

Conservation, distribution and population size update of endangered nocturnal lemur species from Northern Madagascar



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I. Introduction

In the last couple of decades there has been a significant increase in our knowledge of the distribution and number of lemur species across Madagascar (Mittermeier et al. 2008, 2010). However, there are still many regions and species for which very little basic data is available. This is true of recently discovered species, as expected, but this is also true for species that have been known for decades but have limited distribution or live in little studied regions.

This is particularly the case for nocturnal cryptic lemur species such as mouse lemurs (genus: *Microcebus*) and sportive lemurs (genus: *Lepilemur*), for which many new species have only recently been described. The distribution areas and population sizes of most *Lepilemur*, *Microcebus* and *Phaner* species from the north of Madagascar were to a large extent unknown. Consequently, the IUCN Red List assessment for these species was until very recently Data Deficient (DD; e.g. *Lepilemur milanoii*, fig 1) or defined as



Figure 2: *Microcebus tavaratra*, one of the focus species of the project.

Endangered (EN, for *M. tavaratra*, fig 2, and *L. ankaranensis*) but often on the basis of poor and limited field data (Schwitzer et al. 2013).



Figure 1: The *Daraina sportive* lemur, one of the focus species of the project.

Moreover most nocturnal lemurs are threatened by subsidiary and economic hunting, logging and poaching (enhanced by mining activities), and most northern lemur species have small and highly fragmented distribution areas. There was thus an urgent need to acquire data on the biology, distribution, and population size of these species, and to identify the main threats affecting their sustainability.

This project aimed to study poorly known nocturnal lemur populations from 3 genera (*Microcebus*, *Lepilemur* and *Phaner*) in northern remote and understudied regions of Madagascar. It aimed to determine species distribution area and population size, and the main threats on their populations in order to prioritize conservation actions.

This report contains data that could not be included in the RSG standard report and that will not be published in scientific journal and thesis reports. We see it as a scientific document summarizing what has been done, and including some important presence data for species that were not the main focus of the project and of any participant of the project, but that could be useful for other naturalists, conservation agencies and scientists. Moreover, this document might be useful for the members of the project who still have data to process, as it summarizes the basic information gathered during the project. However, this final report does not contain direct results of the "Conservation,

distribution and population size update of endangered nocturnal lemur species from Northern Madagascar". In fact most of the important findings of the study are published and/or will be published in scientific journal and thesis reports (see section XI: Outcomes).

II. Project duration

The project lasted 18 months from July 2012 to December 2014. Field work took place during the 2012 and 2013 dry seasons.

III. Project headquarters

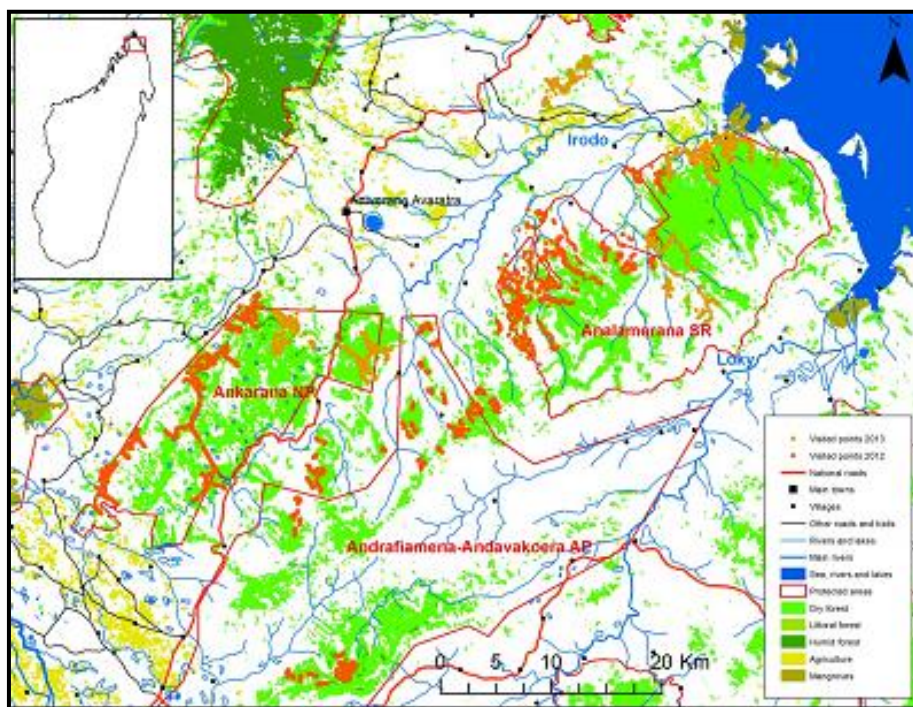
The small town of Anivorano Avaratra has been chosen as a base for the project during discussions held with Emmanuel Rasolondraibe, Fabien Jan, Patrick Ranirison and Sébastien Wohlhauser (see § VIII).

Anivorano Avaratra has a strategic position for the field work of this project due to its location along the National Road and its central position in the area we aimed to visit and survey (Andrafiarana, Andavakoeira, Analamerana, Ankarana; see maps 1 and 2). Moreover the town has electricity, a prerequisite for entering field data in computers and training students to statistics and GIS tools. Finally the town is located in an agriculturally rich area which allowed the team to have access rich vitamin and rich diet in town and to easily provision for field periods.

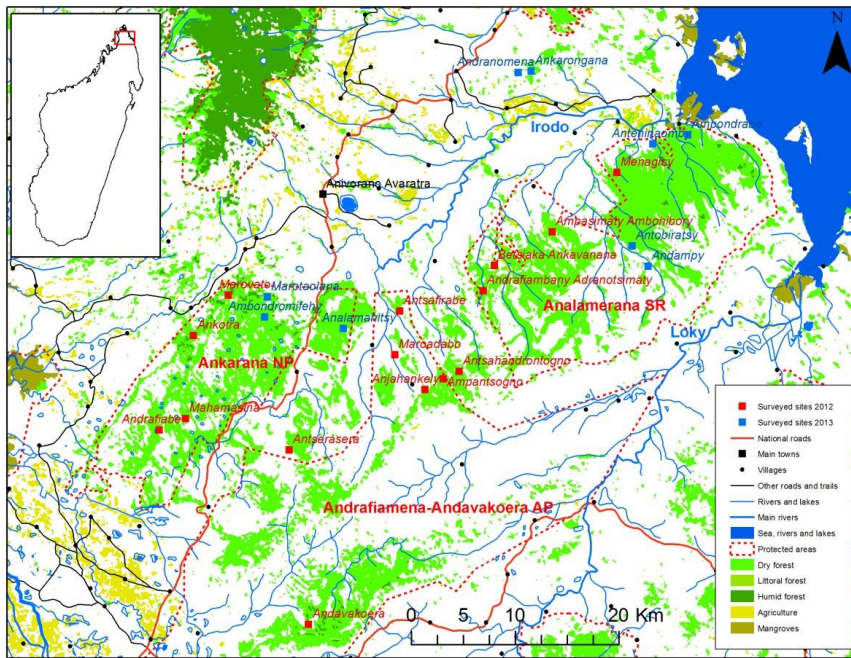
IV. Visited forests

Map 1 shows all the visited places (GPS points) inside and outside the three visited protected areas, Analamerana Special Reserve, Andrafiarana-Andavakoera Protected area and Ankarana National Park.

In total 23 sites were visited during the 2012 and 2013 dry seasons (Map 2).



Map 1: Representation of all GPS points recorded during field work. This map illustrates how well the Project region has been covered. GPS points were recorded throughout the field period and correspond to all the locations visited whichever the purposes (animal observation, transect, forest characterization). The names of all surveyed sites can be found in Map 2.



Map 2: Representation of all visited sites. Each site was visited during a period of five to twenty days (see text).

V. Inventories

Vertebrates' inventories were conducted at all visited sites (Map 2) using Malagasy, French, English and Latin names, taking advantage of the wildlife knowledge of each of the participants of the project (Guides, Park agents, students, etc.). Inventories were conducted using several complementary methods. Diurnal survey, nocturnal line transect distance sampling, nocturnal acoustic surveys and small mammals trapping were thus combined to inventory vertebrates species. Distance sampling and diurnal survey method have previously been used in the group and described (Meyler et al. 2012, Salmona, Jan, et al. 2013, Salmona, Rasolondraibe, et al. 2013). Nocturnal acoustic surveys were performed from 17h30 to 22h00 by periods of five minutes. Acoustic surveys were conducted at the start, intermediate and end point of each surveyed transects.

Inventories mainly focused on the 4 lemur's genus of the RSG project (*Propithecus*, *Microcebus*, *Lepilemur* and *Phaner*). Nevertheless we recorded the presence of all lemurs, birds and vertebrates species encountered (Table I-IV). However, the survey was not developed to inventory all groups of animals, and should not be considered exhaustive. The data represents at least presence records of the encountered species and may be useful for future researchers.

Table I: Inventory results obtained from diurnal surve

Diurnal observations	Analamerana SR	Ankarana NP	Andrafiamena- Andavakoera PA	Ankarongana unprotected area	Total
<i>Accrocephalus newtoni</i>	1	0	0	0	1
<i>Agapornis canus cana</i>	2	0	0	0	2
<i>Boa madagascariensis</i>	1	0	1	0	2
<i>Brookesia spp.</i>	1	0	0	0	1
<i>Buteo brachypterus</i>	1	0	0	0	1
<i>Caprimulgus madagascariensis</i>	6	0	0	0	6
<i>Centropus tolo</i>	4	1	0	0	5
<i>Centropus toulou</i>	0	1	0	0	1
<i>Cisticola cherina</i>	4	0	0	0	4
<i>Copsychus albospecularis</i>	8	0	1	0	9
<i>Coracina cinerea</i>	3	0	0	0	3
<i>Coracopsis spp.</i>	0	3	1	0	4
<i>Coracopsis vasa</i>	11	0	0	0	11
<i>Corythornis vintsioides</i>	2	0	0	0	2
<i>Coua coquereli</i>	6	0	0	0	6
<i>Coua cristata</i>	22	2	2	0	26
<i>Cuculus rochii</i>	1	0	0	0	1
<i>Cuculus spp.</i>	0	0	1	0	1
<i>Daubentonia madagascariensis</i>	0	4	0	1	5
<i>Dicrurus forficatus</i>	10	0	0	0	10
<i>Dryolimnas cuvieri</i>	1	0	0	1	2
<i>Eulemur coronatus</i>	53	18	10	7	92
<i>Eulemur sanfordi</i>	12	19	6	0	37
<i>Eulemur spp.</i>	0	1	7	1	9
<i>Eurystomus glaucurus</i>	1	0	0	0	1
<i>Falco newtoni</i>	2	0	0	0	2
<i>Falco pinnatus</i>	12	0	0	0	12
<i>Fossa fossana</i>	0	0	1	0	1
<i>Hapalemur spp.</i>	0	0	2	0	2
<i>Hartlaubius auratus</i>	1	0	0	0	1
<i>Hypsipetes madagascariensis</i>	8	0	0	0	8
<i>Ispidina madagascariensis</i>	2	0	0	0	2
<i>Lepilemur spp.</i>	24	7	1	0	32
<i>Leptopterus chabert</i>	4	0	0	0	4
<i>Leptosomus discolor</i>	6	0	0	0	6
<i>Lonchura nana</i>	1	0	0	0	1
<i>Lophotibis cristata</i>	23	10	2	6	41
<i>Margaroperdix madagascariensis</i>	1	0	0	0	1
<i>Merops superciliosus</i>	2	0	0	0	2
<i>Mesitornis variegata</i>	1	0	0	0	1
<i>Microcebus spp.</i>	0	0	1	0	1
<i>Motacilla flaviventris</i>	2	0	0	0	2
<i>Nectarinia notata</i>	6	0	0	0	6
<i>Nectarinia souimanga</i>	3	0	0	0	3
<i>Nectarinia notata</i>	1	0	0	0	1
<i>Neomixis spp.</i>	3	0	0	0	3

<i>Neomixis tenella</i>	1	0	0	0	1
<i>Nesillas typica</i>	1	0	0	0	1
<i>Newtonia brunneicauda</i>	2	0	0	0	2
<i>Newtonia spp.</i>	1	0	0	0	1
<i>Numida meleagris</i>	2	0	0	0	2
<i>Otus rutilus</i>	2	0	0	0	2
<i>Picturata striata</i>	2	0	0	0	2
<i>Polyboroides radiatus</i>	8	0	0	0	8
<i>Propithecus perrieri</i>	18	0	3	0	21
<i>Streptopelia picturata</i>	12	0	0	0	12
<i>Terpsiphone mutata</i>	31	1	1	0	33
<i>Treron australis</i>	1	0	0	0	1
<i>Turnix nigricollis</i>	16	2	0	0	18
<i>Upupa marginata</i>	8	1	0	0	9
<i>Vanga curvirostris</i>	2	0	0	0	2
Total	359	70	40	16	485

SR: Special Reserve; PA: Protected Area; NP: National Park

Table II: Inventory results obtained from the nocturnal acoustic surveys.

Nocturnal acoustic records	Ankarongana unprotected forest	Analamerana SR	Andrafiamena Andavakoera PA	Ankarana NP
<i>Asio spp.</i>	0	0	2	2
<i>Buteo brachypterus</i>	1	3	0	2
<i>Canis lupus familiaris</i>	0	1	0	3
<i>Caprimulgus enaratus</i>	21	130	34	243
<i>Caprimulgus madagascariensis</i>	0	35	0	0
<i>Centropus toulou</i>	0	9	2	5
<i>Cheirogaleus spp.</i>	0	0	6	1
<i>Copsychus alba</i>	0	1	0	0
<i>Copsychus albospecularis</i>	0	7	0	0
<i>Coracopsis nigra</i>	0	0	0	2
<i>Coracopsis spp.</i>	0	28	4	86
<i>Coracopsis vasa</i>	0	9	0	0
<i>Coua cristata</i>	1	9	0	11
<i>Cuculus rochii</i>	0	0	0	14
<i>Cuculus spp.</i>	0	0	2	0
<i>Dicrurus forficatus</i>	0	6	0	16
<i>Dryolimnas cuvieri</i>	2	1	0	0
<i>Eulemur coronatus</i>	16	299	330	221
<i>Eulemur sanfordi</i>	0	1	9	20
<i>Eulemur spp.</i>	15	172	229	429
<i>Eurystomus glaucurus</i>	0	0	0	1
<i>Falco newtoni</i>	0	1	0	0
<i>Falco palliata</i>	0	2	0	0
<i>Fossa fosana</i>	0	4	12	33
<i>Foudia madagascariensis</i>	0	2	0	0
<i>Homo sapiens</i>	0	0	0	1
<i>Hypsipetes madagascariensis</i>	0	3	1	0
<i>Langarokobe</i>	0	0	0	1

<i>Lepilemur spp.</i>	30	137	252	178
<i>Lophotibis cristata</i>	1	12	7	46
<i>Microcebus spp.</i>	1	43	134	54
<i>Nectarinia notata</i>	0	3	0	0
<i>Numida melagris</i>	1	0	0	13
<i>Otus rutilus</i>	36	423	98	654
<i>Phaner spp.</i>	2	12	22	531
<i>Polyboroides radiatus</i>	2	0	0	0
<i>Potamochoerus spp.</i>	0	0	0	1
<i>Propithecus perrieri</i>	0	1	1	0
<i>Terpsiphone mutata</i>	0	14	4	7
<i>Tito alba</i>	1	1	1	21
<i>Corvus albus</i>	0	0	0	1
Total	130	1369	1150	2601

SR: Special Reserve; PA: Protected Area; NP: National Park

VI. Density estimates

Nocturnal line transect distance sampling survey were conducted at all visited sites (Map 2) using the previously described methodology (Meyler et al. 2012, Salmona, Rasolondraibe, et al. 2013). For technical, topographical and conservation reasons it was not always possible to create line transects. For example it is forbidden to modify the vegetation in the Ankarana NP and anyway impossible to open line transects in the Tsingy plateau (Fig 3). In consequence we used both existing trails and line transects. The results summarized in Table III show the important survey effort conducted with over 178 transects and trails surveyed, and a total 336 nocturnal distance sampling survey. Another result shown in table III is that mouse lemurs (*Microcebus spp.*) and sportive lemurs (*Lepilemur spp.*) are the most frequently observed species at night and that line transect distance sampling is particularly well adapted for their observation and to estimates their density (Meyler et al. 2012, Salmona, Rakotonanahary, et al. 2014, Salmona, Ralantoharijaona, et al. 2014). Density estimates are not presented here; they will be the presented in Dhurham Said Oussen and Andrianotahina Harivony Honoré Master Thesis. Moreover a meta-analysis of the data together with the environmental data gathered has been performed by Mohamed Thani Ibouroi for his Master thesis in Ecology. The results will then be submitted to and hopefully published in international scientific journal.



Figure 3: *Tsingy plateau* in Ankarana National

Table III: Summary of line transect distance sampling data collected during the RSG project.

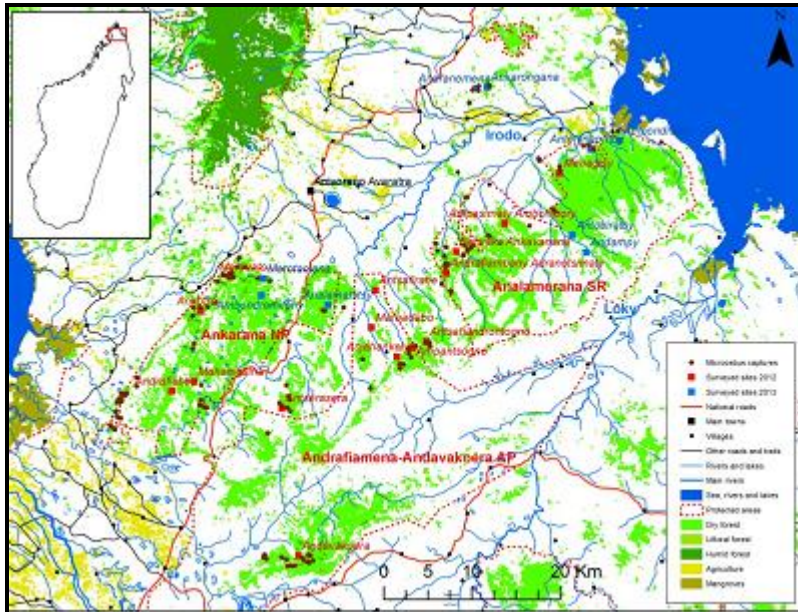
Protected Area	Site												
Analamerana	Ambohibory	6	12		5		30	19		54			
	Ampasimaty	5	15				27	15		42			
	Ampondrabe	7	18	1			1	42	49			93	
	Andrafiambany	4	12		3	1		28	15	2		49	
	Andranotsimaty	4	12	1	2			21	19			43	
	Ankavanana	4	12		1			17	10			28	
	Anteninaomby	13	30				8	97	103			208	
	Betsiaka	5	12	1	1			25	11			38	
	Menagisy	5	9					21	8			29	
	Andrafiamen	Ampantsogno	4	13		1	1		22	14	2		40
Andavakoera	Anjahankely	8	20	9	5			66	22	3		105	
	Ankatsaka	12	23	1				31	98			131	
	Antserasera	7	9				1	27	9	1		38	
Ankarana	Ambondromifehy	5	12		1		2	70	17	9		99	
	Analamahitsy	11	18				4	93	65	3		165	
	Andrafiabe_americans	7	13	1	1	1	1	71	103			178	
	Andrafiabe_jongovy_jiab	7	9		1			36	40			77	
	Andrafiabe_tenan'ankar	5	6	1	6	7		38	20			72	
	Mahamasina_anilotra	9	9				1	71	21	3		96	
	Mahamasina_prince	15	21	1	7	2	1	105	84	2		203	
	Marotaolana	3	9	1	2			28	48	2		81	
	Marovato_ankotra	12	14				1	1	157	25		184	
	Marovato_marovato	11	15	1	1	2		48	72	1		125	
Ankarongana	Ankarongana	9	13					30	17			47	
Total		178	336	17	3	35	14	21	1201	904	21	7	2225

VII. Captures

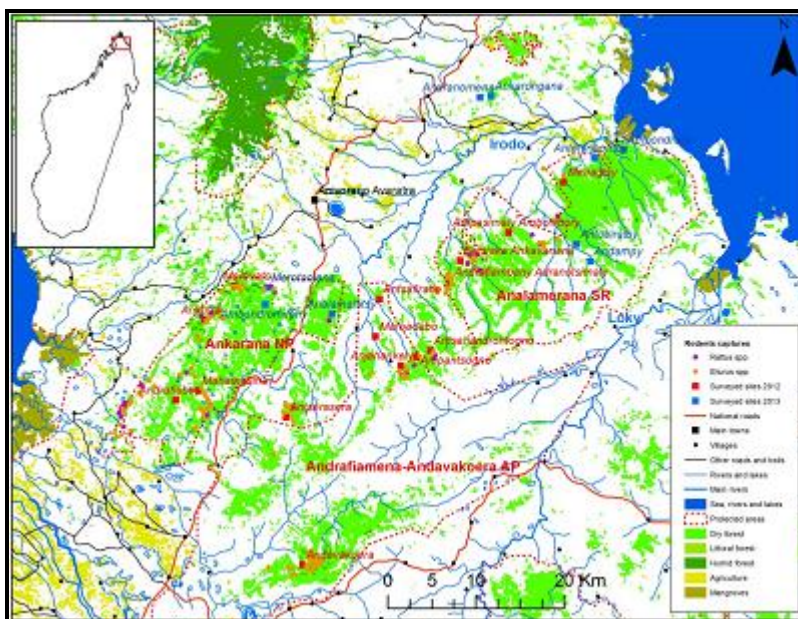
Small mammals' captures were conducted in each forest for tree dwelling species inventories. During total of 14,500 conducted capture opportunities (number of traps*night), 913 small mammals were captured (~6.3%). In the surveyed forests (almost all protected) the proportion of endemic rodents (genus *Eliurus*) was high compared to the proportion of introduced rodents (genus *Rattus*; see Table IV). The maps 3 and 4 show the distribution of mouse lemurs and rodents captures respectively. Sportive lemurs were also captured for population and conservation genetics purposes and to determine the present species in each forest fragment. But the capture data is not presented here.

Table IV: Summary data of capture events.

Protected Area	Site	# transects/ trails	# of capture conducted	<i>Microcebus</i> <i>spp.</i>	<i>Eliurus</i> <i>spp.</i>	<i>Rattus</i> <i>spp.</i>
Analamerana	Ambohibory	8	12	4	6	
	Ampasimaty	6	14	2	5	4
	Ampondrabe	3	3	1		
	Andrafiambany	5	12	5	21	
	Andranotsimaty	5	12	7	9	1
	Ankavanana	5	11	5	10	6
	Anteninaomby	4	4	3	1	
	Betsiaka	6	12	11	14	
	Menagisy	5	12	10	2	
Andrafiamena Andavakoera	Ampantsogno	4	12	5	3	1
	Andrafiabe	6	7	1		
	Anjahankely	8	21	7	9	3
	Ankatsaka	15	29	23	47	
	Antsafirabe	7	8			
	Antsahandrontogno	11	18	6	2	2
	Antserasera	8	11	9	14	1
	Maroadabo	5	6		1	
	Masiamposa	7	8			
Ankarana	Analamahitsy	3	3	3	1	1
	Andrafiabe_americans	6	7	3	7	1
	Andrafiabe_jongovy_jiaby	6	7	18	6	5
	Andrafiabe_tenan'ankarana	5	5	12	5	3
	Mahamasina_anilotra	8	8	2	3	1
	Mahamasina_prince	8	16	10	33	1
	Marotaolana	5	5	2	2	2
	Marovato_ankotra	8	8	6	12	3
Ankarongana	Marovato_marovato	11	11	14	13	
	Ankarongana	8	8	7		
Total		186	290	176	226	35



Map 3: Captures of *Microcebus* spp. SR: Special Reserve; PA: Protected Area; NP: National Park



Map 4: Captures of rodents. SR: Special Reserve; PA: Protected Area; NP: National Park

VIII. Forest characterization

At each capture location, animal sighting location and along transect, the forest was characterized using 14 variables. These variables includes *inter alia*, most of the easily observables human degradation (fire rests, logging), a rough density of small, middle size, large/tall trees, and lianas, the presence of trails and rivers. These variables were recorded to be analyzed together with density and presence data and to try to decipher main drivers of the species presences and densities.

IX. People involved

More than a dozen of researchers, students and volunteers from five nationalities and a large number of local guides and cooks were involved in the project. We are grateful to all participants of this project and hope that they took advantage and gained as much knowledge from us and from the RSG project, as we gained from collaborating with them.

A. Researchers:

Jordi Salmona (French): For the last 8 years I continuously worked in the Indian Ocean Islands and in Europe on research and conservation programs. Since 2009 I was hired by Dr Lounès Chikhi to work on a Madagascar research program which aims to study lemur populations in the North and North-west of Madagascar (Meyler et al. 2012, Salmona, Jan, et al. 2013, Kun-Rodrigues et al. 2014). In 2010 I obtained a Portuguese PhD grant and was at the same time admitted to the prestigious IGC international PhD program, one of the “Centre of excellence” in Europe. In 2010 I started working on mouse lemur and sportive lemur’s population in Daraina (North Madagascar) (Meyler et al. 2012) During the past 5 years I have been leading the field work in Madagascar and have co-supervised 8 Malagasy Master students and 2 Bachelor students (together with Lounès Chikhi and Clément Rabarivola), training and teaching them statistical analyses and to compute density estimates and GIS analysis. I have spent more than 30 months in Madagascar in the five past years and can now speak Malagasy, an important point for field and conservation work which needs interaction with local communities.

This project was related to my PhD thesis. Nevertheless, my PhD project is heavily biased towards population genetics and theoretical work using lemur populations as a model. The project was a satellite or an outlier project in which, together with Malagasy Master Students, I wanted to answer relevant questions on nocturnal lemur species conservation. The idea was also to take advantage of and extend the necessary field period conducted for the Population and Conservation Genetics’ project, in order to study in greater details the biology and ecology, and conservation aspects of the species included in the project.

Lounès Chikhi (French/Algerian) is a researcher in the French prestigious research agency (CNRS) and at the same time the principal investigator of the Population and Conservation Genetics group in The Instituto Gulbenkian de Ciencia. His group in Madagascar has worked and published research on several lemur species, *Propithecus*, *Lepilemur* and *Microcebus* populations and has been working extensively on *P.tattersali* since 2006 (Olivieri et al. 2008, Craul et al. 2009, Quéméré, Champeau, et al. 2010, Quéméré, Crouau-Roy, et al. 2010, Schneider et al. 2010, Meyler et al. 2012, Quéméré et al. 2012, Salmona, Rasolondraibe, et al. 2013, Kun-Rodrigues et al. 2014). Dr L. Chikhi has a population geneticist background and he is interested in understanding how genetic data can be used to uncover patterns of diversity in present-day populations. He also wants to understand how ancient demographic events (contractions or expansion perhaps due to climatic shifts) can be uncovered. He has been working on humans population genetics (notably the Neolithic transition in Europe) and in conservation genetics. In Madagascar, he has been collaborating with Prof. C. Rabarivola and the Fanamby NGO, and has started collaboration with Prof. J. Zaonarivelo from Antsiranana University.

Clément Joseph Rabarivola (Malagasy) is a Professor at the University of Mahajanga, and head of the Master of Primatology. Moreover C. Rabarivola has been working extensively on Malagasy primates since 20 years now, transferring his knowledge about lemurs’ biology to the Malagasy students. Finally, C. Rabarivola has a crucial knowledge and experience of the Malagasy administration necessary for obtaining the research permits. Since 2006 our team has been working in collaboration with C. Rabarivola

John Rigobert Zaonarivelo (Malagasy) is a Professor and also the Head of Department of Life Sciences and the Earth at University of Antsiranana. In 2011 we began collaborating with his department and we are now willing to develop our activities together and to provide training to some students from the Ecology Bachelor degree.

Sebastien Wholhauser (Swiss) was the Development and Research Director of Fanamby NGO since 2005 and is now a well-recognized senior conservationist in Madagascar. He is fluent in Malagasy, and his knowledge of both Madagascar biodiversity and culture has helped us a lot during our last field missions. Moreover, Fanamby NGO manages several protected areas in the north of Madagascar which encompasses the project study area, thus playing an important role for our project.

B. Fellows:

Fabien Jan (French) was the field assistant of the group. He has been involved in several conservation projects since 2004 and he is now a well recognize field ecologist in Indian Ocean region, where he has been working on sea birds, marine turtles and lemurs. From 2010 to 2013, he was leading a field team working on several lemur research and conservation projects in the north and northwest of Madagascar, intensely practicing distance sampling survey, lemur sampling, capture and handling of diurnal and nocturnal lemurs.

Emmanuel Rasolondraibe (Malagasy) holds a Master degree in Primatology obtained in 2008 under the supervision of Dr. L. Chikhi and Pr. C. Rabarivola from Mahajanga University. He first worked with Dr. L. Chikhi in 2008 and has been taking part of all field missions since then. He has a very good knowledge of our field work organization and of cultural and linguistic specificity of northern and north-western regions of Madagascar.

Célia Kun-Rodrigues (Portuguese/Hungarian) holds a Masters in Evolutionary and Developmental Biology from the Lisbon University. She started working at the Population and Conservation Genetics group, in the Instituto Gulbenkian de Ciência (Portugal), after her graduation. She was involved in projects that studied the genetic diversity of Borneo Pygmy Elephant populations and of Sifaka species (*Propithecus*) of northern Madagascar. In 2011, Célia obtained the Optimus! Alive-IGC fellowship which enabled her to join the RSG Project during the 2012 field work season. During the project she did work both on field data collection and data analysis and she gained expertise in distance sampling surveys for ascertainment of nocturnal lemur densities, and in small mammals capture and handling (*Microcebus*, *Lepilemur* and rodents).

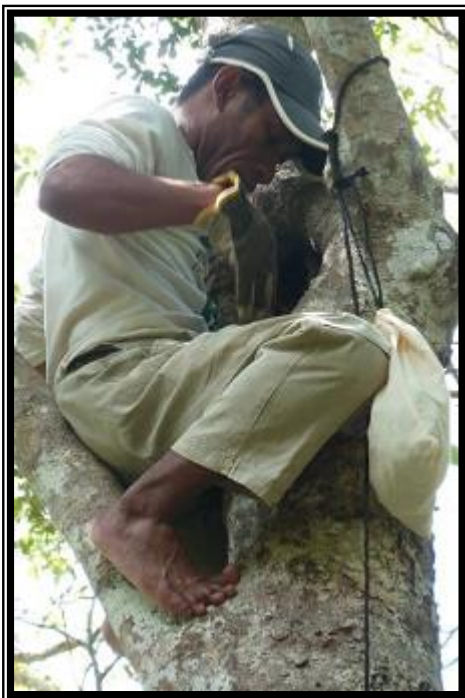


Figure 4: **Radavison Zaranaina** during a sportive lemur capture.

Radavison Zaranaina (Malagasy) is a former Primatology Student from Mahajanga University. Since 2009 he has been interacting a lot with our group and started working with us a field assistant. In 2011 and 2012 he led one of our field work team (Fig 4).

Mohamed Thani Ibouroi (Comoros) is a post graduate student, holding a Master degree of Primatology from the University of Mahajanga. His Master thesis was conducted on *Microcebus* and *Lepilemur* populations of the Loky- Manambato region, and defended in June 2012 just before the beginning of the RSG field work. Last year (in 2013) Thani also received a RSG for his project on north-eastern Madagascar remote pristine forests. Since this collaboration with the IGC Group, he acquired

extensive experience working on conservation biodiversity and many fieldwork experiences which allowed him to enter in a Masters' program of Biodiversity, Ecology and Evolution at the Paul Sabatier University in Toulouse, France. He has just received an IDB (Islamic Development Bank) Merit Scholarship to pursue a PhD in Conservation.

Dhurham Said Oussen (Comoros) is a student of the Primatology Master from Mahajanga University. He has been working with lemur species from north-western and northern regions of Madagascar since 2011, and he is now finishing his Master thesis on “The density, distribution and diversity of Northern sportive lemurs”, a scientific work entirely performed during the RSG project (Field work, courses, data analysis, Thesis writing, etc.).

Tantely Nirina Ralantoharijaona (Malagasy) is a student of the Primatology Master from Mahajanga University who defended his thesis in 2012 on *Daraina sportive* lemur populations. Until now he has been working extensively on sportive lemur populations with C. Schwitzer and our team (Fig 5).

Ando Nantenaina Rakotonanahary (Malagasy) is a former student of the Primatology Master from Mahajanga University. Until now she has been working extensively on *Microcebus* populations with our team and obtained her Master degree in 2012. In 2013 she took responsibility of one of the field team.

Andrianotahina Harivony Honoré is our most recent student from the Master program of Primatology of Mahajanga University. His project will focus on the sportive lemur’s populations of northern Madagascar.



Figure 5: **Tantely Nirina Ralantoharijaona** during a sportive lemur capture

C. Volunteers:

Barbara Le Pors (French) volunteered twice in the group

Field work and participated to the RSG project in 2012 and 2013. She holds a Master degree in Ecology and Regional Planning University of Toulouse (France). She is a GIS (Geographic Information Systems) specialist who worked

Marion Carreira (Portuguese), is a volunteer whom graduated in Ecology in Portugal, and joined the project thanks to crowd funding.

D. Guides and protected area agents:

In each visited locality four to six guides were hired for the duration of the visit. Usually in non-protected areas and/or remote places the guides are chosen together with the local authorities among fellows that have a good knowledge of the neighbouring forest and trails. We were able to hire professional guides only in touristic protected areas: Mahamasina (Ankarana NP) and Anjahakely (Andrafiarana AP).

E. Cooks:

At each visited locality the team hired a local cook for the duration of the visit. Because hired guides are usually men, and because traditionally in Madagascar women cook, we did hire women as cooks. This allows to balance the sex ration of hired people, and to have better cooks on average.

In town (Anivorano) the team hired a part time cook, **Jorjiny**, for the duration of the RSG project.

We are really grateful to all cooks that participated to the project. Their importance is definitely non-negligible as during such long days of exhausting field work, the food quality is one of the main factors that maintain team motivation, health and strength.

X. Courses and capacity building

F. Training

As planned, local students (Malagasy and Comorian), volunteers, local guides, and Park agents were continuously trained during field and office works.

Students, fellows and volunteers were continuously trained to perform vertebrates inventories, use GPS and solar energy devices, assess the forest quality, capture and handle small mammals, perform visual line transect and acoustic point distance sampling survey, write reports, analyse data, use statistics with R, handle large data sets on Excel, use simple GIS tools (Google Earth), to speak French, English, and Malagasy and to read and discuss scientific publication.

Park agents and local guides together with volunteers, students and foreign volunteers were trained to the “line transect distance sampling” principles and practice. This allowed us to discuss the reasons why we were here and why we were interested in conservation. Discussions on the importance of conservation were also quite common when we decided to discuss how animal names were different across languages. By discussing the differences between Malagasy, French and “Latin” (i.e. scientific) names we could both learn each other languages and discuss the diversity of Madagascar vertebrates with guides and Park agents. We also used field guides books as a support to illustrate the discussions, which allowed us to share our material. Local species were compared to species distributed elsewhere in Madagascar. Madagascar's peculiar biogeography was illustrated by the important role of rivers and climate in driving diversity. In a few words, this allowed us to introduce local guides to some of the ideas that drive our work.

The importance of forest and biodiversity conservation was frequently discussed with guides, park agents and locals. The discussion was usually oriented in a way to led them to present their point of view concerning the deforestation-conservation trade-offs. In many ways this forced us to reconsider some of our simplistic view of conservation. It reminded us of their priorities, and of the fact that deforestation is often driven by the consuming habits, outside the forests, and even outside Madagascar.

G. Advance Courses

Three advanced courses on GIS tools, animal density estimates, and the use of Excel were offered to the members of the teams during the field period. I conducted these courses. It allowed us to significantly increase the quality of the students' Master reports, analyses and led to shared publications in which all students took part.

The **first course** intended to teach Students and volunteers “the use of GIS tools (ArcGIS and Google earth) for field ecologist”. This three days course took place in June 2012, was followed by 9 persons (students, volunteers and fellows), built and led by Jordi Salmona and taught by Jordi Salmona and Barbara Le Pors.

The main idea of the course was to give to the student enough knowledge in GIS to be able to create a correct map of any feature of its field work and to calculate simple geographic features useful in ecology (distance to the rivers, to the road, number of occurrence etc...).



The main outcomes of this course can be already measured by the quality of the maps created by Ando Nantenaina Rakotonanahary in her Master thesis report, by Dhurham Said Ousseni in the Master thesis report he is currently writing, and by Mohamed Thani Ibouroi for the RSG project on North-eastern Madagascar remote pristine forests he recently obtained.



The **second** advanced course aimed to bring to Students and volunteers a basic knowledge of Excel. This two days course took place in July 2012, was followed by 9 persons (students, volunteers and fellows), built and led by Jordi Salmona and taught by Jordi Salmona and Célia Kun-Rodrigues.

The main idea of the course was to give to the student enough knowledge to organize large field data sets, to work efficiently with his own field data base and to be able to implement simple links and calculations within and between Excel sheets.

The main outcomes of this course are not as easy to measure as those of the GIS course (easily to assess by the maps quality). Nevertheless, Dhurham Said Ousseni and Ando Nantenaina Rakotonanahary have been able to handle and analyse large field data set for their Master project, and Ando Nantenaina Rakotonanahary was able to defend her Master in early 2013 thanks to their new acquire knowledge. Moreover Ando Nantenaina Rakotonanahary did coordinate part of 2013 field work in the north and managed to handle the whole field database.

The **third** advanced course intended to teach Students and volunteers how to estimates population density and abundance. This three days course took place in August 2012, was followed by 10 persons (students, volunteers and fellows), built and led by Jordi Salmona and taught by Jordi Salmona and Davison Zaranaina.

The main idea of the course was to give to the students enough knowledge to understand the principles and assumptions of the most widespread methods used for density estimates of wild populations (distance sampling), and to practice a case of study using Distance software.



The main outcomes of this course are measurable in Ando Nantenaina Rakotonanahary Master Project report, and Dhurham Said Ousseni master work in progress. Moreover thanks to this gained knowledge, Mohamed Thani Ibouroi is now going to perform a meta-analysis of the density data collected in the last years in Northern Madagascar, as a project for the Master of Ecology and evolution he is now following in Toulouse (France). Finally together with Célia Kun-Rodrigues, we took advantage of the different courses to analyse a distance sampling data set collected in 2009 on *Propithecus coquereli* in the Ankarafantsika National Park. The output of this last work has recently been published in International Journal of Primatology (Kun-Rodrigues et al. 2014).

XI. Interviews

We conducted a total of 38 interviews with local people (Table V). This number is much lower than what we were planning (10 per sites).

First, all the field participants were not able to interview people, because speaking Malagasy is a prerequisite to conduct an interview, and usually volunteers and part of the fellows do not speak Malagasy well enough to interview someone. This reduces a lot the quantity of interview possible, and the dynamics. All other tasks were shared by all members of the team while this task was only for Malagasy speaking members, thus, they had to get motivated almost alone.

The language was not only a barrier at the international level, but also at the Malagasy level. Most of the students that do not originated from the northern or north-western regions were not comfortable when speaking local dialects and when interviewing people. The two fellows that were fluent in northern dialects did in fact perform more than two thirds of the interviews.

Table V: Summary of conducted interview

Protected Area	Site	Interview
Analamerana	Ampasimaty	7
	Andrafiambany	2
	Ankavanana	1
	Betsiaka	6
	Mosorolava	2
Andrafiambena Andavakoera	Ampantsogno	2
	Andrafiabe	4
	Andrafiambena	2
	Anjahankely	1
	Antserasera	3
	Maroadabo	5
Ankarana	Mahamasina	1
	Marovato	2
Total		38

To evaluate the effect of local population uses of the forest on *L. ankaranensis*, *M. tavaratra*, and *Phaner electromontis* presence and densities, the fact that we have only a few interview will not be an issue as we also have field forest characterization. But, to evaluate the effects of traditional belief we will lack data.

XII. Outcomes

H. Courses

The outcomes of continuous training and courses are not necessarily measurable but are obvious and really rewarding for who led the courses. Nevertheless it can already be measured by the size of datasets handled and by the quality of the maps and of density analyses produced by Ando Nantenaina Rakotonanahary in her Master thesis report, by Dhurham Said Ousseni in the Master thesis report he is currently writing, and by Mohamed Thani Ibouroi for the RSG on North-eastern Madagascar remote pristine forests he recently obtained for example.

Moreover, Célia Kun-Rodrigues took advantage of the different courses to analyse a distance sampling data set collected in 2009 on *Propithecus coquereli* in the Ankarafantsika National Park. The output this last work has been published in the International Journal of Primatology (Kun-Rodrigues et al. 2014).

I. Thesis

Dhurham Said Ousseni has analyzed the "Variation of and density and morphology of population of *Lepilemur ankaranensis*". His thesis is now almost ready and being reviewed by his supervisors Lounès Chikhi

and Clément Joseph Rabarivola. We expect the defence to take place in May/June 2014.

Mohamed Thani Ibouroi is realizing a meta-analyse the data from Sportive Lemurs collected from 2010 to 2013 and try to infer for all the northern region the relationships with environmental factor (forest size, habitat type, etc.) with densities. This work will be part of the Master II he is following attending in Toulouse (France) since September 2013 and will defend in June 2014.

Ando Nantenaina Rakotonanahary was building a PhD in 2013 in Madagascar and will take care of the density estimates of *Microcebus Tavaratra*. Hopefully she will analyse the data in the next couple of month and be able to submit a first manuscript to her co-authors in early spring 2014.

J. Papers

a. Published or in press.



Figure 6: *Propithecus coquereli*

Propithecus coquereli: Together with Célia Kun-Rodrigues, we took advantage of the different courses to analyse a distance sampling data set collected in 2009 on *Propithecus coquereli* (Fig 6) in the Ankarafantsika National Park (Northwest of Madagascar). The output this last work is now published in International Journal of Primatology (Kun-Rodrigues et al. 2014). Even if it is not completely related to the RSG project this data was analyzed thanks to the knowledge acquired during the courses, by participants of the RSG project and allowed all those who took part of the analysis to be co- authors. I do thus believe that it is part of the outcomes of the Project.

Propithecus perrieri: The distribution of Perrier's Sifakas (Fig 7), one of the 25 most endangered primates in the work (IUCN 2010) was updated thanks to the field work of the RSG project. This distribution update has been published in *Lemur News* 2013 (Salmona, Jan, et al. 2013).

Loky-Manambato nocturnal lemur density: Two new papers using the distance sampling data gathered in the Loky-Manambato region (Daraina) in 2011 were submitted in March 2014 to the journal *Lemur News* (Salmona, Rakotonanahary, et al. 2014, Salmona, Ralantoharijaona, et al. 2014).

b. In project

The works of **Mohamed Thani Ibouroi**, **Ando Nantenaina Rakotonanahary** will soon lead to publication in international peer reviewed journal.

Hopefully, field's data on lemurs' distribution will be the object of an article in *Lemur News* number 18 in 2014. In particular the distribution of the *Phaner* in the region seems quite unexpected and will be the subject of a future article.



Figure 7: *Propithecus perrieri*

K. The final report

This report is part of the outcomes of the project. It contains data that could not be included in the RSG standard report. We see it as a scientific document summarizing what has been done and including some important presence data for species that were not the main focus of the project and of any participant of the project, but that could be useful for other naturalists, conservation agencies and scientists. Moreover, this document might be useful for the members of the project who still have data to process, as it summarizes the basic information gathered during the project.

L. Species distributions and conservation statuses updates

In summer 2012 four of the members of the Project (Lounès Chikhi, Clément Joseph Rabarivola, John Rigoberto Zaonarivelo and Jordi Salmona) were invited to the IUCN meeting in Antananarivo (Madagascar). This meeting aimed to re-evaluate the Lemurs species Conservation Status. During four days together, with scientist and conservationist from Madagascar and from all over the world the new statuses were defined. The data collected during the RSG project was used in the definition of the concerned species (*Microcebus tavaratra*, *Lepilemur Ankaranensis*, *Propithecus perrieri*, etc.). The knowledge acquired during the field work in the Northern region allowed me to be responsible of building and writing the conservation plans for the regions of Loky-Manamabato/Daraina (Salmona & Zaonarivelo 2013) and of Analamerana-Andrafiomena (Salmona, Zaonarivelo, et al. 2013). The report of this IUCN meeting has been published (Schwitzer et al. 2013) and can be found at the following address (<http://data.iucn.org/dbtw-wpd/edocs/2013-020.pdf>).

Some species distributions (and conservation statuses) still need to be updated using the information gathered during, and will be the object of paper in *Lemur News*.

M. Association project

In 2013, thanks to many discussions between and motivation of the members of the field team, we decided to create an association in Madagascar, as a tool for forest management. The association “Hazo tokana tsy mba ala” has been finally created in autumn 2013, the name being a Malagasy famous proverb literally meaning “a single tree does not make a forest” and with second meaning “union make strength”. This association built together with Malagasy students and friends, aims to be a tool to increase our implication in conservation projects through forests management projects in areas still unprotected, of the still poorly known and studied Northeastern of Madagascar.

XIII. Project perspectives

In the upcoming couple of semesters I, together with other members of the project, will try to finalize data analysis and paper writing in order to publish the data gathered during the RSG project.

In parallel we plan to keep working in the northern region of Madagascar, now focusing on the neighbouring forests and inter-river systems. Different options are appearing.

On the first hand we would like to continue assessing lemurs’ population distribution, density and conservation together with the sampling work done by the Population and Conservation Genetics Group.

On the other hand we are now developing a research and conservation project in the northeast (south of the region I worked on in this RSG project). This project will focus specifically on two forests that were visited in 2013 within the RSG that was awarded to Ibouroi Mohamed Thani. Thani is a student that I have been co-supervising and whom I have trained for all the statistical methods he needed for his Masters project

(density estimation, GIS analysis, basic statistics, etc.) since 2010. Thani obtained RSG funding for a project in which he plans to inventory lemurs and whenever possible provide new taxonomic data. Lounès Chikhi and I helped him build the project and I have been with him in the field together with several students. Unfortunately the recent lemur conservation strategy build by the IUCN/SSC (Schwitzer et al. 2013, 2014) does not include any forest fragment of this North-eastern area of Madagascar, between the Manambato and the Manambery rivers. Two of the forest fragments that we visited, namely Analalava and Ambohitrandrina, are particularly interesting because of their peculiar geographic and conservation situation. They are close to the national road (easy to access), but not yet managed and/or protected. As a consequence they are being actively degraded by a strong logging pressure. We thus aim to inventory and sample a largest range of vertebrates (not just lemurs) over a longer period in these two forest fragments. In fact we believe that it would be crucial to make our presence as permanent as possible in this area in order to build a trustful relationship with local communities and install the first steps of a reforestation/forest management project (administrative work and tree nursery plans) as recently suggested by Schwitzer and colleagues (Schwitzer et al. 2014). In fact we have started to develop a project together with previous Malagasy students, whom we trained in the previous years, and we created an association, which we hope could try and focus on forest management, reforestation and wildlife conservation in the Northern region of Madagascar.

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