FRONTIER-MADAGASCAR FOREST RESEARCH PROGRAMME

SCIENCE REPORT

NOSY BE, NORTHERN MADAGASCAR

Phase Dates: 2nd April 2012 to 11th June 2012

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1 Introduction

1.1 Area and camp overview

Figure 1: Satellite image of the Southern region of Nosy Be indicating the location of new Manta Camp, Nosy Komba, Hellville and the Airport (Image: Google Earth).

Nosy Be is the largest offshore island of Madagascar, with a total surface area of approx 25000 ha. The island falls within the Sambirano domain with the natural vegetation being similar to that of the Eastern rainforests, with which it shares many species. This is not surprising as Nosy Be and its surrounding islands were all joined to the Madagascar mainland until as recently as 8000 years ago, when sea level was much lower. At this time the Sambirano forests formed part of a contiguous belt running from North to South Madagascar.

Lokobe is the only protected area on Nosy Be and is a strict terrestrial nature reserve, allowing entry only to staff and researchers with permits. Madagascar National Park (MNP) intends to extend its boundaries into the local marine zone within the foreseeable future. MNP also intends to change the
parks designation to National Park, allowing development for tourism, with potentially large benefits for local tour operators, guides and MNP itself. Outside of Lokobe, Nosy Be is almost entirely deforested. The remaining land area is divided between pastures and crops to the west and dense scrub and taller crop types such as ylang-ylang and banana to the east.

Nosy Be developed tourism long before mainland Madagascar, and is popular with travellers. It is a favourite destination of Italian families, for whom resorts are based primarily in the north west of the island around Andilana, as well as sexual tourists who are more prevalent in the towns of Hell-ville and Ambataloaka in the south. Within the past several decades the sugar industry on the island began to rapidly decline, and the majority of land has reverted to various forms of subsistence and commercial agriculture. Some land was instead bought up and developed for hotels and tourism.

MGF was combined with MGM in the village of Ambalahonko on the island of Nosy Be during interphase of 111. MGF is approximately 60 minutes by boat from the capital of Nosy Be, Hell-Ville, where all resupply takes place. Ambalahonko literally translates to ‘fence of mangroves’ which reflects the camp setting. Camp itself is surrounded by an enclosed bay, through which access to the mainland is possible through one of two openings in the mangrove fence. To the West of MGF is degraded secondary forest backing on to Reserve Lokobe, to the North a mosaic of dense scrub and agricultural land and fruit trees. Overland transport is unfeasible, restricting the level of through traffic and strangers to the village.

1.2 History and rationale of programme

Frontier Madagascar Forest Research Programme (MGF) has worked at four field sites in Northern Madagascar since moving the project from Tulear in March 2005. The first site was in Montagne des Français, an area approximately 8km to the east of Antsiranana (formerly known as Diego-Suarez). Subsequent to MGF’s research there, the area has been promoted into a temporary reserve, with the management of the region still in discussion between the local communities and governing agencies.

The forest programme then moved to the northern side of the Bay of Antsiranana, adjacent to the village of Ampombofofo, where the close proximity to the coast and the sandstone geology created a unique habitat matrix of primary semi-humid dry deciduous forest fringed by primary coastal forest.
At the beginning of 2008, the project moved south of Antsiranana, near the small village of Tsarakibany, to assess whether forest fragments act as refuges and corridors for wildlife between two existing protected areas (Montagne d’Ambre National Park and Ankarana Special Reserve). It remained in this area for 3 years.

In 2011 MGF moved to Ambalahonko, Nosy Be. This site is adjacent to the Lokobe reserve. In the near future the Reserve status is due to be changed to National Park, allowing tourists and members of the public to enter with registered guides. Additionally, the control of the forests abutting the Lokobe reserve will be transferred from state to community managers (the community conservation council CLB). This brings the potential for Frontier to offer technical support to the CLB via training, resource assessment and ecotourism.

2 Training

2.1 Briefing Sessions

Introductory briefings were given on site during the first two days of phase (Table 1).

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<tr>
<th>Lecture</th>
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</tr>
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<tr>
<td>Introduction to Frontier Madagascar</td>
<td>Julien Godfrey (JG)</td>
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<td>Health and safety</td>
<td>Julien Godfrey (JG)</td>
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<td>Medical</td>
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</tr>
<tr>
<td>Introduction to MGF</td>
<td>Olivia Haggis (OH)</td>
</tr>
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</table>

2.2 Science Lectures

- Project briefing
- Natural History of Madagascar
- Introduction to reptiles and identification practical
- Introduction to birds and practical
- Introduction to mammals
- GPS, GIS and remote sensing and practical
- Principles of Biodiversity
- Biodiversity Conservation
• Conservation strategy
• Survey and monitoring techniques

2.3 Field Training

Field training was given in the areas of bird surveys, supported by sessions on songs and calls using recordings held several times a week, along with small mammal and pitfall trapping.

2.4 BTEC

MGF 10 week diploma
Stephanie Goodwin – The impact of forest clearance on plant species distribution and abundance
Daniel Surtees – Phelsuma behaviour
Adam Crisp – The influence of habitat on Zonosaurus behaviour
Marissa Weis – Black lemur behaviour

3 Research Work Programme

3.1 Overview

During phase 122, MGF research effort was divided between surveys assessing the impacts of forest clearance on vertebrate communities and the influence of human disturbance on lemur behaviour, in particular vocalisations. New projects have started investigating reptile behaviour, in particular Phelsuma and Zonosaurus. A plant species study was carried out by a dissertation student as part of a Masters and BTEC project.

3.2 The impacts of forest clearance on reptiles, amphibians and birds

Introduction

More than 50% of threatened species are found in 1.4% of the earth’s land surface, which includes biodiversity hotspots (Myers et al. 2000). These hotspots include the entire ranges of 44% of the world’s plant species and 35% of terrestrial vertebrates, and have already lost more than 70% or more of their original habitat (Brooks et al. 2008). To date, habitat destruction, primarily for agriculture, has been one of the greatest drivers of anthropogenic extinctions (Diamond, 1989). It is estimated that more than 90% of species endemic to Madagascar are entirely dependent on forest
and woodland habitats (Dufils, 2003). Brooks et al. (2002) predicted that if current deforestation rates continue, Madagascar is amongst the areas that will suffer most species losses in the near future.

Madagascar is one of the ‘hottest’ biodiversity hotspots due to its uniquely high endemism and its relatively recent colonisation by humans but sadly social, cultural, economic and political factors are resulting in continued forest clearance and degradation (Ganzhorn et al. 2001). Estimates of deforestation rates are controversial, and have often been stymied by lack of high quality data. Recent analysis using satellite and aerial imagery suggest that over 40% of remaining forest cover was lost between 1950 and 2000 (Harper et al. 2007). Estimates of eras prior to this are based on often subjective accounts and suffer from bias (Jarosz, 1993). Nonetheless, there is very little doubt that deforestation has been extensive and rapid.

In Madagascar, forests are managed through a number of governmental and community actors, with technical support from NGOs. Madagascar National Parks (MNP, formerly ANGAP) manages areas with the higher protected status. However, even forests outside of the MNP reserves have been found to hold substantial biodiversity and provide significant services to human users (Ingram and Dawson, 2006), thus have a considerable conservation value. A recent assessment of Madagascar’s forests found there to be 40246 km$^2$ of forests outside reserves (Nicoll, 2003), compared to a total reserve area of approximately 170000km$^2$ (Randrianandianina, et al. 2003). The majority of Madagascar’s terrestrial biodiversity is found in its forests. Malagasy endemity is estimated at 51% in birds (Hawkins and Goodman, 2003), 100% in terrestrial mammals (Goodman et al. 2003), 91 % in reptiles (Raxworthy, 2003), 99% in amphibians (Glaw and Vences, 2007), and 81% in terrestrial plants (Gautier and Goodman, 2003). Furthermore, it is estimated that the large majority of these endemic species are forest dependent to some degree, and forest clearance is considered key contributor to biodiversity loss in Madagascar (Harper et al. 2007). In the Southern spiny forests, Scott et al. (2006) found small mammal, lizard and bird communities differed in ‘forest’ and ‘cleared’ sites. Overall, species richness was lower in ‘cleared’ areas for all taxa. Impacts were particularly significant for lizards, with a 50% drop in species richness in ‘cleared’ areas. However, individual species responded differently to clearance, with reptiles and forest specialist species being worse affected.

The Sambirano domain is located in the north west of Madagascar, around the Sambirano River and the regional centre town of Ambanja. It makes up the northern end of the forest band running the length of Madagascar, adjoining the mountainous montane forests of the central domain and the
Eastern humid forests of the east coast. However, the forests are distinct, probably due in part to the different substrate, sandstone, as opposed to the much more widespread igneous and metamorphic basement rocks (Du Poy and Moat, 2003). It has a short and mild dry season (3-4 months) (Legris and Blasco, 1965), and receives over >1800mm rain annually (Wells, 2003); with the climax vegetation being lowland rain forest (Gautier and Goodman, 2003). It is probably the most recent of Madagascar’s biomes, arising as a result of the onset of the Indian Monsoons approximately 8 mya (Wells, 2003). Floral surveys have found a mix of Sambirano endemics (14%), species shared with the Western and Eastern domain (21% and 16%), and the remainder (49%) widespread throughout Madagascar (Gautier, et al. 1996). The area is subject to slash and burn agriculture, charcoal making, selective logging, and collection of timber for fuel and cooking. Due to its limited extent, along with the high mountain domain, it is considered the most threatened domain (Langrand, 1990).

There is substantial literature on community recovery following clearance. In a review of plant and bird community recovery, Dunn (2004) found that over time communities approached their pre-clearance species richness in the overwhelming majority of cases. Bowen et al. (2007) reviewed 68 studies of regrowth forests and found general recovery of species richness over time, but also that factors such as land-use history are important. Few studies have considered multiple taxa, despite the likelihood that different taxa respond to recovery at different spatial and temporal scales. We are not aware of any that have considered recovery of terrestrial animal communities over time in Madagascar, or specifically in the Sambirano domain. This study examines the recovery of reptile and amphibian communities in Sambirano forests. We compare species presence/absence and abundance data from six sites along a recovery gradient, from land currently under agriculture to forest which has never been cleared.

Methods

Study Area

This study was undertaken at sites around the village of Ambalahonko, in the commune of Antafondro, Nosy Be. Nosy Be is the largest island of Madagascar and is found on the north west coast. Ambalahonko lies a short distance from the boundary of Lokobe (Réserve Naturelle Integral de Lokobe), a 740ha Strict Nature Reserve. The reserve is surrounded by forest managed by Ministere des Eaux et Forets (MEF). This contiguous area represents one of the largest remaining relatively undisturbed, large patches of Sambirano type forest, and is the only remaining forest on the island,
the majority of which is now under cultivation. Over recent decades, the amount of land being farmed in the area has fallen, as a result of a growing tourist industry, a decline in agricultural commodity prices and a rise in the value of fish and seafood. In addition, the halting of clearance within the MEF managed buffer zone in 1982 has allowed the regeneration of a strip of forest along the coast, and the later cessation of clearance along the eastern edge of the forest has allowed another area to regenerate for approximately 18 years. These forests are now subject to controlled selective logging for subsistence activities considered important by local resource managers, MEF and the CLB. Large trees can only be taken for use in building houses or pirogues, a wooden canoe with an outrigger used by artisanal fishermen in this area. Collection of plants for medicinal purposes is permitted. In addition, a number of trails have been cut to allow access to guided tourists in several areas, mainly near to the National Park boundary. Interviews suggest that most people consume some kinds of bush meat, although rarely, but hunting mainly occurs outside of the forest in second growth habitats.

Sites were selected along a recovery gradient, all in close proximity to the village of Ambalahonko (Table 2). We substituted spatial for temporal variation, selecting six sites at different stages of recovery. We chose two sites under current agricultural use, one each of 10, 20, 30 years recovery, and one that has not been cleared within local community memory.

Table 2. Location and description of survey sites

<table>
<thead>
<tr>
<th>Site</th>
<th>UTM grid</th>
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<th>y</th>
<th>Time since clearance</th>
<th>Use</th>
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<td>Subsistence timber extraction, vanilla and</td>
</tr>
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<td>3</td>
<td>39S</td>
<td>0212141</td>
<td>8516676</td>
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<td>4</td>
<td>39S</td>
<td>0212174</td>
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<td>10 years</td>
<td>Abandoned land, reverting to forest</td>
</tr>
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<td>5</td>
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<td>0212266</td>
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<td>0212583</td>
<td>8516754</td>
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</table>
Reptile and Amphibians surveys

Ten time-constrained active searches for each site (eight during the day and two at night) and casual observations were conducted to survey reptile and amphibian communities at each of the six sites (giving a total of 60 surveys). Searches were led by at least one Frontier field staff member and a number of volunteers. Group size varied between 4 and 7 surveyors. Surveys lasted a total of 180 observer minutes so larger teams surveyed for a shorter period of time. Searches took place within the ‘cleared’ area or within 100m of old pitfall lines at forest sites. Searches were carried out on foot at a steady pace, observing all forest levels and conducting refuge examinations (i.e. under leaf litter, logs and other microhabitats). All microhabitats, such as streams or riverbeds, within these areas were searched. In addition, a pitfall line with traps was set up at sites 1 and 6 which were checked twice daily (morning and evening) until 15 data points were collected at each site. The pitfall line was 100m and consisted of eleven, 29cm deep by 29 cm diameter buckets, placed at 10m intervals along a plastic fence. The buckets were buried flush to the ground and a small amount of soil and leaf litter deposited to act as a refuge for captured specimens. Small holes were made in the base of the buckets to allow water to drain. A 40cm high drift fence, passing over the centre of each bucket, was erected using wooden stakes and the bottom 5 cm buried in the soil. Captured individuals were recorded and released on site.

Small mammals

We decided to set up Sherman traps only at site 1 as previous work at these sites found very little variation in species with only one species (*Rattus rattus*) of small mammal captured previously in Sherman traps. We wanted to see if, during dry season, there would be different species being caught, but as we also just found rats, it was decided not to set them up at the other sites. A grid of 30 (10 x 3) Sherman traps was opened for 10 nights. Half of the traps were placed on the ground and half were secured in the lower canopy. Bait of rice, bananas, nuts and other food waste was tried. Traps were opened in the evening and checked in the morning. Individuals caught were identified, and morphometric measurements taken where identity was not immediately apparent. Animals were released immediately after identification.

Casual observations

A substantial amount of time was spent at survey sites outside of survey times. Animals were
encountered while setting up Sherman trapping grids. Animals, other than those caught in traps, were encountered during trap checking. Finally, animals were seen on the route, near to the sites. Species encountered in this manner were identified and recorded. Casual observations were not included in the analysis.

Statistics

Statistics were carried out using Graph Pad Prism 5. One way ANOVAs were used to determine the influence of different sites on species numbers.

Results

Herpetofauna species

A total of 35 different species were found over the 60 surveys carried out (10 at each of the six sites; Table 3 below). The average number of species found each survey did not vary significantly over the 10 surveys (Figure 2; One way ANOVA, $F_{9,47} = 1.49$, $p = 0.18$). Overall, for reptile and amphibian species, there was a significant difference between the number of species found at each site (Figure 3A; $F_{5,54} = 4.43$, $p < 0.01$) with post hoc test (Bonferroni’s Multiple comparison test) showing a significant difference between sites 4 compared to sites 1, 3 and 5 with $p < 0.05$ for all. There was also a significant difference in the total number of reptiles and amphibians found at the different sites, with the most found at site 3 and the least at site 4 (Figure 3B; $F_{5,54} = 6.08$, $p < 0.001$). Post hoc tests (Bonferroni’s multiple comparison test) showed significant differences between sites 3 compared to sites 2, 4, 5 and 6, with $p < 0.05$ for all. A greater abundance and diversity was found at all sites in the day searches compared to the night searches (Figure 4). The influence of clearance on specific species is shown in Figure 5.

In total, five species were caught in the pitfall traps; a total of 84 individuals at site 1 and 2 at site 6 (Figure 6). At site 1 we found three different species, mainly the frog *Stumpffia pygmaea* (total = 73), but also *Zonosaurus rufipes* (total = 9) and two *Zonosaurus madagascariensis*. At site 6 we only found two different species, one snake *Mimophis mahfalensis* and one skink *Trachylepis gravenhorstii*. 
Table 3 The diversity and abundance of different reptile and amphibian species found at each of the six sites

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16/11/2012
Figure 2 The variation in the average number of species found at all the six sites over the 10 surveys carried out, with surveys 9 and 10 carried out at night (mean ± SEM)

Figure 3 The average number of different reptile and amphibian species present at each of the six sites over 10 surveys (A) and the total number of reptiles and amphibians found over the 10 surveys at each site (B). Mean ± SEM
Figure 4 The influence of time of day on the number of species (A) and total number of individuals (B) found during active searches in the day (n=8 at each site) and during the night (n=2 at each site)
Figure 5 Total number of Zonosaurus (A), geckos (B), chameleons (C), snakes (D) and amphibians (E)
found over the 10 surveys at each of the six sites.

Figure 6 Total number of reptiles and amphibians found during 15 pitfall trap searches at sites 1 and 6

Discussion

The highest abundance of reptiles and amphibians was seen at site 3 and the lowest at site 4. Site 4 also had a very low number of species present compared to the other sites. Although there was a significant influence of site on herpetofauna communities, overall it was not a clear cut sliding scale with species diversity dropping the more recently clearance occurred as one might predict, and different species appear to be affected by clearance to differing degrees. Very few species were found only in early stage habitats and most were able to persist in more mature forests. Some forest reptiles were found in much higher numbers in older forest, such as chameleons and Zonosaurus and some specific species were not found at all in early young forests and recently abandoned areas, such as the chameleons Brookesia stumpffi and Brookesia minima. These species appear to be particularly at risk from clearance. The diversity of geckos increased in more open areas, which may be a reflection of the less dense foliage, increasing the ease of spotting them in addition to the increase in exposure to the sun found at these more open sites. There was a greater abundance and diversity of species found in the day searches compared to the night, but this may just be a reflection of the increased number of searches conducted during the day. More active searches at night are needed in order to determine the causes of this difference.

Frog communities changed in more mature forests, becoming dominated by the tiny Stumpffia pygmaea with Ptychadena mascariensis being found in high numbers in the more cleared areas. The Stumpffia pygmaea species is considered vulnerable so it is of importance that it seems to be detrimentally influenced by clearance of the forest. However, frog communities did not become
more diverse, even at the site that had never been cleared. The highest number of frogs was found at site 3. This site has a stream running through it, whereas the others were dry for much of the survey.

Continued data collection over the coming months will allow for investigation into the effect of seasonal changes on diversity and abundance. This will allow for more powerful conclusions to be drawn. This study highlights the potential benefits of forest recovery for herpetofaunal communities in the Sambirano domain of Madagascar, but also the likelihood that site scale forest recovery alone is insufficient for the conservation of all species.

3.3 The influence of human disturbance on lemur behaviour

Introduction

Madagascar has one of the highest levels of biodiversity but this diversity is also some of the most threatened by the actions and behaviour of humans (Raxworthy & Nussbaum 1994). With a rapidly growing worldwide population and an ever increasing demand for a wide variety of resources, humans are encroaching on previously undisturbed environments. From a conservation perspective it is important to assess the impact of human behaviour on the environment. Many studies have concentrated on collecting data on the diversity and abundance of species at certain sites comparing between those with most disturbance and those with less. This is an important measure, however, it may be of more value to assess how many of the species will survive in the longer term (Williams & Arayo 2000). An assessment of a species vulnerability and probable long term success will allow for more effective conservation action to be implemented (Hawkins et al. 1990). Therefore it may be of significant value to assess the effect of human disturbance on the behaviour of animals. Negative effects on behaviour could suggest the species is more threatened.

Anthropogenic disturbance has been shown to have a negative effect on behaviour in a range of species. In the long term, birds have been shown to have adapted to anthropogenic noise disturbance by exploiting frequency windows outside of the range of manmade background noise (Slabberkoorn and Smith 2002; Patricelle 2006; Milius 2003). As an example of short term behavioural changes, when in the presence of boats, killer whales, Orcinus orca, were found to reduce their energy intake by 18%. These repeated short term avoidance tactics could lead to longer term impacts at the population level (Williams et al. 2006). These examples show that human disturbance can have negative impacts on individuals in the population, and that if the population cannot adapt to these changes then there will be further negative impacts. Behavioural reactions to
anthropogenic disturbance are clearly an important area of research from a conservation perspective.

The black lemur (*Eulemur macaco macaco*) is one of 28 species of lemurs, and are only found on the north-western tip of Madagascar and the two adjacent small islands of Nosy Komba and Nosy Be. The black lemur is unique among lemurs in that the species displays sexual dimorphism in colour. The natural habitat of the black lemur is undisturbed tropical rain forest, but black lemurs have been reported in regenerated (secondary) forest, tree farms, and croplands with trees (such as coffee and cashew plantations). Although estimates indicate that black lemur numbers are in decline and they are listed as vulnerable on the IUCN Red List of Threatened Species and are protected under Appendix I of CITES, there is still much to be learnt about their behaviour. This study aimed to determine the influence of human disturbance on the behaviour of a population of black lemurs (*Eulemur macaco macaco*) on the border of the Lokobe Reserve on Nosy Be, focusing on vocalisations. This population lends itself well to the study as groups are found in a number of sites ranging in human disturbance levels - from very little in primary rainforest sites on the border of Lokobe Reserve, to very high levels in groups living on the edge of human settlements.

Objectives:

1. To establish if there is a relationship between vocalisations (both grunts and calls) and occurrence of human disturbance
2. To investigate whether the proximity to human habitation and forest type affect group size
3. To establish whether the time to locate a group is influenced by the level of human disturbance
4. To determine if there is a relationship between vocalisations (grunts and calls) and either the group size or the number of females in the group

It was predicted that lemurs living in areas more recently cleared and nearer to human habitation would be more habituated to the presence of humans and would therefore respond to the presence of researchers with less vocalisations. These individuals would therefore be easier and faster to locate for observations.

Methods

*Species*
Surveys were carried out on groups of wild black lemurs (*Eulemur macaco macaco*)

**Sites**

The research camp was located in the village of Ambalahonko, 30 minutes from the capital of Nosy Be, Hellville (in north western Madagascar) on the border of Lokobe Reserve in the south eastern corner of the island. The sites surveyed were divided into three categories; sites in category A were far from human habitation and in areas of forest that had never been cleared (GPS coordinates in Table 4); sites in category B were in forest that was cleared approximately 18 years ago and were accessed often by villagers as they are used for vanilla farming or on paths used to access these areas; sites in category C were very close to human habitation.

**Table 4 GPS coordinates of the sites in Categories A, B and C**

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**Survey protocol**

Surveys were carried out two to three times a day, once or twice in the morning and once in the early evening, with at least one hour of data collected each survey. Surveys were carried out 17 times at each site (a total of 51 hours of data collection) between the 13<sup>th</sup> of November 2011 and the 7<sup>th</sup> of March 2012. Observations were recorded in five minute blocks, and behaviours such as grooming and the number of calls were documented. A grunt score system was implemented to represent call/grunt level (0 = no grunts; 1 = occasional grunts (approximately 5 or less); 2 = frequent grunts (approximately more than 5 but not continuous) and 3 = continuous grunting). The time
when the researchers entered the forest was noted along with the time at which the lemurs were
found and observational data was collected. The total group size and group composition was noted.

Analysis
Statistics were carried out using Graph Pad Prism 5. One way ANOVAs were used to analyse the
influence of sites on the time to locate the group, the group size, the number of young and
vocalisations. The post hoc test used was the Bonferroni’s multiple comparison test. Correlations
between vocalisations (calls or grunts) and group size or number of young were measured using
linear regression. The limit of significance was $\alpha = 0.05$.

Results

There was a difference between the occurrence of human disturbance at A, B and C (Figure 7) with
some form of human interference during surveying occurring every time at C (100%), 13 out of 24
times at B (54%) and twice at A (10%).

![Figure 7](image-url)

*Figure 7* Human disturbance at each site measured by the proportion of surveys out of the 10 in
which some form of human disruption was noted

The time taken to locate a group varied significantly at the different sites (Figure 8; $F_{2,61} = 10.48$, $p < 0.0001$), taking significantly longer at A compared to B and A compared to C (Bonferroni’s Multiple
Comparison post hoc test $p < 0.05$).
The estimated size of the group, based on all individuals seen during the hour of recording, did not vary significantly depending on site (Figure 9; $F_{2,61} = 2.99$, $p = 0.58$).

Figure 8 The influence of the site on the time to locate a group of lemurs at site A (n=20), B (n=24) and C (n=20). Mean ± SEM.

Figure 9 The influence of site on the estimated size of the group (site A n=20, site B n=24, site C n=20). Mean ± SEM.
The number of young in groups did not vary significantly depending on site (Figure 10; \( F_{2,61} = 2.64, p = 0.079 \)).

![Figure 10](image.png)

**Figure 10** The influence of site on the number of young present in the group (A) n=20, (B) n=24, (C) n=20. Mean ± SEM

The location of the site had a significant influence on vocalisations (Figure 10; Grunts \( F_{2,61} = 10.99, p < 0.0001 \); calls \( F_{2,61} = 10.08, p = 0.0002 \)). The number of grunts made was significantly higher at site A compared to both B and C (post hoc test \( p < 0.05 \)) and the number of calls made was also higher at site A compared to both B and C (post hoc test \( p < 0.05 \)).

![Graphs](image.png)
Figure 10 The influence of site on vocalisations A) grunts and B) calls (site A n=20, site B n=24, site C n=20).

There were significantly more vocalisations made by groups at site A compared to B and C (p < 0.05). Furthermore there was a significant positive relationship between the number of calls and the size of the group ($r^2 = 0.16$, p = 0.0012; Figure 11 A) and between the number of grunts and the size of the group ($r^2 = 0.32$, p < 0.0001; Figure 11B).

![Figure 11](image1)

Figure 11 The relationship between the number of calls (A) and number of grunts (B) made in an hour at sites A, B and C and group size (n = 64)

There was a significant positive relationship between the number of calls and the number of young in the group ($r^2 = 0.126$, p = 0.004; Figure 12A) and between the number of grunts and the number of young ($r^2 = 0.33$, p < 0.0001; Figure 12B).

![Figure 12](image2)
Figure 12 The relationship between the number of calls (A) and grunts (B) made in an hour at sites A, B and C and the number of young in the group (n = 64)

Both the number of calls and the number of grunts at all sites are reduced over the course of the surveys (Figure 13).

![Figure 13](image-url)

Figure 13 The relationship between the number of calls (A) and grunts (B) made in an hour at sites A, B and C over the course of the surveys (averaged over blocks of 5 surveys).

Discussion

There was a difference between the occurrence of human disturbance at sites A, B and C with accompanying differences in other factors. At site A, with the least human disturbance, it took longer to locate the lemurs and the lemurs displayed a higher number of both grunts and calls. It seems that the higher level of vocalisations displayed by individuals located at A is not as a consequence of larger group sizes as there was no difference in group size between the different sites so it is likely to be due to their lack of contact with humans. This hypothesis is also supported by the finding that the number of vocalisations (both calls and grunts) made by individuals at all sites decreased over the course of the study which could be due to familiarisation with the researchers. This gradual habituation to human disturbance could also explain the lack of significant differences in vocalisations between sites in categories B and C, compared to A and B and A and C, as individuals in category B have been exposed to human presence prior to the start of the study.
There was no relationship between the number of young in the group and the number of vocalisations. However, this could be linked to the time of year as there are no longer young within the groups.

Previously, during the breeding season, we found that groups with more young communicated more, with a significantly higher number of both calls and grunts when more young were present. Increased vocalisations at this time, with more young, could have been to defend the more vulnerable young from potential threats and to make sure they did not stray too far from the group and get lost. It also may be that some of the vocalisations were part of the developmental learning process of young lemurs, e.g. food sources.

As notes were taken on all aspects of behaviour, more detailed analysis can additionally be carried out on this data, looking for example at the frequency and patterns of grooming (Do males groom females more? Does location influence grooming?), or at which sex was the first to approach and vocalise the most.

I would also like to go on to investigate the effect of recording vocalisations and playing back grunts and calls to groups in different areas. It is predicted that those animals living further away from humans - who respond more to us with calls, will be more responsive to playback calls. It would also be interesting to investigate the effects on behaviour and vocalisations of playing back calls made by the same group compared to vocalisations from individuals from another group.

### 3.4 Plated lizard behaviour and habitat preference

**Abstract**

The study focused on two species of plated lizard, *Zonosaurus madagascariensis* and *Zonosaurus rufipes*, to investigate differences in behaviour and to determine how this might be influencing the high abundance of *Zonosaurus rufipes* only in older forest compared to the more widespread distribution of *Zonosaurus madagascariensis*.

**Introduction**

Madagascar has an incredibly high number of endemic fauna. This is particularly true of the herpetofauna of which 93% is endemic to Madagascar (Glaw and Vences, 2007). The ground lizards of Madagascar are mainly made up of 5 families; Chamaeleonidae, Iguanidae, Gerrhosauridae, Scincidae and Gekkonidae. There are two genera of Gerrhosauridae in Madagascar and eleven...
genera of Scincidae lizard. Together these make up the vast majority of the ground lizards with some species from the scincid lizard group even becoming adapted to a burrowing lifestyle. These two families may superficially look similar but can be distinguished by the lateral longitudinal fold which runs the whole anterior body in Zonosaurus but is lacking in the Trachylepis genus (Glaw and Vences 2007). Of the Gerrhosaurids there are two genera that are found on the African mainland and two from Madagascar (Glaw and Vences 2007). Habitat composition is an important factor in the distribution of many of these species, but deforestation of primary forest has become more and more common in order to support agricultural practices such fruit and spice plantations, rice farming and livestock grazing. This land clearing is particularly detrimental for forest dependent species as it causes forest fragmentation. Degraded habitats cause forest dependant species to be outcompeted and limits them to smaller habitat areas.

Zonosaurus rufipes are found in lowland humid forest and occur at high densities in some areas, especially near streams (Glaw and Vences 2007). Sadly this species is listed as Near Threatened on the IUCN list as the population is presumed to be both declining and severely fragmented due to continuing human pressure on lowland rainforest throughout its range, such as the conversion to farmland and the extraction of timber. On the other hand, Zonosaurus madagascariensis is listed as Least Concern in view of its presumed large population and wide distribution, occurring in most parts of the country and on the nearby islands of Nosy Be, Nosy Komba, Nosy Sakatia, and Nosy Tanikely. It is found in a range of habitat types, including open and degraded humid forest at mid and low altitudes, as well as plantations (Glaw and Vences 2007). It also occurs within relatively intact humid forest vegetation in open patches exposed to the sun (Glaw and Vences 2007). It is predominantly a ground-dweller that can occasionally be found climbing on cliffs and tree trunks. Overall there are no threats to this adaptable species.

Unlike the widespread Zonosaurus madagascariensis, Zonosaurus rufipes is found only in Lokobe, Ankarana and Marojejy protected areas and protection of additional forest may be required to benefit this species. This study investigated the abundance and behaviour of both species in different habitat types around the Lokobe area of Nosy Be island located off the west coast of Madagascar, over the month of May 2012. Research in this field and understanding more about the differences in behaviour that account for the differences in adaptability and the ability to live in cleared areas will help verify population trends in Zonosaurus rufipes. This will improve the understanding of its distribution and assess the impact of threats.
Methods

Behavioural data was collected in 30 minute sessions. During this time, a single individual was observed and the number of minutes spent conducting various activities was recorded, such as resting, foraging, eating and moving its tail. The date, time of day, researchers present, along with an estimation of lizard size and total distance covered during the survey were also noted. As *Zonosaurus rufipes* are normally found in undisturbed environments and *Zonosaurus madagascariensis* are more widespread, data was collected from two different age categories of habitats; site 1 which is primary forest and site 3 which has 20 year regrowth.

Results

Studies from active searches this phase, along with previous transects carried out, showed that *Zonosaurus rufipes* were only found in sites that were 20 years or older, whereas *Zonosaurus madagascariensis* were found in all site types (Figure 14). There was a very high abundance of *Zonosaurus rufipes* found at site 1 and the highest number of *Zonosaurus madagascariensis* found at site 3. Preliminary data so far on the behaviour of the species, carried out at sites 1 and 3, showed that they were both mainly active (moving, foraging and feeding) in the morning and less so in the afternoon, when the majority of time is spent resting.

![Figure 14](image.png)

*Figure 14* The distribution of the two species of *Zonosaurus* across the six study sites

Discussion

From the results that have been gathered so far it is obvious that *Zonosaurus rufipes* is only found in fairly well established forest fragments, with the majority of them found in 30 year forest and
primary forest. Primary habitats and older secondary re-growth contain an increase in microhabitats and a decrease in homogeneity as compared with agricultural land and younger re-growth, which likely provides an increase in diversity of insects for nutrition and living/hiding spaces. The results of this preliminary study confirm that this is an effective method for collecting behavioural data on these species and the findings will be built on in the following months. As both species are more active during the morning, future studies will be carried out at this time of day. Through understanding more about the selective habitat preference of *Zonosaurus rufipes*, the results will aid in the development of environmental conservation strategies to help this more vulnerable population.

4 Summary of outputs produced

NA

5 Community work and public awareness

It was not possible to have any feedback sessions with members of the CLB.

6 Proposed science programme for next phase

6.1 Overview

Phase 123 will continue to build on the active search data collected at the different sites looking at the impact of clearance on reptile and amphibian species (also forming part of a dissertation project). Lemur behaviour and vocalisation research will continue, including the introduction of a time budget component focusing on how the lemurs spend their time. Additionally, playback with grunts and calls from familiar and non-familiar lemur groups will start. A project for the new ARO will start, possibly involving lemur behaviour. The reptile behaviour work with *Zonosaurus* will continue, led by the new forest CA Adam Crisp who has been piloting it for his BTEC project. We are hoping to have permits to take ant specimens and study ant distributions along a disturbance gradient (with a Malagasy student from Diego University).
References


Campbell and Christman (1981) Field techniques for herpetofaunal community analysis


