BERENTY RESEARCH PROJECTS 2015-2017, WITH MANAGEMENT RECOMMENDATIONS

LEMUR POPULATION AND DEMOGRAPHY

RASAMIMANANA, Hantanirina. Ecole Normale Supérieure (ENS),BP 881, Université d'Antananarivo, Antananarivo 101 - Madagascar

Assisted by many current and former ENS students (see below).

Lemur catta census

The *Lemur catta* census was conducted during the gestation period in 2014, in 5 different forest areas: at the north in Ankoba the secondary gallery forest; Malaza, the traditional study forest, including gallery an bush vegetation; to the east, Analamaranga, the gallery forest beyond the cattle drove; to the south, Anefitany, the spiny forest; and lastly to the south-west in Rapily, the xerophytic forest. We proceeded with the census before the usual birth period because the Malaza forest seemed to be empty when we were there. The explanation for the empty forest was that the lemurs did excursions to the surrounding areas such as Analamalangy to the east and to Akesson forest to the south for sisal flowers and Flacourtia ramontchi, fruit that does not exist in Malaza forest.

All forest guards were involved in that census which helped them to understand their responsibility and the need for lemur conservation. The owner Claire Foulon was aware of the necessity of the local community involvement and the relationship between the local population, students, guides, the owners and the forest guards is improving since then. A total of 502 lemurs were counted in 42 groups, averaging 13 lemurs per group. The highest density was in Ankoba, with an average of 52.25 lemurs/km^2.

Propithecus verreauxi census

During 2014 census, the total *Propithecus verreauxi* population in Berenty reserve excluding Anjampolo was 390 individuals in 67 groups. On average the group size is 6 individuals. The sex-ratio is biased to the males on average. Subadults survival rate is higher than juveniles one and the birth rate is low 25%. Ankoba, the secondary gallery forest, has the highest subadult and juvenile survival rates because of the introduced leguminous *Pithecelobbium dulce* however it has a decrease in total population.

Census in the 2015 revealed a total population of 448 individual sifaka that dwelt in a 150ha forest area, with an average density of 298.6 individuals/km^2. Individuals were spread out in three forest subdivisions which are: Ankoba, a secondary gallery forest, Malaza forest and Anefitany, a spiny forest with respectively 40ha, 100ha and 10ha surface. Ankoba forest shelters 171 individuals with 427.5 individuals/km2, Malaza forest shelters 255 individuals with 255 individuals/km2 and Spiny forest shelters 22 individuals with 220 individuals/km2

The 2016 census has shown a very slight decrease in the individuals' number in comparison to 2015 (442 vs 448) with a slight increase in birth rate (35,71% vs 33,40%) and in the number of the groups (80 vs 79), one group split in two but the fissioned groups stayed in their own home range.

These censuses were assisted by many current and former ENS students.

ENS team	Name	Qualification	Research Topic in the present report
(credit: Randrianirina) 	1- Fefy Ravahatramananjarasoa	Currently certified high school teacher at the Lycee of Analavory and university teacher assistant at the University of Soavinandriana- Itasy Experienced in Berenty research from 2009 till now and in other protected area 2011-2015 – Manombo- Vohipao. 2010 Graduated at ENS with a Master in Education 2012 Graduated at ESSA (Ecole Supérieure des Sciences Agronomiques –Antananarivo) with a Master in Forestry, Environment and Development.	Sifaka census *Propithecus verreauxi* Plant phenology Varika *Eulemur cineireceps* territorial behavior From July 28th to August 18th, 2016
(credit: Randrianirina) 	2- Felaniaina Rafenoarisoa	Currently certified high school teacher at the Lycee of Ambositra. Experienced in Berenty research from 2014 and in other protected area 2013-2015 – Manombo- Vohipao. 2012 Graduated at ENS with a Master in Education 2016 Graduated at ESSA (Ecole Supérieure des Sciences Agronomiques –Antananarivo) with a Master in Forestry, Environment and Development	Sifaka census Propithecus verreauxi Plant phenology Varika *Eulemur cineireceps* territorial behavior From July 28th to August 18th, 2016
(credit: Ravahatramananjarasoa) 	3- Tolotra Randrianirina	Currently certified high school teacher at the Lycee of Sakay. Experienced in Berenty research from 2014. 2015 Graduated at ENS with a Master in Education	Sifaka census Propithecus verreauxi Plant phenology From July 10th to 29th, 2016
 (credit: Randrianirina) vonjykely@gmail.com	4- Vonjy Andrianarimalala	Currently certified high school teacher at a private Lycee of Antananarivo and works at Association Impact run by Josia Razafindramanana a famous primatologist. Experienced in Berenty research from 2015. 2016 Graduated at ENS with a Master in Education	Sifaka census Propithecus verreauxi Plant phenology From July 23th to September 12th, 2016

 Saotrar48@gmail.com	5- Saotra Rakotonomenjanahary	Currently certified high school teacher at the Lycee of Antsirabe University Teacher assistant at ENS. Experienced in Berenty research from 2013. 2014 Graduated at ENS with a Master in Education 2015 Post graduated in Endangered Species Recovery at University of Kent - UK	Maki Lemur catta Feeding behavior Sifaka census and feeding behavior Propithecus verreauxi Plant phenology From August 16th to September 12th, 2016
(credit: Ravahatramananjarasoa) 	6- Randriamanantsoa Aurélie	Currently university teacher assistant at the ENS of Antananarivo PhD in Biochemistry at the Faculty of science of the University of Antananarivo Experienced in Berenty research from 2016 and in other protected area 2014 – Manombo- Vohipao. 2011 Graduated at ENS with a Master in Education 2015 Graduated at ESSA (Ecole Supérieure des Sciences Agronomiques –Antananarivo) with a Master in Forestry, Environment and Development	Sifaka census Propithecus verreauxi Plant phenology Varika *Eulemur cineireceps* feeding behavior From August 16th to September 12th, 2016
 (credit: Randrianirina)	7- Ramamonjisoa Benjamin	Currently certified high school teacher at a private Lycee of Fianarantsoa. Experienced in Berenty research from 2016. 2016 Graduated at ENS with a Master in Education	Sifaka census Propithecus verreauxi Plant phenology From July 10th to September 12th 2016.
 (Credit Randrianirina) rasamiratovo@gmail.com	8-Rasamimanana, Hantanirina. Ecole Normale Supérieure (ENS), Université d'Antananarivo, MADAGASCAR	Experienced researcher at Berenty site from the 80s. Principal investigator of LCF Sifaka census project. Recently a full professor at ENS.	Sifaka census Propithecus verreauxi From July 10th to 25th 2016

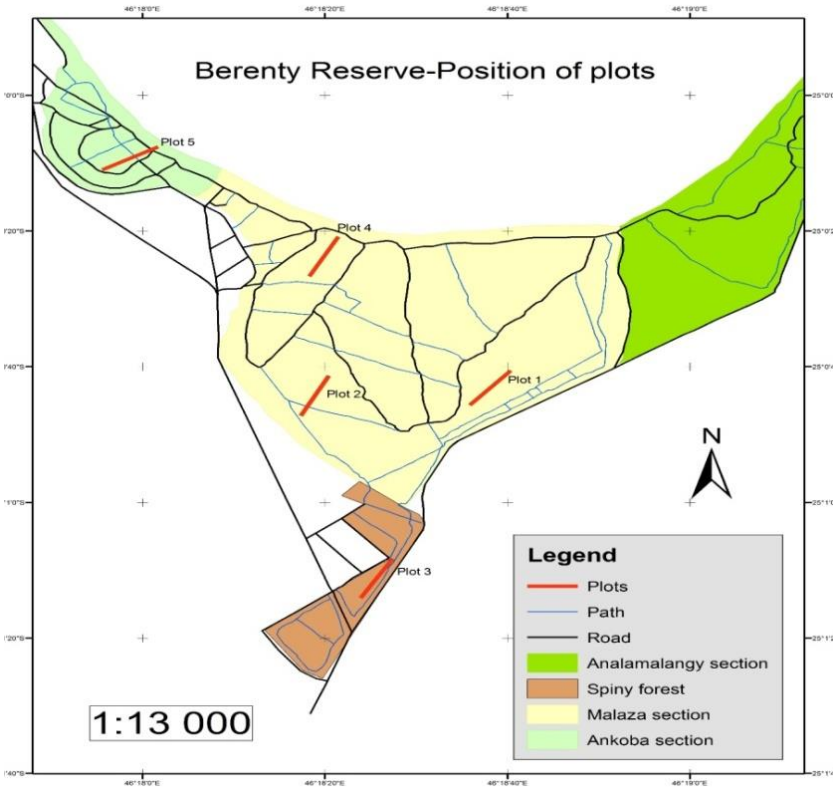
FOREST STRUCTURE, FEATURES AND PHENOLOGY—assessing the health of the forest

RASAMIMANANA, Hantanirina. Ecole Normale Supérieure (ENS),BP 881, Université d'Antananarivo, Antananarivo 101 - Madagascar

Assisted by many current and former ENS students (see above)

2015 Berenty forest structure field-work and the 2016 phenology sampling were also conducted by ENS team, from July to September, involving former students already graduated years ago and teaching at high school and current students doing their Master degree works.

Five transects of 200m long were set in every vegetation site. One transect is in Ankoba, three in Malaza and one in Anefitany. Each transect has 13 circles with10m diameter. Two consecutive circles are distant of 5m. The overall transect is 1 Km. The data collected are: the scientific and vernacular names of the encountered plant; its DBH; its total height; the canopy height, shape and diameter; the leaf stage: young, mature, yellow; the flower stage: buttons, open flowers; the fruit stage: green, ripe. The map below shows the location of the five plots: in the secondary forest of Ankoba: plot 5; in the gallery forest of Malaza plot 4; in its transitional forest plot 2 and in its open canopy forest plot 1 and, finally in the spiny forest Anefitany: plot 3.

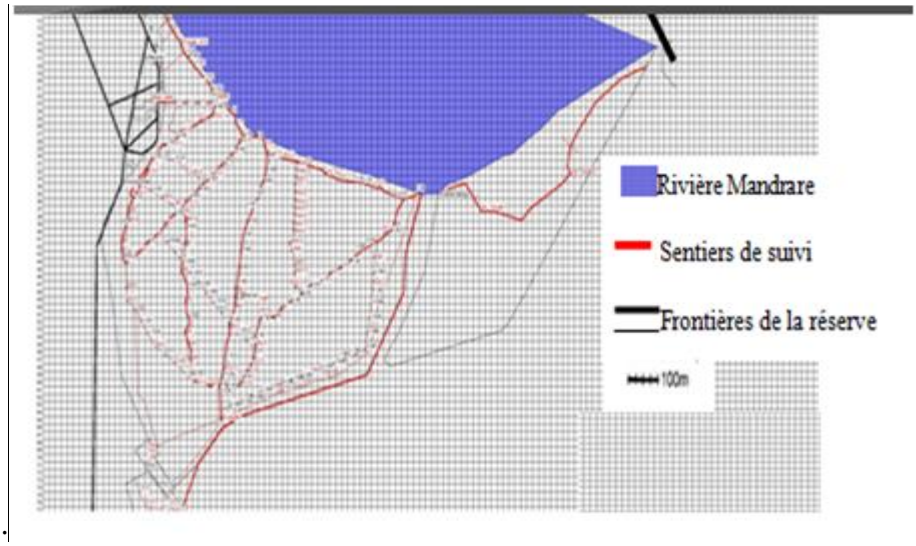


Overall there were 27 tree species in the five transects in 5120m² area. The spiny forest (Plot 3) is rich in species from only five families. On the opposite side the natural gallery forest (Plot 4) has the fewest number of plant species from six families. The open canopy forest has the highest number of families and genus with a good number of species. When comparing the five plots, the highest diversity is in the transitional forests, because of the mixture of the gallery forest with the spiny forest species in this zone. The natural gallery forest

is the poorest in species because one species is dominant. There is heterogeneity of vegetation in the reserve, and the forest structure indicates the trees are still growing and the forest is durable. The owners take care of it and are thinking to replace the dying big trees such as *Tamarindus indica*, but personally I think the Reserve has a good resilience so a reforestation is not needed for the moment.

In 2016, the ENS team sampled the plant phenology along the trails, in red on the map below, 1m inside the forest from both trail sides. This information will be considered when interpreting the sifaka census data relating their numbers and locations to the locations of available resources.

Plant Phenology Trail Sample Locations



FOREST HEALTH AND RESTORATION 2011-2017

Vanessa Winchester, Hantanirina Rasamimanana, Sahoby Raharison (2011), Anne Mertl-Millhollen (2014), Rubin Sagar (2016), Krithika Sampath (2016), Janet McCrae (2014, 2017).

Berenty Reserve has been protected by the de Heaulme family, for over 80 years, but the family together with researchers studying the lemurs are concerned that the forest is in trouble and want to find out if there is something that might be done to restore the canopy.

Malaza, the main forest area at Berenty, covers 100 hectares; of this the continuous gallery forest, formed by the dominant tamarind tree, has shrunk and almost 40% of the rest has fragmented, with large areas covered in grass, prickly scrub, isolated trees and an overwhelming invasive African vine, *Cissus quadrangularis*, that thrives in sunlight (Figure 1)

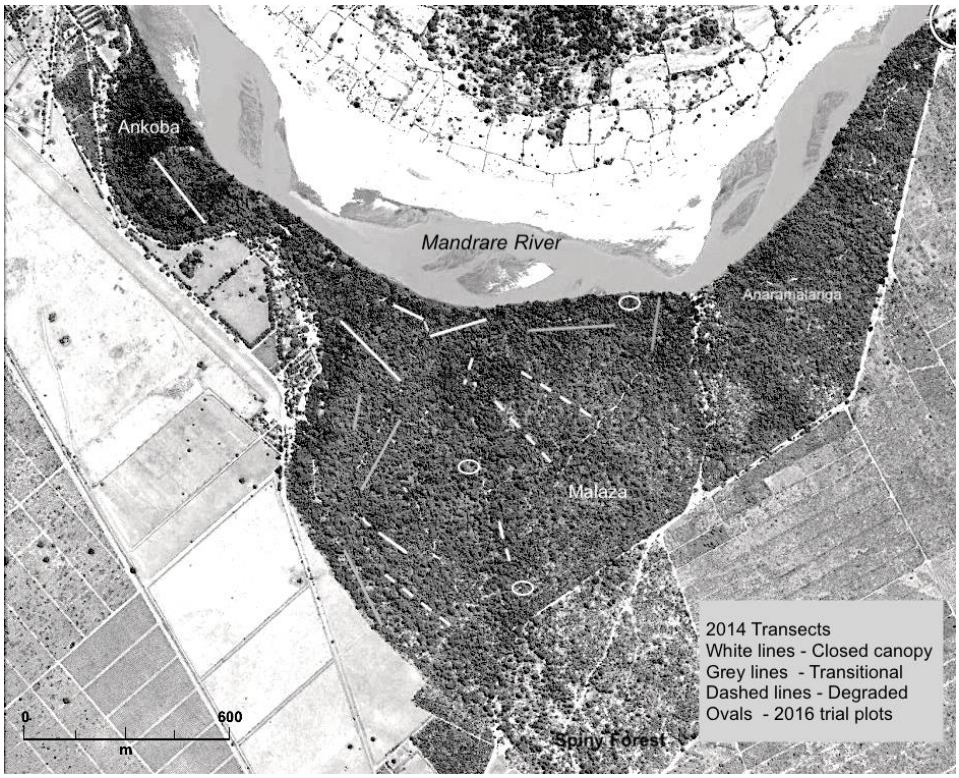
Figure 1 *Cissus* engulfing a dead tree

In 2011 we investigated reasons for the decline in forest cover and found that it is less to do with climate change, riverbank erosion, pests, disease, fungi or introduced animals, but more with forest age and a lack of regeneration of the tamarind. Unfortunately, tamarind seedlings neither thrive under parent trees nor around dead ones and their seedlings elsewhere are out-competed by prickly shrubs and the invasive vine. The average age of the tamarinds is 190 years and, since this species has a common life expectancy believed to be around 200 years, it seems likely that most of the trees will be dead within 20 years.

Before a forest restoration plan can be considered, we needed to know the characteristics and current composition of the different forest areas. So, in 2014, we carried out a vegetation survey (Winchester *et al*, 2018). Species names were provided by Professor Rasamimanana,and local names were supplied by the chief forest guardian, Mr Remanonja. The survey defined three main areas: continuous canopy near the river; transitional canopy where large trees are more widely spaced and there are patches of long grass and vines and degraded dryland with sparse of missing canopy and plentiful grass, vines and shrubs.

In 2016 a planting program was initiated to trial different cultivation practices, with the long-term aim of assisting the restoration of biodiversity levels to those typical of the remaining forest fragments thus conserving key resources for the lemurs and other endangered fauna. Figure 2 shows the vegetation survey transects and the positions of the 3 plots used for the planting trials.

Figure 2. Vegetation survey and trial plot positions



After clearance of shrubs and vines, 1354 seedlings of common forest species were planted, with plots divided: half being planted with seedlings spaced at 1 m and the other at 1.5 m intervals. Each seedling was numbered, measured and plotted on a distribution map and soil samples were taken for analysis of their moisture content and mineralogy.

Since regeneration is a major issue for forest health, we recorded names and stem circumferences of species growing under three mature tamarinds: two in Malaza, under the continuous-canopy near the river and in the mid-forest transitional zone and the third in the secondary forest of Ankoba (Table 1). Other species are certainly present elsewhere under the canopy, but the common species' percentages provide some indication of frequencies in the forest. Specimens of each were collected and dried and also given their local names for a projected herbarium.

Table 1: Tree species that grow (in a 10-m diameter circle, a canopy-width) under mature tamarinds. There were no tamarind seedlings with root collar diameters larger than 1.8 mm*

Species	Count	% species gallery forest Malaza	Count	% species. Ankoba	Count	% species mid-forest Malaza
Rinorea greveana	29	**35.8**	25	**41.7**	3	**2.6**
Tamarindus indica <1.8 mm*	16	**19.75**	5	**8.3**	-	
Celtis philippensis	15	**18.5**	11	**20**	75	**65.7**
Celtis gomphophylla	10	**12.4**	11	**18.3**	20	**17.5**
Trycalysia sp.	3	**3.7**	-	**-**	1	**0.8**
Crataeva excelsa	3	**3.7**	2	**3.3**	-	
Hazunta modesta	2	**2.5**	1	**1.7**	1	**0.8**
Celtis bifida	1	**1.2**	2	**3.3**	2	**1.7**
Enterospermum pruinosum	1	**1.2**	-	**-**	2	**1.7**
Strychnos madagascariensis					1	**0.8**
Neotina isoneura					1	**0.8**
Berschemia discolor					2	**0.8**
INVASIVE SHRUBS						
Capparis sepiaria	1	**1.2**		-	3	**2.6**

Azima tetracantha	-	-	2	**3.3**	2	**1.7**
Allophylus decaryi					1	**0.9**
	n=81		**n=60**		**n=114**	

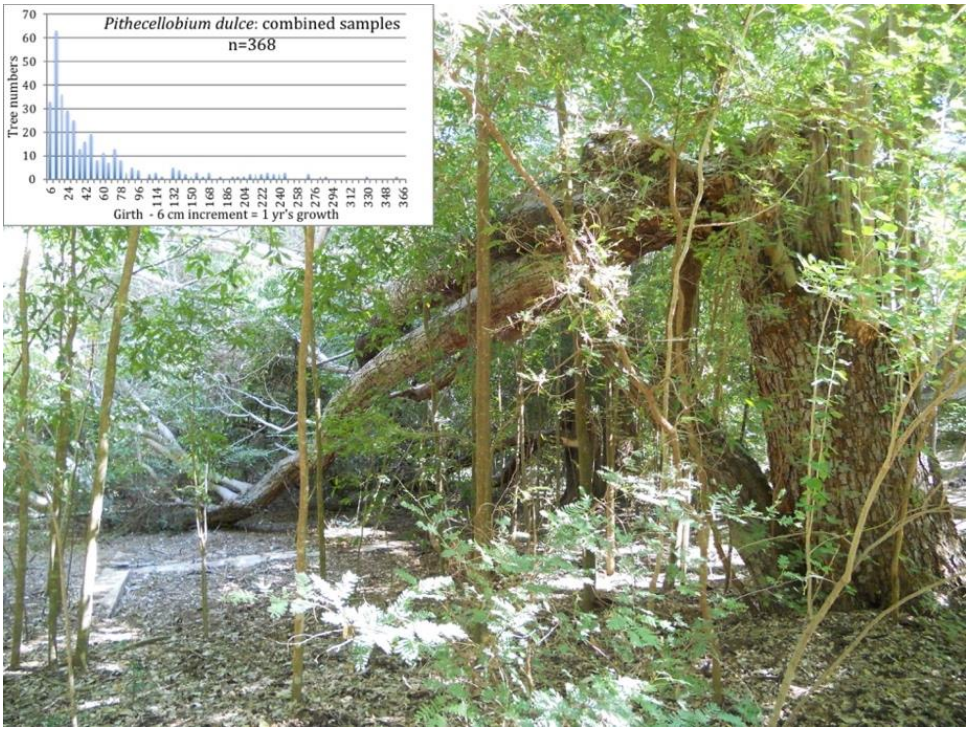
SPECIES PRESENT ELSEWHERE UNDER TAMARINDS
Quisivianthe papinae
Acacia rovumae

In 2017, we returned to re-measure the seedlings and record those that had died. Figure 3 shows Plot 1 by the river with seedling growth by 2017.

Figure 3. Plot 1 former gallery forest area near the river, with a dead tamarind tree centre left.

Measurement of plant growth rates in the nursery was carried out by Ariadna Mondragon and Emeline Auda for comparison with growth rates of the species planted in the plots. We also carried out a survey of *Pithecellobium dulce* a large invasive tree from Central America that was planted in Ankoba about 65 years ago. Today these fast-growing exotics, providing valuable food-items for lemurs, are reaching the end of their life spans, with many of the largest broken or toppled. A good deal of regeneration has occurred especially in the northern part of Ankoba, where new growth is becoming seriously invasive (Figure 4).

Figure 4. 65-year-old broken *P. dulce* tree and saplings in Ankoba.



Following final measurements in 2018, we will analyze the results, using randomized complete block design (RCBD) and ANOVA testing, to enable a species by species assessment of the relative success of different planting regimes and provide a basis for a potential plan for restoration of the degraded areas. It is intended that selection of common native trees will, in time, form a nucleus for the repopulation of the forest with ecological processes and functions similar to those of the existing continuous canopy areas.

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REFERENCE

Winchester, V.; Hardwick, K.; Rasamimanana, H.; Raharison, S.; Mertl-Millhollen, A.; Gärtner, H.; McCrae, J. **2018.** Berenty Reserve a gallery forest in decline in dry southern Madagascar: towards forest restoration. *Land*; *7*, 8, pp. 1-19. doi:10.3390/land7010008. Available online: http://www.mdpi.com/2073-445X/7/1/8/pdf

LEMUR MATING BEHAVIOR, A DOCUMENTARY FILM, AND CONSERVATION EDUCATION

Amber Walker-Bolton, Ph.D., Researcher, The University of Toronto at Scarborough, Department of Anthropology, Canada.

In the spring of 2017, I completed data collection on female response to male mating effort in two groups of ring-tailed lemurs at Berenty Reserve during the mating season. Study groups included “restaurant group” and the “museum group”. Male mating success was measured by counting the number of successful mounts (mounts with intromission and thrusting) and determining whether males ejaculated or not. Female response to male mating effort was recorded in three ways: female sexual presents, female movement away from the sequestering male, and females showing selective obstruction to mating. Preliminary analysis has shown that female sexual presents positively correlated with successful mounts but not with incidence of ejaculation. There was no correlation between selective obstruction to mating and successful mounts or

incidence of ejaculation. There was no correlation between female leaving proximity of the sequestering male and successful mounts but there was a trend toward a negative correlation between female leaving and incidence of ejaculation, suggesting that female's movement (leaving proximity) may have an impact on male's ability to ejaculate.

In addition to research activities in 2017, I also participated in the filming of a documentary on my research and conservation education initiatives. This film, by Devin Sturgeon, will be completed in March of 2018. With financial support from International Conservation Fund of Canada and logistical support from SEED Madagascar, we delivered 30 school desks to Berenty Village school, as well as conducting conservation education in Berenty Village school and Besakoa Ambany.

In 2017 I also began work on a colouring and activity book with Kathy West as illustrator. This colouring book is specifically designed for children living in Southern Madagascar and will be presented in English and Malagasy. The book will be self-published in March 2018.

The 2017 team (from left):

Tojotanjona Razanaparany, Conservation Educator, University of Antananarivo
Amber Walker-Bolton, Researcher
Devin Sturgeon, Filmmaker/Photographer
Tolotra Ranaivoson, Field Assistant, University of Antananarivo