

## Final Project Evaluation Report

---

Your Details	
<b>Full Name</b>	Meredith Semel
<b>Project Title</b>	A Division of the Crown: using novel tracking collars to examine behavioral and physiological responses to fragmentation in golden-crowned sifakas
<b>Application ID</b>	26514-2
<b>Grant Amount</b>	£ 4940
<b>Email Address</b>	merak91@vt.edu
<b>Date of this Report</b>	29 July 2019

**1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.**

Objective	Not achieved	Partially achieved	Fully achieved	Comments
<p><b>1)</b> Identify differences in group cohesion between sifakas in edge (disturbed) habitat and interior (undisturbed) habitat</p>				<p>From September-December 2018 more than 1,000 observation hours were collected on nine groups (54 individuals in total) of golden-crowned sifakas (<i>Propithecus tattersalli</i>). Data concerning proximity between individuals, group geometry measurements, and grooming behaviour were recorded.</p>
<p><b>2)</b> Apply novel tracking devices to the study of golden-crowned sifakas</p>				<p>We are in the process of trialling our FitPET tracking devices on captive sifakas at the Duke Lemur Centre (North Carolina, USA) to ensure they are safe and effective for use on wild golden-crowned sifakas.</p>
<p><b>3)</b> Determine differences in forest structure between dry, moderate, and wet forest fragments in the Daraina region</p>				<p>We completed thorough vegetation surveys of all six forest fragments that we visited during the 2018 field season. My research team and I visited two rainforest fragments, two moderate forests, and two dry forests. I am in the process of using cluster analysis to determine quantifiable habitat differences between the various fragments and microhabitats that are most important to the lemurs.</p>
<p><b>4)</b> Determine differences in stress hormone (faecal cortisol metabolite) levels between different groups of lemurs</p>				<p>I have spent the last 3 months (May-July 2019) initiating faecal hormone analysis. In the next few months, I will finish running the cortisol hormonal assay to quantify stress hormone levels among lemurs across all forest fragments. Once this analysis is complete, I will be able to examine correlations between group size, social cohesion, habitat type, degree of fragmentation, season, and stress hormone levels.</p>
<p><b>5)</b> Collaborate with Madagascar National Parks (MNP) to establish</p>				<p>Based on community requests, during the 2018 field season we focused our environmental education on teaching</p>

<p>an Eco-Schools program in Daraina and complete outreach initiatives in the region</p>			<p>about sustainability in the region, the importance of forests to prevent erosion, taking students into the forest to teach about the biodiversity in the area, safety and hygiene during the rainy season, and improving electricity in the schools through the use of solar energy. We have also continued to teach biweekly English lessons in Daraina and used creative activities to educate primary school students about the value of the biodiversity in their backyards.</p>
<p>6) Collaborate with local NGO Fanamby and work with local guides from the Daraina community</p>			<p>Fanamby's overarching goal is to better understand how biological, social, and economic factors influence threatened ecosystems and how integration of these ideals can lead to successful regional conservation plans. By working alongside Fanamby, I am sharing my results to aid in conservation managements plans in the region. By training and employing local individuals, we bolstered the economy of Daraina and provide jobs that utilised the environment in a non-detrimental manner. By involving local guides in every facet of our research we connected them with nature in ways that enable them to benefit from its protection.</p>

*\*Note: Most objectives are still listed as partially achieved because, as indicated in the comments, a final field season will take place in late 2019-early 2020. This future field season will allow us the additional time needed to fully achieve these objectives.*

**2. Please explain any unforeseen difficulties that arose during the project and how these were tackled.**

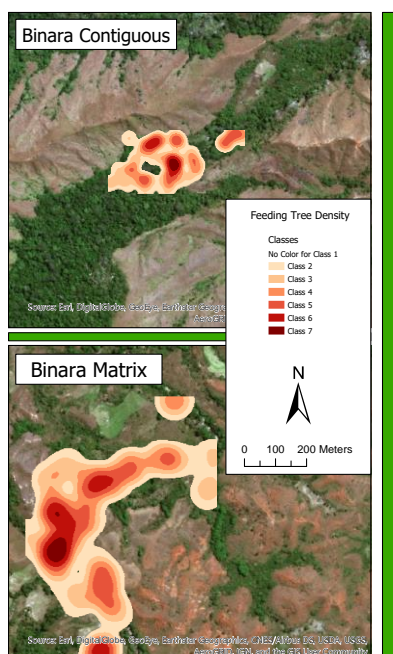
The largest unforeseen difficulty during my second field season in the Daraina region was finding appropriate resolutions for illegal bushmeat hunting, mining, and selective logging in the forest that we observed. In two of the six forest fragments we visited, we found recent evidence of illegal hunting. We tackled this issue by working with the local KMTs (forest guardians) and Celin, Fanamby's conservation coordinator, to remove as many snares and traps as possible. The KMTs in both villages also held group meetings to discuss the chicken coop project and offer alternatives to bushmeat. In the cases of people observed illegally mining and cutting down trees in no extraction zones, the KMTs and Celin worked with the

individuals to determine appropriate punishments as well as showing them the proper protocols to follow in order to obtain the permits to legally extract natural resources.

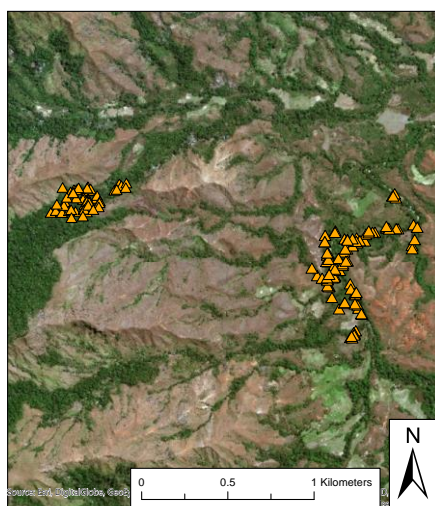
We also faced challenges with the Eco-Schools Program. Due to the small classroom size at the secondary school and the teacher-student ratio (of up to 1:50), we had issues with executing effective outreach to so many participants simultaneously. We tackled this by conducting outreach activities outside and limiting the activities to 20 students at a time. However, this still posed issues because the teacher had to remain with the rest of the classroom inside. We hope to find a permanent solution to this issue by building an outreach centre and hiring an outreach coordinator whose main responsibilities will be planning, leading, and assessing the success of the educational outreach.

### 3. Briefly describe the three most important outcomes of your project.

**a).** One of the most important outcomes of my second field season was being able to identify differences in sifaka home range size, ranging patterns, and cohesion based on the forest type and quality they inhabit. We found that lemurs with home ranges adjacent to the forest edge (matrix habitat) have significantly larger home range sizes compared to nearby groups that live that do not live on the edge (contiguous habitat). For instance, both lemur groups in the wet forest contained six individuals, but in the dry season the matrix habitat group had a home range of 27 hectares, while the contiguous habitat group had a home range of 5 ha. A similar pattern was found among lemurs in the other forest types. We are currently in the process of determining if the home range sizes and locations are different for these groups during the rainy season (using data collected from Feb-April 2019). We have also been collecting the top food resource data for all groups of lemurs and will complete nutritional analysis to identify differences in nutritional quality between forest types and degrees of fragmentation. By understanding their diet, we hope to be able to engage in reforestation efforts using the tree species that are most vital to their sustained health.



### Wet Forest Feeding Tree Kernel Density



**b).** The second important outcome was being able to successfully follow sifaka groups during the rainy season. By obtaining this 2nd Rufford grant, I was able to extend my field season to include another period of data collection from February-April 2019. This was the first time in roughly 30 years

that golden-crowned sifakas have been followed in the rainy season. During this period we our focused efforts on additional follows of the six habituated groups of sifakas in Bekaraoka, Binara, and Solaniampilana. These six groups have now been followed between September-December 2018 and February-April 2019. These data are paramount to our understanding of the effect of seasonality on sifaka social behaviour, ranging patterns, and stress hormones.

**c).** The third, and arguably the most important, outcome of this second field season was developing a **self-sustaining field team** composed of all Malagasy locals, students, and researchers. With the help of the local forest guardians, we produced a book with all of the Malagasy names of the tree species and parts of the tree that the sifakas consume (pictured to the right). This has been an exceptional training tool to help local guides learn the plants and better understand the feeding ecology of the lemurs. In addition to tree



identification, the guides are also trained in height and distance estimation, scan/focal sampling techniques, and are able to reliably distinguish between individual lemurs based on their physical characteristics. Due to the training of the guides, they are now able to collect high quality data without my presence in Daraina. This is important because: **1)** the team can monitor the health and behaviour of the sifakas on a more regular basis, **2)** spend more time in the forest which is a known method of protecting the landscape, **3)** conduct community outreach year round, and **4)** local Malagasy individuals can now be the driving force working to protect Daraina's biodiversity. Overall, the team involved in this project not only maintains an impressive knowledge of research techniques, but they also possess invaluable skills that equip them to be leaders within the local Daraina community and beacons for outreach.

#### **4. Briefly describe the involvement of local communities and how they have benefitted from the project.**

I continued to work closely with Fanamby, the Daraina guide association, and the local schools during my 2018 field season. Fanamby is an NGO in northern Madagascar that seeks to better understand how biological, social, and economic factors influence threatened ecosystems and how integration of these ideals can lead to successful regional conservation plans. By working with Fanamby to complete my research and initiate the Eco-Schools Program, we fostered community/stakeholder engagement and accountability to help Fanamby effectively accomplish their goals as an NGO. It is my goal to continue to work closely with Fanamby to develop strategies to protect Daraina's lemurs and their habitat.

During my 2018 field season I also continued to work closely with Amidou Souleimany, the head guide of the Daraina Guide Association (managed by NGO Fanamby). In addition to his research-based skills of coordinating the guide hiring and training process, Amidou is the president of Daraina's private primary school



and his help is vital in organizing outreach plans and implementing the Eco-Schools Program. He has an excellent rapport within the community and is highly respected as a guide, administrator, and community leader. With Amidou's knowledge of Daraina's educational structure and curriculum, we have been able to form relationships with teachers in the secondary and primary schools in Daraina and will be able to arrange field trips and educational programmes in a way that benefits the students most effectively.

This project also benefited the local community by employing 28 guides throughout the field season and an additional ~60 community members as porters. I purchased all food from local shops in Daraina and bought locally grown beans, rice, potatoes, corn, and fresh fruit whenever possible. The local community also benefited from the outreach activities we completed in the schools and the biweekly English lessons taught. The Eco-Schools Program, which has been designed to meet the needs specified by individuals in the Daraina community, is seeking to improve sanitation, food sustainability, and access to electricity in Daraina. Providing education and training in how to more sustainably produce food will increase intrinsic value of the habitats and lead to more effective resource management. Our hope is that the Eco-Schools Program in Daraina will lead to infrastructure development and behavioural change of local communities.

#### **5. Are there any plans to continue this work?**

As a doctoral dissertation student, this on-going project will continue for at least one additional field season. This was the second field season and I plan to complete at least one more field season in Daraina as part of my studies. In late 2019, I plan to return to Daraina to work with Fanamby to implement my findings and focus specifically on community education and reforestation.

#### **6. How do you plan to share the results of your work with others?**

As part of my dissertation, the results of this work will be shared with the scientific community through publishing peer-reviewed articles and presenting at professional conferences. I recently presented results from my 2018 field season at the international Animal Behaviour conference in July 2019 and will be presenting at the Society for Integrative and Comparative Biology in January 2020. I will also share my results, condensed for a general audience, with Fanamby and will present my findings at the University of Antananarivo in December 2019. I plan on publishing the lemur hormonal validation and captive lemur study (using captive samples from the Duke Lemur Center and wild samples from Daraina) in *General and Comparative Endocrinology* and the results of the field-based study in journals such as *Conservation Physiology*, *American Journal of Primatology*, and *Hormones and Behaviour*. I also plan to continue sharing my results on *Wild Labs* and *Conservation X Labs*, specifically to help other conservationists apply tracking technology and hormonal quantification to their studies of threatened and endangered wildlife.

I am also working with the two primary schools and a secondary school in Daraina to share the results of my field season. By helping expose Malagasy children to the wildlife surrounding them, we hope to connect them with nature in a way that

compels them to be stewards of the environment and advocates of sustainability practices in their homes and local communities. Overall, being able to effectively connect my science to local individuals will also aid in stronger communication pathways between grassroots communities all the way up to local authorities.

**7. Timescale: Over what period was the grant used? How does this compare to the anticipated or actual length of the project?**

I used the grant from August-December 2018, which was the anticipated length of this portion of the project.

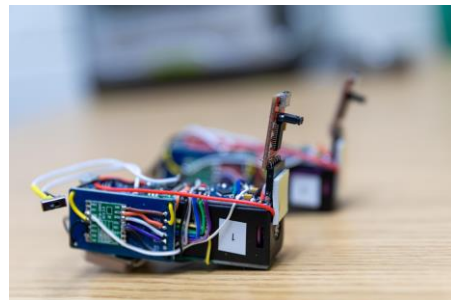
**8. Budget: Provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used. It is important that you retain the management accounts and all paid invoices relating to the project for at least 2 years as these may be required for inspection at our discretion.**

Item	Budgeted Amount	Actual Amount	Difference	Comments
Car rental and fuel to get to Daraina from Antananarivo	620	750	+130	Due to fuel shortages in Madagascar during the 2018 field season, transport was a greater expense than anticipated.
Malagasy guide stipends	1150	1750	+600	Over the course of the field season, I hired 28 local guides (each for 2-6 weeks at a time). At each new forest fragment, I hired 1 Daraina guide and 4 guides from the local village. Thus, I hired more local guides than initially planned, but this enabled the opportunity to spread out employment over the region and work with a variety of individuals.
Malagasy PhD student stipend	1385	1375	-10	The Malagasy student stipend was slightly less than anticipated. The students' advisor did not make the trip up to Daraina from Antananarivo.
Food for myself, guides, and Malagasy student	1450	1380	-70	Due to being able to purchase rice in bulk, we were able to save funds.
Porters to transport supplies to each forest fragment	370	370	0	The funding requested was the exact amount needed to hire porters.
<b>TOTAL</b>	<b>4940</b>	<b>5590</b>	<b>+650</b>	Exchange rate: 1 pound = 4400 Ariary (at the time of the field season)

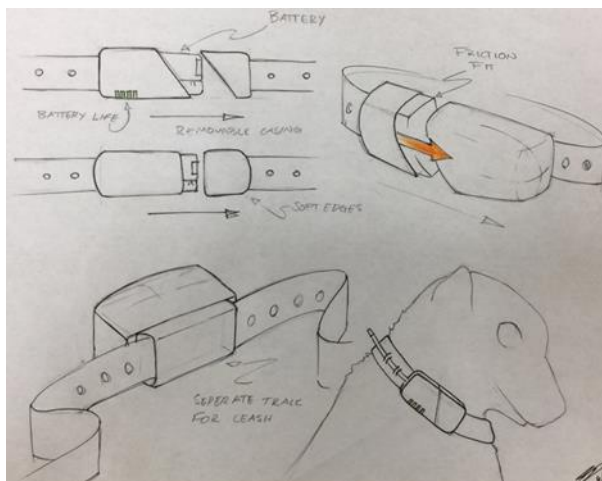
## 9. Looking ahead, what do you feel are the important next steps?

The immediate next steps for my project include in-depth analysis of behavioural data and completing the hormonal analysis of the faecal samples. By understanding the impact of habitat type on sifaka spatial behaviour and physiological responses, we can understand the impacts of land management practices. Once we have quantified glucocorticoid metabolites from the faecal samples, we can understand how chronic stress differs across various habitats and degrees of fragmentation.

Second, we are in the process of constructing additional FitPET devices to collar more golden-crowned sifakas during our late-2019 field season (pictured to the right). In order to collect precise quantitative data to connect sifaka spatial behaviour to their habitat characteristics and physiological responses, we must collar an appropriate number of individuals. We have made substantial improvements to our collars, which have included more precise radio sensors, more efficient batteries, and more durable/ergonomic housings. The previous housings we constructed posed issues with long-term waterproofing and we have recently updated our design (pictured below). We are testing these new housings on captive sifaka at the Duke Lemur Center in early-August 2019. Once the testing has been completed we will collar golden-crowned sifaka adults in Daraina.



Third, a vital step of this project is expanding the scope of the Daraina Eco-Schools Program. Part of the Eco-Schools Program involves teaching local individuals how to



breed chickens and make chicken coops by reusing materials that would be otherwise discarded. This will provide local families with an alternative to hunting lemurs and other bush meat, as a means to provide protein for their families and improve sustainability in the region. During the 2018 field season, we were able to initiate the chicken coop project and form relationships with a nearby veterinarian (who is able to vaccinate the chickens for diseases in the region). We also plan to continue working with Madagascar National Parks to bring in several additional

teachers into the Daraina public primary and secondary school. In 2018, over 540 students were registered at the public primary school (10 teachers) and over 300 students were registered at the secondary school (13 teachers). Teachers in both schools are responsible for teaching all subjects and bringing in at least one additional teacher into each school will help improve the student-teacher ratio. The teachers will be specifically trained in sustainability science and biodiversity



education and will be the main drivers helping to create awareness, action, and accountability concerning environmental sustainability in Daraina.

Lastly, an important next step is increasing educational infrastructure in the region. The secondary school has received an update within the past 10 years; however, both primary schools are quite dilapidated. We hope to construct a building in Daraina that can be used as: **1)** a science outreach station where teachers can bring their students in order to learn about biodiversity in the region, and **2)** a central location where guides from the Daraina guide association can gather to have meetings and where tourists can hire a local guide.

The 160 km national road between Ambilobe and Vohemar (with Daraina located at roughly 100 km) is in the process of being paved by the Chinese Government. This primitive, dirt road has resulted in the area being very challenging to navigate. With the addition of a paved road, the SAVA region of Madagascar will now be more easily connected to the rest of the country. Experts are concerned that the ease of transport will result in an influx of vehicle traffic and individuals within the region. Daraina is expected to have a surge in population growth due to the ever-increasing mining presence in the area. Thus, this area is in immediate need of educational infrastructure and permanent research presence.

**10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?**

Yes, the Rufford Foundation logo was featured on a poster presentation at Virginia Tech for the 2019 Biological Sciences Research Day Conference (February 2019), during an oral presentation at the Virginia Tech - Biologically inspired engineering (BIST) seminar (March 2019), on my poster at the International Primatological Society (Nairobi, Kenya) meeting in August 2018, and featured on my poster at the Animal Behaviour Conference (Chicago, July 2019). It will also be featured on my podium presentation at the Society for Integrative and Comparative Biology meeting (USA, January 2020).

The Rufford Foundation was also given credit in a recent publication in Biology Letters. <https://royalsocietypublishing.org/doi/10.1098/rsbl.2019.0028>

The Rufford Foundation was also given credit in an article about my research in the Spring 2018 edition of the Fralin Explorer magazine put out by Virginia Tech. (<https://vtechworks.lib.vt.edu/handle/10919/83582>)

My research is also being featured in the University-wide magazine in fall 2019. I will send the link when the article is published.

**11. Please provide a full list of all the members of your team and briefly what was their role in the project.**

**Julie Ratovoson:** Malagasy field technician

This field season would not have been possible without Julie! She assisted in every stage of data collection from lemur habituation to vegetation sampling, faecal sample collection, and full day behavioural follows. She also provided important intellectual contributions and was a great asset to the project.

Local guides from Daraina:

Over the course of the field season, I was able to hire over twenty local guides from the Daraina guide association. The local guides have impressive knowledge of the terrain and hiking trails in the region, have superior tree species identification skills, and familiarity with the lemurs and other wildlife species. Julie and I trained all guides on our protocols for collecting lemur behavioural data, faecal samples, and vegetation sampling. I was able to hire the head of the Daraina guide association,

**Amidou Souleimany**, for the entire field season. In addition to coordinating the guide hiring and training process, Amidou is also the president of Daraina's private primary school and was able to help organize outreach plans and implementing the Eco-Schools program.

#### **Mamy Rakotoarijaona**

Dr. Rakotoarijaona is the Director of Operations for Madagascar National Parks (MNP). He provided invaluable assistance with organizing and planning for the Eco-Schools program that we are in the process of implementing in Daraina.

#### **Ignacio Moore**

Dr. Moore is my academic advisor at Virginia Tech and Professor of Biological Sciences, who provides constant feedback on the development of the questions, field techniques, and faecal sample analysis for this project. As a behavioural endocrinologist, he has been particularly beneficial in helping run the hormonal analysis and streamlining the behavioural data collection.

#### **Nicole Abaid**

Dr. Abaid, an Assistant Professor in Biomedical Engineering and Mechanics at Virginia Tech, provided extensive knowledge in studying animal movements through the employment of technology and robotics. She helped with the design and manufacture of our FitPET devices and remote data retrieval technology. She is currently assisting with making all of our data, schematics, code, and documentation for the FitPET devices open source and displayed on Github.

FitPET Engineering team

Undergraduate engineering students and researches **Scott Ziv, Lucas Munn, Haoshen Lee, Rohan Walia, and Alex Moran** were the driving force in helping manufacture and test the FitPET devices. They are all continuing to assist with building additional collars to use during my late 2019 field season.

FitPET Industrial Design team

Industrial designers **Josh Francis** and **Olivia Burke** have been working to improve the external tracking collar casing. In three of our previous collars, humidity and adequate waterproofing posed an issue and the electronics in the collars failed after several months. They have now constructed a fully waterproof casing that is

safe for the lemurs and allows onboard electronics to remain dry in harsh weather conditions.

MICET, NGO in Antananarivo

Although MICET did not directly assist with logistics once I was in Daraina, they provided assistance with applying for a long-term research visa, government export permits for biological samples, transportation to Daraina, and connecting me with Julie, my Malagasy graduate research assistant.

Fanamby, local NGO

Although Fanamby staff were not directly involved in data collection, their assistance with vehicle rentals, hiring of local guides, and overall logistics was invaluable. **Dr. Serge Rajaobelina** was an essential resource and provided knowledge about the golden-crowned sifakas, their habitats, and conservation management plans in Daraina. As the director of Fanamby, Dr. Rajaobelina was able to help my field team orchestrate various field season logistics and will also assist with the success implementation and running of the Eco-Schools program.

## **12. Any other comments?**

I am truly grateful for The Rufford Foundation's substantial contribution to my project. This funding enabled me to equip a strong field team of local Malagasy researchers and guides and this project would not have advanced nearly as far without the Rufford Foundation. Once I have more results and have finished analysing the faecal samples, I will send in a detailed final update.