

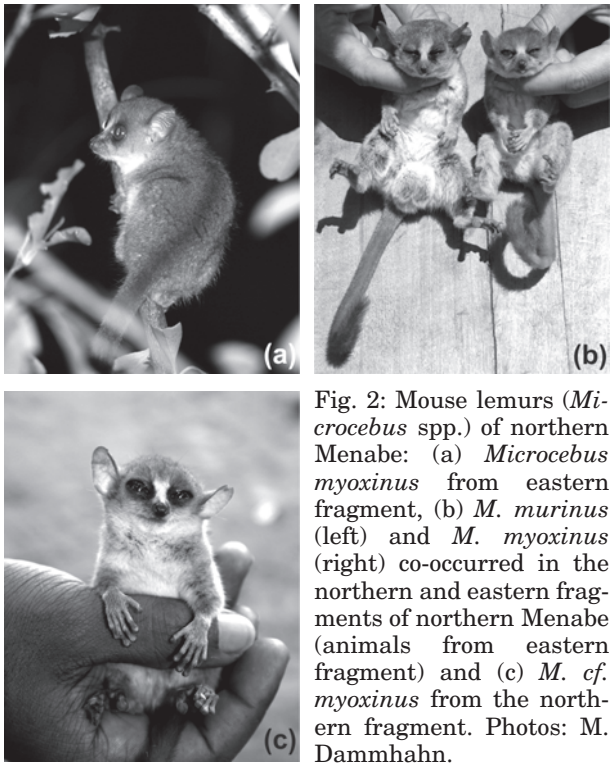

Fig. 2: Mouse lemurs (*Microcebus* spp.) of northern Menabe: (a) *Microcebus myoxinus* from eastern fragment, (b) *M. murinus* (left) and *M. myoxinus* (right) co-occurred in the northern and eastern fragments of northern Menabe (animals from eastern fragment) and (c) *M. cf. myoxinus* from the northern fragment. Photos: M. Dammhahn.

We measured several external characters from every individual (Table 2). Whereas, *M. cf. myoxinus* differed clearly from Kirindy *M. berthae* in having larger body length, head length and head width, it overlapped with

Kirindy *M. murinus* (Kirindy data: Dammhahn and Kappeler, 2005; M. Dammhahn, unpublished data). Ear length of *M. myoxinus* was similar to *M. berthae* and shorter than in *M. murinus* from Kirindy (Kirindy data from Rasoloarison *et al*., 2000). Body weight of *M. myoxinus* (41-51 g) was smaller than in the two *M. murinus* (57-70 g) and higher than Kirindy *M. berthae* (33 g, n = 54) at the same time of year.

Table 2: Morphometry (Mean ± SD) of *M. cf. myoxinus* (n=4) in comparison to *M. berthae* (n=108) and *M. murinus* (n=173) from Kirindy (Dammhahn and Kappeler, 2005; M. Dammhahn unpublished data).

	M. berthae	***M. murinus***	***M. cf. myoxinus***
Body length (mm)	77.1 ± 6.3	95.3 ± 7.2	93.0 ± 8.7
Head length (mm)	30.4 ± 0.8	34.5 ± 1.2	32.9 ± 1.4
Head width (mm)	19.3 ± 0.6	21.7 ± 0.9	21.1 ± 0.9
Ear length (mm)*	17.5	25	18.7
*Kirindy data from Rasoloarison *et al.*, 2000 (*M. berthae* n=3, *M. murinus* n=11)			

Because ecological and behavioural data on *M. myoxinus* are not available, we think that our *ad lib* observations during nocturnal transect walks are noteworthy. *M. myoxinus* individuals ranged in height between 1 and 10 m and used several different food sources including gum, homopteran secretion and fruits of the introduced Jujube (*Ziziphus zizyphus*, Rhamnaceae). One male had testes sizes which were close to maximal size in the Kirindy *M. murinus* population. All female individuals caught were not pregnant, not lactating and the vagina was closed.

Table 3: Morphometry of *L. cf. randrianasoli* (n = 3) in comparison to *L. ruficaudatus* (n=34) from Kirindy (Zinner *et al.*, 2003)

	L. ruficaudatus	***L. cf. randrianasoli***
Body mass (g)		
Mean ± SD	780 ± 88	777 ± 32
Min-Max	610 – 930	740 – 800
Head length (mm)		
Mean + SD	61,9 ± 2,0	61.4 ± 0.2
Min-Max	56.7 – 65.8	61.2 – 61.5
Head width (mm)		
Mean + SD	38.9 ± 1.0	36.3 ± 0.8
Min-Max	36.1 – 41.0	35.4 – 36.9

L. cf. randrianasoli was sighted frequently at one of the two transects in each fragment. During day searches we could not successfully localize inhabited sleeping sites of *Lepilemur* in the northern and eastern fragments. In the central fragment, however, we caught a total of 3 *L. cf. randrianasoli* close to the type location. These individuals as well as the individuals sighted during the transect walks matched colouration patterns of *L. randrianasoli* (Fig. 7 in Andriaholinirina *et al.,* 2006, own pictures from the type specimen). Morphometrically, the three individuals did only separate from Kirindy *L. ruficaudatus* (Zinner *et al*., 2003) in head width, whereas both species are similar in body mass and head length (Table 3). Thus, species determination based on external characters was difficult and genetic data will be used to unambiguously identify the animals caught.

Discussion

The results of our rapid survey covering the three larger remaining forest fragments between the rivers Tsiribihina in the south and Manambolo in the north confirmed the presence of *M. myoxinus* and *L. cf. randrianasoli* in northern Menabe. For unambiguous species determination further genetic analyses are under way. Individuals assigned to *M. cf. myoxinus* in this report were highly variable in external morphology; however, sample size was too small to test for any potential subgrouping patterns. Additionally, recent genetic analyses revealed incomplete lineage sorting between *M. berthae*, *M. myoxinus* and *M. rufus* (Heckman *et al*., 2007). Thus more comparative data on morphology, ecology and reproductive isolation, especially of the completely unstudied *M. myoxinus* is needed to verify species status of these groups and to clarify the status of *M. cf. myoxinus*.

Further, our results confirmed that *M. myoxinus* and *M. murinus* occur in sympatry also in different parts of northern Menabe, as has been proposed but not demonstrated before (e.g. Rasoloarison *et al*., 2000). *Ad libitum* observations revealed that *M. myoxinus* seems to feed omnivorously using similar resources as other western *Microcebus* species during the dry season, i.e. gum, fruit and homopteran secretions. External morphological signs (testes size and vaginal morphology) indicated a mating season of *M. myoxinus* beginning at the end of October. Also, *M. murinus* males caught in northern Menabe had maximal testes sizes and one female already showed signs of beginning reproductive activity. Thus, there are indications that the mating seasons of *M. myoxinus* and *M. murinus* population in northern Menabe may overlap. Given these similarities in feeding ecology and reproductive seasonality between the two co-occurring *Microcebus* species, mechanisms of ecological niche segregation, reproductive isolation and coexistence are very puzzling (see e.g. Dammhahn and Kappeler, 2008).

L. cf. randrianasoli was present in all three larger forest fragments in northern Menabe. However, the species was only sighted at one of the two transects per site, and densities varied between 1 to 5 individuals per 1 km-transect. Captured individuals matched colour patterns of *L. randrianasoli* (Andriaholinirina *et al*., 2006) but differed only marginally in external morphology from *L. ruficaudatus*. For unambiguous species determination further genetic analyses, e.g. determining the species-specific karyotyp, are necessary. Our results provided first details on this recently described species' distribution; however, further intensive surveys in the area are needed to estimate population densities of this locally endemic *Lepilemur*.

Signs of recent (illegal) logging, slash and burn agriculture, and (uncontrolled) burning for creation of cattle pasture highlight the high threat of the currently unprotected forests in northern Menabe. Because of its high lemur species richness including local endemics with narrow ranges the remaining forests of northern Menabe should be incorporated into conservation action plans.

Conclusions

The forests between the rivers Tsiribihina and Manambolo in northern Menabe are already highly fragmented and vanishing rapidly. Despite these threats they were

not subject to any extensive survey and are not protected yet. The results of our rapid survey documented the lemur species richness of this area including at least one locally endemic species (*L. cf. randrianasoli*). We propose further intensive surveys particularly in the northern fragment to clarify the taxonomic status and distribution of *M. cf. myoxinus* and the density and distribution of *L. cf. randrianasoli*.

Acknowledgements
This project was carried out in collaboration and consultation with the Ministry of the Environment, Water and Forests, their local representatives (CIREF Morondava), the CFPF Morondava, Durrell Wildlife Conservation Trust, FANAMBY, ANGAP, WWF Madagascar, Professor O. Ramilijaona and Prof. D. Rakotondravony of the Departément Biologie Animale of the Université d'Antananarivo with the necessary research permits. We thank Nielsen Rabarijaona, Jean-Pierre Rolojanahary, Bruno Tsivamerana, Remy Ampataka and Mamy Razafindrasamba for irreplaceable and unflagging assistance in the field and Léonard Razafimanantsoa and Dr. Rodin Rasoloarison for logistic support. We thank the Primate Action Fund of Conservation International for financial support. Additional funding and logistics were kindly provided by the German Primate Center (DPZ).

References

Andriaholinirina, N.; Fausser, J.-L.; Roos, C.; Zinner, D.; Thalmann, U.; Rabarivola, C.; Ravoarimanana, I.; Ganzhorn, J.U.; Meier, B.; Hilgartner, R.; Walter, L.; Zaramody, A.; Langer, C.; Hahn, T.; Zimmermann, E.; Radespiel, U.; Craul, M.; Tomiuk, J.; Tattersall, I.; Rumpler, Y. 2006. Molecular phylogeny and taxonomic revision of the sportive lemurs (*Lepilemur*, Primates). BMC Evol. Biol. 6: 17.

Dammhahn, M.; Kappeler, P.M. 2005. Social system of *Microcebus berthae*, the world's smallest primate. Int. J. Primatol. 26: 407-435.

Dammhahn, M.; Kappeler, P.M. 2008. Small-scale coexistence of two mouse lemur species (*Microcebus berthae* and *M. murinus*) within a homogeneous competitive environment. Oecologia 157: 473-483.

Ganzhorn, J.U.; Rakotosamimanana, B.; Hannah, L.; Hough, J.; Iyer, L., Olivieri, S.; Rajaobelina, S.; Rodstrom, C.; Tilkin, G. 1997. Priorities for biodiversity conservation in Madagascar. Primate Report 48-1: 1-81.

Hawkins, A.F.A.; Durbin, J.C.; Reid, D.B. 1998. The primates of the Baly bay area, north-western Madagascar. Folia Primatol. 69: 337-345.

Heckman, K.L.; Rasoazanabary, E., Machlin, E.; Godfrey, L.R.; Yoder, A.D. 2006. Incongruence between genetic and morphological diversity in *Microcebus murinus* of Beza Mahafaly. BMC Evol. Biol. 6: 98-109.

Mittermeier, C.G.; Konstant, W.R.; Nicoll, M.E.; Langrand, O. 1992. Lemurs of Madagascar: An action plan for their conservation 1993-1999. IUCN, Gland, Schweiz.

Olivieri, G.; Craul, M.; Radespiel, U.; Randrianambinina, B.; Rasoloharijaona, S.; Rabesandratana, A.; Zimmermann, E. 2005. Diversity and conservation status of mouse lemurs (*Microcebus* spp.) and sportive lemurs (*Lepilemur* spp.), including the description of five new species, in northern and northwestern Madagascar. Primate Report 72-1: 30.

Rakotoarison, N.; Mutschler, T.; Thalmann, U. 1993. Lemurs in Bemaraha (World Heritage Landscape, western Madagascar). Oryx 27: 35-40.

Ralison, J. 2007. Lemur survey of the Andranomanitsy Forest, region Besalampy, province of Mahajanga. Lemur News 12: 36-39.

Rasoloarison, R.M.; Goodman, S.M.; Ganzhorn, J.U. 2000. Taxonomic revision of mouse lemurs (*Microcebus*) in the western portions of Madagascar. Int. J. Primatol. 21: 963-1019.

Sterling, E. 1998. Preliminary report on a survey for Daubentonia madagascariensis and other primate species in the west of Madagascar, June-August 1994. Lemur News 3: 7-8.

Thalmann, U.; Rakotoarison, N. 1994 Distribution of lemurs in central western Madagascar, with a regional distribution hypothesis. Folia Primatol. 63: 156-161.

Zinner, D.; Hilgartner, R.; Kappeler, P.M.; Pietsch, T.; Ganzhorn, J.U. 2003. Social organization of *Lepilemur ruficaudatus*. Int. J. Primatol. 24: 869-888.

Grazing lemurs: exhibition of terrestrial feeding by the southern gentle lemur, *Hapalemur meridionalis*, in the Mandena littoral forest, southeast Madagascar

Timothy M. Eppley, Giuseppe Donati*
Nocturnal Primate Research Group, Department of Anthropology and Geography, Oxford Brookes University, Gipsy lane, OX3 0BP, Oxford, UK,
*Corresponding author: **gdonati@brookes.ac.uk**

Keywords: Grazing behaviour, forest degradation, folivores, southern gentle lemur, *Hapalemur meridionalis*

Gentle lemurs, or bamboo lemurs (genus *Hapalemur*), are peculiar as the majority of them subsist almost exclusively on bamboo (Tan, 1999, 2006). They are distributed in different Malagasy habitats, with many of their populations fragmented in the eastern and northern rain forests, the dry to sub-humid deciduous forests in the northwest, and the marshes in the central eastern area (Tan, 2006). Interestingly, some of these habitats are devoid of bamboo. The Alaotran gentle lemur (*Hapalemur alaotrensis*), for example, subsists mostly on the reed and papyrus beds surrounding Lac Alaotra and has been the focus of much research as it is of major conservation concern (Mutschler and Feistner, 1995; Mutschler *et al*., 1998, 2001). Similar to its congener, the southern gentle lemur, *H. meridionalis*, lives in an environment devoid of bamboo (Mutschler and Tan, 2003) throughout a patchy distribution in the southern-most regions of Madagascar (Mittermeier *et al*., 2006).

The southern gentle lemur was first described in 1987 (Warter *et al*.) as a subspecies of *H. griseus*, with the distinction based on karyological differences and a distinctly darker pelage (Warter *et al*., 1987). Recently, these lemurs were upgraded to full species status based on their mitochondrial DNA sequence (Fausser *et al*., 2002; Pastorini *et al*., 2002; Rabarivola *et al*., 2007). However, no systematic studies have been conducted on the behavioural ecology of the southern gentle lemurs until present.

In this report we present the results of a pilot study which was conducted to gain an initial understanding of the feeding ecology of the southern gentle lemur. A three month field study was carried out during the austral winter to elucidate the seasonal dietary niche of this little known lemur species within the Mandena Conservation Zone, one of the remaining fragments of littoral forest in southeastern Madagascar.

Methods

The Mandena Conservation Zone is located at 24°95'S 46°99'E (Fig. 1), encompassing an area of 148 hectares of fragmented and degraded littoral forest that are among the last in southeastern Madagascar. The area also includes approximately 82 ha of marsh/swamp that segregates the two fragments of the protected area (Ganzhorn *et al*., 2007). Littoral forests are defined as moist coastal forests that have developed on sandy substrates (Dumetz, 1999). They are characterised by high diversity of endemic species, making them among the most threatened ecosystems in Madagascar (Du Puy and Moat, 1996; Ganzhorn *et al*., 2001; Bollen and Donati, 2006).

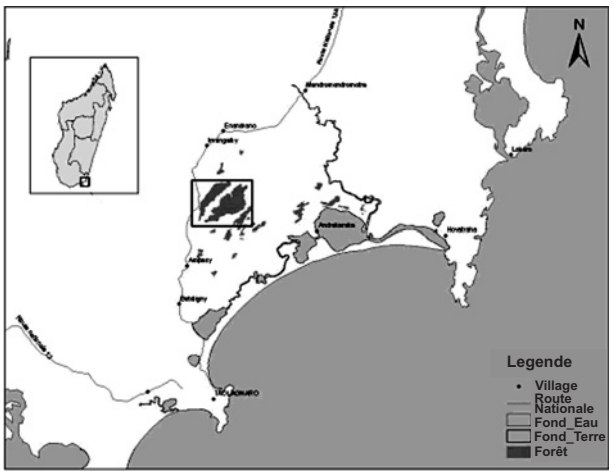

Fig. 1: Location of Mandena Conservation Zone in southeast Madagascar (QMM, 2008).

Southern gentle lemurs were initially censused by systematically searching predetermined areas within the littoral forest, as well as the marshes and swamp located between the two forest fragments. Once selected the study groups, the lemurs were habituated over the course of one month before proper data collection could commence. Daily observations were made from dawn to dusk (6:00 to 18:00 h) from May to July 2008. Dietary data were collected from 3 separate groups of *H. meridionalis*. The largest of these groups was 7 individuals, with the other two groups having 6 and 4 individuals. Observation distance of 3 to 15 m was maintained for all periods of data collection. Individuals were chosen at random for instantaneous focal sampling at 5-min intervals (Altmann, 1974), collecting broad behavioural data. The collection of data was suspended when the focal individual was no longer detected. Behaviours defined in the ethogram were broadly classified as rest, feed, travel, not detectable, and other (Mutschler, 1999). Also, the approximate height (0, 0-4, 4-8, >8 m) of the focal animals was recorded every time a feeding bout occurred. Feeding data, included the plant species and plant part being consumed, were collected via continuous focal sampling (Altmann, 1974). Feeding bouts were considered continuous until the animal disengaged from foraging for more than a sixty second period of time. Plant species were identified to both scientific (Family, genus, species) and vernacular nomenclature by Johny Rabenantoandry and Faly Randriatafika (QMM Environmental Program).

We applied the χ^2 non-parametric tests, as our data set was unable to fulfil the requirements of parametric methods. Statistics was run via SPSS 17.0 and regarded as significant when $p < 0.05$.

Results

Within the Mandena littoral forest, a total of 47 individuals (20.4 ind/km^2) of *H. meridionalis* were identified from 8 separate groups. The average group size was 5.75 ± 0.37 individuals (n = 8) ranging from 4 to 7 animals per group. Each group observed had one juvenile-sized animal while the study group of 7 individuals had two juvenile individuals.

Focal individuals were observed resting for 43.7 % of their time and feeding for 41.6 %. Also, groups spent 67.3 % of their time in the marsh/swamp area, with the remaining 32.7 % of time spent in the surrounding littoral forest. Focal animals were recorded on the ground (Fig. 2) for 69.3 % (n = 428 feeding bouts) of the total feeding time. They spent 9.9 % (n = 61 feeding bouts) at 0 - 4 m, 19.9 % (n = 123 feeding bouts) at 4 - 8 m, and less than 1 % (n = 5 feeding bouts) feeding in vegetation over 8 m (Fig. 3). We found a significant positive association between the frequency of feeding bouts on the ground and the presence of the lemurs in the swamp ($\chi^2 = 371.4$, $df = 2$, $p < 0.001$).

Fig. 2: Family unit of *Hapalemur meridionalis* foraging on various grass species of the Family Poaceae (photo by Tim Eppley).

The diet of *H. meridionalis* consisted of a mixture of monocots, leaves, lianas, fruits, flowers, and fungi. During the study period, the observed individuals fed on 23 different species from 14 families of which the ten most consumed are shown in Table 1. *Hapalemur meridionalis* spent 75.9 % of their time consuming 7 species of the family Poaceae. For each of these 7 grasses, the whole upper part (stem and leaves) was eaten. Nearly half of their time spent on grasses focused on a single species, *Panicum parvifolium*, while in the forest, animals were observed to feed the young leaves of the liana *Secamone* sp. for 7.2 % of the time. *Hapalemur meridionalis* appeared selective over which part of the sedge

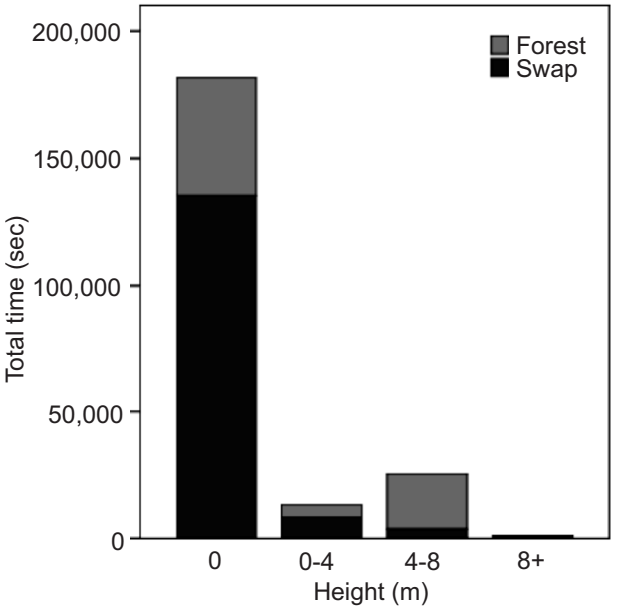

Fig. 3: Total time (sec) spent feeding at different heights (m) within the forest and swamp.

Cyperus sp., having been observed to feed on the young leaves the majority of the time but were also observed feeding on the soft pith of the upper shoots. The southern gentle lemurs spent 3.6 % of their time feeding on the tips of leaves from the liana *Flagellaria indica*, while minimal amounts of time were spent selecting the leaves and soft pith of various sedges, palms (*Dypsis* spp.), as well as feeding on flowers (2.4 %), fruits (1.9 %), and fungi (0.05 %).

Table 1: Ten most consumed plant species by *H. meridionalis*

Species	Family	Malagasy	Consumed parts	Percent feeding
Panicum parvifolium	Poaceae	ahipoly	leaves	35.2
Cynodon sp.	Poaceae	volonanondry	leaves	11.9
Panicum sp.	Poaceae	akatatsipiritry	leaves	11.9
Stenotaphrum dimidiatum	Poaceae	ahipisaka	leaves	10.3
Secamone sp.	Asclepiadaceae	vahihazo	leaves	7.2
Cyperus sp.	Cyperaceae	vendrana	leaves	5.6
Sclerya sp.	Poaceae	zozoro	leaves	4.5
Flagellaria indica	Flagellariaceae	vahipiky	leaves	3.6
Paspalum sp.	Poaceae	akatamanara	leaves	2.1
Ravenala madagascariensis	Strelitziaceae	ravinala	flower	1.7

Discussion

Although we were able to detect 47 *Hapalemur meridionalis* within the Mandena littoral forest, we can assume that more animals/groups still exist within this area. Though group composition was not always precisely determined, data collected from the three focal groups appear to be similar to congeners, consisting of 1 adult male, 1 or 2 adult females, and 1 or 2 offspring. Similar group sizes and compositions have been reported for congeners (Mutschler *et al*., 1998) and the largest group observed at Mandena was 7 individuals, concurrent to the findings of Mutschler and Tan (2003). The three groups of *H. meridionalis* of Mandena spent equivalent periods of time resting and feeding. Though we only have data for a short period, when compared with the behavioural time budget of *H. griseus*, *H. aureus*, and *Prolemur simus* (Tan, 2006), *H. meridionalis* activity pattern was found to be analogous (Fig. 4). Bamboo is the principal diet of most *Hapalemur* sp. (Tan, 1999, 2006). But also other primates have been observed feeding on bamboo both seasonally and/or opportunistically (Mutschler and Tan, 2003). In Ranomafana, three species of bamboo lemur (*H. griseus*, *H. aureus*, and *P. simus*) are year-round bamboo specialists, focusing 88 % of their diet on bamboo and other grasses in the family Poaceae (Tan, 1999). Bamboo is absent from this littoral forest habitat of Mandena (Mutschler and Tan, 2003) and we expected *H. meridionalis* to exploit other resources in this area.

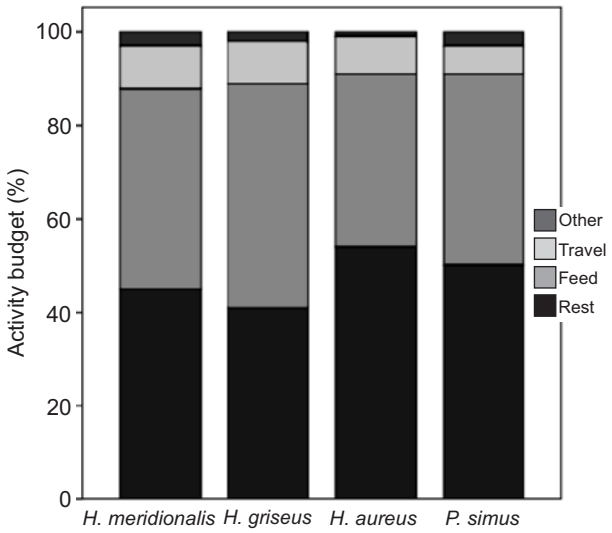

Fig. 4: Behavioural time budget of sympatric *Hapalemur* species in Talatakely, Ranomafana NP (Tan, 2006), and *Hapalemur meridionalis* in the Mandena littoral forest.

As for the plant families included in the diet, *H. meridionalis* within Mandena appeared similar to its congeners, spending over 75 % of its feeding time focused on grasses (Family Poaceae). However, possibly due to the absence of bamboo, these lemurs have resorted to foraging on terrestrial grasses. At Ranomafana National Park, *H. griseus* has been also observed foraging on terrestrial grasses, though this occurrence was seen very infrequently (C. Tan, pers comm). Furthermore, *H. aureus* and *H. griseus* are 99 % arboreal, a lifestyle very different from what is observed in *H. meridionalis*. The greater bamboo lemur, *P. simus*, spends 25-30 % of its time terrestrial or below 1 m feeding on the terrestrial grass *Poecilostachys festucaceus* (Tan, 1999). More recently, *H. g. occidentalis* have also been observed travelling by ground between forest patches in the Masoala peninsula (Martinez, 2008). Thus, terrestrial activities are not uncommon for bamboo lemurs, but observations of the time length recorded in our study were unlike any seen previously. Future long-term studies will clarify whether the extensive grazing behaviour exhibited by

Hapalemur meridionalis is only a seasonal phenomenon or whether it occurs year-round.

During the study period, *H. meridionalis* did not appear to be selective when foraging on grasses, while they did appear selective over which plant parts they feed on from other plant species. When feeding on terrestrial grasses, *H. meridionalis* fed on the entire plant: leaves, culm, and grains. While food items such as terrestrial grasses appear ubiquitous, this might not have always been the case within the forest. If this holds true, grazing behaviour might also be an adaptation to exist in a partially degraded ecosystem, as is the case for Mandena. Disturbance is known to increase the heterogeneity of forest, or ecosystems in general, thus increasing the diversity of plant species and/or food resources (Grassi, 2006). Low levels of disturbance may be beneficial for some folivorous primates as pioneer, light-gap, and terrestrial herbaceous vegetation is able to exploit greater light exposure (Ganzhorn, 1995; Oates, 1996).

Geladas (*Theropithecus gelada*) are the only other primates which exploit a completely graminivorous niche. Their dentition is adapted to this herbivorous diet through their smaller incisors and larger molars enabling them to consume large portions of abrasive, high-fibre vegetation (Dunbar and Bose, 1991). Congeners of *H. meridionalis* have dental specializations that allow them to deal with coarse, fibrous vegetation such as bamboo leaves and culms (Tan, 1999, 2006; Mutschler and Tan, 2003). This being the case, a rapid transition to a grass-dominated diet by *H. meridionalis* would not have such dramatic effects as might be the case with other primates.

With grazing come a number of threats to the livelihood of this species. While grazing, the groups of *H. meridionalis* are left open to aerial predation from the Frances's sparrowhawk (*Accipiter francesii*) and the Madagascar harrier hawk (*Polyboroides radiatus*) which have been observed to prey on *H. griseus* (Goodman *et al*., 1993; Karpanty and Goodman, 1999). In terms of predator avoidance, it has been suggested that exploiting exposed food resources at night would decrease the risk of diurnal raptor predation in comparison to foraging during the day (Curtis and Rasmussen, 2006). The *Hapalemur* population at Mandena most likely exhibits cathemerality, not adhering to a strict diurnal or nocturnal activity but rather distributing its activities uniformly throughout the daily 24 h cycle (Tattersall, 2006), perhaps as an anti-predator strategy. When searched for in the morning (6:00 h), individuals were never in the same area where researchers left them the previous evening (approximately 18:00 h). They were also observed on a few occasions feeding in the swamp three hours after nightfall (21:00 h). This was also the case in the early morning approximately an hour before the sun rose (5:00 h). Cathemerality, however, could also be dictated by other factors, such as the energetic constraints of these small-bodied folivorous primates and the consequent need to extend feeding time over the 24-hour cycle (Mutscheler, 1999; Donati *et al*., 2007). A similar situation has been observed at Lac Alaotra and in the Tampolo littoral forest where *Hapalemur sp*. exhibit a cathemeral activity cycle (Mutschler, 1999; Ratsirarson and Ranaivonasy, 2002).

Summarizing, *H. meridionalis* appears to be unusual among its congeners, at least seasonally, displaying a preference for terrestrial herbaceous vegetation, particularly grasses. The disposition towards feeding on the ground, especially in the swamp, make this taxon exceptional and of interest to further, long-term studies. The field data presented here may facilitate an initial understanding of the evolution and possible correlates of a terrestrial lifestyle in some lemur species.

Acknowledgements

We would like to thank the Ministère de L'Environnement, des Eaux et Forêts of the Malagasy government, the University of Antananarivo, and CAFF/CORE for permission to conduct research, as well as the Malagasy Institute for the Conservation of Tropical Environments (MICET) for all of their logistical assistance. Financial support was provided partly by the Chester Zoo (NEZS) and Qit Madagascar Minerals (QMM). We would also like to thank the QMM Environmental Team, especially Manon Vincelette, Jean-Baptiste Ramanamanjato, Johny Rabenantoandry, Faly Randriatafika, and Christophe for all of their advice, support, and logistical help. We are grateful to Jörg Ganzhorn for his continuous support. Thank you to the entire staff of the Oxford Brookes Primate Conservation MSc program, especially Simon Bearder and Anna Nekaris. My sincere gratitude goes to my field guide Robertin "Tintin" Ravelomanantsoa and research assistant Abi Coleman for their companionship and tireless help in the marecage.

References

Altmann, J. 1974. Observational study of behavior: sampling methods. Behaviour 49: 226-267.

Bollen, A.; Donati, G. 2006. Conservation status of the littoral forest of south-eastern Madagascar: a review. Oryx 40: 57-66.

Curtis, D.J.; Rasmussen, M.A. 2006. The evolution of cathemerality in primates and other mammals: a comparative and chronoecological approach. Folia Primatol. 77: 178-193.

Donati, G.; Bollen, A.; Borgognini-Tarli, S.M.; Ganzhorn, J.U. 2007. Feeding over the 24-h cycle: dietary flexibility of cathemeral collared lemurs (*Eulemur collaris*). Behav. Ecol. Sociobiol. 61: 1237-1251.

Dumetz, N. 1999. High plant diversity of lowland rainforest vestiges in eastern Madagascar. Biodivers. Conserv. 8: 273-315.

Dunbar, R.I.M.; Bose, U. 1991. Adaptation to grass-eating in gelada baboons. Primates 32: 1-7.

Du Puy, D.J.; Moat, J. 1996. A redefined classification of the primary vegetation of Madagascar based on the underlying geology: using GIS to map its distribution and to assess its conservation status. Pp. 205-218. In: W.R. Lourenço (ed.). Biogeography of Madagascar. Orstom, Paris, F.

Fausser, J.-L.; Prosper, P.; Donati, G.; Ramanamanjato, J.-B.; Rumpler, Y. 2002. Phylogenetic relationships between *Hapalemur* species and subspecies based on mitochondrial DNA sequences. BMC Evol. Biol. 2: 1-9.

Ganzhorn, J.U. 1995. Low-level forest disturbance effects on primary production, leaf chemistry, and lemur populations. Ecology 76: 2084-2096.

Ganzhorn, J.U.; Lowry II, P.P.; Schatz, G.E.; Sommer, S. 2001. The biodiversity of Madagascar: one of the world's hottest hotspots on its way out. Oryx 35: 346-348.

Ganzhorn J.U.; Andrianasolo, T.; Andrianjazalahatra, T.; Donati, G.; Fietz, J.; Lahann, P.; Norscia, I.; Rakotondranary, J.; Rakotondratsima, B.M.; Ralison, J.; Ramarokoto, R.E.A.F.; Randriamanga, S.; Rasari-

manana, S.; Rakotosamimanana, B.; Ramanamanjato, J.-B.; Randria, G.; Rasolofoharivelo, M.T.; Razanahoera-Rakotomalala, M.; Schmid, J; Sommer, S. 2007. Lemurs in evergreen littoral forest fragments. Pp. 223-225. In: J.U. Ganzhorn, S.M. Goodman, M. Vincelette (eds.). Biodiversity, ecology, and conservation of the littoral ecosystems in southeastern Madagascar. Tolagnaro (Fort Dauphin), Smithsonian Institution, Washington, D.C., USA.

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

Grassi, C. 2006. Variability in habitat, diet, and social structure of *Hapalemur griseus* in Ranomafana National Park, Madagascar. Am. J. Phys. Anthropol. 131: 50-63.

Karpanty, S.M.; Goodman, S.M. 1999. Diet of the Madagascar harrier-hawk, *Polyboroides radiatus*, in south-eastern Madagascar. J. Raptor Res. 33: 313-316.

Martinez, B. 2007. Occurrence of bamboo lemurs, *Hapalemur griseus occidentalis*, in an agricultural landscape on the Masoala Peninsula. Lemur News 13: 11-14.

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

Mutschler, T. 1999. Folivory in a small-bodied lemur: the nutrition of the Alaotran gentle lemur (*Hapalemur griseus alaotrensis*). Pp. 221-239. In: H. Rasaminanana, B. Rakotosamimanana, J.U. Ganzhorn, S. M. Goodman (eds.). New directions in lemur studies. Kluwer Academic/Plenum Publishing, New York, USA.

Mutschler, T.; Feistner, A.T.C. 1995. Conservation status and distribution of the Alaotran gentle lemur *Hapalemur griseus alaotrensis*. Oryx 29: 267-274.

Mutschler, T.; Tan, C.L. 2003. Genus *Hapalemur*. Pp. 1324-1329. In: S.M. Goodman, J. Benstead (eds.). Natural history of Madagascar. University of Chicago Press, Chicago.

Mutschler, T.; Feistner, A,T.C.; Nievergelt, C.M. 1998. Preliminary field data on group size, diet and activity in the Alaotran gentle lemur *Hapalemur griseus alaotrensis*. Folia Primatol. 69: 325-330.

Mutschler, T.; Randrianarisoa, A.J.; Feistner, A.T.C. 2001. Population status of the Alaotran gentle lemur *Hapalemur griseus alaotrensis*. Oryx 35: 152-157.

Oates, J.F. 1996. Habitat alteration, hunting and the conservation of folivorous primates in African forests. Aust. J. Ecol. 21: 1-9.

Pastorini, J.; Forstner, M.R.J.; Martin, R.D. 2002. Phylogenetic relationship of gentle lemurs (*Hapalemur*). Evol. Anthropol. (Suppl. 1): 150-154.

Rabarivola, C.; Prosper, P.; Zaramody, A.; Andriaholinirina, N.; Hauwy, M. 2007. Cytogenetics and taxonomy of the genus *Hapalemur*. Lemur News 12: 46-49.

Ratsirarson, J.; Ranaivonasy, J. 2002. Ecologie des lémuriens dans la forêt littorale de Tampolo. Lemur News 7: 26-30.

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

Tan, C.L. 2006. Behavior and ecology of gentle lemurs (genus *Hapalemur*). Pp. 369-381. In: L. Gould and M. Sauther (eds.). Lemurs: ecology and adaptation. Springer Science&Business Media LLC, New York.

Tattersall, I. 2006. The concept of cathemerality: history and definition. Folia Primatol. 77: 7-14.

Warter, S.; Randrianasolo, G.; Dutrillaux, B.; Rumpler, Y. 1987. Cytogenetic study of a new subspecies of *Hapalemur griseus*. Folia Primatol. 48: 50-55.

Note on lemurs of the Réserve Spéciale d'Ambohitantely, Madagascar

José M. Ralison
Vahatra BP 3972, Antananarivo 101, Madagascar et Département de Biologie Animale, Université d'Antananarivo, BP 906, Antananarivo 101, Madagascar,
jo_ralison@yahoo.fr

Malagasy intact forests are disappearing due to anthropogenic pressure. Remnants are continually fragmented and isolated, especially in the central highlands. The Réserve Spéciale (RS) d'Ambohitantely of the central high plateau of Madagascar represents one of the forest vestiges suffering repetitive annual fires. This protected area is located in the southeastern side of the Ankazobe *tampoketsa* (old eroded surface restricted to high ground in the surrounding relief) some 130 km northwest of Antananarivo and occupies a surface of ca. 5,600 ha (natural forest, savanna grassland, and exotic tree plantation). Although many studies on forest fragmentation of vertebrates have been carried out in this reserve (Andrianarimisa *et al*., 2000; Goodman and Rakotondravony, 2000; Vallan, 2003), lemur census are rare (Petter and Andriatsarafara, 1987; Goodman, 2000).
This short paper summarizes the result of a brief lemur census in the biggest fragment "Control site" (1250 ha) conducted in January 2007 during the field school conducted by the RAP Gasy team (Rapid Assessment Program Gasy). Observation methods were described in Ralison (2007).
Lemur species encountered were: one diurnal species (*Eulemur fulvus*) and three nocturnal species (*Avahi laniger*, *Cheirogaleus* sp. and *Microcebus rufus*). *Microcebus* and *Cheirogaleus* were not seen in the valley. More than two individuals of *Cheirogaleus* often foraged on the same tree between 2 to 8 m above the ground. Morphological traits (nose, rings on the eyes and pelage) of this species ressembled *C. crossleyi* as defined by Groves (2000). For *Avahi laniger*, the presence of babies on the mother's back was noted at this time. For diurnal lemurs, one group of *E. fulvus* composed by 10 individuals was observed near our campsite and another group with more than five individuals was found along the botanical trail.

References

Andrianarimisa, A.; Bachman, L.; Ganzhorn, J.U.; Goodman, S.M.; Tomiuk, J. 2000. Effects of forest fragmentation on genetic variation in endemic understory forest birds in central Madagascar. J. Ornithol. 141: 152-159.

Goodman, S.M. 2000. Les lémuriens d'Ambohitantely. Pp. 71-74. In: J. Ratsirarison and S. M. Goodman (eds.). Monographie de la forêt d'Ambohitantely. Recherche pour le Développement, Série Sciences Biologiques, 16.

Goodman, S.M.; Rakotondravony, D. 2000. The effects of forest fragmentation and isolation on insectivorous small mammals (Lypotyphla) on the Central High Plateau of Madagascar. J. Zool. 250: 193-200.

Groves, C.P. 2000. The genus *Cheirogaleus*: Unrecognized biodiversity in dwarf lemurs. Int. J. Primatol. 21: 943-962.
Langrand, O.; Wilme, L. 1997. Effects of forest fragmentation on extinction patterns of the endemic avifauna on the central high plateau of Madagascar. Pp 280-305. In: Goodman SM, Patterson BD (eds.). Natural Change and Human Impact in Madagascar. Smithsonian Institution Press, Washington, USA.
Petter, J-J.; Andriatsarafara, F. 1987. Conservation status and distribution of lemurs in the west and northwest of Madagascar. Primate Cons. 8: 169-171.
Ralison, J.M. 2007. Les lémuriens du "Couloir forestier d'Anjozorobe – Angavo". Pp. 183-202. In: S.M. Goodman, L. Wilmé (eds.). Inventaires de la faune et flore du couloir forestier d'Anjozorobe – Angavo. Recherche pour le développement, Série Sciences Biologiques, 24.
Vallan, D. 2003. Consequences of rain forest fragmentation for herpetofauna: A Case Study from Ambohitantely. Pp. 899-907. In: S.M. Goodman, J.P. Benstead (eds.). The Natural History of Madagascar. The University of Chicago Press, Chicago, USA.

Population genetic parameter estimates for six populations of crowned lemurs, *Eulemur coronatus* (Gray, 1842), from northern Madagascar

Ravaka Ramanamahefa[1], Susie M. McGuire[2], Edward E. Louis, Jr.[2], Rick A. Brenneman[2]*
[1]Department of Paleontology and Anthropology, University of Antananarivo, Madagascar
[2]Center for Conservation and Research, Omaha's Henry Doorly Zoo, 3701 South 10th Street, Omaha, USA
*Corresponding author: **rabr@omahazoo.com**

Keywords: Crowned lemur, *Eulemur*, population genetics, Madagascar

The crowned lemur, *Eulemur coronatus*, the smallest of the *Eulemur* species (Terranova and Coffman, 1997), inhabits moist to dry tropical forest habitats below 1400 m across the northern tip of Madagascar (Fig. 1). Often found sympatrically with Sanford's brown lemur, *E. sanfordi* (Wilson *et al*., 1988; Freed, 1996), this cathemeral lemur (Freed, 1996) is primarily frugivorous and utilizes the smaller trees in the forest's understory (Sussman, 2002). As with other brown lemur species, the crowned lemurs are sexually dichromatic (Fig. 2). Males are reddish brown dorsally and pale brown ventrally with a notably dark grey to black V-shaped marking on the head which circles laterally down the cheeks. Females, on the other hand, are dorsally brownish grey and ventrally white. Additionally, the reddish crown on the female lacks the dark center and does not extend onto the face.

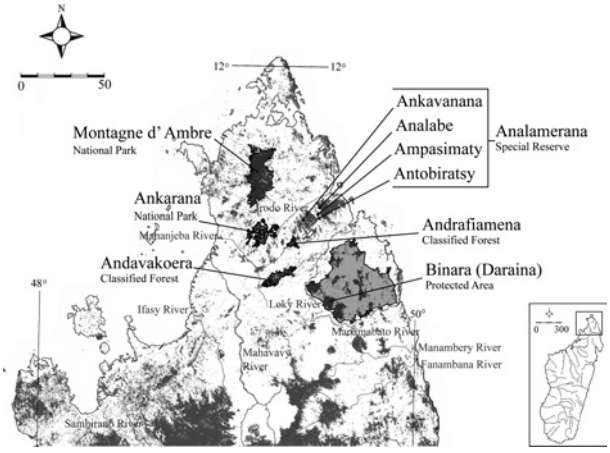

Fig. 1: Distribution of sample sites in the northern tip of Madagascar for *Eulemur coronatus*.

Fig. 2: Male (left) and female (right) crowned lemur, *Eulemur coronatus*, from Ankavanana, Analamerana (photos by Rambinintsoa Andriantompohavana).

The ecology of *E. coronatus* has been well documented and studied in a range of habitat types (Wilson *et al*., 1988; Hawkins *et al*., 1990; Freed, 1996). Expected densities vary greatly among the habitats, increasing in number in the drier forest types (Wilson *et al*., 1988; Fowler *et al*., 1989). Crowned lemurs are listed as Vulnerable, B1ab (i, ii, iii, v), with a decreasing population trend (IUCN, 2008). Little information exists regarding the genetic structure within and among crowned lemur populations. This study is the first to establish baseline parameters for *E. coronatus*.

Methods

Eighty *Eulemur coronatus* individuals were sampled from six populations as follows: Montagne d'Ambre National Park, Ankarana National Park, and the Ampasimaty, Antobiratsy, Analabe, and Ankavanana forests of the Analamerana Special Reserve (Fig. 1). We selected individuals by proximity to the immobilization team while considering the safety of the lemur with respect to position and dart placement. Although crowned lemurs have been documented and sampled from Andrafiamena (Ranaivoarisoa *et al*., 2006), Andavakoera (Zaonarivelo *et al*., 2007), and Daraina (Binara Forest, unpublished data; Fig. 1), a comparative sample set was not completed for any of these sites minimum of ten individuals per population) and were not included in this study. Animals were sedated with Telazol® (Fort Dodge Animal Health, Overland Park, Kansas) at a dose of 10 mg/kg body weight utilizing a CO_2-powered Dan Inject® (DanInject, Kolmården' Sweden) rifle and darting system (Type C; disposable dart, Pneu-Dart, Williamsport, Pennsylvania). In order to document capture and release sites, the coordinates were recorded using a hand-held Global Positioning System (GPS).

Sedated individuals were weighed using Pesola (Pesola AG, Baar, Switzerland) scales. Morphometric measurements were taken according to Smith and Jungers (1997) with temperature, heart rate, and respiratory rate continuously monitored (**www.omahazoo.com/ccr/genetics/lemur/index.asp?page=ccr/genetic/eulemurcoronatus.htm**). Lemurs were designated as adult or juvenile according to their body length and the tooth characteristics. Two 2 mm biopsy punches were taken from the ear pinnae of each animal and were deposited into 1.8 ml Nunc® tubes containing 0.5 ml of room temperature tissue preservative buffer (Longmire *et al.*, 1992). Additionally, a whole blood sample was drawn from the femoral vein at a ratio of 1ml/kg body weight and was deposited directly into room temperature blood storage solution (0.1 M tris base, 0.1 M Sodium EDTA, 2 % SDS; Longmire *et al*., 1992). A microchip (Home Again, East Syracuse, NY) was inserted subcutaneously between the scapulae providing permanent identification. Lactate Ringer's solution (Abbot Laboratories, Chicago, Illinois) equal to twice the volume of blood drawn was administered subcutaneously to replace fluid volume lost. Upon recovery, each lemur was released unharmed at its capture location permitting re-association to the original social group.

Genomic DNA was isolated from blood or tissue according to standard procedures (Sambrook *et al*., 1989). Thirteen microsatellite loci developed from the *Eulemur rubriventer* genome (Andriantompohavana *et al*., 2007) were cross-amplified and screened in the six *E. coronatus* populations. PCR amplification was carried out and fragment analysis was performed as described by Andriantompohavana *et al*. (2007).

The generated data was evaluated for genotype errors (Morin *et al*., 2009) with both Micro-Checker (van Oosterhout *et al*., 2004) and Microsatellite Analyser (MSA; Dieringer and Schlötterer, 2002). CERVUS 2.0 (Slate *et al*., 2000) was utilized to estimate null allele frequencies for each locus, along with marker utility as polymorphic information content (PIC).

A basic assumption of linkage equilibrium for the accepted loci was verified (with Bonferroni-adjusted *P*-values) in FSTAT (Goudet, 1995; 2001). The microsatellite suite was tested globally and by population for deviations from Hardy-Weinberg equilibrium (HWE) using Fisher's exact probability test in the web-based Genepop 3.4 (Raymond and Rousset, 1995). Initially, we used the default settings for the Markov chain Monte Carlo (MCMC) estimation of HWE, and then increased the batch size from 100 to 250 to reduce the standard error of the *P*-value to 0.01 or less. The rarefacted allelic richness (*AR*) were estimated by locus and population in FSTAT. Wright's *FIS* (within population *f* statistic) and Wright's *FST* (among population *f* statistic) were estimated in FSTAT (Weir and Cockerham, 1984). The Mantel test was performed in Genepop 3.4 deriving a regression of *FST* on the logarithm of the Euclidean distance between the sampling locations to determine the effect of isolation by distance. Gene flow between populations was estimated as *NM* (migrants per generation) using the private alleles method in Genepop 3.4. Population differentiation was tested by comparing allele and genotype distributions between populations using the genic and genotypic differentiation pairwise options in Genepop 3.4, assuming a null hypothesis (i.e. no differences between the populations and the allele or genotype distributions are the same).

We used SPAGeDi 1.2 (Hardy and Vekemans, 2002) to estimate relationship coefficients for each dyad whether or not biologically able to reproduce. The estimated relationship coefficient distributions were overlaid on the distributions produced by the Queller and Goodnight (1989) method in a simulation of 10,000 individuals of known multilocus genotypes and pedigree relationships.

The two most common estimators for single-sampled populations, linkage disequilibrium (LD; Hill, 1981) and heterozygote excess (HEx; Pudovkin *et al*., 1996) were used to estimate the number of effective breeders (*Neb*) using NeEstimator to establish a range of *Neb* (Peel *et al*., 2004) as recommended by Waples (1991). The six populations were estimated for evidence of a recent genetic bottleneck using Bottleneck 2.0 (Cornuet and Luikart, 1996; Cornuet *et al*., 1999; Piry and Cornuet, 1999), utilizing the three available models, the Infinite Alleles Model (IAM), the Stepwise Mutation Model, and the Two Phase Model (TPM). TPM permits single step as well as multi step mutation events (Di Rienzo *et al*., 1994).

Furthermore, the model-based clustering program STRUCTURE 2.0 (Pritchard *et al*., 2000) was utilized to test for cryptic substructure within the populations. The ancestry model with admixture, correlated allele frequencies, and different *FST* values were assumed for each subpopulation, with a uniform prior for alpha (max: 10, SD for updating: 0.025), a constant lambda value (1), a prior *FST* mean (0.01) and standard deviation (0.05). We tested three genetic clusters more than the number of sampling locations (1-9) as suggested by Evanno *et al*. (2005). The initial burn in period was set at 10^5 iterations to reduce noise before launching 10^6 MCMC repetitions to obtain the genetic cluster proportion estimates (*q*) for each individual. The *ad hoc* test statistic ΔK (Evanno *et al*., 2005) was used to aid in elucidating the most likely number of genetic clusters. We then compared the model with the highest posterior probability and the model with the maximum ΔK to the demographic populations. While Cornuet and Luikart (1996) and Paetkau *et al*. (2004) warn of small sample size bias in their simulations, Pritchard *et al*. (2000) demonstrated the utility of the program with small data sets (n = 4 individuals typed with 7 loci).

Results

Populations were tested for significant morphometric differences in pairwise tests, but ANOVA analyses indicated that none were found to be significant (data not shown). The averages for the various measurements collected with standard deviations are presented in Table 1.

Table 1: Morphometric measurement averages with standard deviations across all *Eulemur coronatus* populations sampled. Weight in kg; other measurements in cm.

Weight	1.3 (0.2)	Length	28.1 (1.8)
Head Crown	9.8 (0.8)	Tail	48.1 (3.2)
Phallux	3.0 (0.5)	Hallux	5.6 (0.5)
Long Digit	2.9 (0.4)	Rear Long Digit	3.0 (0.4)
Hand	6.4 (0.5)	Foot	9.7 (0.6)
Radius/Ulna	8.9 (0.6)	Tibia	10.9 (0.9)
Humerus	7.6 (0.8)	Femur	11.8 (0.8)

Of the 13 loci amplified, two loci that contained greater than moderate estimates of null allele frequencies (*nf* > 0.2) were eliminated (Callen *et al*., 1993, Hoffman and Amos, 2005; Chapuis and Estoup, 2007). Each locus pair was found to be in linkage equilibrium, satisfying the assumption of marker independence. We report the relative quality of the loci in these data as polymorphic information content (PIC) values and locus characteristics in Table 2. The mean number of alleles was 7.5 per locus and 4.9 per population. One locus (EUL164) and two of the sample sites (Ankarana and Analabe) deviated by exact tests from Hardy-Weinberg equilibrium ($P < 0.05$).

Table 2: Number of alleles detected (k) and global tests for the eleven microsatellite loci for observed and expected heterozygosities (HO and HE respectively), polymorphic information content (PIC), significance of deviation from Hardy-Weinberg equilibrium (HWE), and Wright's F-statistics for overall (*FIT*), among population (*FST*) and within population (*FIS*) fixation indices.

Locus	k	Ho	He	PIC	HWE	*FIT*	*FST*	*FIS*
EUL16	6	0.663	0.762	0.718	NS	0.152	0.033	0.122
EUL35	5	0.663	0.641	0.590	NS	-0.024	0.057	-0.117
EUL42	6	0.788	0.808	0.773	NS	0.048	0.099	-0.057
EUL83B	8	0.637	0.735	0.689	NS	0.144	0.083	0.068
EUL91	9	0.450	0.544	0.516	NS	0.182	0.016	0.169
EUL119	8	0.676	0.768	0.725	NS	0.144	0.072	0.084
EUL124	7	0.563	0.524	0.485	NS	-0.099	0.020	-0.120
EUL164	7	0.500	0.703	0.653	*	0.315	-0.008	0.323
EUL287	9	0.722	0.758	0.716	NS	0.046	0.017	0.028
EUL475	9	0.557	0.625	0.574	NS	0.140	0.154	-0.140
EUL480	9	0.613	0.724	0.696	NS	0.157	0.025	0.137
*$P < 0.05$; NS not significant								

Establishing baseline parameters for the crowned lemur, population genetic estimates, evidence for bottleneck, and estimates of *Neb* are presented in Table 3. Populations were differentiable by *FST* which was generally low but significant between most of the populations (Table 4), while genic and genotypic differentiation was significant between most population pairs. Ampasimaty, Antobiratsy and Analabe tended to show more similarity than more distant population pairs (Table 5). However, isolation by distance was positively correlated though not significant (Fig. 3). Only the Analabe population was significant for the difference between observed and expected heterozygosity (0.527 and 0.671, $P < 0.01$ one-tailed *t*-test). Analabe was also the only population with a high *FIS* estimate (*FIS* = 0.214).

Table 4: Population differentiation estimated with *FST* below and significance above the diagonal using FSTAT.

	Ampasimaty	Antobiratsy	Ankavanana	Ankarana	Montagne d'Ambre	Analabe
Ampasimaty		NS	NS	NS	*	NS
Antobiratsy	0.0122		**	**	**	NS
Ankavanana	0.0529	0.0855		***	***	*
Ankarana	0.0094	0.0341	0.0960		***	**
Montagne d'Ambre	0.0341	0.0710	0.0870	0.0725		*
Analabe	0.0043	0.0235	0.0534	0.0402	0.0569	
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; NS not significant						

We found that the overall relationship distributions in each population demonstrate a level of relatedness slightly higher than the relationship coefficient distribution for unrelated individuals (Fig. 4a-f). Comparing the multilocus genotypes within each dyad independently, we found 13 of the 3081 dyads could not be excluded as parent offspring relationships by allelic transmission inheritance (data not shown). One pair (out of 45 possible dyads in the population) qualified as parent offspring in the Montagne d'Ambre population, one pair (out of 45) in the Antobiratsy population and eleven pair (out of 378) in the Ankarana population. The majority of the eleven dyads involved ANK1, CAR2, CAR5 and CAR8 with each other and other individuals.

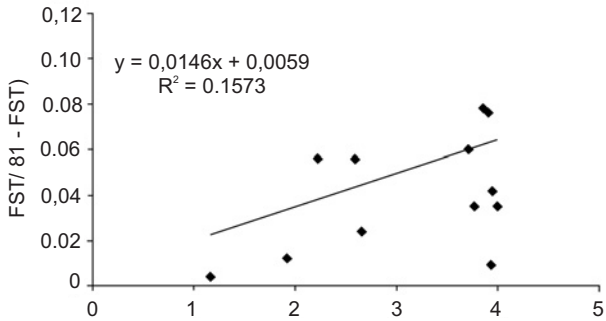

Fig. 3: Isolation by distance regressing *FST*/ (1-*FST*) on the logarithm of the Euclidean distance. $P = 0.3844$.

Table 3: Population genetic parameter estimates for n individuals from each of six populations, number of years sampled (Yrs), number of groups with more than one individual sampled (Groups), number of single samples for a given GPS location (Singles), significance of deviation from Hardy-Weinberg equilibrium (HWE), mean number of alleles (MNA), rarefacted allelic richness (*AR*), observed and expected heterozygosities (HO and HE respectively), detection of a recent bottleneck event (BNK) and the number of effective breeders (*Neb*) in each population estimated with the linkage disequilibrium method (LD) and 95 % confidence interval (CI).

	n	Yrs	Groups	Singles	HWE	MNA	*AR*	Ho	He	*FIS*	BNK	*Neb*	
												LD	95% CI
Ampasimaty	10	1	1	4	NS	4.9	4.5	0.777	0.720	-0.080	*	9.4	7.1- 13.2
Antobiratsy	11	2	3	1	NS	5.2	4.5	0.649	0.691	0.061	NS	41.9	21.2-342.8
Ankavanana	10	1	3	1	NS	4.5	4.0	0.642	0.649	0.010	NS	16.0	10.5-30.1
Ankarana	28	2	ND	ND	*	5.2	3.9	0.570	0.626	0.089	*	64.7	39.6-150.7
Montagne d'Ambre	11	1	2	6	NS	4.9	4.4	0.648	0.680	0.047	NS	18.9	12.6-34.1
Analabe	10	2	3	2	*	4.7	4.3	0.527	0.671**	0.214	NS	24.0	14.2-62.2
*$P < 0.05$; **$P < 0.01$; NS not significant; ND not determined													

Table 5: Population differentiation by allele frequency distributions (allele differentiation) and genotypic distributions (genotypic differentiation).

Population Pairs	Allele differentiation	Genotypic differentiation
Ampasimaty X Antobiratsy	NS	NS
Ampasimaty X Ankavanana	**	**
Ampasimaty X Ankarana	**	*
Ampasimaty X Montagne d'Ambre	**	**
Ampasimaty X Analabe	**	NS
Antobiratsy X Ankavanana	****	****
Antobiratsy X Ankarana	****	****
Antobiratsy X Montagne d'Ambre	****	****
Antobiratsy X Analabe	*	NS
Ankavanana X Ankarana	****	****
Ankavanana X Montagne 'd Ambre	****	****
Ankavanana X Analabe	****	***
Ankarana X Montagne d'Ambre	****	****
Ankarana X Analabe	****	***
Montagne d'Ambre X Analabe	****	****

*P < 0.05; **P < 0.01; ***P < 0.001; ****P < 0.0001; NS not significant

We found slight evidence for genetic bottleneck in the Ampasimaty and Ankarana populations ($P < 0.05$) under the IAM only. We estimated an average gene flow of 1.52 migrant exchanges per generation following a correction for sample size among the populations. The range of effective migrants was from 0.97 between Ampasimaty and Ankavanana to 2.33 between Ankavanana and Montagne d'Ambre. Only the LD method for estimating the number of effective breeders yielded

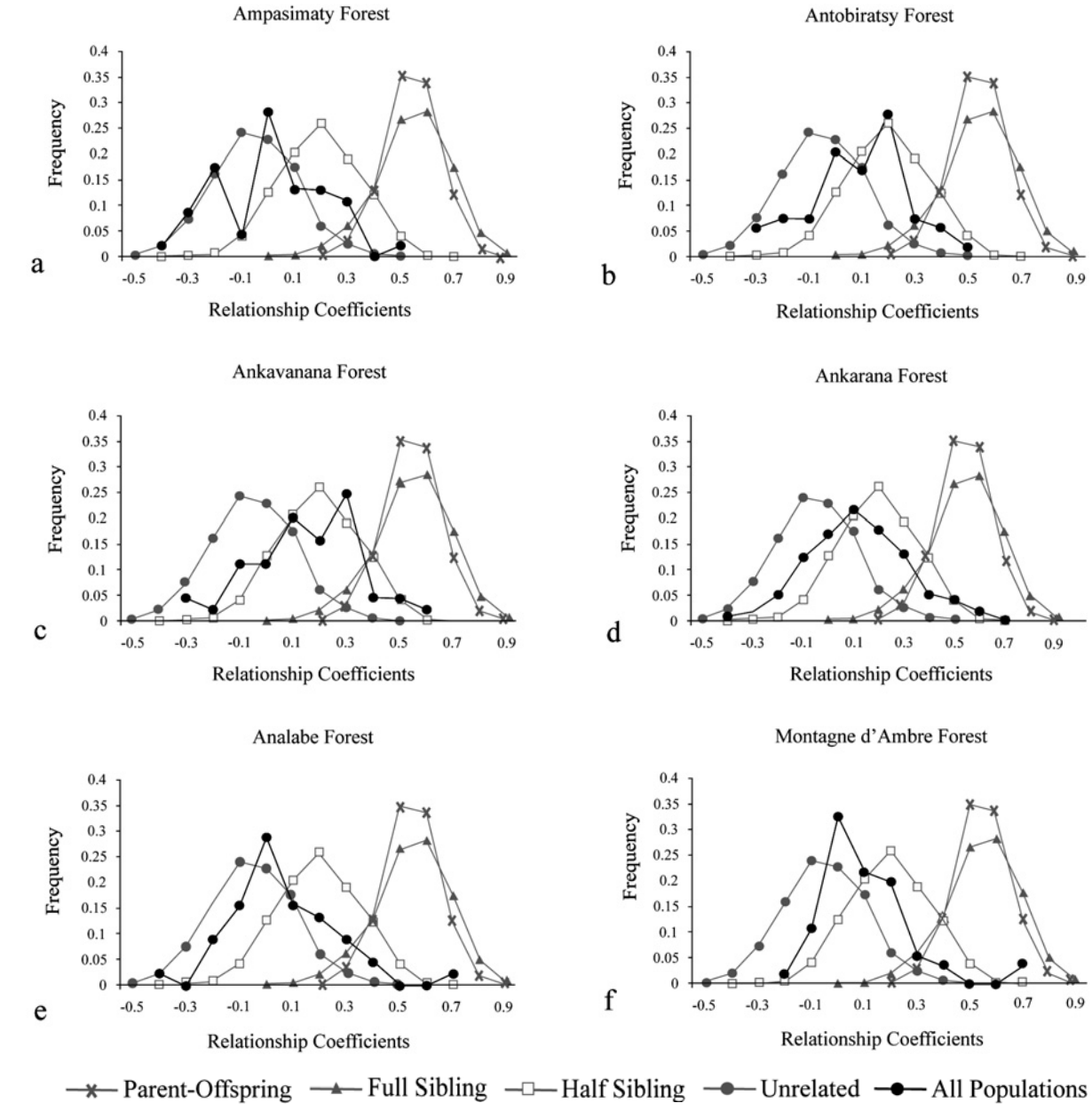

Fig 4: Relationship coefficient distributions for each of the forests overlaid on the frequency distributions derived from multilocus genotypes from 10,000 individuals of known relationship status.

meaningful results. Those estimates and 95 % confidence interval (CI) are presented in Table 3. Population substructure was not detected by either the posterior probability of *Q* or *K* (K = 1, data not shown).

Discussion

The results from the morphometric analyses and from the population genetics estimates show that the crowned lemur (*Eulemur coronatus*) is a species with little variation even though some population pairings themselves are distinguishable. The average weights of the individuals sampled in this study were greater (outside the 95 % CI) than wild caught *E. coronatus* values reported by Terranova and Coffman (1997). This discrepancy could be due to differences of sampling sizes between Terranova and Coffman's study (n = 4) and this data set (n = 80) or due to seasonal effects (1984-1996, Terranova and Coffman, 1997 and this study, 2002-2006).

Although five populations have comparatively low to moderate *FIS* estimates, a high *FIS* was estimated for Analabe population (Table 3). This deviation may be a result of sampling different social groups or generations between the 2002 (n = 5) and the 2005 expeditions (n = 5), thus producing a Wahlund effect. Stable social groups cannot be confidently identified without pedigree information or long-term behavioral observations, thus warranting future research. We identified "Groups" as the observation of multiple individuals at a given GPS coordinate at the time of immobilizations (Table 3). The Ankarana population showed a higher level of homozygosity which may be due to sampling of relatives; however, upon examination of the critical individuals' multilocus genotypes, we find that the shared alleles are in fact the most common alleles at each locus with frequencies as low as 0.190 and as high as 0.663.

While genic differentiation, genotypic differentiation and *FST* values were more often significant between populations (Table 4), a weak but not significant correlation between *FST* and the Euclidean distance tested by isolation by distance was noted (Fig. 2). This observation is supported by the number of effective migrants per generation where one migrant per generation is considered adequate to maintain gene flow between populations over time. This species ability and willingness to travel across open ground permits gene flow between forest fragments which may be deterred in primarily arboreal lemur species. Although Analamerana has been historically fragmented by cultural agriculture practices (slash and burn or "tavy"), forest corridors between the Analamerana forest fragments still exists along small riverine beds, thus providing avenues for gene flow. When tested for cryptic substructure, the posterior probabilities, *Q* admixture proportions, and *K* indicate that in spite of significant population differentiation by *FST* estimates, no evidence supporting significant substructure among the populations was detected.

Although population parameters indicate that the sampled populations are quite similar to each other, indications suggest that each fragmented population has not been subject to the same stochastic or anthropogenic challenges. The deviation from the genetic mutation-drift equilibrium in the Ampasimaty and Ankarana populations provides evidence that these populations have undergone a decrease in the effective population size in recent times. This is supported by the disruption of the expected allele frequency distributions in the Ampasimaty and Analabe populations. Lawler (2008) estimated the temporal limits of recent bottleneck events as the number of generations equal to four times the effective population size (Ne). Substituting *Neb* for Ne, bottleneck events can be detected no more than 50 generations ago in the Ampasimaty forest as many as 600 generations ago in the Ankarana forest. Furthermore, the Analabe population may be also affected by a decline in the effective population size. However, this signal is only supported by an allelic mode shift indicator and not by a statistical probability.

The baseline population genetic parameters established here for the crowned lemur provide benchmarks for future monitoring studies within these populations and can offer comparative studies for other population not yet investigated such as those from Andrafiamena (Ranaivoarisoa *et al*., 2006), Andavakoera (Zaonarivelo *et al*., 2007), and Daraina (Binara Forest, unpublished data; Fig. 1). Additionally, the crowned lemur population parameters may also be utilized in comparison with other conspecifics sharing these ecosystems.

Acknowledgements

We acknowledge the Ministère des Eaux et Forêts of Madagascar, Madagascar National Parks (MNP), and the Department of Paleontology and Anthropology, University of Antananarivo for their assistance and support. This project would not have been possible without the support of the staffs of Institute for Conservation of Tropical Environments, Madagascar (ICTE-MICET) and Henry Doorly Zoo's Madagascar Biodiversity and Biogeography Project (MBP-HDZ), as well as, U. S. Fish & Wildlife Service, Bill and Berniece Grewcock, The Ahmanson Foundation, the Theodore F. and Claire M. Hubbard Family Foundation, and the James Family Foundation.

References

Andriantompohavana, R.; Morelli, T.L.; Behncke, S.M.; Engberg, S.E.; Brenneman, R.A.; Louis, Jr., E.E. 2007. Characterization of twenty *Eulemur*-specific microsatellite loci characterized in two populations of the red-bellied Brown Lemur, *Eulemur rubriventer*. Mol. Ecol. Notes 7: 1162-1165.

Callen, D.F.; Thompson, A.D.; Shen, Y.; Phillips, H.A.; Richards, R.I.; Mulley, J.C.; Sutherland, G.R. 1993. Incidence and origin of "null" alleles in the (AC)n microsatellite markers. Am. J. Hum. Genet. 52: 922-927.

Chapuis, M.-P.; Estoup, A. 2007. Microsatellite null alleles and estimation of population differentiation. Mol. Biol. Evol. 24: 621-631.

Cornuet, J.M.; Luikart, G. 1996. Description and power analysis of two tests for detecting recent population bottlenecks from allele frequency data. Genetics 144: 2001-2014.

Cornuet, J.M.; Piry, S.; Luikart, G.; Estoup A.; Solignac, M. 1999. New methods employing multi-locus genotypes to select and exclude populations as origins of individuals. Genetics 153: 1989-2000.

Di Rienzo, A.; Peterson, A.C.; Garza, J.C.; Valdez, A.M.; Slatkin, M.; Freimer, N.B. 1994. Mutational processes of simple-sequence repeat loci in human populations. Proc. Natl. Acad. Sci., USA 91: 3166-3170.

Dieringer, D.; Schlötterer, C. 2002. Microsatellite analyser (MSA): a platform independent analysis tool for large microsatellite data sets. Mol. Eco. Notes 1: 167-169.

Evanno, G.; Regnaut, S.; Goudet, J. 2005. Detecting the number of clusters of individuals using the software STRUCTURE: a simulation study. Mol. Ecol. 14: 2611-2620.

Fowler, S.V.; Chapman, P.; Checkley, D.; Hurd, S.; McHale, M.; Ramangason, G.-S.; Randriamasy, J.E.; Stewart, P.; Walters, R.; Wilson, J.M. 1989. Survey and management proposals for a tropical deciduous forest reserve at Ankarana in northern Madagascar. Biol. Conserv. 47: 297-313.

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.

Goudet, J. 1995. FSTAT, a computer program to test F-statistics. J. Hered. 86: 485-486.

Goudet, J. 2001. FSTAT, a program to estimate and test gene diversities and fixation indices (version 2.9.3). Updated from Goudet, 1995.

Hardy, O. J., Vekemans, X. 2002. SPAGeDi: a versatile computer program to analyse spatial genetic structure at the individual or population levels. Mol. Ecol. Notes 2: 618-620.

Hawkins, A.F.A.; Chapman, P.; Ganzhorn, J.U.; Bloxam, Q.M.C.; Barlow, S.C.; Tonge, S.J. 1990. Vertebrate conservation in Ankarana Special Reserve, northern Madagascar. Biol. Conserv. 54: 83-110.

Hill, W.G. 1981. Estimation of linkage disequilibrium in random mating populations. Heredity 33: 229-239.

Hoffman, J.I.; Amos, W. 2005. Microsatellite genotyping errors: detection approaches, common sources and consequences for parental exclusion. Mol. Ecol. 14: 599-612.

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

Lawler, R.R. 2008. Testing for a historical population bottleneck in wild Verreaux's sifaka (*Propithecus verreauxi verreauxi*) using microsatellite loci. Am. J. Primatol. 70: 990-994.

Longmire, J.L.; Gee, G.F.; Hardekoff, C.L.; Mark, G.A. 1992. Establishing paternity in whooping cranes (*Grus americana*) by DNA analysis. The Auk 109: 522-529.

Morin P.A.; Leduc, R.G.; Archer, F.I.; Martien, K.K.; Huebinger, R.; Bickham, J.W.; Taylor, B.L. 2009. Significant deviations from Hardy-Weinberg equilibrium caused by low levels of microsatellite genotyping errors. Mol. Ecol. Res. 9: 498-504.

Paetkau, D.; Slade, R.; Burdem, M.; Estoup, A. 2004. Direct real-time estimation of migration rate using assignment methods: a simulation-based exploration of accuracy and power. Mol. Ecol. 13: 55-65.

Peel, D.; Ovenden, J.R.; Peel, S.L. 2004. NeEstimator: software for estimating effective population size, Version 1.3. Queensland Government, Department of Primary Industries and Fisheries.

Piry, S.; Luikart, G.; Cornuet, J.M. 1999. BOTTLENECK: A computer program for detecting recent reductions in the effective population size using allele frequency data. J. Hered. 90: 502-503.

Pritchard, J.K.; Stephens, M.; Donnelly, P. 2000. Inference of population structure using multilocus genotype data. Genetics 155: 945-959.

Pudovkin, A.I.; Zaykin, D.V.; Hedgecock, D. 1996. On the potential for estimating the effective number of breeders from heterozygote-excess progeny. Genetics 144: 383-387.

Queller, D.C., Goodnight, K.F. 1989. Estimating relatedness using genetic markers. Evolution 43: 258-275.

Raymond, M.; Rousset, F. 1995. GENEPOP (Version 3.1): Population genetics software for exact tests and ecumenicism. J. Hered. 86: 248-249.

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.

Sambrook, J.; Fritch, E.F.; Maniatus, T. 1989. Molecular Cloning: a Laboratory Manual. 2nd edn. Cold Spring Harbor Press, New York, USA.

Slate, J.; Marshall, T.C.; Pemberton, J.M. 2000. A retrospective assessment of the accuracy of the paternity inference program CERVUS. Mol. Ecol.9(6): 801-808.

Smith, R.J.; Jungers, W.L. 1997. Body mass in comparative primatology. J. Hum. Evol. 32: 523-559.

Sussman, R.W. 2002. Adaptive array of lemurs of Madagascar revisited. Evol. Anthropol. (Suppl. 1): 75-78.

Terranova, C.J.; Coffman, B.S. 1997. Body weights of wild and captive lemurs. Zoo Biol. 16 17-30.

van Oosterhout, C.; Hutchinson, W.F.; Wills, D.P.M.; Shipley, P. 2004. Micro-Checker: software for identifying and correcting genotyping errors in microsatellite data. Mol. Ecol. Notes 4: 535-538.

Waples, R.S. 1991. Genetic methods for estimating the effective size of Cetacean populations. Pp. 279-300. In: A.R. Hoezel (ed.). Genetic Ecology of Whales and Dolphins, Special Issue 13. International Whaling Commission, London, UK.

Weir, B.; Cockerham, C.C. 1984. Estimating F-statistics for the analysis of population structure. Evolution, 38: 1358-1370.

Wilson, J.M.; Stewart, P.D.; Ramangason, G.-S.; Denning, A.M.; Hutchings, M.S. 1988. Ecology and conservation of the crowned lemur, *Lemur coronatus*, at Ankarana, N. Madagascar, with notes on Sanford's lemur and other sympatrics and subfossil lemurs. Folia Primatol. 52: 1-26.

Zaonarivelo, J.R.; Andriantompohavana, R.; Razafindrakato, A.; Andrianasolo, J.; Rajaobelina, S.; Brenneman, R.A.; Wolhauser, S.; Louis, Jr., E.E., 2007. Preliminary lemur survey of Andavakoera Classified Forest and regional forest fragments of Madagascar. Lemur News. 12: 26-29.

Population genetic parameter estimates for five populations of Sanford's lemur, *Eulemur sanfordi* (Archbold, 1932), from northern Madagascar

Ravaka Ramanamahefa[1], Susie M. McGuire[2], Edward E. Louis, Jr.[2], Rick A. Brenneman[2]*

[1]Department of Paleontology and Anthropology, University of Antananarivo, Madagascar

[2]Center for Conservation and Research, Omaha's Henry Doorly Zoo, 3701 South 10th Street, Omaha,USA

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

Key words: Sanford's lemur, *Eulemur*, population genetics, Madagascar

Eulemur sanfordi (Archbold, 1932), Sanford's lemur (Mittermeier *et al*., 2008), is a medium-sized brown lemur (Terranova and Coffman, 1997) inhabiting moist to dry tropical forest habitats in the northern tip of Madagascar. The distribution of *E. sanfordi* extends from

Montagne d'Ambre National Park, Analamerana Special Reserve, and Ankarana Special Reserve in the north to Daraina in the south (Fig. 1). Often found sympatric with *E. coronatus* (Wilson *et al*., 1988; Freed, 1996), the cathemeral Sanford's lemur's (Freed 1996) diet consists primarily of fruits but will also eat flowers, leaves and invertebrates in the mid-level canopy of secondary forests (Wilson *et al*., 1988; Fowler *et al*., 1989; Hawkins *et al*., 1990; Freed, 1996). As with other brown lemurs, Sanford's lemur is sexually dichromatic with the males being brown, dorsally darker and ventrally pale with distinct ear tufts of cream to reddish in color matching the beard on the lower cheeks. This also matches the color on the top of the head which stands out against the very dark face. The female on the other hand is dorsally grey becoming ventrally paler without the distinct ear tufts and beard (Mittermeier *et al*., 2006). In the IUCN Red List, Sanford's lemur is listed as Endangered, B1ab (i, ii, iii, v), with a decreasing population trend (IUCN, 2008). Little information exists; therefore, this population study is the first to establish baseline genetic parameters regarding the structure within and among Sanford's lemur.

Methods

Fifty four *E. sanfordi* individuals were sampled from five populations as follows: Montagne d'Ambre National Park (n = 9), Ankarana Special Reserve (n = 15), and the Ampasimaty (n = 10), Antobiratsy (n = 10), and Ankavanana (n = 10) forests of the Analamerana Special Reserve (Fig. 1). Animals were sedated with Telazol® (Fort Dodge Animal Health, Overland Park, Kansas) at a dose of 10 mg/kg body weight by remote delivery dart injection (Type C; disposable dart, Pneu-Dart, Williamsport, Pennsylvania) from a CO_2 powered DanInject® (DanInject, Kolmården, Sweden) Mod JM dart rifle. The capture location coordinates were recorded using a hand-held Global Positioning System (GPS). These coordinates were used for the animal's release and for mapping purposes.

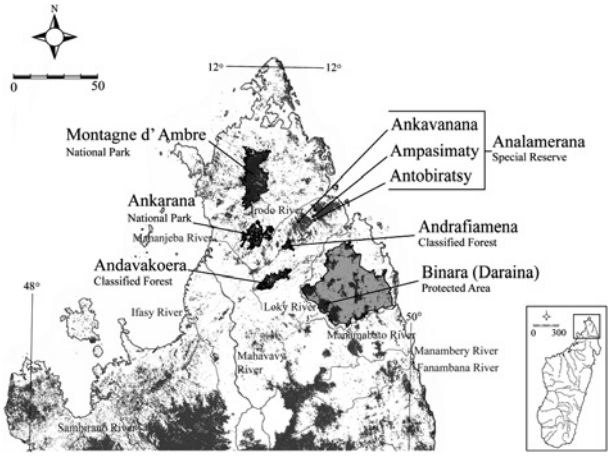

Fig. 1: Sampling locations of Sanford's lemur (*Eulemur sanfordi*).

Sedated individuals were weighed using PESOLA® scales (Pesola AG, Baar, Switzerland). Morphometric measurements were taken according to Smith and Jungers (1997), rectal temperature, heart rate, respiratory rate, and gender were recorded (**www.omahazoo.com/ccr/genetics/lemur/index.asp?page=ccr/genetics/lemur/Lemuridae.htm**).

Fig. 2: Male (left) and female (right) Sanford's lemur (*Eulemur sanfordi*).

Lemurs were aged as adult or juvenile according to their body length and tooth characteristics. Two 2.0 mm biopsy punches were taken from the ear pinnae of each animal and a whole blood sample was drawn from the femoral vein at a ratio of 1 ml/kg body weight for biomaterial banking. The whole blood samples were deposited into a room temperature blood storage solution while tissue samples were deposited into room temperature tissue preservative buffer (Longmire *et al*., 1992). While sedated, a HomeAgain® microchip (Schering-Plough, Kenilworth, NJ) was inserted with an injection needle subcutaneously between the scapulae providing permanent identification. Lactate Ringer's solution (Abbot Laboratories, Chicago, Illinois) equal to twice the volume of blood drawn was administered subcutaneously to replace fluid volume lost and improve recovery from the anesthesia. After monitoring the recovery, each animal was released unharmed during daylight at the same location where it was captured to permit regrouping with appropriate family or social groups.

Genomic DNA was isolated from tissue or blood samples according to standard procedures (Sambrook *et al*., 1989). Fourteen microsatellite loci developed from the *E. rubriventer* genome (Andriantompohavana *et al*., 2007) were amplified in the *E. sanfordi* samples and screened in the five populations. PCR amplification was carried out and fragment analysis was performed as described by Andriantompohavana *et al*. (2007).

The nuclear DNA microsatellite data file was evaluated for genotype errors that can significantly affect Hardy-Weinberg equilibrium (HWE) estimates (Morin *et al*., 2009) with both Micro-Checker (van Oosterhout *et al*., 2004) and Microsatellite Analyser (MSA; Dieringer and Schlötterer, 2002). CERVUS 2.0 (Slate *et al*., 2000) was used to estimate null allele frequencies for each locus and the utility of the markers as polymorphic information content (PIC). Loci with high estimates of null allele frequencies (*nf* > 0.2) were deleted (Callen *et al*., 1993, Hoffman and Amos, 2005).

We assured a basic assumption of linkage equilibrium for the accepted loci (with Bonferroni-adjusted *P*-values) in FSTAT (Goudet, 1995, 2001). We tested the microsatellite loci globally and by population for deviation from HWE using Fisher's exact probability test in the web-based Genepop3.4 (Raymond and Rousset, 1995). Initially, we tested the default settings for the Markov Chain Monte Carlo (MCMC) estimation of HWE, and then increased the batch size from 100 to 400 to reduce the standard error of the *P*-value to 0.01 or

less. Rarefacted allelic richness (*AR*) by locus and population, Wright's *FIS* (within population *f* statistic) and Wright's *FST* (among population *f* statistic) were estimated with FSTAT using Weir and Cockerham (1984). Observed (*Ho*) and expected (*He*) heterozygosities were estimated in Genepop 3.4. Population differentiation was tested by comparing allele and genotype distributions between populations using the genic differentiation and genotypic differentiation pair wise options also in Genepop 3.4. These are tested under the null hypotheses that there are no differences between the populations and that the allele and the genotype distributions are the same in each population. An unbiased estimate of the *P*-value of a log-likelihood (G) based exact test was performed as developed by Goudet *et al*. (1996) to generate the genic differentiation table derived from the genotypic table. The Mantel test was performed in Genepop 3.4 regressing *FST*/(1-*FST*) on the logarithm of the Euclidean distance between the sampling locations to determine the effect of isolation by distance. Gene flow between populations as *NM* (migrants per generation) was estimated using the private alleles method, again using Genepop 3.4. We used SPAGeDi 1.2 (Hardy and Vekemans, 2002) to estimate relationship coefficients for each dyad combination in each of the populations. The estimated relationship coefficient distributions were overlaid on the distributions derived using the method of Queller and Goodnight (1989) in a simulation of 10,000 individuals of known multilocus genotypes and pedigree relationships. The two estimators recommended by Waples (1991) for single-sampled populations, linkage disequilibrium (LD; Hill, 1981) and heterozygote excess (HEx; Pudovkin *et al*., 1996), were tested in NeEstimator (Peel *et al*., 2004) to estimate ranges in the number of effective breeders (*Neb*) in each population. In using the latter method, HEx, Pudovkin *et al*. (1996) and Luikart and Cornuet (1999) found that this method may overestimate *Neb*.

We examined four of the populations for evidence of a recent genetic bottleneck using Bottleneck 2.0 (Cornuet and Luikart, 1996; Cornuet *et al*., 1999; Piry *et al*., 1999). The Montagne d'Ambre population failed to meet the threshold of 10 individuals. We used the three models available, the Infinite Alleles Model (IAM), the Stepwise Mutation Model (SMM), and the Two Phase Model (TPM). The TPM permits single step as well as multi step mutation events in the microsatellite repeat motif (Di Rienzo *et al*., 1994).

As an exploratory measure to test for structure in the populations, we used the model-based clustering program STRUCTURE 2.0 (Pritchard *et al*., 2000; Falush *et al*., 2003). The procedure uses a Bayesian clustering based method to determine whether populations should be further subdivided into genetically distinct groups to reflect the cryptic substructure. STRUCTURE attempts to identify population groups that maximize HWE and minimize LD using multilocus genotypes (Pritchard *et al*., 2000). We used the ancestry model with admixture, correlated allele frequencies, different *FST* values assumed for each subpopulation, a uniform prior for alpha (max: 10, SD for updating: 0.025), constant lambda value of 1, prior *FST* mean (0.01) and standard deviation (0.05). We estimated 1-8 genetic clusters, as Evanno *et al*. (2005) suggests, estimating a range of at least three clusters more than sampling locations. We set the initial burn in period at 10^5 iterations to reduce noise before launching 10^6 MCMC repetitions to obtain the genetic cluster proportion estimates (q) for each individual. Occasionally, STRUCTURE overestimates the number of genetic clusters in a data set by generating similar likelihood values for adjacent values. We used the *ad hoc* test statistic ΔK (Evanno *et al*., 2005), developed to overcome that limitation, to aid in elucidating the most likely number of genetic clusters. We then compared the model with the highest posterior probability and the model with the maximum ΔK to the sampled demographic populations.

Results

Populations were tested in ANOVA pairwise tests for significant morphometric differences. The results of the analyses indicated that none were significant by gender or by population (data not shown). The averages for the various measurements collected with standard deviations are presented in Table 1.

Table 1: Morphometric averages with standard deviations for five populations of *Eulemur sanfordi*. Weight in kg; other measurements in cm.

Weight	1.9 (0.2)	Length	32.4 (2.6)
Head Crown	9.9 (0.4)	Tail	50.4 (4.8)
Thumb	3.3 (0.6)	Hallux	6.0 (0.5)
Long Digit	3.4 (0.4)	Rear Long Digit	3.3 (0.6)
Hand	7.2 (0.4)	Foot	10.4 (0.5)
Radius/Ulna	10.1 (0.6)	Tibia	11.4 (0.6)
Humerus	8.4 (0.8)	Femur	12.8 (0.6)

To control parameter estimate variance caused by excessive null allele frequencies (Chapuis and Estoup, 2007), three loci with high estimates of null allele frequencies ($nf > 0.2$) were deleted. Each locus pair was found to be in linkage equilibrium following a Bonferroni correction in FSTAT satisfying the assumption of marker independence. We report the relative quality of the loci in these data as PIC values and locus characteristics in Table 2. The mean number of alleles was 6.3 per locus and 4.0 per population. One locus (44HDZ42) and none of the sample sites deviated by exact tests from Hardy-Weinberg equilibrium ($P < 0.05$).

Table 2: Global information, number of alleles (k), observed and expected heterozygosity (Ho and He respectively), polymorphic information content (PIC), *F*-statistics for total (*FIT*), between populations (*FST*) and within population (*FIS*) fixation indices, for the final marker suite used to generate population genetic parameter estimates for five populations of *Eulemur sanfordi*.

Locus	**k**	**Ho**	**He**	**PIC**	***FIT***	***FST***	***FIS***
44HDZ16	4	0.444	0.494	0.430	0.160	0.288	0.169
44HDZ35	7	0.759	0.798	0.759	0.052	0.038	0.016
44HDZ40	4	0.352	0.321	0.293	-0.098	0.051	-0.154
44HDZ42	6	0.500	0.743	0.700	0.385	0.265	0.148
44HDZ83B	8	0.741	0.713	0.676	-0.030	0.084	-0.128
44HDZ91	4	0.759	0.713	0.650	-0.059	0.059	-0.128
44HDZ124	5	0.204	0.223	0.214	0.069	0.015	0.058
44HDZ164	6	0.396	0.467	0.438	0.179	0.081	0.113
44HDZ193	7	0.685	0.650	0.580	-0.045	0.062	-0.111
44HDZ287	9	0.585	0.634	0.599	0.090	0.080	0.011
44HDZ475	9	0.774	0.788	0.749	0.033	0.140	-0.128

Table 3: Population parameter estimates for n (number of individuals) from five populations of *Eulemur sanfordi*. The mean number of alleles (MNA), rarefacted allelic richness (AR), observed and expected heterozygosities (HO and HE, respectively), an inbreeding estimator (*FIS*), and estimates for the number of effective breeders (*Neb*) in each population by the linkage disequilibrium (LD and corresponding 95% confidence interval) and by the heterozygote excess (HEX) methods are presented.

	n	MNA	*AR*	HO	HE	*FIS*	*Neb*		
							LD	95 % CI	HEx
Ampasimaty	10	3.5	3.4	0.545	0.528	-0.033	10.9	7.3-18.8	4.0
Antobiratsy	10	3.7	3.6	0.582	0.555	-0.058	24.5	13.7-78.2	4.0
Ankavanana	10	4.3	4.0	0.618	0.602	-0.027	12.3	8.1-22.3	15.1
Ankarana	15	4.5	3.7	0.539	0.518	-0.045	6755.1	54.0-4.0	505.1
Montagne d'Ambre	9	3.8	3.7	0.525	0.508	-0.051	30.9	13.9-4.0	13.0

Table 4: Population differentiation estimated by *FST*; all estimates were significant at $P < 0.05$.

	Ampasimaty	Antobiratsy	Ankavanana	Ankarana
Antobiratsy	0.0697			
Ankavanana	0.0690	0.0518		
Ankarana	0.1572	0.1176	0.0779	
Montagne d'Ambre	0.1694	0.1399	0.1391	0.1163

We present population genetic parameter estimates, evidence for bottleneck, and estimates of *Neb* in Table 3 to establish baseline data for *E. sanfordi*. Population differentiation as *FST* was low to moderate with significance ($P < 0.05$) between each population pair (Table 4). Isolation by distance was positively correlated with a moderate R^2 (Fig. 3). Population differentiation by genic and genotypic differentiation was significant in each pairwise test ($P < 0.001$) indicating that genetic drift is affecting the allele frequency and genotypic frequency distributions. None of the populations differed significantly between observed and expected heterozygosities, although in each population *Ho* exceeded *He*. Each population showed *FIS* estimates less than zero. While relationship coefficient distributions for each of the populations indicated relationships greater than those expected from unrelated sample sets (Fig. 4), only 23 of the 1485 (1.55 %) total dyads qualified as parent-offspring relationships based on non-exclusion of allele inheritance at the eleven loci tested. We found no evidence for genetic bottlenecks in the four populations sampled. The range of effective migrants per generation was from 1.03 between Antobiratsy and Ankarana to 1.72 between Ampasimaty and Antobiratsy. The *NM* estimates for Montagne d'Ambre and the other locations were below one migrant per generation. The estimates of *Neb* by the LD method and corresponding 95 % CI and the HEx method are presented in Table 3. A low level of population substructure was detected by both the posterior probability of *q* and *K* (*K* = 2; Fig. 5).

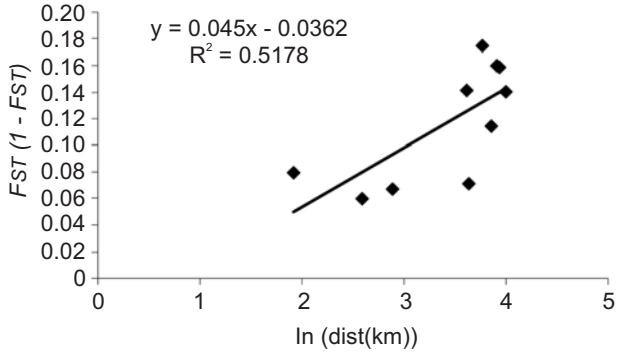

Fig. 3: Isolation by distance regression of a genetic distance measure, *FST*/(1-*FST*), on the logarithm of the Euclidean distance between sampling locations ($P = 0.04$).

Discussion

The results from the morphological analyses show that Sanford's lemur (*E. sanfordi*) is a species with little phenotypic variation between males, between females, between sexes, or among the populations sampled in various habitats across the species' range.

Within population genetic parameters show *FIS* estimates actually less than zero, indicating that the populations are randomly mating with respect to related individuals and that there is no evidence of a Wahlund effect that would indicate sampling of discreet subpopulations. While relationships within sample groups tended to be greater than those of unrelated individuals, the negative *FIS* estimates and the fact that no population deviated from HWE suggests that these apparent familial relationships did not bias the population genetic parameters estimated. In some cases, two individuals harboring alleles with the higher frequencies (in this case, between 24 and 88 %, MSA data not presented) in a population, may in fact qualify as parent-offspring due to shared alleles in state though not necessarily shared by descent.

The *FST* values were significant between populations (Table 4) and we detected an association with a significant though low correlation of isolation by distance (Fig. 4). One migrant per generation is considered adequate to maintain gene flow between populations (Hedrick, 2005). The isolation by distance is supported by the number of effective migrants per generation between the dry forest populations but low number of migrants between the dry and moist forest populations. When tested for cryptic substructure, Structure analysis (posterior probabilities, *q* admixture proportions, and *K*) indicates that in spite of significant population differentiation by *FST* estimates, the five populations are not differentiated by the genetic clustering tests. On the other hand, the genetic clustering provides evidence to support significant substructure that may indicate two ancestral genetic pools among the populations sampled. Lastly, none of the dry forest populations yielded evidence of demographic bottlenecks.

From these estimates, the five populations of *E. sanfordi* appear to be in relatively good genetic health, despite the species designation as endangered by the IUCN Red List. These population genetic parameters establish baseline population genetic values for future studies in these populations and for comparison to other lemur species sharing these ecosystems with Sanford's lemur.

Acknowledgements

We acknowledge the Ministère des Eaux et Forêts of Madagascar, Madagascar National Parks, and the De-

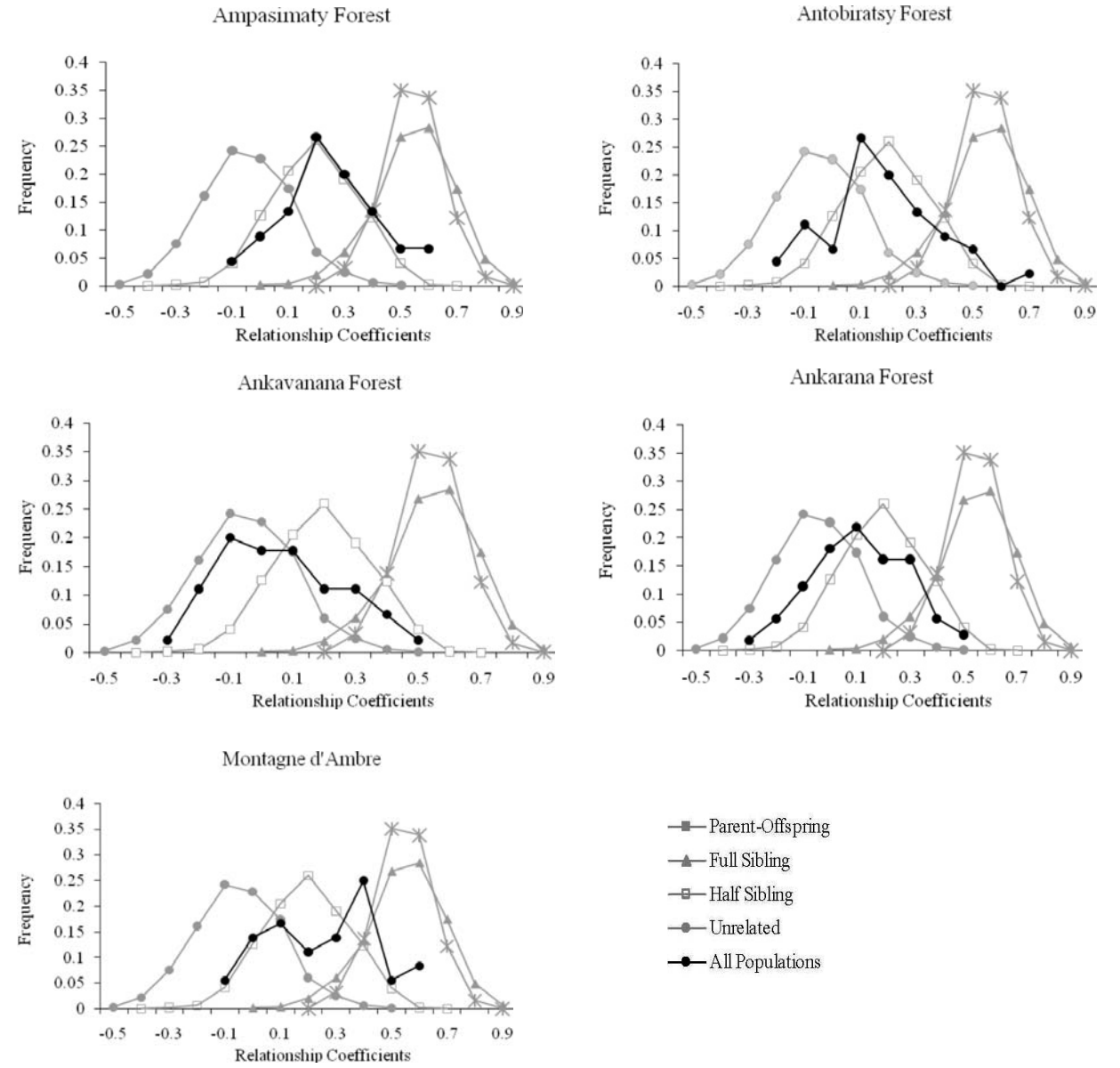

Fig. 4: Relationship coefficient distributions for each of the sampling locations for *Eulemur sanfordi*.

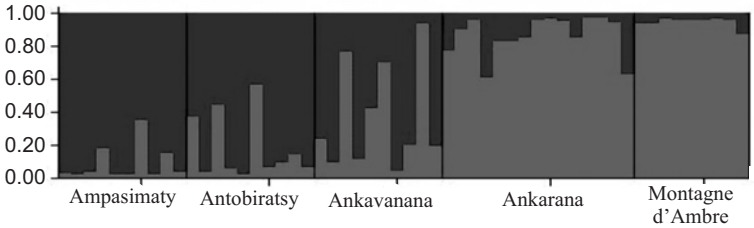

Fig. 5: Bar graph of *q* proportions of cluster 1 and cluster 2 in the data.

partment of Paleontology and Anthropology, University of Antananarivo for their assistance and support. This project would not have been possible without the support of the staffs of Institute for Conservation of Tropical Environments, Madagascar and Henry Doorly Zoo's Madagascar Biodiversity and Biogeography Project, as well as, U. S. Fish & Wildlife Service, Bill and Berniece Grewcock, the Ahmanson Foundation, the Theodore F. and Claire M. Hubbard Family Foundation, and the James Family Foundation. We thank Lisa Kimmel for the creation of the graphics used in this manuscript.

References

Andriantompohavana, R.; Morelli, T.L.; Behncke, S.M.; Engberg, S.E.; Brenneman, R.A.; Louis, Jr., E.E. 2007. Characterization of twenty *Eulemur*-specific microsatellite loci characterized in two populations of the red-bellied brown lemur, *Eulemur rubriventer*. Mol. Ecol. Notes 7: 1162-1165.

Archbold, R. 1932. A new lemur from Madagascar. Am. Mus. Novit. 518: 1.

Callen, D.F.; Thompson, A.D.; Shen, Y.; Phillips, H.A.; Richards, R.I.; Mulley, J.C.; Sutherland, G.R. 1993. Incidence and origin of "null" alleles in the $(AC)_n$ microsatellite markers. Am. J. Hum. Genet. 52: 922-927.

Chapuis, M.-P.; Estoup, A. 2007. Microsatellite null alleles and estimation of population differentiation. Mol. Biol. Evol. 24: 621-631.

Cornuet, J.M.; Luikart, G. 1996. Description and power analysis of two tests for detecting recent population bottlenecks from allele frequency data. Genetics 144: 2001-2014.

Cornuet, J.M.; Piry, S.; Luikart, G.; Estoup, A.; Solignac, M. 1999. New methods employing multi-locus genotypes to select and exclude populations as origins of individuals. Genetics 153: 1989-2000.

Di Rienzo, A.; Peterson, A.C.; Garza, J.C.; Valdez, A.M.; Slatkin, M.; Freimer, N.B. 1994. Mutational processes of simple-sequence repeat loci in human populations. Proc. Natl. Acad. Sci., USA 91: 3166-3170.

Dieringer, D.; Schlötterer, C. 2002. Microsatellite analyser (MSA): a platform independent analysis tool for large microsatellite data sets. Mol. Ecol. Notes 1: 167-169.

Evanno, G.; Regnaut, S.; Goudet, J. 2005. Detecting the number of clusters of individuals using the software STRUCTURE: a simulation study. Mol. Ecol. 14: 2611-2620.

Falush, D.; Stephens, M.; Pritchard, J. 2003. Inference of population structure using multilocus genotype data: Linked loci and correlated allele frequencies. Genetics, 164: 1567-1587.

Fowler, S.V.; Chapman, P.; Checkley, D.; Hurd, S.; McHale, M.; Ramangason, G.-S.; Randriamasy, J.E.; Stewart, P.; Walters, R.; Wilson, J.M. 1989. Survey and management proposals for a tropical deciduous forest reserve at Ankarana in northern Madagascar. Biol. Conserv. 47: 297-313.

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

Goudet, J. 1995. FSTAT, a computer program to test F-statistics. J. Hered. 86: 485-486.

Goudet, J. 2001. FSTAT, a program to estimate and test gene diversities and fixation indices (version 2.9.3). Updated from Goudet, 1995.

Goudet, J.; Raymond, M.; de Meeüs, T.; Rousset, F. 1996. Testing differentiation in diploid populations. Genetics 144: 1931-1938.

Hardy, O.J.; Vekemans, X. 2002. SPAGeDi: A versatile computer program to analyze spatial genetic structure at the individual or population levels. Mol. Ecol. Notes 2: 618-620.

Hawkins, A.F.A.; Chapman, P.; Ganzhorn, J.U.; Bloxam, Q.M.C.; Barlow, S.C.; Tonge, S.J. 1990. Vertebrate conservation in Ankarana Special Reserve, northern Madagascar. Biol. Conserv. 54: 83-110.

Hedrick, P.W. 2005. Genetics of Populations, 3rd ed., pp. 501. Jones and Bartlett, Sudbury, MA, USA.

Hill, W.G. 1981. Estimation of linkage disequilibrium in random mating populations. Heredity 33: 229-239.

Hoffman, J.I.; Amos, W. 2005. Microsatellite genotyping errors: detection approaches, common sources and consequences for parental exclusion. Mol. Ecol. 14: 599-612.

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

Longmire, J.L.; Gee, G.F.; Hardekoff, C.L.; Mark, G.A. 1992. Establishing paternity in whooping cranes (*Grus americana*) by DNA analysis. The Auk 109: 522-529.

Luikart, G.; Cornuet, J.-M. 1999. Estimating the effective number of breeders from heterozygote excess progeny. Genetics 151: 1211-1216.

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

Mittermeier, R.A.; Konstant, W.R.; Hawkins, F.; Louis, Jr., E.E.; Langrand, O.; Ratsimbazafy, J.; Rasoloarison, R.M.; Ganzhorn, J.U.; Rajaobelina, S.; Tattersall, I.; Meyers, D. 2006. Lemurs of Madagascar 2nd ed.. Pp. 297-299. Conservation International, Washington DC, USA.

Morin, P.A; Leduc, R.G.; Archer, F.I.; Martien, K.K.; Huebinger, R.; Bickham, J.W.; Taylor, B.L. 2009. Significant deviations from Hardy-Weinberg equilibrium caused by low levels of microsatellite genotyping errors. Mol. Ecol. Res. 9: 498-504.

Peel, D.; Ovenden, J.R.; Peel, S.L. 2004. NeEstimator: software for estimating effective population size, Version 1.3. Queensland Government, Department of Primary Industries and Fisheries.

Piry, S.; Luikart, G.; Cornuet, J.M. 1999. BOTTLENECK: A computer program for detecting recent reductions in the effective population size using allele frequency data. J. Hered. 90: 502-503.

Pritchard, J.K.; Stephens, M.; Donnelly, P. 2000. Inference of population structure using multilocus genotype data. Genetics 155: 945-959.

Pudovkin, A.I.; Zaykin, D.V.; Hedgecock, D. 1996. On the potential for estimating the effective number of breeders from heterozygote-excess progeny. Genetics 144: 383-387.

Queller, D.C.; Goodnight, K.F. 1989. Estimating relatedness using genetic markers. Evolution 43: 258-275.

Raymond, M.; Rousset, F. 1995. GENEPOP (Version 3.1): Population genetics software for exact tests and ecumenicism. J. Hered. 86: 248-249.

Sambrook, J.; Fritch, E.F.; Maniatus, T. 1989. Molecular Cloning: a Laboratory Manual. 2nd ed. Cold Spring Harbor Press, New York, USA.

Slate, J.; Marshall, T.C.; Pemberton, J.M. 2000. A retrospective assessment of the accuracy of the paternity inference program CERVUS. Mol. Ecol. 9(6): 801-808.

Smith, R.J.; Jungers, W.L. 1997. Body mass in comparative primatology. J. Hum. Evol. 32: 523-559.

Terranova, C.J.; Coffman, B.S. 1997. Body weights of wild and captive lemurs. Zoo Biol. 16: 17-30.

van Oosterhout, C.; Hutchinson, W.F.; Wills; D.P.M.; Shipley, P. 2004. Micro-Checker: software for identifying and correcting genotyping errors in microsatellite data. Mol. Ecol. Notes 4: 535-538.

Waples, R.S. 1991. Genetic methods for estimating the effective size of Cetacean populations. Pp. 279-300. In: A.R. Hoezel (ed.). Genetic Ecology of Whales and Dolphins, Special Issue 13. International Whaling Commission, London, UK

Weir, B.; Cockerham, C.C. 1984. Estimating F-statistics for the analysis of population structure. Evolution, 38: 1358-1370.

Wilson, J.M.; Stewart, P.D.; Ramangason, G.-S.; Denning, A.M.; Hutchings, M.S. 1988. Ecology and conservation of the crowned lemur, *Lemur coronatus*, at Ankarana, N. Madagascar, with notes on Sanford's lemur and other sympatrics and subfossil lemurs. Folia Primatol. 52: 1-26.

Re-introduction of diademed sifaka (*Propithecus diadema*) and black and white ruffed lemurs (*Varecia variegata editorum*) at Analamazaotra Special Reserve, eastern Madagascar

Sabine R. Day[1], Roger E. A. F. Ramarokoto[1], Brandon D. Sitzmann[2], Réné Randriamboahanginjatovo[3], Hery Ramanankirija[3], Veloarivony Rence Aimée Randrianindrina[4], Gisele Ravololonarivo[1], Edward E. Louis, Jr.[2]

[1]Department of Biological Anthropology and Paleontology, Faculty of Sciences, P.O. 906, University of Antananarivo, Madagascar

[2]Center for Conservation and Research, Omaha's Henry Doorly Zoo, 3701 South 10th Street, Omaha, NE 68107, USA

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

[4]Department of Botany and Ecology, Faculty of Sciences, P.O. 906, University of Antananarivo, Madagascar

Corresponding author: edlo@omahazoo.com

Key words: translocation, re-introduction, *Varecia*, *Propithecus*, Madagascar

Deforestation, mainly as a result of slash-and-burn agriculture (tavy) and selective logging, has occurred continuously since the arrival of humans to Madagascar over 2000 years ago (Jolly, 1989; Harcourt and Thornback, 1990). This has resulted in rising pressure on native wildlife as the island has lost 80-90 % of its original forest habitat (Mittermeier *et al.*, 2005). One group experiencing the greatest impact from this biodiversity loss are lemurs, a diverse assembly of over 100 primate species found no where else in the world (Green and Sussman, 1990; Du Puy and Moat, 1998; Mittermeier *et al.*, 2006). In addition to disappearing habitat, lemurs are also under continuous pressure from illegal poaching as a food source (Lehman and Wright, 2000; Mutschler *et al.*, 2001; Goodman and Raselimanana, 2003), especially the larger species such as sifakas and ruffed lemurs (Mittermeier *et al.*, 2006). This hunting pressure ultimately led to the local extinction of the endangered Diademed sifaka (DS, *Propithecus diadema*) and the critically endangered black and white ruffed lemur (BWRL, *Varecia variegata editorum*; IUCN, 2009; Mittermeier *et al.*, 2008) from Analamazaotra Special Reserve (ASR) in 1973 and 1976, respectively (pers. comm., B. M. Ratsisakanana, P. Rabearisoa, Joseph).

Analamazaotra Special Reserve (810 ha), also referred to as Andasibe after the neighboring local village or as Perinet by European tourists, was initially part of a continuous forest with Mantadia National Park (15,500 ha) to the north, Maromizaha Classified Forest (1,600 ha) to the southeast, and Anosibe an'ala (1,500 ha) to the south (ANGAP, 2005). Although all four are now relatively isolated forest fragments, Andasibe-Mantadia National Park and ASR remain one of the most popular tourist destinations in Madagascar due to the opportunity to view the indri (*Indri indri*), Madagascar's largest remaining extant lemur. These four rain forest habitats are home to vast biodiversity encompassing many endemic rare and endangered plants and animals, including 13 lemur species. Although hunted to extinction in ASR, *P. diadema* and *V. v. editorum* continued to exist in the forests of Mantadia, Maromizaha, and Anosibe an'ala.

Beginning in January 2006, after more than four years of planning, the Madagascar Biodiversity and Biogeography Project of Henry Doorly Zoo (MBP-HDZ), in collaboration with Madagascar National Parks (MNP; formerly known as Association Nationale pour la Gestion des Aires Protégées, or ANGAP) and the Ministère de l'Environnement, des Forêts et de Tourisme (MEFT), initiated the first ever attempt to recover a species' former distribution in Madagascar. Following the recommendations of the *IUCN/SSC Re-introduction Specialist Group: Guidelines for Nonhuman Primate Re-introductions* (2002), the MBP-HDZ initiated the Analamazaotra Re-introduction/Translocation (ART) Project. This paper provides a summary to date of the project's efforts to re-establish the Diademed sifaka and the black and white ruffed lemur back into their historical habitat range within Analamazaotra Special Reserve.

Methods

Institutional Animal Care and Use Committee approval for the project was obtained through Omaha's Henry Doorly Zoo. Permits to work at forests in Madagascar were obtained from and with the collaboration of the Tripartite Committee (CAFF/CORE), MNP, MEFT, and the University of Antananarivo.

Translocation sites: Four forests with significant, ongoing habitat deterioration due to mining or agricultural activities were chosen as sites from which to translocate animals (Fig. 1). These included Mantadia National Park (S18º48'57.6", E048º25'19.9"), Sahanody Classified Forest (S18º51'24.3", E048º25'15.8"), Ambatovy Classified Forest (S18º51'04.3", E048º17'58.5"), and Anosibe an'ala Classified Forest (S19º14'05.0", E048º16'18.9"). In the case of Mantadia, Sahanody, and Anosibe an'ala, human encroachment for hunting, crop production and/or firewood collection has had a detrimental impact on forest integrity while Ambatovy Classified Forest has been altered due to activity from the Ambatovy nickel mining project.

Re-introduction Site: Analamazaotra Special Reserve (S18º48'56.1", E048º25'11.2") is an evergreen rain forest located approximately 150 km east of the capital city of Antananarivo. The 810 ha reserve consists of rain forest with altitudes ranging from 850 m to 1100 m above sea level (Tattersall and Sussman, 1975); mean annual rainfall in the region is 1700 mm with an average temperature of 18° C (MNP, 2006).

Animals: A total of 27 Diademed sifakas (Fig. 2) and 7 black and white ruffed lemurs (Fig. 3) were translocated between January 2006 and July 2007; all animals were free ranging juveniles or adults. Animals were moved with their entire social or family group and were extensively evaluated prior to the translocation event. In the case of the DS and BWRL from Mantadia, complete genetic and biomedical information had already been determined for these animals prior to the initiation of the ART Project. Groves (2001) reported that BWRL has three distinct subspecies: *Varecia variegata subsincta, Varecia variegata editorum*, and *Varecia variegata variegata*. The later was the subject subspecies according to geographic distribution (Mittermeier *et al*., 2008) and pelage (Vasey and Tattersall, 2002).

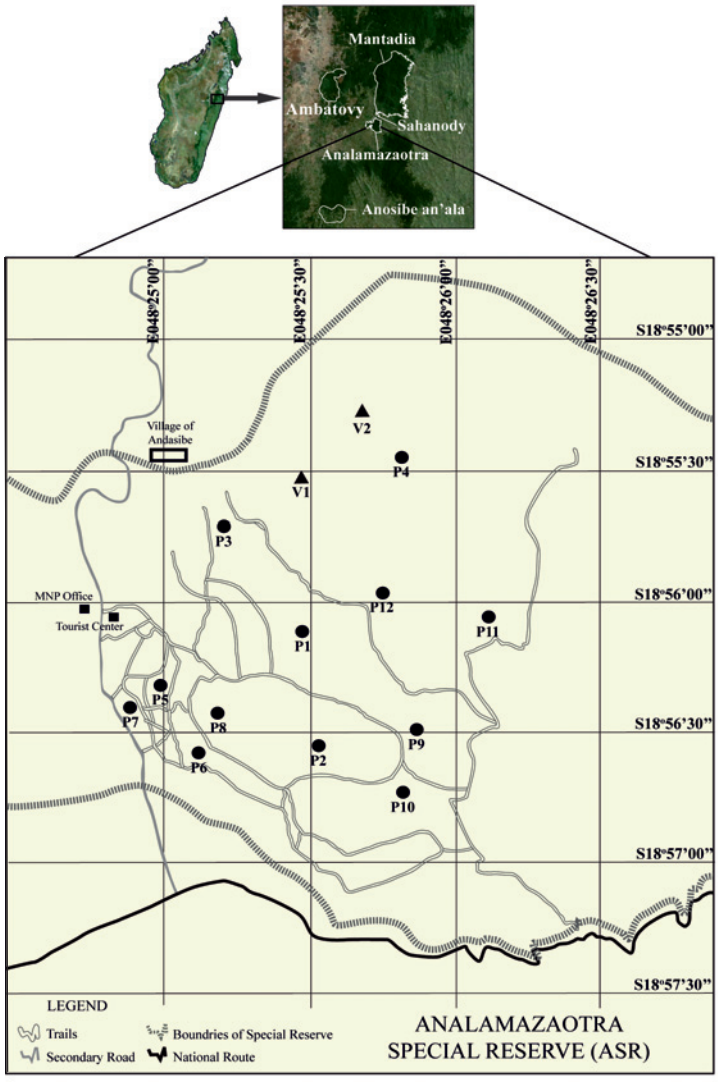

Fig. 1: Analamazaotra Special Reserve (ASR) and the four translocation sites. Approximate home range locations of the 12 Diademed sifaka (P#; *P. diadema*) and 2 black and white ruffed lemur (V#; *V. v. editorum*) groups are shown within ASR.

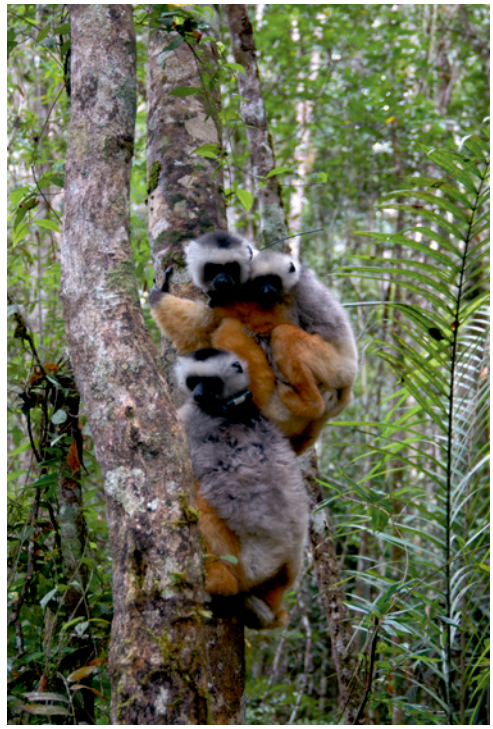

Fig. 2: Three re-introduced diademed sifaka females (2 adult, 1 juvenile) from Sahanody Classified Forest. (Photo E. E. Louis, Jr., February 2006)

Capture, Evaluation and Sampling: The detail of capture method and evaluation protocol has been previously described in Junge *et al.* (2008). Briefly, 2-8 months before a translocation was carried out, each lemur to be re-introduced was immobilized using a CO_2 projection rifle (Dan-Inject MJ model, Dan-Inject, Knoxville, TN) and dart (Type C Disposable Dart, Pneu-Dart, Williamsport, PA) with 10 mg/kg of Telazol® (Fort Dodge Animal Health, Fort Dodge, IA) and given a complete physical examination. To generate genetic data later, four 2.0 mm biopsies were collected from each sedated animal and immediately stored in a room temperature storage buffer (Longmire *et al.*, 1992). Additionally, 1.0 cc whole blood per kg body weight was also collected for later biomedical analysis. The location of each captured lemur was recorded using a Garmin eTrex Summit global positioning system (GPS; Garmin International, Inc., Olathe, KS) and a HomeAgain® microchip (Schering-Plough HomeAgain LLC, Kenilworth, NJ) was implanted subcutaneously between the scapulae of each animal. This procedure was used to field catalog each animal with a unique recognition code to provide the capability to positively re-identify individuals during future immobilizations. When the date for translocation arrived, each animal was again immobilized and given a follow-up physical. During this second physical a radiocollar (Advanced Telemetry Systems, Inc., Isanti, MN) was also placed on each individual adult to support the monitoring and habituation phases of the re-introduction (Williams and Feistner, 2003).

Hard Release: ASR is divided between a tourist area accessible to the public and a re-

Fig. 3: Black and white ruffed lemur offspring (one of two F2 twins) born in November 2008 to the F1 female and a male translocated from Anosibe an'ala Classified Forest. (Photo E. E. Louis, Jr., March 2009)

serve area that is off-limits to all but authorized personnel. The first groups of re-introduced animals were initially released inside the reserve area where habitat assessments had demonstrated desirable forest cover. Later releases were more centrally located near the boundary between the tourist and reserve areas.

Habituation and Behavioral Observations: Habituation of the study animals typically lasted three to eight weeks using radiocollars to track and monitor the animals. In contrast to solitary males, who were highly sensitive to the movements of those monitoring them, habituation of male-female pairs was achieved more quickly. Collection of behavioral data began in 2006 with the first translocations and continues today. Animals are monitored five days a week from dusk to dawn using focal animal sampling and continuous recording (Altmann, 1974) to collect behaviors such as group interaction, predator response, scent marking and reproductive activity.

Territorial Home Range Determination: GPS locations are taken during daily monitoring in order to determine home range, daily range, sleeps sites and food trees for all re-introduced groups. In some instances, animals have been fitted with GPS collars (e-obs GmbH, Grünwald, Germany) to allow remote monitoring of movement within the reserve. Animal territories and ranges are determined using either GPS Utility, ver 4.0 (GPS Utility Limited, Southampton, United Kingdom) or polygon area determination in Google Earth Pro (Google, Inc., Mountain View, CA).

Reproductive Monitoring: Fecal collections for both lemur species have been ongoing since the initiation of the ART Project. For each translocation, collection began following a two month habituation period, during which time the animals were tracked but no samples were collected. Fecals have since been used to determine reproductive hormone profiles for both species (unpublished data).

Botanical Survey: After determining approximate home ranges for each group of DS and BWRL, five plots (100 m by 20 m) were laid out inside the animals' territory. Within the plot, the following parameters were recorded: all trees with diameter at breast height (DBH) > 5 cm, tree height, canopy height, canopy size, canopy cover and ground cover. For lignin plants with DBH # 5 cm, species name, number and diameters were recorded for one 10 m by 10 m subset plot within the original, larger plot. Food plants that were observed to be eaten by the animals were identified by species; DBH, height, and canopy volume were recorded. Samples of each type of fruit were then collected in order to record size, shape, color, weight, and seed type.

Results

Group Size and Territorial Home Range: Immediately after release individuals typically took to the trees quickly and rested for a few hours. Over the next few days many of the animals were observed to change their behavior in the presence of field guides, spending more time traveling, resting and sending out alarm calls. Approximately one month after release, DS groups began to establish their ranges and were observed using their scent glands to mark or define their territories. Territories for multiple male-female DS subgroups were established and became relatively stable, whereas the territories of solitary males initially remained more fluid, perhaps in attempts to join established groups or to opportunistically breed. Eventually these lone individuals became settled in their new habitat and their activity budget and behavioral ecology appeared to be the same as *P. diadema* in their original forest habitat.

In the 30 months since the first translocations, both species have spread throughout ASR to occupy the reserve and tourist areas. BWRL have formed 2 groups while DS have divided into 12 stable units. Group size varies between either 3 or 4 for BWRL and 1 to 4 for DS. GPS collar data from one BWRL group has shown a home range of 150 ha while territory size for the GPS-collared DS group is smaller at 95 ha.

Behavior: Similar to their behavior prior to translocation, relocated *P. diadema* and *V. v. editorum* individuals were found to spend the majority of daylight hours actively feeding, socializing, and resting. During the cold season both species start their daily activity later in the morning, but during the warmer months are active earlier in the day.

Botanical Survey and Diet: Between the two lemur species, more than 33 families of food plants have been recorded, with the most important being *Euphorbiacea, Lauraceae*, *Apocynaceae*, *Myrtaceae*, *Clusiaceae*, *Erythroxylaceae*, *Pittosporaceae*, *Moraceae*, and *Flacourtaceae*. DS have been documented feeding on > 53 species (Table 1) while BWRL have been shown to consume approximately 20 species (11 listed in Table 2). In addition to leaves (buds, immature, mature) and fruit, *P. diadema* routinely consumes a variety of plant materials such as herbs, lianas, bark, ferns, flowers, and parasitic plants, as well as soil. The primary dietary component for BWRL is ripe fruit (> 80 %) from trees with an average DBH of 40 cm (range 15 to 100 cm, 120 feeding trees).

Reproductive Success: To date, multiple births have occurred within the original social groups and within newly established founder groups formed with animals mixing from different translocation sites. Two sets of BWRL twins have been born, with the female from the first pair (F1 generation) recently giving birth to her own set of twins (F2 generation; Fig. 3). Seven individual DS offspring have also been born over the last 30 months.

Survival: Shortly after the initial BWRL release in March and April 2006, the animals moved to the northern portion of the reserve. Following a weekend when the animals were not monitored, two juvenile offspring disappeared from radio contact; no remains or radiocollars were found. Given the history of Analamazaotra Special Reserve, reports of local hunting activity in the region, and the fact that the animals were still too young to have willingly left their parents, MNP officials and the MBP-HDZ team suspected both individuals had been poached due to their proximity to the forest edge and the two surrounding villages. In addition, another female and her offspring moved southwest from the release site in the direction of Mitsinjo Reserve, a small forested area adjacent to ASR. It is believed that these two animals crossed the road and settled in this area, with its own small population of *Varecia*, as it is the only forest accessible in that direction.

Of the 27 re-introduced DS, one appeared to die of natural causes (remains found) while another animal left the area and returned to Mantadia National Park; the remaining animals dispersed throughout ASR. Out of the

Table 1: Food plants (53 species) consumed by Diademed sifaka in ASR between October 1, 2008 and March 31, 2009.

Plant name	**Family name**	***Scientific name***	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Ambavy	Annonaceae	*Polyathia ghesquiereana*	LF			LF		LF
Ambora	Monimiaceae	*Tambourissa* sp.						LF
Ampody	Pittosporaceae	*Pittosporum* sp.	LF	LF				LF
Cabucala	Apocynaceae	*Cabucala* sp.				FR		
Camellia	Theacea	*Camellia thea*	FR					
Dipaty	Moraceae	*Pachytrophe* sp.				FR	LF	LF
Ditimena	Anacardiaceae	*Protorhus ditimena*	LF					LF
Famelona	Sapotaceae	*Gambeya boiviniana*	LF					
Famohalambo	Mimosaceae	*Desmanthus tenuifolius*		LF	LF	LF	LF	LF
Fandramanana	Flacourtiaceae	*Aphloia theaeformis*				LF		
Fanjavala	Euphorbiaceae	*Blotia oblongifolia*	LF	LF				
Fotona	Chlaenaceae	*Leptolaena pauciflora*			FL			
Goavitsinahy	Myrtaceae	*Psidium cattleyanum*						FR
Havoha	Moraceae	*Bosqueia boiviana*		FR				
Hazoambo	Flacourtiaceae	*Homalium albiflorum*	LF	LF				
Hazolahy	Apocynaceae	*Carissa edulis*						FR
Hazombary	Pittosporaceae	*Pittosporum ochrosiaefolium*	LF					LF
Hazomboahangy	Moraceae	*Maillardia montana*						FR
Hazondomohina	Euphorbiaceae	*Domohinea perrieri*	LF / FL	FL				
Hazontoho madinidravina	Myrsynaceae	*Oncostemum* sp.	LF	LF				
Hoditrovy	Erythroxylaceae	*Erythroxylum corymbosum*	LF			FR		
Karakaratoloha	Schizaeaceae	*Lygodium lanceolatum*	LF		LF			LF
Karambito	Sapindaceae	*Allophylus cobbe*		FR				
Kijy	Clusiaceae	*Symphonia* sp.	LF	LF / FR / FL	LF / FR / FL		LF	LF
Kijy boalavo	Clusiaceae	*Symphonia tanalensis*		LF / FR / FL	LF / FR / FL		LF	
Kijy bonaka	Clusiaceae	*Symphonia macrocarpa*	LF	LF / FR / FL	LF / FR / FL	LF	LF	LF
Kijy fotsy	Clusiaceae	*Mammea* sp.		LF / FR / FL	LF / FR / FL	FR	LF	
Kijy masina	Clusiaceae	*Mammea bongo*	LF	LF / FR / FL	LF / FR / FL	LF/ FR	LF	
Kijy rano	Clusiaceae	*Symphonia fasciculata*		LF / FR / FL	LF / FR / FL		LF	
Kijy vongo	Clusiaceae	*Symphonia* sp.		LF / FR / FL	LF / FR / FL	FR	LF	
Lianas (ambiguous)			LF	LF / FL		FR	LF / FR	LF
Maitsoririnina	Olacaceae	*Olax glabriflora*	LF	LF		LF		LF
Malambovony	Ochnaceae	*Campylospermum lanceolatum*						LF/ FR
Menahihy	Erythroxylaceae	*Erythroxylum* sp.	LF / FL	LF / FL	LF / FR / FL	LF / FR		
Menahihy be ravina	Erythroxylaceae	*Erythroxylum* sp.			LF / FR / FL			
Menahihy fotsy	Erythroxylaceae	*Erythroxylum* sp.			LF / FR / FL			
Meanahihy madinidravina	Erythroxylaceae	*Erythroxylum* sp.			LF / FR / FL			
Mistletoe	Lorantaceae	*Bakerella clavata*	FL	LF			LF	LF
Nonoka	Moraceae	*Ficus pyrifolia*	LF	LF				
Pitsikahitra	Rubiaceae	*Schismatoclada* sp.	LF	LF				
Robary	Myrtaceae	*Eugenia emirnense*	LF		LF/ FR	LF	LF	LF
Ropadirana	Myrtaceae	*Eugenia* sp.		LF				LF
Rotra be ravina	Myrtaceae	*Eugenia jambolana*	LF	LF / FR			LF	FR
Tavolo lava ravina	Lauraceae	*Ravensara acuminata*	LF	LF		LF		
Tsiramiramy	Anacardiaceae	*Micronychia tsiramiramy*				FR		FL
Vahinkorofoka	Apocynaceae	*Secamone* sp.	LF	LF		LF	LF	LF
Varongy mainty	Lauraceae	*Ocotea cymosa*	LF	LF		LF / FR	FR	LF / FR
Varongy fotsy	Lauraceae	*Ocotea macrocarpa*	LF	LF		LF / FR	FR	
Voamboana	Papilionaceae	*Dalbergia baroni*	LF			LF		LF
Voantsilana	Araliaceae	*Schefflera vantsilana*	LF	LF				
Voapaka	Euphorbiaceae	*Uapaca thouarsii*	LF					
Vongo	Clusiaceae	*Garcinia verrucosa*	LF	FR		FR		
Zamborizano	Myrtaceae	*Eugenia jambosa*	LF	LF				

Table 2: Food plants (11 species) consumed by black and white ruffed lemurs in ASR between October 1, 2008 and March 31, 2009.

Malagasy name	**Family**	**Species**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Dipaty	Moraceae	*Pachytrophe* sp.				FR	LF/FR	
Ditimena	Anacardiaceae	*Protorhus ditimena*		LF				
Gavoala	Myrtaceae	*Eugenia gavoala*			FR			
Kijy	Clusiaceae	*Symphonia* sp.		FL				
Nanto	Sapotaceae	*Mimusops* sp.			FR			
Rotra be ravina	Myrtaceae	*Eugenia jambolana*	FR	FR	FR			FR
Tavolo lava ravina	Lauraceae	*Ravensara acuminata*	FR	FR				
Tikitiky	Palmaceae	*Dypsis* sp.					FR	
Tsikafekafe	Rubiaceae	*Tricalysia* sp.					FR	
Vagnana	Elaeocarpaceae	*Elaeocarpus* sp.		LF				
Vongo	Clusiaceae	*Garcinia verrucosa*	FL					
LF = leaves; FR = fruits; FL = flowers								

seven *P. diadema* offspring born, three have fallen victim to infanticide from competing adult females. Two others were lost to natural aerial predation, leaving two surviving offspring.

Competing Fauna: Several lemur species are sympatric with *P. diadema* and *V. v. editorum* in ASR, including *Eulemur fulvus*, *Hapalemur griseus*, *Indri indri*, and *Eulemur rubriventer*. Despite regular intra-species encounters, no persistent, aggressive behavior was observed between DS or BWRL and these other species. In their original forests, all relocated animals had previously encountered these species and did not appear to be disturbed by their

presence. These other diurnal and cathemeral species at Analamazaotra, however, had not experienced DS or BWRL in their territory since the early 1970's. As a result they were found to react by sending out long alarm calls and other territorial defining behaviors. Indri were occasionally observed to be aggressive to *P. diadema* by running after the groups, but this aggression coincided with indri mating season. Aerial predators, such as the Madagascar kestrel and Peregrine falcon, are found in ASR and caused re-introduced DS and BWRL to send out loud alarm calls. Although not abundant, blue pigeons also fed frequently on fruits with BWRL.

Discussion

The Diademed sifaka, *Propithecus diadema*, inhabits Madagascar's eastern rain forests and is one of the largest, most colorful of all lemurs (Mittermeier *et al.*, 2006). It is described as a diurnal, folivorous/frugivorous indridae (Powzyk, 1997; Powzyk and Mowry, 2003) weighting 5.5-8.5 kg (Glander *et al.*, 1992; Smith and Jungers, 1997; Lehman *et al.*, 2005). Living in groups of two to eight individuals with multiple males and females, DS defend home ranges of 20 to 50 ha using perimeter scent territorial markings by both males and females (Powzyk, 1997; Powzyk and Mowry, 2003).

The black and white ruffed lemur (*V. variegata*) also inhabits the eastern humid forests of Madagascar (Ratsimbazafy, 2002; Vasey, 2005). These critically endangered animals are the most frugivorous lemurs (Mittermeier *et al.*, 2006) and have a body mass of 2.6-4.1 kg with 73 % of their diet composed of fruit (Ratsimbazafy *et al*., 2002; Vasey and Tattersall, 2002). Due to the large amount of fruit required in their diet, and the associated territory size necessary to provide it, BWRL can be viewed as an indicator species as to the health of the forest and its related biota (Vasey, 2005). BWRL also play an important role as pollinators and seed dispersers (Wright, 1998).

It was precisely for these reasons, as indicator species and as potential dynamic ambassadors to the existing local ecotourist industry, that MNP and MEFT approached MBP-HDZ with a request to return these remarkable animals to Analamazaotra Special Reserve. As a result, the collaborative, multi-disciplinary ART Project translocated 27 Diademed sifakas and 7 black and white ruffed lemurs from four forests experiencing significant, ongoing habitat deterioration. Currently, the project has successfully evaluated the biomedical, genetic, habitat, nutritional, and reproductive parameters of these animals while monitoring their daily activity via radiocollar tracking.

Varecia reproduction is strictly seasonal and dependent upon food availability (Ratsimbazafy, 2002; Vasey and Tattersall, 2002). In October 2006, one set of twins (a male and female) was born to a translocated pair of BWRL. This F1 female offspring subsequently gave birth in 2008 to her own set of twins sired by a translocated male from Anosibe an'ala. Additionally, seven Diademed sifakas have been born since the first translocations. Although five of the DS offspring have been lost to natural causes (2 to raptors, 3 to infanticide), as of March 2009, two offspring from the June 2008 births are thriving and doing quite well. In the two and a half years since the first translocations, both species of re-introduced animals have adjusted well as evidenced by these 11 successful births and 6 surviving offspring.

While the ART Project is the first to successfully translocate wild black and white ruffed lemurs within Madagascar, the Madagascar Fauna Group has previously re-introduced captive-born BWRL (*Varecia variegata variegata*) into a protected low altitude rain forest in eastern Madagascar (Britt *et al*., 2004, 2008). Between November 1997 and January 2001, in an attempt to reinforce a small, isolated resident wild population, 13 captive-born BWRL underwent a soft release into Betampona Reserve (2,228 ha). Although this project initially suffered from high *Cryptoprocta ferox* predation, most likely due to animal naiveté (Britt *et al*., 2001), and utilized supplemental food provisioning (Britt *et al*., 2004), parallels can still be drawn between the two re-introduction efforts. Data show that ten of the eleven plant families consumed by lemurs within ASR were also consumed by Betampona BWRL (Britt and Iambana, 2003). Additionally, the ART Project and the Betampona re-introduction effort have both led to a strengthening or restoration of indigenous lemur populations in their respective reserves. Although only 3 of the 13 original Betampona animals still survive, five of the lemurs reproduced post-release, with three of those believed to have bred with the resident wild population. And like the work within ASR, a number of offspring have survived, contributing much needed genetic diversity to Betampona Reserve's BWRL population (Britt *et al*., 2008).

Overall, the MBP-HDZ ART Project has succeeded in 1) re-establishing healthy, viable wild populations of *P. diadema* and *V. v. editorum* into ASR; 2) confirming a natural expansion of each species as evidenced by births of multiple offspring; 3) training two doctorate students from the University of Antananarivo and a revolving contingent of six MNP and two local field guides to collect data on activity budgets, social behavior, feeding habits, and response to predation and competition; 4) training another doctorate student to collect nutritional data for both species; 5) collecting and preserving fecal samples for hormone analysis to better understand reproductive physiology and behavior; 6) increasing protection of ASR and habituating the re-introduced groups to human presence in order to enhance ASR's established eco-tourism industry; and 7) educating the local communities about the biodiversity of their local ecoregion.

Acknowledgements

We thank the Government of Madagascar for authorization to do research in Madagascar, especially Madagascar National Parks (MNP; formerly known as Association Nationale pour la Gestion des Aires Protégées, or ANGAP), the Ministère de l'Environnement, des Forêts et de Tourisme (MEFT), and the Tripartite Committee (CAFF/CORE). We also thank the employees of Andasibe-Mantadia National Park, the MNP guides association and the Madagascar Institut pour la Conservation des Ecosystèmes Tropicaux (MICET). Financial and technical support is gratefully acknowledged for the following institutions and individuals: White Oak Conservation Center, Minnesota Zoo, Gladys Porter Zoo, Kansas City Zoo, Memphis Zoo, Houston Zoo, Denver Zoo, Ambatovy Minerals SA and Dynatec Madagascar SA, Donald Boy, Martin Davey, and John Zaonarivelo. This manuscript was supported by the staff at Omaha's Henry Doorly Zoo Center for Conservation and Research and we thank them for their extensive contri-

butions, especially Lisa Kimmel for her assistance with all graphics.

References

Altmann, J. 1974. Observational study of behavior: Sampling methods. Behavior 49: 227-267.

ANGAP (Association Nationale pour la Gestion de Aires Protégées). 2005. Plan de Gestion du Réseau National des Aires Protégées de Madagascar. Antananarivo, Madagascar.

Britt, A.; Welch, C.; Katz, A. 2001. The impact of *Cryptoprocta ferox* on the *Varecia v. variegata* reinforcement project at Betampona. Lemur News 6: 35-37.

Britt, A.; Iambana, B.R. 2003. Can captive-bred *Varecia variegata variegata* adapt to a natural diet on release to the wild? Int. J. Primatol. 24: 987-1005.

Britt, A.; Welch, C.; Katz, A. 2004. Can small, isolated primate populations be effectively reinforced through the release of individuals from a captive population? Biol. Cons. 115: 319-327.

Britt, A.; Welch, C.; Katz, A.; Freeman, K. 2008. Supplementation of the black and white ruffed lemur population with captive-bred individuals in the Betamponа Reserve, eastern Madagascar. Pp. 197-201. In: P.S. Soorae (ed.). Global Re-introduction Perspectives: Re-introduction Case-Studies From Around the Globe. IUCN/SSC Re-introduction Specialist Group, Abu Dhabi, UAE.

Du Puy, D.J.; Moat, J.F. 1998. Vegetation mapping and classification in Madagascar (using GIS): Implications and recommendations for the conservation of biodiversity. Pp. 97-117. In: D.F. Cutler, C.R. Huxley, J.M. Lock (eds.). The Ecology, Chorology and Taxonomy of the African and Madagascan Floras - Proceedings of the Frank White Memorial Symposium. Kew Bulletin Additional Series. Royal Botanic Gardens, Kew, Surrey, UK.

Glander, K.E.; Wright, P.C.; Daniels, P.S.; Merenlender, A.M. 1992. Morphometrics and testicle size of rain forest lemur species from southeastern Madagascar. J. Hum. Evol. 22: 1-17.

Goodman, S.M.; Raselimanana, A. 2003. Hunting of wild animals by Sakalava of the Menabe region: A field report from Kirindy-Mite. Lemur News 8: 4-6.

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

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

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

IUCN/SSC Re-introduction Specialist Group. 2002. Guidelines for nonhuman primate re-introductions. Re-introduction News 21: 1-32.

IUCN. 2009. IUCN Red List of Threatened Species. Version 2009.1. **www.iucnredlist.org**. Downloaded on 28 May 2009.

Jolly, A. 1989. The Madagascar challenge: Human needs and fragile ecosystems. Pp. 198-215. In: H.J. Leonard (ed.). Environment and the Poor: Development Strategies for a Common Agenda. Transaction Publishers, Edison, NJ, USA.

Junge, R.E.; Dutton, C.J.; Knightly, F.; Williams, C.V.; Rasambainarivo, F. T.; Louis, Jr., E.E. 2008. Comparison of biomedical evaluation for white fronted brown lemurs (*Eulemur fulvus albifrons*) from four sites in Madagascar. J. Zoo Wildl. Med. 39: 567-575.

Lehman, S.M.; Wright, P.C. 2000. Preliminary study of the conservation status of lemur communities in the Betsakafandrika region of eastern Madagascar. Lemur News 5: 23-25.

Lehman, S.M.; Mayor, M.; Wright, P.C. 2005. Ecogeographic size variations in sifakas: A test of the resource seasonality and resource quality hypotheses. Am. J. Phys. Anthropol. 126: 318-328.

Longmire, J.L.; Gee, G.F.; Hardekoff, C.L.; Mark, G.A. 1992. Establishing paternity in whooping cranes (*Grus americana*) by DNA analysis. The Auk 109: 522-529.

Mittermeier, R.A.; Hawkins, F.; Rajaobelina, S.; Langrand, O. 2005. Wilderness conservation in a biodiversity hotspot. Int. J. Wilderness 11: 42-45.

Mittermeier, R.A.; Konstant, W.R.; Hawkins, F.; Louis, E.E.; Langrand, O.; Ratsimbazafy, J.; Rasoloarison, R.M.; Ganzhorn, J.U.; Rajaobelina, S.; Tattersall, I.; Meyers, D.M. 2006. Lemurs of Madagascar, 2nd ed. Conservation International, Washington, DC, USA.

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

MNP. 2009. Le Parc National de Mantadia et la Réserve Spéciale d'Analamazaotra. **www.parcs-madagascar.com** Downloaded on 28 May 2009.

Mutschler, T.A.; Randrianarisoa, J.; Feistner, A.T.C. 2001. Population status of the Alaotran gentle lemur (*Hapalemur griseus alaotrensis*). Oryx 35: 152-157.

Powzyk, J.A. 1997. The socio-ecology of two sympatric indriis: *Propithecus diadema diadema* and *Indri indri*, a comparison of feeding strategies and their possible repercussions on species-specific behavior. Ph.D. Dissertation, Duke University, Durham, NC, USA.

Powzyk, J.A.; Mowry, C.B. 2003. Dietary and feeding differences between sympatric *Propithecus diadema diadema* and *Indri indri*. Int. J. Primatol. 24: 1143-1162.

Ratsimbazafy, J.H.; Ramarosandratana, H.V.; Zaonarivelo, J.R. 2002. How do black and white ruffed lemurs still survive in a highly disturbed habitat? Lemur News 7: 7-10.

Ratsimbazafy, J.H. 2002. On the brink of extinction and the process of recovery: Responses of black and white ruffed lemurs (*Varecia variegata variegata*) to disturbance in Manombo forest Madagascar. Ph.D. Dissertation, Stony Brook University, Stony Brook, NY, USA.

Smith, R.J.; Jungers, W.L. 1997. Body mass in comparative primatology. J. Hum. Evol. 32: 523-559.

Tattersall, I.; Sussman, R.W. 1975. Note on topography, climate, and vegetation of Madagascar. Pp. 13-21. In: I. Tattersall, R.W. Sussman (eds.). Lemur Biology. Plenum Press, New York, USA.

Vasey, N.; Tattersall, I. 2002. Do ruffed lemurs form a hybrid zone? Distribution and discovery of *Varecia* with systematic and conservation implications. Am. Mus. Novitates 3376: 1-26.

Vasey, N. 2005. New developments in the behavioral ecology and conservation of ruffed lemurs (*Varecia*). Am. J. Primat. 66: 1-6.

Williamson, E.A.; Feistner, A.T.C. 2003. Habituating primates. Pp.25-38. In: M.S. Joanna, J.C. Deborah (eds.). Field and Laboratory Methods in Primatology: A Practical Guide. Cambridge University Press, Cambridge, UK.

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

Distribution of a conservation-based activity book at two primary schools near Analamazaotra Special Reserve, Madagascar

Susie M. McGuire[1], Brandon D. Sitzmann[1], Kelly Herrington[1], Sabine R. Day[2], Roger E.A.F. Ramarokoto[2], Edward E. Louis, Jr.[1]
[1]Center for Conservation and Research, Omaha's Henry Doorly Zoo, 3701 South 10th Street, Omaha, NE 68107, USA
[2]Department of Biological Anthropology and Paleontology, Faculty of Sciences, P.O. 906, University of Antananarivo, Madagascar
Corresponding author: edlo@omahazoo.com

Key words: conservation, education, Analamazaotra, Madagascar

Madagascar's current population of approximately 20.6 million people, and an estimated annual growth rate of 3 % (UNICEF, 2009; U.S. Department of State, 2009), poses a tremendous threat to the country's endemic fauna and flora. Lemurs, a diverse group of over 100 primate species found only in Madagascar (Green and Sussman, 1990; Du Puy and Moat, 1998; Mittermeier *et al.*, 2006), are under continuous anthropomorphic pressure from deforestation and illegal poaching (Jolly, 1989; Harcourt and Thornback, 1990; Lehman and Wright, 2000; Mutschler *et al.*, 2001; Goodman and Raselimanana, 2003). According to district guides and forest agents, hunting in the mid-1970's led to the local extinction (B.M. Ratsisakanana, P. Rabearisoa, Joseph, pers. comm.) of the endangered Diademed sifaka (*Propithecus diadema*) and the critically endangered black and white ruffed lemur (*Varecia variegata editorum*; IUCN, 2009; Mittermeier *et al.*, 2008) from Analamazaotra Special Reserve (ASR). Both of these species inhabit Madagascar's eastern rain forests and are two of the largest, most colorful of all lemurs (Mittermeier *et al.*, 2006). Due to the enormous amounts of leaves and fruits required in their diet (Ratsimbazafy *et al*., 2002; Vasey and Tattersall, 2002; Mittermeier *et al.*, 2006), and the associated territory size necessary to provide it, both animals are considered indicator species as to the health of the forest and its related biota (Vasey, 2005). Black and white ruffed lemurs also play an important role as pollinators and seed dispersers (Wright, 1998). In addition, with their athletic leaping abilities, raucous vocalizations and gregarious nature, both *P. diadema* and *V. variegata* are charismatic, appealing animals for the ecotourism industry. Tourism currently accounts for approximately 6.3 % of Madagascar's GDP, representing more than $400 million annually (World Travel and Tourism Council, 2007; Organisation for Economic Co-operation and Development, 2008).

In January 2006, at the request of Madagascar National Parks (MNP; formerly known as Association Nationale pour la Gestion des Aires Protégées, or ANGAP) and the Ministère de l'Environnement, des Forêts et de Tourisme (MEFT), the Madagascar Biodiversity and Biogeography Project of Henry Doorly Zoo (MBP-HDZ) initiated the Analamazaotra Re-introduction/Translocation (ART) Project. The goal of this project was to re-establish *P. diadema* and *V. v. editorum* back into their historical habitat range within ASR. A total of 27 Diademed sifakas and 7 black and white ruffed lemurs were translocated between January 2006 and July 2007 from four forests experiencing significant, ongoing habitat deterioration due to mining or agricultural activities (Day, 2009). All animals were free ranging juveniles or adults and were moved with their entire social or family group. Currently, the MBP-HDZ has successfully evaluated the biomedical, genetic, habitat, nutritional, and reproductive parameters of these animals while monitoring their daily activity via radiocollar tracking.

While the ART Project has been successful by every measurable standard, it has not been without its minor setbacks. Shortly after the initial black and white lemur release in March and April 2006, the animals moved to the northern portion of the reserve. Following a weekend in May 2006 when the animals were not monitored, two juvenile offspring disappeared from radio contact. No remains or radiocollars were found and given ASR's history, reports of hunting in the region, and the fact that the animals were still too young to have willingly left their parents, MNP officials and the MBP-HDZ team suspected both animals had been poached. Originally MNP personnel wanted to begin an investigation in the two nearby communities with the intention of finding any responsible parties and criminally prosecuting them. Instead, after lengthy discussion and at MBP-HDZ's suggestion, it was determined that a more tactful and focused approach might be more effective long-term than heavy handed enforcement.

Creation and Distribution of Activity Books

Determining public expenditures for education in Madagascar over the last 30 years has been difficult. Due to annual fluctuations in disbursements, estimates of yearly spending vary from 1.9 to 13 % of gross domestic product (Encyclopedia of the Nations, 2009; Globalis, 2009; UNICEF, 2009), with as much as 95 % of the total money allocated going towards teacher and administrative salaries (Metz, 1995). With nearly half the population under the age of 14 (CIA World Factbook, 2009), the MBP-HDZ had wanted to create a conservation-based activity book for schoolchildren of Madagascar for a number of years. In fall 2005, despite a lack of designated funding, we had begun designing a potential environmental activity book. With the help of the project's Malagasy graduate students, we drew pictures of indigenous plants and animals, designed puzzles and word games in Malagasy, and provided the general input for the book's design. Given that Madagascar's national curriculum places little emphasis on their biodiversity or distinctive cultures, the project felt there was a unique opportunity to supplement local school instruction with a book aimed at primary-age schoolchildren. The idea was to design a book which would incorporate a biodiversity conservation message into a fun, educational learning tool. This message would then be relayed from the children to the adults in their households and communities.

Motivated by the loss of the two re-introduced *V. v. editorum* at ASR in May 2006, the MBP-HDZ staff completed the general design of the book with 135 pages of activities, messages about conservation and biodiversity, and fun images for the children to color. The final result was a book called *Lemurs: Your National Treasure*. The project was now going to have a unique oppor-

tunity to see what kind of impact our activity book could have on shaping conservation opinions. A total of 350 books and 22 teachers' guides were printed. In addition, boxes of crayons, colored pencils, notebooks, pens, pencils, and sharpeners were purchased at stores in the Omaha area. These were then packaged up so that each child would receive a packet of school supplies to accompany their activity book. Shipping was arranged and all items sent via air cargo to Madagascar.

Once the shipment arrived, permission to distribute the books and education packets was received from CISCO of Moramanga (supervisory school district) and local MNP education coordinators for Andasibe. Distribution was then coordinated with local school officials and teachers, the *fokontany* chiefs from Andasibe, Antsapanana, Anevoka, and Andasifahatelo, the local *tangalamena* (respected village elders), and various local NGOs including Association Mitsinjo, AGA Association, and MNP officials. The schools selected to receive the books were Anevoka and Andasifahatelo, two primary schools near the northern boundary of Analamazaotra Special Reserve, which had a combined enrollment of over 300 students.

Finally, in September 2006, everything was in place to hand out the books and arrangements were finalized for the *fomba* (traditional ceremony) and a festival to be held in conjunction with the distribution. Sixteen graduate students and 16 field assistants from the MPB-HDZ were on hand to assist Dr. Louis with the day's events (Fig. 1). The children and their teachers were transported from the two schools to the visitors' center at ASR. Although living near the forest, most of the children had never experienced the local wealth of biodiversity due to the 600 Ariary (~$0.30) entry fee at the reserve. In coordination with MNP officials, all the children were led on an expedition by MNP and MBP-HDZ staff into the reserve to view the animals, including Diademed sifaka, black and white ruffed lemurs, and indri (*Indri indri*). Afterwards the schoolchildren, teachers, and guests returned to the park entrance for a communal feast.

At the completion of the meal the books and supplies were handed out. Books and school supplies were given to the children and their 8 teachers while local officials, children of our Malagasy staff, and local dignitaries received copies of the activity book (Fig. 2 and 3). Teachers' guides were also distributed to 14 educators from other schools within the area in hopes that they could use the information in their own classrooms. The day was not over, however. Before returning home a coloring contest was held with all of the schoolchildren with awards for a variety of ages and categories. Prizes included stuffed toy animals and backpacks with a conservation theme. The day ended when the schoolchildren and their guests were transported home along with the remaining portions of uncooked meat as a *nofonkena mitampihavanana* to confirm the new relationship between conservation and the local community. Later in the year, during a second translocation/re-introduction of Diademed sifakas into ASR, school groups, members of the local communities, and officials from national wildlife and conservation agencies were present during the release. The children even provided 'names' for all of the animals in order to personalize the re-introduced lemurs to the community.

Fig. 1: Malagasy graduate students from the MBP presented the coloring and activity books along with a message promoting conservation and responsible stewardship toward their unique environment.

Fig. 2: Each child received an educational packet, including the coloring and activity book, *Lemurs: Your National Treasure*, along with colored pencils and sharpeners, pens, notebooks, and crayons.

Fig. 3: Malagasy primary school students at Andasibe, displaying their conservation based coloring and activity books, *Lemurs: Your National Treasure.*

Follow-up

The MPB-HDZ believes that a key component in the effort to save the remaining biodiversity of Madagascar is education. By providing information about the value and importance of their environment, our project hopes to instill in local people a desire to protect their surroundings. Since distributing the books at the two schools near Analamazaotra Special Reserve, no more re-introduced animals have been poached and no fur-

ther incidences of observed or reported hunting have occurred in the area. Efforts to aid the local teachers in using the activity books in their classrooms have continued. This has included hiring a full-time Malagasy education coordinator to receive feedback from the community and assist with improvements for future editions. In total, the design, production, shipping, and distribution of the initial 350 activity books (including the party) cost approximately $6000. Considering the success of the project and the response from the local schoolchildren, we regard this as money well spent.

In October 2007, stemming from the success of the pilot study at ASR, an expanded version of the original coloring and conservation-based activity book was created. A massive shipment of 15,000 copies of this 200-page book, along with 15,000 crayon packs, notebooks, colored pencils and pens, arrived in Madagascar for distribution. The theme of this version corresponded to five carefully targeted regions, each home to one of the four critically threatened lemur species listed on the top 25 most endangered primates in the entire world (Mittermeier, 2007).

Conclusion

The MBP-HDZ conservation-based activity book project has succeeded in 1) proceeding toward our long-term vision to educate and influence the youngest generation of Malagasy leaders; 2) producing and distributing a large volume of supplemental educational materials to a rural area of Madagascar lacking these items; 3) augmenting local education efforts with an integrated message of biodiversity conservation that had not previously existed in the curriculum; 4) educating local communities about the biodiversity of their local ecoregion; 5) changing the mindset within these communities with regards to the social and economic value of local biodiversity; and 6) increasing protection of ASR and helping to care for ASR's established eco-tourism industry.

We are optimistic that educating Malagasy schoolchildren about the importance of their unique wildlife will in turn influence their parents and their attitudes toward the environment. In this way, all generations will become effective stewards of the endemic biodiversity of Madagascar. Through continuous evaluation and development of our program, we will be able to improve and expand our efforts, and the efforts of others, to enhance the educational experiences for the children of Madagascar.

Acknowledgements

We thank Madagascar National Parks, the employees of Andasibe-Mantadia National Park, the MNP guides association, Association Mitsinjo, AGA Association, local Malagasy education officials, and community members around ASR for their assistance. Financial and technical support is gratefully acknowledged for the following institutions and individuals: HDZ Chapter of the American Association of Zoo Keepers (AAZK), HDZ Docent Association, Oriental Trading Company, Kinko's, and Ronn Nolin at CEZA Logistics. The community festival would not have been possible without logistical support from MBP-HDZ students, guides, drivers, and their family members. This manuscript was supported by the staff at Omaha's Henry Doorly Zoo Center for Conservation and Research and we thank them for their extensive contributions to this project.

References

CIA World Factbook. 2009. **https://www.cia.gov/library/publications/the-world-factbook/geos/ma.html**
Downloaded on 28 May 2009.

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

Du Puy, D.J.; Moat, J.F. 1998. Vegetation mapping and classification in Madagascar (using GIS): Implications and recommendations for the conservation of biodiversity. Pp. 97-117. In: D.F. Cutler, C.R. Huxley, J.M. Lock (eds.). The Ecology, Chorology and Taxonomy of the African and Madagascan Floras - Proceedings of the Frank White Memorial Symposium. Kew Bulletin Additional Series. Royal Botanic Gardens, Kew, Surrey, UK.

Encyclopedia of the Nations. 2009. **www.nationsencyclopedia.com/Africa/Madagascar-EDUCATION.html**
Downloaded on 1 June 2009.

Globalis. 2009. **http://globalis.gvu.unu.edu/indicator_detail. cfm?Country=MG&IndicatorID=141#row**
Downloaded on 1 June 2009.

Goodman, S.M.; Raselimanana, A. 2003. Hunting of wild animals by Sakalava of the Menabe region: A field report from Kirindy-Mite. Lemur News 8: 4-6.

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

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

IUCN. 2009. IUCN Red List of Threatened Species. Version 2009.1. **www.iucnredlist.org**
Downloaded on 28 May 2009.

Jolly, A. 1989. The Madagascar challenge: Human needs and fragile ecosystems. Pp. 198-215. In: H.J. Leonard (ed.). Environment and the Poor: Development Strategies for a Common Agenda. Transaction Publishers, Edison, NJ, USA.

Lehman, S.M.; Wright, P.C. 2000. Preliminary study of the conservation status of lemur communities in the Betsakafandrika region of eastern Madagascar. Lemur News 5: 23-25.

Metz, H.C. (ed.). 1995. Indian Ocean: Five Island Countries, 3rd ed. Federal Research Division, Library of Congress, Washington, DC, USA Online at **www.country-studies.com/**

Mittermeier, R.A.; Konstant, W.R.; Hawkins, F.; Louis, Jr., E.E.; Langrand, O.; Ratsimbazafy, J.; Rasoloarison, R.M.; Ganzhorn, J.U.; Rajaobelina, S.; Tattersall, I.; Meyers, D.M. 2006. Lemurs of Madagascar, 2nd ed. Conservation International, Washington, DC, USA.

Mittermeier, R.A.; Ratsimbazafy, J.; Rylands, A.B.; Williamson, L.; Oates, J.F.; Mbora, D.; Ganzhorn, J.U.; Rodríguez-Luna, E.; Palacios, E.; Heymann, E.W.; Kierulff, M.C.M.; Yongcheng, L.; Supriatna, J.; Roos, C.; Walker, S.; Aguiar, J.M. (compilers). 2007. Primates in Peril: The World's 25 Most Endangered Primates 2006–2008. Report, IUCN/SSC Primate Specialist Group (PSG). International Primatological Society (IPS) and Conservation International (CI), Arlington, VA, USA.

Mittermeier, R.A.; Ganzhorn, J.U.; Konstant, W.R.; Glander, K.; Tattersall, I.; Groves, C.P.; Rylands, A.B.; Hapke, A.; Ratsimbazafy, J.; Mayor, M.I.; Louis, Jr., E.E.; Rumpler, Y.; Schwitzer, C.; Rasoloa-

rison, R.M. 2008. Lemur diversity in Madagascar. Int. J. Primatol. 29: 1607-1656.
Organisation for Economic Co-operation and Development. 2008. Tourism in OECD Countries 2008: Trends and Policies. OECD Publishing, Paris, France.
Ratsimbazafy, J.H.; Ramarosandratana, H.V.; Zaonarivelo, J.R. 2002. How do black and white ruffed lemurs still survive in a highly disturbed habitat? Lemur News 7: 7-10.
U.S. Department of State. 2009. **www.state.gov/r/pa/ei/bgn/5460.htm** Downloaded on 28 May 2009.
Mutschler, T.A.; Randrianarisoa, J.; Feistner, A.T.C. 2001. Population status of the Alaotran gentle lemur (*Hapalemur griseus alaotrensis*). Oryx 35: 152-157.
UNICEF. 2009. The State of the World's Children 2009. **www.unicef.org/sowc09/docs/SOWC09-FullReport-EN.pdf** or summary at **data.un.org/Data.aspx?q=madagascar+education+expenditure&d=SOWC&f=inID%3a84%3bcrID%3a87** Downloaded 1 June 2009.
Vasey, N.; Tattersall, I. 2002. Do ruffed lemurs form a hybrid zone? Distribution and discovery of *Varecia* with systematic and conservation implications. Am. Mus. Novitates 3376: 1-26.
Vasey, N. 2005. New developments in the behavioral ecology and conservation of ruffed lemurs (*Varecia*). Am. J. Primat. 66: 1-6.
World Travel and Tourism Council. 2007. Madagascar: The 2007 Travel and Tourism Economic Research **www.wttc.org/bin/pdf/original_pdf_file/1madagascar.pdf**. Downloaded on 28 May 2009.
Wright, P.C. 1998. Impact of predation on the behaviour of *Propithecus diadema edwardsi* in the rainforest of Madagascar. Behaviour 135: 483-512.

Population survey of the greater bamboo lemur (*Prolemur simus*) at Kianjavato Classified Forest

Susie M. McGuire[1], Carolyn A. Bailey[1], Jean-Norbert Rakotonirina[2], Lamaherisolo G. Razanajatovo[2], Jean F. Ranaivoarisoa[1,2], Lisa M. Kimmel[1], Edward E. Louis, Jr.[1]
[1]Center for Conservation and Research, Henry Doorly Zoo, Omaha, NE 68107, USA
[2]Madagascar Biodiversity and Biogeography Project, VO 12 Bis A, Manakambahiny, Antananarivo, Madagascar
Corresponding author: **edlo@omahazoo.com**

The greater bamboo lemur (*Prolemur simus*), the largest of all bamboo lemurs, is considered so distinct that it has recently been placed into a discrete genus (Kappeler, 1991; Tan, 1999, 2000; Groves, 2001). Once widespread throughout the island, it is now restricted to a few isolated populations primarily in southeastern Madagascar (Schwarz, 1931; Godfrey and Vuillaume-Randriamanantena, 1986; Meier and Rumpler, 1987; Sterling and Ramaroson, 1996; Godfrey and Jungers, 2003; Dolch *et al*., 2008; Delmore *et al*., 2009; Wright *et al*., 2008). Anthropogenic threats such as loss of habitat (tavy), mining, and hunting have led to the greater bamboo lemur's status as one of the world's most critically endangered primates (Mittermeier *et al*., 2005; IUCN, 2008). The greater bamboo lemur has a specialized diet consisting of 95 % Giant bamboo, *Cathariostachys madagascariensis* (Tan, 1999). This lemur's reliance on primarily one food item not only restricts its overall range, but also increases the need for a large territory to meet its dietary requirements.

At one point, this elusive primate was thought to be extinct; however, in 1986, a population was rediscovered at both Ranomafana and Kianjavato (Meier *et al*., 1987; Wright *et al*., 1987). Due to its small numbers and patchy distribution, little is known about this obscure primate (Tan, 1999, Wright *et al*., 2008). Kianjavato Classified Forest is a non-protected site, managed by FOFIFA (FOibe Flkarohana ampiharina amin'ny Fampandrosoana ny eny Ambanivohitra), a Malagasy agricultural station, and the commune of Kianjavato. In 2008, we sought to evaluate the status of this species at Kianjavato. In April, a community-based monitoring and surveillance program was initiated. This study provides baseline data and preliminary home-range sizes of *P. simus* found to date at Kianjavato.

Methods

Kianjavato is located in the Vatovavy-Fitovinany region in southeastern Madagascar (21°22' 44 S/ 47°52' 3 E; Fig. 1). This study focuses on Kianjavato and the surrounding areas of Vatovavy, which lies to the east, and Fotobohitra which lies to the west of the commune of Kianjavato. This area consists of the FOFIFA agricultural station (approximately 150 ha), which includes a large coffee plantation, and the unprotected Kianjavato Classified Forest (4,725 ha), which is a secondary forest interspersed with bamboo. The practice of slash and burn agriculture (tavy) is common in the region, and the majority of the population are subsistence farmers.

Between the months of September and October 2008, 15 *P. simus* individuals were immobilized from the Kianjavato forest, primarily around the FOFIFA station. Immobilizations were done with a Dan-Inject CO_2 projection rifle with 10 ml/kg of Telazol® (Fort Dodge). Four 2.0 mm biopsies and 1.0 cc per kg of whole blood were collected from each animal and stored in room temperature storage buffer for future genetic analysis (Longmire *et al.,* 1992). A HomeAgain® microchip was placed subcutaneously between the scapulas of each lemur as a method of permanently identifying each individual, which will assist any re-capture or longevity studies. In addition, 12 animals were radio-collared (three of the 15 individuals were juveniles and therefore collars were not placed) and morphometric measurements were recorded for each individual (Table 1). The radio-collared animals are continuously monitored daily by two local field assistants. Observations were recorded on behaviours to develop individual activity budgets (forage, movement, social, rest, sleep, other).

Table 1: Summary morphometrics of *Prolemur simus* individuals immobilized at Kianjavato Classified Forest.

ID No.	Gender	Weight (kg)	Body Length (cm)	Head Crown (cm)	Tail Length (cm)	Date of Sedation	Group No.
KIAN8.1	Female	1.5	25.2	10.0	45.6	09/24/08	3
KIAN8.2	Male	2.4	30.6	11.7	51.2	09/24/08	3
KIAN8.3	Male	2.6	30.0	11.5	53.4	09/24/08	3
KIAN8.4	Male	2.9	32.2	12.0	49.1	09/26/08	1
KIAN8.5	Male	2.2	30.3	10.6	45.4	09/27/08	2
KIAN8.6	Female	1.7	28.0	10.7	49.7	09/27/08	2
KIAN8.7*	Male	1.3	22.5	9.6	42.7	09/27/08	3
KIAN8.8	Female	2.5	31.6	11.2	49.2	09/28/08	3

ID No.	Gender	Weight (kg)	Body Length (cm)	Head Crown (cm)	Tail Length (cm)	Date of Sedation	Group No.
KIAN8.9	Female	1.8	28.6	10.8	48.5	09/28/08	3
KIAN8.10*	Male	1.5	26.2	11.0	45.0	09/29/08	2
KIAN8.11	Male	2.6	33.2	11.5	47.0	09/29/08	3
KIAN8.12	Female	3.0	34.2	11.5	50.4	09/30/08	3
KIAN8.13	Male	2.7	33.1	11.8	51.8	10/01/08	3
KIAN8.14	Male	2.7	32.7	12.1	44.5	10/01/08	3
KIAN8.15	Female	2.7	30.7	10.4	52.8	10/04/08	1
Mean ± SD		2.3± 0.5	30.3± 3.1	11.1± 0.7	48.4± 3.2		

*Juvenile, not radio-collared and therefore not included in the calculations for average and standard deviation.

Results

To date, the Kianjavato population represents the largest known population of greater bamboo lemur with an estimated population of 100 (12 animals radio-collared, 45 individuals confirmed). By monitoring the 12 radio-collared individuals, three groups have been identified with group sizes ranging from 13-17 animals. Incredibly, each of the three groups produced five offspring in November 2008. Group One consists of 17 individuals (12 adults and five offspring) with one radio-collared individual. Territory size of Group One is approximately 27.1 ha. Group Two has 13 individuals (eight adults and five offspring) with two radio-collared individuals. Group Three has 15 individuals (10 adults and five offspring) with 9 radio-collared individuals. Territorial size of Groups Two and Three are 50.2 ha and 43.8 ha, respectively. greater bamboo lemurs were found at elevations ranging from 41 to 175 m.

Of the daily behaviours recorded, we observed *P. simus* not only consuming Giant bamboo, *Cathariostachys madagascariensis*, but surprisingly the cultivated pineapple plants at the FOFIFA station. Additionally, individuals have been documented feeding on grasses in the median portion of the dirt roads that transverse the station grounds. Other behavioural observations noted *P. simus* eating, moving, and resting on occasion within *Eulemur rufifrons* and *Varecia variegata* social groups.

Recently, two substantially sized groups have been observed to the west of the FOFIFA station in the adjoining forest of Fotobohitra (Fig. 1). Additionally, Mr. Rakotonirina documented another group of approximately ten individuals moving into the territory of Group Two. The arrival of these new individuals east of the station was in response to forest fires set to burn tavy. The exact population numbers have not yet been confirmed; however, daily monitoring will begin in mid- 2009 to establish the demographics of these neighbouring groups. From this information, we estimate the total number of *P. simus* in the Kianjavato area to be approximately 100 individuals. Therefore, the greater bamboo lemur population at Kianjavato essentially doubles the overall population size of this critically endangered species estimated by Wright *et al*. (2008).

Discussion

In Tan (1999), the home range of the greater bamboo lemur was found to be 60 ha at Ranomafana National Park (39,200 ha). At the FOFIFA Kianjavato station and adjacent forest (4,875 ha), we estimated the home range sizes to be between 27.1 and 50.2 ha. Differences in home range size may be attributed to habitat loss in the Kianjavato Classified Forest. Another contributing factor for the smaller home ranges of these *P. simus* groups may be due to human hunting pressure. The monitoring of the three groups shows them to be primarily concentrated within the FOFIFA agricultural station with overlapping dynamic territories (Fig. 1). Primarily functioning as a coffee plant repository, this research facility has restricted access limiting unauthorized human activity, thus consolidating lemur populations within its boundaries.

Studies by Sterling and Ramaroson (1996), Tan (1999, 2000) and Wright *et al*. (2008) have reported the average group size of *P. simus* to be between seven to 11 individuals. Our study, however, has recorded an average group size of 15 individuals, which may be elevated due to the November 2008 births of five offspring within each group. Since the Kianjavato population has been intensely monitored for only six months, long term monitoring is warranted to corroborate current group averages which could potentially fluctuate due to subsequent dispersal events or seasonal demographic social changes. As the community education program continues to decrease the pressure of anthropogenic hunting on the greater bamboo lemur, the average size and number of social groups and the overall population structure will certainly be influenced. Furthermore, the consequences of an expanded population on the carrying capacity and long term viability of the remaining habitat at Kianjavato will have to be evaluated.

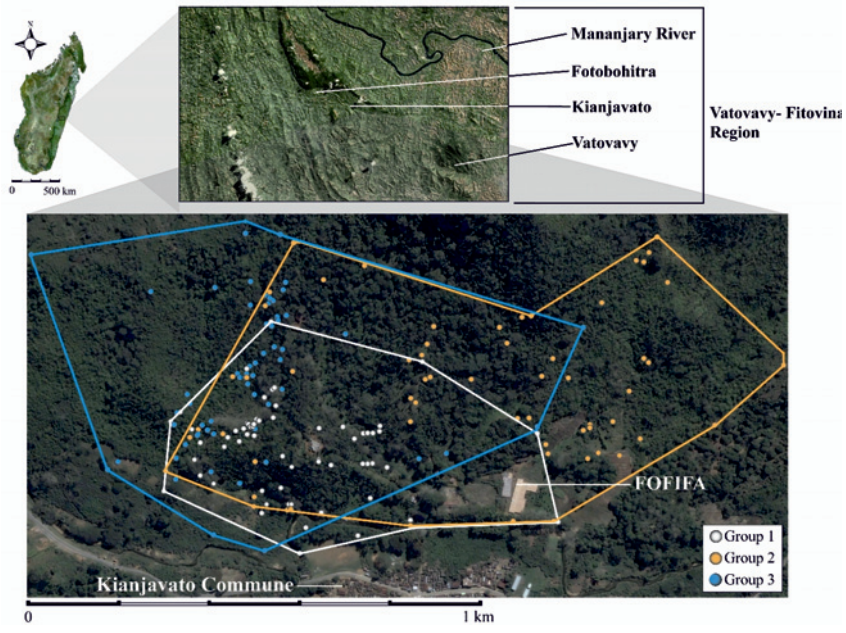

Fig. 1: Aerial view of the three radio-collared *Prolemur simus* groups at Kianjavato. Each colored circle represents a GPS location of a focal group from October 2008 to March 2009. The corresponding colored lines represent the territorial perimeter for each group. Images courtesy of Google Earth and Microsoft Virtual earth.

Acknowledgements
We would like to acknowledge the Primate Action Fund for their financial support of the field work, along with the Riverbanks Zoo and Garden's Conservation Support Fund for sponsoring the monitoring program. The authors wish to acknowledge the generosity of Bill and Berniece Grewcock and The Ahmanson Foundation for their long term support of Malagasy graduate students. We graciously thank the Theodore F. and Claire M. Hubbard Family Foundation for their long-standing support of the Henry Doorly Zoo's Madagascar Biodiversity and Biogeography Project and its field staff. This project would not have been possible without the support of the staff of FOFIFA Antananarivo and Kianjavato Station, the Commune of Kianjavato, the Institute for Conservation of Tropical Environments, Madagascar (ICTE-MICET), the Madagascar National Parks, the Ministère des Eaux et Fôret, Madagascar, and Conservation International.

References

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

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

Godfrey, L.R.; Vuillaume-Randriamanantena, M. 1986. *Hapalemur simus*: endangered lemur once widespread. Primate Cons. 7: 92-96.

Godfrey, L.R.; Jungers, W.L. 2003. Subfossil lemurs. Pp. 1248-1252. In: S.M. Goodman, J. Benstead (eds.). The Natural History of Madagascar. The University of Chicago Press, Chicago, USA

Groves, C.P. 2001. Primate Taxonomy. Pp. 81-82. Smithsonian Institution, Washington, DC, USA.

IUCN. 2008. IUCN Red List of threatened species: **www.iucnredlist.org**. Downloaded on 09 October 2008.

Kappeler, P.M. 1991. Patterns of sexual dimorphism in body weight among prosimian primates. Folia Primatol. 57: 132-46.

Longmire, J.L.; Gee, G.F.; Hardekoff, C.L.; Mark, G.A. 1992. Establishing paternity in whooping cranes (*Grus americana*) by DNA analysis. The Auk. 109: 522-529.

Meier, B.; Albignac, R.; Peyrieras, A.; Rumpler, Y.; Wright, P.C. 1987. A new species of *Hapalemur* (Primates) from southeast Madagascar. Folia Primatol. 48: 211-215.

Meier, B.; Rumpler, Y. 1987. Preliminary survey of *Hapalemur simus* and of a new species of *Hapalemur* in eastern Betsileo, Madagascar. Primate Cons. 8: 40-43.

Mittermeier, R.A.; Gil, P.R.; Hoffman, M.; Pilgrim, J.; Brooks, T.; Goettsch, C.; Lamoreux, J.; da Fonseca, G.A.B. 2005. Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. Distributed for Conservation International. 392 p.

Schwarz, E. 1931. A revision of the genera and species of Madagascar Lemuridae. Proc. Zool. Soc. Lond. 1931: 399-426.

Sterling, E.J.; Ramaroson, M.G. 1996. Rapid assessment of the primate fauna of the eastern slopes of the Réserve Naturelle Intégrale d'Andringitra, Madagascar. Fieldiana Zool. 85: 293-305.

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

Tan, C.L. 2000. Behavior and ecology of three sympatric bamboo lemur species (Genus *Hapalemur*) in Ranomafana National Park, Madagascar. PhD dissertation, State University of New York, Stony Brook, USA.

Wright, P.C.; Daniels, P.S.; Meyers, D.M.; Overdorff, D.F.; Rabasoa, J. 1987. A census and study of *Hapalemur* and *Propithecus* in southeastern Madagascar. Primate Cons. 8: 84-88.

Wright, P.C.; Johnson, S.E.; Irwin, M.T.; Jacobs, R.; Schlichting, P.; Lehman, S.; Louis, E.E.; Arrigo-Nelson, S.J.; Raharison, J-L.; Rafalirarison, R.R.; Razafindratsita, V; Ratsimbazafy, J.; Ratelolahy, F.J.; Dolch, R.; Tan, C. 2008. The crisis of the critically endangered greater bamboo lemur (*Prolemur simus*). Primate Cons. 23: 5-17.

Impact du tourisme sur *Prolemur simus* à Talatakely, dans le Parc National de Ranomafana

Jeanne Aimée Norosoarinaivo[1], Chia Tan[2], Lydia Rabetafika[1], Daniel Rakotondravony[1]
[1]Département de Biologie Animale, Faculté des Sciences, Université D'Antananarivo, Antananarivo 101, Madagascar.
[2]Conservation and Research for Endangered Species, Zoological Society of San Diego, 15600 San Pasqual Valley Road, Escondido, CA 92027-7000, USA

Prolemur simus est la seule espèce de lémurien du genre *Prolemur* (Groves, 2001). Cette espèce figure parmi celles rares et menacées d'extinction (IUCN, 2006-2008, Mittermeier *et al.*, 2006). Chaque groupe de *P. simus* est composé de 4 à 28 individus (Wright *et al.*, 2008), voire plus de 30 individus (E. Lamey, P.C. Wright, communications personnelles). Ce lémurien de grande taille se nourrit exclusivement de bambou appartenant à l'espèce *Cathariostachys madagascariensis* et vit par groupe de 7 à 11 individus dans la forêt de Talatakely dans le Parc National de Ranomafana (Tan, 1999, 2000). L'exploitation du bambou par l'homme aggrave sa disparition (Tan, 1999, 2000; Mittermeier *et al.*, 2006).

Son aire de distribution actuelle, dans la forêt tropicale humide de l'Est de Madagascar, est localisée (Meier *et al.*, 1987; Meier and Rumpler, 1987; Wright *et al.*, 1987) et comprend: Vondrozo, Kianjavato, Andringitra; le corridor Ranomafana-Andringitra, Manambolo, à Mahasoa et Torotorofotsy (Dolch *et al.*, 2004, 2008 ; Wright *et al.*, 2008). *Prolemur simus* sympathise avec *Hapalemur aureus* et avec *Hapalamur griseus*. Cette cohabitation de ces trois espèces de lémuriens mangeurs de bambou devient l'un des aspects caractéristiques du Parc de Ranomafana qui attire beaucoup de visiteurs. L'influence de touristes pourrait jouer un rôle important dans le déclin local de cette population, à travers la perturbation comportementale et la destruction de la végétation (Ratelolahy, 2002).

Le but de ce travail était d'évaluer l'impact du tourisme sur l'effectif et la composition du groupe de *P. simus*. Les

Tableau 1: Composition et nombre d'individus de *P. simus* (de 1996 à 2005).

Année	Adulte male (>6 ans)	Adulte femelle (>6 ans)	Sub-adulte (>3 ans)	Juvenile (1-3 ans)	Enfant (0-1 an)	Total	Observations
1996	1	2	2	0	2	7	
1997	1(YS)	2 (PG,NC)	2	2	2	9	2 nouvelles naissances
1998	1(YS)	2 (PG,NC)	0	4	2	9	2 nouvelles naissances et 2 disparitions (subadultes)
1999	1(YS)	2 (PG,NC)	2	4	2	11	2 nouvelles naissances et une disparition (enfant)
2000	1(YS)	1(PG)	3	1	1	7	une nouvelle naissance et 4 disparitions (un subadulte, NC et deux enfants)
2001	1(YS)	2 (PG,RG)	2(G, B)	2	1	8	une nouvelle naissance
2002	1(PRP)	2 (PG,RG)	1(B)	2	2	8	2 nouvelles naissances et trois disparitions (YS, G et un enfant)
2003	1(PRP)	2 (PG,RG)	1(Pink)	2	1	7	une nouvelle naissance et 2 disparitions (B et un enfant)
2004	1(PRP)	2 (PG,RG)	1(RBn)	2	1	7	une nouvelle naissance et une disparition (Pink)
2005	0	2 (PG,RG)	0	3		5	2 disparitions (PRP et RBn)

YS (collier jaune et médaille argentée); PRP (collier violet); PG (collier rose et médaille verte); NC (une femelle sans collier); RG (collier rouge et médaille verte); G (collier vert); B (collier bleu); Pink (collier rose); RBn (collier rouge)

objectifs visent à suivre la variation annuelle de nombre d'individus et la composition du groupe, à recenser les touristes et à déterminer la relation entre la fluctuation de *P. simus* et celle des touristes.

Méthodologie

Cette étude a été réalisée entre 1996 et 2005, a Talatakely (21°15 S et 47° 25 E) dans la parcelle numéro 3 du Parc National de Ranomafana. La végétation y est caractérisée par une forêt secondaire a dominance de bambou d'espèces: *Cathariostachys madagascariensis*, *Cephalostachyum viguieri* et *C. perrieri* et de goyave (*Psidium cattleyanum*). Le climat est du type tropical humide. Pendant 4 jours par mois (un jour par semaine), un groupe de *P. simus* a été suivi de 6 h à 18 heures. Durant notre observation, le nombre total d'individus, la composition du groupe (adultes, subadultes, juvéniles et enfants), la naissance et la disparition ont été notés. Quelques membres du groupe sont identifiés par la couleur du collier et de la médaille qu'ils portent autour du cou. Les autres individus qui n'ont pas de collier se distinguent par leur taille et leur âge. Le nombre annuel de touristes ayant fréquenté la région a pu recueillir auprès du Madagascar National Parks à Ranomafana. Pour étudier la taille moyenne annuelle du groupe, l'analyse statistique descriptive est utilisée. Le test de corrélation de Spearman, basé sur le coefficient r, est adopté pour évalue la relation entre le nombre d'individus et le nombre de touristes ainsi que la relation du tourisme et la population de *P. simus*.

Résultats

A l'issue des 240 jours (2880 heures) de suivi, le tableau 1 résume la variation du nombre d'individus et la composition de *P. simus* à Talatakely entre 1996 et 2005.

La taille maximale du groupe comporte 11 individus et le nombre minimal compte 5 individus. La taille moyenne (± standard déviation) du groupe est de 7 (± 1) individus. Quatorze nouveaux-nés sont observés. Depuis l'année 1998, 15 animaux ont disparu dont 2 adultes mâles, 1 femelle adulte, 7 subadultes, 1 juvénile et 4 enfants. Les dates de disparition des membres du groupe sont détaillées ci-après:

Mars 1998: deux subadultes mâles,
Novembre 1999: un enfant de PG, né en 1998,
Mars 2000: un sudadulte mâle sans collier (né en 1996),
Mai 2000: un adulte femelle (NC) et ses deux enfants (nés en 1998 et 1999),
Mars 2002: un sudadulte mâle (G), né en 1997,
Avril 2002: un enfant de PG (né en 2001),
Septembre 2002: YS, mâle reproducteur du groupe,
Avril 2003: un subadulte mâle (B), né en 1997 et un enfant de PG (né en 2002),
Mars 2004: un subadulte mâle (Pink), né en 1999,
Janvier-Mars 2005: un adulte mâle (PRP) et un subadulte mâle (RBn), né en 2000.

Sur les 14 nouveaux-nés, 4 enfants ont disparu à l'âge de 5 à 12 mois. Ils ont pu mourir à cause de la prédation ou suite à l'attaque des adultes mâles.

Les subadultes mâles (G; B, Pink; RBn) atteignant l'âge de maturité sexuelle entre 5 et 6 ans quittent leur groupe natal avant la période d'accouplement suite à la pression de mâles.

En 2000, le subadulte mâle sans collier, l'adulte femelle (NC) et ses deux descendants (un juvénile de 18 mois et un enfant de 6 mois) ont pu former un autre groupe.

En 2002, un nouveau mâle (PRP) vient chasser l'adulte mâle (YS) pour le remplacer.

Nombre de touristes

Tableau 2: Nombre de touristes recensés entre 1996 et 2005.

Année	**1996**	**1997**	**1998**	**1999**	**2000**
Touristes	5947	8163	10796	11952	13145
Année	**2001**	**2002**	**2003**	**2004**	**2005**
Touristes	15668	2964	11768	15613	14741

L'étude de l'impact des visites de touristes sur l'effectif de *P. simus* a permis de dresser la figure 1.

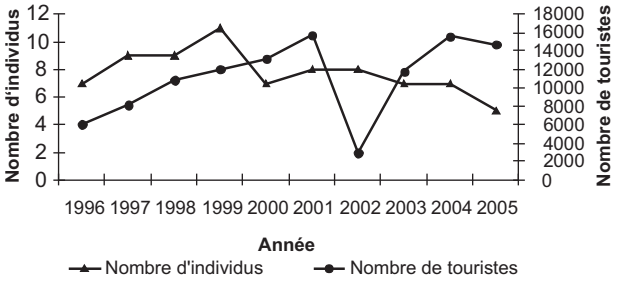

Fig. 1: Variation du nombre de touristes et du nombre d'individus de *P. simus*.

Entre 1996 et 1999, le nombre d'individus de *P. simus* augmente, atteint le maximum en 1999 (11 individus), il en fut de même pour le nombre de touristes visitant le Parc dont le nombre maximal de visiteurs s'élèvera à

15668 personnes en 2001. En 2002, ce nombre a diminué à cause de la crise politique survenue à Madagascar, pour reprendre en 2003 et 2004 avant de subir une petite chute en 2005. En 2000, l'effectif du groupe de *P. simus* diminuait à cause de la disparition de 4 individus. En 2001, une légère augmentation de l'effectif est due à la naissance d'un bébé. Le groupe restait apparemment stable en 2002, même avec la diminution du nombre de touristes. En 2003, le nombre d'individus descendait et se stabilisait en 2004. En 2005, ce nombre régressait après la disparition de deux individus. Le bilan fait ressortir une chute de l'effectif de *P. simus* de 11 à 5 individus entre 1999 et 2005 alors que celui des touristes est passé de 11952 à 15613.

L'analyse de la corrélation entre la variation du nombre de touristes et la fluctuation d'effectif de *P. simus* montre une tendance négative ($r = -0,29$) bien que cela ne soit pas significative ($p = 0,42$). Il existe une corrélation négative hautement significative ($r = -0,78$, $p < 0,01$) avec le nombre des enfants.

Discussion

Impact du tourisme (perturbation de comportement et stress)

De 2001 à 2005, l'effectif de *P. simus* enregistra une baisse allant de 11 à 5 individus, alors que le nombre de touristes connut une hausse générale de 5947 à 14741 entre 1996 et 2005. L'affluence de touristes aurait probablement joué un rôle important dans cette réduction de la population. Ce résultat confirme ce qu'annonça Ratelolahy Félix en 2002; selon cet auteur, *P. simus* serait sensible à la perturbation générée par l'écotourisme. En effet, lorsqu'elle se nourrit de la moelle intérieure ou du parenchyme médullaire du tronc de bambou, *P. simus*, espèce diurne, est très exposée aux regards des visiteurs: elle ne se déplace pas très loin et devient ainsi très facile à observer, encourageant les visites fréquentes des touristes. Cependant, plus la distance d'approche devient réduite (moins de 1 m), plus les animaux ont tendance à fuire et aussi plus le nombre croissant de touristes rend cette fuite à s'éloigner plus loin encore. Par conséquent, les animaux sont très dispersés et ont du mal à communiquer entre eux, ainsi deviennent faciles à detecter par toute sorte de prédateurs. On pourrait dire qu'une perturbation de comportement et de stress en découle: crier, gesticuler, siffler les dérangent.

En plus, les visites ininterropues en grand nombre pourraient détruire la végétation, plus particulièrement les jeunes pousses de bambou, les plus fragiles qui constituent les 98 % du régime alimentaire de *P. simus* (Tan, 2000). La quantité de la nourriture disponible serait donc diminuée. On pourrait conclure que la pression montante du nombre de touristes entre 1996 et 2005 aurait une influence sur le déclin local de *P. simus* dans la forêt de Talatakely.

Prédation et perturbation touristique

D'après ce qui est déclaré précédemment, la présence de touristes change le comportement de *P. simus*. Par rapport aux deux autres congénères, cette espèce est la plus habituée au contact avec l'homme. De ce fait, tous les membres du groupe deviennent plus vulnérables et plus exposés aux prédateurs habitués les plus fréquents observés dans la forêt de Talatakely comme les carnivores terrestres: *Cryptoprocta ferox* et *Galidia elegans* (Wright, 1998; Karpanty and Wright, 2006). Cela pourrait partiellement expliquer la disparition des jeunes *P. simus*.

Compétition avec les espèces sympatriques (H. aureus et *H. griseus)*

Durant cette étude B Talatakely, il a été constaté que le bambou géant (*Cathariostachys madagascariensis*) constitue la base du régime alimentaire de *H. aureus* et de *H. griseus* (respectivement à concurrence de 78 et 72 %). Et en outre, depuis 1996, le nombre de groupes de *H. aureus* a augmenté de 2 à 5 avec 2 à 8 individus puis de 2 à 10 groupes de 2 à 7 individus de *H. griseus*. Compte tenu de cette augmentation de charge, il se pourrait que la compétition entre les différentes espèces exploitant la même ressource alimentaire deviennent très ardue. Par conséquent, l'espèce la plus abondante va dominer par effet de masse et celle minoritaire va régresser. Ce phénomène de compétition expliquerait en partie la diminution du nombre de *P. simus*. D'ailleurs, c'est un mécanisme d'autorégulation pour la survie (nombre et composition stable autour de la moyenne) de 7 individus afin de réduire la compétition. A notre avis, il s'agirait de la cause de la disparition des 4 individus en même temps. Au mois de mai 2006, les guides touristiques et les villageois d'Ambatolahy ont signalé que ce groupe s'est déplacé dans un autre bloc forestier non protégé dans la partie nord-est du Parc (Ambatolahidimy), c'est-à-dire à 1,5 km de Talatakely. Ce déplacement devrait se justifier par la recherche d'une vie tranquille sans perturbation, ou sans compétition avec les autres espèces.

Dispersion des mâles

Chez *P. simus*, lorsque les jeunes mâles arrivent à maturité sexuelle à plus de 3 ans, ils deviennent périphériques avant de devoir quitter définitivement leur groupe natal suite à la pression de l'adulte mâle reproducteur (Tan, 2000; Ratelolahy, 2002). Ces résultats viennent confirmer ceux établis par les auteurs antérieurs. Cela pourrait constituer la raison de cette dispersion mais non disparition totale des mâles sudadultes. Chez les primates, la compétition sexuelle entre les adultes mâles pour conquérir les femelles adultes s'avère intense. Le mâle dominant chasse les mâles subordonnés (Smuts, 1987) surtout au moment de la reproduction. Ce phénomène donnerait la cause du conflit entre les deux adultes mâles (YS et PRP).

Conclusion

Cette étude nous permet de comprendre les menaces subies par *P. simus* à Talatakely et d'avancer ainsi que la réduction du nombre d'individus à partir de l'année 2000 serait due à la combinaison de plusieurs facteurs: l'augmentation du nombre de touristes, la prédation, la compétition alimentaire avec les autres espèces sympatriques et la dispersion des mâles. Le déplacement dans un bloc forestier non protégé dans la partie nord-est du Parc (Ambatolahidimy) semblerait une stratégie de survivre loin des pressions de la perturbation et afin de réduire la compétition. Pour empêcher une nouvelle extinction locale des espèces, plus particulièrement de *P. simus*, il serait souhaitable que ces résultats puissent servir aux gestionnaires des Parc nationaux à améliorer les règlements des visites touristiques. Des études com-

paratives de végétation et d'abondance en bambous sur les deux sites, Talatakely et Ambatolahidimy, puis de suivi des comportements du groupe et l'étude génétique basée sur le flux de gènes s'avèrent immédiatement indispensable à accomplir.

Remerciements
Nous tenons à remercier la Direction Générale de l'Environnement et des Forêts et le Directeur de Madagascar National Parks pour nous avoir permis de réaliser cette étude dans Parc National de Ranomafana. Nos vifs remerciements s'adressent à tout le personnel de l'Institute for Conservation of Tropical Environments (I.C.T.E) et à tous les guides sur terrain pour leurs aimables collaborations. Nous adressons également nos remerciements à Douroucouli Foundation, à l'Earthwatch Institue, à Margot Marsh Biodiversity Foundation, National Geographic Society, National Science Foundation, Primate Conservation, Inc., Sigma Xi, Wildlife Conservation Society, G. Williams et Zoological Society of San Diego pour leurs aides financières. Notre reconnaissance s'adresse spécialement aux reviewers qui nous ont beaucoup aidé par leurs critiques constructives et suggestions.

Références

Dolch, R.; Hilgartner, R.D.; Ndrianary J.N; Randriamahazo, H. 2004. The grand mother of all bamboo lemurs-evidence for occurrence of *Hapalemur simus* in fragmented rainforest surrounding the Torotorofotsy marshes, central eastern Madagascar. Lemur News 9: 25-26.

Dolch, R.; Jonathan, L.F.; Ndrianary J.N.; Rafalimandimby, J.; Randriamampionona, R.; Shannon, E.E.; Louis, E.E. 2008. Confirmation of the greater bamboo lemur, *Prolemur simus*, north of Torotorofotsy, eastern Madagascar. Lemur News 13: 14-17.

Goodman, S.M.; Razafindratsita, V.R. 2001. Inventaire biologique du Parc National de Ranomafana et du couloir forestier qui la relie au Parc National d'Andringitra. Recherches pour le Développement. Séries Sciences Biologiques. 17: 231-242.

Gray, J.E. 1871. Description of *Hapalemur simus* (*Prolemur*). Proc. Zool. Soc. Lond.: 828.

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

IUCN, (2006-2008) IUCN Red List of threatened Species. **www.iucnredlist.org**, download on 15 May 2009.

Karpanty, S.M; Wright, P.C. 2006. Multiple Predator on Lemurs in the Rainforest of Madagascar: Observations and Experiments.

Meier, B.; Rumpler, Y. 1987. Preliminary survey of *Hapalemur simus* and of a new species of *Hapalemur* in eastern Betsileo, Madagascar. Primate Cons. 8: 40-43

Meier, B.; Albignac R.; Peyrieras A.; Rumpler Y.; Wright, P.C. 1987. A new species of *Hapalemur* (Primates) from south east Madagascar. Folia Primatol. 48: 211-215.

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

Rakotondravony, D.; Razafindramahatra, L.V. 2004. Contribution à l'étude des populations de *Hapalemur aureus* dans le couloir forestier Ranomafana-Andringitra. Lemur News 9: 28-32.

Ratelolahy, F.J. 2002. Etude du statut de chef de groupe et impact de l'écotourisme sur *Hapalemur simus* (Gray, 1870) dans le Parc National de Ranomafana (Madagascar). Mémoire de D.E.A. Option Anthropologie Biologique.

Smuts, B.B. 1987. Conflict and genreder. In: Smuts B.B.; Cheney, D.D.L.; Seyfarth, R.M.; Wrangham, R.M.; Strusaker, T.T. (eds). Primates Societies. The University of Chicago Press, Chicago, USA..

Sterling, E.J.; Ramaroson, M.G. 1996. Rapid assessment of the primate fauna of the eastern slopes of the Réserve Naturelle Intégrale d'Andrigitra. Fieldiana: Zool. 85: 293-305.

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

Tan, C.L. 2000. Behavior and ecology of three sympatric bamboo lemur species (genus *Hapalemur*) in Ranomafana National Park, Madagascar. Ph.D. dissertation, State University of New York, Stony Brook, USA.

Wright, P.C. 1988. Lemurs lost and found. Nat Hist 97: 56-66.

Wright, P.C.; Johnson, S.E.; Irwin, M.T.; Jacob, R.; Schlichting, P.; Lehman, S.; Louis, Jr., E.E.; Arrigo-Nelson, S.J.; Raharison, J.L.; Rafalirarison, R.R.; Razafindratsita, V.; Ratsimbazafy, J.; Ratelolahy, F.; Dolch, R.; Tan, C.L. 2008. The Crisis of the Critically Endangered greater Bamboo Lemur (*Prolemur simus*). Primate Cons. 23: 5-17.

Possible new *Mirza* taxon from the Fiherenana River valley, Atsimo-Andrefana Region

Charlie J. Gardner[1], Louise Jasper[2]
[1]Durrell Institute of Conservation and Ecology, University of Kent, Canterbury CT2 7NS, UK,
cjamgardner@yahoo.co.uk
[2]Cultures and Conservation, Cité Sisal 7, 601 Toliara, Madagascar, **louisedjasper@gmail.com**

Until recently, only one species was recognised within the genus *Mirza* Gray 1870 of the family Cheirogaleidae – *M. coquereli*, distributed in the lowland forests of western Madagascar, with a presumed disjunct distribution stretching between the Onilahy River in the south to the Sambirano region in the north (Mittermeier *et al*., 2006). A second species, *Mirza zaza*, was described in 2005 from the Sambirano population based on behavioural, morphological and genetic differences (Kappeler *et al*., 2005). Knowledge of *Mirza* distribution within the southern portion of its range has been improved by the recent documentation of two previously unknown populations in the Fiherenana and Manombo river valleys, approximately 5 and 50 km to the north of Toliara respectively (Gardner *et al*., 2009a), but this paper presumed the observed individuals to be referable to *M. coquereli*. Here we present the first field description and photograph of a specimen from the Fiherenana population, and suggest, drawing on a range of observed and rather more circumstantial evidence, that this may represent a previously undescribed taxon.

On the 9th of May 2009 we conducted a night walk in an area of gallery forest on the northern bank of the Fiherenana River, at a site known as Ranofoty (23°13 28.9 S,

043°53' 73.3 E) in the Rural Commune of Behompy, Atsimo-Andrefana Region, approximately 27 km north-east of Toliara. The gallery forest is dominated by the naturalised *Pithecellobium dulce* (Fabaceae), but also contains specimens of *Tamarindus indica* (Fabaceae), at least four species of *Ficus* (Moraceae), and species atypical of the arid south-west (e.g. three species of *Pandanus*, Pandanaceae). At approximately 19:30 we observed a *Mirza* apparently foraging at a height of approximately three meters from the ground within the intertwined foliage of two fig trees, *Ficus* cf. *grevei* and *Ficus* sp., of which the latter was in fruit. We did not directly observe the animal feeding on figs but presume that it may have been prior to being disturbed. The animal initially climbed higher into the canopy, perhaps disturbed by our presence, but once illuminated with head torches displayed some curiosity and descended to a height of approximately five meters where it remained fairly motionless for about two minutes. The animal clearly responded to 'pishing' sounds that we made of the type that you would use to attract the attention of a domestic cat or fledgling passerines. The animal moved slowly and quadrupedally, head-first along both horizontal and vertical branches, and after about six minutes of observation climbed unhurriedly into the canopy where it was lost from view. We relocated the animal at approximately 21:30 in the same tree, but this time it was more easily disturbed and climbed immediately into the canopy where it remained motionless for some time, continuously staring at the red-filtered light from our head torches. We did not hear the animal vocalise, although *Mirza* are known to be highly vocal elsewhere (Kappeler, 2003).

We are not sufficiently familiar with other *Mirza* populations to be able to knowledgeably comment on differences in size or behaviour, but our photographs apparently reveal several differences in pelage colouration from published descriptions of *M. coquereli*. The pelage colouration of *M. coquereli* is described by Mittermeier *et al*. (2006) as follows: "the dorsal coat is rich brown or gray-brown; rose or yellow shades are often found as well. Ventrally, the gray hair base is visible beneath rusty or yellow tips. The tail… is darker towards the tip". Kappeler *et al*. (2005) note that "there may be a tendency for the pelage of northern animals to be less grey and slightly more reddish; their tails also appeared less dark towards the tip and their ventral parts were brighter". The specimen that we observed appears to have a lighter dorsal colouration than is noted for *M. coquereli*, and has conspicuous reddish or rusty patches on the dorsal surface of the distal ends of both fore- and hindlimbs. The ventral pelage is also conspicuously light in colour, and the animal possesses a strikingly red tail, also becoming darker at the end. While Kappeler *et al*. (2005) state that pelage colouration is as variable within populations as it between them, we are not aware of any published descriptions matching that of our specimen – if anything, it more closely matches Kappeler *et al*.'s (2005) description of northern individuals.

In addition to differences in pelage colouration, two lines of evidence also suggest that the Fiherenana *Mirza* population may represent a distinct taxon. *Mirza* is now known to be present in three, presumably discreet populations along westward draining watercourses in southwestern Madagascar; the Onilahy (Emmett *et al*., 2003), the Fiherenana, and the Manombo rivers (Gardner *et al*., 2009a). The species was not recorded in the Forêt de Mikea between the Manombo and Mangoky rivers by Ganzhorn and Randriamanalina (2004), but is present further inland in Zombitse-Vohibasia (Ganzhorn, 1994; Goodman *et al*., 1997) and Isalo National Parks (Hawkins, 1999). Wilmé *et al*.'s (2006) retreat-dispersal model of speciation suggests that the Manombo and Fiherenana rivers, which arise from headwaters at relatively low elevations, may have acted as centres of allopatric speciation during Quaternary glacial maxima, and have accordingly designated the Mikea sub-region in which they lie as the South Mangoky centre of microendemism: this model therefore supports the hypothesis of an undescribed *Mirza* taxon within these river systems. The Onilahy river to the south however, which arises at higher elevations, served as a retreat-dispersal watershed, thereby allowing continual genetic interchange between this and other watersheds; this raises the intriguing possibility that the Onilahy *Mirza* population is not taxonomically distinct from *M. coquereli*, and therefore that the range of the candidate Fiherenana/Manombo taxon lies entirely within that of its sister taxon.

The second line of evidence concerns relative differences in research effort between lemur taxa. Amongst nocturnal lemurs, recent revisions or novel research within the Cheirogaleid genera *Microcebus* (e.g. Zimmermann *et al*., 1998; Rasoloarison *et al*., 2000), *Cheirogaleus* (Groves, 2000) and *Phaner* (Groves, 2001 cited in Mittermeier *et al*., 2008), as well as the Lepilemuridae (e.g. Louis *et al*., 2006; Craul *et al*., 2007) and the genus *Avahi* (Thalmann and Geissmann, 2000, 2005) have resulted in the description or resurrection from synonymy of a large number of new species. No such research, as far as we are aware, has been carried out within the southern part of the range of *Mirza*. While the validity of certain new taxa is disputed (Tattersall, 2007; Mittermeier *et al*., 2008), it appears that wherever taxonomists take a close look at isolated lemur populations, they are able to find sufficient morphological, osteological or genetic differences to merit describing new taxa. We therefore believe that a similar research effort within the southern *Mirza* population complex may also reveal additional taxa.

Fig.1: *Mirza* sp. from the Fiherenana River valley.

Conservation considerations

If the Fiherenana specimen does indeed represent an undescribed taxon, this serves to further underline the importance of the new PK-32 Ranobe protected area (PA), and in particular of its proposed extension, for the conservation of southern Madagascar's biodiversity. This PA, which is co-managed by WWF and the inter-

communal association MITOIMAFI, received temporary protection status in December 2008 (Repoblikan'i Madagasikara, 2008). Due to potential spatial conflicts with areas of mining interest, the limits of the PA as defined by this decree did not extend to include the gallery forests of either the Fiherenana or Manombo rivers, or spiny thicket habitats on unconsolidated sands to the west of the Mikoboka Plateau (Gardner *et al*., 2009a). WWF are currently applying for the extension of the PA to include these key habitats within the decree of definitive protection which is expected to be granted within two years, and the physical redelimitation of the PA to include these areas has been under way since April 2009 (B. Rasolonandrasana pers. comm.). With these habitats included, PK32-Ranobe consistently shows the greatest species richness across terrestrial vertebrate taxa of any existing or proposed protected area within southern Madagascar (Gardner *et al*., 2009 a,b). The PK32-Ranobe protected area should therefore be considered the single most important conservation area within this globally important ecoregion.

The gallery forests of the Fiherenana River, which grow on fertile alluvial soils, have been devastated by clearance for agricultural land; only small fragments remain, of which none are within 30 km of the coast. The long-term viability of *Mirza* within these forest fragments must therefore be called into question. While the Ranofoty forests are afforded some cultural protection through the presence of a sacred spring and a sacred lake, we saw an active charcoal camp within 100 m of both the sacred lake and the location of our *Mirza* specimen; interviews with the ex-mayor of the commune indicated that charcoal burning has only recently become a livelihood option for local communities, and is likely to increase in intensity due to the recent (early 2009) influx of large numbers of economic migrants from the neighbouring commune of Andranovory. Urgent, holistic conservation action is therefore required to ensure the survival of these gallery forests and their associated fauna. The gallery forests of the Manombo River, on the other hand, remain relatively intact and undegraded (C. Gardner, pers. obs.), and we have few immediate concerns over the long-term viability of *Mirza* within this area.

Acknowledgements

We would like to thank M. Ismael of Behompy for help with arranging our visit, and Aviation sans Frontiers, Madagascar National Parks and WWF's Ala Maiky Programme for the over-flight which allowed us to identify Ranofoty as an area of potential conservation importance.

References

Craul, M.; Zimmermann, E.; Rasoloharijaona, S.; Randrianambinina, B; Radespiel, U. 2007. Unexpected species diversity of Malagasy primates (*Lepilemur* spp.) in the same biogeographical zone: A morphological and molecular approach with the description of two new species. BMC Evol. Biol. 7: 83. (doi:10.1186/1471-2148-7-83).

Emmett, D.A.; Fanning, E; Olson, A. (eds.) 2003. The Proposed Parc Régional de Belomotse: Biodiversity survey and conservation evaluation. Frontier-Madagascar Environmental Research Report 6. Society for Environmental Exploration, UK and University of Toliara, Institute of Marine Sciences, Toliara, Madagascar.

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.

Ganzhorn, J.U.; Randriamanalina, M.H. 2004. Les lémuriens de la forêt de Mikea. Pp. 87-93. In: A.P. Raselimanana; S.M. Goodman (eds.). Inventaire Floristique et Faunistique de la Forêt de Mikea: Paysage Écologique et Diversité Biologique d'une Préoccupation Majeure pour la Conservation. Recherches pour le Développement. Série Sciences Biologiques n° 21. Centre d'Information et de Documentation Scientifique et Technique, Antananarivo, Madagascar.

Gardner, C.J.; Fanning, E.; Thomas, H.; Kidney, D. 2009a. The lemur diversity of the Fiherenana-Manombo Complex, southwest Madagascar. Madagascar Conservation and Development 4: 38-43.

Gardner, C.J.; Kidney, D.; Thomas, H. 2009b. First comprehensive avifaunal survey of PK32-Ranobe, a new protected area in south-western Madagascar. Phelsuma 17: 30-39.

Goodman, S.M.; Langrand, O.; Rasoloarison, R.M. 1997. Les lémuriens. Pp. 156-161. In: O. Langrand; S.M. Goodman (eds.). Inventaire biologique; Forêt de Vohibasia et d'Isoky-Vohimena. Recherches pour le Développement, Série Sciences Biologiques n° 12. Centre d'Information et de Documentation Scientifique et Technique, Antananarivo, Madagascar.

Groves, C.P. 2000. The Genus *Cheirogaleus*: unrecognized biodiversity in dwarf lemurs. Int. J. Primatol. 21: 943-962.

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

Hawkins, A.F.A. 1999. The primates of Isalo National Park, Madagascar. Lemur News 4: 10-14.

Kappeler, 2003. *Mirza coquereli*, Coquerel's dwarf lemur. Pp. 1316-1318. In: S.M. Goodman; J.P. Benstead (eds.). The Natural History of Madagascar. University of Chicago Press, Chicago, USA.

Kappeler, P.M.; Rasoloarison, R.M.; Razafimanantsoa, L.; Walter, L.; Roos, C. 2005. Morphology, behaviour and molecular evolution of giant mouse lemurs (*Mirza* spp.) Gray, 1870, with a description of a new species. Primate Report 71: 3-26.

Louis, E.E., Jr.; Engberg, S.E.; Lei., R.; Geng, H.; Sommer, J.A.; Randriamampionona, R.; Randriamanana, J.C.; Zaonarivelo, J.R.; Andriantompohavana, R.; Randria, G.; Prosper; P.; Ramaromilanto, B.; Rakotoarisoa, G.; Rooney, A.; Brenneman, R.A. 2006. Molecular and morphological analyses of the sportive lemurs (Family Magaladapidae: Genus *Lepilemur*) reveals 11 previously unrecognised species. Special Publications of the Museum of Texas Tech University 49.

Mittermeier, R.A.; Konstant, W.R.; Hawkins, F.; Louis, E.E.; Langrand, O.; Ratsimbazafy, J.; Rasoloarison, R.M.; Ganzhorn, J.U.; Rajaobelina, S.; Tattersall, I; Meyers, D.M; 2006. Lemurs of Madagascar, 2nd Edition. Conservation International, Washington, DC, USA.

Mittermeier, R.A.; Ganzhorn, J.U.; Konstant, W.R.; Glander, K.; Tattersall, I.; Groves, C.P.; Rylands, A.B.; Hapke, A.; Ratsimbazafy, J.; Mayor, M.I.; Louis Jr., E.E.; Rumpler, Y. 2008. Lemur Diversity in Madagascar. Int. J. Primatol. 29: 1607-1666.

Rasoloarison, R.M.; Goodman, S.M.; Ganzhorn, J.U. 2000. Taxonomic revision of mouse lemurs (*Microcebus*) in the western portions of Madagascar. Int. J. Primatol. 21: 963-1019.

Repoblikan'i Madagasikara, 2008. Arrêté Interministériel N. 21482-2008/MEFT/MAEP/MEM/MRFDAT portant Protection Temporaire de l'Aire Protégée dénommée "Ranobe PK 32". Government of Madagascar, Antananarivo.

Tattersall, I. 2007. Madagascar's lemurs: Cryptic diversity or taxonomic inflation? Evol. Anthropol. 16: 12-23.

Thalmann, U.; Geissmann, T. 2000. Distribution and geographic variation in the western woolly lemur (*Avahi occidentalis*)) with description of a new species (*A. unicolor*). Int. J. Primatol. 21: 915-941.

Thalmann, U.; Geissmann, T. 2005. New species of woolly lemur *Avahi* (Primates: Lemuriformes) in Bemaraha (Central Western Madagascar). Am. J. Primatol. 67: 371-376.

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

Zimmermann, E.; Cepok, S.; Rakotoarison, N.; Zietemann, V.; Radespiel, U. 1998. Sympatric mouse lemurs in north-west Madagascar: A new rufous mouse lemur species (*Microcebus ravelobensis*). Folia Primatol. 69: 106-114.

Rapid primatological surveys of the Andringitra forest corridors: direct observation of the greater bamboo lemur (*Prolemur simus*)

Kira E. Delmore[1], Margaux F. Keller[2], Edward E. Louis Jr.[3], Steig E. Johnson[1]

[1]Department of Anthropology, University of Calgary, Calgary, AB T2N 1N4, Canada

[2]Department of Anthropology, Temple University, Philadelphia, PA 19122, USA

[3]Center for Conservation and Research, Henry Doorly Zoo, Omaha, NE 68107, USA

The rainforests of southeastern Madagascar contain a high degree of primate diversity, comprising 14 species of lemur in ten genera and six families (Table 1 in Irwin *et al*., 2005). Five of these species are endemic to southeastern Madagascar and seven are endemic to the island's eastern rainforests (Irwin *et al*., 2005). Many of these species are currently at risk of extinction: the southern ruffed lemur (*Varecia variegata editorum*) and greater bamboo lemur (*Prolemur simus*) are listed as critically endangered; Milne-Edward's sifaka (*Propithecus edwardsi*), the gray-headed lemur (*Eulemur cinereiceps*) and golden bamboo lemur (*Hapalemur aureus*) are listed as endangered; the gray bamboo lemur (*H. griseus*) and red-bellied lemur (*E. rubriventer*) are listed as vulnerable on the IUCN red data list (IUCN, 2008).

P. simus is of particular interest since it has been listed as one of the 25 most endangered primates in the world (Mittermeier *et al*,. 2006) and was recently the subject of a substantial review focusing on their conservation status (Wright *et al*., 2008). *P. simus* is an obligate bamboo eater, depending largely on *Cathariostachys madagascariensis* (Tan, 1999, 2000). This highly specialized diet likely places *P. simus* at greater risk (Wright *et al.*, 2008). Once found in almost all the forested areas of Madagascar (Godfrey and Vuillaume-Randriamanantena, 1986; Simons, 1997; Godfrey *et al*., 2004), this species is now restricted to eastern rainforests of the island, occupying only 1 to 4 percent of its original range (Wright *et al.*, 2008). Wright *et al.* (2008) estimated its total population size at 100 individuals, from a total of 12 groups. Recent studies by Dolch *et al.* (2008) and McGuire *et al.* (2009), however, have almost tripled this estimate. In a survey conducted at Torotorofotsy, the most northern contemporary population of *P. simus*, Dolch *et al.* (2008) observed between 4 and 11 groups of *P. simus*, with a total estimated population size of just under 100 individuals. McGuire *et al.* (2009) observed six groups of *P. simus* at Kianjavato, with a total estimated population size of 100 individuals.

Our study focuses on the eastern rainforests of the Andringitra Massif region. Lemurs found in these forests typify the primate community of southeastern Madagascar, with all 14 species listed above occurring here (Sterling and Ramaroson, 1996). This region includes Andringitra National Park (ANP; Fig. 1). ANP is connected by forest corridors to Ranomafana NP to the north, Pic d'Ivohibe Special Reserve to the southwest, and Midongy du Sud National Park to the south (Irwin *et al*., 2005), although the latter corridor is not entirely continuous.

Irwin *et al.* (2005) highlighted the importance of forest corridors for maintaining gene flow between populations and preventing effective population sizes from declining. Accordingly, the forest corridors in the Andringitra region may warrant increased protection status. Primatological surveys, however, have been restricted to areas surrounding the Andringitra NP and forest fragments to the east of the southern corridors. Here, we report on rapid assessments conducted in multiple sites in the northern and southern corridors. Our objectives are to evaluate the most recent range estimates for diurnal lemurs in the region (Irwin *et al*., 2005; Wright *et al.*, 2008) and the potential importance of including these corridors in Madagascar's protected area system.

Methods

We collected survey data between the months of June and November 2008 from eight sites within the forest corridors connecting Andringitra NP to both Ranomafana NP (northern corridor) and Midongy-du-Sud NP (southern corridor; Table 1; Fig. 1). We collected data using two methods: daily searches and diurnal line-transect surveys (Table 1). We conducted daily searches with multiple observers for four to 13 days at each site, with a mean search time of 32 person-hours per day. We established one to two line-transects (1200 - 3600 m in length) at each site except for Ranomena Masakafatsy (RAN), where data are restricted to daily searches for *P. simus* and *E. cinereiceps*. We walked transects an average of two times each day, in the morning and afternoon, and identified lemurs by both direct observations and vocalizations. For both methods, we restricted observations to day active lemurs. We also recorded evidence of anthropogenic disturbance. Evidence could include the occurrence of zebu tracks and droppings, traps and hunting, logging, slash-and-burn agriculture and small-scale mining.

Results

Signs of degradation were observed at all sites. Ambato Rakanana was by far the most disturbed site. Evidence of hunting using slingshots was common here, as was deforestation by means of selective logging, slash-and-

Table 1: Survey sites, abbreviations and survey methods.

Site	Abbreviation	Coordinates		Daily search days	Transect length (m)	Number of transect walks
		Latitude (S)	Longitude (E)			
Andavav'Androngo	AND	21°56'18.2	47°16'30.9	8	1200, 1200	12, 9
Ambondro	DRO	22°00'06.1	47°13'46.3	13	3100	34
Iharagara	IHA	22°04'04.0	47°10'02.1	6	1500, 1000	7, 5
Ambato Rakanana	RAC	22°07'38.8	47°06'36.6	8	1500, 1500	3, 6
Ampasy	AMP	22°16'58.5	47°05'13.4	6	2000, 1000	6, 4
Ankorabe	ANK	22°21'21.8	47°07'37.1	6	3600	3
Ambohitsara	SAR	22°25'07.1	47°10'44.7	7	2800	7
Ranomena Masakafatsy [a]	RAN	22°31'11.2	47°12'32.0	4	-	-

[a]Data from this site are restricted to daily surveys for *Prolemur simus* and *Eulemur cinereiceps*.

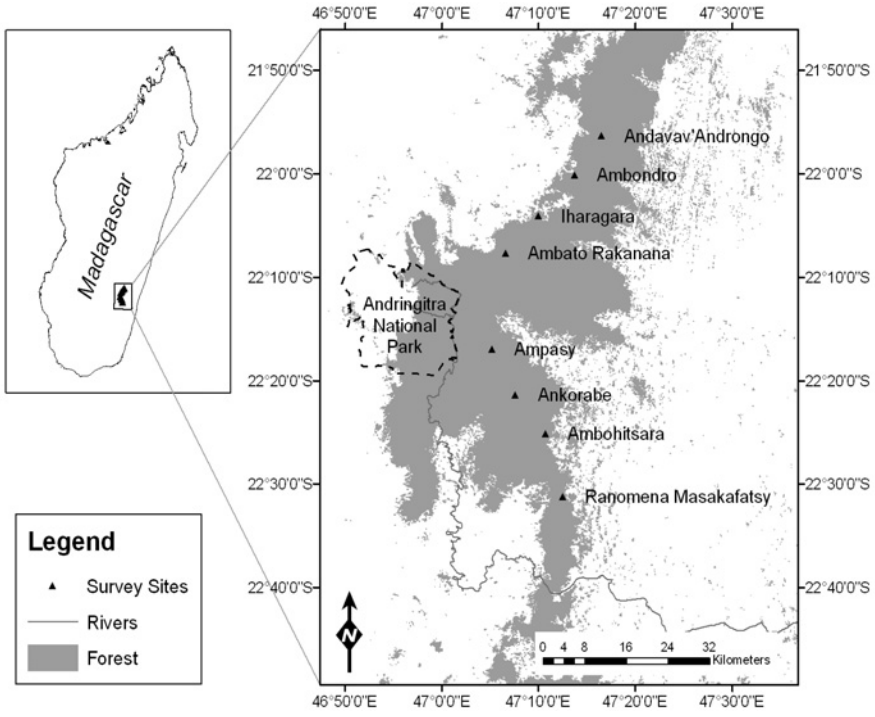

Fig. 1: Survey sites in southeastern Madagascar.

burn agriculture and mining. Direct and indirect (tracks and droppings) observations of zebu in the forest were frequent.

Table 2 summarizes the species of lemur recorded at each site. *P. simus, H. aureus*, *H. griseus*, *V. v. editorum*, *P. edwardsi*, *E. rubriventer*, *E. rufifrons*, *E. cinereiceps*, and hybrids between the latter two species were identified. Two *P. simus* individuals were observed in Ankorabe (ANK), located in the southern corridor. Interviews with villagers also suggested that *P. simus* was present at RAN, which is also located in the southern corridor. *H. aureus*, *H. griseus*, *P. edwardsi* and *E. rubriventer* were recorded in both the northern and southern corridors. Observations of *V. v. editorum* were restricted to one site in the northern corridor (Andavav' Androngo, AND). A transition from *E. rufifrons* in the north to *E. cinereiceps* was observed, with hybrids between these two species occurring in the central sites.

Discussion

In general, findings from this study support recent range distributions for the diurnal lemur species observed (Rakotondravony and Razafindramahatra, 2004; Irwin *et al*., 2005; Wright *et al*., 2008). The high lemur species richness, including the presence of multiple endangered taxa, supports the inclusion of these forest corridors in Madagascar's protected areas system.

Wright *et al.* (2008) suggested that the range of *P. simus* extends from 18º52' to 22º26' S, including the forest corridors surveyed in our study. Survey sites included in their study, however, were restricted to the areas surrounding Andringitra NP and forest fragments to the east of the southern corridor (Karianga and Morafeno; Sterling and Ramaroson, 1996; Johnson and Wyner, 2000; Goodman *et al*., 2001; Johnson, 2002). We document the first sightings of *P. simus* in the southern corridor, confirming Wright *et al*.'s (2008) estimations. The other two bamboo lemur species, *H. aureus* and *H. griseus*, were not observed in the most southern sites of our study. Recent surveys in Vevembe (30 km south of RAN), however, recorded the occurrence of the latter two species (S.E. Johnson, unpub. data; P. Rabeson, pers. comm.). Observations may have been missed due to their cryptic behavior and patchy distribution, likely related to their habitat requirements (Tan, 1999, 2000).

Two notable exceptions to range limits estimated by Irwin *et al.* (2005) were observed in our study. Irwin *et al.* (2005) estimated that the ranges of both *P. edwardsi* and *V. v. editorum* extend as far south as the Manampatrana River. *P. edwardsi*, however, was absent from the most southern sites of our study. In addition, observations of *V. v. editorum* were restricted to AND, the most northern of our study sites. Both of the latter species were also absent from surveys conducted at Vevembe (S.E. Johnson unpub. data). Unlike with *H. aureus* and *H. griseus*, it is unlikely that we missed either of these species during our study: both are conspicuous, exhibiting large body masses (*P. edwardsi*: 6.1 kg, *V. v. editorum*: 3.6 kg, Smith and Jungers, 1997) and emitting loud calls. Instead, our findings could indicate that a revision of the southern limit for these species may be necessary; they may be limited by factors other than the Manampatrana River. *V. v. editorum*, for instance, may

Table 2: Lemur species identified (*Prolemur simus, Hapalemur aureus, H. griseus, Varecia variegata editorum*, *Propithecus edwardsi*, *Eulemur rufifrons*, *E. cinereiceps and Eulemur hybrids*[b]) by means of daily searches and line-transect surveys. Site abbreviations are listed in Table 1.

Site	*P. simus*	*H. aureus*	*H. griseus*	*V. v. editorum*	*P. edwardsi*	*E. rubriventer*	*E. rufifrons*	*E. cinereiceps*	*E.* hybrids[b]
AND	-	+	+	+	+	+	+	-	-
DRO	-	-	+	-	+	+	+	-	-
IHA	-	-	+	-	+	+	+	-	+
RAC	-	+	+	-	+	+	-	-	+
AMP	-	+	+	-	+	+	-	+	+
ANK	+	-	-	-	-	+	-	+	+
SAR	-	-	-	-	-	+	-	+	-
RAN[a]	-[c]					+		+	-

[a]Data from this site are restricted to daily surveys for *P. simus* and *E. cinereiceps*.
[b]Hybridization between *Eulemur rufifrons* and *E. cinereiceps* occurs in this region (Wyner *et al.*, 2002). Animals were classified as *Eulemur* hybrids using diagnostic pelage features (K.E. Delmore, unpublished data).
[c]Interviews with locals suggest *P. simus* occurs here.

be restricted by elevation. A significant increase in elevation occurs from north to south in the northern corridor, increasing from 1016 m in AND to 1277 m at Ambato Rakanana. Irwin *et al.* (2005) and Goodman *et al.* (2001) suggested that *V. v. editorum* may be restricted to elevations of less than 1200 m.

Findings from our study support the inclusion of both corridors in Madagascar's protected areas system. The critically endangered *V. v. editorum* and *P. simus* were confirmed in the corridors, as were the endangered *P. edwardsi*, *E. cinereiceps*, and *H. aureus*. The observation of a new population of *P. simus* in a relatively intact landscape is particularly valuable, identifying a new locality that could be critical for the species' survival. In addition, our results suggest that further examination into factors influencing species limits (e.g. elevation) is needed to clarify range boundaries and set conservation priorities in this region.

Acknowledgements

This project was supported funds from Primate Action Fund (to KED), Primate Conservation Inc. (to KED), American Society of Primatology (to KED) and the University of Calgary (to KED and SEJ). We would like to thank the Government of Madagascar for allowing us to conduct research in Madagascar and the following people for help in field data collection: Brandon Sitzmann, Justin Andrianasolo, François Randrianasolo, Gerard Nalanirina, Philibert Randriamaronjaka, Nirina Jean de Dieu Andriamadison, and Ranaivoarisoa Jean Freddy.

References

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

Godfrey, L.R.; Simson, E.L.; Jungers, W.L.; De Blieus, D.D.; Chatrath, P.S. 2004. New discovery of subfossil *Hapalemur simus*, the greater bamboo lemur in western Madagascar. Lemur News 9: 9-11.

Godfrey, L.R.; Vuillaume-Randriamanantena, M. 1986. *Hapalemur simus*: endangered lemur once widespread. Primate Cons. 7: 92-96.

Goodman, S.M.; Razafindratsita, V.; Schütz, H.; Ratsimbazafy, R. 2001. Les lémuriens. Pp.231-240. In: S.M. Goodman; V.R. Razafindratsita (eds.). Inventaire biologique du Park National de Ranomafana et du couloir forestier qui la relie au Parc National d'Andringitra. Recherches pour le Développement, Série Sciences Biologiques, vol 17. Centre d'Information et du Documentation Scientifique et Techniques, Antananarivo, Madagascar.

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

Johnson, S.E. 2002. Ecology and speciation in brown lemurs: white-collared lemurs (*Eulemur albocollaris*) and hybrids (*Eulemur albocollaris* x *Eulemur fulvus rufus*) in southeastern Madagascar. Unpubl. Ph.D. thesis, University of Texas, Texas, USA.

Johnson, S.E.; Wyner, Y. 2000. Notes on the biogeography of *Eulemur fulvus albocollaris.* Lemur News 5: 25-28.

McGuire, S.M.; Bailey, C.A.; Rakotonirina, J.-N.; Razanajatovo, L.G.; Ranaivoarisoa, J.F.; Kimmel, L.M.; Louis, E.E., Jr. (2009). Population survey of the greater bamboo lemur (*Prolemur simus*) at Kianjavato Classified Forest. Lemur News 14: 38-41.

Mittermeier, R.A.; Valladares-Pádua, C.; Rylands, A.B.; Eudey, A.A.; Butynski, T.M.; Ganzhorn, J.U.; Kormos, R.; Aguiar, J.M.; Walker, S. 2006. Primates in peril: the world's 25 most endangered primates, 2004-2006. Primate Cons. 20: 1-28.

Rakotondravony, D.; Razafindramahatra, L.V. 2004. Contribution à l'étude des population de *Hapalemur aureus* dans le couloir forestier Ranomafana – Andringitra. Lemur News 9: 28-32.

Simmons E.L. 1997. Lemurs old and new. Pp.142-166. In: S.M. Goodman; B.D. Patterson (eds.). Natural Change and Human Impact in Madagascar. Smithsonian Institution Press, Washington DC, USA.

Smith, R.J.; Jungers, W.L. 1997. Body mass in comparative primatology. J. Hum. Evol. 32: 523-559.

Sterling, E.J.; Ramaroson, M.G. 1996. Rapid assessment of the primate fauna of the eastern slopes of the Réserve Naturelle Intégrale d'Andringitra, Madagascar. Fieldiana: Zool. 85: 293-305.

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

Tan, C.L. 2000. Behavior and ecology of three sympatric bamboo lemur species (Genus *Hapalemur*) in Ranomafana National Park, Madagascar. Unpubl. Ph.D. thesis, State University of New York, Stony Brook, New York, USA.

Wright, P.C.; Johnson, S.E.; Irwin, M.T.; Jacobs, R.; Schlichting, P.; Lehman, S.; Louis, Jr., E.E.; Arrigo-Nelson, S.J.; Raharison, J-L.; Rafalirarison, R.R.; Razafindratsita, V; Ratsimbazafy, J.; Ratelolahy, F.J.; Dolch, R.; Tan, C. 2008. The crisis of the critically endangered greater bamboo lemur (*Prolemur simus*). Primate Cons. 23: 5-17.

Wyner, Y.M.; Johnson, S.E.; Stumpf, R.M.; DeSalle, R. 2002. Genetic assessment of a white-collared x red-fronted lemur hybrid zone at Andringitra, Madagascar. Am. J. Primatol. 67: 51-66.

Allomothering and allonursing behaviour in collared lemurs (*Eulemur collaris*)

Kristina Kesch
Animal Ecology and Conservation, Hamburg University, Martin-Luther-King Platz 3, 20146 Hamburg, Germany, Kristina.Kesch@gmx.de

Allomothering and allonursing behaviour imposes very high costs on allomothers and is therefore hardly understood. Several hypotheses have attempted to explain this apparently altruistic behaviour. These include the misdirected parental care hypothesis, the reciprocity hypothesis, the kin selection hypothesis, the milk evacuation hypothesis, the parenting hypothesis, the brood parasitism hypothesis and the "aunting to death" hypothesis (Kohda, 1985; Packer *et al*., 1992; Ross and MacLarnon, 2000; Roulin, 2002; Eberle and Kappeler, 2006). There is mixed evidence for all of these attempted explanations. Thus, they are most likely to be linked and should therefore not be considered separately.
This behaviour has already been described in several mammalian species (Packer *et al*., 1992; König, 1997). In lemurs it has only been detected in ring-tailed lemurs (*Lemur catta*), grey mouse lemurs (*Microcebus murinus*), ruffed lemurs (*Varecia variegata*), and silky sifakas so far (König, 2006; Patel, 2007). During data collection for a study investigating the flexibility in behavioural ecology in collared lemurs (*Eulemur collaris*), I observed allomothering and allonursing behaviour, which has never been reported in this species of brown lemurs.

Study site and study animal
These observations occurred in October and November 2007 in the evergreen littoral rainforest of Mandena (24°56'S, 46°59'E, 5-20 m above sea level). This forest is situated 10 km north-east of Fort Dauphin and consists of different sized forest fragments. The area belongs to the conservation zone established by QIT Madagascar Minerals (QMM). Rainfall averages 1680 mm/year. The dry season lasts from May until September with lower rainfall from 75 to 149 mm/month, and the rainy season lasts from October to April with higher rainfall from 152 to 179 mm/month. Average monthly temperatures range between 19.8° C (July, dry season) and 26.2° C (January, February, rainy season; (Vincelette *et al*., 2007).
Collared lemurs (*Eulemur collaris*) live in multi-male/multi-female groups consisting of 2-17 individuals (Donati, 2002). After a gestation period of 120 days, females normally give birth to one, sometimes two babies (Garbutt, 1999). The offspring is carried on the mother's abdomen and weaned with an age of six to seven months (Mittermeier *et al*., 2006). *Eulemur collaris* is distributed in the south-east of Madagascar exclusively (Mittermeier *et al*., 2006). The species is categorised as "vulnerable" by the IUCN's Red List of Threatened Species (IUCN, 2007) and is mainly threatened by deforestation, charcoal production and hunting. The population in Mandena has been reintroduced in this area in 2000 and 2001 (Donati *et al*., 2007). Since then, the animals have been followed and observed for 8 - 12 hours a day to monitor their behaviour.

Results and Discussion
During the observations, 2 females, which were mother and daughter (pers. comm. staff of QMM), each gave birth to one female infant with a time-lag of two days. After 4 days the older female adopted the younger female's infantin addition to her own. Thus, the allomother cared for her granddaughter. She carried and nursed both of the infants with no obvious differences. The biological mother was seen close to the allomother more often than the other group members. However, she was never seen to carry or nurse her biological child. I observed this behaviour during the remaining 6 weeks of my data collection for another project.
Most of the hypotheses mentioned in the introduction cannot be evaluated here, because the time span of the observation was too short. The fact that the allomother was the grandmother of the adopted child is consistent with the kin selection hypothesis which suggests that the allomother was able to increase her indirect fitness by enhancing the survival and reproduction of her daughter and her granddaughter (Ross and Mac Larnon, 2000).

Fig. 1: left & middle: Adult female collared lemur with her own daughter and her granddaughter; right: Adult female and adult male collared lemur with both infants (photos: Kristina Kesch).

Acknowledgements
I thank the German Academic Exchange Service (DAAD) for their financial support in terms of a scholarship. Furthermore I thank QIT Madagascar Minerals for the permission to carry out the project in the Conservation Zone of Mandena and Giuseppe Donati, Jörg Ganzhorn and Erik Patel for their advice.

References
Donati, G. 2002. Activity rhythms and feeding behavior of *Eulemur fulvus collaris* [dissertation]. University of Pisa.
Donati, G.; Ramanamanjato, J.B.; Ravoahangy, A.M.; Vincelette, M. 2007. Translocation as a conservation measure for an endangered species in the littoral forest of southeastern Madagascar: the case of *Eulemur collaris*. Pp. 237-245. In: J.U. Ganzhorn, S.M. Goodman, M. Vincelette (eds.). Biodiversity, Ecology and Conservation of littoral Forest Ecosystems in southeastern Madagascar, Tolagnaro (Fort Dauphin). Smithsonian, Washington DC, USA.
Eberle, M.; Kappeler, P.M. 2006. Family insurance: kin selection and cooperative breeding in a solitary primate (*Microcebus murinus*). Behav. Ecol. Sociobiol. 60: 582-588.
Garbutt, N. 1999. Mammals of Madagascar. Yale University Press, New Haven.
IUCN 2007. 2007 IUCN Red List of Threatened Species. www.iucnredlist.org Downloaded 10.03.2008.
Kohda, M. 1985. Allomothering behaviour of New and Old World Monkeys. Primates 26: 28-44.
König, B. 1997. Cooperative care of young in mammals. Naturwiss 84: 95-104.
König, B. 2006. Non-offspring nursing in mammals: general implications from a case study on house mice. Pp 191-208. In: P.M. Kappeler, C.P. van Schaik, (eds). Cooperation in primates and humans. Berlin and Heidelberg, Springer.
Mittermeier, R.A.; Konstant, W.R.; Hawkins, F.; Louis, E.E.; Langrand, O.; Ratsimbazafy, J.; Rasoloarison, R.; Ganzhorn, J.U.; Rajaobelina, S.; Tattersall, I.; Meyers, D.M. 2006. Lemurs of Madagascar, Second Edition. Conservation International, Tropical Field Guide Series.
Packer, C.; Lewis, S.; Pusey, A. 1992. A comparative analysis of non-offspring nursing. Anim. Behav. 43: 256-281.
Patel, E.R. 2007. Non-maternal infant care in wild Silky Sifakas (*Propithecus candidus*). Lemur News 12: 39-42.
Ross, C.; MacLarnon, A. 2000. The Evolution of non-maternal care in anthropoid primates: A test of the hypotheses. Folia Primatol. 71: 93-113.
Roulin, A. 2002. Why do lactating females nurse alien offspring? A review of hypotheses and empirical evidence. Anim. Behav. 63: 201-208.
Vincelette, M.; Dumouchel, J.; Giroux, J.; Heriarivo, R. 2007. The Tolagnaro (Fort Dauphin) region: a brief overview of the geology, hydrology, and climatology. Pp 9-17. In: J.U. Ganzhorn, S.M. Goodman, M. Vincelette (eds.). Biodiversity, Ecology and Conservation of littoral Forest Ecosystems in southeastern Madagascar, Tolagnaro (Fort Dauphin). Smithsonian, Washington DC, USA.

Costs of alarm calling: lemur alarm calls attract fossas

Claudia Fichtel
Abteilung Verhaltensökologie und Soziobiologie, Deutsches Primatenzentrum, Kellnerweg 4, 37077 Göttingen, Germany, Claudia.Fichtel@gwdg.de

Key words: Alarm calls, costs, predation, fossa

The extreme fitness costs incurred by a successful predation event have driven the evolution and maintenance of elaborate and expensive antipredator behavior. Antipredator behavior can be broadly classified into strategies and tactics employed before and after encountering predators. The former include predator sensitive foraging, vigilance and the formation of groups or mixed species associations (Elgar, 1989; Caro, 2005, Hamilton, 1971; Lima, 1995; Ruxton *et al*., 2007). After encountering predators, prey can either flee or seek the confrontation and mob the predator or give alarm calls. Acoustic warning signals are a widespread form of antipredator behavior, in which one or more group members give loud calls to signal the presence of predators to conspecifics. On the one hand, alarm calls facilitate proposed antipredatory benefits of group-living (Lima, 1995) and cooperative defense (Curio, 1978). On the other hand, alarm calling might also be costly because vocalizing in the presence of a predator might attract the predator's attention to the caller (Caro, 1995). In addition, because a third party can extract information from a communicative interaction (McGregor and Dabelsteen, 1996), loud calling may attract additional predators (Ryan *et al*., 1981, 1982; Mougeot and Bretagnolle, 2000). Although attraction of predators has been suggested as a fundamental cost of alarm calling, there is little evidence that predators are indeed attracted by prey's alarm calls. Here, I report 5 anecdotal observations in which the fossa (*Cryptoprocta ferox*) has been attracted by alarm calls of three different lemur species in Kirindy Forest.

Alarm calls of redfronted lemurs (*Eulemur fulvus rufus)*
In order to study antipredator behavior in redfronted lemurs, I presented one group with either a crocodile model made out of bastfibres or a stuffed snake model. Both models were connected to a rope with which a second observer pulled the models towards the group on the ground. In both experiments, redfronted lemurs responded with mobbing behavior and produced alarm calls, so-called woofs and croaks (Fichtel and Kappeler, 2002). Approximately 10 minutes after the lemurs started to alarm call at the snake model and approximately 15 minutes after the presentation of the crocodile model, respectively, a fossa approached the group. In both cases, we prevented an attack by chasing the fossa away, while the redfronted lemurs continued alarm calling. In contrast to these experiments, during more than 300 hours of regular behavioral observations of redfronted lemurs, I never detected a fossa in the vicinity of the group.

Alarm calls of grey mouse lemurs (*Microcebus murinus)*
Beside snakes, raptors and the fossa, grey mouse lemurs are also preyed upon by Coquerel's giant mouse le-

mur (*Mirza coquereli*) (Goodman, 1993). In order to study mouse lemur's anti-predator behavior in response to Coquerel's giant mouse lemurs, I conducted confrontation experiments with them. To this end, individuals of both species were kept individually in $1m^3$ cages in different buildings for a maximum of two consecutive days.

During the confrontation experiments, a cage housing a mouse lemur and a cage housing a Coquerel's giant mouse lemur were placed next to each other at a distance of 20 cm for 5 minutes. The behavior of both species was video- and audio-recorded. In most experiments mouse lemurs started alarm calling at the Coquerel's giant mouse lemur and moved around in their cage. During two of these experiments, a fossa sneaked up and jumped on the cages approximately 3 and 4 minutes after the onset of the experiments. In both cases, a second observer and me chased the fossa immediately away and stopped the experiment. During control experiments in which we confronted a mouse lemur with an empty cage and mouse lemurs did not vocalize, fossas were never attracted to the experimental site. The experiments were conducted at the Kirindy research camp, where 2-3 fossas have been regularly sighted, indicating that eavesdropping on prey's alarm calls might be one element of fossas's hunting strategies.

Alarm calls of fat-tailed dwarf lemurs (*Cheirogaleus medius)*

During a pilot-study on inter-specific mobbing behavior in nocturnal lemurs (Schülke, 2001), I presented a grey mouse lemur with a stuffed snake model in combination with simultaneously broadcasting mobbing calls of a fat-tailed dwarf lemur. The snake model was presented on the ground and the loudspeaker was hidden in the vegetation at a distance of 2 m from the snake. Right after the onset of the playback calls, the mouse lemur disappeared and moved in the opposite direction of the snake model. A second observer and I followed the mouse lemur while the playback was still on-going. After approximately 5 minutes, we abandonded the mouse lemur and returned towards the snake model when we discovered a fossa inspecting the snake model.

In conclusion, these anecdotes clearly indicate that loud alarm calls addressed at one type of predator can attract additional predators; in this case a fossa. Prey animals therefore face a fundamental trade-off when alarm calling: facilitating antipredatory benefits of alarm calling for conspecifics and attraction of the predator's attention to the caller as well as attracting even more predators. Eavesdropping on prey alarm calls might be an advantageous hunting strategy of ambush hunting predators that rely on an element of surprise because prey usually focus their attention on the direction of the originally detected predators, thereby facilitating the ambush hunt of an attracted predator. Eavesdropping on prey's loud calls by predators has already been demonstrated in frogs and birds (Ryan *et al*., 1981, 1982; Mougeot and Bretagnolle, 2000). Some bats, for example, are attracted by sexual advertisement calls of frogs, or brown skuas (*Catharacta antarctica lönnbergi)*, use the mate attraction calls of colonial blue petrels (*Halobaena caerulea*) to locate prey. Thus, eavesdropping on prey's loud calls may be a widespread predator strategy to locate prey.

Although the fossa is one of the main predators of lemurs, little is known about the hunting strategy of this carnivore. Because their faeces contained remains of arboreal primates as well as of terrestrial rodents, it is likely that fossas hunt on the ground as well as in the canopy (Goodman *et al*., 1993; Rasoloarison *et al*., 1995; Dollar *et al.*, 2007). Anecdotal reports revealed that occasionally several males hunt cooperatively (Lührs and Dammhahn, 2010) but that solitary fossas exhibit an ambush hunting strategy (Wright *et al*., 1997). Thus, eavesdropping on prey's alarm calls might be one adavantage for solitarily hunting fossas to locate prey.

In conclusion, these anecdotes indicate that (lemur) alarm calling bears not only costs in terms of signal production or attraction of the predator's attention to the caller, but also in terms of attracting additional predators; in this case the fossa.

References

Caro, T.M. 1995. Pursuit-deterrence revisited. Tree 10: 500-503.

Caro, T.M. 2005. Antipredator defenses in birds and mammals. University of Chicago Press, Chicago, USA.

Curio, E. 1978. The adaptive significance of avian mobbing. I. Teleonomic hypothesis and predictions. Z. Tierpsychol. 48: 175-183.

Dollar, L.; Ganzhorn, J.U.; Goodman, S.M. 2007. Primates and other prey in the seasonally variable diet of *Cryptoprocta ferox* in the dry deciduous forest of western Madagascar. Pp. 63-76. In: S.L. Gursky, K.A.I. Nekaris (eds.). Primate anti-predator strategies. Springer, New York, USA.

Elgar, M.A. 1989. Predator vigilance and group size in mammals and birds. a critical review of the empirical evidence. Biol. Rev. 64: 13-33.

Fichtel, C.; Kappeler, P. M. 2002. Anti-predator behavior of group-living Malagasy primates. mixed evidence for a referential alarm call system. Behav. Ecol. Sociobiol. 51: 262-275.

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

Hamilton, W.D. 1971. Geometry of the selfish herd. J. Theor. Biol. 31: 295-311.

McGregor, P.K.; Dabelsteen, T. 1996. Communication networks. Pp. 409-425. In: D.E. Kroodsma, E.H. Miller (eds.). Ecology and evolution of acoustic communication in birds. Cornell University Press, Ithaca, NY.

Mougeot, F.; Bretagnolle, V. 2000. Predation as a cost of sexual communication in nocturnal seabirds: an experimental approach using acoustic signals. Anim. Behav. 60: 647-656.

Lima, S. 1995. Back to the basics of anti-predatory vigilance: the group-size effect. Anim. Behav. 49: 11-20.

Lührs, M.-L.; Dammhahn, M. 2010. An unusual case of cooperative hunting in a solitary carnivore. J. Ethol. 28: 379-383.

Rasoloarison, R.M.; Rasolonandrasana, B.P.N.; Ganzhorn, J.U.; Goodman, S.M. 1995. Predation on vertebrates in the Kirindy forest, Western Madagascar. Ecotropica 1: 59-65.

Ruxton, G.D.; Jackson, A.L.; Tosh, C.R. 2007. Confusion of predators does not rely on specialist coordinated behavior. Behav. Ecol. 18: 590-596.

Ryan, M.J.; Tuttle, M.D.; Taft, L.K. 1981. The costs and benefits of frog chorusing behavior. Behav. Ecol. Sociobiol. 8: 273-278.

Ryan, M.J.; Tuttle, M.D.; Rand, A.S. 1982. Bat predation and sexual advertisement in a neotropical anuran. Am. Nat. 119: 136-139.

Schülke, O. 2001. Social anti-predator behaviour in a nocturnal lemur. Folia Primatol. 172: 332-334.
Wright, P.C.; Heckscher, S.K.; Dunham, A.E. 1997. Predation on Milne-Edward's sifaka (*Propithecus diadema edwardsi)* by the fossa (*Cryptoprocta ferox*) in the rain forest of southeastern Madagascar. Folia Primatol. 68: 34-43.

Involving local communities in conservation: an example involving blue-eyed black lemurs (*Eulemur flavifron*s)

M.S.N. Volampeno and C.T. Downs
School of Biological and Conservation Sciences, University of KwaZulu-Natal, Private Bag X01, Scottville, Pietermaritzburg, 3209, South Africa, **downs@ukzn.ac.za** or **svolampeno@yahoo.fr**

Key words: *Eulemur flavifrons*, education, conservation, local communities

Conservation areas often have local communities living in or near them. During the creation of protected areas local communities have often been disregarded by institutions and organizations involved in establishing conservation areas (West and Brechin, 1991; Western and Wright, 1994; Stevens, 1997). Consequently, conflicts may arise between wildlife managers and local communities when the use of natural resources becomes restricted, because local communities' livelihoods depend on the forest (Hough, 1988; Hales, 1989; Rodgers, 1989; Gadgil, 1990; Mishra *et al*., 1992). Protected areas should make allowance for the maintenance of the livelihoods of local communities (McNeely, 1995; Ghimire and Pimbert, 1997).

Over the last decade, involving local populations in conservation activities has become a priority of conservation policy (Adams and Hulme, 1998; Agrawal and Gibson, 1999). Several studies have documented that participation and support from local communities is an effective method for sustainable conservation (Heinen, 1993; Durbin and Ralambo, 1994; Fiallo and Jacobson, 1995). For example, sustainable forest management requires that the people living in the forest should learn how to use the forest resources without depleting them in the long term (Brookfield, 1988).

The major objectives of environmental education are to provide local people with the knowledge they need to protect and improve their environment, and to assist them in assessing the impacts of resource use so that they can modify their behaviour to ameliorate environmental problems as they arise (Palmer, 1998). Here we report on our contribution to environmental education of the local community in the Sahamalaza – Iles Radama National Park (SPNP), which contains the major part of the range of the blue-eyed black lemur (*Eulemur flavifrons*). Our objectives were to increase local population awareness of the necessity for conservation of the blue-eyed black lemur and its habitat, and to shift local attitudes away from deforestation to sustainable management of natural resources.

The SIRNP is located in north-western Madagascar in the province of Mahajanga (between 14° 04' and 14° 37' S and 47° 52' and 48° 04' E) with altitudes varying from 0 to 355 m. It covers an area of approximately 26,000 ha, limited by the Sahamalaza Bay in the east, the Mozambique Channel in the west and the Loza River in the south (see Volampeno, 2009).

Why protect the blue-eyed black lemur?

Because of the presence of the critically endangered blue-eyed black lemur in the SIRNP, the area has been the focus of scientific and conservation interest by the Association Européenne pour l'Etude et la Conservation des Lémuriens (AEECL), which is a consortium of European zoos engaged in lemur research and conservation (**http://www.aeecl.org**). The blue-eyed black lemur can be considered one of their "flagship" species because it represents conservation efforts in the SIRNP. This lemur is among the most distinctive lemurs, with its bright blue eyes and strong sexual dichromatism; the males are completely black and the females reddish-orange (Mittermeier *et al*., 2006). It ranks also among the least studied of the diurnal lemurs and was rediscovered relatively recently (Koenders *et al*., 1985).

The distribution of this lemur is restricted to a small area of forest in north-western Madagascar, most of which occurs within the SIRNP (Mittermeier *et al*., 2006). The species is classified as critically endangered because of continued habitat destruction for wood exploitation, uncontrolled fire, and slash and burn agriculture (Mittermeier *et al.*, 2006; pers. obs.).

Blue-eyed black lemurs are arboreal and frugivorous, and thus totally dependent on the forest. Several studies have demonstrated that many frugivorous primates, including lemurs, play an important role in seed dispersal for forest trees and the pollination of some forest canopy flowers (e.g. Kress *et al.*, 1994; Birkinshaw and Colquhoun, 1998; Lambert, 1998; Ganzhorn *et al.,* 1999; Oliveira and Ferrari, 2000; Fedigan and Jack, 2001; Lambert, 2001; Koné *et al.*, 2008). The frugivorous nature of blue-eyed black lemurs indicates that it probably plays a role in seed dispersal and forest regeneration.

Why involve the local population?

Habitation of the forest by people goes back more than a thousand years, and the local communities have a good practical knowledge of the forest, and the skills to manage and develop their environment (Palmer, 1998). Members of the Sakalava ethnic group constitute the majority of the population found in the SIRNP, but migrants from the Tsimihety ethnic group also inhabit this region (Andrianantenaina, 1996). In the SIRNP, the majority of the villages are situated along the eastern and western coastal areas, with only a few settlements scattered in the interior of the peninsula (Andrianantenaina, 1996). Rice is the main crop cultivated. This agricultural practice consists of cutting and burning forested zones of one to two acres for paddy fields. After one or two years of production, the soil is exhausted, and the farmers abandon the site and search for new site (pers. obs.). Subsistence fishing is also practiced, but on a small scale due to the difficulty of obtaining fishing equipment (Andrianantenaina, 1996). Most of the households on the peninsula have free-ranging cattle. Consequently the local population has burned grasslands near the forest savannahs to encourage the growth of young grasses for livestock pastures (Rakotondratsima, 1999). This practice results in uncontrolled fire on the peninsula. In addition, the villagers practice logging inside the forest for private sale.

If the forest continues to decline at its present rate, the blue-eyed black lemur will face extinction and the local populations will lose the benefits of the forest. Our rationale was that, if the local community was made more aware of the consequences of degrading their environment, they could be convinced to take responsibility for conserving and managing the natural resources in their vicinity.

Materials and methods

Song and sketch performance

The AEECL/WCS consortium helped the local communities to establish the local conservation association "VOLAMAINTSO"" and other local associations in order to help them manage their natural resources sustainably (Schwitzer, 2006; Schwitzer *et al*., 2006). Since 2005, VOLAMAINTSO has organized an annual "lemur festival" for three days each September. The main goal of this festival is to increase the local population's awareness of the biodiversity, and especially of the need for lemur conservation. During the festival, villages living within the SIRNP participate in devising songs and dances and in sports events. The songs are presented as part of a competition, and the village which performs the best song receives a prize from the AEECL. The lyrics of the songs must relate to conservation.

Since 2006 M.S.N.V. has been a lemur festival organizer, and in 2007 her local research assistants and she participated in the festival, which took place in Antafiabe, a village inside the SIRNP. They performed a song and a play about the blue-eyed black lemur (Figure 1). They practiced every night for a period of a month before the lemur festival. M.S.N.V. wrote the song lyrics and play script and an assistant translated it into the local language "Sakalava" so the public could understand the message. The performance was both educational and entertaining and could be understood by all age/sex classes. The lyrics of the song were about the importance and benefits of biodiversity protection and the disadvantages of deforestation and slash and burn agriculture. The title of the play was **"*Protect the blue-eyed black lemur to protect the forest*"**. All the research assistants acting in the play wore costumes that matched that of the actor playing the blue-eyed black lemur and imitating its vocalization and movement. They were taught to act naturally during the show in order to keep the full attention of the public. The play illustrated how the local population benefits from blue-eyed black lemurs and the forest, and showed that the presence of the lemurs in the SIRNP provides advantages for the local population in the form of tourism and jobs, and contributes to forest regeneration. It also demonstrated that the needs of the local people (e.g. wild fruits, medicinal plants, fuel-wood, construction materials) depend on the survival of the forest. The play ended with a strong message: "Protecting this lemur will help forest protection". The song was performed for about 10 min on the first day of the festival, while the play lasted 30 min and was performed on the second day. Both were performed once at the festival.

Distribution of T-shirts

Conservation International (CI) agreed to provide 50 cotton T-shirts to promote lemur conservation as a contribution to M.S.N.V. PhD research support. The AEECL programme coordinator (Guy Randriatahina) and M.S.N.V. designed the logo for the T-shirt, which was drawn by Stephen Nash (Fig. 2). A conservation message was written on both sides in the local language. On the front was a colour picture of the Sahamalaza sportive lemur *(Lepilemur sahamalazensis*), a recently described species (Andriaholinirina *et al.,* 2006), and the text message: "***Stop fire, deforestation and lemur hunting***". On the back were colour pictures of a male and female blue-eyed black lemur with the text message: **"*Protect biodiversity*"**.

Fig. 1: Enactment of the play during the Lemur Festival September 2007, Antafiabe Village.

Fig. 2: Design of the T-shirt for conservation awareness of lemurs showing.

The T-shirts were distributed in September 2008. The number of shirts was insufficient for all villagers in the SIRNP, and so they were distributed to our research assistants, teachers at primary schools and village chiefs. We arranged meetings with the respective teachers and village chiefs during which we explained our reasons for protecting blue-eyed black lemurs and the consequences of deforestation. We included research assistants in the programme because they have made observations of blue-eyed black lemurs and know the importance of protecting the species and its habitat. The village chiefs have frequent contact with the local population, and are decision makers whose words carry authority (pers. obs.). During classes, teachers have the opportunity to discuss conservation with pupils, and also have contact with the pupils' parents. We encouraged them to pass on the conservation message whenever possible, such as at village meetings or environmental events like Environment Day, Tree-planting Day and the Lemur Festival.

Local community perceptions

After our performance we asked 30 people (excluding children) from eight different villages a series of six questions relating to their comprehension of the play contents and lessons learned from our performance. Of these 64 % were female and 36 % male, and all had watched the performance. Of these 50 % highlighted that they had enjoyed the performance, 23 % highlighted learning about the behaviour of blue-eyed black lemurs including aspects of their vocalizations and movements, 17 % highlighted learning the advantages of the presence of this lemur eg tourism, while 10 % highlighted learning the costs of deforestation. In addition, after the event the local conservation association (which is the main organizer of the lemur festival) and the village chiefs conducted an evaluation of the festival. Overall, the local communities enjoyed the performances, gained knowledge of behaviour of the blue-eyed black lemurs (e.g. vocalization, movement), and were more aware of the costs of deforestation and advantages accruing from the presence of blue-eyed black lemurs. The village chiefs and teachers were highly motivated to encourage a change of attitude towards lemur hunting and deforestation among the local population, and decided to wear the T-shirts during meetings and environmental events. Many people asked us for more T-shirts. Our play was the first to be performed since the initiation of the annual lemur festival in the SPNP. In 2008 we were asked about a new play, as the people had enjoyed the previous one.

Discussion and conclusions

Ours was not the only conservation education measures that have been/are being carried out in Sahamalaza — Iles Radama National Park (e.g. distribution of educational booklets, participation in JME and local fares) (Schwitzer, 2006; Schwitzer *et al.*, 2006). Our contribution to environmental education was a basic step towards practical blue-eyed black lemur conservation. It received a positive response from the local population. Further projects, such as the production of leaflets, T-shirts, posters, handbooks for schools, and documentaries, are necessary to increase public awareness of the need for sustainable conservation of the blue-eyed black lemur and its habitat. Communities have lived in the forest for thousands of years and depend on forest wildlife and resources. Through programmes like ours, they can be encouraged to take ownership of and responsibility for the management and protection of the forest and its resident lemur species.

Acknowledgements

This research was supported by grants from the Association Européenne pour l'Etude et la Conservation des Lémuriens (AEECL), Conservation International (CI), and the Third World Organization for Women in Sciences (TWOWS). M.S.N.V. wishes to thank the School of Biological and Conservation Sciences, University of Kwa Zulu-Natal, South Africa, IdeaWild and the Wildlife Conservation Society for support, and the Madagascar National Parks for permission to conduct research in Sahamalaza – Iles Radama National Park. M.S.N.V. is grateful to Russell Mittermeier and Stephen Nash for their help with the T-shirts. Special thanks are due to Guy Randriatahina, the local assistants and the local communities in the Sahamalaza Peninsula.

References

Adams, W.M.; D. Hulme. 1998. Conservation and communities: Changing narratives, policies and practices in African conservation. Community Conservation in Africa working paper Manchester: IDPM, University of Manchester.

Agrawal, A. and C.C. Gibson. 1999. Enchantment and disenchantment: The role of community in natural resource conservation. World Dev. 27: 629-649.

Andriaholinirina, N., J.L. Fausser, C. Ross, D. Zinner, U. Thalman, C. Rabarivola, I. Ravoarimanana, J.U. Ganzhorn, B. Meier, R. Hilgartner, L. Walter, A. Zaramody, C. Langer, T. Hahn, E. Zimmermann, U. Radespiel, M. Craul, J. Tompjuk, I. Tattersall, Y. Rumpler. 2006. Molecular phylogeny and taxonomic revision of the sportive lemurs (*Lepilemur*, Primates). Evol. Biol. 6: 17.

Andrianantenaina, F. 1996. Région autour de la baie de Sahamalaza: Etude socio-économique Ministére Eaux et Forêt. Unpublished report.

Birkinshaw, C.R.; I.C. Colquhoun. 1998. Pollination of *Ravenala madagascariensis* and *Parkia madagascarienis* by *Eulemur macaco* in Madagascar. Folia Primatol. 69: 252-259.

Brookfield, H. 1988. The new great age of clearance and beyond. Pp. 209-224. In: J.S. Denslow and C. Padoch (eds). People of the tropical rain forest. University of California Press, Los Angeles, USA.

Durbin, J.C., J.A. Ralambo. 1994. The role of local people in the successful maintenance of protected areas in Madagascar. Environ. Conserv. 22:115-120.

Fedigan, L.M., K. Jack. 2001. Neotropical primates in a regenerating Costa Rican dry forest: A comparison of howler and capuchin population patterns. Int. J. Primatol. 22: 689-713.

Fiallo, E.A. and S.K. Jacobson. 1995. Local communities and protected areas: Attitudes of rural residents towards conservation and Machalilla National Park, Ecuador. Environ. Conserv. 22: 241-249.

Gadgil, M. 1990. India's deforestation, patterns and processes. Soc. Natur. Res. 3: 131-143.

Ghimire, B.K.; Fimbert, M.P. 1997. Social change and conservation: An overview of issues and concepts. Pp. 1-45 In: P.G. Krishna, P.P. Michel (eds.). Social change and conservation. Earthscan Publications Limited, London, UK.

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

Haies, D. 1989. Changing concepts of national parks. Pp. 139-144. In: D. Western, M. Pearl (eds.). Conservation for twenty-first century. Oxford University Press, Oxford, UK.
Heinen, J.T. 1993. Park-people relations in Kosi Tappu Wildlife Reserve, Nepal: A socio-economic analysis. Environ. Cons. 20: 25-34.
Hough, J.L. 1988. Obstacles to effective management of conflicts between national parks and surrounding human communities in developing countries. Environ. Cons. 15: 129-136.
Koenders, L., Y. Rumpler, J. Ratsirarson, A. Peyrieras. 1985. *Lemur macaco flavifrons* (Gray, 1867): A rediscovered subspecies of primate. Folia Primatol. 44: 210-215.
Koné, I., J.E. Lambert, J. Refisch, A. Bakayoko. 2008. Primate seed dispersal and its potential role in maintaining useful tree species in the Tai region, Cote d'Ivoire: Implications for the conservation of forest fragments. Trop. Conserv. Sci.1: 293-306.
Kress, W.J., G.E. Schatz, M. Andrianifahanana, H.S. Morland. 1994. Pollination of *Ravenala madagascariensis* (Strelitziaceae) by lemurs in Madagascar: Evidence for an archaic co-evolutionary system. Am. J. Bot. 81: 542-551.
Lambert, J.E. 1998. Primate frugivory in Kibale National Park, Uganda, and its implications for human use of forest resources. Afr. J. Ecol. 36: 234-240.
Lambert, J.E. 2001. Red-tailed guenons (*Cercopithecus ascanius*) and *Strychnos mitis*: Evidence for plant benefits beyond seed dispersal. Int. J. Primatol. 22: 189-201.
McNeely, J.A. 1995. Expanding partnerships in conservation. Island Press, Washington DC, USA.
Mittermeier, R.A., W.R. Konstant, F. Hawkins, E.E. Louis, O. Langrand, J. Ratsimbazafy, R. Rasoloarison, J.U. Ganzhorn,, S. Rajaobelina, I. Tattersall, Meyers, D.M. 2006. Lemurs of Madagascar, 2nd. Edition. Conservation International, Washington DC, USA.
Mishra, H.R.; Wemmer, C.; Smith, J.L.D.; Wegge, P. 1992. Biopolitics of saving Asien mammals in the wild: Balancing conservation with human needs in Nepal. Pp. 9-35. In: P. Wegge (ed.). Mammal conservation in developing countries: A new approach. Agricultural University of Norway, Norway.
Oliveira, A.C.M., S.F. Ferrari. 2000. Seed dispersal by black-handed tamarins, *Sanguinus midas niger* (Callitrichinae, Primates): Implications for the regeneration of degraded forest habitats in eastern Amazonia. J. Trop. Ecol. 16: 709-716.
Palmer, J.A. 1998. Environmental education in the 21st Century. Theory, practice, progress and promise. Routledge, London, UK.
Rakotondratsima, M. 1999. Etude quantitative de *Eulemur macaco flavifrons* dans la Presqu'ile Radama. Wildlife Conservation Society, Madagascar. Unpublished report.
Rodgers, W.A. 1989. Policy issues in wildlife conservation. Indian Institute of Public Administration, New Delhi.
Schwitzer, C. 2006. AEECL Programme Sahamalaza — Iles Radama: Conservation and study of critically endangered lemurs in northwestern Madagascar. EAZA Madagascar Campaign 2006/7 Info Pack, 64-68. EAZA Executive Office, Amsterdam.
Schwitzer, C., N. Schwitzer, G.H. Randriatahina, C. Rabarivola, W. Kaumanns. 2006. "Programme Sahamalaza": New perspectives for the *in situ* and *ex situ* study and conservation of the blue-eyed black lemur (*Eulemur macaco flavifrons*) in a fragmented habitat. Pp. 135-149. In: C. Schwitzer, S. Brandt, O. Ramilijaona, M. Rakotomalala Razanahoera, D. Ackermand, T. Razakamanana and J.U. Ganzhorn (eds.). Proceedings of the German-Malagasy Research Cooperation in Life and Earth Sciences. Concept Verlag, Berlin, D.
Stevens, S. 1997. Conservation through cultural survival: Indigenous peoples and protected areas. Island Press, Washington, DC, USA
Volampeno, N.S.M. 2009. Reproductive Behaviour and Habitat Use in the Blue-eyed black lemur (*Eulemur flavifrons*, Gray, 1867) at the Sahamalaza Peninsula, National Park Madagascar. PhD thesis, University of KwaZulu-Natal, Pietermaritzburg campus.
West, P.C.; Brechen, S.R. 1991. Resident peoples and National Parks: Social dilemmas and strategies in international conservation. Tucson, AZ, USA.
Western, D.; Wright, R.M. 1994. Natural connections: Perspectives in community-based conservation. Island Press, Washington, DC, USA.

FUNDING AND TRAINING

The Society for Conservation Biology (SCB) Africa Section

The deadline has run out for this year, but it might be worth to keep the program in mind and check whether it will be continued: The Society for Conservation Biology (SCB) Africa Section instituted SCB Africa Section Communications/Mentoring Program in 2007 funded by John D. and Catherine T. MacArthur Foundation to expand the pipeline of seasoned African Conservation Biologists and foster the development of young aspiring professionals in Conservation Biology.
The program is targeted at coaching African students and Conservation Biologists on writing high standard manuscript and proposal. Mentees (upcoming scientists) are paired with mentors (experienced African or non African scientists) who will coach them through 8 months of well structured e-mentoring process. The program is open to SCB Africa Section members; however SCB membership is not a requirement.
Enrolment exercise commenced 1st August 2009 to close by 31st. For more information on how to enrol as a mentee or mentor, please visit
www.conbio.org/Sections/Africa/AfricaMentor.cfm
Ademola Ajagbe, Program Coordinator, Africa Section Communications/Mentoring Program,
+234-806-022-5618, **www.conbio.org/africa**

The Mohamed bin Zayed Species Conservation Fund

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

- Provide targeted grants to individual species conservation initiatives
- Recognize leaders in the field of species conservation; and

- Elevate the importance of species in the broader conservation debate.

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

Details on this important new source for species conservation initiatives and research can be found at **www.mbzspeciesconservation.org/**

Rapid Respone Facility

The Rapid Response Facility (RRF), the emergency small grants programme jointly operated by Fauna and Flora International (FFI), UNESCO World Heritage Centre, and the United Nations Foundation, has just launched a new website at **www.rapid-response.org**.

The RRF is a unique small grant programme. With a target processing time for grant applications of just 8 working days, the RRF provides rapid support to enable conservation practitioners to tackle emergencies in some of the World's most important sites for biodiversity. To date it has supported 16 rapid interventions in 14 UNESCO designated natural World Heritage sites, responding to the conservation impacts of a range of emergencies such as natural disaster, armed conflict and sudden increases in illegal activity within these protected areas.

For those interested in approaching the RRF for emergency funding, the new website provides details on application procedures, funding criteria, and case studies of past RRF grants.

The RRF website also houses tools and guidance for practitioners dealing with emergency conservation response around the globe, including resources developed as part of FFI's exploration of the value of cross-sectoral partnerships in post-conflict and post-disaster situations. This work, funded by the United States Agency for International Development (USAID), has generated tools and case studies designed to support both conservation and development practitioners maximise the efficacy of cross-sectoral partnerships, particularly in very challenging situations.

At the request of several RRF grantees, the new website also features an interactive forum where past and current grantees, potential applicants and other interested parties can pose questions and share experiences of conservation emergency. This forum represents an important step in the RRF's efforts to share knowledge across stakeholders, to improve the speed and efficacy of emergency conservation response.

For further information about the RRF please visit the website, or contact the RRF Secretariat at: **rrf@fauna-flora.org**.

New small grants scheme for Malagasy researchers launched by AEECL

From 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 redlisted 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**

Theses completed

Andriambololoniaina, F. M. V. 2008. Adaptation ethoécologique à la qualité de la forêt: cas de l'espèce *Eulemur rubriventer* (E. Geoffroy, 1850) dans le Parc National de Ranomafana. Mémoire de DEA en Sciences de la vie, option biologie, écologie et conservation animales, Département de Biologie Animale, Faculté des Sciences, Université d'Antananarivo.

Au cours de la période d'étude à compter de mars à juillet 2001, la forêt dense humide de Ranomafana (21°02° B 21°25 de latitude Sud et de 47°37 de longitude Est) renferme 12 espèces de lémuriens dont 7 sont diurnes et 5 nocturnes et/ou cathémérales. L'effet de la qualité de l'habitat à travers l'état de la forêt, primaire ou secondaire, sur l'éthoécologie de l'espèce cathémérale *Eulemur rubriventer* constitue l'objet de cette étude. La déforestation change la structure et la composition floristique de la forêt. Par rapport à la forêt primaire, la taille des arbres diminue de l'ordre de 7,6 % en hauteur et 23,4 % en DHP. La surface boisée régresse et diverses espèces sont

éliminées. D'autres arbres secondaires sont repoussés. Ces paramètres floristiques renvoient les activités et le repos de l'animal plutôt aux basses hauteurs. Les dortoirs deviennent plus exposés, les arbres sources de nourritures sont éliminés à 70 % et beaucoup plus immatures pour se fructifier. La déforestation diminue la préférence de l'espèce en dortoirs et en nourritures. Ainsi, l'animal subit une certaine adaptation en réponse de la déforestation. Il se déplace plus fréquemment à la recherche de nourritures mème à la surface du sol. Ses besoins supplémentaires en dehors des plantes augmentent de 112,82 %, pendant la rareté des fruits de *Psidium cattleyannum*. Son territoire est beaucoup plus défendu en réponse de la multitude des autres lémuriens compétiteurs. Il diminue d'environ 70 % la durée de sommeil. Par contre, ce sommeil devient plus fréquent. L'inactivité s'étend en durée et en fréquence. L'animal dort sur plusieurs arbres dortoirs. Ces dortoirs sont utilisés proportionnellement à l'abondance relative et la fréquence relative des arbres. La probabilité de toilettage régresse de 25,08 %. L'animal s'individualise en alimentation et au sommeil. Par conséquent, pour s'adapter au changement de l'habitat, l'animal se comporte de plus en plus irrégulier. Le temps mis à ses activités augmente de 71,95 %. Le groupe limite sa taille souvent pour deux individus uniquement. L'avantage du groupe et la préférence vis-à-vis des besoins de l'espèce *Eulemur rubriventer* sont discutés suite à la déforestation.
Mots clés: *Eulemur rubriventer*, Forêt dense humide, Déforestation, Adaptation, Madagascar.

Randrianarimalalasoa, V.O. 2008. Etude de la morphométrie, du comportement et de l'habitat de *Microcebus griseorufus* de la forêt galerie et de la forêt sèche de la Réserve Spéciale de Beza Mahafaly. Mémoire de DEA en Paléontologie et évolution biologique, option évolution biologique spécialité Primatologie, Département de Paléontologie et d'Anthropologie Biologique, Faculté des Sciences, Université d'Antananarivo.
La recherche sur la biologie et l'écologie de *Microcebus griseorufus* s'est déroulée durant la période de pluie d'au moins d'octobre jusqu'au mois de mars dans la Résèrve Spéciale de Bezà Mahafaly. La reproduction a eu lieu dans cette période chez *Microcebus griseorufus.* Les données collectées sont la morphométrie qui est traitée par "independant sample t-test", le comportement qui est traité par le test libre "chi-square" et les données sur les ressources forestières sont calculés par la "fréquence relative". La masse corporelle entre les femelles des deux parcelles présente une différence significative. Les femelles de la parcelle 1 sont plus lourdes et la moyenne de leur masse corporelle est de 42,6 ± 3,45 g. Par contre, la différence est non significative entre la masse corporelle des mâles des deux parcelles. La longueur du corps, la longueur de la queue, la longueur de la tête, la largeur bizygomatique et la longueur de l'oreille entre mâle et entre femelle des parcelles ne présente pas de différence significative. Le rythme d'activité entre les mâles des parcelles ne présente pas de différence significative alors que cette différence est significative entre celui des femelles des parcelles. Les activités "déplacement" et "repos" sont les plus prépondérantes pour les femelles des parcelles. Dans la parcelle 1, on a pu observé 1049 déplacements tandis que dans la forêt sèche, on n'a que 704. Pour ce déplacement, l'espèce *Microcebus griseorufus* fréquente plutôt les hauteurs supérieures à 5 m dans la parcelle 1 alors qu'elle préfère les supports de 3 à 6 m de haut dans la parcelle 2. En, plus toutes les formes de supports on été utilisées pour son déplacement dans la parcelle 1. Les branches obliques sont les plus appréciées par cette espèce dans la parcelle 2 dont le taux de fréquentation est de 13,67 % pour l'activité déplacement. *Microcebus griseorufus* a un régime alimentaire carnivore. Il consomme à fort taux les fruits, les gommes et les insectes. Et se sont les fruits, les gommes, les bourgeons des plantes appelées localement "Tsikidrakatra" qui sont les plus appréciées dans la parcelle 1 et le *Terminalia fatrae* et *Dychrostachys humbertii* dans la parcelle 2. Cette espèce de lémurien est abondante dans la Réserve de Bezà parce qu'on a trouvé 413 individus par km^2 dans la forêt sèche. Par contre, les pressions et les menaces affectant l'habitat de cette espèce cible continuent às'aggraver toujours dans la Réseve. Ainsi, un plan de conservation sera proposé pour assurer la survie de cette espèce.
Mots-clés: *Microcebus griseorufus,* Habitat, Comportement, Lémurien nocturne, Bezà Mahafaly, Madagascar.

Raharison, V.S.F. 2008. Etude anatomique d'une espèce de lémurien (*Eulemur fulvus*): coupes topographiques et tomodensitométriques du thorax, de l'abdomen et du bassin, application à la pratique de l'échographie du cœur et des reins. Thèse en cotutelle de Doctorat de l'Université de Toulouse et de l'Université d'Antananarivo, Ecole Doctorale de Sciences Ecologiques, Vétérinaires, Agronomiques et Bioingénieries (S.E.V.A.B.), Spécialités: Pathologie, Toxicologie, Génétique et Nutrition, Biologie, Ecologie et Conservation Animales.
L'objectif de notre étude est d'élaborer un document de référence mettant en relation l'anatomie, l'imagerie et la clinique du lémurien brun (*Eulemur fulvus*) et débouchant sur des mesures échographiques normales des reins et du cœur. Les études anatomiques et tomodensitométriques ont été effectuées sur deux lémuriens et l'étude échographique sous différents modes sur 16 animaux après anesthésie. Les coupes anatomiques et tomodensitométriques nous ont permis de préciser la position et la conformation des organes in situ. L'échographie Doppler a montré, pour le cœur, une vitesse aortique moyenne de 0,99 m/s et une vitesse pulmonaire de 0,95 m/s. Pour le rein, la vitesse sanguine est plus élevée chez le mâle. Enfin anatomiquement les reins du lémurien brun sont comparables à ceux du rat mais avec une papille allongée. En conclusion, l'échographie est parfaitement envisageable cliniquement en parcs zoologiques. Des précisions d'ordre anatomique et topographique mériteraient d'être apportées par l'utilisation de l'IRM.
Mots clés: *Eulemur fulvus*, Anatomie, Echographie, Scanner, Vascularisation, Rein, Cœur, Doppler.

Randrianasy, J. 2008. Analyses biomécaniques des sauts des *Propithecus verreauxi verreauxi* (Grandidier, 1867) et *Eulemur fulvus rufus* (Audebert, 1799) et leur évolution biologique dans la forêt de Kirindy-Région du Menabe. Thèse de Doctorat en Sciences de la terre et de l'évolution, option évolution biologique, spécialité Primatologie, Département de Paléontologie et d'Anthropologie Biologique, Faculté des Sciences, Université d'Antananarivo.
Saut, principal facteur commun de ces deux Lémuriens présente deux variantes: saut vertical agrippeur pour le *Propithecus verreauxi verreauxi* et saut d'une branche terminale horizontale à une autre ho-

rizontale pour l'*Eulemur fulvus rufus*. Les analyses de ces deux variantes de saut s'expliquent d'une manière biomécanique et statistique à partir des mesures prises et calculées pouvant s'interpréter par leurs anatomies ostéologiques, morphologiques, propriétés physiologiques, alimentaires et supports préférentiels. Ainsi, il se dégage que *Propithecus verreauxi verreauxi* gagne aisément tant en hauteur qu'en distance par rapport à l'*Eulemur fulvus rufus* en particulier à l'angle de 45° avec les différents types de saut. Ces variantes constituent non seulement un facteur de l'appréciation de l'état environnemental mais permettent de comprendre le processus de la tendance évolutive de la locomotion.
Mots-clés: Biomécanique, Locomotion, Sauts, Centre de gravité, Hauteur, Distance et Angle.

Rivotsimahafoy, M.F. 2008. Etudes des activités et évaluation des paramètres écologiques de l'habitat de *Eulemur fulvus* (Geoffroy, 1812) dans la forêt de Sahafina. Mémoire de Certificat d'Aptitude Pédagogique de l'Ecole Normale (CAPEN), Département de formation initiale scientifique, centre d'étude et de Recherche Sciences Naturelles, Université d'Antananarivo, Ecole Normale Supérieure.
La présente étude a été menée dans la forêt de basse altitude de Sahafina dans la Commune rurale d'Anivorano-Est, District de Brickaville en Octobre et Novembre 2005. Elle a pour but de connaître les activités journalières de *Eulemur fulvus* et d'évaluer la potentialité de la forêt en tant qu'habitat et en terme d'alimentation, afin de contribuer à l'amélioration du plan de conservation de l'espèce dans la forêt. La méthode de Scan Sampling est utilisée pour la récolte des données sur les activités des animaux. Les données sur l'habitat sont recueillies par l'inventaire des plots préétablis et par des enquêtes menées auprès des guides. Les groupes de *Eulemur fulvus* sont composés en moyenne de 4 individus surtout dans la partie Sud Ouest de la forêt. Les résultats obtenus ont montré que *Eulemur fulvus* de Sahafina passe presque la moitié de son temps à se déplacer, étant consacré aux autres activités. L'habitat est constitué de 55 % d'espèces de grands arbres dont 11 % dépassent les 10 mètres. Trois espèces ont été vues consommées lors des observations directes dont l'*Uapacca thouarsii* et *Dypsis* sp., mais le taux d'abondance de ces espèces est très bas. Cependant, les guides au cours des enquêtes ont énoncé que *Eulemur fulvus* dispose 97 espèces végétales pour son alimentation. En général, les caractéristiques de la forêt répondent aux besoins vitaux de l'espèce, néanmoins la rareté des espèces végétales consommées par l'animal nécessite un projet de reforestation. Pour assurer une meilleure conservation de la forêt et de sa biodiversité. L'éducation et la sensibilisation de la population sont nécessaires, c'est pourquoi proposons des séances d'Education relative à l'Environnement dans les établissements scolaires aux environs de la forêt de Sahafina.
Mots clés: *Eulemur fulvus*, Activités, Habitat, Education relative à l'Environnement, Forêt de Sahafina.

Andrianandrasana, H. 2009. Développement des systèmes de télédétection en vue d'améliorer le suivi de l'habitat et des feux de marais au lac Alaotra. Mémoire de DEA en Foresterie, Développement et Environnement, Département des Eaux et Forêts, Ecoles Supérieur des Sciences Agronomiques, Université d'Antananarivo.
Cette étude relate le rôle essentiel de la télédétection dans la conservation de la biodiversité à Madagascar. Elle consiste à mettre en évidence les actions de conservation et de suivis des zones humides d'Alaotra composées de 23000 ha de marais et de 20000 ha de lac, ainsi que de leur biodiversité. Ces zones tiennent une importance capitale tant au niveau socio-économique qu'écologique. Pourtant, pour de multiples raisons, le marais d'Alaotra est, chaque année, victime des feux dont la plupart sont volontaires. Ainsi, trouver les moyens d'arrêter les feux constitue une des préoccupations majeures des autorités locales et régionales. Les trois méthodes de suivi des feux existantes telles que les suivi écologique participatif: le suivi des alertes feux journaliers et l'interprétation des images satellites landsat, ont été étudiées pour déterminer leurs avantages et inconvénients. Les résultats de suivi issus de ces trois méthodes ont été analysés afin de voir leurs correspondances, leurs différences, ainsi que leurs complémentarités. Les images Landsat de 2001, 2005 et 2007 ont été interprétées lors de cette étude pour deux objectifs: détecter les feux et sortir des cartes de végétation du marais. Les analyses de changements des pixels et des classes ont conduit à la précision des impacts des feux sur la qualité du marais. Les résultats montrent une baisse progressive des feux de 2001 à 2007 mais aussi une baisse considérable de la qualité du marais. La durée de régénération naturelle du marais brûlé s'est ralentie. Elle est estimée à 5 ans actuellement si c'était 3 ans en 2002. Les zones situées à proximité des plans d'eau sont les plus victimes des feux. La pêche constitue la première cause des feux car les pêcheurs veulent créer de nouveaux espaces de pêche et accéder ainsi à toutes les zones inaccessibles. Une perte considérable de 5919 ha de marais (19925 à 14006 ha) a été constatée entre 2001 et 2007. En outre, les plantes envahissantes présentent un danger sur la viabilité des zones humides d'Alaotra car elles se prolifèrent progressivement pour envahir le marais de 365 ha jusqu'à 2931 ha entre 2001 et 2007. Les feux ont d'autres impacts négatifs importants sur la productivité piscicole, sur la surface de marais habitable par *Hapalemur alaotrensis* et sur le respect des règlementations de pêche. Plus les feux augmentent, plus la productivité piscicole et la proportion de marais habitable par le Lémurien diminuent. Les impacts des feux se manifestent généralement une année après leur passage. Des suggestions et recommandations axées sur l'amélioration des suivis des feux, sur la réduction des feux ainsi que sur l'amélioration de la gestion, sont adressées au Gouvernement, autorités et ONGs concernés. Elles visent à favoriser dans le meilleur délai la restauration naturelle de la viabilité des zones humides d'Alaotra, base du développement régional.
Mots-clés: Suivi, feux, Marais, Lac Alaotra, Habitat, Télédétection, Images Satellites, Systèmes D'informations Géographiques, Conservation.

Mevanarivo, Z.E. 2009. Caractéristiques de la forêt dense sèche de Kirindy et de ses environs comme habitat naturel de *Microcebus berthae*. Mémoire de DEA en Foresterie, Développement et Environnement, Département des Eaux et Forêts, Ecoles Supérieur des Sciences Agronomiques, Université d'Antananarivo.
Avec plusieurs recherches faites sur *Microcebus mu-*

rinus et *Microcebus berthae*, faisant partie des plus petits Primates du monde, une étude a été menée sur les caractéristiques des forêts denses sèches de Kirindy et de ses environs qui constituent l'habitat naturel de ces espèces animales. Ces recherches ont comme finalité d'expliquer la relation entre structure de l'habitat et de la densité respective des deux Microcèbes. Dans le monde rural de Madagascar, la dépendance envers les ressources forestières est flagrante des la vie quotidienne de la population. Dans la région de Menabe, ces pratiques se présentent sous forme de défrichement pour la conquète de nouveau terrain de culture et d'exploitation illicite. Ces pratiques anthropiques constituent une menace tant pour l'écosystème que pour la biodiversité qu'il abrite. L'objectif principal de l'étude est de connaître la structure et la dynamique des forêts denses sèches qui abritent ces petits primates. Plusieurs étapes ont été franchies pour mener à terme cette recherche. La méthode de collecte de données est basée sur l'inventaire floristique avec des enquêtes et des observations sur le sol et surtout des investigations bibliographiques. La forêt est stratifiée en trois zones selon son degré de dégradation. Chaque strate a ses caractéristiques structurales et possède sa composition floristique avec des familles dominantes différentes selon les compartimentations adoptées. Ce qui constitue les critères de choix de l'habitat pour les deux Microcèbes: zones où *Microcebus berthae* domine, zones propres pour *Microcebus murinus* et zones de chevauchement entre les deux espèces. Le type de sol qui constitue le substrat de la forêt se diffère au niveau de sa consistance et sa couleur. Une étude de corrélation a été entre ce type de sol et la composition floristique ainsi qu'entre le diamètre et la hauteur des arbres de la forêt. Des attentions particulières ont été destinées aux espèces qualifiées de principales pour cette recherche. Ces espèces sont constituées par les arbres utilisés par les deux Microcèbes comme éléments constitutifs de leurs nourritures. Les arbres morts encore sur pieds et les lianes sont considérés comme éléments accessoires à ces espèces principales. De part les résultats obtenus, des mesures doivent être renforcées pour le maintien de l'équilibre de cet habitat; La perturbation de cet habitat peut entraîner la disparition irréversible de la faune et la flore qu'il abrite qui, ont une place importante dans la biodiversité mondiale.
Mots-clés: *Microcebus murinus*, *Microcebus berthae*, Habitat, Forêt Dense Sèche, Kirindy, Structure, Dynamique, Diversité Floristique.

Rabemananjara, Z.H. 2009. Etude d'une espèce de lémurien: *Indri indri* (Indridae) dans le couloir forestier d'Anjozorobe-Angavo. Mémoire de Maîtrise Spécialisée en Gestion des Ressources Naturelles et Environnement. Université de Toamasina.
Ce travail a été mené dans le couloir forestier d'Anjozorobe-Angavo, au nord ouest de la ville d'Antananarivo. C'est l'un des derniers vestiges de forêts naturelles du haut plateau qui abrite une population de lémurien qui a fait l'objet de notre étude sur l'*Indri indri*. Une espèce qui ne vit pas en captivité alors notre étude c'est de mettre au point une méthode de suivi écologique de cette espèce. Pour localiser le groupe d'étude, nous n'avons pas utilisé la radiotélémetrie mais nous avons localisé à partir des chants et la recherche active des chercheurs. Les observations directes ont été effectuées et nous avons contribué à l'habituation du groupe à la présence humaine. Les résultats des observations nous montrent les activités journalières du groupe tel que les comportements manifestés par les individus, le nombre d'individus qui compose le groupe et la surface totale occupée par le groupe qui est de 10,75 ha. Nous avons constaté que c'est en fonction du comportement que le groupe occupe les espaces de son territoire. La surface occupée pour le repos est bien supérieure (9 ha) par rapport à celle occupée pour les autres comportements comme l'alimentation (6 ha). Concernant l'alimentation, nous avons obtenu quelques espèces végétales consommées par l'*Indri indri* durant nos séjours de travail. En connaissant l'éthologie de l'*Indri indri*, il est possible que cette espèce soit une indicatrice pour le suivi écologique. Cette étude est très limitée dans le temps alors les résultats que nous avons mentionnés sont préliminaires.
Mots-clés: Lémurien, *Indri indri*, Comportements, Anjozorobe-Angavo, Madagascar.

Rakotoarivelo, H.V. 2009. Etude des parasites gastro-intestinaux de *l'Eulemur cinereiceps* dans les sites forestiers de Mahabo et de Manombo. Thèse de Doctorat en Médecine Vétérinaire, Département de Médecine Vétérinaire, Faculté des Sciences, Université d'Antananarivo.
L'infestation par les parasites gastro-intestinaux augmente les risques d'extinction des primates non-humains en danger, dont la déforestation est la principale menace. Ainsi, nous conduisons à étudier les interactions hôte-parasites chez l'espèce *Eulemur cinereiceps* dans les sites forestiers de Mahabo et de Manombo. Des échantillons de matières fécales ont été collectés pendant la saison humide: Janvier et Février 2008, et pendant la saison sèche: Septembre et Octobre 2008. La diversité des parasites ainsi que leur prévalence ont été identifiées. Et les charges parasitaires moyennes entre les deux saisons et selon la perturbation d'habitats ont été comparées en utilisant le test de Student. Au total, 162 échantillons de matières fécales chez 83 individus ont été collectés et analysés au microscope après la technique de flottaison avec une solution de sulfate de zinc. Les espèces *Callistura* sp. (99 %), *Lemuricola* sp. (67 %) et *Ascaris* sp. (61%) ont eu une prévalence la plus élevée. D'autres parasites ont été identifies, *Strongyloides* sp. (54 %); *Pararhabdonema* sp. (40 %); *Trichiuris* sp. (18 %); et *Enterobius* sp. (13 %). *Callistura* sp. (p=0,001) et *Trichiuris* sp. (p=0,01) présentent une différence significative sur le niveau élevé de la charge parasitaire durant la saison humide. Ce sont des parasites qui se transmissent directement sans hôte intermédiaire et ont une période prépatente courte. Les individus vivant dans les habitats perturbés ont été plus infestes par *Lemuricola* sp. (p=0,001), *Trichiuris* sp. (p=0,001) et *Ascaris* sp. (p=0,03). Ce dernier a une longe période prépatente pendant laquelle il peut vivre très longtemps dans le milieu extérieur. Les habitats a coté des villages sont très fréquents par les chiens, bétails et les activités humaines. Ces perturbations augmentent le risque d'infestation, ainsi le stress de l'espèce.
Mots-clés: Parasite, Primate, *Eulemur cinereiceps*, Prévalence, Reserve Spéciale de Manombo

Rakotobe, H.R. 2009. Analyse sylvicole pour la restauration du paysage forestier et en vue d'assurer la pérennité des lémuriens de la forêt de Sahafina (Anivorano-Est, Mahatsara, Brickaville). Mémoire de DEA en Foresterie, Développement et Environnement, Département des Eaux et Forêts, Ecoles Supérieur des Sciences Agronomiques, Université d'An-

tananarivo.
Devant le fait des états de la déforestation qu'a subi Madagascar derniPrement, la restauration du paysage forestier doit être capitale dans les actions entreprises dans la conservation pour valoriser les biens et services que la forêt fournisse. Effectivement, Biodiversity Conservation Madagascar dans sa gérance de la forêt de Sahafina, qui consiste un lambeau de la forêt témoignant encore les caractéristiques de la forêt de l' Est de basse altitude, inclut dans leur programme, la reforestation et l'enrichissement afin d'assurer également la pérennité des lémuriens, qui a amené à la problématique "quelles sont les informations scientifiques de base pour conduire la reforestation et l'enrichissement de la forêt de Sahafina ?". Ainsi, pour y répondre, des hypothèses et objectifs ont été émises avec les méthodes adaptées, telles les enquètes et observations pour connaître les essences utiles par la population et par les lémuriens, puis l'inventaire floristique de différents types de forêt qui a été précédé par une analyse cartographique de la végétation et un examen du profil pédagogique pour savoir la potentialité du sol forestier. Après l'analyse des données, les résultats ont donné que par les nombres élevés et variés des essences principales, elles contribuent considérablement dans la composition floristique. Puis, l'analyse comparative des types de forêt a montré les références pour conduire la reforestation et l'enrichissement, oj les lacunes ont été également détectées. Bref, les résultats ont bien répondus à la problématique. Cependant, elles suscitent encore plusieurs thèmes à traiter pour aboutir à de plus amples résultats, qui seront bénéfiques sur le plan recherche qu'opérationnel.
Mots-clés: Analyse sylvicole, Restauration du Paysage forestier, Lémuriens, Forêt de Sahafina.

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. Doctoral Dissertation, Universität Hamburg.
From April 2003 to October 2005, 427 fecal samples obtained from 169 different individuals of *M. murinus* from five fragments of the Mandena forest were analyzed to assess the parasite species richness of this animal based on parasite egg morphology. Screening all fecal samples by with the modified technique of the McMaster flotation, revealed at least nine different intestinal parasites, which included: 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; two Plathelminthes: two cestodes of the genus *Hymenolepis* (Hymenolepididae); one Protozoa: belonging to the order Coccidia. Parasite excretion was related to the degradation and fragmentation of the forest and to seasonal variation.
Mots-clés: Parasite, Primate, *Microcebus murinus*, Prévalence, Fragmentation, Degradation

Instructions for Contributors

Lemur News publishes manuscripts that deal largely or exclusively with lemurs and their habitat. The aims of Lemur News are: 1) to provide a forum for exchange of information about all aspects of lemur biology and conservation, and 2) to alert interested people to particular threats to lemurs as they arise. Lemur News is distributed free-of-charge to all interested persons. To the extent that donations are sufficient to meet the need, the policy of free distribution will continue. Manuscripts should be sent to the editor at the address on the letterhead by mail, fax or e-mail. Lemur News welcomes the results of original research, field surveys, advances in field and laboratory techniques, book reviews, and informal status reports from research, conservation, and management programs with lemurs in Madagascar and from around the world. In addition, notes on changes in the legal status of lemurs, public awareness programs, the availability of new educational materials (include the name and adress of distributor and cost, if applicable), job announcements (paid or volunteer), and notification of newly published scientific papers, technical reports and academic theses are all appropriate contributions. Readers are also encouraged to alert Lemur News to pertinent letter-writing campaigns and other activities which may need the support of the lemur research and conservation community. Finally, Lemur News serves as a conduit for debate and discussion and welcomes contributions on any aspect of the legal or scientific status of lemurs, or on conservation philosophy.
Manuscripts should be composed either in English or French, be legibly typewritten and double spaced (generally 1-8 pages including references and figures).
All manuscripts should be typewritten, double spaced with generous margins, and sent on diskette in Word format or by e-mail in RTF or as a Word document. Macros, various formats and automatic numbering provided by text processing programs, such as WORD, must be avoided. The author's name, affiliation and address must be provided; please provide fax, e-mail and pertinent telephone numbers also. Tables and figures should include brief captions. Graphics should be clear and "camera ready" (large lettering is appreciated). Subtle differences in shading should be avoided as they will not show up in the final print. Tables and figures originally not made in WORD **must not** be integrated into the WORD file but submitted as separate files saved in the respective format, e.g. Excel, Corel,.... Hard copies of figures should be provided. Please give all measurements in metric units. Please accent all foreign words carefully.

Maps: Maps should always be made as concise as possible and should include an inset showing the location of the area discussed in relation to its home country or continent.
Photographs: Black-and-white prints are ideal. Original color slides from which we can make prints are also acceptable. However, please send only sharply-focused, high quality slides and photographs. Please label each slide or photograph with the photographer credit and number the identifying caption. Captions should be listed on a separate sheet, or after "Literature Cited". We are always interested in receiving high quality photographs for our covers, especially those of little known and rarely photographed primates, even if they do not accompany an article.
All Figures: Please indicate on all figures the title and author of the manuscript to which they belong and package them carefully to avoid damage in the post. Figures will only be returned at the special request of the author. Maps, photographs and figures can sent in any one of the following types of file: WMF, EPS, TIF, JPG, XLS,CDR. Please, however supply a hard copy of all drawn maps or figures, preferably in the size in which they should be published.

Background information and criteria applied in the review process of manuscripts to be submitted to the "Article" section

Reviewers will be asked to provide detailed comments to the authors and a recommendation to the editors.

Recommendation to the editors:
- Excellent manuscript, recommend publication as is
- Very good paper, recommend publication with minor revision
- Acceptable paper, recommend publication (with major revision) if there is sufficient space available
- Might become acceptable after major revision, recommend re-review of a revised manuscript
- No acceptable

If you recommend acceptance, please comment on the presentation.
- Has the work been published previously?
- Has work published previously by the author(s) or other researchers been quoted properly?
- Is the title appropriate?
- Does the Introduction provide background information?
- Does the Introduction lead towards the question(s) to be answered by the study?
- Do the Methods explain what the author(s) did?
- Are the statistical analyses correct?
- Are the Conclusions justified?
- Are the References complete?
- Are the References correctly prepared?
- Are all Figures or Tables necessary and of acceptable quality for publication?
- Do Tables have proper Table heads?
- Do Figures have proper legends which explain all symbols shown in the Figure?
- Do maps have a scale?
- Is the manuscript too long relative to the new ideas and information?
- Did the authors follow the manuscript guidelines?

Call for voluntary contributions

As most of the readers of Lemur News are certainly aware fund raising has become more difficult. We will continue to distribute Lemur News free of charge to everybody interested in receiving this newsletter. However, we also would like to ask subscribers for voluntary contributions. For our readers in North America: please make checks out to the Duke University Primate Center with a notation on the bottom left of the check that they are for Lemur News and send them c/o Melissa Dean, Duke University Primate Center, 3705 Erwin Road, Durham, NC, 27705, USA. Subscribers in Europe should send checks or cash to Jörg Ganzhorn, Abt. Tierökologie und Naturschutz, Universität Hamburg, Martin-Luther-King-Platz 3, 20146 Hamburg, Germany.

Table of Contents

Lemur News Vol. 14, 2009
ISSN 1608-1439