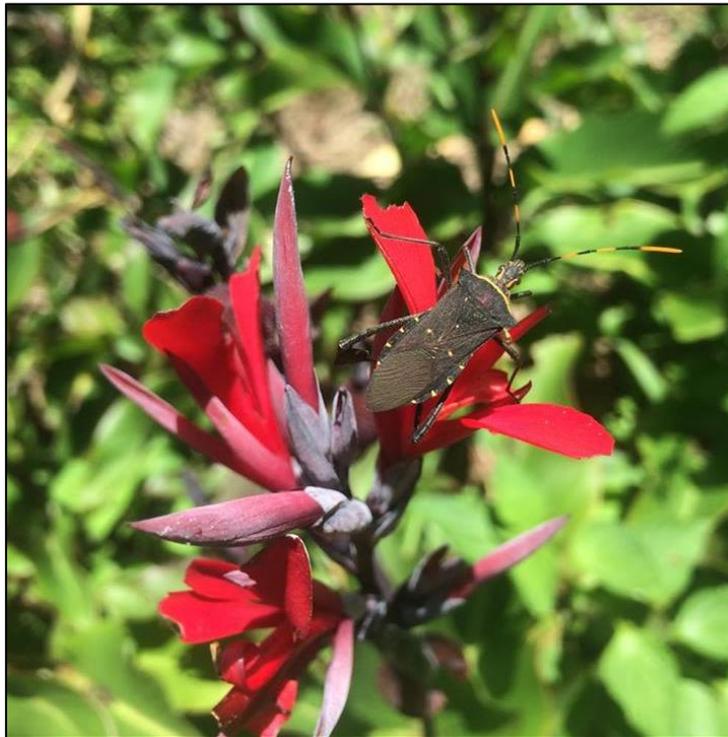


FRONTIER

FRONTIER - MADAGASCAR

Terrestrial Science Report

July–September 2018



Principal Investigator: Ryan M. Clark

1. GENERAL INTRODUCTION

Madagascar is one of the world's largest and most important biodiversity hotspots (Myres et al. 2000). Owing to taxonomic distinctness in its higher clades, Madagascar's flora and fauna are biologically unique and the vast majority of species hosted on the island are found nowhere else on earth. Growing human-induced pressures on Madagascar's natural communities put these systems under a unique and time-sensitive regime of ecological change that makes conservation action across the island a key site in terms of combating biodiversity loss worldwide.

Madagascar's ancient forests host, by far, the most species of the island's habitats—over 90 percent (Dufils 2003). These precious woodlands are currently under threat from habitat loss and fragmentation (Dewar 2014). As such, deforestation is a core element of any discourse involving Madagascar's environmental trajectory. Forest clearance for 'tavy' (swidden agriculture) and oxen grazing is central to Madagascan culture and widely practiced (Clark 2012; Gade 1996; Marcus 2001). While the degree to which these local agricultural practices contribute to forest decline is debated (Scales 2014b), the majority of literature agrees that farming, subsistence and that of 'cash crops', has played a significant role in the restructuring of Madagascar's forests (Clark 2012; Harper et al. 2007; Scales 2014a; 2014b). Moreover, natural resource extraction, chiefly for timber, is also accepted as a major contributor to woodland decline in Madagascar (Clark 2012; Harper et al. 2007). Ergo, although factors such as climatic change have been suggested as drivers of forest loss on Madagascar, direct human activity has undoubtedly played a central role (Gade 1996; Marcus 2001; Randrianja & Ellis 2009).

The dominant train of thought in preserving Madagascar's forests up until the last decade was that of 'fortress conservation', where access to sites of biological and/or geological importance is severely reduced, often this takes the form of a physical or patrolled barrier. Indeed this paradigm was, and still is, prevalent in conservation initiatives across the globe (REF). While the value of protecting such sites seems intuitive, consequences to local human populations are often overlooked in such plans. A growing body of evidence indicates that 'fortress conservation' in certain socio-geographic contexts is unsustainable (REF). This has dramatic implications for Madagascar's National Park and protected areas programmes. At this crossroads of conservation ideas, Madagascar, its government, and its people once again have important decisions to make in regard to the future of their natural landscapes and the species within them.

Considering the overarching factors of human-driven forest loss, socio-political stochasticity, and evolving international thoughts on conservation, it is now more than ever important to build

a fuller understanding of the relationships that Madagascar's human populations have with their environment and how these links are likely to change in the short to medium term.

1.1 Madagascar

The importance of Madagascar in a global conservation context can be summarised in the following sentence: the majority of extant flora and fauna on Madagascar are found nowhere else on earth (Goodman & Benstead 2003; Hobbes & Dolan 2008; Phillipson et al. 2006). Moreover, not only are the island's species biologically unique but they contain ancient clades that have radiated in isolation for tens of millions of years, creating distinct branches in the tree of life full of genera and families endemic to Madagascar (Callmander et al. 2011). Some claim that higher taxa distinctness leaves Madagascar peerless in biological uniqueness (Ganzhorn et al. 2014). This rarity in its ecology and the threats to Madagascar's natural habitats have led to the preservation of the island's biological communities being considered a global conservation priority (Goodman & Benstead 2005; Mittermeier et al. 2005).

1.1.1 Geologic Origins

Much of Madagascar's extraordinary biological distinctness is thought to have arisen due to its isolation from other landmasses, which has lasted at least 90 million years (Storey et al. 1995). Compounded by the Cretaceous–Tertiary extinction event (K–T) ~65 million years ago (mya) (Alvarez et al. 1980), geographic isolation has allowed Madagascar's taxa to radiate into previously impoverished niche space (Ali & Krause 2011; Fortey 1999; Renne et al. 2013).

Throughout the latter half of the 20th century, the role of dispersal in the post-Mesozoic faunal colonisation of Madagascar was largely ignored in favour of a vicariance dominated narrative (Yoder & Nowak 2006). The first years of the 21st century have seen this status quo reversed; current thinking is that the majority of Madagascar's basal fauna stocks originated from Cenozoic colonisation events from 65 million years ago onwards (Salmonds et al. 2012; 2013). Fossil records buttress this model by revealing that most extant Malagasy vertebrate taxa were not present during the Cretaceous (Krause et al. 1997; 1998; 1999)—hence their arrival must have been later. However some clades are known to have survived from Madagascar's shared plate tectonic history with Gondwanaland (Gaffney & Forster 2003; Noonan & Chippindale 2006).

Stochastic dispersal post-K–T has given rise to peculiar taxonomic assemblages on Madagascar (e.g. Poux et al. 2005; Reinthal & Stiassny 1991), where a handful of speciose radiations make up the majority of fauna (Bossuyt & Milinkovitch 2001; Nagy et al. 2003; Vences 2004) and entire animal groups, such as large mammals, are absent. However, human driven extinctions of certain taxa during the Holocene may compound our ability to assess ‘natural’ patterns of Madagascan biodiversity (Crowley 2010). Nevertheless, modern biological communities on Madagascar are widely thought to be unique in structure and composition (Ganzhorn et al. 2014; Horvath et al. 2008; Reddy et al. 2012; Salmonds et al. 2012; 2013).

1.1.2 Modern Biogeography

Often cited as a pseudo-continent (de Wit 2003), Madagascar is the world’s fourth largest island (587,000 km²), lying ~400km east of mainland Africa in the Indian Ocean. Madagascar’s topography is dominated by an eastern massif running north-south, dividing the island into two slopes: a steep eastern escarpment and a gentler western slope (27% and 73% of land cover respectively (Ganzhorn et al. 2014)). This topography determines large aspects of moisture deposition across Madagascar. Humid prevailing winds rolling in off the Indian Ocean are forced upward by eastern mountains and unload precipitation on the east coast and central highlands; western Madagascar is left in a seasonal rain shadow and experiences pseudo-monsoon conditions (Jury 2003). What results is a fine-grain diversity of microclimates: discrete abiotic pockets of different weather conditions (Dewar & Richard 2007; Rakoto-Joseph et al. 2009). These heterogeneous moisture patterns shape much of Madagascar’s local landscape diversity. Although ~65% of the island’s land cover is savannah (Moat & Smith 2007), habitat mosaics of scrub, wetland, and forests typify most regions (Mayaux 2000; 2004). The centrepieces of these landscapes are scattered woodland blocks; forest archipelagos that support the majority of Madagascar’s species (Dufils 2003).

The unique structure, composition, and history of Madagascar’s biological communities leaves them as exquisite examples of radiation in isolation. This biological uniqueness coupled with the threats Madagascan ecosystems face bolster calls for conservation of these ecosystems.

1.2 Measuring Biodiversity

More biodiverse communities are considered to be ecologically healthier; generally having greater stability, productivity, and resistance to disturbance (Levins 2013; Purvis & Hector

2000). Thus, measuring biodiversity can provide insights into the condition of biological communities, track changes over space and time, and inform practical management and conservation (Casey 1999; Gotteli & Chao 2013).

Biodiversity is often measured in two ways: richness and evenness. Richness, often synonymous with species richness, is recorded by a total tally of species in an area, ecosystem, or landscape. While this method hints at biodiversity levels, the structure and composition of wild populations is not eluded to. Evenness, describes the proportions of individuals in an area: the more equal groups are the greater the evenness of the site. Both measures are required to give a relatively robust estimate of biodiversity, and indeed there are many more detailed methods to quantify more specific aspects of biodiversity.

Estimating biodiversity provides a snapshot in biological time but regular and consistent repeat measures can provide a window onto the trends and trajectories of species in an area with reference to external factors, such as human driven reordering of biological communities. Ergo, at the beginning of this, our project's new five year research plan, we build surveys around a framework of measuring the abundance and proportions of various taxa in our research area over time; various estimates that denote richness and evenness will be made at least once per dry and wet season for core animal clades (lemurs, reptiles and amphibians). In exploring finer-grained aspects of ecological dynamics we hope to expand our repertoire of surveys to include habitat descriptions, more complete inventories of terrestrial invertebrates, and ecomorphological investigations of certain reptiles. Further, we aim to measure different aspects of human disturbance in our study area and to pair this data with that of our ecological investigations. It is hoped that elucidating these relationships, and others, will not only develop a more complete understanding of these ecosystems but also spread awareness of these forests and support future conservation management in the area if required.

2. STUDY AREA

2.1 'Big Island'

The Madagascar Frontier project (MGF) is currently located on Nosy Be, Madagascar's largest offshore island (25, 000 ha), Nosy Be lies ~8km from the mainland and is itself part of an offshore archipelago of several islands and many more small islets (Fig. 2.1).

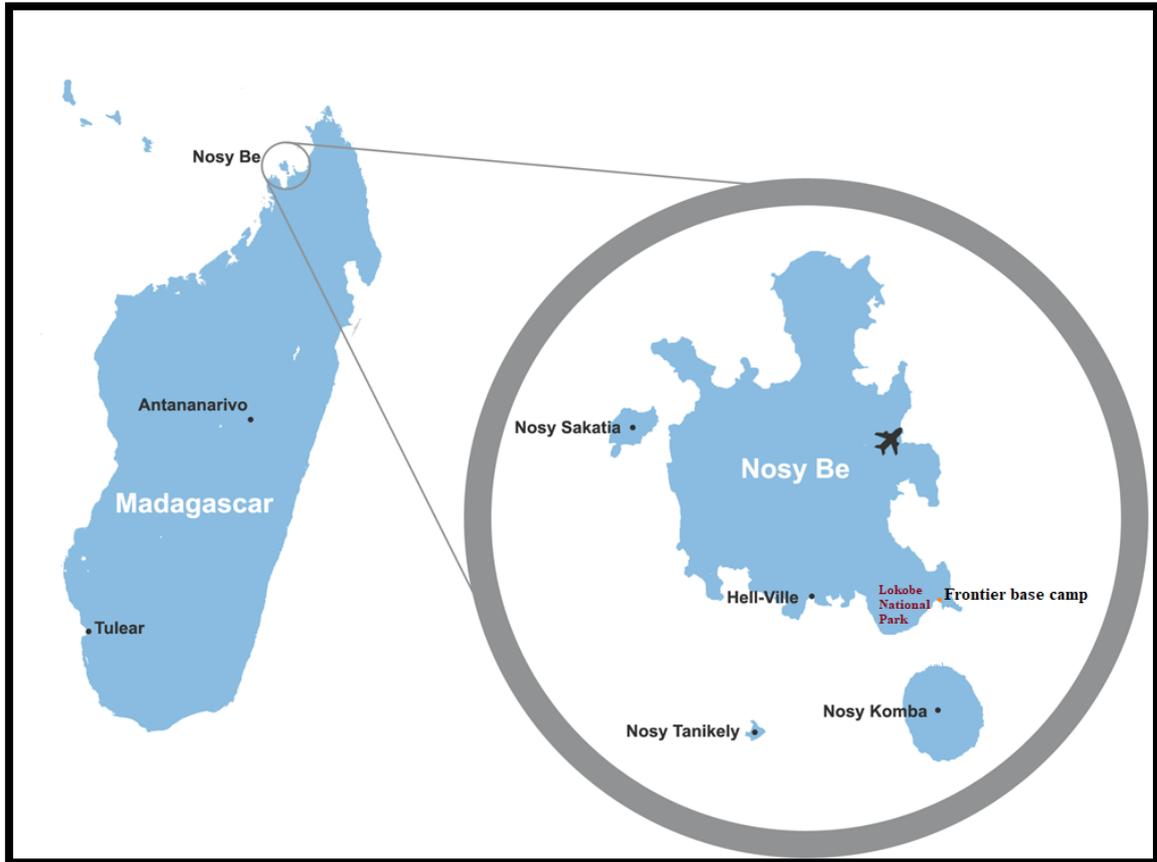


Figure 2.1: Map showing Nosy Be, its surrounding islands, and MGF's camp.

Within Madagascar Nosy Be is a relatively developed area. The island's thriving tourist industry has fuelled the development of several large holiday resort areas that provide a large proportion of the islands 75,000 inhabitants a sustainable income. Ecotourism on Nosy Be takes the form of guided tours of the islands forests or seas; these are very popular as Nosy Be has a large area of pristine woodland and has several coral reefs in its coastal waters.

The MGF study area is located at the southeast tip of Nosy Be, on a peninsula bordered by Lokobe National Park. The small adjacent village of Ambalahonka has a population of ~100 people that

are largely a subsistence community. No road access exists for this area; hence, small local boats are the only method of reaching our study area.

2.1.2 *Sambirano*

Named after a mainland watershed, the Sambirano region is a semi-distinct biogeographic domain of which Nosy Be occupies the northern extreme locality. This region is a transitional zone between the dry deciduous forests of western Madagascar and the humid eastern rainforests. As such, characteristics of both habitats are found on Nosy Be. This transitional arrangement defines much of the ecology in our research area.

2.2 **Survey Routes**

MGF has nine terrestrial survey routes that run through forests in our research area. Each route is 400m in length and present on pre-existing forest trails, many are used extensively by local populations to access the forest or other human populations. Routes run as straight as possible, this (a). reduces variation in visual overlap between observers, i.e. over/under-surveying on bends (b). simplifies routes so as to flatten the learning curve for new researchers attempting to memorise the complex network of forest trails in our study area. Routes run along a gradient of human disturbance; while many see a significant and regular amount of footfall, on others people are rarely, if ever, encountered. We measure the human use of routes to pair with data from ecological surveying.

Routes are predominantly used to maintain a long-term biodiversity monitoring project on herptiles and lemuriforms—it is hoped that in the mid to near future lepidopterans can also be surveyed in this manner.

3. PROJECTS

3.1 Lemur Abundance

3.1.1 Lemurs

Lemuriforms are old world prosimians endemic to Madagascar, and perhaps the most famous of the island's fauna. Placing their date of divergence from the other primates is still the subject of robust scientific debate; some studies argue this is around 60 million years ago (Yoder & Nowak 2006; Horvath et al. 2008), while others have suggest dates tens of millions of years later (Godinot 2006; Sussman 2003). Nevertheless, most authors on the subject agree that this date was after Madagascar split from India. Hence, lemurs are thought to have colonised the island transoceanically sometime later, most likely their ancestors being carried over on vegetation rafts (Tattersall 2006). Once on mainland Madagascar, lemurs underwent several million years of adaptive innovation and radiated into diverse niche space provided by the island's unique landscape and climatic conditions. Today there are over 130 species of lemur on Madagascar.

Modern lemurs are near exclusively arboreal and are commonly found in all layers of the Malagasy canopy. From the world's smallest primate, the mouse lemur, to the largest extant lemur, the Indri, these animals occupy a broad range of ecological roles within their respective habitats. While lemurs are generally predominantly frugivours, some species commonly feed on leaves, nectar, and opportunistically predate smaller animals such as small lizards (REF).

3.1.2 Lemurs on Nosy Be

Three lemur species are found on Nosy be: the black lemur (*Eulemur macaco macaco*), Hawk's sportive lemur (*Lepilemur tymerlachsonorum*), and Clair's mouse lemur (*Microcebus mampiratra*). These species have different niches and life histories, and may use their habitat in different ways. For instance, both *L. tymerlachsonorum* and *M. mampiratra* are nocturnal and are found in relatively small groups (often solitary); this is not true for diurnal, group-living *E. macaco macaco*. Thus, impacts from external stimuli such as human disturbance or environmental catastrophe may be different among these species. We aim to address this question.

Aims:

- Determine if lemuriform abundance varies in our research area as a function of habitat type.
- Determine if lemuriform abundance varies in our research area as a function of human disturbance.

3.1.1 Methods

During phase 183 lemur surveys were walked along nine pre-existing 400 m routes that run through our study area. Teams of trained research staff walked these routes at a regular pace and visually scanned the path and surrounding area for lemurs. Observers left at least 2 m between each other. When an individual was spotted the survey leader—a member of research staff—identified the species and confirmed the group size and measurements. A tape measure was used to measure the distance from path. Height of individuals was estimated by eye as most lemurs were well above a height that could be recorded using a tape measure. Both day and night surveys were conducted; electric light was used to assist observations during night routes.

3.1.2 Results

During 2018 34 lemur surveys (21 diurnal, 13 nocturnal) were walked over 18 hours, 12 on degraded routes, 8 on secondary routes, and 14 on primary routes. 123 lemurs were spotted in total. 84% of individuals spotted were sportive lemurs, 14% black lemurs, and 2% mouse lemurs. Sportive lemurs were found mostly on degraded (48%) and secondary routes (38%), only a few individuals were found in primary forest (Fig. 3.1.1), two individuals were spotted during diurnal surveying. Black lemurs were most often found on primary routes (62%), this species was only encountered once on a degraded route (Fig. 3.1.1).

Non-parametric testing revealed that black lemurs were found in significantly higher numbers on primary routes than degraded ($P < 0.0001$) and secondary routes ($P < 0.01$). Sportive lemurs were found significantly more often on degraded routes than primary routes ($P < 0.005$) but not compared to secondary routes ($P = 0.34$).

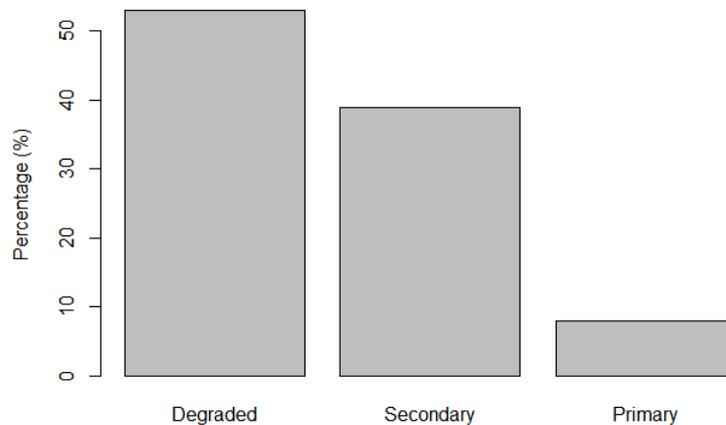


Fig. 3.1.1: Barplot showing the total percentage of Sportive lemur encounters in different forest types.

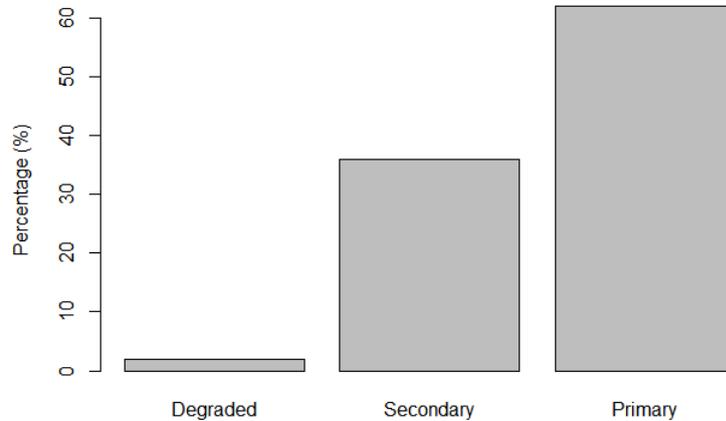


Fig. 3.1.2: Barplot showing the total percentage of Black lemur encounters in different forest types.

3.1.3 Discussion

Our results provide tentative evidence that sportive lemurs' habitat usage is heavily geared towards degraded forest habitat and that Black lemurs strongly favour inhabiting more pristine woodland habitat. In other areas of Madagascar sportive lemurs are found in higher densities in degraded forests (Seiler et al. 2013). Our results are commensurate with this. 'Degraded' forests are typically more open, with gaps in their relatively low canopy and often have obvious signs of deforestation and human disturbance. Such habitat may confer advantages to sportive lemurs over other lemurs; more open canopies could provide better foraging opportunities or the preferred food of sportive lemurs may thrive better with more exposed conditions. Also, sportive lemurs may cope better when subjected to a higher level of human disturbance. The higher canopy in primary forest route may be attractive to Black lemur groups that generally prefer large tree crowns to forage in.

Further research is required to fully explore the habitat usage of lemur species in our research area. Future work should look to investigate microhabitat usage of individuals more closely and examine this over a habitat and human disturbance gradient. Unfortunately as only a few mouse lemur individuals have been encountered total, we currently do not have enough data to draw any conclusions from on their ecology in our research area.

3.2 Herpetofauna abundance and species richness

Reptiles and amphibians are by far the most diverse groups of vertebrates on Madagascar (Glaw and Vences 2007). These hold such enigmatic clades as the leaf-nosed snakes and the chameleons—one of a handful of taxa thought to have dispersed across continents from a Madagascan epicentre. Shaped by Madagascar's geographic isolation and unique ecological pressures, herpetofauna on the island has taken on a unique form, full of peculiarities not found anywhere else on earth.

All wild amphibians on Madagascar are frogs. These species are near exclusively restricted to woodland habitat, not being able to withstand long periods in direct sunlight and needing humid conditions and access to waterbodies for reproduction. As such, amphibian diversity is heavily concentrated in the islands eastern rainforests. The heterogeneity of these habitats has helped catalyse microendemism of frogs along Madagascar's eastern coast. These amphibians fill broad niche ranges in their respective habitats, from leaf litter dwelling *Stumpfia*, to *Boophis* capable of bounding between high tree tops, Madagascar's frogs can be very locally abundant and occupy many key positions in their trophic webs.

Reptiles on Madagascar are generally less restricted to the islands forests, their scaled dermis allows them to thrive in areas of intense ultraviolet exposure and to store water so as to go much longer between hydrating. Therefore, Madagascar's reptiles can occupy areas of scrub and savannah—the most common habitat type on the island. These reptile include a number of charismatic and well-known species, such as the chameleons; Madagascar holds ~50% of the globes chameleon species.

Most reptiles and amphibians on Madagascar are found nowhere else on earth (Glaw & Vences 2007). Owing predominantly to a unique pattern of stochastic transoceanic dispersal to the island after biological impoverishment ~65 million years ago (Ali & Krause 2011; Alvarez et al. 1980), peculiar assemblages have taken hold; for instance, Madagascar is the global hub for chameleon species diversity, yet hosts no salamander species (Glaw & vences 2007). These disharmonic biological communities came about due to a few speciose taxa radiating into unoccupied niche space on Madagascar—they now typify the ecology of the island (Goodman & Benstead 2005; Poux et al. 2005; Salmonds et al. 2013). Investigating the ecology of these strange communities can provide unique lenses onto evolutionary biology, consequences of environmental change, and practical conservation potential.

3.2.1 Methods

During phase 182 herpetofauna surveys were walked along nine pre-existing 400 m routes that run through our study area. Teams of trained research staff walked these routes at a regular pace and visually scanned the path and surrounding area for reptiles and amphibians. Observers left at least 2 m between each other. When an individual was spotted the survey leader—a member of research staff—identified the species and confirmed the group size and measurements. A tape measure was used to measure the distance from path and height above ground, if individuals were too high the height above ground was estimated by eye. Both day and night surveys were conducted; electric light was used to assist observations during night routes.

3.2.2 Results

During 2018 54 herpetofauna surveys were walked (24 diurnal, 30 nocturnal); 20 were walked on degraded forest routes, 18 on secondary, and 16 on primary. 654 herptiles were recorded in 630 separate encounter events. The vast majority of individuals were the ground dwelling lizards, mostly of the genus *Zonosaurus* and *Trachylepid* skinks, these species accounted for over 50% of all herptile encounters. The average number of species per survey was significantly higher on primary survey routes than that of secondary ($P < 0.01$) and degraded routes ($P < 0.01$). The number of individual encounters did not differ significantly between forest types.

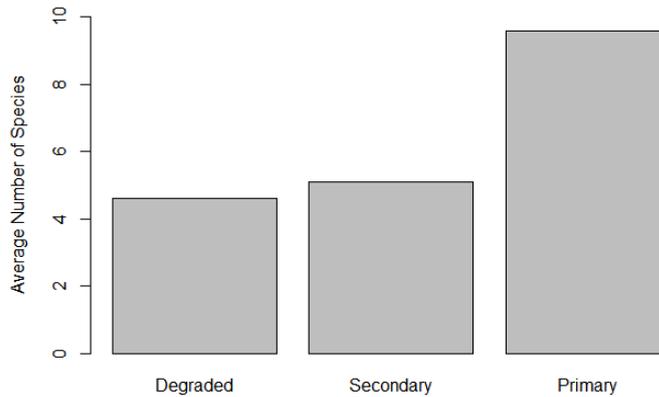


Fig. 3.2.1: Barplot showing the average number of species encountered per survey in different forest types.

3.2.3 Discussion

Owing to significant non-parametric testing we conclude that species richness along our primary routes is generally higher than that on degraded and secondary routes. Abundance of animals did not vary significantly across habitat types. These results are commensurate with similar studies into the diversity of herpetofauna across gradients of human disturbance (e.g. Gibbon et al. 2000). However, these results are tentative as our classification of ‘degraded’ forest for example, is arbitrary and based on past land use and anecdotal observations by our research team. In subsequent these findings will be tested against data that has empirically measured human use of our routes.

This lower species richness on degraded routes could be explained by a lack of suitable microhabitat for a variety of reptile and amphibian species. Degraded forest intrinsically provides less vegetative cover than secondary or primary woodland, ergo, species that prefer shaded habitats may choose to secondary and primary forest over more open, degraded vegetation. However, species may be more conspicuous on secondary and primary routes and surveying may have underestimated populations on degraded routes. Additional surveying will produce higher-resolution data to compare abundance and species richness across habitats.

3.3 Microhabitat Use and Chameleon Ecomorphology

Animals that are better adapted to their local ecological area are generally fitter (Schluter 2000). Exploring and mapping the relationships between animals and their immediate environment can elucidate the processes that generate and maintain biodiversity, and is thus among the most enduring themes of evolutionary biology (Gavrilets 2004; Gould 1983; 2002; Losos et al. 2013; Raeymaekers et al. 2017).

In the context of our study area and research infrastructure the most important microhabitat is wooded vegetation—networks of trees, shrubs and branches—throughout the forest. For arboreal lizards such as chameleons or geckos these habitats provide surfaces to locomote through their environment, foraging grounds, and locations that defend against certain forms of predation, as such they and their architecture is a large influencing factor on these species’ ecological performance.

Chameleons are a flagship Malagasy clade of arboreal lizards that comprise the family chamaeleonidae (Tolley & Herrel 2014). Although chameleons are thought to have evolved on Madagascar they have since become one of the few animals to have radiated intercontinentally

from a Malagasy epicentre (Tolley et al. 2013; Townsend & Larson 2001), yet over 50% of chameleon species are still endemic to the island (Glaw 2015; Klaver & Böhme 1997). We chose to focus our investigation of arboreal lizard microhabitat use and selection on chameleon species for two major reasons: a). chameleons, due to their unique morphology and mode of gripping their perch, have a very particular relationship with how they use their immediate ecological area, this has been frequently noted in the literature (e.g. Higham & Jane 2004), and b). the chameleons within our research area are relatively abundant and frequently encountered during surveying, ergo we were able to conduct research on chameleons with ease and to gather a sufficient dataset in a relatively short space of time. *Furcifer pardalis*, the panther chameleon, is the largest and one of the most frequently encountered chameleon species in our research area.

3.3.2 Methods

During August, September, and November of 2018 microhabitat surveys and chameleon ecomorphology surveys were conducted. Microhabitat surveys proceeded in the following way: 10 random GPS locations were selected using a random number generator along our nine forest survey routes, at each location an imaginary sphere, its centre being 0.5m from the ground, was drawn, within this sphere three planes were rotated using a metre stick: one parallel to the route, one perpendicular, and one horizontal. Every wooded substrate that came into contact with one of these planes was width measured. The same method was used for a sphere with its centre 1.5m above our randomly selected points. These measurements were tallied and collated. Further, to explore wooded microhabitat networks deeper we also collected branch lengths and internodal lengths (the distance between the nearest two off-shoots on the branch) for every tenth diameter measurement. Chameleon ecomorphology surveys proceed in the following way: a research groups walks along random forest trails visually scanning the surrounding habitat in a similar fashion to herpetofauna surveys, when a *F.pardalis* is encountered the team take a suite of morphological measurements: snout-vent, tail, hand, ulna, humerus, foot, tibia, and femur lengths, and weight. The following habitat measurements are also recorded: branch diameter, length, and height, and internodal length. Then an imaginary sphere is analysed in the same way as during microhabitat surveys using the chameleon's location as its centre, in this way the microhabitat available to the individual is measured. Chameleon ecomorphology surveys are still ongoing, survey period is expected to last into December 2018.

3.3.3 Results

A total of 3429 wooded substrate diameters were measured across 90 randomly selected GPS points throughout our research area; 301 internodal and branch lengths were also recorded. Diameter of wooded substrates available in our research area range from 0.01-1723 mm, the

median is 2.85mm, the mean is 7.62mm, however this may be skewed by several very wide outliers in our dataset.

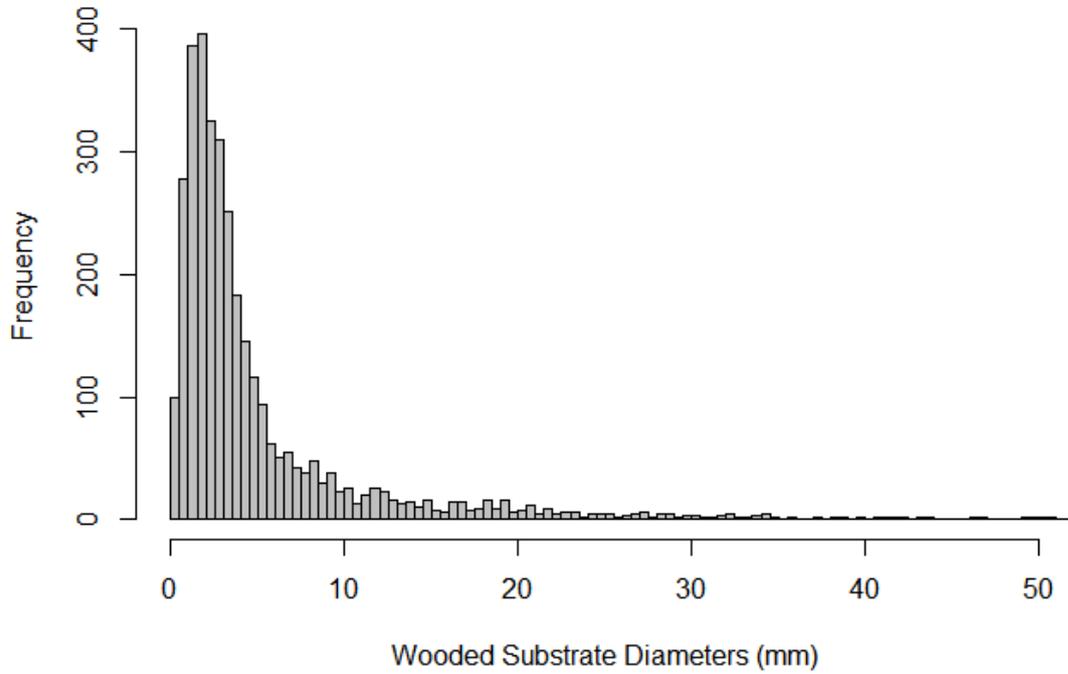


Figure 3.3.1: Histogram of the empirical distribution of available wooded perch diameters in our research area. Actual measurements stretch to over 1700 mm on the x-axis however the vast majority (>99.9%) of measurements are shown here; this continuation of data is denoted by the arrow extending from the x-axis.

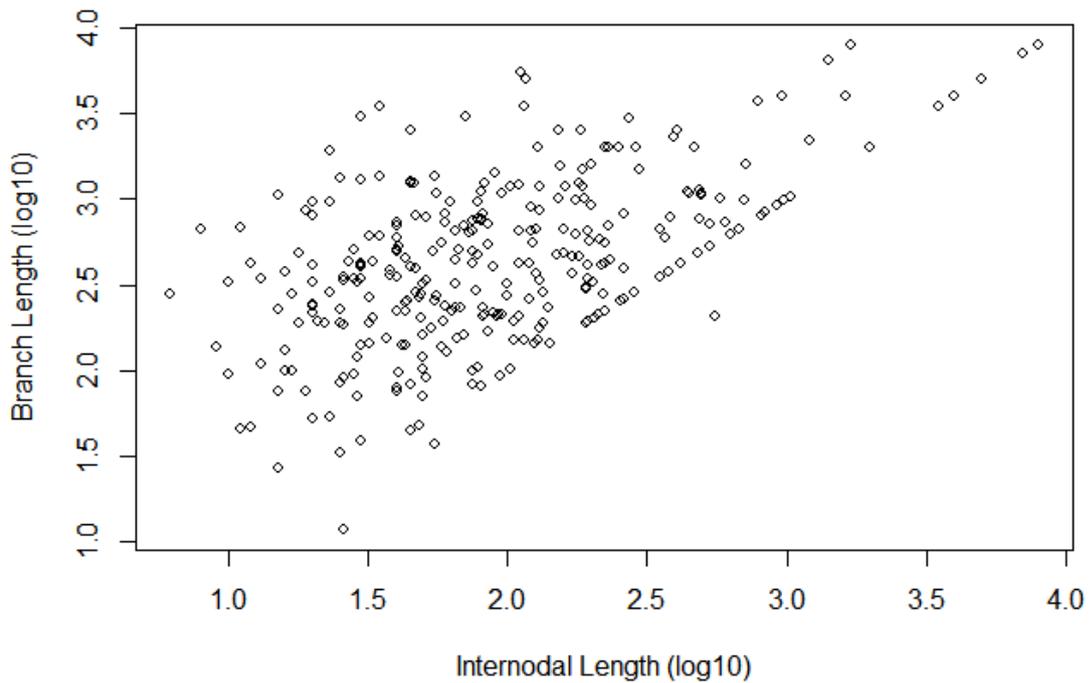


Figure 3.3.2: Scatterplot showing the correlation between branch and internodal length within our research area.

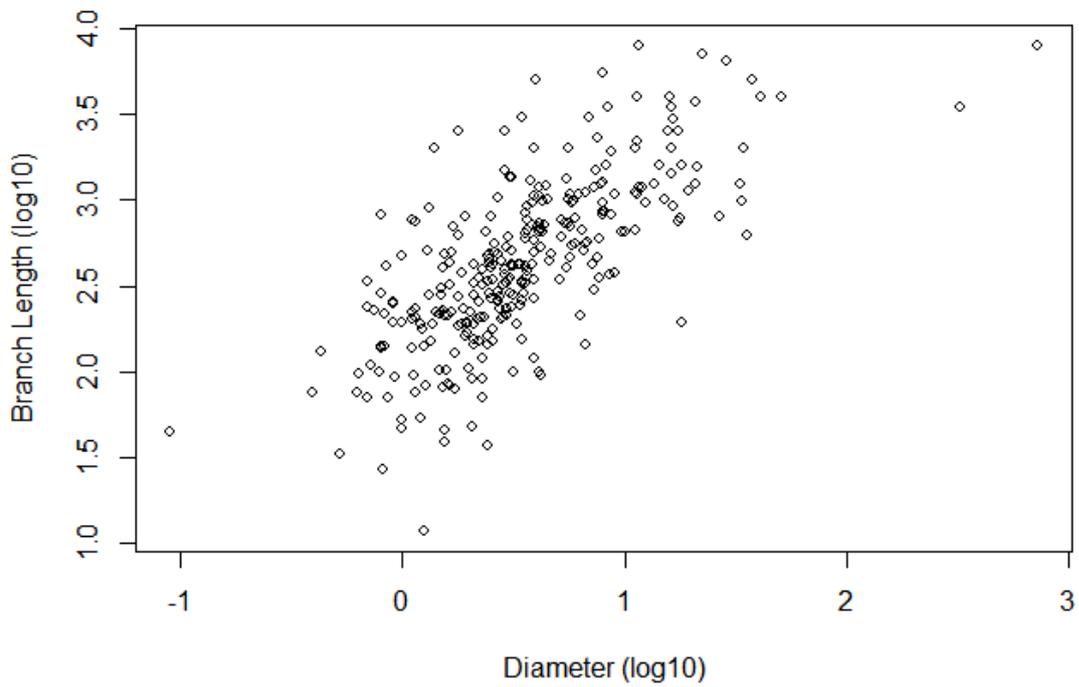


Figure 3.3.3: Scatterplot showing the correlation between branch length and perch diameter within our research area.

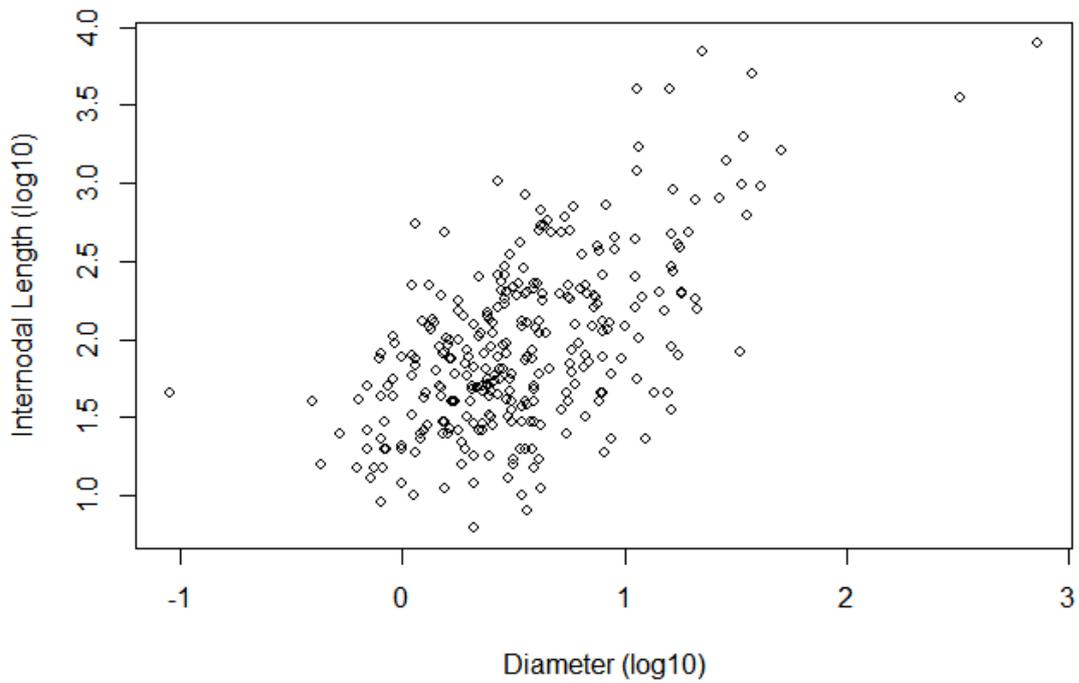


Figure 3.3.4: Scatterplot showing the correlation between branch length and perch diameter within our research area.

Wider branches were significantly longer ($P < 0.01$) and had wider internodal lengths ($P < 0.001$) than narrower substrates. Further, longer branches also generally had longer internodal lengths ($P > 0.001$).

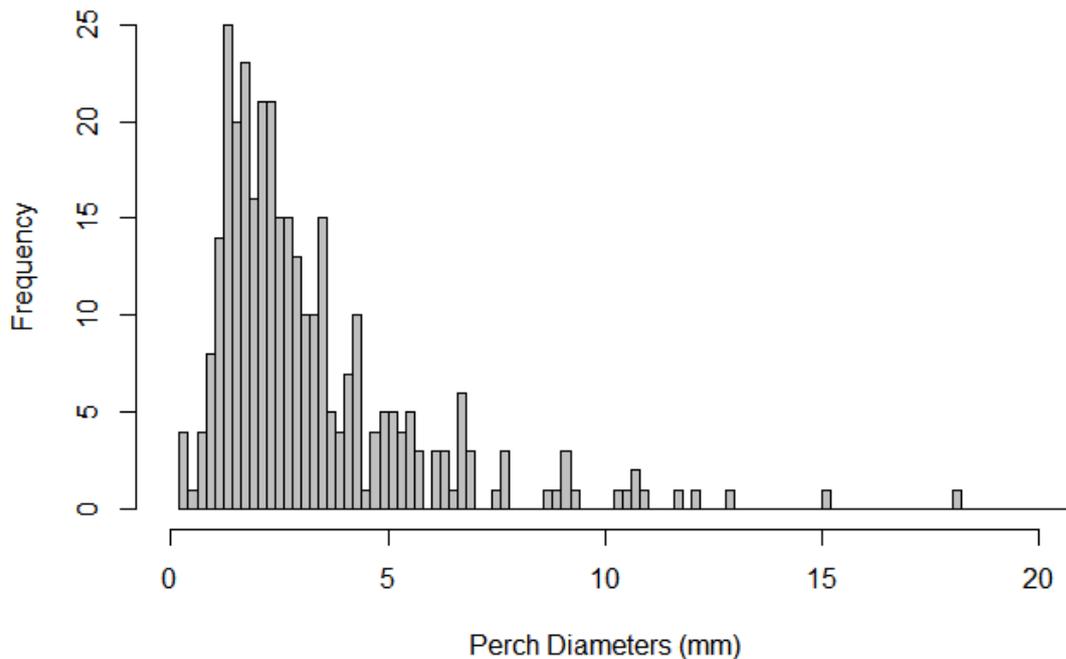


Figure 3.3.5: Histogram of the empirical distribution of perch diameters within 0.5 m of chameleons. Actual measurements stretch beyond 20 mm diameter but for completeness of data the majority of measurements are given within the bracket shown; this continuation of data is denoted by the arrow on the x-axis.

At the time of writing 26 individuals have been sampled during chameleon ecomorphology surveys.

Adult chameleons selected an average perch diameter of 3.66mm. Using the non-parametric Wilcoxon signed rank test it was determined that chameleon substrate use did not significantly differ from what available Perch diameters ($P = 0.47$). Diameter measurements taken within 0.5 m of chameleons were significantly wider than those available in our research area ($P < 0.001$).

However, as the notches on the boxplot in Fig. ?? do not overlap, this is considered strong evidence that the medians of these data differ (Chambers et al. 1983).

3.3.4 Discussion

Our results show that chameleons do not seem to be selecting perches that are significantly wider or narrower than the average of what is available to them in their habitat. However, we can show tentative evidence that chameleons seem to select microhabitats that contain generally wider diameters than the average of wooded substrates, and these microhabitats are generally more open. As our data collection period has not yet finished it would be difficult to draw any lasting conclusions from.

Our data also show that perches that are wider generally have a wider internodal length and are longer. Therefore, chameleons selecting more open microhabitats with wider branches than the average may confer locomotor and foraging advantages. As the internodal length is wider on wider branches there would be less interference for chameleons to navigate along these substrates, and there would likely be less branches to hinder predation using their ballistic tongues. However, as these data were recorded on nocturnal surveys we must consider other ecological motives for selecting more open, less ‘cluttered’ microhabitats. Chameleons tend to select roost perches on the ends of outstretched branches, this could have benefits twofold: a). this provides a quick escape route to the ground or other branches if a predator disturbs any other part of their wooded perch (we have frequently seen chameleons leap to the floor at the sign of potential danger, their body size means that severe damage is unlikely), and b). this could provide good foraging habitat for the early morning when, as a reptile, chameleons’ metabolism is slow and has not been assisted by solar input. While both of these motives may contribute to how chameleons select their roost perch we would need more data on their rates of predation and early-morning feeding habits to draw any solid conclusions. Further data will be collected on a larger sample size of chameleons in the coming phase and will be elaborated upon in the next science report.

3.3 Invertebrate Inventories

Terrestrial invertebrate communities on Madagascar are generally understudied. Yet, as in most other terrestrial habitats, insects and their close relatives make up the majority of faunal species diversity. This paucity of data connecting habitats to the animals that inhabit them hinders attempts to fully understanding Malagasy ecosystems and their environmental trajectory. Further, many forest-dwelling invertebrates can be studied to elude to the health of their local ecological area, so-called ‘environmental sentinels’. Thus, investigating insect ecology within the woodland habitats in our research area could provide a lens onto the overall health of these forests.

During phase 183 day-flying butterflies and spiders continued to be surveyed. These surveys took the form of opportunistic sampling where random GPS locations were chosen, groups of varying size then visually scanned the surrounding area for particular taxa, spiders for example. Individuals were identified (if possible) and photographed. While this data cannot be used to make general ecological statements about these animals, it is hoped that through continued use of these methods MGF can build a full inventory of these species with an associated photographic catalogue. Along these lines we have made specific progress and identified 32 butterfly species, what we suspect to be a significant proportion of the butterfly assemblage in our research area.

For the coming phase we wish to begin more in-depth butterfly surveys, to continue with opportunistic spider surveys, and to begin sampling beetle species within our research area.

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