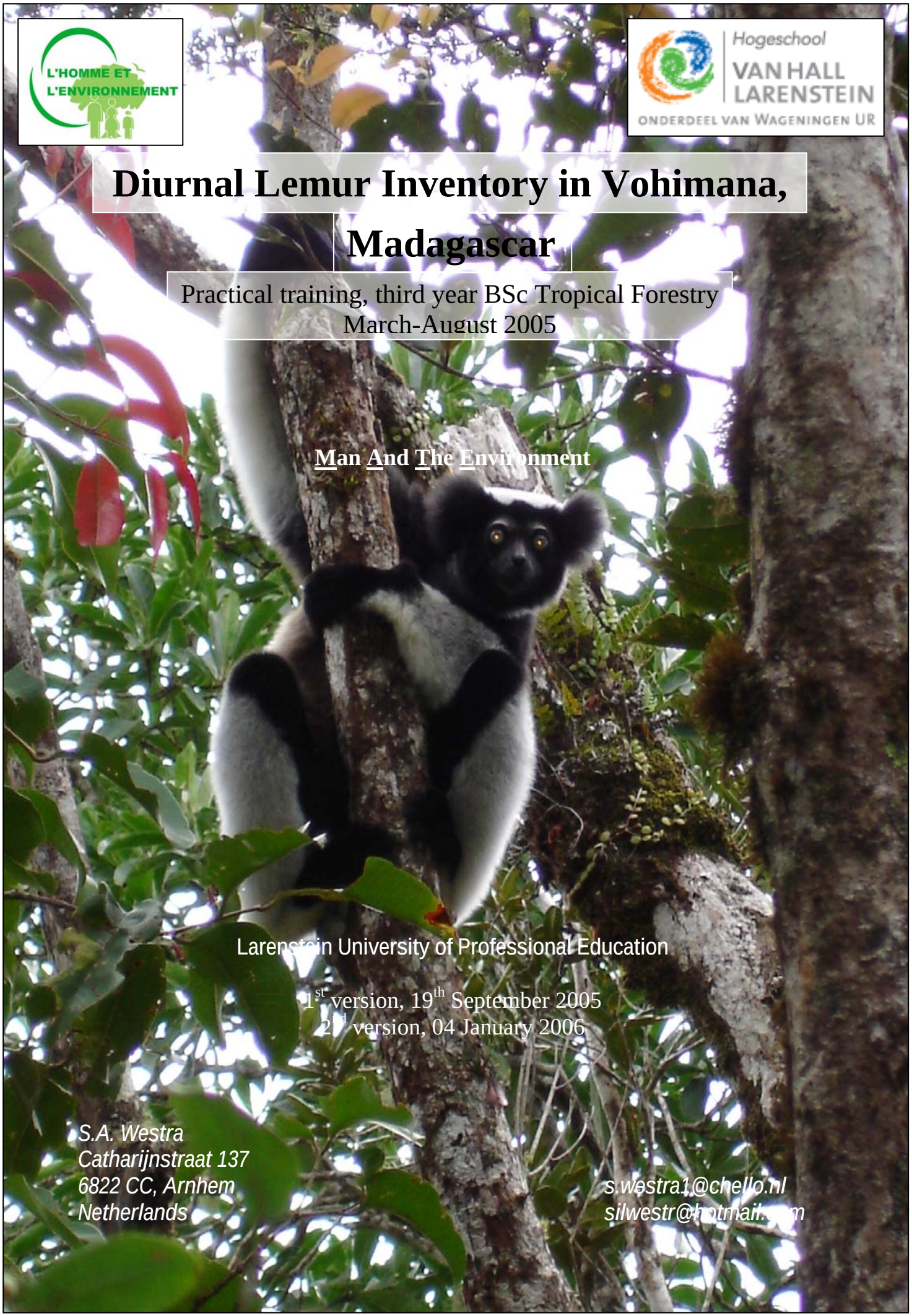

Diurnal Lemur Inventory in Vohimana, Madagascar

Practical training, third year BSc Tropical Forestry
March-August 2005

Man And The Environment

Larenstein University of Professional Education

1st version, 19th September 2005
2nd version, 04 January 2006

S.A. Westra
Catharijnstraat 137
6822 CC, Arnhem
Netherlands

s.westra1@chello.nl
silwestr@hotmail.com

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Abstract

From March to August 2005 a diurnal lemur inventory commissioned by the NGO Man And The Environment, or MATE, was conducted in one of their management sites Vohimana, just east of resérve spéciale d'Analamazoatra in Madagascar. MATE is working on a project in Vohimana to restore the currently broken corridor of the eastern rainforest belt and until now there has not been any research on abundance and populations of lemurs in the remaining pocket of forest. With a group of three students and with help of local guides the presence and abundance of lemur species were estimated using the line-transect method. Four existing forest trails with various lengths and leading through a variety of vegetation types, including degraded forest and eucalyptus plantation, were flagged with 50 meter intervals and their positions were pinpointed with a Global Positioning System. Thereafter these transect trails were surveyed regularly with groups of two people looking for animals and gathering as much data as possible. With this data maps were made to determine the locations of the different groups and density estimates were made. Six lemur species were recorded; *Indri indri, Propithecus diadema diadema, Eulemur fulvus fulvus, Hapalemur griseus griseus, Eulemur rubriventer* and *Varecia variegata variegata*. In a total of 278.25 survey hours 197 individuals were recorded in 88 groups. Nearly half of this was *Indri indri*. Average group size is highest for *Eulemur fulvus fulvus* with 3.38 individuals per group. Average group size for *Eulemur rubriventer* is the lowest with 1.5 animals per group. Although this research is not extensive enough to determine an accurate estimation of the actual number of groups, absolute density in animals per square kilometer was estimated. Relative densities in recordings per hour of survey and recordings per kilometer of surveyed transect trail were also calculated. Species accumulation graphs per transect trail were also made. Species richness is highest on the trail with the most natural forest cover (all six species) and the eucalyptus plantations and degraded areas are home to only the two most adaptable species *Eulemur fulvus fulvus* and *Hapalemur griseus griseus*. Over time the unhabituated lemurs in Vohimana became more adapted to seeing humans, especially some *Indri indri* groups seemed quite habituated coming on to the end of the research. *Indri indri* appears to be the most common and is the most easily observed species. *Propithecus diadema diadema* is also quite common and after *Indri indri* the most recorded lemur. *Eulemur rubriventer* is very rare and was only observed twice. *Varecia variegata variegata* is also very rare and was never observed but heard only a few times. Further research and conservation efforts are necessary to ensure the long term protection of the lemurs in Vohimana. Forest product extraction, encroachment, trapping and forest grazing still occur and form a threat for the remaining lemurs stuck in this isolated pocket of forest. Local people should be helped and stimulated to change their habits and turn to more sustainable alternatives. Tourism can also be a key factor and generate income for conservation and development activities. It is unclear whether the relatively small lemur populations in these remaining pockets of forest can be sustainable. A fresh input of new genes to ensure a healthy gene pool within these populations or an expansion of the current forested area or connection to other forests might be needed. If a good estimation of the absolute densities and the viability of the lemur populations in Vohimana is wanted, more extensive research is needed.

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Foreword

In the third year of the course Tropical Forestry at the University of Professional Education Larenstein a practical placement in the tropics has to be full filled. Through a fellow student I contacted the Malagasy NGO called MATE (Man And The Environment) in Madagascar, and they agreed on a practical placement of five months. MATE has got management over several rural areas in critical hot spot locations throughout Madagascar. One of these management areas is Vohimana.
I have partly worked together with two French students, Denis Marechal and Marie-Emilie Navel, to accomplish a diurnal lemur inventory in Vohimana. The NGO would also have liked us to observe the lemurs' feeding habits and to do an ecology preliminary approach. But it proved there was too little time to accomplish this, since the three of us were only together for about three months. We tried to collect as much data as possible in the available time. Although we worked together in the field we decided to write separate reports. This is because we did not spend an equal amount of time in the field and our universities demanded different deadlines. It was great fun working and living with you anyway, same for all other students, MATE's employees, guides and locals for that matter. Misoatra betsaka.
I have shot a lot of video footage of the lemurs in the forest of Vohimana, which I will use to make a small film about the diurnal lemurs of Vohimana. As soon as it is finished I will make sure I send it to the office of MATE in Antananarivo. I have tried to write this research paper as complete as possible, in this way I hope I have contributed to the conservation and long term protection of the lemurs in Vohimana.

Arnhem, Netherlands, August 2005

Sil Westra

Introduction

In terms of primate conservation, there is no doubt that Madagascar is the world's single highest conservation priority. This is the case because it is, despite its relatively small size (only about 2% of the land area of the African continent), comparable in diversity (especially at generic and family levels) to each of the three other major continental regions with wild primate populations, namely, mainland Africa, Asia, and the Neotropical region.
A key element in a long-term strategy to conserve lemurs and their habitats in Madagascar is the creation of conservation corridors to link parks and reserves in broader landscapes (Mittermeier et al. in Goodman et al. 2003). MATE is currently managing such a project to realize a forest corridor in Vohimana linking Mantadia National Park in the north to Maromiza forest in the south. Although at this stage the remaining forest in Vohimana, some 400 hectares, is isolated and cut of from continuous forest, it is still home to a variation of lemurs. With a 5 month line-transect research I have tried to make an inventory of the number of Diurnal lemur species and individuals present in the remaining forest of Vohimana.

The main research question I try to answer in this report is:

- What are the species, population numbers and abundance of diurnal lemurs to be found in the forest of Vohimana?

This question is divided in the sub questions:

- How many groups per diurnal lemur species inhabit the forests of Vohimana?
- What is the group size per diurnal lemur species?
- What is the situation of lemur densities in Vohimana compared with other sites?

MATE is a small non-profit and non-governmental organisation (NGO), based in Madagascar. It works for the promotion of conservation by development and underlines the importance of the work in association with rural populations to handle the dramatic problem of the threats of overexploitation and disappearance of natural resources (Web publishing, MATE). Their project in Vohimana started in the beginning of 2001. MATE has been given management over the site for the coming 25 years from the Ministry of water and forests and the autonomic province of Toamasina.

The goal of this research is to provide the NGO MATE with a good estimation of the number of lemur species and number of groups and individuals per lemur species living the forest of their management site Vohimana.
The eventual goal could be to look if the different lemur species present in Vohimana have viable population sizes and if Vohimana could be a viable and sustainable stepping stone in the future forest corridor between Mantadia National park and Maromiza forest. Although the base of this long term study was laid, there was not enough time for this now and further study is needed to determine this.

With this inventory I would like to make a contribution to the conservation and protection of lemurs in Madagascar. I hope that it gives MATE valuable information concerning lemur populations and that it will be beneficial in their corridor project and possible other projects and studies.
In the first chapter I discuss general information about Madagascar, the research site Vohimana and on the lemurs that were researched. This chapter gives additional introductive background information before discussing the actual research. I recommend that employees of the NGO MATE and people familiar with Madagascar, Vohimana and lemurs should disregard this chapter. Secondly there is a chapter on methods in which I have described the preparations and research methods that were used in detail. Then I have described difficulties we faced during the research in chapter 3. The actual results and data are presented in chapter 4. Finally in chapter 5 I have written some discussion points and I have made some recommendations.
I have written this report for the NGO MATE, the University of Professional Education Larenstein, Researchers, Scientists, future students working for MATE and anyone interested in Lemurs.

1. General information

1.1 Madagascar

1.1.1Introduction

Madagascar is a continent island off the coast of Mozambique in south-eastern Africa. It is approximately the size of France and Belgium combined and has roughly 17 million inhabitants. The Red Island, as it is often called, lies in the Indian Ocean and it is separated from mainland Africa by the Mozambique Channel. The capital Antananarivo, or Tana for short, is located in the central highlands of the country. The Local inhabitants consist of many different ethnic groups and tribes. Surprisingly, the first settlers came from Asia and later others came from Africa. The staple food is rice as Malagasy people are the biggest rice consumers in the world. Madagascar is number 6 on the list of the poorest countries in the world and Corruption is draining the countries prosperities even further.

1.1.2 Natural history

Madagascar has been isolated for more than 165 million years after it separated from the mega continent Gondwanaland. Because of this very long isolation the islands' animal and plant species evolved very differently to other species around the world. This makes much of the flora and fauna found on the island truly unique. It is sometimes said that the island was an experiment of nature because many of the species are so bizarre looking. Madagascar is one of the 12 most important countries for biodiversity on the planet. It is home to so many species for two reasons: it is near to the equator and it has an astonishing array of habitats (Bradt, 2005). 80 % of its species are endemic to the island, so this makes it even more remarkable. With the discovery of two new lemur species last august (Web publishing by National geographic), the 49 species of lemur found on Madagascar are 100% endemic.

1.1.3 Threats

The natural wonders of the island are severely threatened by ever expanding human population. Slash and burn agriculture (Tavy), Poaching, forest encroachment, fire wood extraction and logging all contribute to the continuous habitat loss of the many endemic plant and animal species.
According to the national inventory of forest resources (1998), the total area of forest cover in Madagascar has decreased to 17 - 21% (Web publishing by PIEC). Currently 7,249,800 ha of forest remain, of which only 383,700 ha are protected (Web publishing by WCMC).

1.1.4 Geography

The Island of Madagascar extends some 1650 km from 12° to 25° S off the southeast coast of Africa in the longitudes 43° to 51° E. A 1200-m mountain ridge with massifs above 2600 m runs north-south throughout the length of the island (Goodman et. al., 2003). The highest mountain of Madagascar is Maromokotro at 2,876 meters. Remnants of rainforest grow along the entire mountain ridge from north to south. The mountain ridge leaves only a narrow coastal plain on the east coast, but the western plain is wider and the climate there is drier. It supports deciduous forests and savannah grassland. In the far south there is spiny desert. The central plateau, or hauts plateux, are mostly deforested. All but the most southern tip of the Island lies north of the tropic of the Capricorn.

1.1.5 Climate

Madagascar has a tropical climate with a dry season and a wet season. November to march there is the summer, which is the wet season, and April to October is winter, which is the dry season. Madagascar is occasionally hit by cyclones.

1.2 Research area Vohimana

Vohimana, where the Lemur research was conducted, lies in the eastern rain forest belt of Madagascar. It lies about 150 kilometres east of Antananarivo, some 35 kilometres east of Moramanga. The area has a size of about 800 ha. of which 400 ha. is forest. Several rural communities are present within Vohimana and in total about 900 peasants inhabit the area. Although Slash and burn agriculture (or Tavy as it is called in Madagascar) is officially prohibited by law, it is still practiced here. However the remaining forest area in Vohimana is still quite extensive and encompasses about 400 ha.

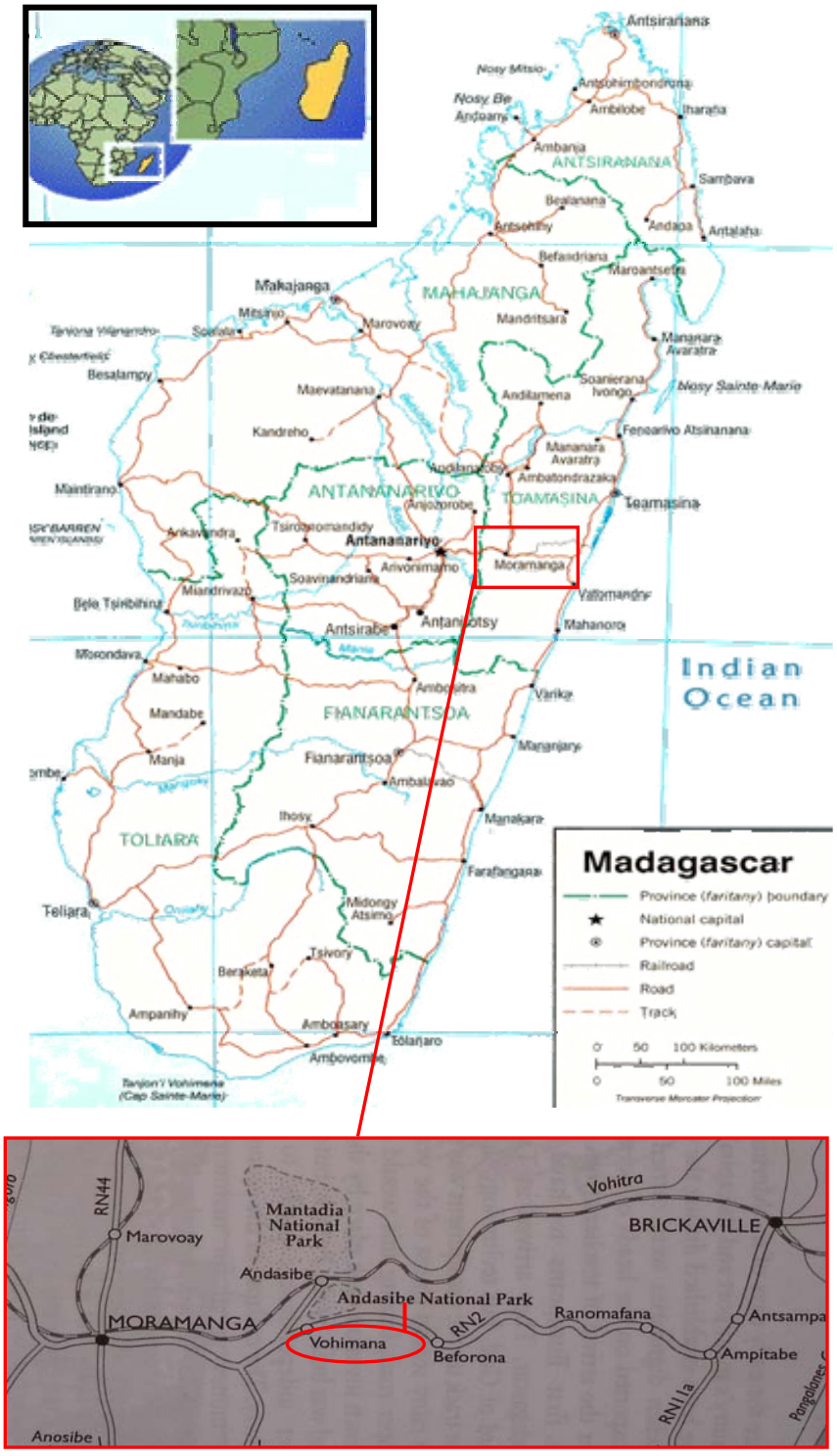


Fig.1: Geographic location of Madagascar and Vohimana.

The remaining natural forest fragments include primary rainforest and secondary rainforest. These fragments are no longer connected to continuous forest but are islands in agricultural land. In the northern part of the area there are also eucalyptus plantations, created mainly for construction and fire wood and for the production of charcoal. The area is only accessibly on foot as there are no roads. There is one main road, the Route National 2 from Antananarivo to Tamatave, which crosses through the village of Ambavaniasy. This is the biggest village in Vohimana and is located in the south. From here it is about a one and a half hour walk to the research village. Altitude in Vohimana ranges between 900 and 1,044 m.

1.3 Diurnal Lemurs in Vohimana

Lemurs belong to a group of primates called *prosimians*, a word which means 'before monkeys'. Lemurs reigned the world until about 35 million years ago until the superior monkey evolved. Monkeys quickly out competed Lemurs and they vanished from the world. Because Madagascar has been isolated the Lemurs on the island found a safe heaven here and remained until this day.
Recently two new species of lemur were disovered. "Finding a new species of lemur is rare; this discovery brings the number of known lemur species from 47 to 49" (Web publishing by eurekalert). They only occur in Madagascar accept for two species. Two Lemuridae, *Eulemur fulvus* and *E. mongoz*, occur on the Comoros islands. It is generally accepted that these animals were introduced there (Mittermeier et al. 1994).Fully eight genera and at least 15 species of lemur already have gone extinct on this island since the arrival of our own species less than 2000 years ago, and many others could disappear within the next few decades if rapid action is not taken (Mittermeier et al. 1994). Trapping and hunting in Vohimana was quite common until about 3 years ago when MATE got management over the site and more control and regulation became evident. According to the local guides there still might be some traps at the present time but this is minimal. Trapping and hunting affects lemur populations but there is a bigger threat; slash and burn agriculture. This used to be a sustainable practice but this is no longer the fact. Officially forbidden, there is virtually no control so the practice continues. The practice is still practiced in Vohimana too. Forest product extraction, like timber, also affects the lemurs. The locals believe there are 11 lemur species present in the research area Vohimana. 6 of them are diurnal and 5 are nocturnal. What would soon prove itself in the field, there was not enough time to research all of them. Therefore we decided to focus primarily on the diurnal species and we managed to see 5 out of 6 of the species that inhabit the area. *Varecia variegata variegata* was only heard. In July an observatory was build in the treetops for lemur research. Several times a group of *Indri indri* was observed from the top.

	Indri indri	***Propithecus diadema diadema***	***Eulemur fulvus fulvus***	***Hapalemur griseus griseus***	***Eulemur rubriventer***	***Varecia variegata variegata***
IUCN	Endangered	Critically endangered	Lower risk/ Near threatened	Lower risk/ Near threatened	Vulnerable	Endangered
CITES	Annex 1	Annex 1	Annex 1	Annex 1	Annex 1	Annex 1

Table 1: Conservation status of the 6 diurnal lemurs to be found in Vohimana

Source: IUCN Red Data Book, 1999 and Mittermeier, 2003

In Appendix I (page 44) extensive and detailed information on each of these 6 species can be found.

2. Methods

2.1 Preparations

2.1.1 General preparations

First of all a good impression of all present trails in the research area had to be gathered. We did this by looking at GIS maps provided by MATE showing forest cover of the area. We also explored the forest on foot. We got acquainted with the local guides and they showed us around the research area. They shared their knowledge with us on where the most lemurs could be found. With help of the local guides trails that lead through possible Lemur habitat were selected and chosen to be used for the research. This meant pre-existing trails leading through as much as natural forested area as possible. The trails were also chosen in such a way that they would cover the research area as completly as possible. We chose not to cut any new trails because this could stimulate forest product extraction in previously untouched areas. All the trails were pre-existing and all but one was used by humans, the other was a bush pig trail. In total 5 trails of varying lengths leading through various vegetation types were prepared. We were able to borrow a Global Positioning System (GPS) from the Cirad, which is a French organisation that does agricultural research for developing countries (her (ex-) colonies). A measuring tape, some plastic foil, markers and machete's were bought. The plastic foil was cut into small strips which would be used as flags. Documentation about Lemurs and Lemur research were sought and studied, especially concerning the 6 diurnal species that are to be found in Vohimana. We also spoke to several people at MATE, WWF Madagascar and Conservation International about how to approach the research and what would be the best research methods.

2.1.2 Preparations in the field

First of all, the trails that were selected for the research were cleared from any obstructing vegetation so passage would be easier. This was not only done beforehand, but also occasionally as we went along. It was both done by us and by local guides. The clearing of the pig trail, later trail I, took quite some work. It took one of the guides about 5 days to clear the whole 4300 metres of trail.
After the trails had been cleared they were all numbered with flags every 50 metres and mapped using a GPS. Numbered flags were attached to vegetation every 50 metres along the trails using a measuring tape. Two people worked together, one on each end of the 50 metre measuring tape. The one in front attached the flag and numbered them consecutively with a marker. The one in the back pinpointed the position of each of the flags with the GPS and named them according to the number. This way all of the 5 trails were flagged with 50 metre intervals. The trails were also numbered individually. The trails have varying lengths; Trail I (86 flags, 4300 metres), Trail II (100 flags, 5000 metres), Trail III (53 flags, 2650 metres), Trail IV (25 flags, 1250 metres), Trail V (78flags, 3900 metres). The trails do not only run through untouched natural forest but also through disturbed habitats. Trail three, four and part of trail five run through degraded forests and Eucalyptus forest. Refer to Table 2 on page 25 for detailed information of every trail. On the next page you can find a map which shows geographical situation of Vohimana with the transect tails. In total 5 trails of varying lengths leading through various vegetation types were surveyed. Because the first two months there were no observations on trail IV we decided not to continue to census this particular trail. On trail III there were very little observations so after the first few months we tried to focus more on the other tails and this trail was not surveyed as often anymore.

Transect trail number	Length (m)	Vegetation cover
I	4300	Primary rainforest
II	5000	Primary rainforest
III, flag 0-14	700	Secondary rainforest
III, flag 14-16	100	Eucalyptus plantation
III, flag 16-22	300	Secondary rainforest
III, flag 22-23	50	Eucalyptus plantation
III, flag 23-25	100	Forest clearing
III, flag 25-42	850	Secondary rainforest
III, flag 42-44	100	Forest clearing
III, flag 44-53	450	Secondary rainforest
V, flag 0-14	700	Natural rainforest
V, flag 14-26	600	Degraded secondary rainforest
V, flag 26-35	450	Forest clearing
V, flag 35-71	1800	Natural rainforest (Although there is a small narrow clearing between flag 65-68, there are three old lemur trap sites at this spot)

Table 2: Overview of the different habitats that are traversed by the transect trails

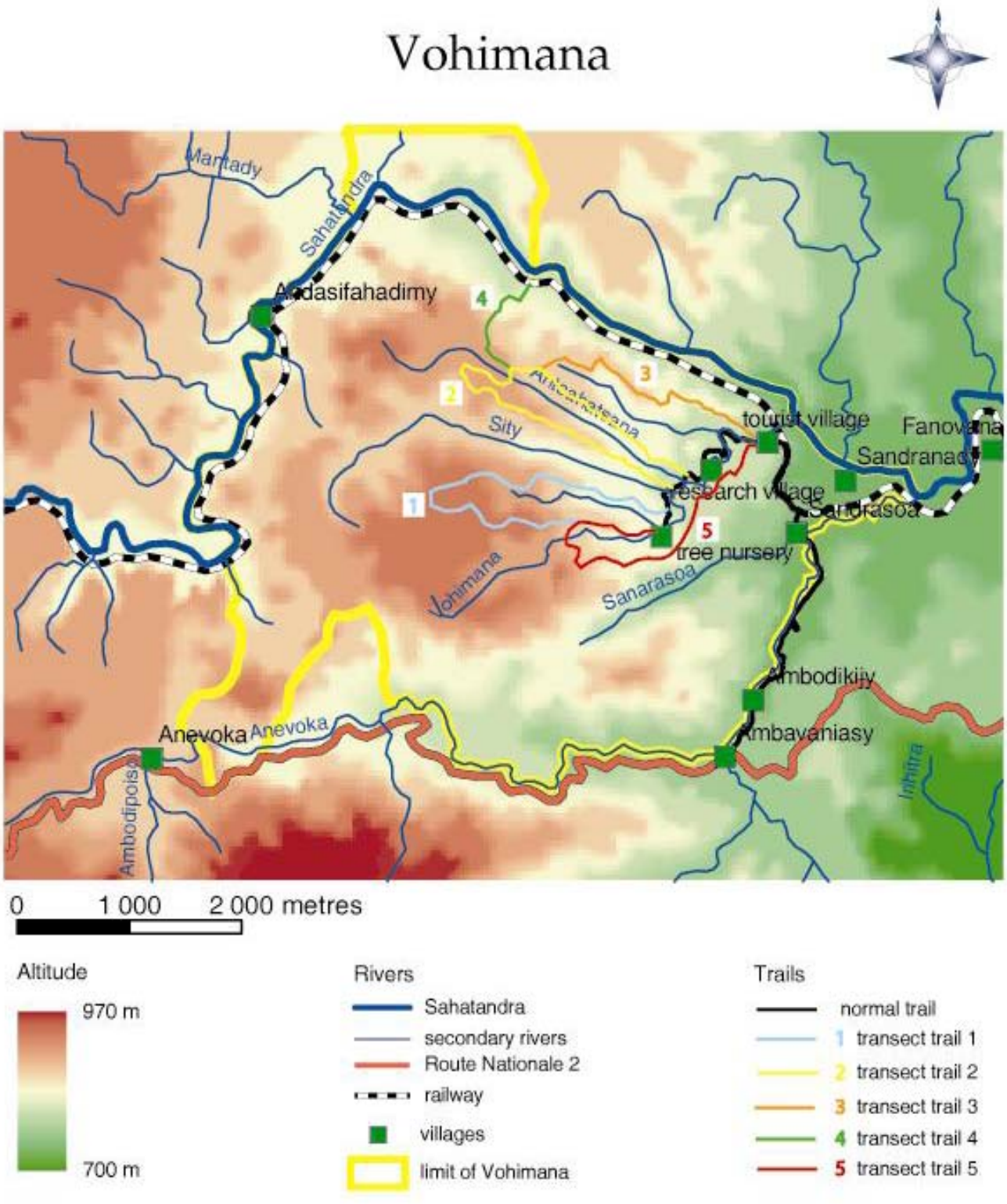


Fig 2: Geographical map of Vohimana showing topography, altitude and transect trails.

2.2 Census technique

The primate census techniques that we used differ in several ways from classic methods (Southwick and Cadigan 1972, Struhsaker 1975, Defler and Pintor 1985 in Merenlender et al. 1998).
As research method to survey the trails the line transect method was used. In this case the trails were used as the 'line' and thus they are not straight lines. A lot of the time the trails would run along crests of the hills. This is advantageous because cries and sounds of encountered animals can be heard better and the view across the forest downhill is also better. The trails were walked by groups of two people looking for animals. Depending on the number of participating people we could form one or two groups of two people. In March I was working with Denis Marechal, and from April to May Marie-Emilie Navel joined me and Denis. In June and July I worked alone. Normally a guide would help and in a few cases other students have joined us too. Trails are walked back and forth each day to make sure the time of observation is spread as evenly as possible. By doing this we make sure that certain areas are not monitored only at the same time of the day. In general what we would do is the following: We would start at the beginning of one transect trail around 7.30 am and walk the whole trail to the end. Depending on the length of the trail this would take anywhere between 4 and 5 hours. At the end of the trail we would have a break of half an hour to an hour to eat lunch. Afterwards we return back on the same trail to the beginning. Usually each one would pick a side of the trail and he or she would observe this side of the trail for the day. Average walking speed is 1 kilometre an hour. After every Lemur sighting the closest flag was noted. If the group or individual lemur could be followed over a distance the consecutive number of flags would be noted. Furthermore, as much as data as possible would be gathered at every sighting; name of the species, number of individuals, composition of the group (number of males, females and infants), whether they were heard or seen, perpendicular distance from the trail, height in the tree, on which side of the trail they were observed, in which environment the lemur(s) were observed, in which direction the trail is walked by the observers, possible observed activities such as vocal communication, displacement, the date and time of day, the weather, which observers observed the individual(s), Departure time and departure point, number of the trail, distance from the beginning of the trail (flag 0), in which direction the lemur(s) departed (See appendix I for the notation sheet used in the field). All this information was used to interpret the position, size, composition and home range of the different lemur groups. This information is also crucial for future viability studies. Only sighted animals were noted and animals that were heard moving very close to the trails. Vocal cries heard over long distances were disregarded. I made one exception for the species of *Varecia variegata variegata*. I decideded to do this because this species is extremely rare in Vohimana. I was able to hear its cries several times but I was never fortunate enough to see it in Vohimana.
When an individual or group of lemurs was spotted we would occasionally venture off the trail to get a better look. This way we were able to collect data like group size, composition, etc. more accurately. No more than 10 minutes were spent observing the animals if they would not displace themselves to minimise disturbance.

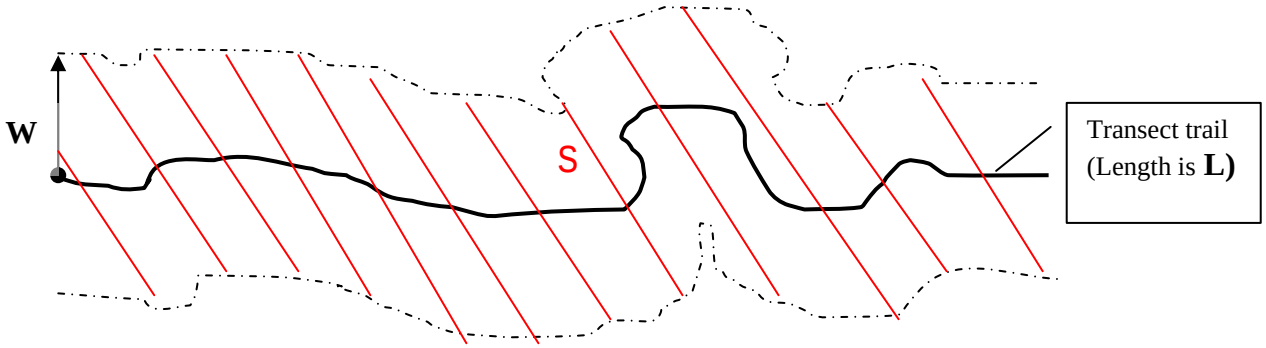
2.3 Calculation of densities

2.3.1 Density per square kilometre

2.3.1.1 Density per square kilometre per species

This density calculation method is the best for comparing different sites, but extensive research is needed to accurately determine it. Here it is calculated with estimates of lemur numbers so it is not accurate.
The method used to calculate the number of individuals per square kilometre is as follows:

First of all the surveyed surface (S) is calculated.
By multiplying twice the distance limit from the trail where 80% of all lemurs were observed (W) with the Total length of the transect trails (L) the total surveyed area (S) is calculated.
So 'W' is the distance from the trail where more than 80% of all the lemurs were spotted. W is the mean distance and therefore it is the same for every trail (12m.). Sometimes W is also called critical width.



S= 2. W. L

- S= Surveyed surface (Km²)
- W= Distance limit of observations (Km)
- L= Total length of transect trails (Km)

Secondly the density per square kilometre can be calculated.
Dividing the Number of estimated individuals* (N) by the surveyed area (S) gives us the density per square kilometre (D). 'N' is the number of estimated individuals which have an overlapping home range on the surveyed area (S).

D= N/S

- N= Number of estimated individuals per species in the surveyed area
- S= Surveyed surface (km²)
- D= Density (Number of individuals/km²)

**The number of estimated individuals (N) is reached by interpreting the observation maps as described in chapter 4.3*

2.3.1.2 Density per square kilometre per transect trail

The same method is used as described above. First the surveyed surface is calculated. Only here, instead of using the (L) total length of all the transect trails, (K) length of the separate trail, is used in the same formula.

S= 2. W. K

- S= Surveyed surface (Km^2)
- W= Distance limit of observations (Km)
- K= Length of transect trail (Km)

Now knowing the surveyed surface of the concerning trail (S), this number is divided by the estimated number of individuals that inhabit this surveyed surface (N). Density per trail (D) is calculated.

D= N/S

- N= Number of estimated individuals per species in the surveyed area
- S= Surveyed surface (km^2)
- D= Density per trail (Number of individuals/km^2)

2.3.2 Relative density per hour of observation

2.3.2.1 Number recorded individuals per hour of survey

The density of individuals per hour of survey (D) is calculated by dividing the number of encountered individuals within the surveyed area (N) by the total survey hours per trail (H). This density is calculated per individual trail to be able to compare trails and it is calculated for all the trails together as an average for the whole of Vohimana so it can be compared to other sites.

D= N/H

- N= Number of encountered individuals in the surveyed area
- H= Total survey hours per trail (h)
- D= Density (Number of individuals/hour of survey)

2.3.2.2 Number observed groups per hour of survey

The density of sightings or groups per hour of survey (D) is calculated by dividing the number of encountered groups within the surveyed area (G) by the total survey hours per trail (H). This density is calculated per individual trail to be able to compare trails and it is calculated for all the trails together as an average for the whole of Vohimana.

D= G/H

- G= Number of encountered groups in the surveyed area
- H= Total survey hours per trail (h)
- D= Density (Number of individuals/hour of survey)

2.3.3 Relative density per kilometre of surveyed transect trail

2.3.3.1 Number of individuals per kilometre of transect trail

This is a common relative density used in short assessments to compare populations over time or in different areas. The density of individuals per kilometre of transect (D) is calculated by dividing the number of encountered individuals in the surveyed area (N) by the length of the transect trail (K).

D= N/K

- N= Number of encountered individuals in the surveyed area
- K= Length of the trail (Km)
- D= Density (number of individuals/kilometre of trail)

2.3.3.2 Number of groups per kilometre of transect trail

The same formula is used as above. The only difference is that the number of encountered groups is taken into account instead of the number of individuals. The density of lemur groups per kilometre of transect (D) is calculated by dividing the number of encountered groups in the surveyed area (G) by the length of the transect trail (K).

D= G/K

- G= Number of encountered groups in the surveyed area
- K= Length of the trail (Km)
- D= Density (number of individuals/kilometre of trail)

3. Difficulties/Problems

In the beginning it was not easy to determine what lemur species was observed. Lemurs were not yet habituated and still very shy, they would flee quickly. Occasionally we were in the forest without a local guide, if this was the fact it was basically impossible for us to determine the species if just a glimpse was observed. Back then we had no knowledge of lemur species yet. In the end we could usually hear almost immediately what species it was before we even saw it.

The weather could also be a problem. Especially in June it was raining a lot, this caused severe decline in number of observations. Lemurs tend to shelter during the rain; they sit still under leaves in the trees. They are therefore a lot harder to find and observe. However, once they are found they can be observed from close range.

Determining actual number of individuals when a group is observed can also be problematic. Sometimes an observed group is scattered over a wide area and not all group members can be heard or observed. This can be misleading. Many individuals have no distinct physical characteristics, therefore it is usually very hard to know whether if the group was observed before. Determining the actual number of groups was therefore very hard.

Interpreting the observation maps shown in chapter 4.3 was also quite difficult. Some groups were recognised at different positions and their home range could more or less be estimated quite accurately. But for most groups this was very hard. Distinguishing separate groups was basically impossible since almost all individuals of the same species have the same features.

Especially at the start of the research we would occasionally hear an individual flee immediately without making any distinct noise. It is too quick for an observation and there cannot be determined which species is concerned.

Eulemur rubriventer and *Varecia veriagata variegata* are very rare in Vohimana. In the 5 months of the research only three individuals of *Eulemur rubriventer* were observed. *Varecia variegata variegata* was only heard, never seen. This makes it virtually impossible to make any estimation about their densities.

The blue coua (*Coua caerulea*) is a blue forest bird that lives in the canopy of the forest. It flies short distances from one branch to another. It makes many different sounds some of which resemble *Hapalemur griseus griseus* and *Eulemur fulvus fulvus*. Although usually in this situation the bird was observed, this can be misleading and annoying. Sometimes it was as if the bird was following you around the forest imitating lemurs.

The language barrier was also quite difficult in the beginning. Especially with the local guides it was hard to communicate since they only speak French. Virtually nobody speaks English in Madagascar. In the beginning communication with the guides was only possible through other students who did speak French. After 5 months however, my French was enough to communicate adequately.

4. Results

4.1 Cumulative number of observations

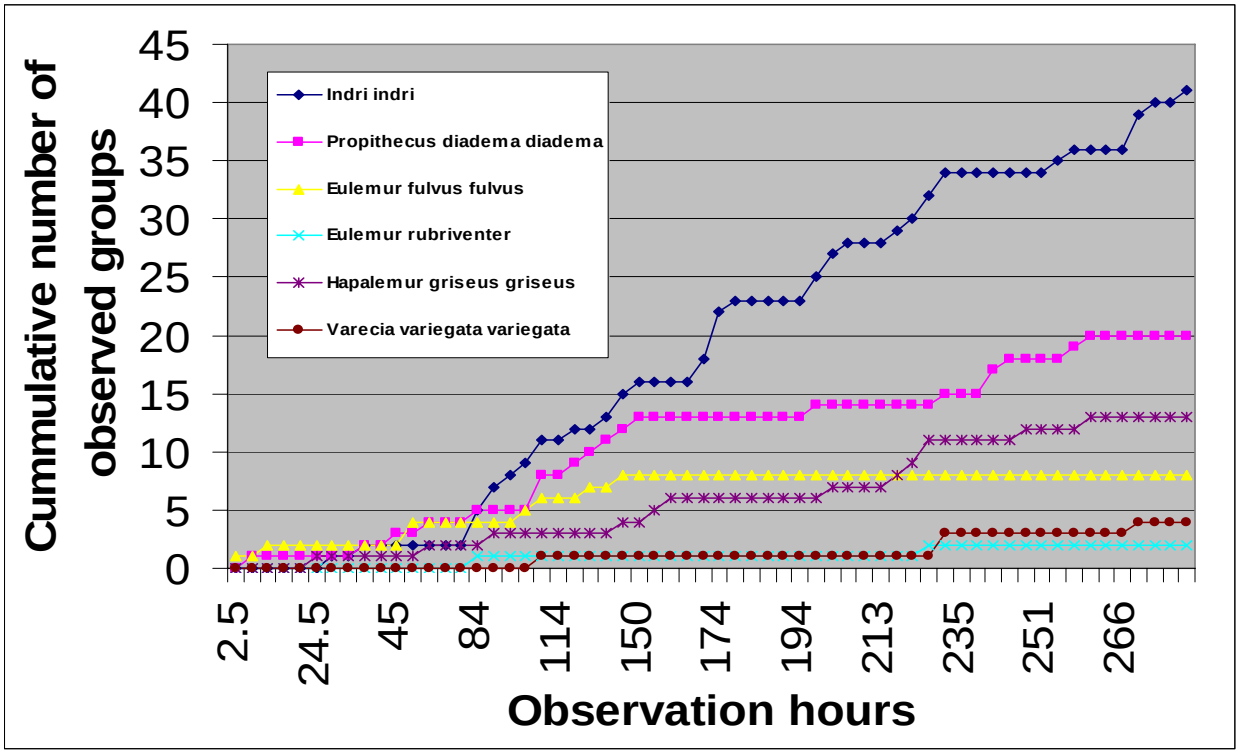
During the five months of survey 6 diurnal lemur species were recorded. In Table 3 below the total number of recorded groups is shown. The number in brackets is the number of individuals within these groups. *Indri indri* is by far the most observed species with 84 individuals in 41 groups. More than twice the number of groups than the number two of most observed species, *Propithecus diadema diadema* with 53 individuals in 20 groups. *Hapalemur griseus griseus* is the only species recorded on all transect trails, and *Varecia variegata variegata* was only recorded on trail II. Trail two is the only trail where all species were recorded and also has the most recorded groups, namely 40 lemur groups. On trail III only *Eulemur fulvus fulvus* and *Hapalemur griseus griseus* were recorded. Trail II and V have more than twice as much survey hours than the other two trails. Trail three was the least surveyed.

survey hours	**Trail I**	**Trail II**	**Trail III**	**Trail V**	**Total**
	43.75	107.75	34	92.75	**278.25**
Indri indri	10 (22)	19 (33)	0	12(29)	**41 (84)**
Propithecus diadema diadema	3 (6)	12 (33)	0	5 (14)	**20 (53)**
Eulemur fulvus fulvus	0	2 (5)	3 (9)	3 (13)	**8 (27)**
Hapalemur griseus griseus	4 (4)	2 (3)	2 (4)	5 (12)	**13 (23)**
Eulemur rubriventer	1 (2)	1 (1)	0	0	**2 (3)**
Varecia variegata variegata	0	4 (7)	0	0	**4 (7)**
Total	**18 (34)**	**40 (82)**	**5 (13)**	**25 (68)**	**88 (197)**

Table 3: Total number of recorded groups per species

note: The number in brackets behind the number of groups is the total number of individuals in these groups

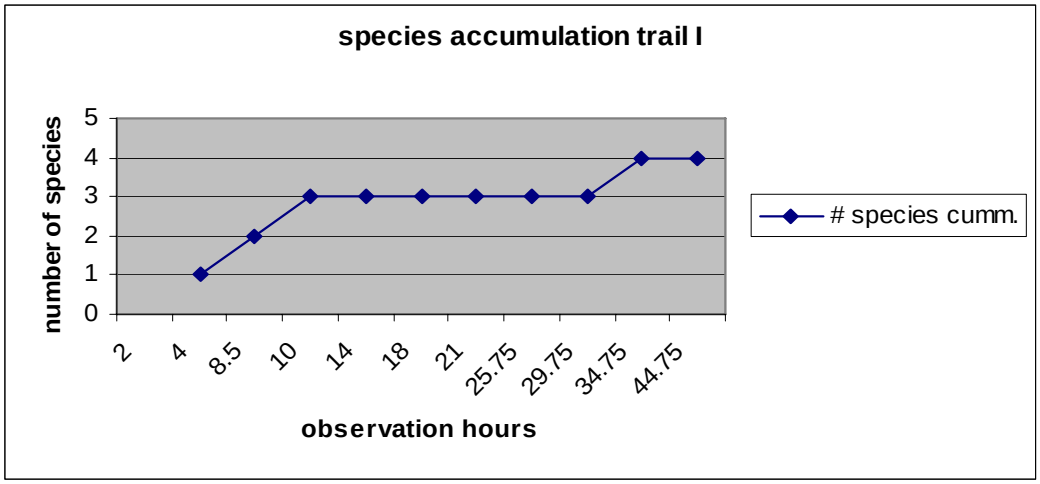
Graph 1 shows the number of recorded lemur groups over time. The steeper the slope of the line, the more the species was observed. This graph illustrates once more that *Indri indri* is by far the most observed and abundant species.



Graph 1: Cumulative number of observed groups over time for all the transect trails combined

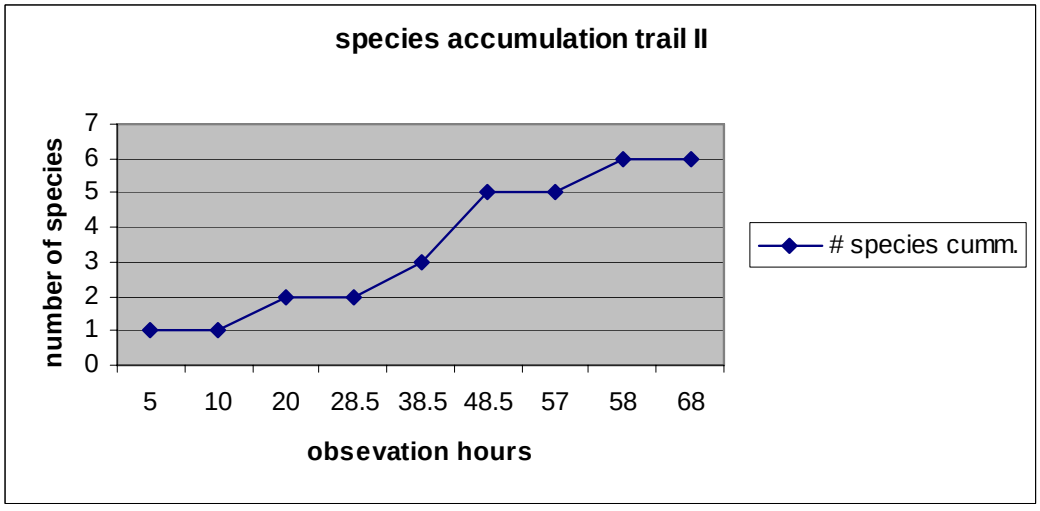
4.2 Species accumulation graphs per trail

In total there are 6 diurnal lemur species to be found in Vohimana. The number of species that were encountered on each trail differs. The following species accumulation graphs show the number of observation hours that were needed to encounter the total number of species present per trail.



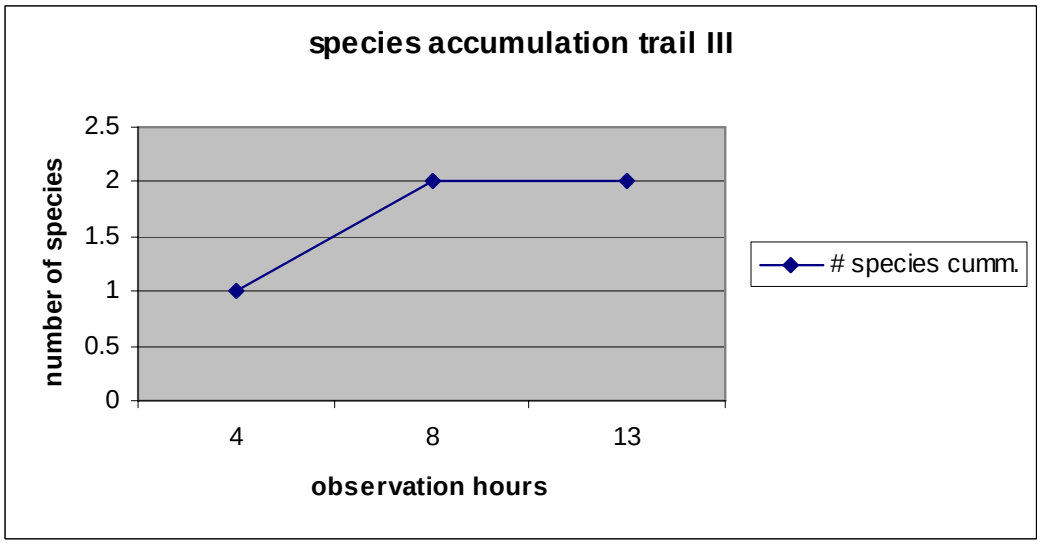
Graph 2: Species accumulation graph of transect trail 1

As can be seen in graph 2 there were a total of 34 hours and 45 minutes needed to encounter the total 4 lemur species present at trail 1. This corresponds with 9 survey days in the field.



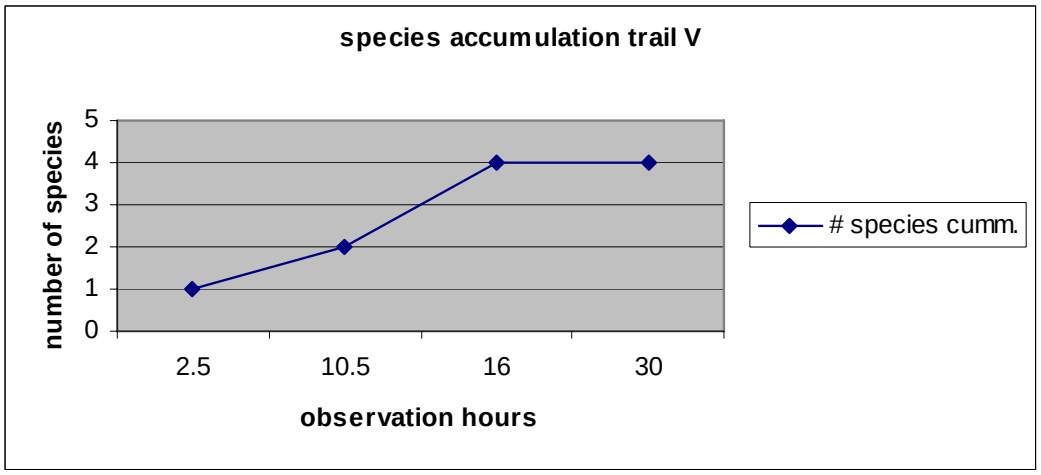
Graph 3: Species accumulation graph of transect trail 2

As can be seen in graph 3 there were a total of 58 hours needed to encounter the total 6 lemur species present at trail 2. This corresponds with 8 survey days in the field.
Note that one of the species, *Varecia variegata variegata*, was not observed but only heard. It was recorded as the last one, the sixth species.



Graph 4: Species accumulation graph of transect trail 3

As can be seen in graph 4 there were a total of only 8 hours needed to encounter the total 2 lemur species present at trail 3. This corresponds with 2 survey days in the field.



Graph 5: Species accumulation graph of transect trail 5

As can be seen in graph 5 there were a total of 16 hours needed to encounter the total 4 lemur species present at trail 5. This corresponds with 3 survey days in the field.

Species richness is highest on the trail with primary forest cover (all six species on trail II) and the eucalyptus plantations and degraded areas are only home to *Eulemur fulvus fulvus* and *Hapalemur griseus griseus* (trail III).

4.3 Encounters and estimation of group numbers per species

When a group of lemurs was encountered as much as data as possible was noted, including the number of the closest flag. The exact positions of the flags were pinpointed earlier with a Global Positioning System, so with the data collected in the field the maps on the following pages were made. The GIS software Mapinfo was used for the construction. These maps show the vegetation cover, position and number of recordings per diurnal lemur species. It also shows the number of individuals per observed group and encircled in green is the size of their home range. The sizes of their home range are estimations taken from Goodman, S.M. and J.P.Benstead (2003), Mittermeier, et al. (1994) and Garbutt, N. (1999).

Indri indri:	18 ha	(Mittermeier, et al., 1994)
Propithecus diadema diadema:	20 ha	(Mittermeier, et al., 1994)
Eulemur fulvus fulvus:	20 ha	(Mittermeier, et al., 1994)
Hapalemur griseus griseus:	15 ha	(Mittermeier, et al., 1994)
Eulemur rubriventer:	15 ha	(Goodman, S.M. and J.P.Benstead, 2003)
Varecia variegata variegate:	10 ha	(Garbutt, N., 1999)

The maps show the number of lemur observations but obviously many of these observations were the same groups. Some individuals in groups had distinct features and could be recognised, but most of the other groups could not be distinguished. This makes it difficult to estimate the number of groups actually living around the transect trails. With the maps shown on the next pages, the experience gained in the field and help of the local guides an estimation of the actual number of groups was made:

Indri indri:	5 groups of 3 individuals, 1 group of 4 individuals.
Propithecus diadema diadema:	2 groups of 4 individuals, 1 group of 2 individuals.
Eulemur fulvus fulvus:	1 group of 6, 1 group of 5 and 1 group of 3 individuals.
Hapalemur griseus griseus:	1 group of 4 individuals, 2 groups of 3 individuals.
Eulemur rubriventer:	1 group of 2 individuals, 1 group of 1 individual.
Varecia variegata variegata:	1 group of 2 individuals, 1 group of 1 individual.

The following table gives an overview of the estimated number of groups that inhabit the different trails. The number in brackets is the number of individuals in per group.

	Trail I	Trail II	Trail III	Trail V	Total
Indri i.	2 (4,3)	3 (3,3,3)	-	1 (3)	6
Propithecus d. d.	1 (2)	1 (4)	-	1 (4)	3
Eulemur f. f.	-	1 (3)	1 (6)	1 (5)	3
Hapalemur g. g.	-	1 (3)	-	2 (3,4)	3
Eulemur r.	1 (2)	1 (1)	-	-	2
Varecia v. v.	1 (2)	1 (1)	-	-	2
Total	5	8	1	5	19

Table 4: Number of estimated groups per lemur species and per trail.

4.3.1 Indri indri, indri

Indri is definitely the most observed lemur in Vohimana. In total 41 groups were observed consisting out of 84 individuals. Average group size is 2.05 individuals per group. A lot of solitary animals were observed that obviously separated from their group. For Indri we estimated that there are 5 groups of 3 individuals and 1 group of 4 individuals living on or near the trails. The group of three animals in the

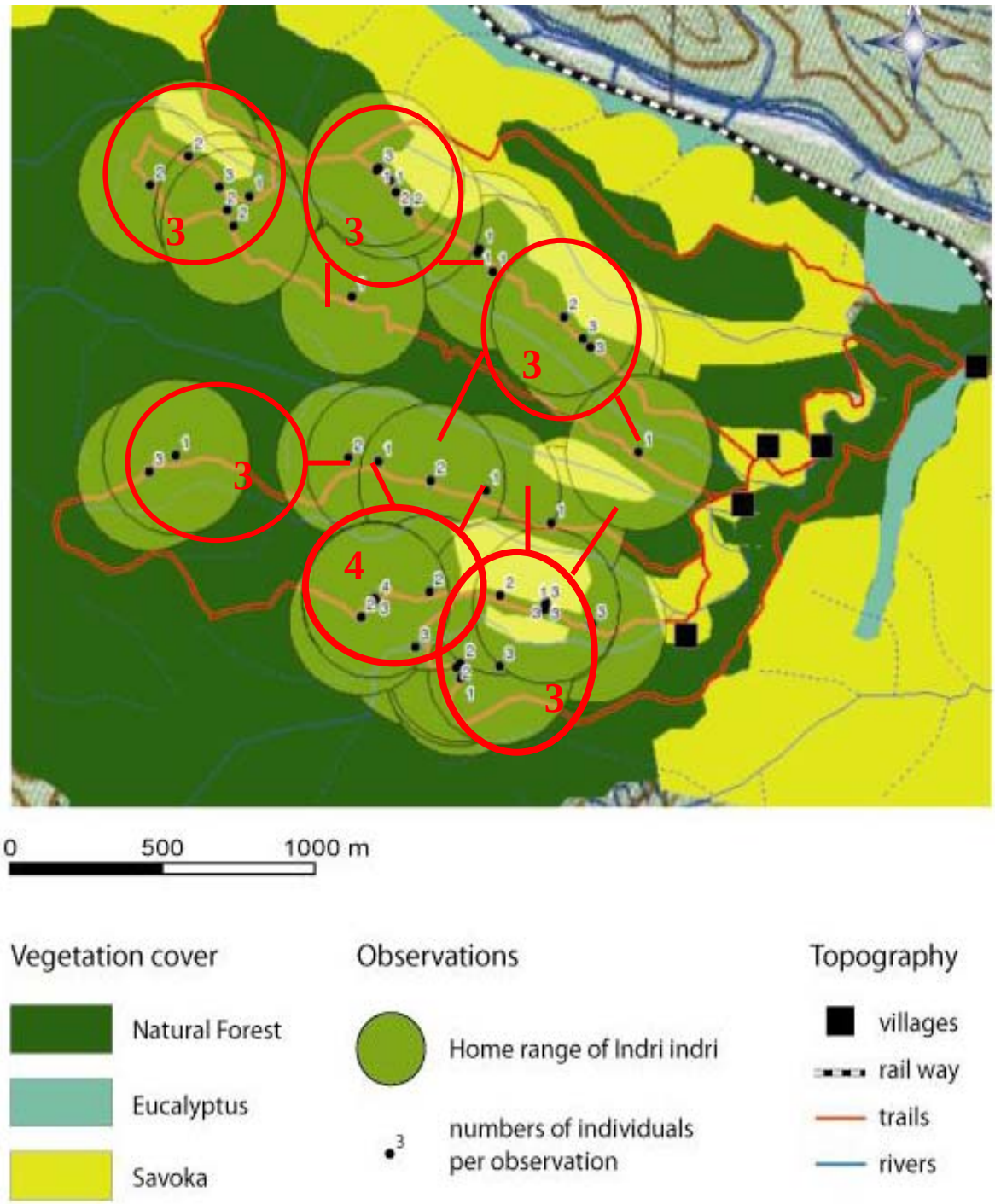


Fig 3: Observations of Indri indri and its home range in Vohimana

*The estimated position of the core range of each of these groups is encircled in red, and the red lines indicate possible movement of the group (members)

south at the bottom of the map can be easily recognised. The group consists out of one large female and two smaller males. The female has a distinct white patch on her left cheek and on the left side of her lower back. She can be easily recognised and she was named Cheeky bastard, referring to the patch on her cheek. This group also seems to be the most habituated and can be observed at close range. The group is often seen at trail V close to the tree nursery. The group of four animals has its core range close to the observatory and has been observed several times from it. This group consists out of several quite small individuals and one large female with a grey back. This group is also quite habituated and can be observed from up close without too much effort.

4.3.2 Propithecus diadema diadema, Diademed Sifaka

Although the Diademed Sifaka is known to be hard to observe it is fairly easily seen in Vohimana. There was even one survey day when 3 groups were encountered on trail II. In total 20 groups were observed consisting out of 53 individuals. Average group size is 2.65 individuals per group. There are most likely 2 groups of 4 individuals and 1 group of 2 or 3 individuals present near the transect trails.

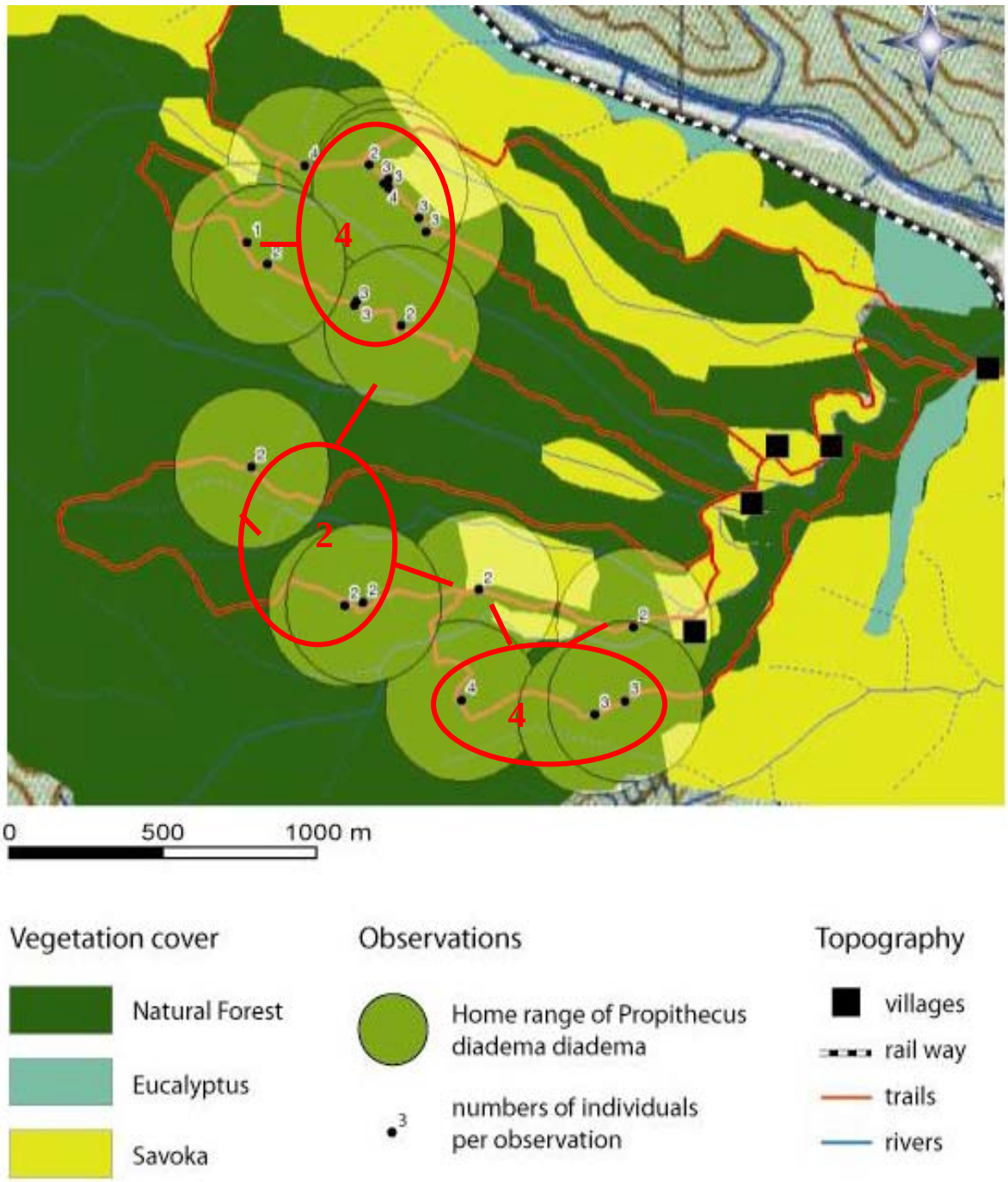


Fig 4: Observations of Propithecus diadema diadema and its home range in Vohimana

*The estimated position of the core range of each of these groups is encircled in red, and the red lines indicate possible movement of the group (members)

4.3.3 Eulemur fulvus fulvus, Common Brown Lemur

The Common Brown Lemur has the biggest group size. In total only 8 groups were observed consisting out of 27 individuals. Average group size is 3.38 individuals per group. Together with Hapalemur griseus griseus they are the only ones to inhabit a thin long stretch of severely degraded forest and eucalyptus plantations in the east of Vohimana. Possibly they use this as a corridor from the northeast to get to the more natural forest in the south. There are most likely 3 groups of respectively 3, 5 and 6 individuals.

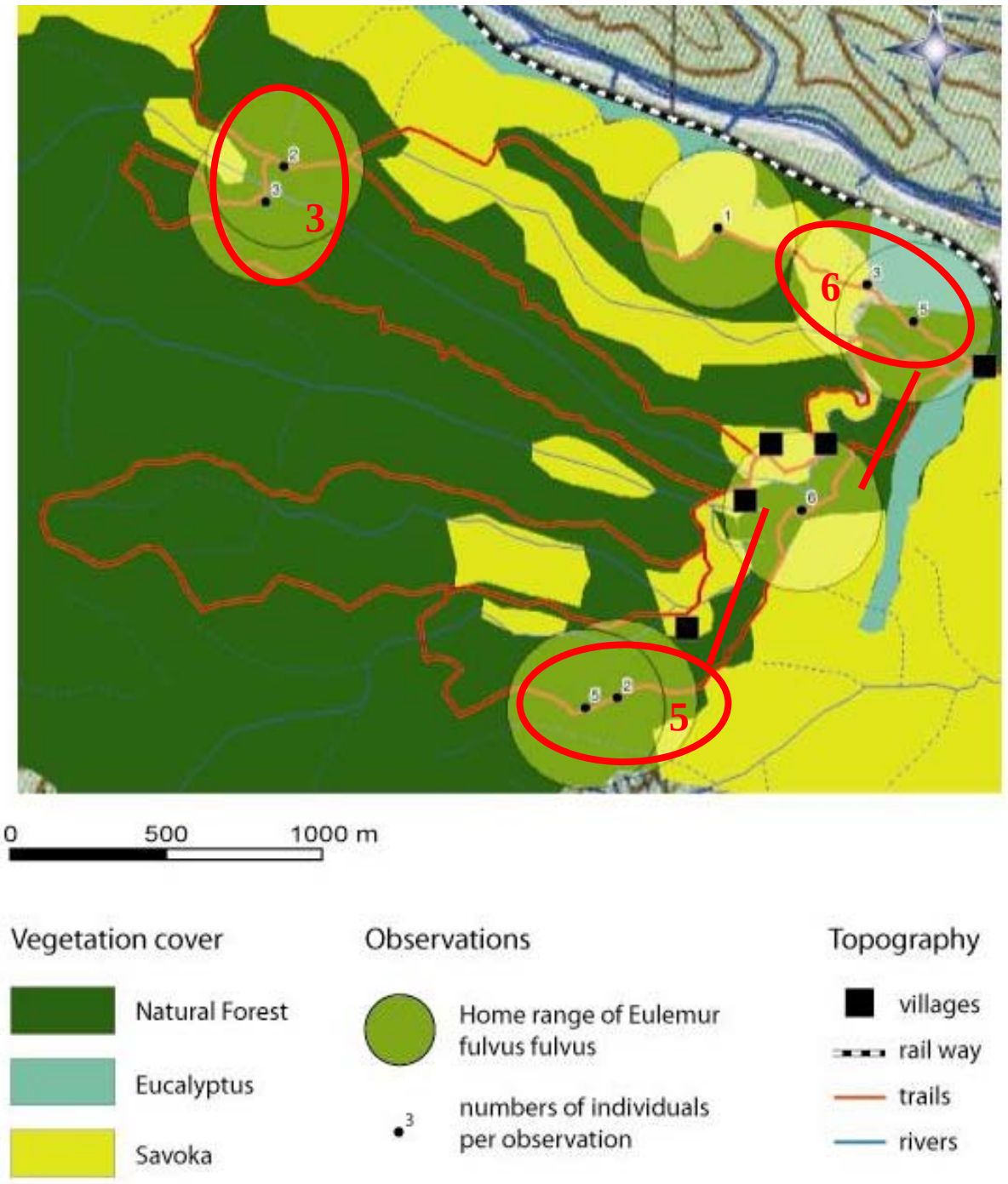


Fig 5: Observations of Eulemur fulvus fulvus and its home range in Vohimana

*The estimated position of the core range of each of these groups is encircled in red, and the red lines indicate possible movement of the group (members)

4.3.4 Hapalemur griseus griseus, Eastern Lesser Bamboo Lemur

More than half of the observations of the Eastern Lesser Bamboo Lemur were solitary animals. In total 13 groups were observed consisting out of 23 individuals. Average group size is 1.77 individuals per group. This makes it hard to determine which solitary animals belong to what group. There are probably 2 groups of 3 individuals and 1 group of 4. The solitary observation in the southwest might be an individual from another group but this is uncertain.

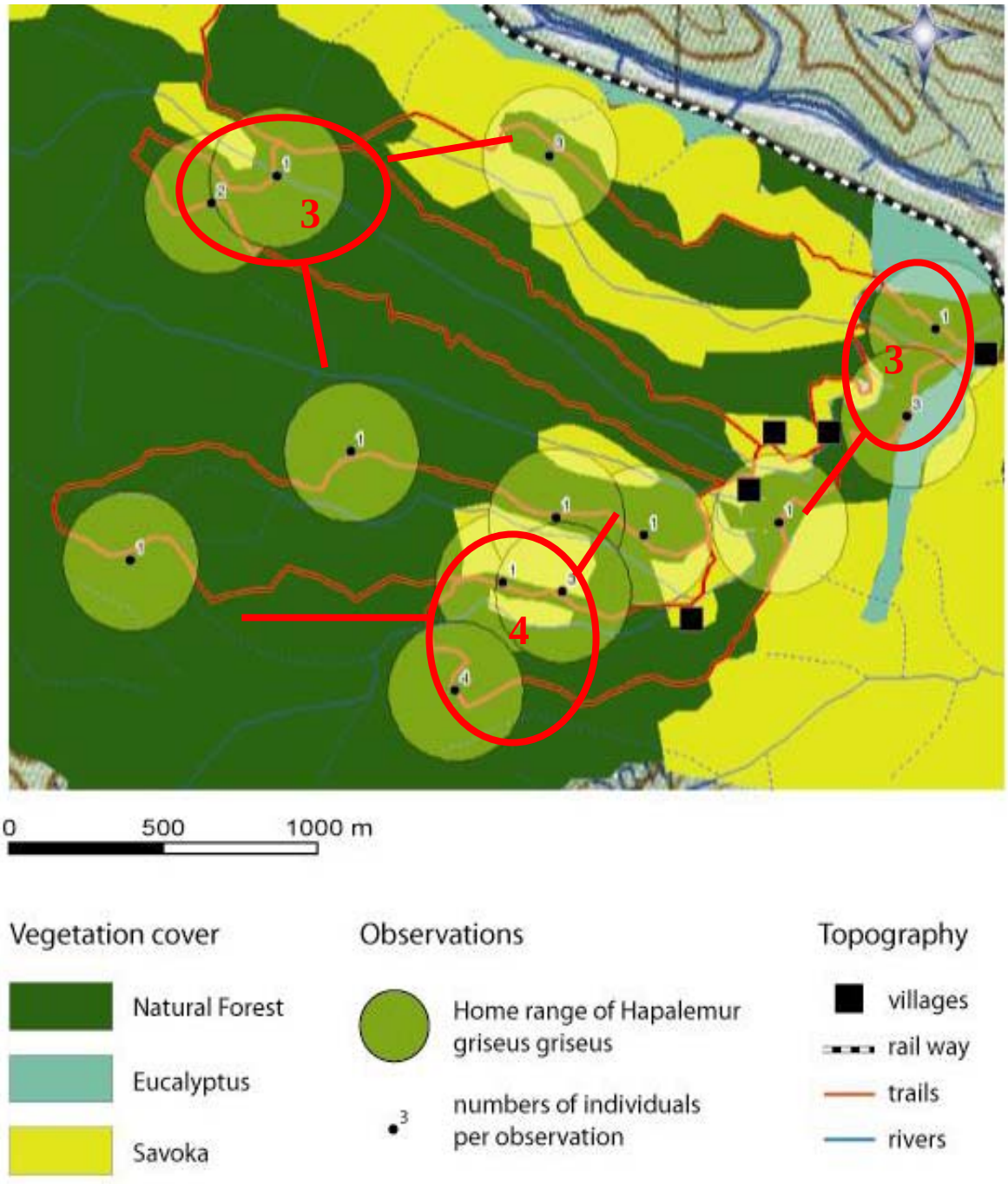


Fig 6: Observations of Hapalemur griseus griseus and its home range in Vohimana

*The estimated position of the core range of each of these groups is encircled in red, and the red lines indicate possible movement of the group (members)

4.3.5 Eulemur rubriventer, Red-bellied Lemur

In total 2 groups were observed of respectively 1 and 2 individuals. Average group size is 1.5 individuals per group. The two observations were at such a distance (approximately 1500m) from each other that there was assumed that this concerns two different groups. The one individual in the north will most likely belong to a group of at least two individuals. The group of two consist out of a couple, one female and one male.

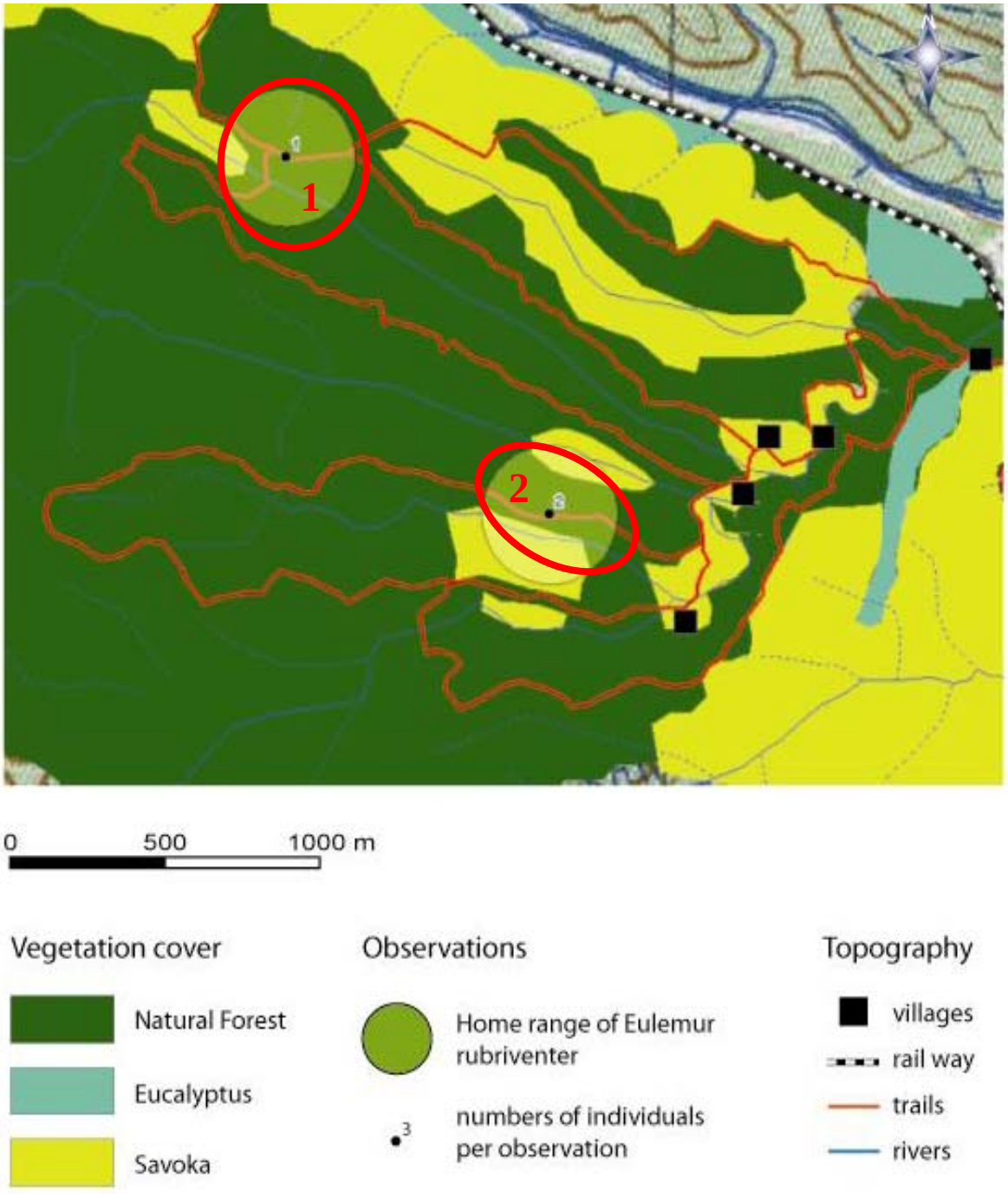


Fig 7: Observations of Eulemur rubriventer and its home range in Vohimana

*The estimated position of the core range of each of these groups is encircled in red, and the red lines indicate possible movement of the group (members)

4.3.6 Varecia variegata variegata, Black-and-white Ruffed Lemur

In total 4 groups were recorded consisting out of 7 individuals. Average group size is 1.75 individuals per group. This species was never actually observed but vocal cries were heard. There are at least 2 groups of respectively 1 and 2 individuals.

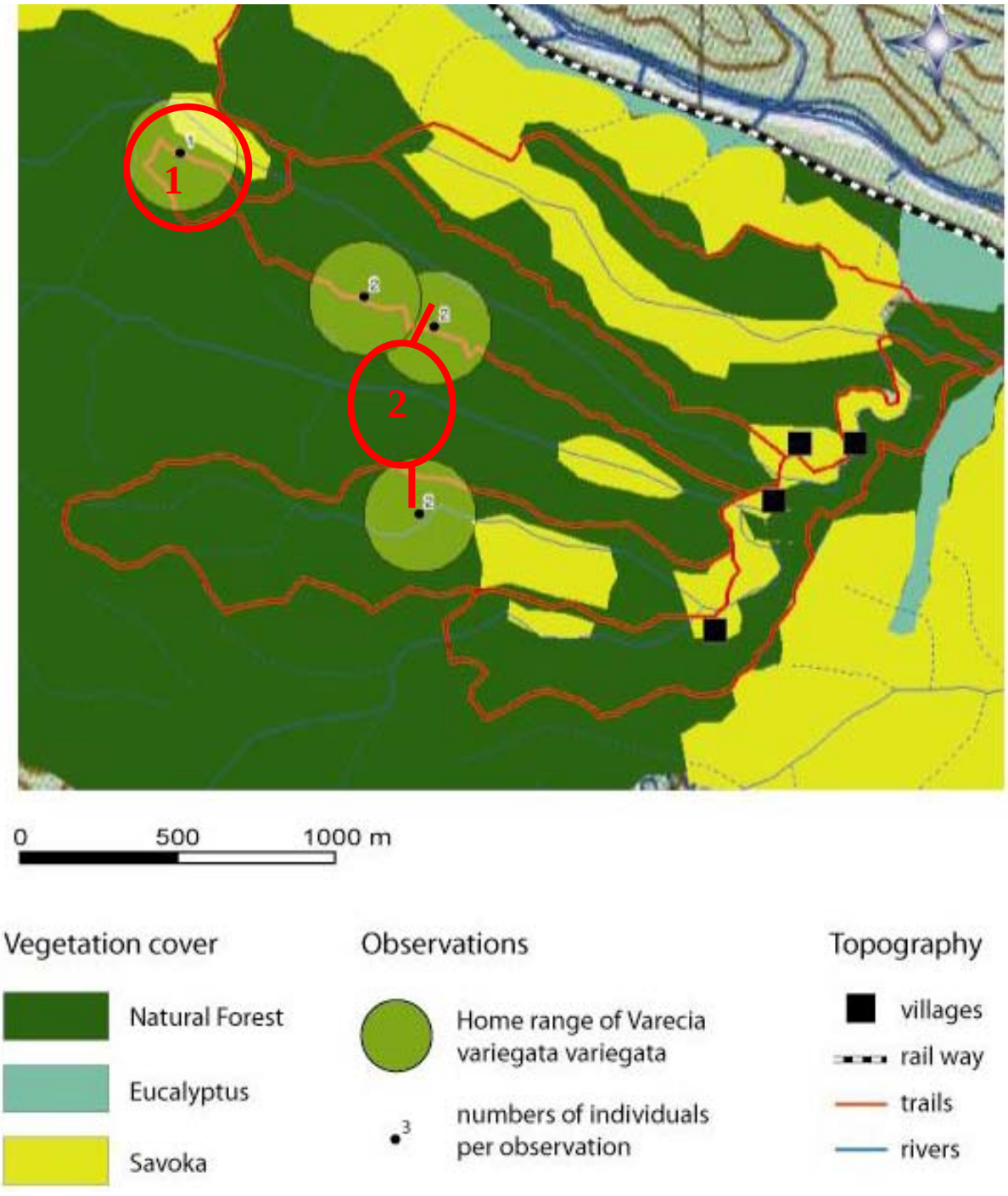


Fig 8: Recordings of Varecia variegata variegata and its home range in Vohimana

*The estimated position of the core range of each of these groups is encircled in red, and the red lines indicate possible movement of the group (members)

4.4 Lemur Densities in Vohimana

4.4.1 Densities per square kilometre

4.4.1.1 Density per square kilometre per species

Now knowing the estimated number of individuals (N)per species, the surveyed area (S) and in turn the density per square kilometre (D) per species is calculated (see chapter 2.3, page 16 for details). Although more research is needed to determine the actual number of groups inhabiting the area adjacent to the trails, I did decide to calculate the density per square kilometre with the estimated number of groups. This was done to give a ruff idea of what population densities to expect in the remaining rainforests of Vohimana, but it is *not* accurate.
Table 5 shows the estimated density per square kilometres per lemur species in Vohimana. As shown in the table *Indri indri* has the highest density in Vohimana and *Eulemur rubriventer* and *Varecia variegata variegata* are relatively rare.

	Number of individuals	(L) Length (km)	(W) Width (km)	(S) Sensused surface (km²)	(D) Density/Km²
Indri i.	19	15.9	0.012	0.3816	**49.79**
Propithecus d.d	10	15.9	0.012	0.3816	**26.20**
Eulemur f.f.	14	15.9	0.012	0.3816	**36.68**
Hapalemur g.g	7	15.9	0.012	0.3816	**18.34**
Eulemur r.	3	15.9	0.012	0.3816	**7.86**
Varecia v.v.	3	15.9	0.012	0.3816	**7.86**
Total Vohimana	**56**	15.9	0.012	0.3816	**146.75**

Table 5: Density estimations of individuals per square kilometre per lemur species in Vohimana

By comparing the outcome in the table below you can see that there is a low density for all the species except *Indri indri*. There could be several reasons for this which are discussed in the next chapter.

	Density in Vohimana	comparison LOM	comparison IUCN	comparison MOM
Indri i.	49.79	9-16	9-16	9-16
Propithecus d.d	26.20	-	-	-
Eulemur f.f.	36.68	40-60	40-60	40-60
Hapalemur g.g	18.34	47-62	47-62	47-62
Eulemur r.	7.86	-	30	30
Varecia v.v.	7.86	20-30	20-30	5.5
Total	**146.75**			

Table 6: Literature comparison of density estimations of individuals per square kilometre per lemur species in Vohimana

Note; the following literature was used in the density comparisons:
LOM = Mittermeier, R.A., Tattersall, I., Konstant, W.R., Meyers, D.M., Mast, R.B. (1994). *Lemurs of Madagascar, Conservation international tropical field guide series*. 1st edn. Conservation International, Washington DC, USA
IUCN = Harcourt, C. *et al*.(1999). *Lemurs of Madagascar and the Comoros*, The UICN Red Data Book, IUCN, Gland, Switserland and Cambridge, U.K.

MOM = Garbutt, N. (1999) *Mammals of Madagascar.* Pica Press, East Sussex, U.K.

Table 7 compares absolute densities in Vohimana with other sites. Especially densities of *Indri indri Propithecus diadema diadema* and *Varecia variegata variegata* seem very high.

Species	W-Maro	E-Maro	Ambato	PN Mantadia	RS Analamazaotra	Vohimana
Indri i.	7.57	3.32	8.3	22.54	14.69	49.79
Propithecus d.d.	3.74	10.75	7.88	17.07	-	26.20
Eulemur f.f.	5.27	8.93	2.53	6.4	29.14	36.68
Hapalemur g.g	8.75	7.91	3.05	10.24	18.15	18.34
Eulemur r.	0.52	6.28	3.48	5.69	7.04	7.86
Varecia v.v.	1.11	1.98	1.45	-	-	7.86

Table 7: Site comparisment of density estimations of individuals per square kilometre per lemur species in Vohimana

Source: Lemur news Vol. 9, 2004 page 21

4.4.1.2 Density per square kilometre per transect trail

By calculating the density per square kilometre per trail you can get an idea which one of the trails would be best for lemur observations. Densities per trail can also be compared with each other in relation to vegetation cover. In the table below the number of individuals is the total number of individual lemurs of all species living near the trail. See chapter Methods for calculation details. In table 8 you can see that trail V has by far the highest density.

Trail number	Length (km)	W (km)	Sensused surface	Number individuals	Density/Km2
Trail I	4.3	0.012	0.1032	13	**125.97**
Trail II	5	0.012	0.12	18	**150.00**
Trail III	2.7	0.012	0.0648	6	**92.59**
Trail V	3.9	0.012	0.0936	21	**224.36**
Total Vohimana	15.9			**TOTAL**	**151.99**

Table 8: Density estimations of individuals of all species per square kilometer per transect trail.

4.4.2 Relative densities per hour of survey

Relative density per hour of survey is the average number of lemur recordings per hour of surveyed transect trail. They were calculated per group and per individual; per separate species and for all species combined (See chapter methods page 30 for details). Table 9 shows the total observation hours and the observation hours per transect trails.

Trail number	Number of kilometres	Number of survey hours	Total (hours/Km)
Trail I	4.3	43.75	**10.17**
Trail II	5	107.75	**21.55**
Trail III	2.7	34	**12.59**
Trail V	3.9	92.75	**23.78**
Total Vohimana	15.9	278.25	**17.5**

Table 9: Total survey hours per kilometre of transect trail

Soon after we began surveying the trails it became evident that trail three is not ideal; not many lemurs were seen here and only two species. Thereafter it was not surveyed as much as the other trails. For trail I It took some time to clear obstructing vegetation and therefore the survey of this trail started much later than the other trails. This explains the low number of observation hours for these two particular trails. Trail V and II have the highest number of observation hours with more than 20 hours per kilometre.
Table 10 shows densities of observed groups and individuals of all lemur species per hour of survey per transect trail. On trail one the most lemurs were seen per hour of survey and on trail three the least. In theory you will see a group of lemurs every two and a half hours on trail I, and every seven and a half hours on trail III. With a total of more than 278 hours of survey 197 individuals in 85 groups were recorded, this gives an average density of 0.7 individuals and 0.3 groups per hour of survey.

Trail number	Survey hours	Total observed *individuals*	total observed *groups*	Number of observed *individuals* of all spp. /hour of survey	Number of observed *groups* of all spp/ hour of survey
Trail I	43.75	34	18	0.777	0.411
Trail II	107.75	82	37	0.761	0.343
Trail III	34	13	5	0.382	0.147
Trail V	92.75	68	25	0.733	0.269
Total Vohimana	278.25	197	85	0.707	0.305

Table 10: Number of recorded individuals and groups (of all species) per hour of survey

4.4.2.1 Number of recorded individuals per species per hour of survey

In table 11 you can see that *Indri indri* are the most observed individuals per hour of survey. It has the highest density on trail I, II and V. *Eulemur fulvus fulvus* has the highest density of individuals on trail III. *Varecia variegata variegata* and *Eulemur rubriventer* are rare.

Trail number	Indri i.	Propithecus d. d.	Hapalemur g. g.	Eulemur f. f.	Eulemur r.	Varecia v. v.*
Trail I	0.502	0.137	0.091	0	0.045	0
Trail II	0.306	0.306	0.027	0.046	0.009	0.064
Trail III	0	0	0.117	0.264	0	0
Trail V	0.312	0.150	0.129	0.140	0	0
Total Vohimana	0.301	0.190	0.082	0.097	0.010	0.025

Table 11: Number of recorded individuals per species and per trail per hour of survey
* *note that Varecia variegata variegata was only heard and never seen.*

4.4.2.2 Number of recorded groups per hour of survey

The number of recorded groups per hour of survey was also calculated and shown in table 12. If table 11 and table 12 are compared you can see that differences between species are bigger. Average group sizes of the different species vary and influence the outcome. *Hapalemur griseus griseus* for instance has a large average group size and therefore has a low density of groups per hour of survey in comparison individuals per hour of survey.
Here again, *Indri indri* shows the highest density on trails I, II and V. On trail III it is *Eulemur fulvus fulvus*.

Trail number	Indri i.	Propithecus d.d.	Hapalemur g.g.	Eulemur f.f.	Eulemur r.	Varecia v.v.
Trail I	0.228	0.068	0.091	0	0.022	0
Trail II	0.176	0.111	0.018	0.018	0.009	0.037
Trail III	0	0	0.058	0.088	0	0
Trail V	0.129	0.053	0.053	0.032	0	0
Total Vohimana	0.147	0.071	0.046	0.028	0.007	0.014

Table 12: Number of recorded groups per species and per trail per hour of survey

4.4.3 Relative densities per kilometre of surveyed transect trail

Table 13 shows the relative density per kilometer of surveyed transect trails of the individuals and groups of all recorded species. A total of 197 individuals in 85 groups were recorded. Average group size is 0.7 individuals per group. Recorded individuals per kilometer of transect trail is highest fort trail V. In total 17.4 individuals per kilometer were recorded here. Recorded number of groups per kilometer of transect trail is highest for trail II, 7.4 groups were recorded per kilometer here. The average densities for all the trails combined are 12.4 individuals and 5.3 groups per kilometer per kilometer.

	length(km)	Total recorded *individuals*	total recorded *groups*	# recorded *individuals* /km	# recorded *groups* /km
Trail I	4.3	34	18	7.907	4.186
Trail II	5	82	37	16.400	7.400
Trail III	2.7	13	5	4.815	1.852
Trail V	3.9	68	25	17.436	6.410
Total Vohimana	15.9	197	85	12.390	5.346

Table 13: Number of recorded individuals and groups (of all species) per kilometer of surveyed transect trail

4.4.3.1 Number of recorded individuals per species per kilometre of surveyed transect trail

The number of recorded individuals and groups per species per kilometre of surveyed transect trail is a common relative density used in short assessments to compare populations over time or in different areas. Table 14 shows the relative density of recorded individuals per species per kilometre of surveyed transect trail in Vohimana in comparison with other sites. The literatures used for the comparison are taken from reports of short lemur assessments in other parts of Madagascar. The locations where these

assessments took place are written in the second column. The density of *Hapalemur griseus griseus* in Vohimana of 1.4 individuals per kilometre seems fairly high compared to the other sites where the highest density is 1 individual per kilometre. The density of *Eulemur fulvus fulvus* in Vohimana lies within the range of densities given by the other studies. The recorded 0.19 individuals per kilometre of Eulemur rubriventer in Vohimana is very low in comparison with the density found in Morojejy National park. There must be said that none of the literature used for the comparison mentions the hours of survey which are critical in this comparison.

VOHIMANA	**total # individuals all spp. recorded/km**	**Indri i.**	**Propithecus d.d.**	**Hapalemur g.g.**	**Eulemur f.f.**	**Eulemur r.**	**Varecia v.v.**
Trail I	7.907	5.116	1.395	0.930	0.000	0.465	0.000
Trail II	16.400	6.600	6.600	0.600	1.000	0.200	1.400
Trail III	4.815	0.000	0.000	1.481	3.333	0.000	0.000
Trail V	17.436	7.436	3.590	3.077	3.333	0.000	0.000
Total vohimana	12.390	5.283	3.333	1.447	1.698	0.189	0.440
Literature comparison	**Sites**						
Goodman, 1998	Andohahela			0.1-0,3			
Goodman, 1996	Andringitra			0.6-1			
Ganzhorn, 2000	Marojejy				1-3	1-4	
Goodman, 1998	Bevahaza				0-5.9		

Table 14: Comparison of number of recorded individuals per species and per trail per kilometer of surveyed transect trail

4.4.3.2 Number of recorded groups per species per kilometre of surveyed transect trail

The same comparison as in table 14 is made with the number of observed groups per species per kilometer of surveyed transect trail. *Indri indri* and *Propithecus diadema diadema* seem to have a higher density in comparison with other sites. All the other species are within the values found in the other sites and seem to have an average density. Here again, there must be said that none of the literature used for the comparison mentions the hours of survey which are critical in this comparison.

VOHIMANA	**# groups all spp. /km**	**Indri i.**	**Propithecus d.d.**	**Hapalemur g.g.**	**Eulemur f.f.**	**Eulemur r.**	**Varecia v.v.**
Trail I	4.186	2.326	0.698	0.930	0.000	0.233	0.000
Trail II	7.4	3.800	2.400	0.400	0.400	0.200	0.800
Trail III	1.851	0.000	0.000	0.741	1.111	0.000	0.000
Trail V	6.410	3.077	1.282	1.282	0.769	0.000	0.000
Total Vohimana	5.345	2.579	1.258	0.818	0.503	0.126	0.252
Literature comparison	**Sites**						
Goodman, 1997	Anjanaharibe sud	0.060	0.400	0.1-0.8	0.1-0.8	0.1-0.3	
Goodman, 1997	Andringtra				0.2-1.1		
Alonso, 2002	Ankrafantsika				0.1-1		
Alonso, 2002	Zahamena-Mantadia corridor	0.1-0.4	0.1-0.2	0,1-0,3	0.1-0.2	0.04-0.1	
Goodman, 2001	Ranomafana			0,04-0,075		0.15-0.3	0.21-0.575

Table 15: Comparison of number of recorded groups per species and per trail per kilometer of surveyed transect trail

Discussion

Less than 40 years ago the total area of Vohimana was covered in forest. Over the years more than half of this forest was cleared. Most of the cleared forest was located on the edge of the forest area (see appendix III, page 59). Thus the clearing of this forest caused the remaining forest to be disconnected from continuous surrounding forest. The forest in Vohimana became a relatively small pocket of forest; an island of forest surrounded by agricultural land. The lemurs living in the forest that was cleared on the edges were forced in this pocket causing a higher density of lemur populations here. It might very well be that the numbers of lemurs currently living inside Vohimanas' forests exceeds the maximum carrying capacity of the forest. In this case the higher densities would be only temporary and will decrease in the future

Until about 3 years ago lemur traps in Vohimana were common. These traps are placed on horizontal branches in small forest clearings. Guavas and bananas are used to lure the lemurs. Because *Indri indri* and *Propithecus diadema diadema* do not 'walk' on horizontal branches but merely jump from one vertical tree trunk to another, these two species are not affected by trapping. Although *Propithecus diadema diadema* is not affected by trapping, it used to be hunted for bush meat. But this is not an easy practice as *Propithecus diadema diadema* is one of the shyest lemurs in Vohimana Populations of *Eulemur rubriventer*, *Eulemur fulvuf fulvus*, *Hapalemur griseus griseus* and *Varecia variegata variegata* are severely affected by these traps. *Eulemur rubriventer* is known to especially like the guavas and therefore this species is likely to be most affected by the traps. *Hapalemur griseus griseus* is not especially keen on guavas and this species is probably least affected by trapping. For most people in Vohimana killing of *Indri indri* is fady, a local believe or superstition meaning that it is taboo to kill this species. These consecutive happenings, effects and the taboo that rests on killing *Indri indri* could be the reason for a higher density of *Indri indri* and *Propithecus diadema diadema* and an average or lower density of the other 4 diurnal lemur species in Vohimana compared to other sites. *Indri indri* seems by far the most abundant species in Vohimana and an estimated 6 groups live near the transect trails. *Eulemur rubriventer* seems the rarest with only two recorded groups in the total of five month research.

Density calculations and comparisons:
Although it will not very accurate and it will take more research to determine this I did decide to make an estimation of the absolute density in number of individuals per species per square kilometre. However, this is just to give a rough idea of what to expect in Vohimana. Because a lot of the individuals of the different groups of the same species look the same it is really hard to distinguish different groups. Therefore there may be an error in the estimated absolute number of groups that live near the transect trails. This in turn will give an error in the calculated absolute density in number of individuals per square kilometre. Because the transect trails are close to each other the chances are that more than one trail crosses through the home range of one and the same lemur group. Especially for *Indri indri* surely, all groups living near the trails have been encountered. The high density of transect trails that were used causes more square kilometres to be surveyed that are very close to each other. This can also give a higher density outcome that is indeed the fact.
Relative density per kilometre of surveyed transect trail is used in many studies to compare populations over time or in different areas. However, none of the reports mentions what the total survey hours of the research is. If a study with extensive survey hours would be compared with a study with very little survey hours it could be very misleading. The relative densities that were taken from other literature to make a comparison in this report were also unclear about what their total survey hours were.
Recommendations:
The lemurs in Vohimana are part of a unique ecosystem which is very rich in species and has very high endemism. Yet so much has already been lost in Madagascar and further efforts are necessary to

ensure the long term protection of not only the lemurs, but the ecosystem as a whole in Vohimana. Vohimana could be a prime example of how to accomplish this in cooperation with the local population. However, forest product extraction, encroachment, trapping and forest grazing still occur and form a threat for the flora and fauna in the remaining pocket of forest. With good communicative and informative projects, guidance, financial help and provision of alternatives the ecosystem can be managed in a sustainable manner.

The staple diet of the population of Vohimana is rice, and this is what people really want to eat. Maybe it would be possible to construct more rice paddies in low lying wet areas such as close to the tree nursery. Several locals indicate that the planting of papaya and other crops is not very much desired but that they prefer more rice. Maybe if the local people could get more of a say in what agricultural development MATE implements, this could stimulate the people's attitude towards the NGO and they could become more helpful and cooperative. The construction of permanent rice paddies would in turn also lead to a reduction in the need for tavy.

A decline in population growth would also lead to a decrease of the pressure on the land and the environment in the long term. People could be informed and stimulated to do family planning and decrease their family size.

According to the local people there is a person who still sets lemur traps in remote areas of Vohimana. With help of the guides and local people this person could possibly be traced. Obviously he knows the lemurs and the forest very well. Maybe it could be an idea to persuade this person to work on conservation in cooperation with MATE. This would probably be easily achieved if the person would see that there are some benefits for him too.

Maybe this could be the same answer for the people who collect honey, orchids and other plants, Liana roots, etc. from the forest. It is unclear whether these practices are sustainable but if these people can be convinced that there are better alternatives their interest in wild products and pressure on the environment might decrease.

Since the collection of lemur data is very fairly simple and straight forward it might be a good idea to print some notation sheets (Appendix I, page 56) and put them in a box near the tourist village. Whenever tourists go out in the forest we could encourage them to fill out these forms whenever they see lemurs. This way MATE could gather a steady supply of lemur data out of their forests, and the tourist can get a feel that they are participating in lemur research and conservation activities. More tourists can be attracted and stimulated to cooperate in such activities. This would also generate alternative income that could be pumped back into the project. Hopefully when the train from Tana to Tamatave is running again it would be possible to attract more tourists to visit Vohimana.

The observatory that was built as sort of an experiment worked fine. I went there three times of which two times I saw *Indri indri* at very close range. One time there were 2 Indris literally in the tree next to the observatory. It is probably worthwhile to allow tourists to get into the observatory, since Indri's and other lemurs are a good tourist attraction. It might be a better idea however, to construct a second observatory which is more accessible to tourists and leaves the more remote area of the current observatory undisturbed by tourists.

If further research of *Indri indri* in Vohimana is desired the two most habituated groups are to be found at the end of trail five and the end of trail one; between the tree nursery and the observatory (the two groups on the bottom of the map on page 36). There is a group of three and a group of four animals living there. The area around the observatory is home to a group of four *Indri indri,* which can be observed at close range from the observatory without too much effort. But the most habituated is the group of three *Indri indri* living more towards the tree nursery.

Further research is needed to be able to determine the absolute density (km²) of lemurs in Vohimana. This research was very limited and just the start. The most easy, effective and time saving way to be able to tell what populations are present is radio tracking. If animals would be fitted with radio transmitters the different lemur groups could be numbered and home ranges can also be accurately

determined. With this information accurate absolute densities can be calculated. This is also valuable information to be able to tell whether populations could be sustainable. At this point this is unclear, and a fresh input of new genes to ensure a healthy gene pool within these populations, an expansion of the current forested area or connection to other forests might be needed. If the forest of Vohimana remains isolated this could cause extinction due to inbreeding for the lemurs. Further research is vital. The forest corridor connecting forests to the north and south of Vohimana, that will be realized in the near future, might be more successful if the remaining forest area in Vohimana itself would be used as a stepping stone. Lemurs travelling from one side to another would have a safe heaven half way and can breed and interact with lemurs living here. This might be beneficial or even essential for the remaining populations within Vohimana's forests.
There is very little known about the density and home range of *Propithecus diadema diadema* and Vohimana could be an ideal site to determine this with radio tracking devices that would be fitted to the animals. Maybe the local still setting traps at this moment would be the ideal person to assist with this? Although lots of time and financial support is needed, I am convinced that with help of locals, employees, students, volunteers and researchers and with persistence and patience MATE can succeed in making Vohimana an example of success in both nature conservation and rural development.

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List of survey participants:

Denis Marechal (Fr.)
Marie-Emilie Navel (Fr.)
Rakotomanansoa (Mg.)
Lekamisy Justin (Mg.)
Roy van Oene (Nl.)
Fanny Kammenthaler (Fr.)
Sil Westra (Nl.)
Lucy Brousse (Fr.)
Melanie Saulnier (Fr.)
Audrey Marin (Fr.)
Sarah Pirotais (Fr.)
Vincent Vandaele (Bg.)
Patrice Navel (Fr.)

References

Literature

- Alonso, L.E., Schulenberg, T.S., Radilofe, S. and Missa, O. (2002). *A Biological Assesment of the Réserve Naturelle Intégrale d'' Ankarafanstika, Madagascar.* RAP Bulletin of Biological Assesment. Conservation International (CI), Washington DC, USA.

- Bradt, H.(2005), *Madagascar, the bradt travel guide*. 8th edn. Bradt Travel Guides Ltd., UK

- Ganzhorn, J.U., Goodman, S.M., Ramanamanjato, J. –B., Ralison, J., Rakotondravony, D. and Rakotosamimanana, B. (2000). *Effects of fragmentation and assessing minimum viable populations of lemurs in Madagascar.* Bonn. Zool. Monogr. 46, pg. 265-271.

- Garbutt, N. (1999) *Mammals of Madagascar.* Pica Press, East Sussex, U.K.

- Goodman, S.M. (1996). *A Floral and Faunal Inventory of the Eastern slopes of the Réserve Naturelle Intégrale d'Andringitra, Madagascar: With Reference to Elevation Variation.* FIELDIANA, Zoology. New series, no. 85, pg.293-306. Field Museum of Natural History, Chicago, USA.

- Goodman, S.M. (1997). *A Floral and Faunal Inventory of the Réserve Spéciale d' Anjanaharibe-Sud, With Reference to Elevational Variation.* FIELDIANA, Zoology. New series, no. 90, pg.227-238. Field Museum of Natural History, Chicago, USA.

- Goodman, S.M. (1998). *A Floral and Faunal Inventory of the Réserve Spéciale d' Andohahela, Madagascar: With Reference to Elevational Variation.* FIELDIANA, Zoology. New series, no. 94, pg.269-283. Field Museum of Natural History, Chicago, USA.

- Goodman, S.M. and J.P.Benstead (2003). *The Natural History of Madagascar.* The University of Chicago Press, Chicago, USA.

- Goodman, S.M. and Rasolonandrasana, B.P.M. *(1997).*, *Inventaire biologique de la réserve sépciale du pic D' Ivobihe et du couloir forestier qui la relie au Parc national d' Andringitra.* Recherches pour le developpement, Série Sciences biologiques n°15.

- Goodman S.M. and 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 developpement, Série Sciences biologiques n°17.

- Harcourt, C. *et al*.(1999). *Lemurs of Madagascar and the Comoros*, The UICN Red Data Book, IUCN, Gland, Switserland and Cambridge, U.K.

- Hartcourt, C., and Thornback, J. (1990) *Lemurs of Madagascar and the Comoros. The IUCN Red Data Book.* IUCN, Gland, Switserland and Cambridge, U.K.

- Irwin, M.T., Johnson, S.E. and 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, Vol.39, No. 2.

- Lehman, S.M. and Wright, P.C. (2000). *Notes on the Biogeography of Eulemur fulvus albocollaris.* Lemur news Vol. 5, pg. 25-27

- Merenlender, A., Kremen, C., Rakotondratsima, M. and Weiss, A. (1998). *Monitoring impacts of Natural Recource Extraction on Lemurs of the Masoala Peninsula, Madagascar.* Conservation ecology, online document. http://www.ecologyandsociety.org/vol2/iss2/art5/inline.html

- Mertz, E. and Toborowsky, C. (2005). *Une etude de la distribution et la densite du Propithecus diadema diadema et le Eulemur fulvus albifrons de la Réserve Naturelle de Betampona, Madagascar.* Rapport d'activite, Institute for the Conservatrion of Tropical Environments (ICTE).

- Mittermeier, R.A., Konstant, W.R., Ganzhorn, J.U., Louis, E., Langrand, O., Shenkin, A. (2003). *Lemurs of Madagascar, Conservation international tropical field guide series*. 2nd edn. Conservation International, Washington DC, USA.

- Mittermeier, R.A., Tattersall, I., Konstant, W.R., Meyers, D.M., Mast, R.B. (1994). *Lemurs of Madagascar, Conservation international tropical field guide series*. 1st edn. Conservation International, Washington DC, USA.

- Patterson, B.D., Goodman, S.M. and Sedlock, J.L. (1995). *Environmental Change in Madagascar.* The Field Museum of Chicago, Chicago, USA.

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

- Rakotosamimanana, B. *et al.* (2003). *Relations entre les pressions humaines et le statut de conservation des lemurien dans les sites d' ambato et de maromizaha (region de moramanga).* Group d'Etude et de Recherche sur les Primates de madagascar (GERP) and Conservation International (CI), Antananarivo, Madagascar.

- Razanahoera-Rakotomalala, M. et al (2002). *Evaluation et Plan de Gestion pour la Conservation (CAMP) de la faune de Madagascar: Lemuriens, Autres Mammifères, Reptilesbet Amphibiens, Poissons d'eau douce et Evaluation de la Viabilité des Populations et des Habitats de Hypogeomys antimena (Vositse).* SSC/IUCN Conservation Breeding Specialist Group, Apple Valley, USA.

- Totsalis, S. (1995). *Conservation and Development*. Institute for the Conservation of Tropical Environments (ICTE). Pg.39-43.

World Wide Web

- http://www.mate.mg
- http:///www.animalinfo.org/species/primate/indrindr.htm
- http://www.animalinfo.org/species/primate/propdiad.htm
- http://www.tsidy.com/lemurs/species/species.asp
- http://pin.primate.wisc.edu/aboutp/phys/lifespan.html
- http://animaldiversity.ummz.umich.edu/site/accounts/information/Indri_indri.html
- http://www.ecologyandsociety.org
- http://www.eurekalert.org/pub_releases/2005-08/fm-tnl080205.php
- http://www.wcmc.org.uk/forest/data/cdrom2/aftabs.htm#Table%201
- http://news.nationalgeographic.com/news/2005/08/0809_050809_lemur_photo.html
- http://www.piec.org/mswg_toolkit/mswg_toolkit/data/casestudies/5_Madagascar.doc

Appendix

Appendix I, Detailed information on diurnal lemurs present in Vohimana

Concerning *Indri indri* (Indri), *Propithecus diadema diadema* (Diademed Sifaka), *Hapalemur griseus griseus* (Easten Grey Gentle Lemur) and *Varecia variegata variegata* (Black-and-white Ruffed Lemur) information is cited from Hartcourt, C. et al (1999). *Lemurs of Madgascar and the Comoros*, *The IUCN Red Data Book*. For *Eulemur fulvus fulvus* (Common Brown Lemur) and *Eulemur rubriventer* Red-bellied Lemur) I used Garbutt, N. (1999) *Mammals of Madagascar.* Pica Press, East Sussex, U.K.

Indri indri indri, Indri, Babakoto

INDRI ENDANGERED
Indri indri (Gmelin, 1788)
Order PRIMATES Family INDRIDAE

Fig 9: Indri indri, Vohimana

SUMMARY
Indri is the largest of the living lemurs. It's now confined to a stretch of approximately 500 kms of the north and central eastern rain forest, a much smaller area than it was found in even a few decades ago. Population figures are not known, but it is not thought to occur at high densities anywhere. It is a diurnal, territorial, family living species, which feeds principally on leaves and fruits. The species has been a subject of a 15 month study in the forest of Analamazaotra. Its numbers are declining as the eastern forest is destroyed for timber, fuel and agricultural land. *Indri indri* is found in at least four protected areas, one of which was created specifically for its protection. None is in captivity. Listed in Appendix 1 of CITES, Class A of the African Convention and protected by Malagasy law.

DISTRIBUTION
Now confined to the eastern rain forest from the Mangoro River northwards to near the latitude of Sambava, but excluding the Masoala Peninsula (Petter et al, 1977; Tattersall, 1982). Other authors consider that Indri extends only to around Maroantsetra (Petter and Peter, 1971) or just north of there to the Antanambalana River (Petter and Petter-Rousseaux, 1979). However, it has recently (1989) been reported in the Special Reserve of Anjanaharibe-Sud (Nicolle and Langrand, 1989). Tattersall, in 1982, considered that Indri was rare or even extirpated from the more northern extremities of its range. Whatever the present distribution, it has certainly been considerably reduced even within the past few decades (Petter et al, 1977). As recently as 1939, it was recorded by Lamberton as far south as Mananjary (noted in Tattersall, 1982). Subfossil evidence indicates that it used to occur in the interior of Madagascar, at least as far west as the Itasy Massif (Tattersall, 1982).

Fig 10: Distribution of Indri

POPULATION Numbers are unknown and population density varies widely making it difficult to estimate even an approximate figure of the number of Indri in Madagascar (Pollock, 1975). In 1972 in the forest of Analamazaotra and those of Fierenana and Vohidrazana nearby, Pollock estimated densities of 9-16 individuals per sq.km (Pollock, 1975). He found no noticeable difference in the density of Indri between those in primary forest and those in selectively degraded forest, however his sample size was small (Pollock, 1975). Petter and peyrieras (1974) found only one group (presumably three or four animals) per sq.km in undisturbed rain

forest near Maroantsetra and they suggested that the higher densities in Analamazaotra (Perinet) were due to human interference.

HABITAT AND ECOLOGY Found in the eastern rain forest from sea level to 1500m (Petter et al, 1977). Indri is one of the few lemurs that has been studied for more than a few months at a time. Pollock (1975, 1977, 1979) observed several groups in the forest of Analamazaotra for 15 months, from June 1972 to August 1973. He found, as Petter had reported earlier (Petter, 1962), that Indri lives in groups of between two and five individuals, these are usually an adult pair their offspring. The two main groups studied by Pollock (1979) occupied defended territories of approximately 18 ha with little overlap between ranges. Petter and Peyrieras (1974) suggested a home range size for each group of 100ha, but this was based on plotting the locations of calling groups rather than on direct observation. Loud morning calls advertise the presence of the groups within their ranges and these calls may be answered from as far as 3 km away (Petter and Peyrieras, 1974; Pollock, 1975, 1979, 1986). The Indris may also call at night (Olivier and O'Connor, 1980). Arboreal locomotion is principally by leaping from one vertical trunk to another. The daily distance travelled by the two groups in Analamazaotra was between 300 and 700 m (Pollock, 1979). *Indri indri* is strictly diurnal and has an activity period lasting 5-11 hours depending on season and weather (Pollock, 1975, 1979b). It sleeps in trees from 10- 30m above the ground, no more two animals ever sleep in contact and distances between individuals can be 100m or more (Pollock, 1975)

Indri feed on leaves (mostly young ones), flowers and fruits with feeding continuing throughout the day, reaching a peak at midday (Pollock, 1979). Females and very young individuals have priority of access to food (Pollock, 1977, 1979b). When certain plant species flushed into leaf, flowered or bore fruit, *Indri* groups made an early progression to these trees and then fed in them continuously for one to three hours. This was followed, in the early afternoon, by a series of short feeding bouts on a diverse array of plant species and usually ended in a central sleeping area (Pollock, 1979). Alternatively, when no concentrated source of food was present, the *Indri* ranged in a less predictable fashion with small feeding progressions scattered throughout the day (Pollock, 1979). All levels of the forest are used, including the ground to which the animals descend to eat earth exposed by upturned tree trunks (Pollock, 1979).

Infants are born in May after a gestation of 120-150 days and are carried on the front of the female until they are four or five months old, after which they transfer to ride on her back (Pollock, 1975). They move independently by the age of eight months but remain feeding closer to their mother than to any other group member into their second year (Pollock, 1975). The infants sleep with their mothers every night for the first year of life, but do so irregularly thereafter (Pollock, 1975). Females probably give birth no more than once every two or three years and reproductive maturity is not reached until between seven and nine years of age (Pollock, 1977, 1984).

THREATS *Indri indri* is severely threatened by destruction of its habitat for fuel, timber and, particularly, local agricultural development (Pollock, 1984). This destruction continues even in the protected areas as none of these eastern reserves is adequately guarded or manned. For instance, in 1984 over 3 000 people were reported to be living in a central valley enclave of Zahamena and more than 2000 ha of the forest there had been destroyed (Rabemazara peers. comm. to Pollock, 1984b). There is also a risk that the north/south paths from this legal central enclave to villages outside the reserve will bisect the protected area, hunting already occurs along these paths (Nicoll and Langrand, 1989). Hunting of lemurs does occur, even in the protected areas, but it is not clear if the Indri is killed. To some of the local groups it is taboo to hunt this species. The Indri is certainly declining in numbers (Richard and Sussman, 1975,1987). Its slow reproductive rate makes it more vulnerable to extinction.

CONSERVATION MEASURES *Indri* are found in several reserves in Madagascar including Zahamena and Betampona Natural Reserves and the Special Reserves of Anjanharibe-Sud and Analamazaotra (Nicoll and Langrand, 1989). The Reserve at Analamazaotra (Permet) was created in 1970 specifically

for the protection of *Indri* (Petter and Peyrieras, 1974; Pollock, 1984b) and it is here that tourists can most easily this species. However, the Reserve is small and has become isolated from previously continuous forest blocks so it is of greater educational than conservation value (Pollock, 1984b). Regular patrols of the Reserve are needed to protect it from encroachment and from hunters (Nicoll and Langrand, 1989). A local conservation group "Friends of the Reserve of Andasibe has been created and it is suggested that this group could play a role in increasing local public awareness of the Special Reserve (Nicoll and Langrand, 1989). It has been proposed that a National Park be created in the region of Mantady just north of Analamazaotra and the management of the two areas could be combined (Nicoll and Langrand, 1989). I*ndri* is found in Zahamena Reserve, which is the largest protected area in the eastern rainforest, though it probably exists at a lower density there than in Analamazaotra (Raxworthy, 1986). Members of an expedition to Zahamena in 1985 suggested that fire breaks and boundary trails be cut round the Reserve and that more people were needed to guard it adequately (Thompson *et al,* 1986; Raxworthy. 1986). That expedition financed a two kilometre fire break in the south-west of the Reserve (Raxworthy, 1986). Several guard stations are probably essential to effect adequate control of Zahamena, one or more of these are needed within the central enclave (Pollock, 1984b). It may be that a new demarcation of the Reserve, excluding the central human settlement, is necessary in order to create a viable protected area (Pollock, 1984b).

Pollock (1984b) reports that a few *Indri* are present in Betampona Nature Reserve but he suggests that there may not be sufficient numbers left to create a self-sustaining population within the isolated forest island which is all that remains of the Reserve. It is surrounded by extensive agricultural development. As for the other reserves, funds are needed to support permanent guards within the area and frequent patrolling of the reserve is needed (Pollock, 1984b). Though there is already a good network of paths, some extra ones are needed for a comprehensive coverage of the region (Pollock, 1984b).

Petter *et al* (1977) suggests that it may be possible to introduce *Indri indri* onto the island of Nosy Mangabe. However, the small size of the island (520 ha) makes it unlikely that it would support many of these large, territorial lemurs. An area around Mananara has been proposed as a Biosphere Reserve and this would protect the Indris found there (Nicoll and Langrand 1989).

Surveys are needed to make accurate estimates of population numbers and to determine the true distribution of this species so that these data can be used as the basis for conservation management of the species. Participants at the St Catherine's Lemur Workshop in 1986 suggested that range-wide surveys of this species are needed as soon as possible.

It may be possible to try breeding *Indri* in captivity, perhaps at an Eaux et Foret station within the range of the species but this would need full time monitoring from a highly qualified lemur specialist (St Catherine's Workshop, 1986). If breeding in captivity is to be attempted at all, it is suggested that the individuals taken into captivity are from doomed habitats that have no long term hope for survival (St Catherine's Workshop, 1986).

All species of Indriidae are listed in Appendix 1 of the 1973 Convention on International. Trade in Endangered Species of Wild Fauna and Flora. Trade in them, or their products, is subject to strict regulation and may not be carried out for primarily commercial purposes.

All Lemuroidea are listed in Class A of the African Convention, 1969. They may not, therefore, be hunted, killed, captured or collected without the authorization of the highest competent authority, and then only if required in the national interest or for scientific purposes. Though legally protected from capture or killing within Madagascar, enforcement of this is difficult in practice.

CAPTIVE BREEDING *Indri* has never been successfully kept in captivity. One young individual was kept for more than a year at Ivoloina in Madagascar, but generally this species does not survive long when caged (Petter *et al,* 1977).

REMARKS *Indri indri* is the largest of the Living lemurs, weighing 7-10 kg or more (Pollock 1984) Pelage colouration and pattern are highly variable, mostly black with some white grey or brown

(Tattersall, 1982; Jenkins, 1987). It is the only lemur species with virtually no tail. For a more detailed description see Tattersall (1982) or Jenkins (1987).
Babakota, one of the Malagasy names for this species, means "the father of man" or "the ancestor" (Petter et al, 1977). Other local names for the Indri are amboanala and endrina (Tattersall, 1982).

Propithecus diadema diadema,Diademed Sifaka, Simpona

DIADEMED SIFAKA ENDANGERED
Propithecus diadema diadema (Bennett, 1832)
Order PRIMATES Family INDRIDAE

Fig 11: Propithecus diadema diadema, Vohimana

SUMMARY The Diademed Sifaka is a comparatively large, diurnal lemur found in Madagascar's eastern rain forest. Opinions differ as to the number of subspecies. The distribution of each is not clear, but members of the species are found from Sambava in the north to, possibly, as far as Andohahela Reserve in the south. Population numbers are mostly unknown, but it was estimated in 1988 that there were a maximum of 2000 individuals remaining of the most endangered subspecies, *Propithecus diadema perrieri.*
Density appears to be low in most subspecies and all are threatened by habitat destruction and all are classified as Endangered. There have been only a few brief studies of the species. It lives in small groups of up to eight animals, the composition of which is very variable. Its diet consists of fruit, leaves and flowers. There are no *P. diadema in* captivity. The species is found in most of the reserves in the east though one subspecies, *P. d. perrieri,* occurs in no protected area. Listed in Appendix 1 of CITES, Class A of the African Convention and protected by Malagasy law.
DISTRIBUTION This is the most widely distributed of the *P. diadema* subspecies though the precise limits of its range are not known. It is found throughout the eastern primary rain forest from the Mangoro River in the south to near Maroantsetra in the north (Petter *et al,* 1977; Tattersall, 1982; Petter and Petter-Rousseaux, 1979).
POPULATION Population numbers are unknown, but Pollock (1975) and Tattersall (1982) state that this subspecies is never found at high densities.
HABITAT AND ECOLOGY *P. d. diadema* has been observed in the forests around Analamazaotra in groups of two to five individuals (Pollock, 1979). One group had a home Range size of last at least 20ha (Pollock, 1979) Petter " et *al* (1977) estimate range sizes of between 25ha to more than 50ha.
THREATS The Diademed Sifaka is threatened by habitat destruction due to agricuicural encroachment and extraction of timber and by hunting. They are reported to be commonly eaten in Zahamena (Smions, 1984).

Fig 12: Distribution of Propithecus diadema diadema

CONSERVATION MEASURES Found in Analamazaotra Special Reserve and in Zahamena Nature Reserve (Smions, 1984; Pollock. 1975,1984b; Raxworthy. 1986,1988; Nicoll and Langrand, 1989). It may still occur in Betampona Nature Reserve where it was reported by Andnamampianma and Peyrieras in 1972 but was not seen by Pollock in 1984 it is not

common in either Analamazaotra or Zahamena. All the reserves need adequate protection. Studies of this subspecies are needed to determine population numbers, limits of its distribution and its ecological requirements. It has been suggested that it be introduced to the island of Nosy Mangabe (St Catherine's Workshop, 1986). Two new protected areas are proposed within the range of *P. d. diadema:* Mananara proposed as a Biosphere Reserve and Mantady as a National Park (Nicoll and Langrand, 1989).

Hapalemur griseus griseus, Eastern Lesser Bamboo Lemur, Bokombolo

GREY GENTLE LEMUR
Hapalemur griseus (Link, 1795)
Order PRIMATES Family LEMURIDAE

Fig 13: Hapalemur griseus griseus, Parc zoologique Ivoloina, Toamasina

SUMMARY Three subspecies of the Grey Gentle lemur are recognised. One of these (H. g. griseus) is widely distributed throughout the eastern rain forest, a second (H. g. occidentalis) occurs in two isolated populations in the west. Both of these subspecies are associated with bamboo, which is the principal component of their diet. The third subspecies (H. g. alaotrensis) occurs in the reed beds and marshes around Lake Alaotra, where the reeds and papyrus replace bamboo in its diet. The latter subspecies is especially threatened by habitat destruction and is classified as endangered, but none is safe from destruction of the forests. However, it has been suggested that the eastern subspecies may be found at higher densities in areas where bamboo has colonised the cleared forests. There have been some brief studies of H. g. griseus. It lives in small groups and may be active during the night as well as during the day. H. g. alaotrensis is the only subspecies that is not found in any protected area. About 20 individuals are in captive colonies and most of these are wild caught, they do not appear to breed easily in captivity. Listed in Appendix 1 of CITES, Class A of the African Convention and is protected by Malagasy law.

Grey Gentle Lemur Insufficiently known
Hapalemur giseus griseus (Link, 1795)

DISTRIBUTION The nominate subspecies, Hapalemur griseus griseus, is the most widespread. It is found throughout the eastern forests from Tsaratanana Massif in the north to Taolanaro (Fort Dauphin) in the south (Tattersall, 1982). Tattersall (1982) reports that it is rare in the north western part of its range, but Petter-Rousseaux (1979) show it occurring further north and west than does Tattersall.
POPULATION Population numbers are unknown. Pollock (1979) estimates a density of 47-62 individuals per sq. km in the eastern rain forest around Analamazaotra (Perinet). Richard (1982) gives densities of 1.1-1.2 per ha (i.e. 110 – 120 individuals per sq.km). Pollock (1986) suggests that the total population size must be substantial, though Tattersall (1982) considers that H.g. griseus is rarely found at great density and Richard and Sussman (1975, 1987) consider it to be declining. However, it has been suggested that H. g. griseus will not suffer from forest destruction as it apparently occurs at higher densities in areas where bamboo has replaced the original

Fig 14: Distribution of Hapalemur griseus

forest (Petter and Pevrieras, 1970, 1975; Jolly et al, 1984). Pollock (*in litt*), however, considers it unlikely that the Grey Gentle Lemur will benefit from the destruction of the forests.

HABITAT AND ECOLOGY H. g. griseus is confined to forests characterised by bamboo or bamboo vines (Petter and Peyriesias, 1970; Tattersall, 1982). A two month study of this subspecies at Analamazaotra in "winter" found that 90% of feeding time was spent eating the new shoots, leaf bases and stem pith of the bamboo Bambusa (Wright, 1986). The Grey Gentle Lemur browsed continuously on the bamboo, at a rate of 10-12 leaf stems per minute and spent 48% of the day feeding. Other foods include fig leaves, leaf stems of terrestrial grasses, young leaves from trees and small berries (Wright, 1986). It was suggested that fruit eating might increase when more was available (Wright, 1986). The Gentle Lemurs ranged in all habitats that contained bamboo, including stream edges and ridge tops, feeding at all heights from the ground to tree canopies (Wright, 1986).

Group size ranged from between four and six individuals at Analamazaotra, eight groups were counted ((Wright, 1986). Petter and Peyrieras (1970) found the most usual group size to be between three and five individuals and Pollock (1986) gives a mean group size of 2,6 individuals with sightings of between one and five individuals together. In Wright's study (1986), each group contained at least one adult pair, one juvenile and an infant ((Wright, 1986). Petter and Peyrieras (1970) and Pollock (1986) found that it was not uncommon to have a second adult female in a group. Wright (1986) reported that home range sizes of between 6 and 10 ha; one group had a mean daily path length of 425m (range 375-495m). At Ranomafana, a group of H. g. griseus, composed of an adult pair with two offspring, defended a 15ha territory (Wright, 1989). Gentle Lemurs were active throughout the day except for an hour or so around midday when they rested, they were not active at night at Analamazaotra (Wright, 1986). Petter and Peyrieras (1970, 1975) found them to continue to be active for a couple of hours after sunset at Marontsetra. They are often considered to be crepuscular (Pollock, 1979; Joly et al, 1984). In the wet season at Analamazaotra, Grey Gentle Lemurs can be active by 04.30 hr (Pollock, *in litt*.). During Wright's (1986) study, they left the emergent trees that they used as sleeping site between 06.00 and 06.30 hours and returned between 15.45 and 17.25. The group members slept in contact trees located throughout their home range (Wright, 1986).

In the area around Maroantsetra, the females give birth to single infants (Petter and Peyrieras, 1970), this is also the rule in captivity, (Pollock, 1979). Gestation period is reported to be 140 days and infants at Maroantsetra are born in December and January (Petter and Peyrieras, 1970). Pollock (1986) suggests a birth season from late October to January at Analamazaotra. The infants ride on their mothers back from when they are first born (Petter and Peyrieras, 1970), rather than initially in a ventral position as appears to be more common in most other lemurs. In captivity, both the male and the female carry the infant (Petter and Peyrieras, 1970, 1975).

THREATS The main threat to this subspecies is the destruction of the rain forest. FAO/UNEP (1981) estimated that in each year between 1976 and 1980, 40,000 ha of previously undisturbed forest was cleared and it is likely that most of this was in the eastern forests. It is, however, reported that in areas burned and abandoned long ago, where bamboo had entirely replaced original forest, the density of H. g. griseus appeared to be higher than undisturbed habitat (Petter and Peyrieras, 1975).

CONSERVATION MEASURES This subspecies is reported in Tsaratanana, Marojejy, Zahamena, Betampona and Andohalela Nature Reserves and in Anjanaharibe-Sud, Anlamazaotra and Manombo Special Reserves (Pollock, 1984; Nicoll and Langrand, 1989; O'Connor et al, 1986; Safford et al, 1989). It is also found in Ranomafana, Masoala and Mananara, all of which have been proposed as protected areas (Nicoll and Langran, 1989).

No conservation measures have been suggested for this subspecies other than a range wide survey (St Catherine' Workshop, 1986). It would be useful to ascertain if it does reach higher densities in disturbed areas where bamboo has replaced the original forest. Its conservation status cannot be assessed unless some estimates of its numbers are made.

REMARKS H. griseus griseus is overall a brown grey colour and it weighs around 700-1000g. (Tattersall, 1982). One individual trapped at Ranomafana wighed 770g, whereas the average weight of five captive H. griseus at Duke Primate Center was 936g (range 941-1226g) (Glander et al, in press). Its Malagasy names are bokobolo and kotrika.

Eulemur fulfus fulfus, Common Brown Lemur, Varikosy

MEASURMENTS Total length:845-1,010mm. Head/body lenghth: 430-500mm. Tail length:415-510mm. Weight:2-3 kg.
DESCRIPTION This is the only Eulemur fulvus subspecies where both males and females are similarly coloured- all other subspecies are sexually dichromatic. The upperparts are uniform brown to grey-brow, while the underparts are paler and slightly greyer. The face, muzzle and crown are dark to grey black (females may be slightly paler than males), with slightly paler faint eyebrow patches and paler brown-grey fur around the moderately prominent ears, cheeks and underneath the chin. The eyes are rich orange-red. The tail is long and slightly bushy towards the tip.

Fig 15: Eulemur fulvus fulvus, Vohimana

IDENTIFICATION A medium-sized lemur with a long tail and horizontal body posture which moves quadrupedally both on the ground and in the canopy. In the eastern part of its range the Common Brown Lemur may be confused with the Red-bellied Lemur E. rubriventer, but the latter is very much more reddish in colour and males have distinctive white tear-drops beneath there eyes, while females have a creamy-white throat, chest and belly. In the north-western forests, E. f. fulvus is distinguished from the Mongoose Lemur E. mongoz by its uniform brown coloration: the Mongoose Lemur is mainly grey with slight brownish tinges and is sexually dichromatic.

Fig 16: Distribution of Eulemur fulvus fulvus

HABITAT Rainforest, moist montane forest and dry deciduous forest.
DISTRIBUTION Two major populations remain – one in the east, the other in the north-west. In eastern Madagascar the Common Brown Lemur is found in the rainforest north of he Mangoro River to an as et indeterminate latitude between 16ºS and 18ºS. Between these latitudes the range of this subspecies meets that of the White-fronted Brown Lemur E. f. albifrons but the boundaries between the two remain unclear and there may be some overlap where hybridisation occurs. A latitude just to the north of Toamasina (around 18ºS) is often quoted as the northern limit for E. f. fulvus in the east. However groups of E. f. fulvus seen in both Zahamena Nature Reserve and Ambatovaky Special Reserve, which respectively lie approximately 40 km. and 140 km. to the north of the accepted boundary, appear to resemble the nominate race far more closely than E. f. albifrons. In the north-west this subspecies is found in the dry deciduous forest north of the Betsiboka River and continues north into the moist evergreen forests of the Sambirano region as far as the Mahavavy River and probably including some of the Tsaratanana Massif.
Between these two main blocks, E. f. fulvus also survives in some isolated forests remnants in the central highlands, for example at Ambohitantely Special Reserve, around 130 km north-west of

Antananarivo. This suggests that the range of this taxon was once continuous when the forests were intact. There is also an isolated population on the island of Mayotte in the Comoros which is believed to have been introduced by man. However, this population has been described as a separate subspecies, E. f. mayottensis, by some authorities.
BEHAVIOUR The Common Brown Lemur is generally encountered in troops of 3-12, with 9-12 being the norm (on the island of Mayotte groups of 30 have been reported). Groups contain several adult males and females together with subadults, juveniles and infants. Agnostic interactions seem infrequent and there are no discernable dominance hierarchies. They are active for most of the daylight hours, spending virtually all the time in the forest canopy. However, feeding and movement often continues after dark. The extent of their nocturnal activity may well be influenced by the lunar cycle: when the moon is full, nocturnal activity reaches its peak. The home range size appears to be strongly influenced by habitat. In western dry forest it is between 7 and 8 hectares, while in eastern rainforest home ranges as large as 20 hectares have been recorded. Groups continually scent-mark their territory although some overlap between ranges still occurs: loud vocalisations help groups avoid one another. The diet is varied and consists of leaves, buds, shoots, flowers and fruits, the proportion of which vary seasonally. In some eastern areas this species has been observed feeding in plantations on the flowers of introduced pine and eucalyptus trees. Mating takes place in May and June and after a gestation period op about 120 days births occur in September and October at the onset of the rainy season. A single offspring is usual, although twins have been recorded. Weaning occurs between four and five months, and sexual maturity is reached around 18 months.
POPULATION The overall population on Madagascar is not known. On the island of Mayotte in the Comoros there may be around 20,000 Common Brown Lemurs. In western forests population densities of 170 individuals/km² have been estimated, dropping to 40/60 individuals/km² in eastern rainforests.
THREATS Habitat destruction remains the primary threat. In eastern areas, rainforests are cleared by slash-and-burn to make way for agriculture, while the drier western forests are threatened mostly by fires started to promote new flushes of grass for grazing cattle. The Common Brown Lemur is found in at least eight protected areas. Its presence in others is suspected but cannot be confirmed until thorough surveys are undertaken.

Eulemur rubriventer,Red-bellied Lemur, Tongona

Eulemur rubriventer (I.Geoffroy, 1850)
Order PRIMATES Family LEMURIDAE

MEASURMENTS Total length: 780-930mm. Head/body length: 350-400 mm. Tail length: 430-530 mm. Weight: 1.6-2.4 kg.
DESCRIPTION Sexually dichromatic. Males: The pelage is long and dense. Upperparts, chest and underparts are rich dark chestnut-brown, while the tail is noticeably darker, often appearing almost black. The top of the head, face and muzzle are darker, often slate-grey and there are conspicuous patches of white bare skin forming teardrops beneath the eyes. Although there are no ear-tufts as such, the fur around the ear is particularly dense and gives the head a Squarish look. Females: The upper-parts are rich chestnut-brown as in the males, but the chest and upper parts are creamy white. The tail is dark grey to black. The head is less squarish in shape than in males and the top is

Fig 17: Male Eulemur rubriventer, Parc zoologique Tsimbazaza, Antananarivo

not darkened. The face and muzzle are dark slate grey, but the bare patches of white skin are dramatically and in some individuals completely absent. The lower cheeks and beard maybe creamy-white like the chest and upperparts.

IDENTIFICATION A medium-sized lemur with horizontal body posture and rich dense coat. Throughout its range the Red-bellied Lemur occurs sympatrically with a number of Brown Lemur E. fulvus subspecies, all of which are broadly similar in size and shape. With a good view distinguishing E. rubriventer should be straightforward. Its coat is much more dense and richly coloured than any E. fulvus subspecies and it is far less obviously sexually dichromatic than any exept E. fulvus fulvus. Furthermore the Red-bellied Lemur is generally encountered in small family groups, rather than the larger multi-adult groups seen in E. fulvus.

HABITAT Primary and secondary eastern rainforest.

DISTRIBUTION The Red-belied Lemur appears to be thinly distributed throughout the eastern rainforest belt from the area to the south of Andringitra Massif in the south to the Tsaratanana Massif in the north, but not including the Massoala peninsula. Throughout this range middle to high elevations are preferred – In the Tsaratanana Massif this species has been recorded at altitudes of 2,400m.

Fig 18: Distribution of Eulemur rubriventer

BEHAVIOUR The Red-bellied Lemur lives in small family units of two to six animals which generally comprise an adult pair and dependant offspring, although larger group do contain more than one adult of each sex. These family groups occupy a home range of around 10-20 ha which is actively defended, although some observations suggest that neighbouring groups rarely show aggressive behaviour towards one another. Aggressive behaviour between two males apparently belonging to the same group has, however, been observed. On average, the group travels 400-500m. per day, but this distance varies seasonally according to food availability. In times of shortage the group may travel as much as a 1,000m. per day. The movements of the units are instigated and led by the dominant female.

This species is cathemeral, although activity patterns may vary with the seasons and be related to food availability. Fruits spear to be the mainstay of the diet and include introduced species like Chinese Guava *Psidum cattleyanum*. When fruits are unavailable, flowers and leaves are also taken and it is at these times that feeding bouts often continue after dark. The Red-belied Lemur has been recorded utilizing nearly 70 different plant species over the course of the year. It also seems that invertebrates, especially millipedes, constitute an important element in the diet. The single young are usually born in September and October, and initially carried on the mother's belly, then later move around to ride on her back. At this stage infants are also carried by the male, who may form a focus for other infants as well. After about 35 days the female stops carrying the offspring although the male may continue to do so until it approaches 100 days of age.

POPULATION No overall population figures are available. The species is known to be only sparsely distributed throughout its fairly extensive range, so that authorities believe this to be one of the rarest Eulemur species. In Ranomafana National Park, a population density of 30 individuals/km² has been estimated.

THREATS The continued destruction of the eastern rainforest remains the primary threat to this species. Each year large areas are lost to shifting agriculture and logging. The Red-bellied Lemur is known to occur in at least nine protected areas.

Varecia variegata variegata, Black and White Ruffed Lemur, varikandana

RUFFED LEMUR
Varecia variegata (Kerr, 1792)
Order PRIMATES Family LEMURIDAE

Fig 19: Varecia variegata variegata, Ile sainte marie

SUMMARY The Ruffed Lemur is found in the eastern rain forest, but does not appear to be common anywhere. Two subspecies are commonly recognised, Varecia variegata variegata and V. v. rubra, both are considered endangered, the latter is restricted to the Masoala Peninsula. Population numbers are unknown and there are no estimates of density. Numbers are certainly declining. A long term study of this species on Nosy Mangabe has recently been completed. It lives in small groups of up to five individuals. It is primarily frugivorous, though some leaves, nectar and seeds are also taken. The species is threatened by forest destruction and by hunting. V. v. variegata is found in at least five reserves; V. v. rubra does not occur in any protected area and this should be remedied. Surveys of the numbers and distribution of both subspecies are needed. There are over 700 individuals in captivity and they breed very well there. Listed in Appendix 1 of CITES, in Class A of the African Convention and protected by Malagasy law.

Black and White Ruffed Lemur Endangered
Varecia variegata variegata (Kerr, 1792)

Fig 20: Distribution of Varecia variegata variegata

DISTRIBUTION The distribution of V. v. variegata, is poorly known (Tattersall, 1977, 1982). It is found in the eastern rain forest, extending southwards from the Antainambalana River (which is the boundary between the two subspecies) as far as Manakara (Petter and Petter, 1971) or to just north of the Manakara River (Petter et al, 1977); Tattersall, 1982; Petter and Petter-Rousseaux, 1979). The subspecies is also found on the small island of Nosy Mangabe where it was introduced in the 1930s (J. Petter pers. Comm.. to Constable et al, 1985).
POPULATION Numbers are not known. The Black and White Ruffed Lemur does not appear at high densities anywhere other than on Nosy Mangabe (Pollock, 1984). It is estimated (Simons Morland, in prep) that there may be as many as 100-150 individuals on the 520 ha island (i.e. approximately 20-30 individuals per sq. km). In 1984, Pollock estimated at 175 animals per sq km (Iwano, 1989), i.e. a total of 910 individuals, which is a much higher estimate than that of Simons Morland or Pollock.
HABITAT AND ECOLOGY A three month (June –August 1988) study of the Black and White and Ruffed Lemur has been carried out near Ranomafana in the south-east of Madagascar (White, 1989). The results of a longer term study (1600 observation hours between July 1987 and January 1989) of the subspecies on Nosy Mangabe are currently being written up (Simons Morland, in prep). At Ranomafana, the study group consisted of an adult male and adult female which travelled through a large home range, of 197 ha, as a cohesive pair (White, 1989). A subadult was observed in the area but, though it exchanged calls with the adult pair, It did not associate with them. The pair frequently range more than 1 km each day, usually feeding, travelling and resting high (20-25 m) in canopy. Locomotion was principally quadrupedal, with frequent leaping (White, 1989; Pereira et al, 1988). White

et al (1989) suggest that the larger groups of Varecia with smaller home ranges that are found on islands and in isolated forest blocks may be a consequence of the limited space available there for dispersion. The diet of V. v. variegata in both Ranomafana and Nosy Mangabe was mostly fruit, supplemented with small amounts of nectar, seeds and leaves; on Nosy Mangabe, the diet varied seasonally (White, 1989; Simons Morland, in prep). Some earth was also eaten. Chorusing loud calls were used as territorial advertisement and for coordination of movement within the territory (White, 1989). Simons Morland (in prep) reports that it is female V. v. variegata which defend the territories. Other reports of group size are of between two and five individuals (Petter et al, 1977; Pollock, 1979; Jolly et al, 1984). On Nosy Mangabe, there was seasonal variation in activity levels and patterns; levels were highest during the summer months and some nocturnal activity may have occurred (Simons Morland, in prep). In general, the Ruffed Lemurs on the Island were most active in the early morning and late afternoon/evening (Simons Morland, in prep). Pollock (1979) describes Varecia as crepuscular. In captivity, the animals were more active in the morning and evening and there was no sign of nocturnal activity (Klopfer and Dugard, 1976; Kress et al, 1978).

More details of reproduction come from studies in captivity. Gestation period is 90-102 days (Hick, 1976; Bogart et al, 1977; Boskoff, 1977). Up to six offspring may be produced in a litter (Anon, 1984), although two or three is the most common number and primiparous females frequently have singletons (Boskoff, 1977; Foerg, 1982). On Nosy Mangabe, most females had twins, these were born in October and November (Simons Morland in prep). When the infants are born, they do no cling to their mother's fur, as happens in most other lemur species, but are left in nests (Petter et al, 1977; Klopfer and Dugard, 1976; Joly et al, 1984). These may be constructed by the female, but are frequently just bundles of epiphytes (Jolly et al, 1984). On Nosy Mangabe, infants were kept in nest constructed by their mother, 15-20 m high in large trees; they were never seen in thick tangles of epiphytes but were parked in trees once they were one to two weeks old (Simons Morland, 1989, in prep). In a forest enclosure at Duke, nests were built by the female Varecia on the ground; infants remained in these until they were approximately three weeks old after which their mothers frequently left them parked high up in trees (Pereira et al, 1987). When they are carried, it is in their mothers' mouth (Klopfer and Dugrd, 1976; Petter et al, 1977). The infants begin to follow their mother at three weeks of age and are as fully mobile and active as adults at seven weeks old (Klopfer and Boskoff, 1979). In the wild, infants were close to adult size at six months of age (Simons Morland, in prep). Females can conceive at 2 months of age (Boskoff, 1977), but in captivity, average age at first reproduction is 3.4 years (SSP Masterpla, 1988). Simons Morland (in prep.) suggests that the high rate of population increase seen in captive Ruffed is not typical of wild populations.

THREATS There is considerable destruction of the eastern forests, these are being cleared principally for growing crops. The lemurs are heavily hunted for food, both trapping and shooting occurs (Nicoll and Langrand, 1989; Constable et al, 1985; Lindsay and Simons, 1986). Iwano (1989) implies that there was a considerable decline in the number of Varecia present on Nosy Mangabe between 1983 and 1984 because of the poaching of this species on the island.

CONSERVATION MEASURES The Black and White Ruffed Lemur is present in Betampona Nature Reserve, it is reported to be common in Zahamena Nature Reserve (Pollock, 1984; Nicoll and Langrand, 1989). Nicoll and Langrand (1989) were informed that it was in Marojejy Nature Reserve but an expedition there in 1988 failed to see or hear them (Safford et al, 1989; W. Duckworth, pers comm..) The subspecies is also found in the Special Reserve of Nosy Mangabe and seems to be reappearing in Analamaozatra Special Reserve (Nicool and Langrand, 1989).

A number of new protected areas, in which Varecia is present, have been proposed (Nicoll and Langrand, 1989). These are Ranomafana, Mantady (both proposed as National Parks) and Mananara (proposed as a Biosphere Reserve). Surveys to discover the distribution and numbers of existing populations of V. v. variegata are essential. Special attention should be paid to determining whether there are several subspecies within the Black and White Ruffed Lemur population, or whether the

variation in colour is nothing more than individual variation (see Remarks below). If here are, in fact, distinct forms, the conservation problem for this species will be much greater than currently recognised (St Catherine's Workshop, 1986).

REMARKS There is considerable variation in coat colour and pattern within V. v. variegata, and it possible that better knowledge of the distribution of the varieties may ultimately suggest their recognition as subspecies (Petter et al, 1977; Tattersall, 1982). Tattersall (1982) recognises four distinct and consistent coat patterns within the Black and White Ruffed Lemur: Type a) Face black except for short white hairs on muzzle below eyes; black forehead and crown; ears, cheeks and throat tufted white; otherwise white except for ventrum, tail, lateral aspect of thighs and shoulders, proximal part of forelimbs and extremities, all of which are black. Type b1) Resembles type a, except that the black shoulder patches extend posteriorly onto the flanks and medially o meet in the midline. Type b2) Pattern as in b1, except that a narrow white stripe runs forward in the dorsal midline, invading the back forequarters but not reaching the neck area. Type c) Entirely black except for white cheeks, ears and throat, a white transverse band extending across the back and sides just below the shoulders and another across the rump extending down the posterior aspect of the thighs onto the lateral surface of the lower leg. White patches also occur laterally on the lower arm. It is this dark type, often referred to as V. v. subcintus, that is found on Nosy Mangabe and in the surrounding mainland forests (Simons Morland, *in litt*.). Adult sized animals weighed on Nosy Mangabe were between 2400 and 3700g; weights were seasonally variable (Simons Morland, in prep.). The Malagasy names of this subspecies are varikandana and varikandra (Tattersall, 1982).

Appendix II, Notation sheet for survey field work

Fiche d'identification et de suivi des Lémuriens de Vohimana

Date : ……/……/……
Heure :…….
Météo :…….
Observateur :…….
Point de départ :……..
Heure de départ :…….

Nom du groupe : ……

Espèce : ……

	Mâle	Femelle	Juvénile	Indéterminé
Observé(s)				
Entendu(s)				

Localisation

Sentier : …… Distance au point 0 : ……....

Distance perpendiculaire au sentier : …… Hauteur : ……

Côté du sentier : …… Sens de parcours : ……..

Activités

Alimentation ☐ Repos ☐ Communication ☐ (vocale)

Déplacement ☐ Toilettage ☐ Activité sexuelle ☐

Réchauffement au soleil ☐ Excrétion fécale ☐ Excrétion urinaire ☐

Allaitement ☐ Jeux ☐ Bataille ☐

Marquage du territoire ☐ Autre :

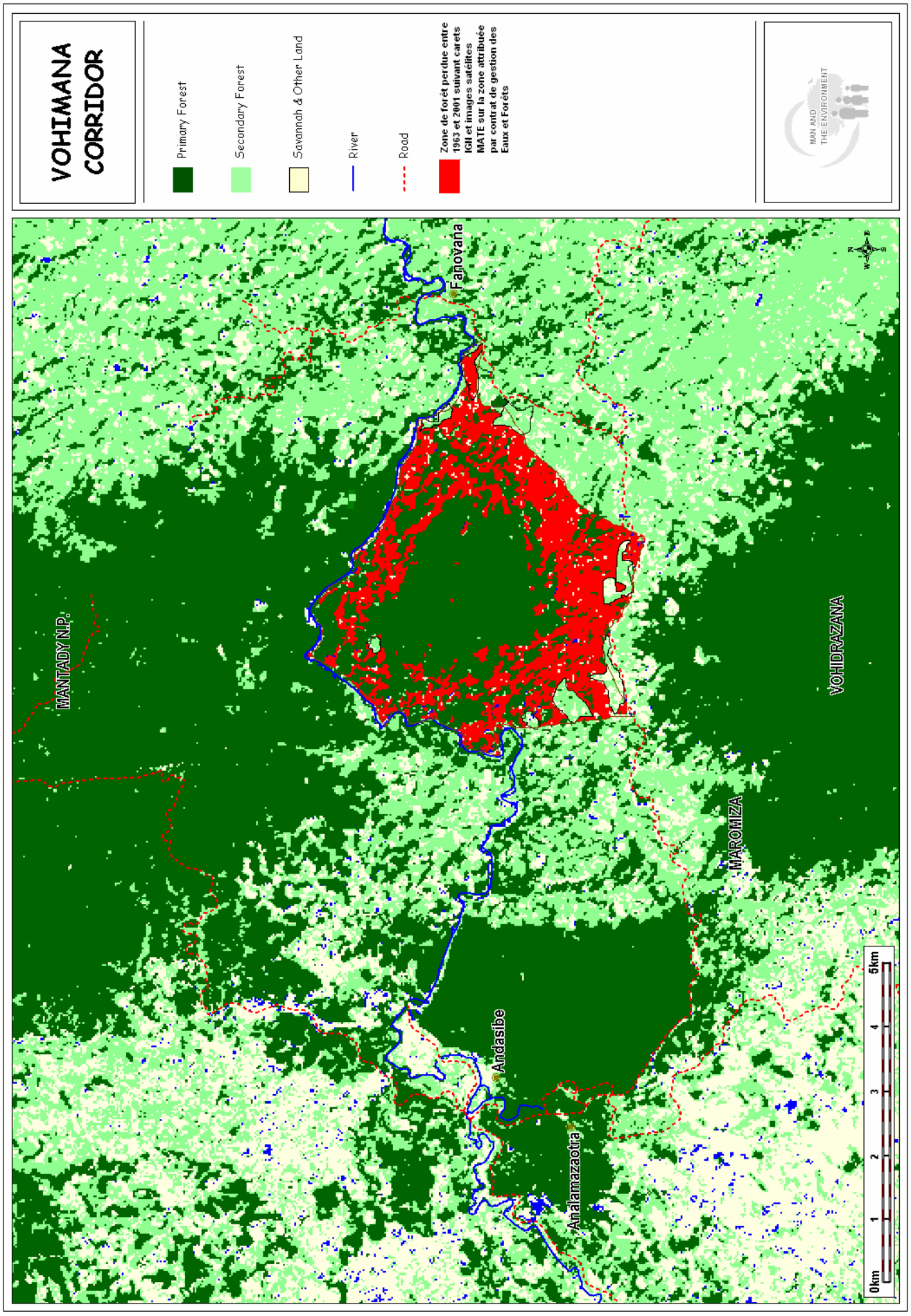
Observations particulières

Taille : Age : Nom :

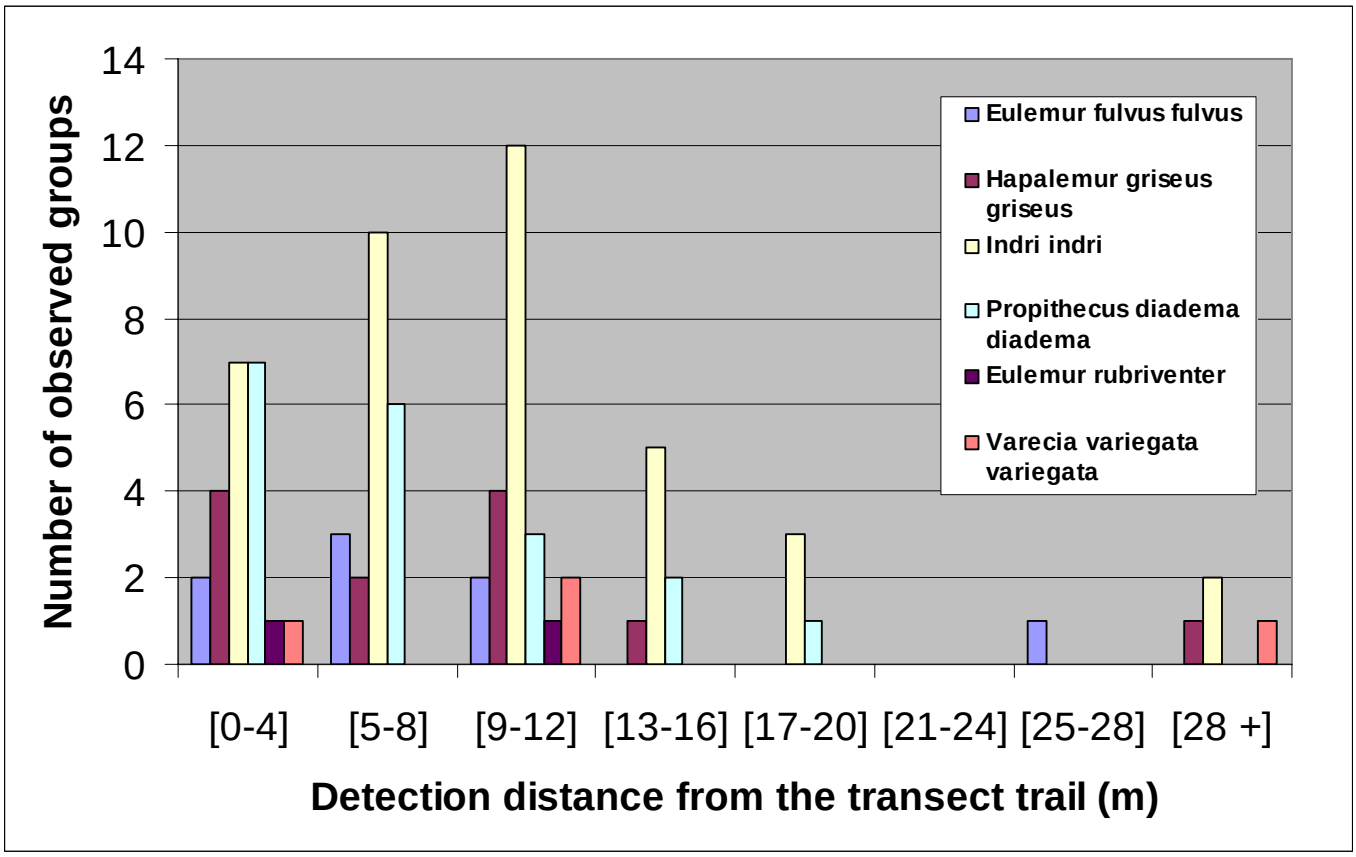
Spécificité physique :

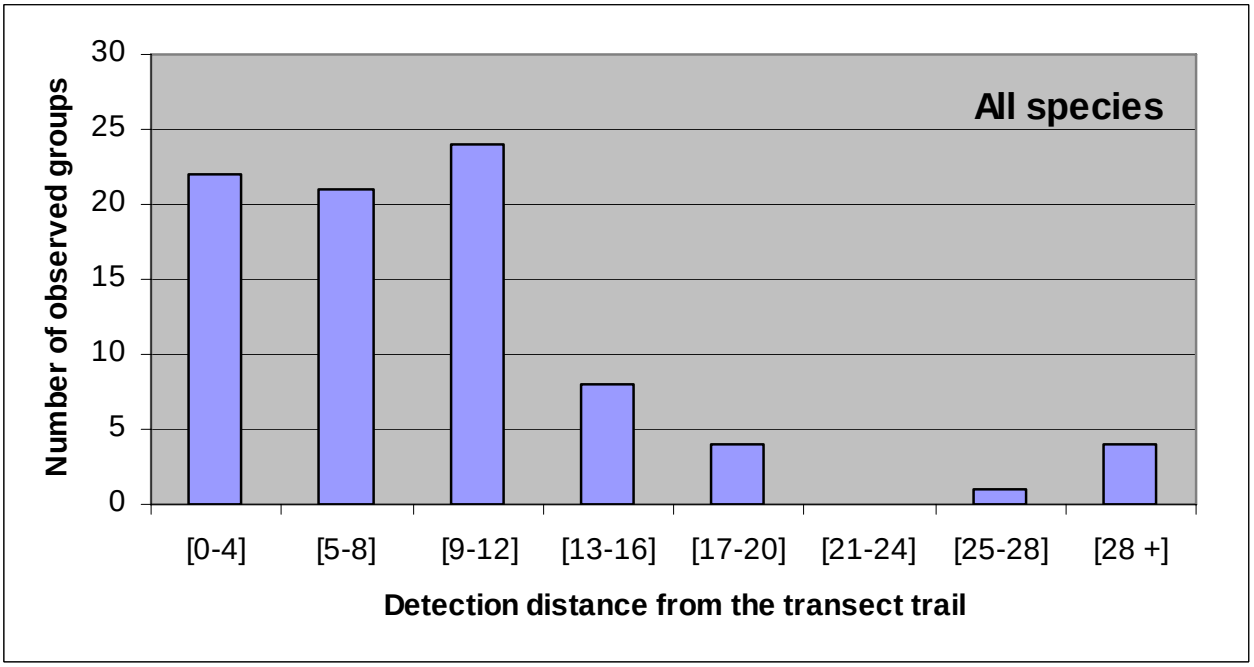
Autre :

Appendix III, Loss of natural forest in Vohimana between 1963 and 2001

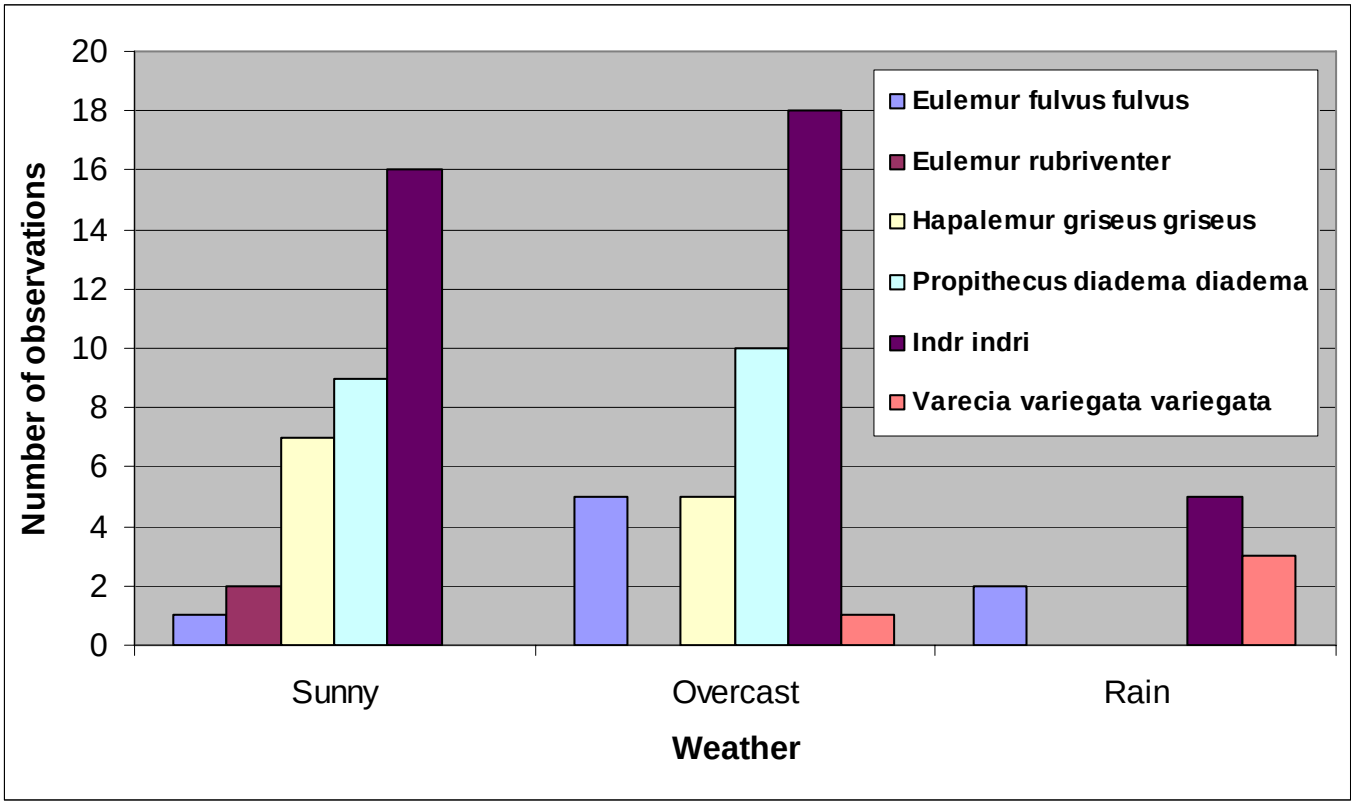

VOHIMANA CORRIDOR
Primary Forest
Secondary Forest
Savannah & Other Land
River
Road
Zone de forêt perdue entre 1963 et 2001 suivant carets IGN et images satélites MATE sur la zone attribuée par contrat de gestion des Eaux et Forêts
MAN AND THE ENVIRONMENT
Fanovana
MANTADY N.P.
VOHIDRAZANA
MAROMIZA
Andasibe
Analamazaotra
0km
1
2
3
4
5km

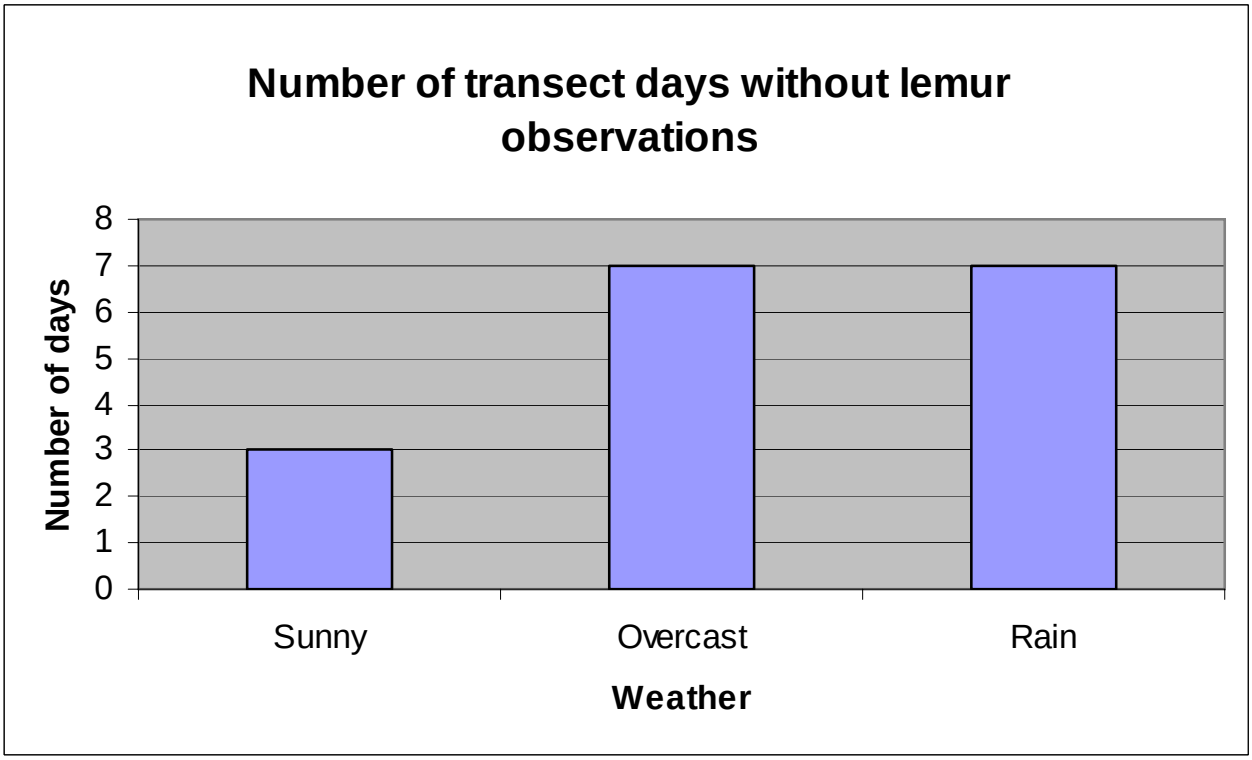
Appendix IV, Detection distance graphs


Number of observed groups
14
12
10
8
6
4
2
0
Eulemur fulvus fulvus
Hapalemur griseus griseus
Indri indri
Propithecus diadema diadema
Eulemur rubriventer
Varecia variegata variegata
[0-4]
[5-8]
[9-12]
[13-16]
[17-20]
[21-24]
[25-28]
[28 +]
Detection distance from the transect trail (m)

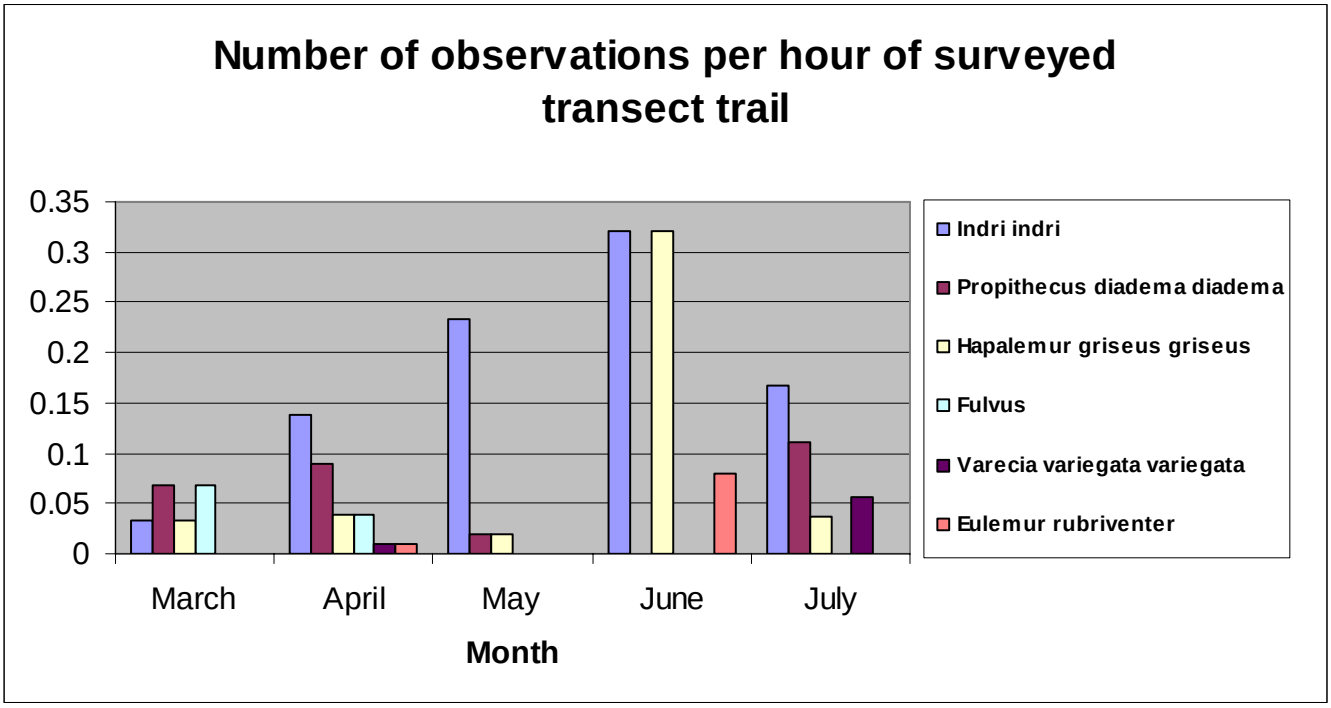

Number of observed groups
30
25
20
15
10
5
0
All species
[0-4]
[5-8]
[9-12]
[13-16]
[17-20]
[21-24]
[25-28]
[28 +]
Detection distance from the transect trail

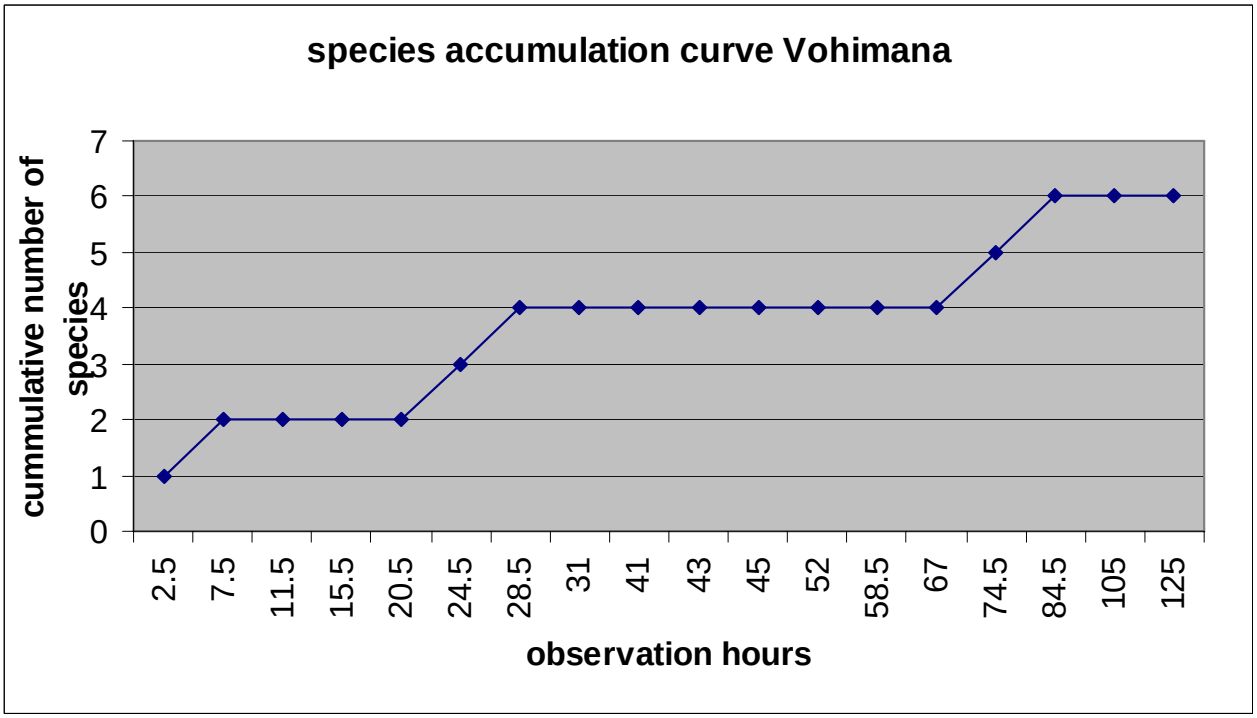
Appendix V, Graphs of weather influence on number of lemur observations


Number of observations
20
18
16
14
12
10
8
6
4
2
0
Sunny
Overcast
Rain
Weather
Eulemur fulvus fulvus
Eulemur rubriventer
Hapalemur griseus griseus
Propithecus diadema diadema
Indr indri
Varecia variegata variegata


Number of transect days without lemur observations
Number of days
8
7
6
5
4
3
2
1
0
Sunny
Overcast
Rain
Weather

Appendix VI, Average number of observation per hour over time
and
Species accumulation graphs


Number of observations per hour of surveyed transect trail
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
March
April
May
June
July
Month
Indri indri
Propithecus diadema diadema
Hapalemur griseus griseus
Fulvus
Varecia variegata variegata
Eulemur rubriventer


species accumulation curve Vohimana
cummulative number of species
0
1
2
3
4
5
6
7
2.5
7.5
11.5
15.5
20.5
24.5
28.5
31
41
43
45
52
58.5
67
74.5
84.5
105
125
observation hours