Abstract

Malagasy lemurs are under great threat from destruction of their habitat. Since humans colonized Madagascar 2000 years ago roughly 90% of Madagascar's forests have been destroyed (Benstead & Goodman, 2005). Alongside this, fully eight genera and 17 species have gone extinct (Mittermeier et al, 2010). With the present situation it is of the utmost importance to recognize the ecological plasticity and response of lemur species towards anthropogenic threats. The behaviour of three groups a total of 15 Verreaux's sifaka (*Propithecus verreaxi*) were observed for 5 weeks, from July 1- August 2, 2013 in Mandrare valley, Southern Madagascar. The study took place in three different habitats, one having relatively little disturbance, another having been greatly influenced by selective logging and grazing, and the third lying somewhat in the middle. Data was collected on activity budgets, feeding ecology, and habitat preferences in each of the three groups and statistically compared. This project aided the research effects of Operation Wallacea.

Key words: Lemur, Verreax's Sifaka, *Propithecus verreauxi*, Activity Budgets, Feeding Ecology, Habitat Preferences, Spiny Thicket.

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Introduction

Madagascar is the fourth largest island in the world and is identified for its wide range of ecosystems and its largely diverse flora and fauna. Separating from India and the Seychelles roughly 90 million years ago the island completed its severance from its Gondwana (supercontinent) roots (Mittermeier et al, 2010). This micro-continent has since created its own geological history; it is referred to as the eighth continent by many scientists for its inimitable paleontological record. As Africa and India’s fauna had exposure and opportunity for replacement, the isolated fauna of Madagascar did not. It has become an interesting question as to how primates arose on the island, which has not moved for the past 90 million years. It has been apart from its Gondwana roots for too long to have an African “founder effect”. Lemurs are comparable on an evolutionary level to euprimates which did not appear in fossil records until 55 million years ago (Mittermeier et al, 2010). These “primates of modern aspect” are different from plesiadapiforms which have a fossil record of 65 million years. Fossil records of euprimates have largely been seen in North American and Europe with fragments in Egypt and the Arabian Peninsula (Mittermeier et al, 2010). This leads scientists to believe that there must be a much older common ancestor of the euprimates that was once spread across Africa. Regardless, it appears that the ancestors of lemurs must have reached Madagascar by crossing the sea known today as the Mozambique Channel. Certain species of lemur, such as *Microcebus* and *Cheirogaleus*, are able to hibernate and therefore had the opportunity to travel the sea while hibernating on a large mass of vegetation that drifted over from Africa (Samonds et al, 2012). There are other theories such as land bridges, however none have been proven (McCall, 1997). Despite the flux in theories lemurs are monophyletic and all share a sole common ancestor. Yet the origin of lemurs on Madagascar remains a mystery.

The richness of Madagascar's flora and fauna has evolved in isolation to be unmatched by biota elsewhere on Earth. Madagascar's high species diversity and endemism on genus and family levels make it a biodiversity hotspot. Despite the size of the island, Madagascar has radically different climate zones. Biomes on the western side of the island consist of dry savannah. The tropical rainforest, with a high level of rainfall, is located on the eastern side of the island, facing the Indian Ocean. Several high mountain ecosystems are also host to this island (Brooks et al., 2002). These contrasting biomes in turn support the many contrasting species in Madagascar. Madagascar contains several ecosystems such as, rainforest, dry deciduous forest, montane forest, grasslands, wetlands, bare-rock highlands, and the endemic spiny thicket (Benstead & Goodman, 2003). The island's ecosystems have allowed for a vast array of ecological niches allowing for a wide range of wild life. Endemism rates are estimated to be 92-100% in terrestrial animals and 52-60% in avian animals (Benstead & Goodman, 2005).

Madagascar's 101 species and subspecies of primates are found nowhere else on Earth, making their conservation of particular concern. As a flagship species, they have become prioritized for conservation and protection. The International Union of Conservation of Nature (IUCN) has classified 8 species as critically endangered, 15 as vulnerable, 4 as near threatened, 8 as least concern, 41 as data deficient, and 7 have yet to be evaluated (IUCN, 2012). Since the arrival of humans 2000 years ago eight genera and at least 17 species have gone extinct (Mittermeier et al, 2010).

Threats to lemurs include habitat destruction, hunting, and invasive species. Clear cutting forests for agriculture is becoming increasingly popular with Madagascar's increasing human population. Many Malagasy farmers do not know proper techniques and frequently deplete the soil of all its nutrients before moving onto a new area. With these methods, it can take nearly 15 years for the soil to restore itself causing the Malagasy people to continue to destroy forests, preventing the regeneration of habitats (Green et al, 1990). Tavy, also known as slash-and-burn agriculture or hatsake, is the essence of the Malagasy economy and culture (Green et al., 1990). Typically, an acre or more of forestland is cut, burned, and replanted with crops. Most often, this method is used to convert the tropical rainforest into rice fields. The production of rice on these fields last a couple of years and then are left fallow before the cycle is repeated. This cycle can only be repeated about two or three times before the soil is drained of nutrients and can support nothing more than scrub vegetation or alien grasses (Green et al., 1990). These areas are of particular concern on slopes because the vegetation is insufficient to anchor the soil, making landslides and erosion a problem. Despite the lack of sustainability of this method it is the most expedient way for countless Malagasy to provide for their families. With a growing human population, this requires more land to be exploited for crops. This is problematic for all other species that survive on the forests. The spiny forests that are endemic to Madagascar are also being cut down at alarming rates, due to charcoal production (A Guide to Madagascar, 2012). The destruction of these forests has a detrimental impact on numerous species causing lack of food availability and habitat. Since human colonization of Madagascar 90% of its forests have been lost (Benstead & Goodman, 2005).

Although it has been illegal to kill a lemur since 1964, they are still hunted in unprotected areas (Madagascar, 2013). It is also a fady (taboo) for the Malagasy people to eat lemurs. Nevertheless, lemurs are still commonly hunted for bush meat. A study done by Randrianandrianina et al. (2010) interviewed villages near an area where Sifaka were known to be hunted for food. The people had admitted to eating lemur meat but said they found it to be unpleasant. Randrianandrianina et al. suggested that they may have lied about disliking the taste of lemur meat, knowing that it is illegal to hunt. In the area where this present study was carried out, known as the Androy region, the local people are considered to be very spiritual. A fady is an inherited law passed down from ancestors of which violation will be suffering brought on by the spirits or a fine of one zebu to the elders of the village (Tengo et al, 2007). The fady has contributed to much conservation of nature since parts of the nearby forests and lakes are considered impenetrable because the ancestral spirits reside there (Jones et al, 2007). Respect for elders and these spirits is prominent in this region. The protection by the Malagasy belief system seems to be the most beneficial in a severely exploited area. In the same region, sifaka's are thought to be the embodiment of ancestral spirits and are therefore also a taboo to kill (Jones et al, 2007). A study by Jones et al. (2007) concluded that the dominance of fady in the Malagasy culture is considerable enough to protect forests and selected species that dwell in it.

This study focuses on Verreaux's Sifaka (*Propithecus verreauxi*), an arboreal lemur found in southern Madagascar. It is a folivorous prosimian with a wet nose (strepsirrihnes) (Richard et al, 1991). *P. verreauxi* tend to live in mulit-male, multi-female groups with a group size ranging from 2-14 individuals (Richard, 1985). Their average length ranges from 90-110cm, with a weight of 3.0-3.5kg (Mittermeier et al., 2010). They have a tendency to remain and return to their site of birth, known as philopatry (Richard, 1985). This species is listed as vulnerable on the IUNC redlist and cannot be found in captivity anywhere on Earth. Due to extensive habitat degradation the population of *P. verreauxi* is estimated to decline by 30% in the next 30 years (IUCN, 2013). In the Beza Mahafaly private reserve the population is estimated to be decreasing by 2% every year (Lawler et al, 2009). In order to enhance the chances of survival for the sifaka, an in-depth understanding of this species is imperative.

Deforestation is a threat to the present flora as well as the fauna that reside in Madagascar. *P. verreauxi* has a diet comprised mostly of leaves; however, they will also eat fruit, bark, and flowers (Norscia et al, 2006). They have a low energy diet and generally remain in trees but are known to move bipedally across the ground. Spending most of their lives as arboreal creatures makes them particularly sensitive to the effects of habitat destruction. Norscia et al. also suggested in 2006 that there is a preference to quality of the food over quantity. They are diurnal creatures with the majority of their activity spent in the relatively cool mornings searching for leaves with high concentrations of protein and low in fiber (Ganzhorn, 1992). A previous study by Simmen at al. (2012) showed a tendency for primates to be in abundance where there is a higher nutritional content in the leaves. Being a herbivorous species, toxins are commonly found in food and digesting these is a consequence which makes finding quality food important (Norscia et al, 2006). Sifaka do not drink water directly and rely on succulent leaves to stay hydrated.

Deforestation results in habitat loss, but also creates an edge effect. This exposes the Sifaka to more danger such as land use change and hunting. When deforestation is done with improper techniques, the fragments left are not of substantial size and are not well connected to allow dispersion. Along with nutritional quality of food, Sifaka's are known to be more abundant in correlation with trees that have a diameter at breast height greater than 5 cm (Norscia et al, 2010). This is an important factor when considering the structure of forest fragments. The connections between fragments by bridges are of particular importance to maintain gene flow among populations. Without gene flow between familial groups, inbreeding, population decrease and even extinction is possible (Quemere et al, 2010).

Southern Madagascar is known to have two distinct seasons, the dry season and the wet season. Between these two seasons there are dramatic changes in water availability and food resources. Simmen et al, in 2003, discussed differences in annual rainfall from 229-912mm/year. The variable climate, often including cyclones, can have huge impacts on *P. verreaxi's* reproduction, food supply, and locomotion methods (Lewis and Rakotondranaivo, 2011). Lewis and Kappeler (2005) discussed the reproductive success of *P. verreaxi's* dependent on weather. The breeding season takes place between January and March and gestation lasts between 160-170 days. Food supply is usually at its peak during the rainy season and disruption in this may prevent breeding for the year. In this sense, climate can strongly influence the survival of Vereaux's sifaka. Alloparenting care is seen in sifaka, which includes the entire family groups and not only the genetic parents (Teco et al, 2012). In 2004, Godfrey et al showed that sifakas have an increased rate of dental development compared to other primates, allowing mastication of seeds and unripe fruit at a younger age.

This study took place in the Ifotaka North Protected Areas, located at the southern tip of Madagascar. The protected area was established in 2006, covering 22,256 hectares (Madagascar Biodiversity Fund, 2013). Figure 1 outlines the location of this area.

Figure 1: Map of Ifotaka North Protected area. (Adapted from http://www.protectedplanet.net).

A monitoring plan for the Ifotaka North Protected Area in currently ongoing under Durban Vision. The government has targeted 8 conservation priorities. These consist of high spiny thicket, low spiny thicket, coua’s, gallery forest, songo trees, radiated tortoises, diurnal lemurs, and other rare species (Ifotaka Monitoring Plan, 2011). In the category diurnal lemurs falls Verreaux’s sifaka. This plan also takes into consideration the largest threats to these conservation priorities, which include hunting, deforestation, selective logging and burning, and invasive species. This plan was started in 2011 and will continue until 2016 (Ifotaka Monitoring Plan, 2011).

The Ifotaka North Protected Area is exceptionally unique because it incorporates the villages currently residing in the area. It integrates the people, live stock, and agricultural land into their strategy. It is important not to take previously inhabited land away from the people. 68.7% of the islands’ inhabitants live below the poverty threshold, with 85% of these people living in rural areas, according the most recent data published in 2005 by the National Institute of Statistics. Incorporating the current population in the protected area categorizes it as an IUCN category V park (Ifotaka Monitoring Plan, 2011).

Home range can be defined as “the area over which a group travels to fulfill its dietary needs” (Wieczkowski, 2006). Most folivores often have a constant and wider home range, compared to such diets as frugivores, where food sources are generally clumped together. (Wieczkowski, 2006). In 1985, Richard completed an extensive study on the home ranges of sifaka. He concluded they have relatively small home ranges, from 1-8.5 hectares. He also noticed an inconsistency in strict borders. Sifakas found in the Ampijoroa have home ranges that overlap significantly, Hazafotsy sifakas home ranges have minimal-moderate overlap, and Berenty sifakas have no overlapping at all. Specifically in family groups with no overlap and comparatively small home range sizes, forest fragmentation can have major impacts on the dispersal for breeding. Habitat destruction can have two possible outcomes on sifaka home range size. The family group will expand its home range in the search for resources, or it will decrease its home range size to limit energy expenditure (Gerber et al, 2013).

This study focuses on Propithecus verreaxi in the Ifotaka North Protected Area, spiny thicket. This research will contribute to understanding of this species' ecological plasticity to anthropogenic threats. Three family groups from different levels of disturbed spiny thicket were observed from June 29-August 3, 2013. The family group located in the most severe degradation of habitat is hypothesized to have significant difference in activity budgets from the group located in an area of least degradation. The plant species of which the individuals are feeding and for how long are hypothesized to be different as well as the home range sizes. The objective of this research is to definitively compare:

- Activity budgets in minimal, moderate, and severely disturbed habitats.
- Feeding ecology in minimal, moderate, and severely disturbed habitats.
- Habitat preferences in minimal, moderate, and severely disturbed habitats.

Methods

Study site:

The study was carried out near the town of Ifotaka, Madagascar. This is roughly between 600 000-620 000, 724 000-726 000 UTM. The specific study sites were located in the spiny thicket of southern Madagascar. This is part of the Ifotaka North Protected Area, located in the Mandrare Valley. The reserve is unique from most in that it contains villages and agricultural land amongst the spiny thicket. All data was collected for a period of 6 weeks. There were a total of 15 Verreaux's sifakas followed, 3 belonging to site 1, 6 to site 2, and 6 to site 3. The study took place during the summer of 2013 from June 29-August 3.

Focal Animal Data:

This form of data collection was used to look at specific behaviors, such as socialization and diet.

There was one focal animal in each of the three habituated groups per day. The animals were on rotation, so as not to cause a bias towards one animal. The start time was recorded, to the nearest second, when a specific behavior began. When the behavior started, key details were recorded, such as the species of tree the subject is in, the plant part consumed (if feeding), and the height in tree. If it was a social activity, the lemur the subject was in contact with was recorded. Then the stop time, to the nearest second, was also recorded. This was defined to be when the behavior has ceased for a period of five seconds.

The tree in which the subject was engaged in feeding or sleeping for five minutes or more was marked as a focal tree. These trees were revisited during the point-center-quarter method and GPS coordinates recorded for home range analysis.

Instantaneous Scan Data:

This data was used to analyze the changes in activity budgets between the three habituated groups. The behavior was recorded every five minutes for each individual, using the codes found in the Ethogram (Table 1).

The time begun when the animals are located each morning. The observer was given one minute to locate all of the individuals and record the behavior at first glance. If an animal was located outside the first minute then is must be recorded as out of view.

Along with each scan, the observer also recorded the weather, using the codes from the Ethogram (Table 2), and the minimum and maximum heights for all individuals in the group.

Weather Data:

The temperature and the humidity were also recorded at 06:00, 12:00, and 18:00 daily.

Table 1: Ethogram Codes

Resting	Inactive (RI)	Stationary. Eyes open, head down.
	Alert (RA)	Stationary. Eyes open, head up.
	Inactive social (RIS)	Stationary. Eyes open, head down. In direct contact with another member of the group.
	Alert social (RAS)	Stationary. Eyes open, head up. In direct contact with another member of the group.
	Basking in sun (RB)	Stationary. Sitting in upright position exposed fully to sunlight.
	Scratch (RS)	Stationary. Hand or foot being used to relieve some itch.
	Self-groom (RG)	Stationary. Tooth comb being passed over own fur.
Feeding	Feeding (F)	Actively searching for, holding, or masticating something to be swallowed; swallowing.
Social	Groom (SG)	Engaged in allogrooming (tooth comb passing through fur), giving and/or receiving.
	Aggression (SA)	Engaged in some hostile encounter, possible chatter-squeal.
	Vocalization (SV)	Engaged in some audible call to communicate with group.

	Scent-mark (SS)	Engaged in rubbing some scent gland (stenal gular or ano-genital) on some object or gouging tree with teeth with intention of leaving some scent.
	Play (SP)	Engaged, close physical contact with some other individual that does not resemble rhythmic grooming or aggression.
Travelling	Within tree (TW)	Moving along/between branches within the same tree.
	Tree to tree (TT)	Moving between two trees.
	Pause (TP)	Moving, currently stopped <10 seconds.
	Ground (TG)	Moving along the ground.

Table 2: Weather Codes

0	No clouds (0-5%)
1	Minimal cloud cover (5-25%)
2	Moderate cloud cover (25-50%)
3	Cloudy (50-75%)
4	Mostly cloudy (75-100%)
+	Drizzle
++	Light rain
+++	Rain
++++	Heavy rain

Table 3: Additional Ethogram Codes

D	Animal defecating
U	Animal urinating

OV	Animal cannot be seen within 1 minute of the 5 minute interval.

Table 4: Food Item Codes

YL	Young leaves
ML	Mature leaves
F	Fruits
S	Seeds
STM	Stems
W	Flowers

Point-Center-Quarter Method:

The previously flagged sleeping and feeding trees were used as "point centers" to determine the difference in habitat type used by the three groups of sifaka.

Random trees that are representative of the thicket were also sampled along a transect line for additional comparisons. A point center tree was chosen every 10 meters along a 50-meter transect line. A random numbers table was then used to determine the number of meters away from the transect line a point center tree was located. The tree used had a circumference at breast height of at least 31.41cm.

From the point centers (selected either randomly or by sifaka use) a cardinal coordinate system was used, refer to Figure 2. The GPS coordinates, circumference at breast height, name, height, and phenology was recorded for both the center tree as well as for the four cardinal quadrants. The trees in the quadrants must also have a minimum circumference at breast height of 31.41cm. The distance from the center tree was also noted.

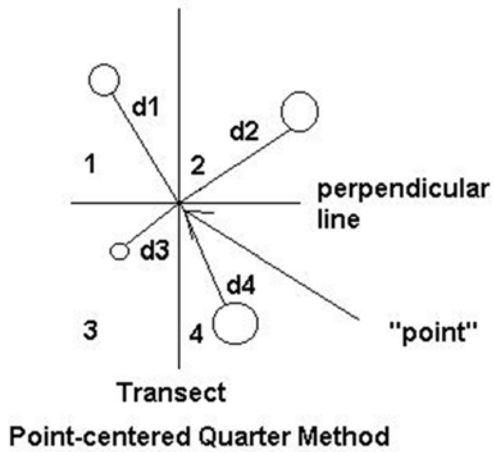


Figure 2: Point-center quadrants (Serach, 2004).

While collecting the PCQ data, an assessment of environmental disturbance is completed using the following table.

Table 5: Level of disturbance corresponding to a numerical value.

	1	**2**	**3**	**4**
Evidence of grazing	No evidence of grazing by ungulates- no droppings, footprints, or grazing traces.	Minimal evidence of grazing- few traces of footprints, droppings, or grazing (not significant to alter forest composition).	Increased to high level of grazing- definite traces of footprints, droppings, or grazing, but original composition of forest not drastically damaged.	Extensive evidence of grazing- many traces of footprints, droppings, and grazing that has altered the area in a drastic way.
Paths/Roads and fences	No paths/roads or fences present.	1-2 small paths or fences, no roads.	2-3 paths or fences and possibly a road.	More than 3 paths, or fences and roads that obviously disturb the surrounding

				forest.
Selective logging/burning	No signs of logging or burning- no burnt trees or cut stumps.	Several signs of logging or burning- a couple of cut or burnt stumps, but not to an extent that transformed the forest composition.	Lots of evidence of logging and burning- cut and burnt stumps present, and/or plank making evidence.	Significant evidence of logging or burning- clear or burned areas.
Invasive species	No species of cactus or sisal plants.	A couple of species of cactus or sisal plants, but not significant numbers.	Increased populations of sisal and cactus plants- not the dominant species, but less than half.	Extensive invasive species present- dominant species in the area and obviously not the original forest composition.
Overall quality of forest	Hardly disturbed- forest very well intact.	Some disturbance- forest shows signs of disturbance, but still mostly intact.	Disturbed- lots of disturbance, but original form of forest still visible.	Very disturbed- so many disturbances that the forest is unrecognizable.

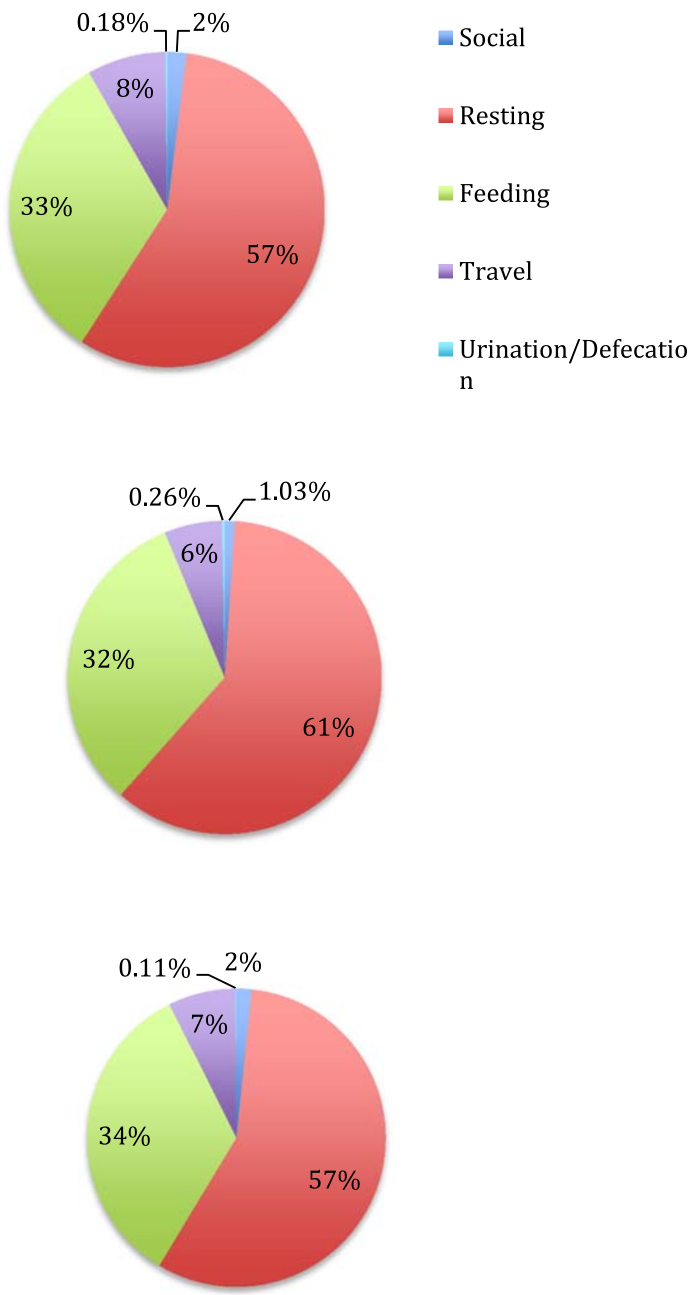
Analysis

Activity budgets were compared graphically and trends compared. Feeding preferences were shown graphically and further compared between the three groups. Habitat preferences were also displayed graphically and the use of ArcGIS to map out home ranges. A one-way ANOVA was used to determine if there was a significant difference in the level of disturbance between the three groups.

Results

Activity Budgets

Activity budgets of the three sifaka groups were determined using table 1. Data was recorded for group 1 between 07:25-18:27. The data recorded from group 2 was between 07:40-17:00. Group 3 was recorded between 08:00-17:35. If any of the codes were typed into the computer wrong they were not identified as a similar mistyped code, rather they were changed to out of view (OV) and not included in the analysis. Figure 3 shows a comparison of the broader activity budgets of social, resting, feeding, travelling, and other. The total percentage of social time by group 1 was 2%, group 2, 1.03%, and group 3, 2%. The percentage of time spent resting by group 1 was 57%, group 2, 61%, and group 3, 57%. The percentage of time spent feeding by group 1 was 33%, group 2, 32%, and group 3, 34%. The percentage of time spent travelling by group 1 was 8%, group 2, 6%, and group 3, 7%. Figure 4 shows a comparison of the specific behaviours in each of the three groups.



<u>Figure 3:</u> The percentage of time devoted by Sifaka to each broad behavioral class. Top: Site 1, Middle: Site 2, Bottom: Site 3.

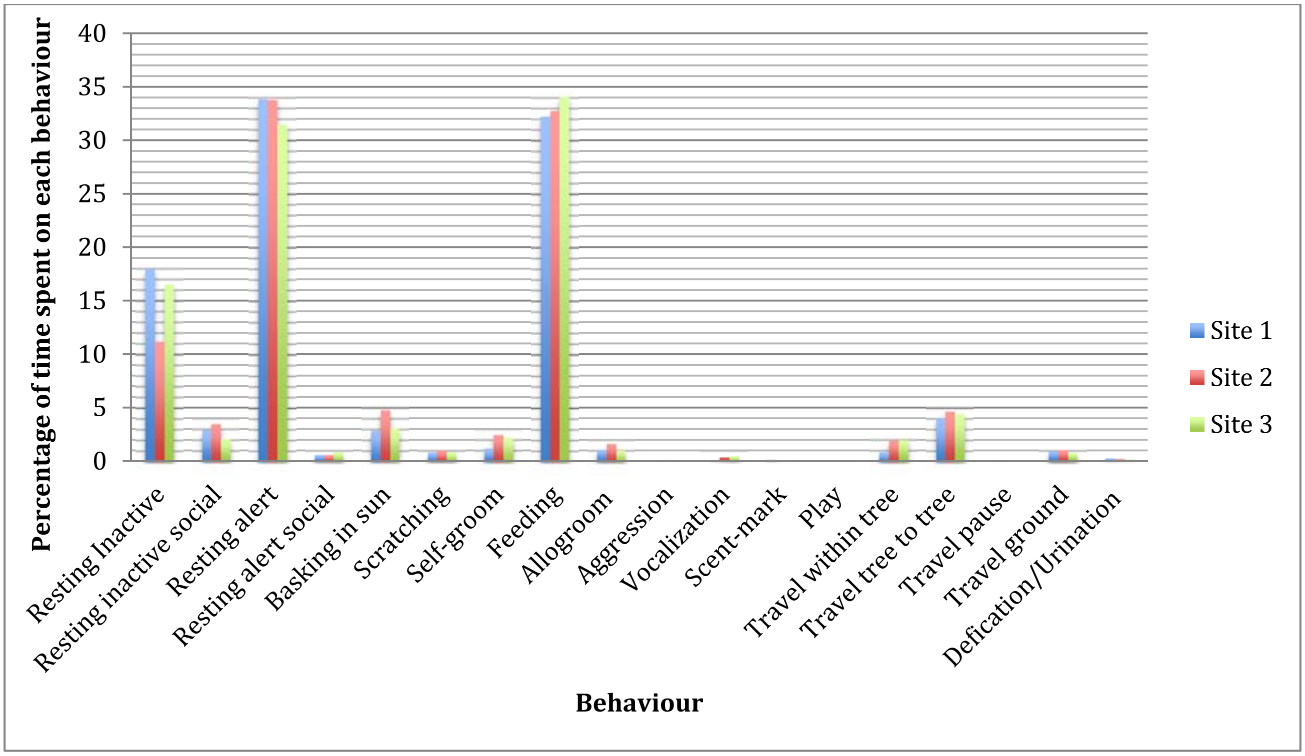


Figure 4: Allocation of time dedicated to each specific behaviour at the three lemur sites.

The percentage of time spent on each behaviour in the morning compared to the afternoon was compared for site 1 (figure 5), site 2 (figure 6), and site 3 (figure 7). In the morning the majority of time is spent resting while in the afternoon the majority of time is spent feeding. This is seen at all three sites. The effects of cloud cover were then compared at all three sites to activity budgets. Site 1 shows increasing social activity with increasing cloud cover (figure 8). The amount of time spent resting is also at a maximum on very sunny and very cloudy days. There is no trend between cloud cover and activity budgets in sites 2 and 3 (figure 9, figure 10).

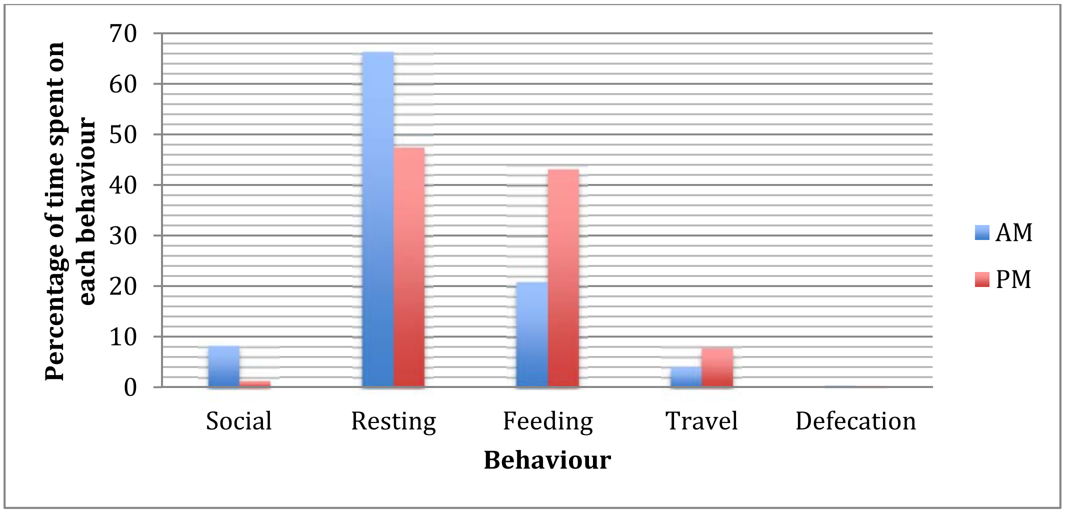


Figure 5: Comparison of activity budgets from the morning (blue) and afternoon (red) of Sifaka at Site 1.

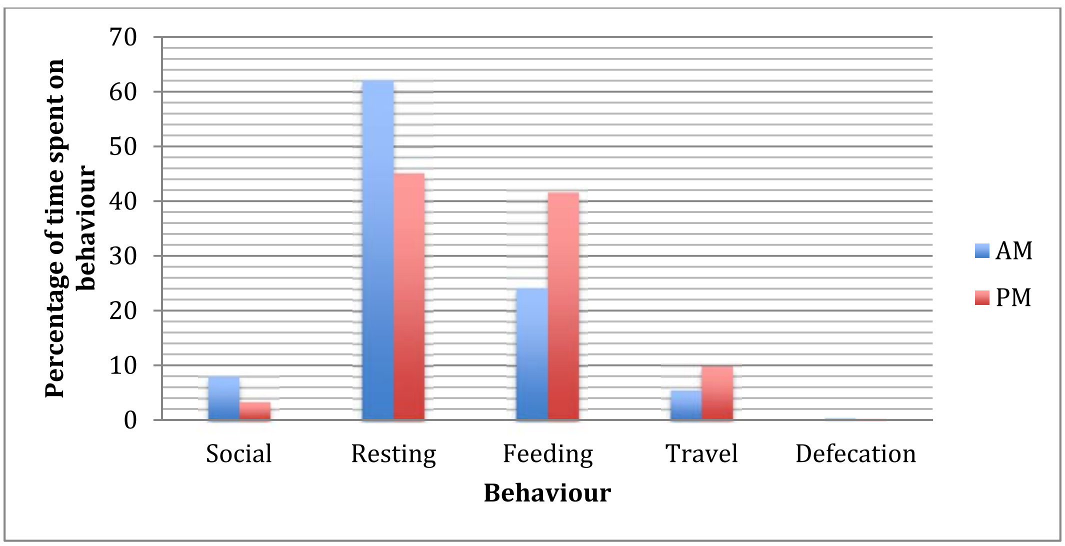


Figure 6: Comparison of activity budgets from the morning (blue) and the afternoon (red) of Sifaka at Site 2.

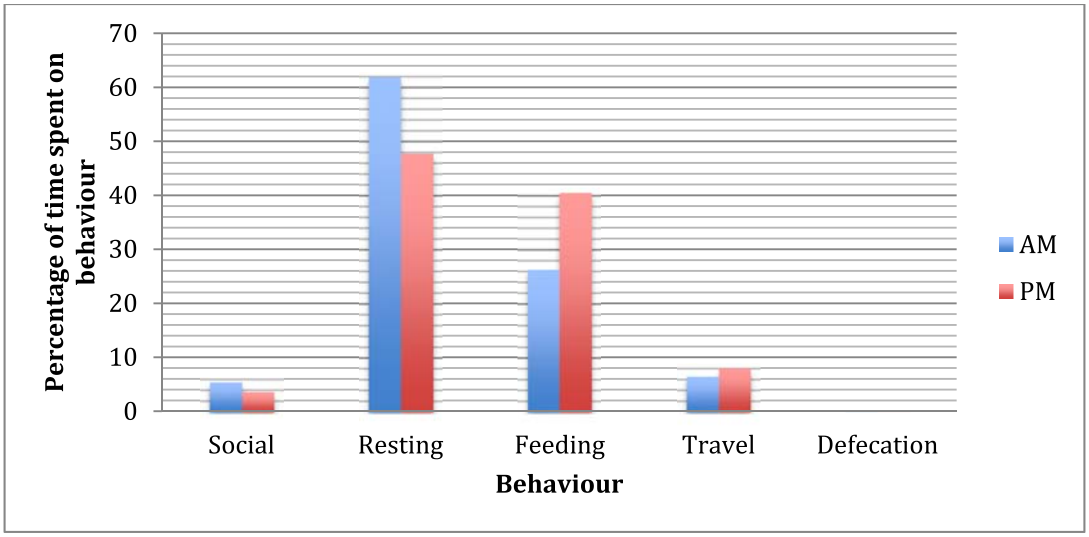


Figure 7: Comparison of activity budgets from the morning (blue) and the afternoon (red) of Sifaka at Site 3.

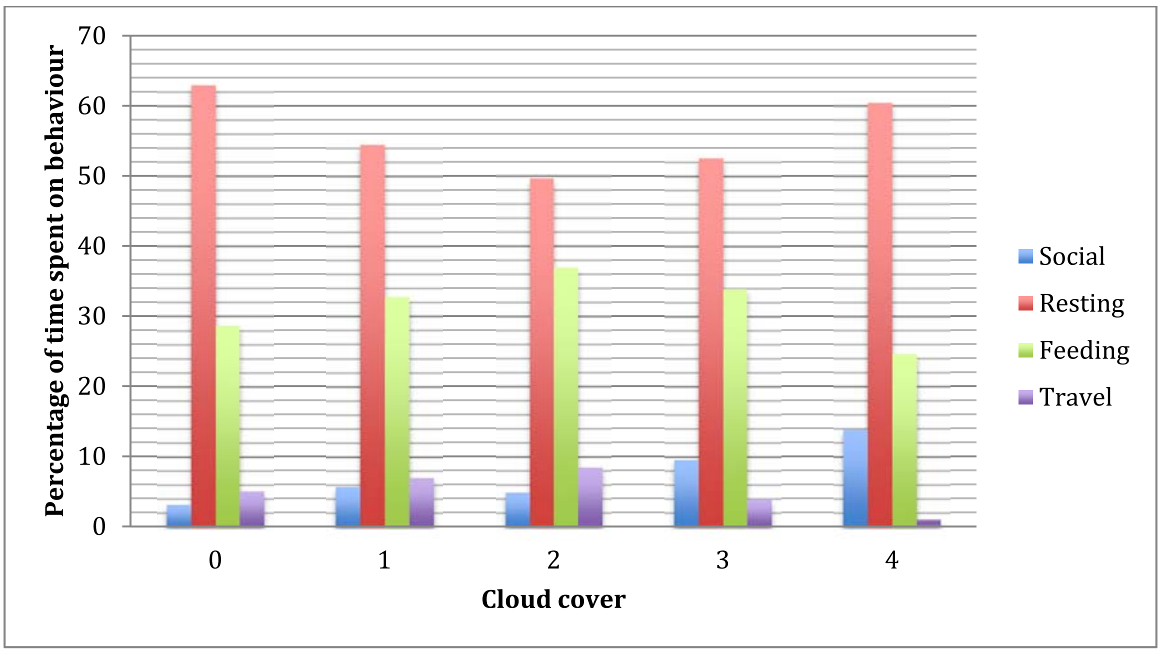


Figure 8: The effects of cloud cover on the behaviour of the Sifaka at Site 1. (Refer to table 2.4 for the weather ethogram codes).

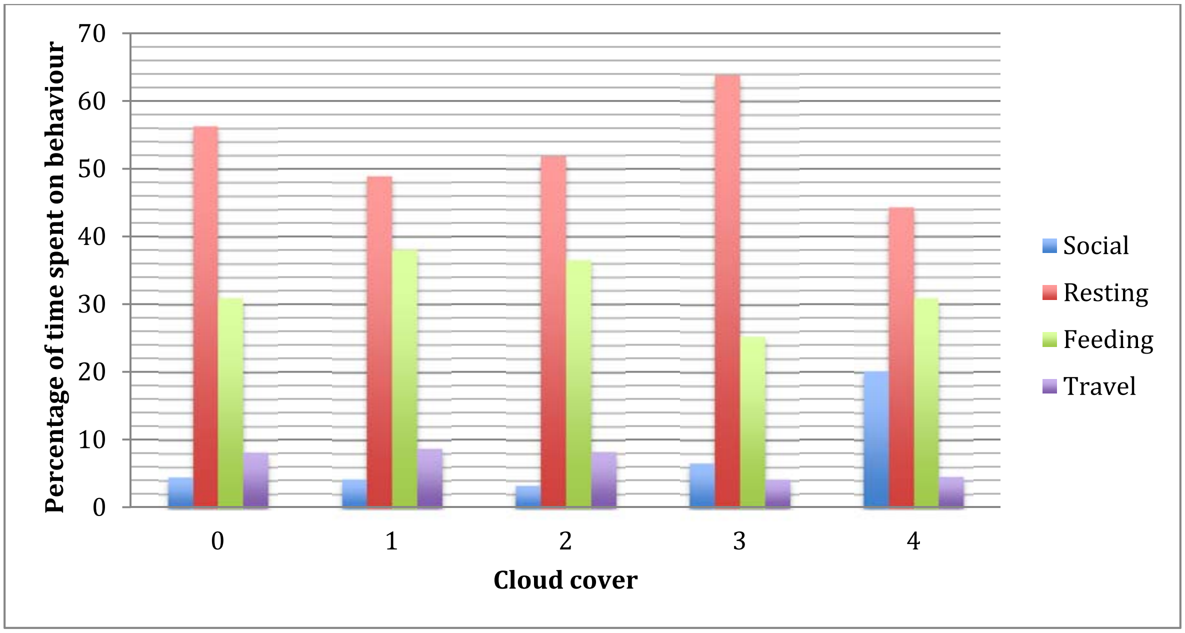


Figure 9: The effects of cloud cover on the behaviour of the Sifaka at Site 2. (Refer to table 2.4 for the weather ethogram codes).

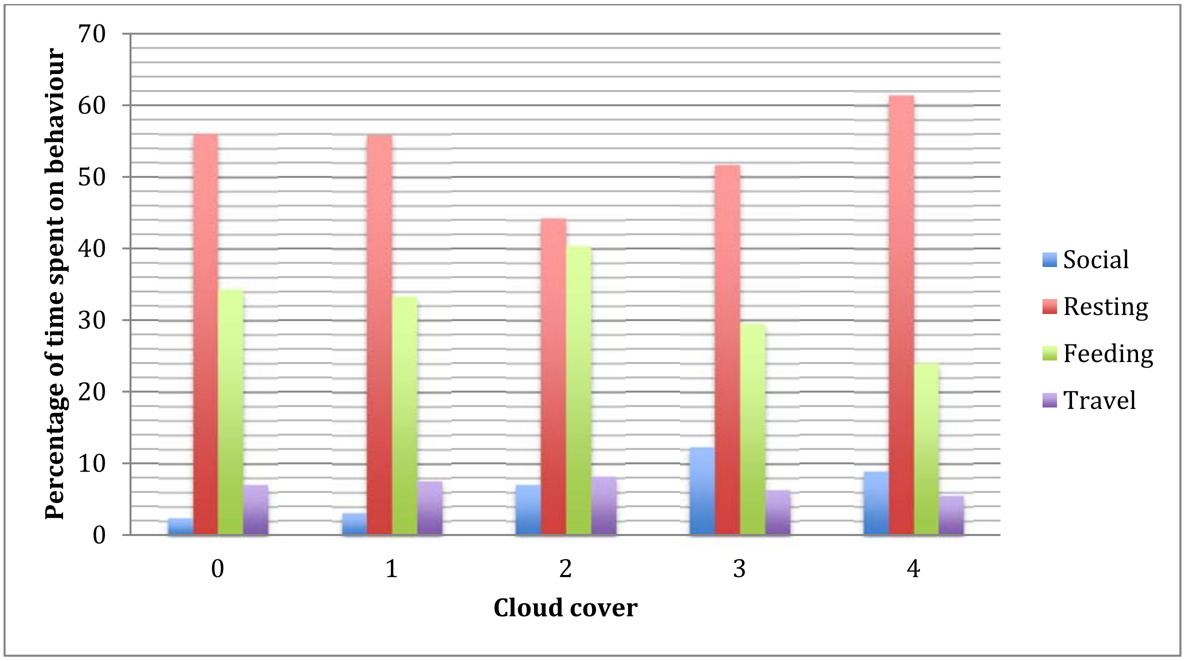
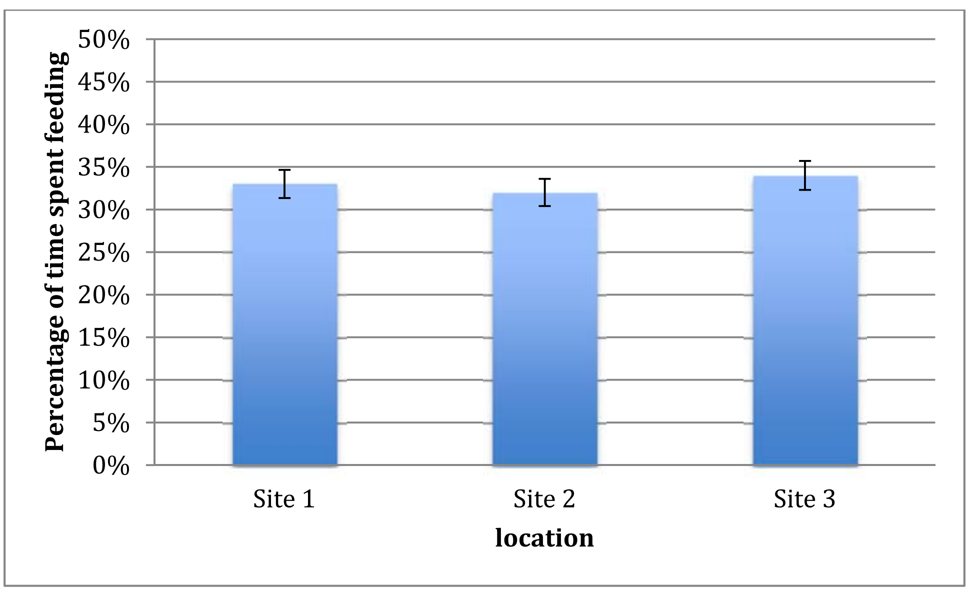


Figure 10: The effects of cloud cover on the behaviour of the Sifaka at Site 3. (Refer to table 2.4 for the weather ethogram codes).

Feeding Ecology

We did not do focal animal for group three because the thicket was too dense to keep track of one individual (activity budgets needed 2 people to collect data) and we did not have each individual strictly identified.

Group 1 had a total feeding time of 73 hours, 48 minutes, and 30 seconds ±3 minutes, 16 seconds. Forchetty's total feeding time was 23:26:12. Clint's total feeding time was 21:42:11. Ngesa's total feeding time was 28:40:7. It should be noted that Ngesa was pregnant for the duration of this study which may have altered the amount of time she spent feeding compared to the other individuals in her group. Group 2 had a total feeding time of 59 hours, 44 minutes, and 54 seconds ±19 minutes, 20 seconds. Mavovavy's total feeding time was 08:05:29. Fotivavy's total feeding time was 05:11:26. Fotilahy's total feeding time was 08:04:48. Retoloho's total feeding time was 08:36:13. Maintilahy's total feeding time was 18:43:16. Marley's total feeding time was 11:03:42. Figure 11 compares the percentage of time spent feeding between all three groups and Figure 12 compares the total time spent feeding between group 1 and group 2.



<u>Figure 11:</u> Percentage of time spent by each sifaka group feeding.

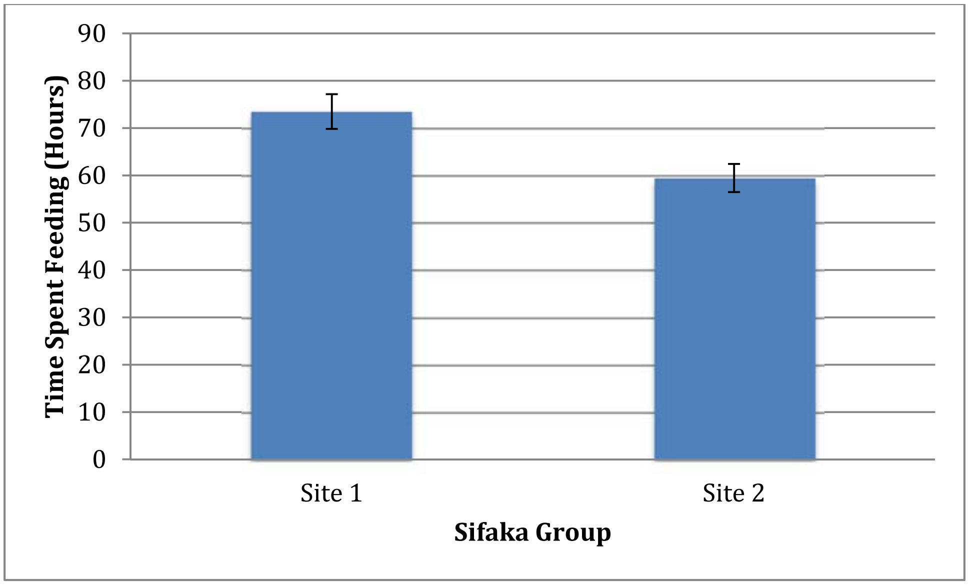


Figure 12: Comparison of hours spent feeding from June 29- August 3, 2013 between sifakas at Site 1 and Site 2.

Habitat Preferences

Focal trees and well as random point center trees and the corresponding quarter trees were used to identify the vegetation present at each site and the number of plant species used at each site. There were a total of 89 plant species identified between all three sites. 53 of those species were found at site 1, with 25 for lemur usage. 62 species were found at site 2 and 35 had lemur usage. 50 species were found at site 3 and 23 had lemur usage.

<u>Table 6:</u> Comparison of the diversity of vegetation at all three sites and species for sifaka usage.

Vernacular Name	**Latin Name**	**Present at Site 1**	**Sifaka usage at Site 1**	**Present at Site 2**	**Sifaka usage at Site 2**	**Present at Site 3**	**Sifaka usage at Site 3**
Befoste	*Euphorbia leucodendron*	□		□		□	
Bekaleo	Unknown species					□	
Bemaimbo	Unknown species	□		□		□	
Dagoa	*Strychnos decussata*	□	□	□	□	□	□
Daro	Unknown species	□	□			□	
Daroanomby	*Commiphora sp.*	□	□	□	□	□	□
Daro Mena	Unknown species	□		□			
Daro Sengatse	*Commiphora aprevalii*	□				□	
Darosike	*Commiphora cf mahafaliensis*	□	□	□	□	□	□
Darotandroke	*Commiphora sp.*			□		□	
Fantiolotse	*Alluaudia procera*	□	□	□	□	□	□
Farehetse	*Uncarina leandri*	□		□	□		
Feka	*Tabarnaemontana coffeoides*	□				□	□
Fihamy	Unknown species			□	□		
Fihañe	*Euphorbia plagiantha*	□	□	□	□	□	
Halomborognema halay	Unknown species			□		□	□
Hamboro	Unknown species	□					
Haradrato	Unknown species			□			
Hazobatango	*Indigofera cloiselii*	□		□	□		
Hazomby	*Neobeguea mahafaliensis*			□			
Hazolava	*Neobeguea mahafaliensis*	□		□			
Herotse	*Euphorbia intisy*	□		□	□	□	
Hetay Mainty	Unknown species					□	□
Hetonge	Unknown species			□			
Hily	Unknown species	□		□	□		
Hororoke	*Thylachium sp.*	□	□	□			
Jabihy	*Operculicarya decaryi*	□		□		□	
Kaleogne	Unknown species			□	□		
Katrafay	*Cedrelopsis grevei*	□	□	□	□	□	□
Kirava	*Mimosa deliculata*					□	□
Kobahy	*Terminalia sp*					□	
Kolao	Unknown species					□	
Kolohoto	*Boesqueia sp.*	□	□	□	□	□	□
Korapikes	Unknown species					□	□
Kororoke	Unknown species			□			
Lambinga	*Baudouinia fluggeiformis*	□	□	□	□	□	
Lamoty	Unknown species			□	□		
Lazagne	*Adenia sp.*	□		□		□	
Mafaibelona	Unknown species					□	

Magnary	Unknown species	□					
Maintefo	*Diospyros humbertiana*	□	□	□	□	□	□
Mang	*Hibiscus ambovombensis*	□		□		□	
Mañary	*Dalbergia trichocarpa*	□					
Mangily	Unknown species	□		□			
Maninjo	Unknown species			□	□	□	
Manongo	*Zanthoxylum decaryi*	□	□	□	□		
Marandoha	*Coptosperna ribbrechtii/Enterospermun pruinosum*	□		□		□	
Mongy	Unknown species					□	
Mosese	Unknown species	□					
Nato	Unknown species					□	
Papolahy	Unknown species	□		□			
Piso piso	Unknown species	□		□			
Relefo	*Strychnos sp.*	□	□	□	□	□	□
Retsilaitse	Unknown species			□	□	□	
Ringitse	Unknown species					□	
Rohondroho	*Alluaudia dumosa*	□	□	□		□	
Rouselitse	Unknown species			□			
Sakoandalitse	*Poupartia sp.*	□	□	□	□	□	□
Savoa	Unknown species					□	□
Siro siro	*Gyrocarpus americanus*	□	□			□	□
Sohihy	Unknown species			□	□		
Sohongidretraky	Unknown species			□	□		
Somoro	Unknown species					□	
Somotsoy	Unknown species			□		□	
Songombarike	*Alluaudia humbertii*	□	□	□		□	□
Songy	*Alluaudia ascendens*	□	□	□		□	
Taitsnadra	Unknown species					□	
Takisakisaky	Unknown species			□	□		
Taligne	Unknown species	□	□		□		
Talindrano	Unknown species	□					
Taly forokoko	*Terminalia tropophylla*	□	□	□	□	□	
Taly tivoka	*Terminalia divaricata*	□	□	□	□	□	
Taolaka	Unknown species	□	□				
Taolonkafotse	*Grewia sp.*	□		□			
Tarantagne	Unknown species			□	□	□	□
Tombombitsy	Unknown species			□	□	□	□
Tsimalagnalamba	Unknown species			□	□		
Tsimena	Unknown species			□			
Tsingaryfary	Unknown species			□			
Tsiongake	*Rhopalcarpus lucidus*	□		□	□	□	□
Tsivokoa Sifaka	Unknown species			□	□	□	□
Vahipindy	Unknown species			□	□		
Vahipoty	*Combretum meridionalis*	□	□	□	□		
Vala	Unknown species	□					
Vaovy	*Tetrapterocarpon geayi*	□		□			
Vinoanga	*Hildegardia erythrosiphon*	□	□				

Vontaka	*Pachypodium lamerei*	□	□	□	□	□	□
Zanapoly	*Croton sp.*	□		□			
Zebahe	Unknown species	□					

Figure 13 shows the distribution of measurements of circumference at breast height of trees found in each group. Figure 14 shows the percentage of trees and each distance from the focal point center trees to its four quadrant trees. Figure 15 shows the distribution of heights on trees in each of the three groups, based off all the trees collected from PCQ focal trees. Figure 16 displays the height of trees identified by sifaka use only.

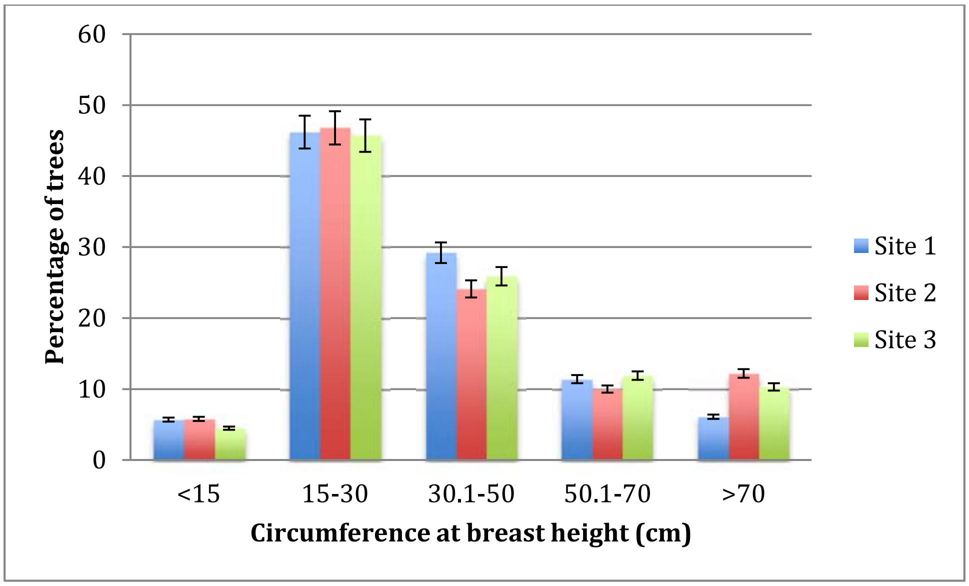


Figure 13: The percentage of sifaka usage trees with the allotted circumference at breast height at each site, measured in centimeters.

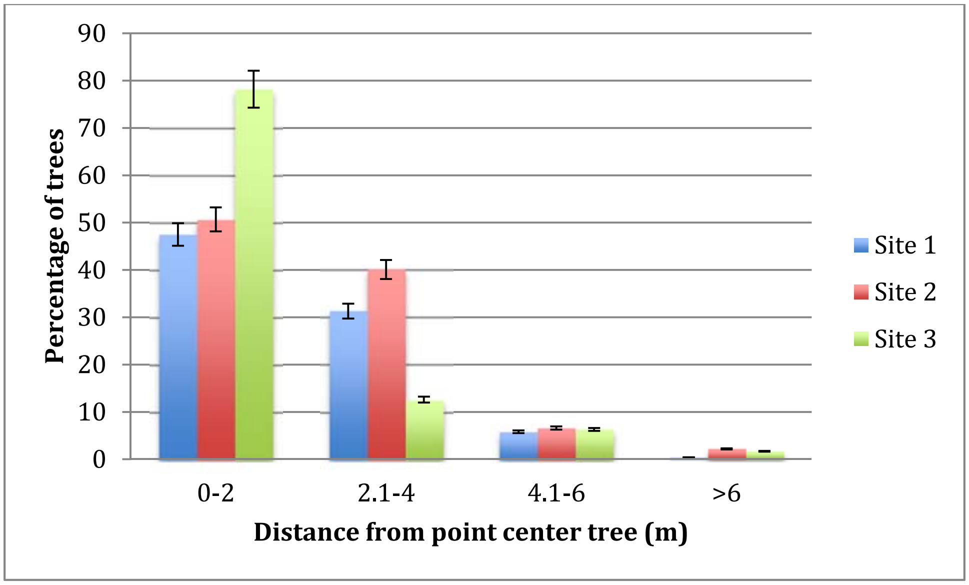


Figure 14: Distance between point center trees for sifaka usage and quarter trees at each site, measured in meters.

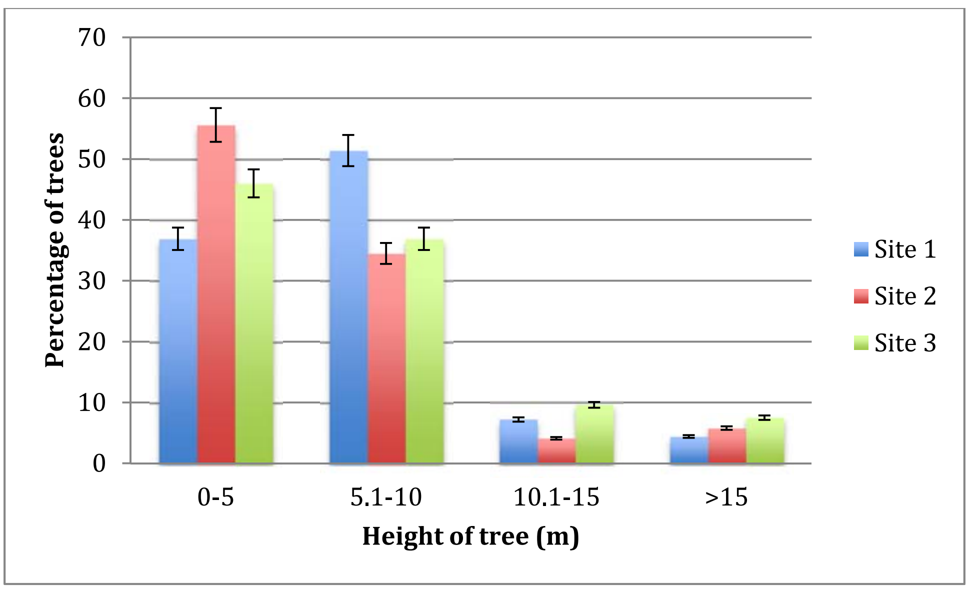


Figure 15: Percentage of sifaka usage PCQ trees at specific heights at each sites.

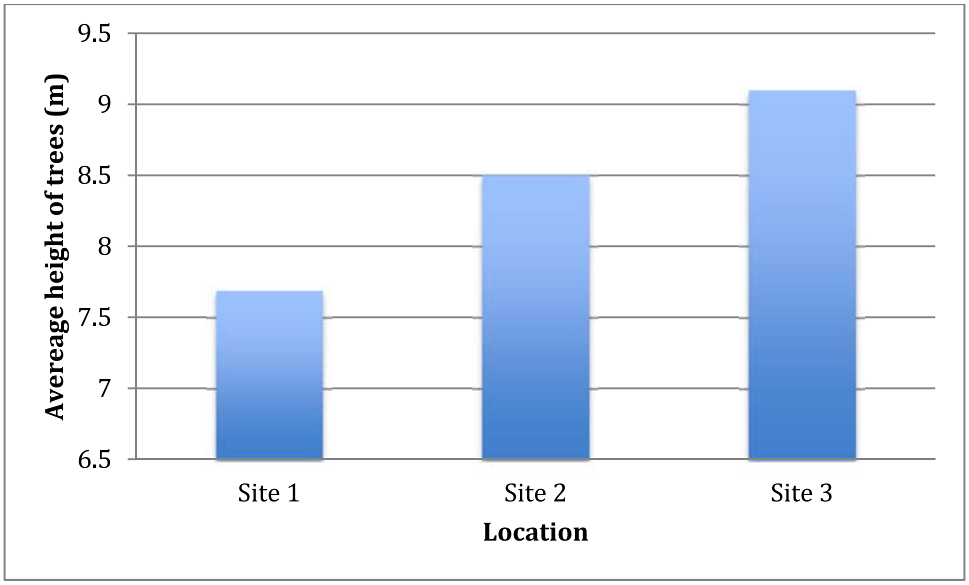


Figure 16: Average height of focal trees based on lemur usage at each site.

Level of disturbance was determined using table 7. This data was collected at every tree used for the point center quarter analysis. The following table shows the level of disturbance in each of the three habituated groups.

Table 7: The average level of disturbance at each site using both random PCQ data and PCQ data based off of trees used by the sifaka. The higher the numerical value, the more environmental disturbance present in the group.

	Random PCQ	**PCQ based on Sifaka usage**	**Average level of disturbance**
Group 1	7.0	7.94	7.47
Group 2	6.76	5.85	6.03
Group 3	5.29	6.10	5.69

A one-way ANOVA was used to determine a significant difference in the level of disturbance between the three groups. The null hypothesis is no significant difference in the level of disturbance between the three groups. If $P<0.05$ then the null hypothesis is not true. After completion of the one-way ANOVA, $P<0$, this means that the null hypothesis is false and there is a significant difference in the level of disturbance among the three groups.

Home range size was determined with the aid of ArcGIS. A kernel density analysis was used to plot the home ranges and a minimum convex polygon used to determine the home range size. Home range size was determined for different percentages of time spent in each area. For the purpose of this study, the focus will be drawn to the core region where the sifakas spent 95% of their time.

Table 8: Home range size of each sifaka site in square hectares. Core range size of 95% is highlight in red.

Percentage of Home Range	Site 1 (square ha)	Site 2 (square ha)	Site 3 (square ha)
25%	52.58	31.50	49.11
50%	34.06	18.10	19.92
75%	21.45	10.37	10.79
85%	11.22	4.62	4.72
95%	7.02	2.58	2.69

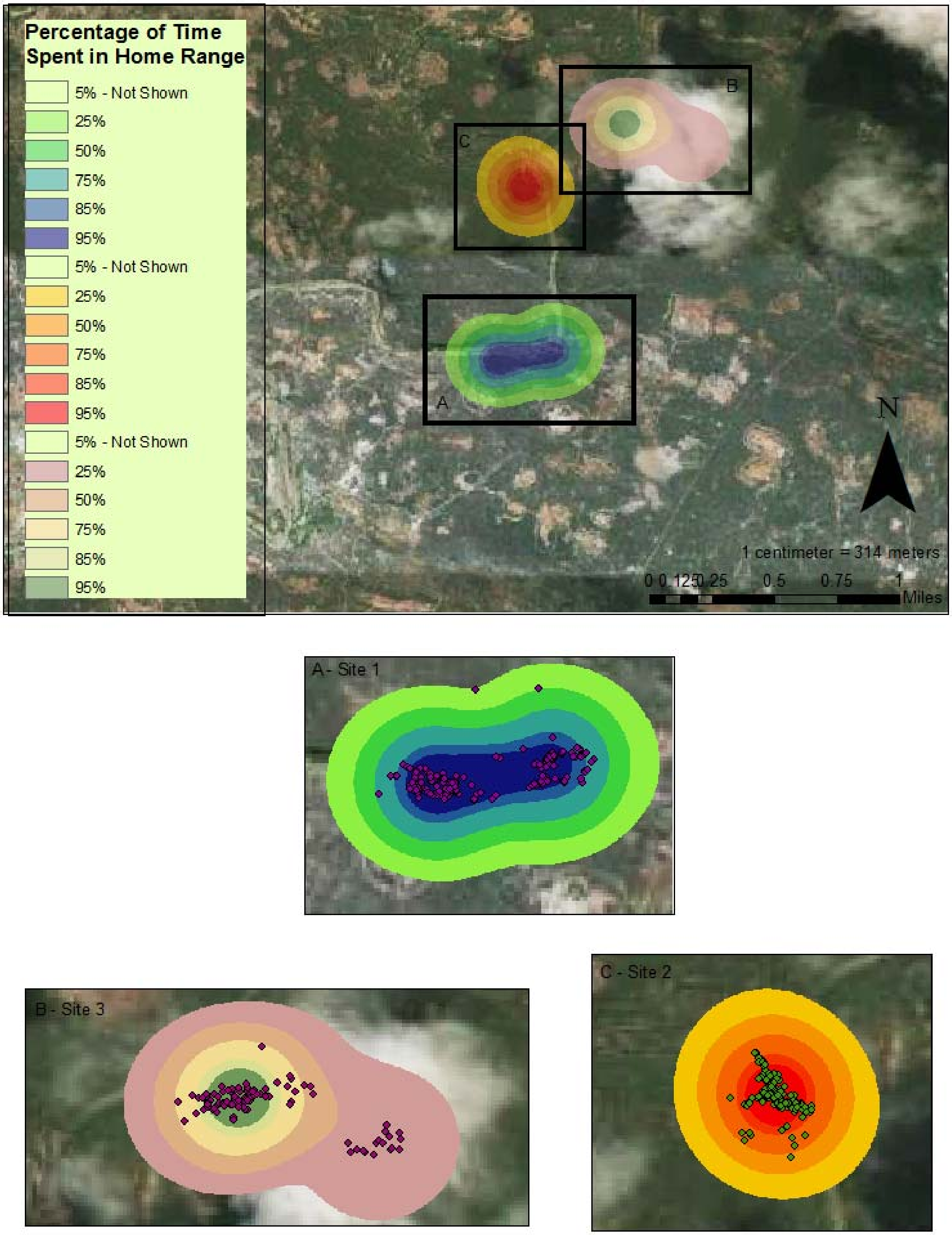


Figure 17: Map of home ranges created with ArcGIS.

Discussion

The objective of this study was to determine the ecological plasticity of *Propithecus verreaxi* to anthropogenic threats. This was carried out by collecting data on activity budgets, feeding ecology, and habitat preferences between three family groups living in different levels of disturbed spiny thicket.

Activity Budgets

Activity budgets were obtained with the use of scan sampling every 5 minutes. The activity of every lemur was recorded within 1 minute and otherwise recorded as out of view (OV). Group 3 had high number of OVs because the thicket was exceptionally dense and hard to maneuver through along with the individuals not being well habituated to our presence. This part of the study is important because anthropogenic disturbances can alter how primates partition their day.

First a comparison of the broad categories from the ethogram (table 1) was made between the three groups (figure 4). The majority of the day by groups 1, 2, and 3 was spent resting with 57%, 61%, and 57% respectively. Followed by feeding with 33%, 32%, and 34% and travelling at 8%, 6%, and 7%. The differences in partitioning of the day were not substantial between the three groups. This means that the level of disturbance does not affect activity budgets.

A more in-depth comparison was made using the more specific ethogram codes (figure 5). Again, the percentage of time spent on each behaviour is reasonably similar, with the majority of their day spent feeding and resting alert, followed by resting inactive. Aggression was never seen for the duration of the study.

The activity budgets in the AM versus the PM were also taken into account. In all three groups the main activity in the morning was resting and the main activity in the afternoon was feeding (figure 6).

Lastly, the effect of weather on three groups was compared. At site 1, resting is at its maximum on very sunny days and very cloudy days (figure 7). The percentage of social behaviour also increases with the amount of cloud cover. This is most likely do to conserving body heat by cuddling on cold days. Sites 2 and 3 (figure 8, figure 9) did not show a trend with weather. Site 1 is disturbed, the sparse trees allow for cold winds to blow through on cloudy days and the hot sun to reach the forest floor on days with minimal cloud. On the other hand, sites 2 and 3 are less disturbed with dense trees, preventing cold winds and hot sun from penetrating deep inside the thicket. Having protection from changes in weather by vegetation is mostly likely the reason for having marginally the same activity budgets throughout different amounts of cloud cover. Other potential factors contributing to activity budgets are sex, age, and pregnancy.

In 1997, Oates et al conducted a study on black colobus monkeys. He concluded that home range sizes are smaller when feeding trees are closer together. This suggests that the amount of time spent travelling is decreased and with less energy expended the amount of time spent resting can be increased.

Feeding Ecology

Focal animal data could only be taken from groups 1 and 2. This is because the individuals from group 3 were not identified and, as a new group to Operation Wallacea, they were not well habituated and were therefore difficult to follow, making 2 people necessary for collecting instantaneous scans. The total time spent feeding from group 1 was 73hrs 38min for the duration of this study. The total time spent feeding from group 2 was 59hrs 45min. The extra time spent feeding in group 1 may be due to a pregnant female. Ngesa from group 1 gave birth, as well as an unknown individual from group 3, shortly before the end of the study. The beginning of august represents the end of most gestation periods in Verreaux's sifaka. Sifakas hide pregnancy very well and it is unknown if a female from group 2 was carrying a child before the study came to completion. The percentage of time spent feeding in group 1, 2, and 3 is 33%, 32%, and 34% respectively. The overall difference in time spent feeding between the 3 groups is insignificant. There are 10 species that are common to all three sites and are marked for lemur usage. These species are: dagoa, daroanomby, darosike, fantiolotse, katrafay, kolohoto, maintefo, relefo, and vontaka. The listed species are important to the sifaka diet.

Habitat Preferences

The number of lemur species to go extinct since the colonization of Madagascar has led many scientists to believe anthropogenic influences are a key factor. At each focal tree where a point center quarter analysis was taken, the level of disturbance was also measured using table 5. A numerical value was then given to each lemur site (table 7). A one-way ANOVA was calculated to determine if there was a significant difference in the level of disturbance between the three sites. With a value of $P<0.05$, the level of disturbance between the three groups is declared significant. This includes evidence of grazing, paths/roads, selective logging/burning, and invasive species. Since it has been determined that there is a significant difference between the three sites, correlation of the attributes in this study can made.

The home range size for each group was determined using the computer software program ArcGIS. A kernel density was used to plot the points and map out home ranges. A minimum convex polygon was used to determine the size of each home range. The home ranges were further split into regions of which the sifakas spent percentages of time. The focus in this study is where each group spends 95% of their time. This is because some of the outlying data points are not important factors in home range size, also the ArcGIS program spreads the home range out equally in all directions, when this isn't the case. There is a dry river bed that is being incorporated into the home ranges which the sifakas never crossed. The core range of 95% does not cross the river bed and gives an accurate account of where the family groups spend the majority of their time. Site 1 had a core home range of 7.02 ha, site 2 had a core home range of 2.58 ha, and site 3 had a core home range of 2.69 ha (table 8).

Richard's study in 1985 suggested that *P. verreaxi* have home ranges of 1-8.5 ha. The core home range values for the three sifaka groups parallel her study. The home range sizes of sites 2 and 3 are comparatively similar, however, site 1 has a home range size roughly 260-270% larger. This suggests that the sifakas do not need to travel as far when they are in close proximity to feeding and resting trees.

Gerber et al (2012) studied *Propithecs edwarsi* in logged and unlogged rainforest, central Madagascar. The study took place for the duration of the year, through changing seasons, and showed that the home range sizes in the logged areas was always larger. Gerber's explanation for this is an energy intake maximizing strategy. This means that sifakas will increase their daily path link or home range size in order to obtain additional resources (Gerber et al, 2012).

A total of 89 plant species were identified between the three sites. Of those species 53 were found at site 1, 62 at site 2, and 50 at site 3. The number of species utilized by lemurs at site 1 was 25, 35 at site 2, and 23 at site 3 (table 6). The percentage of species used by each site is 47%, 57%, and 46% respectively. The Point-Center Quarter (PCQ) method was carried out on trees that were used by the lemur for 5 minutes or greater. Some of the tree species used by the lemurs were not picked up by the vegetation survey which confirms that not all the species were accounted for in each site, however an indication of overall diversity is still provided. At each site, given the number of species available, the lemurs are showing preference to specific species out of a wider variety available.

Nine tree species were common in all three sites for lemur usage. These species are: dagoa, daroanomby, darosike, fantiolotse, katrafay, kolohoto, maintefo, relefo, and vontaka. The common tree species used are due to the composition of habitat. This suggests that the selective logging in site 1 has not yet had significant impacts on the requirement of species. These species are therefore the most popular among Verreax's sifaka. These trees were recorded for a usage of 5 minutes or longer, therefore some species of worth may not have been identified for lemur usage. Haris & Chapman in 2007 completed a study with black and white colobus monkeys comparing the diets of groups in logged and unlogged habitats. Differences on dependence of species were detected and were correlated to the availability of resources.

The circumference at breast height for each groups was taken (through PCQ method) and the percentage of trees categorized into <15cm, 15.1-30cm, 30.1-50cm, 50.1-70cm, and >70cm. The majority of trees fell into the 15.1-30cm category, by nearly 50% at all three sites (figure 13). The height of trees used by the sifaka at each site was also recorded. The percentage of trees were categorized into <5m, 5.1-10m, 10.1-15m, and >15m. Site 3 had the highest percentage of trees >15m compared to the other sites (figure 15). This may be due to selective logging. The majority of trees at sites 2 and 3 are less than 5 meters, however the majority of trees at site 1 are between 5.1-10 meters. A likely cause of this is less regeneration due to the anthropogenic influences present at site 1. However, the predominant heights at all three sites are between 0 and 10 meters, with site 3 having a comparatively higher number of trees over 10 meters. The average height of the lemur used and random PCQ trees at site 1 was 6.2m, at site 2 was 5.63m, and at site 3, 6.42m. The average of height of all the trees between the three groups is within 1 meter of each other. The average height from site 1, 2, and 3 for lemur usage only was 7.69m, 8.50m, and 9.1m respectively (figure 16). This confirms the notion that sifaka actively seek out higher trees, possibly to avoid competition with other folivorous species or from predation.

The distance between focal lemur trees (PCQ) and the quarter trees was calculated and categorized as < 2m, 2.1-4m, 4.1-6m, and > 6m (figure 14). The majority of quarter trees fall with 2 meters of the point center tree, however site 3 stands out, with an average of nearly 80% falling within 2 meters. Sites 1 and 2 have roughly 50% of quarter trees falling within 2 meters. There is no considerable difference in the distance of trees from point centers at sites 1 and 2. However, since the quarter trees had a minimum circumference at breast height (CBH) of 31.41cm, smaller vegetation is not taken into account. There is a sizeable difference at site 3 having the majority of its quarter trees, with a CBH greater than 31.41cm, fall within 2 meters. This is a clear sign of selective logging that is present at site 1 and 2 but not at site 3.

Ganzhorn in 1985 showed the benefits of selective logging based on sifaka diet. Selective logging opens the forest to more sunlight allowing for an increase of protein in leaf chemistry. Sifaka became more abundant near forest edges after logging due to this. Although this proves beneficial in terms of dietary needs, it exposes the individuals to predators (humans, fossa, etc.).

Limitations

Field studies are known to have drawbacks because of their inability to control variables and running into unforeseen situations. The major limitation of this study that affected comparison of results was not being able to obtain focal animal data at site 3. The group was assumed to be habituated to human presence before we arrived, however finding the group each morning was difficult and staying on their tail throughout the day was equally as difficult.

Towards the end of the study the group became accustomed to human presence. On the same note, there were a lot of out of views recorded for the scan sampling behaviour for the same reason.

The species of the trees were identified by local guides and having a language barrier made communication difficult at times and some of the species may have been misspelled, preventing the Latin name from being found. There are also a number of Malagasy names for the same tree which may have played a role in wrongful identification of trees.

Data being entered into the computers at the end of the day was also sloppy at times. Countless data points had to be discarded due to improper ethogram codes being entered or obscene numbers for tree measurements. On a few of the days the focal animal data was recorded to the nearest minute rather than to the nearest second. This was most likely the work of a research assistant rather than a dissertation student who has daily practice with the method.

Future Research

There are two main seasons in the southern Madagascar spiny thicket, the dry season and the wet season. This study was carried out during the dry season. The next step would be to carry out the same study in the wet season. Expected changes may be seen in feeding ecology due to blooming flowers and the presence of more succulent leaves. The presence of rain and other weather patterns may change activity budgets and habitat preferences. An analysis of the nutritional content in the diet could also be completed and compared between the different in levels of disturbance. An annual study to compare these changes would be ideal.

Conclusion

This study found that in relation to activity budgets Verreaux's sifaka have considerable plasticity when placed in different levels of disturbed spiny thicket. The time spent feeding between groups is also similar despite differences in habitat. The tree species known to be used by all three sifaka groups are dagoa, daroanomby, darosike, fantiolotse, katrafay, kolohoto, maintefo, relefo, and vontaka. Their presence and usage make them important trees for feeding ecology and habitat preferences. The average circumference at breast of trees present in all three groups based on lemur usage PCQ is between 15.1-30 cm. The distance of quarter trees to the focal point center tree was mainly < 2m, however group 3 stood out with almost 80% of its quarter trees with in 2 meters. There was no substantial difference in the height of the trees between the three groups except site 3 has a small number of trees >10m. The home range sizes between site 1 and sites 2 and 3 are significant. The home range of site 1 is 260-270% larger than sites 2 and 3. There were some obvious flaws in data collection than became more apparent while completely the analysis, however the data sets were large enough to allow for this error. Future research should look at activity budgets, feeding ecology, and habitat preferences in the wet season. As well as a chemical analysis of the nutritional content of the food sources.

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Appendix

Risk Assessment

L=low

H=high

M=moderate

Ifotaka Village Camp

Risk	**Likelihood of occurrence**	**Severity of occurrence**	**Control measures**
Attack by mammal	L	H	The only potentially dangerous terrestrial mammals in Madagascar are the fossa and the wild boar. These will not pose a risk around the campsite because they are frightened of humans and will run away. However all volunteers to be briefed on how to react if faced by a potentially dangerous mammal either in the campsite or out in the field.
Sting or bite from a scorpion or black spider	M	H	All volunteers are briefed on arrival on preventative measures to avoid being stung or bitten, such as checking your boots in the morning, checking any rock surfaces before you sit down, never walking around bare-foot, and keeping your tent closed to stop them getting in during the day. Should a sting or bite occur, a treatment kit with methyprednisolene is available at the sites.
Medical problem for staff or volunteer member	H	L	There are medical facilities in Fort Dauphin, approximately 5 hours from the site, and there will be a medical officer on-site with an extensive medical kit.
Need for emergency	L	H	There will be vehicles available at Ifotaka village camp (2 hrs walk) at all times for evacuation to the hospital by road (3 hrs approx). If Air Evacuation is required, the terrain is easily accessible to helicopters, and an emergency response unit can be deployed from Antananarivo (3 hrs).

Tripping or falling in camp	M	H	All incoming volunteers to be given a full safety briefing and tour of the camp on arrival which will include advise on taking care in slippery areas such as the shower, and always watching your footing around the camp, particularly at night.
Lack of hygiene increasing risk of disease	M	M	Camp Manager to ensure that kitchen is kept clean and that food types are prepared separately. The eating area and the toilets to have handwashing facilities immediately adjacent and all volunteers to be briefed on the importance of washing your hands.
Fire	L	H	Staff are aware of procedures in the event of a fire, and volunteers to be briefed on arrival. No smoking to be allowed other than in a designated area away from any building or tent with a sand bucket for extinguishing cigarettes.
Volunteer getting lost in the forest and unable to find the camp	L	H	All volunteers to be briefed on safe trekking procedures on arrival (e.g. keeping the person in front and the person behind you in-sight at all times, what to do if you should lose the group, etc). All groups leaving camp to be accompanied by a guide and a radio, to sign out on the whiteboard, and to state destination and estimated return time. The Group Leader (designated Staff member) is responsible for ensuring that each group member has sufficient water.
Control measures not implemented	M	M	The Opwall coordinator to be responsible for auditing the control measures and camp procedures on a weekly basis (see relevant audit form). These audit reports including details of non-compliances and corrective measures to be available for inspection on site.

Survey Work on Foot

Risk	**Likelihood of occurrence**	**Severity of occurrence**	**Control measures**
Bite or sting from	L	H	All volunteers and staff in the bush are required to wear strong, close-toed footwear

dangerous organism			which protects the ankles as well as the feet, long baggy trousers and long sleeved shirts. All volunteers are told never to approach a scorpion or spider without alerting a guide first. All volunteers to be briefed on the dangerous flora and fauna as part of the training course.
A fall resulting in serious bleeding or a bone fracture	L	H	Ensure that all staff and volunteers have footwear with good grip and ankle support. Ensuring that a medical officer with a mobile First Aid kit is in radio contact with so that additional help can be summoned quickly. Ensure that an evacuation plan is in position for each location in which the staff and volunteers will be working. Ensure a hammock is available at the camp to be used as a stretcher if needed.
Dehydration	M	H	All volunteers to be briefed about the need to carry sufficient water supplies with them, the symptoms of dehydration, and the importance of fast action to combat it.
Becoming separated from the rest of the group	L	H	All volunteers to be briefed on safe trekking procedures on arrival (e.g. keeping the person in front and the person behind you in-sight at all times, what to do if you should lose the group, etc). Volunteers are also requested to carry a whistle to signal for attention if needed.
Control measures not implemented	M	M	Senior coordinator to be responsible for auditing the control measures and camp procedures on a fortnightly basis (see relevant audit form). These audit reports including details of non- compliances and correctivemeasures to be available for inspection on site.

Road Travel

Risk	**Likelihood of occurrence**	**Severity of occurrence**	**Control measures**

RTA or other vehicle related incident	L	H	All buses and 4x4 vehicles are checked before use for meeting health and safety standards, and have drivers with a full driving license. Drivers to be assessed and selected as suitable by DBCAM/Island Quest staff prior to expedition, and to sign a code of conduct regarding suitable driving standards. All vehicles are subject to pre-departure checks for each journey. Each vehicle on a road journey to have a staff member and mobile phone, the necessary equipment for changing the wheels and to carry a torch and sufficient water for the journey in case of breakdown.
Pedestrian accident	L	H	The volunteers will only be near public highways after the first and last hours of their expedition after the start in Mahajanga, but will be briefed on road safety on arrival in case the vehicles break down during this period and they have to get out.
Control measures not implemented	M	M	Senior coordinator to be responsible for auditing the control measures and camp procedures on a fortnightly basis (see relevant audit form). These audit reports including details of non- compliances and corrective measures to be available for inspection on site.

Medical Support

Risk	**Likelihood of occurrence**	**Severity of occurrence**	**Control measures**
Stomach upsets	M	M	Ensure that personal hygiene issues are emphasised in briefings to avoid spread of infectious diseases amongst a group of people living in close proximity. Ensure that all drinking water is treated with iodine prior to use. Ensure that good standards of hygiene are adhered to in the kitchen, including the cooks washing their hands before preparing food, and that any salad or raw vegetables are washed in treated water prior to serving.

Malaria	L	M	Ensure that all volunteers are advised to visit their local travel clinic or physician prior to travel in order to obtain the correct Malaria prophylaxis. Ensure all volunteers are advised to cover exposed skin during the evenings to avoid bites, and that the fly sheet on the tents is always kept zipped up.
Heat stroke and sunburns	M	M	Ensure that all volunteers and staff are aware of the need to drink adequate water each day, and of the symptoms and treatment for dehydration. All volunteers and staff to be told of significant risk of sunburn and heat exhaustion from the survey work, and to have come adequately prepared with high factor sun block for the duration of their stay.
Wounds	M	M	Ensure all cuts, however insignificant, are cleaned with clean water and antiseptic is applied. All volunteers and staff to be made aware that there is a greatly increased risk of secondary infections. Assess daily and if the wound appears to becoming infected then report it to the medical staff.
Lack of medical advice	M	M	Detailed medical questionnaires to be completed by all staff and volunteers before joining the expeditions. These questionnaires to be reviewed by an Expedition Medic prior to the start of the expeditions and any staff or volunteers that appear to have medical conditions that might affect their ability to participate in the expeditions, informed so that additional medical advice can be obtained. Medical advice and hospital facilities are within 4 hours of the site. There are evacuation plans for different levels of emergency (Emergency, high, medium) in position at each site: these procedures will have been tested by the staff prior to the start of the season.