

### **Final Project Evaluation Report**

Your Details					
Full Name	Meredith Semel				
Project Title	A Division of the Crown: using novel tracking collars to examine behavioral and physiological responses to fragmentation in crowned lemurs ( <i>Eulemur coronatus</i> )				
Application ID	78c6a2-1				
Grant Amount	£ 4965				
Email Address	merak91@vt.edu				
Date of this Report	13 July 2018				



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
1) Identify differences in group cohesion between sifakas in edge (disturbed) habitat and interior (undisturbed) habitat				From August-December 2017 more than 1,600 observation hours were collected on 11 groups (57 individuals in total) of golden-crowned sifakas ( <i>Propithecus tattersalli</i> ). Data concerning proximity between individuals, group geometry measurements, and grooming behaviour were recorded.
2) Apply novel tracking devices to the study of golden-crowned sifakas				Due to intense hunting pressure of crowned lemurs and Fanamby's subsequent suggestion to combat the issue, we shifted our focus onto the sympatric, critically endangered golden-crowned sifaka. 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. We will then be able to collar and remotely track the lemurs during our next field season in 2018.
3) Determine differences in forest structure between dry, moderate, and wet forest fragments in the Daraina region				I completed thorough vegetation surveys of all nine forest fragments that we visited during the 2017 field season. My research team and I visited two rainforest fragments, three moderate forests, three dry forests, and one littoral forest. 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.
4)Determinedifferencesinstresshormone(faecalcortisolmetabolite)				I am currently freeze drying and running hormonal extractions for all faecal samples. Once all fecael samples are collected, I will finish



levels between different groups of lemurs		running the cortisol hormonal assay and be able to quantify stress hormone levels among lemurs across all nine forest fragments (and additional three forest fragments during my 2018 field season). Once this analysis is complete, I will be able to examine correlations between group size, social cohesion, habitat type, degree of fragmentation, and stress hormone levels.
5) Collaborate with Madagascar National Parks (MNP) to establish an Eco- Schools program in Daraina and complete outreach initiatives in the region		During the beginning phase of the Daraina Eco-Schools programme (August 2017), I met with the head teachers and presidents of the three schools in Daraina to gauge the immediate needs of the community. Based on their requests, we are primarily focusing the environmental education on teaching 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. Subsequently, my research team and I worked to paint a world map on the secondary school in Daraina. We also taught biweekly English lessons in Daraina and used creative activities to educate primary school students about the value of the biodiversity in their backyards.
6) Collaborate with local NGO Fanamby and work with local guides from the Daraina community		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 able to share my results and 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.
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\*Note: Objectives have been partially achieved because, as indicated in the comments, another field season will take place from August-December 2018. 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.

My initial goal for this field season was to examine the behaviour, baseline physiology, and habitat characteristics of the endangered crowned lemur (Eulemur coronatus). However, I experienced difficulties finding this species, which were behaving more nocturnally than previously described. After speaking with local guides, hunting of the species appeared to be a far greater problem than we imagined. In several fragments we found evidence of E. coronatus hunting, including an area where a small stagnant water source was poisoned. With the help of Fanamby and local guides, I decided that habituating troops of *E. coronatus* to human presence would place the lemurs at an increased likelihood of hunting. Luckily, my research team and I were given the opportunity to study another species in the area. Fanamby, the local NGO that I am partnering with, recommended that I examine the behavior and physiology of Propithecus tattersalli, the critically endangered golden crowned sifaka; a sympatric species to E. coronatus that are found only in the Daraina region. The golden crowned sifaka is an umbrella species in the region and understanding how fragmentation impacts their social behavior and health will also aid in making conservation decisions for E. coronatus and other lemurs in the area. Unlike crowned lemurs, which are heavily persecuted in the area, there is a local taboo against hunting golden-crowned sifakas. Thus, they can be safely habituated without imposing any additional risks (such as increasing the likelihood of being hunted for bushmeat). Despite the challenge of not being able to study crowned lemurs, Fanamby was able to help me shift this study in a direction that will produce meaningful results that can be applied to conservation plans in the region.

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

a). One of the most important outcomes of my first season as a graduate student was being able to effectively follow and identify individual lemurs to the extent of being able to collect and successfully store faecal samples (n=283). Non-invasive analysis of hormonal responses is becoming a common practice in studies concerning conservation and environmental change, but has not been applied to studies of lemurs in northern Madagascar. Stress hormones (glucocorticoids) coordinate the physiological responses necessary for survival in capricious environments, which is needed for long-term monitoring of wildlife physiological



health. In other words, these samples can provide indications of population health before any decline is evidenced. The samples are currently in the stage of freezedrying and hormonal extraction, and once my 2018 field season is complete, fecael glucocorticoid metabolites will be measured. I am waiting to run all of my samples in one large batch because it will lead to more objective quantification of glucocorticoid metabolites. By determining cortisol levels in golden-crowned sifakas across various habitats (rainforest, deciduous forest, dry evergreen forest, and littoral forest) we can determine the influence of habitat type and degree of fragmentation on their physiological health. Through understanding their stress responses, we can determine the degree of fragmentation the sifakas can handle before declines in their physiological health occur. Knowledge of this threshold will allow us to focus restoration efforts and forest protection in appropriate habitat types and locations.

**b)**. The second important outcome was being able to successfully collect precise quantitative data concerning golden-crowned sifaka social grouping and proximity. Preliminary analysis reveals that fragment type results in a significant amount of variance on group spread with sifakas displaying decreased group cohesion in rainforest fragments. Our success with following golden-crowned sifaka groups across nine diverse forest fragments has allowed us to understand their habitat structure across their range, resources within their various habitat types, and how anthropogenic disturbances impact their social behavior. We have shared our preliminary findings with Fanamby, who used these results during the 2018 IUCN Red List meeting in Madagascar and will use our results to develop plans to protect the most suitable habitat and reforest prime golden-crowned sifaka habitat.

c). Another important outcome was the confirmed discovery of golden-crowned sifaka groups in a very small forest fragment along the coast of north-eastern Madagascar. Prior to this discovery, golden-crowned sifakas were thought to only occur in rainforests, deciduous forests, and evergreen forests surrounding Daraina, and this is the first documentation of the species being found in a littoral (coastal) forest. This is important because we were able to engage with the local community outside Ampitsikinana and hire local individuals within the village to help with our survey of the site. This was the first survey completed in this coastal forest and the first time locals in the village have assisted with biological research. Many of the goldencrowned sifakas we observed in this forest fragment also had small home range sizes and poor body condition compared to sifakas in other fragments. I will revisit this forest fragment in my second field season to continue accessing the habitat characteristics, social cohesion, and stress physiology in this population of goldencrowned sifakas. Overall, by including this fragment into my field season, it will allow us to understand a more holistic view of golden-crowned sifaka habitats and yield results that can help determine the appropriate conservation management on a specific site level.



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

I worked closely with Fanamby, the Daraina guide association, and the local schools during my 2017 field season. Fanamby is a non-governmental organisation 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.

This project also benefited the local community by employing 22 guides throughout the field season and an additional ~50 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 behavioral 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 several additional field seasons. This was the first field season and I plan to complete at least two more field seasons in Daraina as part of my studies. I will be returning to Daraina again this year from August-December 2018 to work with the local community in Daraina to follow additional groups of golden-crowned sifakas and continue testing our FitPET devices. In 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?

In addition to 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 am presenting results from this field season at the International Primatological Society meeting in August 2018 and at the Society of Integrative and Comparative Biology in January 2019. I will also share my results with Fanamby and will present my findings at the University of Antananarivo in December 2018. I plan on publishing the lemur hormonal validation (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 Behavior. I also plan to share 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 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 2017, 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. Exchange rate: 1 pound = 4100 Ariary

Item	Budgeted Amount	Actual Amount	Difference	Comments
Car rental and fuel to get to Daraina	390	550	+160	Due to poor road conditions driving from Antananarivo to Daraina, we spent an extra day traveling (4 days instead of 3)
Malagasy guide costs	1460	1750	+290	Over the course of the field season, I hired 22 local guides (each for 2-4 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	1485	1390	-95	The Malagasy student stipend was



stipend				slightly less than anticipated. The students' advisor did not make the trip up to Daraina from Antananarivo.
Food for myself, guides, and Malagasy student	1550	1380	-170	Due to a drought in the region, fresh vegetables were often unavailable and the bulk of our food was rice and beans.
Porters to transport supplies to each forest fragment	80	310	+230	Due to a drought in the region, we had to travel farther from roads to find a water source adjacent to camp. As a result, we had to hire more porters than anticipated. *we hired zebu carts to transport supplies along roads and porters to carry the remaining distances by hand
TOTAL	4965	5380	+415	

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

Firstly, the immediate next steps for my project include further analysis of behavioural data and completing the hormonal analysis of the faecal samples. By understanding the impact of habitat type on sifaka spatial behavior and physiological responses, we can understand the impacts of land management practices. Once we have quantified glucocorticoid metabolites from the fecael samples, we can understand how chronic stress differs across various habitats and degrees of fragmentation. This knowledge will help us to determine if slight changes need to be made during our 2018 field season (i.e. increasing the frequency of scans during behavioral follows, collecting additional vegetation surveys, or identifying the number of fecael pellets sufficient to run our hormonal analysis).

Secondly, we are in the process of constructing additional FitPET devices to collar ~35 golden-crowned sifakas during our 2018 field season. In order to collect precise quantitative data to connect sifaka spatial behavior to their habitat characteristics and physiological responses, we must collar an appropriate number of individuals. By collaring ~35 lemurs, which would entail collaring all adults from 7-8 groups of sifakas, we can determine precise areas of sifaka habitat that result in group member fissioning and the stress levels that correspond.

Thirdly, we want to expand the number of lemur groups followed and visit other forest fragments in the Daraina region. During my 2017 field season, I visited nine forest fragments surrounding Daraina, however, there are still three additional forest fragments that have not been surveyed. During the 2018 field season, I plan to return to half of the already visited forest fragments (Binara, Bekaraoka, Ampondrabe, Solanampilana, and Ampitsikinana) and also visit the three additional fragments



(Bobankora, Ambilodamba, and Ambohitsitondroina). By the conclusion of the 2018 field season, we will have visited all the fragments where golden-crowned sifakas are found and have an understanding of their habitat needs, baseline physiological stress, and group dynamics across their entire range. This will allow us to determine which species of trees they rely most heavily upon for food and refuge as well as which parts of their habitat they spend the most time in. Understanding their ecological needs across their entire range will enable Fanamby, my partner NGO, to develop plans to protect the most suitable habitat and reforest prime sifaka habitat.

Lastly, 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 2017 field season, we ran into issues initiating the chicken coop project because chickens in the Daraina region are unvaccinated and spread disease when kept in close proximity with other chickens. To combat this issue, we plan to bring in vaccinated chickens from a nearby town (Ambilobe, ~100km from Daraina). We also plan to work with Madagascar National Parks to bring in several additional teachers into the Daraina pubic primary and secondary school. In 2017, 507 students were registered at the public primary school (10 teachers) and 283 students were registered at 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.

# 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 2018 Biological Sciences Research Day Conference. It was also featured during an oral presentation at the Virginia Tech Integrative and Organismal biology seminar (March 2018). It will also be featured on my poster at the International Primatological Society (Nairobi, Kenya) meeting in August 2018 and Society for Integrative and Comparative Biology in January 2019.

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

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

Yasmireilda Richards: Malagasy field technician



This field season would not have been possible without the immense help of Yasmi! She assisted in every stage of data collection from lemur habituation to vegetation sampling, fecael sample collection, and full day behavioral follows. When slight changes in methodology were necessary, she 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. Yasmi and I trained all guides on our protocols for collecting lemur behavioral data, fecael 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 fecael sample analysis for this project. As a behavioral endocrinologist, he has been particularly beneficial in helping run the hormonal analysis and streamlining the behavioral 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**, **Jose Rosa**, **Sam Anderson**, and **Matt Erwin** 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 2018 field season.

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 Yasmi, 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.