FRONTIER

MADAGASCAR FOREST CONSERVATION PROGRAMME

Nosy Be, Madagascar

MGF Phase 174 Science Report

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General Introduction

Madagascar is famous for its biological communities (Scales, 2014). Percolating literature, documentary, and even motion picture, indicates the islands' charismatic species that are known globally for their unique ecology.

Madagascar is the world's fourth largest island and lies in the western Indian Ocean, adjacent to South Africa and Mozambique (Mayaux 2004). Rugged massifs dominate the topography of its eastern coast and central highlands; over 50 percent of Madagascar's landmass is above 500m (Moat & Smith 2007). These features, accompanied by unique trade winds and ocean currents around the island (Jury 2003), have shaped large aspects of biotic cover distribution. Madagascar is characterised by a high diversity of microclimates—discrete abiotic pockets of different weather conditions (Dewar & Richard 2007). Thus, vegetation and habitats in general are complementary fine-grained heterogeneity. This variation is largely implicated as the driver of micro-endemism in Madagascar, where species show high levels of adaption to local environments, are less able to disperse, and accumulate reproductive isolation (Vences et al., 2009; Wilme et al., 2006).

Most species in Madagascar are found nowhere else on earth (Goodman & Beanstead, 2003; Philipson *et al.* 2006). Having radiated into depauperate biological communities following the cretaceous-tertiary extinction event (Alvarez *et al.*, 1980), Malagasy taxa have since become dominated by a few speciose clades (Goodman & Benstead 2005; Poux et al. 2005). Subsequently, peculiar assemblages have taken hold on the island. An example being that Madagascar is the global hub for chameleon species richness, yet hosts no salamanders (Glaw & Vences 2007). Madagascar's ecosystems have evolved in relative isolation from other landmasses since its separation from India 90 million years ago (Storey *et al.*, 1995). This has meant that, not only does the island host native species, but entirely endemic genera and families; this higher taxa distinctness is often cited as what sets Madagascar apart from analogous landmasses in terms of biological uniqueness (Ganzhorn et al., 2014).

Forest habitats on Madagascar are under threat (Harper *et al.*, 2007). A gamut of anthropogenic activities, including 'tavy' (slash and burn) and oxen grazing, have caused historic forest declines across the island (Clark, 2012). Over 90 percent of Madagascar's endemics rely on forests (Dufils, 2003). Thus, the decline of the island's woodlands has been implicated as leaving species more vulnerable to population declines, extirpations, and extinctions (Irwin et al., 2010). The uniqueness of its assemblages and the continued threat of human-driven deforestation have led to Madagascar being classified as a biodiversity hotspot (Myers *et al*., 2000), and being widely considered a global conservation priority (Ganzhorn *et al.*, 2014).

The capacity of Madagascar's species to adapt to dynamic and changeable environmental conditions will likely influence their fitness and impact their long-term prospects of persistence in the years to come (Scott *et al*., 2006). Liberating knowledge about how animals use Malagasy forests, and how these relationships are changing (if at all) can provide insights into the trajectories of these ecosystems amid evolving human influences, and as a result can inform future conservation interventions.

Research Mission

Frontier's Madagascar project (MGF) has continuing aims to: measure and monitor the abundance of forest animals over time and space; map the structure and geographic layout of woodlands adjacent to Lokobe national park (LNP); build a fuller understanding of how species utilise forests and their resources; and to examine these factors along a human disturbance gradient to elucidate potential effects of changing anthropogenic influences.

In exploring these topics our goal is to better understand the ecology of the biological communities in our research area and propose future conservation efforts if required. We conduct this research within a frame of sustainable development of local subsistence communities so that historic use of forests can continue, informed by empirical data of community – forest interactions.

Training

Briefing sessions & Science Lectures

Introductory briefings were given in our community house prior to deployment to the field; science lectures were carried out within the first two weeks (Table 1).

Field training was given to new team members and repeated throughout their contract at appropriate intervals to maintain high levels of competency in terms of species identification and data management. Initial training consisted of a series of group sessions, each focusing on a specific topic, where Research Assistants (RAs) were shown how to identify certain species and families, and how to record various data (Table 2.). Once RAs passed their species tests with a score of ≥ 98% using computer tests they were then tested in the field. Competency in skills such as bird call identification and animal handling were evaluated by the principal investigator.

Table 1: Training sessions

Briefing sessions	Presenter
Unit 1.1 House Tour and Town Orientation	ALL
Unit 1.2 General Frontier Madagascar Introduction	ALL
Unit 1.3 Health & Safety Presentation and Test	ALL
Unit 1.4 Medical Presentation and Test	ALL
Unit 1.5 Camp Tour	ALL

Table 2: Science sessions

Scientific lectures	Presenter
Unit 2.1 Introduction to MGF	ALL
Unit 2.2 Introduction to Reptile ID and survey techniques	ALL
Unit 2.3 Introduction to Bird ID and survey techniques	ALL
Unit 2.7 Introduction to Lemur Behavior and Ethogram	ALL
Unit 2.8 Introduction to Bird calls	ALL

- **Introduction to bird survey techniques and ID calls:** field guides, diagnostic features, and evaluation of flight patterns and audio calls. Regular evaluation was tested using flash cards and pre-recorded bird calls.
- **Introduction to reptile survey techniques:** field guides, diagnostic features, and evaluation of habitat use.
- **Introduction to lemur behaviour and ethogram:** field guides and diagnostic features. Appropriate behaviour during surveying and surveying techniques. Methodology of recording primate behaviour was taught.

During phase 174 two new lectures were introduced, presented by specialised staff.

- **Insect lecture (presenter: GH)**: Introduction to insect diversity, characteristics and classification.
- **Lemur lecture (presenter: OS)**: Introduction to lemur origins, diversity, characteristics and describing lemur behaviour and conservation issues.

Survey Area

All research described in this report was conducted at MGF’s terrestrial research site, currently located on Nosy Be. This offshore island is Madagascar’s largest (320 km^2) and lies ~8km off the northwest coast (Fig. 1). Nosy Be is a staple part of the Sambirano domain—a bio-geographic region in the northwest of Madagascar characterised by transitional habitat from eastern humid rainforests to western dry forests. For example, the Sambirano region has significantly less rainfall than eastern forests but significantly more than those in the west (Goodman & Benstead 2003). Thus, the forests on Nosy Be are classified as sub-humid with seasonal monsoon conditions (Andreone *et al*. 2003).

Our study area is situated on a peninsula to the southwest of Nosy Be, sandwiched between LNP—the only protected habitat on Nosy Be—and the sea. LNP is renowned for its biological diversity, typified by high species richness and endemism. The scatterings of woodland south of LNP are where our research was conducted.

Adjacent to our research camp is the small subsistence community of Ambalahonko. This village hosts approximately 100 people who use their neighbouring habitats in a variety of ways. Many small patches of agricultural land are maintained around our study area. Culturing these fields, using forests for timber, and generally moving through these forests is likely to introduce some aspect of disturbance into these habitats.

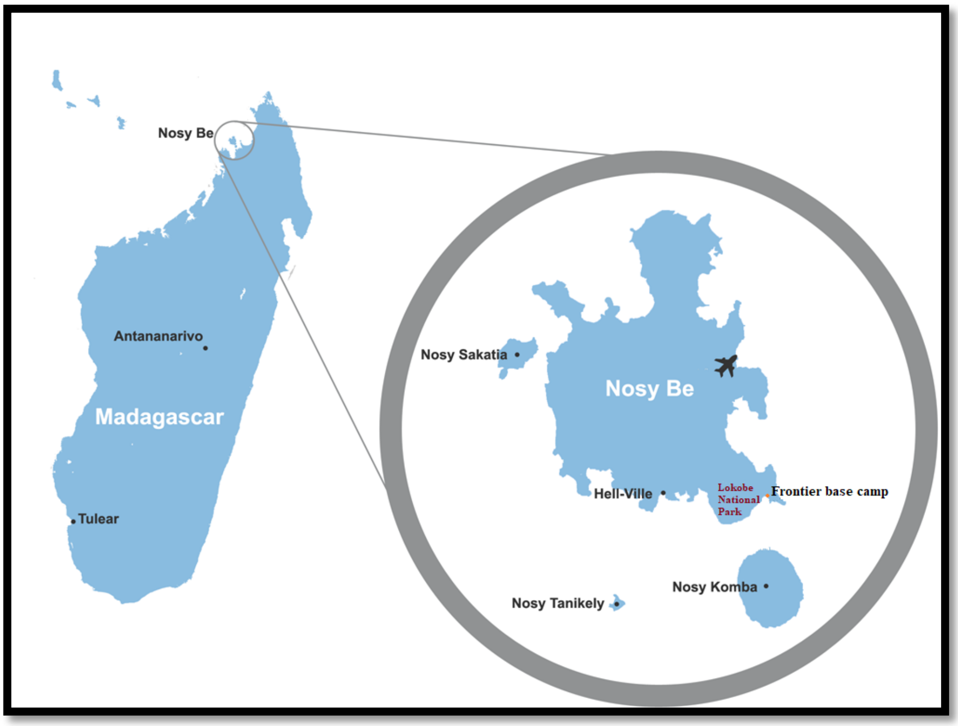

Figure 1: location of Nosy be, LNP, and MGF study area

Survey routes

Within our study area sixteen survey routes running through forests and adjacent habitats were selected along a suspected gradient of human disturbance (Fig. 2; Table 3). Survey routes used pre-existing forest trails with a 'no-chop' policy to reduce impacts of our research on the ecological health of these habitats.

Routes were classified as 'primary', 'secondary', or 'degraded'; this was determined by amateur observations of vegetative structure and composition, time since they were last cleared, and current land usage. Primary forest was generally assumed to have lower levels of human disturbance than areas cleared regularly for agricultural purposes etc. The primary survey routes ran very close to the border of LNP; secondary and degraded routes were generally closer to human settlements.

Survey sites

- Seven sites were used for reptile surveys: two primary, two secondary and three degraded. These were each 200m in length. A new degraded survey route was introduced during this phase.
- Five transects were used for bird surveys: one primary, one secondary, two degraded, and one in mangroves adjacent to our research camp. These were each 800m in length.
- Four survey routes were used for lemur surveying. These survey routes are combinations of existing routes used for reptile and bird surveys.
- Lemur ethograms are carried out at random locations near all survey routes.

Figure 2: location of survey routes in our study area. Red dots = herpetofauna routes; yellow dots = bird routes; blue dot = research camp. (Image from Google earth).

Survey Site Overview

Site Code	**GPS Location of starting point** *South 13°*	*East 48°*	***Survey***	***Habitat Type***	***Description***
BP	24’48”	20’2”	Reptile	Primary	Primary forest along the border of LNP. Trail is kept free of vegetation to mark boundaries. Steep in places.
GG	24’40”	20’8”	Reptile, Lemur	Primary	Primary forest, with high density of Ravenala palms. Steep in places.
ZB	24’31”	20’18”	Bird, Lemur	Primary Closed Forest	Primary closed canopy forest; not been heavily cleared for many years. Individual trees have been recently removed for timber.
FC	23’46”	20’29”	Reptile	Secondary	Secondary closed canopy forest, located in Ampasipohy. Sparse ground vegetation. Several vanilla plantations. Guided tours occur frequently.
LKL	23’52”	20’28”	Reptile	Secondary	Secondary closed canopy forest, located in Ampasipohy. Dense ground vegetation.
FP	23’84”	20’52”	Bird, Lemur	Secondary	Secondary closed canopy forest, located in Ampasipohy. Dense ground vegetation. Guided tours occur frequently.
SS	24’12”	20’30”	Reptile	Degraded	Young secondary regrowth, primarily used for timber extraction. Located on a hillside. Vegetation is not diverse.
PP	24’7”	20’57”	Reptile, Lemur	Degraded	Located along a main pathway. Clear felled recently for charcoal production and agriculture.
LL	24’26”	20’59”	Reptile, Lemur	Degraded	Located along a main pathway, heavily degraded. Clear felled recently for charcoal production and agriculture.
TS	24’20”	21’0”	Bird	Degraded Open Habitat	Pathway through mixed plantations.
RP	13’24”	48’20”	Bird	Degraded Open Habitat	Pathway near mixed plantation and completely exhausted areas.
Mangrove	24’45”	20’84”	Bird, Lemur	Open habitat	Pathway running alongside the beach between the forest edge and mangroves.
TP	24’25”	20’49”	Reptile	Open habitat	Regenerating degraded steep path with some plantations along the way. Lots of palm trees.

Research Projects

Determining the abundance of Nosy Be Sportive lemurs (*Lepilemur tymerlacsonorum*)

Introduction

Sportive lemurs are medium-sized lemurs that populate the genus *Lepilemur*. They are distributed throughout most of Madagascar's remaining woodlands (Harcourt &Thornback, 1990; Mittermeier *et al*., 2003), yet their ecology is still poorly understood in comparison to other lemuriforms (Mittermeier *et al*., 2003). Recent taxonomic research has revealed that intra-genera diversity of sportive lemurs has likely been underestimated (Mittermeier et al., 2010), hence there may be further phylogenetic subdivisions warranted among sportive lemurs.

The species found in our study area, *Lepilemur tymerlachsonorum* (Hawk's or Nosy Be Sportive lemur), is a regional endemic to Nosy Be (Ranaivoarisoa *et al*., 2013). Usually spotted over 10m high in the canopy, this arboreal species is nocturnal and opportunistically feeds on fruit, nectar, and sometimes small animals, such as geckos (Ranaivoarisoa *et al*., 2013). These lemurs are frequently predated on by feral dogs (*Canis vulgaris*) and raptors (Andrews & Birkinshaw, 1998). *L. tymerlachsonorum* is listed as Critically Endangered on the IUCN's red list (Sawyer *et al*., 2015).

L. tymerlachsonorum in our study area are frequently found in areas that are used by human populations, e.g. above forest paths and adjacent to rice paddies (per. obvs.). Further, sportive lemurs are known to have difficulty adapting to some habitat change (Ganzhorn *et al*., 2001; Olivieri *et al*., 2005). Thus it may be important, with reference to future conservation efforts involving this species, to investigate the impacts of human disturbance and reveal any geographic asymmetry in *L. tymerlachsonorum* ecology across our study area.

Aim

Examine the long-term effects of human disturbance on Hawk's sportive lemurs. Determine if *L. tymerlachsonorum* abundance varies between survey routes in 'secondary' and 'degraded' forest.

Methodology

In October, November, and December of 2017 three 1km survey routes were walked to survey sportive lemurs. All surveys were conducted from 19:00-22:00. A group of trained research assistants headed by a member of staff walked each route slowly looking for lemurs. Electric light was used to spot lemurs using visual encounter methods. All lemurs within 10m of the survey route were recorded; distance from path was measured using measuring tape and group size and composition was noted. These methods lend heavily from previous research involving congenerics (Meyler *et al*., 2012; Randrianambinina *et al.*, 2010).

Analysis

Encounter rates were used to determine abundance. This survey method has been successfully used previously to survey small lemur populations (Nguyen *et al*., 2013; Holmes *et al*., 2015). To calculate encounter rates the total number of individuals is divided by the total length of the survey routes (Gazhorn *et al*., 2007).

Results

A total number of 20 surveys were conducted: 8 in secondary forests and 12 in degraded areas. During one survey in secondary habitat no lemurs were encountered. It was found that encounter rate is nearly 25% higher in degraded habitat than in secondary forest with the total number of 226 individuals in degraded habitat and only 55 in secondary forest (Table 4.).

Table 4: Results of surveys conducted in secondary and degraded habitats

	Encounter rate (ind/km)	Total number of individuals	Total length of transect (km)	Average perpendicular distance (m)
Degraded	18.83	226	12	5.56
Secondary	6.88	55	8	4.74

Discussion

The number of individuals was expected to be lower in degraded habitats than in secondary forests due to potential extirpation caused by human disturbance. Yet, our results indicate that populations of *L. tymerlachsonorom* may be more abundant in degraded habitats. However, this conclusion is tentative. Difficulty in visually identifying *L. tymerlachsorom* was not considered during this investigation. It is likely more difficult to detect lemurs in areas of denser canopy (Petter *et al*., 1977)—such as secondary versus degraded forest. Further, *L. tymerlachsonorom* are known to be less active in dense vegetation (Bederu, 2014), and feed on fruit in generally more open habitat, such as plantations (Sawyer *et al.*, 2015), thus, individuals may be more conspicuous in denser habitat and be observed on surveys less often.

Despite these potential confounding factors, there is a large difference between the encounter rates in degraded and secondary habitat. An additional explanation could be that degraded forests which are near local villages are now separated from secondary forests, making it less permeable to lemurs and thus, causing them to overpopulate degraded areas. To test this hypothesis further, surveys should be conducted during the day and night, as well as a further investigation into habitat use, the existence of possible forest corridors, and lemur behaviour.

Describing the behaviour of the Nosy Be Sportive lemur (*Lepilemur tymerlachsonorum*) using ethograms and casual observations

Introduction

Sportive lemurs are nocturnal prosimians common to our research area (per. obvs.). Individuals are often encountered alone or in small family groups; they are rarely found in groups >3. As opportunistic feeders, *L. tymerlachsonorum* may use a variety of habitats and exhibit a similar breadth of behaviour to compliment these. Impacts of human disturbance on sportive lemur behaviour remain untested assumptions for most habitats in their distribution (Mittermeier *et al.*, 2010).

Aim

To begin an initial investigation into the range of behaviours displayed by *L. tymerlachsonorum* in our research area and identify any observed asymmetry in behavioural characteristics across habitat types.

Methodology

Behavioural ethograms were designed to include common lemur behaviours. Walking pre-existing trails at night, we used red electric light and visual encounter methodology to search for *L. tymerlachsonorum*. When individuals/groups were encountered the research team (<5 people) stayed to observe them for a maximum of 20 minutes; if animals moved off during this time, surveys were cut short. A randomly selected individual was selected and observed throughout the survey period. Every 20 seconds the individual's behaviour was observed, categorised, and recorded. Canopy height was estimated by eye. Weather was also recorded.

Results

13 surveys were conducted during this phase: 6 surveys (total of 1 hour 54 minutes) in degraded habitats, 6 in secondary forest (total of 1 hour 30 minutes) and 1 in primary forest, which is excluded from this section but described below.

Total behaviours were tallied (Fig. 3). Overall, a high level of vigilance (V) was noted in both habitats, although vigilance behaviour was higher in the secondary forests. Lemurs were also observed resting (R) for a high portion of the time however active behaviours (FT, ST, F, FD, SG, AG &VO) were also recorded in both habitats (Fig. 3).

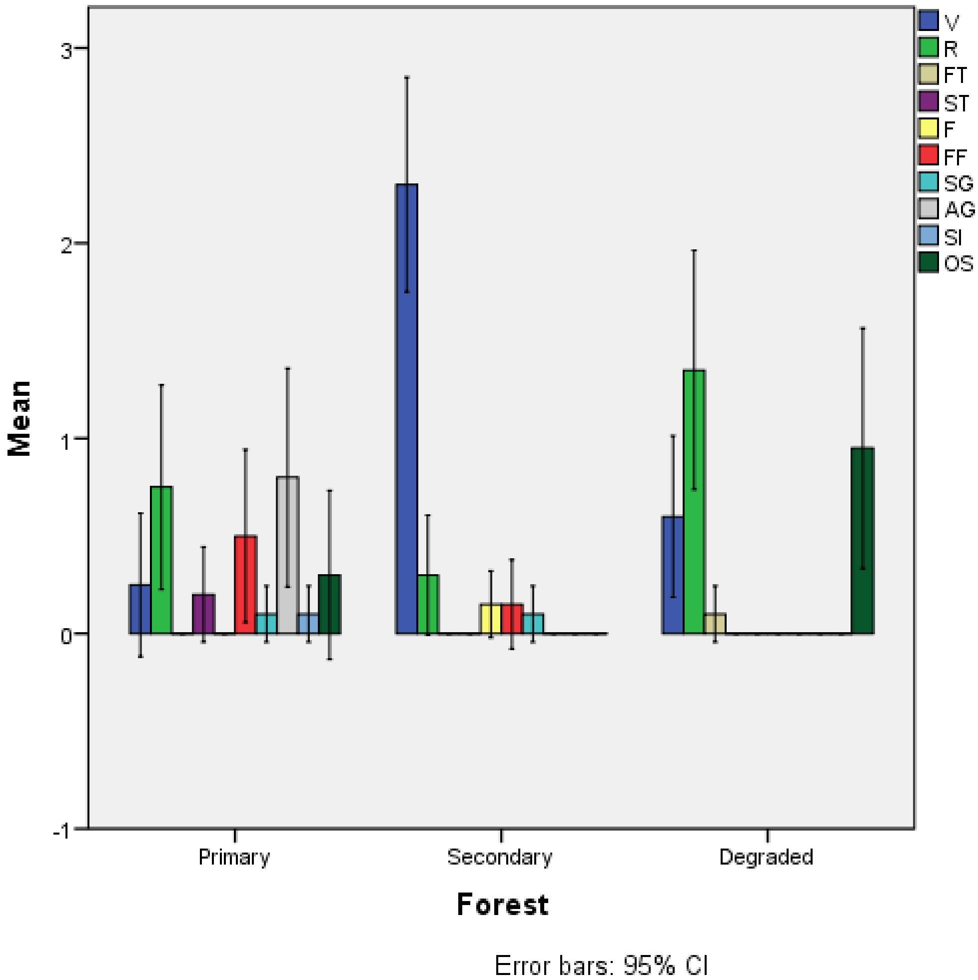

Figure 3: The mean count per survey of common sportive lemur behaviours observed in primary, secondary and degraded forests. The behaviour types are: V-vigilant, R-resting, FT- Fast Travel, ST-slow travel, F- Foraging, FF-feeding, SG-self grooming, AG-allogrooming, SI- Social Interaction, OS-out of sight

Discussion

Sportive lemurs strongly rely on visual and olfactory senses and can be sensitive to low levels of disturbance (Rushmore *et al.*, 2012). When observed with white electric light they tend to move off quickly and therefore it is unlikely that 'natural' behaviour will be observed, regardless of habitat type—previous research has suggested that lemurs are less sensitive to red light (Fuller *et al.*, 2018). However due to their nocturnal nature it is likely that the animal will still show a high level of vigilant behaviour. Noises made by researchers during surveys are almost entirely unavoidable and will likely cause some level of disturbance. Thus, vigilant behaviour is expected to be higher in secondary forests where lemurs generally experience less human disturbance. The amount of observed resting, feeding and grooming behaviour is expected to be higher in degraded habitats where lemurs are more habituated to humans. According to Petter *et al*. (1977), sportive lemurs are less vocal in forested habitats than in degraded areas (Mittermeier *et al.*, 2010); our results are commensurate with these findings. Lemurs in secondary forest moved off before the end of the 20 minute survey time more frequently than those in degraded areas.

Lower levels of alertness can make lemurs more vulnerable not only to predation but also for capture by humans within the area. At night, dogs and boas become a threat to these lemurs because they are known to frequently spend their active hours at a height lower than 10m (Sawyer *et al*., 2015).

The effects of human disturbance on Black lemurs (*Eulemur macaco macaco*) using behavioural ethograms

Introduction

Black lemurs are the only 'true' lemurs, of the *Eulemur* genus, on Nosy Be—also being found in the Northwest of mainland Madagascar—and are the island's largest lemur. This species is sexually dimorphic, where males are the characteristic black colour and females display different colouration, such as browns and beiges. Total populations of black lemurs are declining (Mittermeier *et al*., 2010).

E. macaco macaco plays a central role in the generation and persistence of Nosy Be's forests; this species is known to be very important in the pollination of the Madagascar travelling palm *(Ravenala madagascariensis*), a species iconic to most wet Malagasy forests. Furthermore it is an important seed disperser for a number of Nosy Be's forest species (Birkinshaw, 1999; Colquhoun, 1998). They are cathemeral, in that they have active periods during the day and night. Their night time activity is, to some extent, associated with the phases of the moon which allows them a longer foraging time (Andrews & Birkinshaw, 1998; Colquhoun, 1998). Troops of *E. macaco macaco* typically comprise of 2–15 individuals occurring in all types of forest habitats (Garbutt, 1999). As with many other lemur species, black lemurs live in female dominant groups which are led by an alpha female (Andrews, 1998). This species is thought to be tolerant of environmental change yet resistance to human disturbance is still poorly understood (Wright, 1999).

Aims

Make initial assessment of black lemur behaviour on Nosy Be; and analyse if and how these factors change along a human disturbance gradient.

Methodology

Behavioural ethograms were designed to include commonly occuring lemur behaviours. Walking pre-existing trails during the day, we used red visual encounter methodology to search for *E. macaco macaco*. When individuals/groups were encountered the research team (<5 people) stayed to observe them for a maximum of 20 minutes; if animals moved off during this time, surveys were cut short. A randomly selected individual was observed throughout the survey period. Every 20 seconds the individual's behaviour was observed, categorised, and recorded. Canopy height was estimated by eye. Weather was also recorded.

Results

56 surveys were carried out from January to December 2017: 26 each in degraded and secondary habitats and 4 in primary habitats. To compare the low number of primary forest surveys each tally has been increased proportionally.

The total time spent surveying was highest in secondary forest with 13 hours 30 minutes (24 full 20 minutes surveys); 7 hours 36 minutes (17 full 20 minutes surveys) in degraded; and in primary areas, 1 hour 1 minute (1 full 20 minutes survey). The level of vigilance (V) was the highest in primary forest while equal in secondary and degraded habitats; however lemurs were witnessed watching observers more often in the latter two habitats (Fig. 4). Resting (R) behaviour was also highest in primary habitat. Movement (fast travel - FT and slow travel- ST) was observed for the least amount of time in primary forests, although individuals generally moved off quickly.

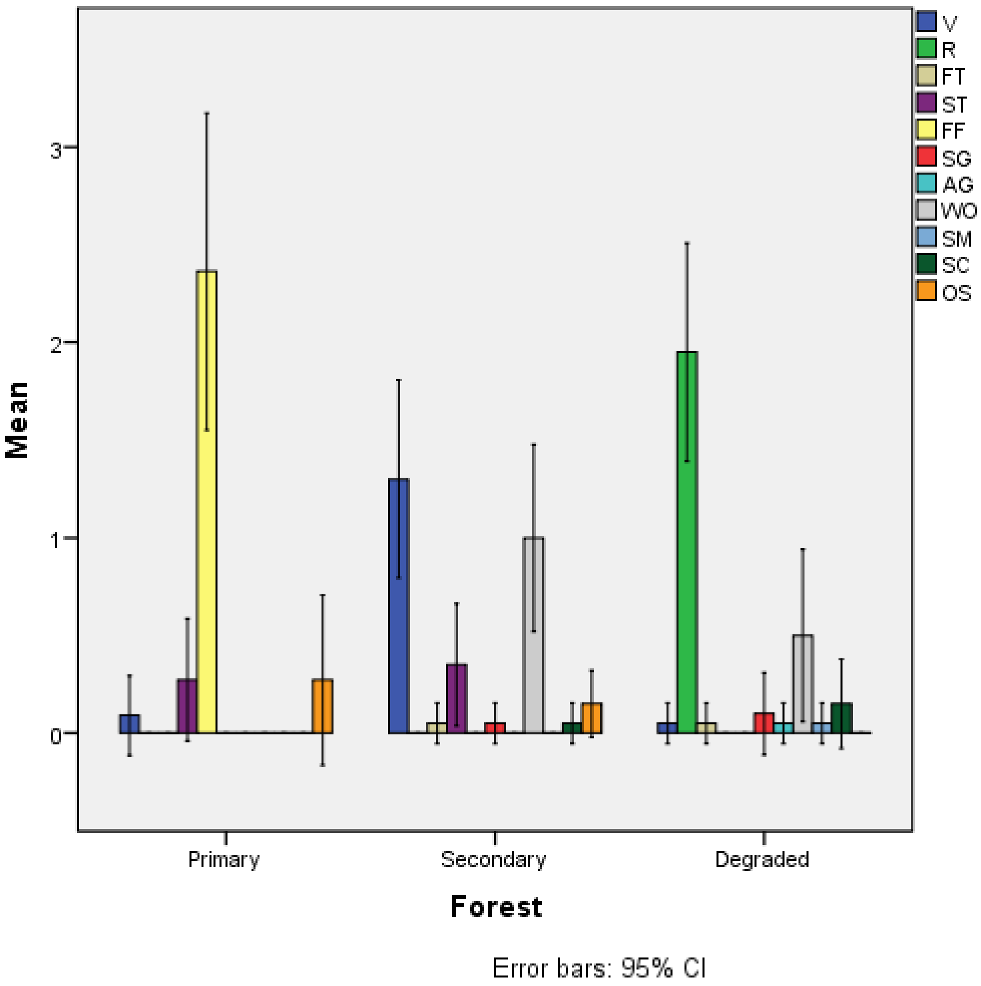

Figure 4: The mean count per survey of common black lemur behaviours observed in primary, secondary and degraded forests. The behaviour types are: V-vigilant, R-resting, FT- Fast Travel, ST-

slow travel, FF-feeding, SG-self grooming, AG-allogrooming, WO- Watching Observer, SM- Scent Marking, SC- Scratching, OS-out of sight

Discussion

It is thought that lemurs in degraded and disturbed habitats are more likely to be habituated to humans, in addition, tourist fed lemurs would also show heightened levels of boredom and are seen to venture close distances to humans (Lee & Priston 2005). Foraging behaviour was observed more frequently for lemurs in primary forests and would display caution when humans approached by sounding alarm calls and keeping distance (pers. obvs.). Generally, lemurs were mostly observed displaying resting behaviours across all habitat types (Fig. 4). This is possibly due to the time that surveys were conducted as black lemurs are less active after 8:00 (Colquhoun, 1998)—most of our surveys started after this time. Future investigations should include time of day as a factor potentially influencing lemur behaviour.

No significant differences in lemur behaviour were observed between different habitat types. This may imply little or no reaction to human disturbance. However, considering our sample size and relatively small surveying (total time) in areas of primary forest, these results must be viewed cautiously, and only give tentative conclusions that black lemurs show little response to disturbance. Future research should seek to expand surveying of all habitat types and evaluate straight line distances of human settlements from observed lemur groups. Data should be shared and collated with research from LNP, where tourists visit and interact regularly with black lemurs. Long-term monitoring of group size and composition may also be useful to track demographic changes and inform future conservation efforts.

The effect of habitat degradation on reptile communities

Introduction

Reptiles are generally facing a global decline (Gibbons *et al*., 2000); in Madagascar, the primary cause of this decline is through habitat loss via deforestation (Andreone *et al*., 2005; Clark, 2012). Over 90% of Madagascar's reptiles are endemic (Raxworthy & Nussbaum, 1994). Hence, it is a global conservation concern when Malagasy species are threatened with extirpation, population decline, and extinction.

There are approximately 60–70 reptile species on Nosy Be, including the endemic colour morph of *Furcifer paradalsis*—the blue panther chameleon (Glaw & Vences, 2007). Snake diversity is also quite high compared to analogous forested areas in Madagascar. The majority of herpetofauna research on Nosy Be, as with all of Madagascar, has focused on building species inventories and resolving phylogenetic issues (Glaw & Vences, 2007). This often leaves other scientific questions open, including those of possible conservation concern, such as effects of human disturbance on herpetile ecology (Irwin *et al*., 2010).

Aim

Compare the abundance and species occurrence of reptiles and amphibians across habitat types. Examine relationships between herpetile distribution and local environmental factors.

Methodology

Diurnal and nocturnal herpetofauna survey routes were walked from October to November in 2017. A small research team walked each route at a pace of ~300 meters per hour. Animals seen within 5m of either side of transect were recorded. Individuals were identified to species level using field guides and dichotomous keys. The distance from the path and individual's height were recorded using a tape measure. Distance sampling is a common method used to survey herpetiles in the tropics (Doan, 2003; Jestrzemski *et al*., 2013). Seven transects were used for surveying.

Despite visual encounter surveying being a widely used and accepted method of surveying (Andreone *et al*., 2003; D'Cruze *et al*., 2008), not all species will be surveyed with equal efficiency as their appearance and/ or behaviour will differ. Species living in high canopy or amongst the leaf litter will be particularly under-represented. Those which are sensitive to disturbance may be more likely to flee/hide (D'Cruze *et al*., 2008). Structural complexity also tends to mean species are more difficult to spot in less open habitats. A not time-restricted survey was intended to account for this, as a correspondingly larger time may have needed to be spent searching dense vegetation.

Discussion

Previous studies have found that certain species are more sensitive to habitat degradation and only found in relatively undisturbed areas, whereas others may do better at forest edges and in degraded habitats (Lehtinen *et al.*, 2003). It has also been shown that edge tolerance varies seasonally across species and there is a correlation between edge avoiding species and their vulnerability to extinction (Lehtinen *et al.*, 2003), however there is no evidence that this is the case for Malagasy species. A recent increase in the interest towards exotic reptile pets such as *Phelsuma* and *Uroplatus* also poses a threat; live capture and export has been increasing in recent years (Schlaepfer *et al.*, 2005). The Malagasy 'fady', taboo, contains various superstitions regarding native herpetofauna: chameleons in the house bring bad luck to a person in Nosy Be for example (Mannle & Ladle, 2012).In many areas of Madagascar snakes are the subject of innuendo and are often attacked on sight. Although this does not apply to all species; Boas, for example are considered sacred (Mannle & Ladle, 2012).

Further studies should seek to understand the relationship between herpetile abundance and occurrence with microhabitat features and structure. Mark and recapture techniques would provide a finer-grain understanding of how these species use the forests on Nosy Be.

The effects of habitat degradation on bird communities

Introduction

Avifauna on Madagascar is often considered depauperate compared to other similar-sized landmasses; <250 species are hosted on the island (Goodman & Jonathan, 2003). Despite low species richness, around 40 percent of Madagascar's bird species are endemic and contain a number of high conservation priority populations (Morris *et al.*, 1998). Over 80 of the islands bird species are entirely restricted to forest habitats (Morris *et al*., 1998). Pripp *et al.*, (2014) evaluated the bird communities on Nosy Be. Many specialist, non-edge species were not found in core areas of forest; such species were concluded to be of high ecological value for factors such as seed dispersal or equilibrium in insect populations. Exploring the relationships that birds have with the forests in our research area could reveal more unique interactions, provide insight into general forest ecology, and inform future management of particular species.

Aim

The aim of this project is to examine the effect of habitat degradation on bird species richness and abundance along a gradient of human disturbance.

Methodology

Bird surveying was carried out using point counts along 800m survey routes, with a point count station positioned every 200m (Gregory *et al*., 2004; Hutto *et al*., 1986). Point counts are used to explore bird habitat relationships and to determine species richness and abundance (Ralph *et al*., 1995). A sampling period of five minutes was used at each point count station. All birds within an estimated radius of 25m from the observers were recorded (Hutto *et al*., 1986; O'Dea *et al*., 2004) and identified to species level based on both auditory and visual diagnostics. Surveys in heavily vegetated habitats relied almost exclusively on auditory detections (Scott *et al*., 1981). Birds which were heard and then subsequently seen were recorded as seen and those located outside of the 25m radius and subsequently entered it were recorded as being within the point count radius. Surveys were conducted in the morning, between 06:30 and 07:30 in order to record bird abundance at peak activity times.

Results

Due to insufficient data collected in secondary forests, data analysis comparing abundance and species richness between habitats was not possible. This data will, however, be represented in phase 181.

Discussion

Quantifying the species diversity of bird communities has gained increasing importance in environmental impact assessments, conservation planning (Bibby *et al*., 1992; Stotz *et al*., 1996), and ecological research (Huston, 1994). The precise mechanisms for the creation and maintenance of avian species diversity are still being debated, although there is a general consensus that variables related to habitat heterogeneity play a prominent role (Kissling *et al*., 2008).

Biases are unavoidable when using the point count methods because species within dense forests will be more difficult to detect than those in open habitats. Birds may remain undetected by researchers in dense vegetation and there is the potential for vocalisations to be too faint, as sound attenuation in closed forest is reduced (Schiek, 1997). When relying solely on auditory recognition, some individuals can be counted several times at multiple stations. The two species of sunbirds, the souimanga sunbird (*Cinnyris sovimanga*) and the long-billed green sunbird (*Cinnyris notatus*) are documented just with the family name as their calls are very difficult to distinguish.

A study conducted by Peh *et al* (2006) suggested that nearby primary forest could act as a source habitat, resulting in a steady influx of forest birds to degraded areas. Thus, the bird community we have observed may not be representative of the forest avifauna in degraded lands that have no primary forests nearby. The results may also be biased due to the inherent difficulties of sampling in a closed forest. Future studies should include a larger survey effort that will increase the chances of encountering those species with very low levels of detectability.

It may be the case that true forest specialists, such as vasa parrots (*Coracopsis spp.)* (Morris *et al.*, 1998) existed historically on the island of Nosy Be, but have been extirpated, leaving only more tolerant species. During this and the last phase there have been unconfirmed sightings of Vasa parrots in degraded areas of habitat. Surveying more pristine core forest areas along the edge of LNP would be desirable for further examination of habitat degradation effects on avian communities. During a recent trip to LNP there was an auditory detection of vasa parrot (*Coracopsis spp.)* and ashy cuckoo shrike (*Coracina cinerea*); this suggests that forest specialist birds may be restricted to core areas of forest, therefore protection, conservation and restoration of degraded forest should be considered.

The subject of Malagasy bird in the pet trade has received relatively little empirical attention. However, it is possible that trade in both export and local captivity is already influencing bird communities (Webster, 1997). Helmeted guinea fowls (*Numida meleagris*) and pigeons are regularly seen in cages for sale in Hell-Ville (pers. obvs.). More than 30 grey headed lovebirds (*Agapornis canus*) were observed in a cage for sale at the local market. Helmeted guinea fowls (*N. meleagris*), green (*Treron phoenicoptera*) and blue pigeons (*Alectroenas madagascariensis*) are known to be hunted and consumed locally (pers. comm.). Lovebirds, however, are unlikely to be used for consumption but more for the pet trade since they have been popularly kept as pets for years (Birdlife International, 2016).

Further studies should focus on how human disturbance and habitat degradation affect bird populations; active conservation and habitat restoration should be considered.

General conclusion

Our research supports previous reports that highlight asymmetry in aspects of animal ecology along our presumed gradient of habitat disturbance/degradation. Although many of our results must be treated tentatively due to limitations surrounding sample size and field methods (particularly due to a heavy rainy season), our main findings show distinct differences in abundance, behaviour, and habitat use between different habitat types.

Future investigations should seek to refine the methods outlined here by expanding the sample size of all research and testing specific hypotheses to determine the underlying factors driving observed differences across habitat types. A particular aim should be to examine the microhabitat use of herpetofauna; elucidating how species utilise their local environment can build fuller understanding of their ecology and a more general knowledge of how ecosystem interactions operate in these enigmatic forests.

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