

## Final Evaluation Report

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Your Details	
<b>Full Name</b>	Raphael Reinegger
<b>Project Title</b>	Fruit availability drives dietary, activity and ranging patterns of invasive <i>Macaca fascicularis</i> in Mauritius: implications for conservation of <i>Pteropus niger</i> and native forests
<b>Application ID</b>	31861-B
<b>Grant Amount</b>	8100
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<b>Date of this Report</b>	29-03-2021

**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
Study the relationship between seasonal fruit availability, ranging patterns and diet composition of <i>M. fascicularis</i> in order to provide evidence for scarcity of native fruits and insights into the competition between the Mauritian flying fox <i>Pteropus niger</i> and <i>M. fascicularis</i> .				
Quantify the consumption of native fruits and damage to native plants by the invasive long-tailed macaque <i>Macaca fascicularis</i> in a degraded native forest remnant in Mauritius.				
Estimate macaque density in order to provide a new population estimate based on a similar approach as described in the last population study on <i>M. fascicularis</i> in Mauritius from 1994.				Not achieved because of considerable home range overlap of our study troop with neighbouring troops. As a result, a reliable density estimate could not be obtained, which is necessary when using the methods from Bertram (1994). Instead, we address the inaccuracies of population estimation methods used by Bertram (1994) and propose a better method for obtaining a reliable population estimate in our extensive report.
Continue our study established in 2019 to assess the effects of invasive plant removal on fruit production of native trees, bat consumption of native fruits and changes in native seedling/sapling cover.				Study has been continued and preliminary results are included in the extensive report.

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

Towards the end of the study period our study troop migrated to the north-western forest edge of the Calebasses Mountain Range close to the orchards. Troop migrations are uncommon in macaques but have also been observed in Japanese macaques in degraded habitats that consist of a mosaic of human settlements, forest and agricultural land, similar to our scenario. The migration was probably driven by fruit scarcity and facilitated by macaque capture near the orchards early in 2020.

Luckily, the troop took several days to migrate and gradually moved closer to the orchards every day. The last few days were extremely tough as the macaques descended down a steep cliff and entered nearly impenetrable vegetation. But when it became clear that the troop was not going back up the mountain, we started accessing the forest from the orchards, making observation days considerably easier. The details of this migration are described in the extensive report.

Furthermore, we did not use the methods from Bertram (1994) to obtain a new estimate of the *M. fascicularis* population. The main issue was that the home range of our study troop overlapped considerably with neighbouring troops, making density estimation impossible as we could not determine the home range of the other troops. Bertram (1994) already addressed the shortcomings of his study. We also address the shortcomings of Bertram's method and the macaque density estimation on which they rely. Subsequently, we recommend a better method that will require additional work but will be more reliable and reproducible.

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

*Macaca fascicularis* preferred fruits and increasingly fed on leaves, invertebrates, flowers and crops as fruits became scarcer. Furthermore, *M. fascicularis* preferred ripe over unripe fruit and increasingly fed on unripe fruit as forest fruits became scarcer. Additionally, exotic fruit was preferred over native fruit. Of all the time *M. fascicularis* spent feeding on fruits, the majority was spent feeding on exotic fruits, which is probably a result of *M. fascicularis* preference for exotic fruits and that exotic fruits accounted for 70% of all available forest fruit.

Moreover, of the total time spent feeding on exotic fruits, *M. fascicularis* spent the majority of time feeding on only three invasive species: *Flacourtia indica*, *Litsea* sp. and *Psidium cattleianum*. These species also constituted the bulk of all available exotic fruit (90%). Our results indicate that *M. fascicularis* may be an important seed-disperser for these species, as the majority of *F. indica* and *P. cattleianum* fruits were consumed when ripe and *Litsea* seeds were typically cleaned of pulp and then spat out (seed-spitting). Furthermore, *M. fascicularis* was probably a poor disperser of native fruits, as the majority was consumed when unripe.

Moreover, our findings indicate that *M. fascicularis* likely dropped the majority of available fruit from trees within their home range (~66%) and depleted nearly all

fruits of at least four native species at an unripe stage. Consequently, the most considerable fruit resources that probably remained available to *P. niger* within our study site were native *C. paniculatum*, *P. mauritianum* and *S. glomeratum*, accounting for 24% of available forest fruit. Even though native forest composition can largely vary across the island, invasive *F. indica*, *Litsea* spp. and *P. cattleyanum* have invaded most forested areas. Therefore, a similar imbalance in fruit availability between native and invasive species and similar dietary patterns of *M. fascicularis* are expected to be observed elsewhere on the island. Consequently, availability of forest fruits to *P. niger* is potentially limited.

In summary, we report the first case of how fruit preference and the imbalance in fruit production between native vs. exotic species in a fragmented forest habitat can promote consumption of unripe native fruits and dispersal of invasive plant species by an invasive frugivore, potentially restricting the diet of a native, key-stone seed disperser.

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

To obtain information about macaque capture by locals and crop raiding by macaques we contacted several farmers in the orchards, because our troop started raiding orchards towards the end of the study period. Even though the farmers do not receive direct benefits from providing information, we believe their helpfulness will be rewarded in the long-term. All farmers we contacted experienced crop-raiding by macaques year-round and our research shows that Mauritian forests are likely at carrying capacity, promoting crop-raiding by macaques. Hopefully, disseminating this information will pressure the government to control macaques.

Furthermore, to continue the weed removal project, a research assistant was hired: Vashist Seegobin. He was trained in plant identification, identification of bite marks in fruits, collection of vegetation data and use of camera traps for several months. He is also responsible for maintenance weeding and will continue measuring fruit drop of several plant species until October 2021. This study is likely to continue for another year, as the effects of weed removal on fruit production are likely to become clearer after two years. Additional funding will have to be acquired and the project may be transferred to Vashist because he is a PhD student in ecology at the University of Mauritius. However, the terms for this transfer still have to be discussed.

Moreover, two camera traps, climbing harness and climbing tapes and a ground quadrat were left with Vashist, so he could continue the weed removal study.

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

It is clear that *M. fascicularis* has detrimental impacts on native plant communities by destroying unripe fruit and facilitating dispersal of invasive plants. However, it is still unclear how big the population is currently. Past attempts at estimating the population size of *M. fascicularis* involved methods that were very inaccurate. I am planning to get in touch with Dr Eva Gazange from the University of Liege, who is currently trialling thermal infrared imaging with drones to estimate the size of

populations of endangered primates in Vietnam. It would be a great opportunity to apply this technology in estimating population size of *M. fascicularis* in Mauritius.

Moreover, it would be good to continue the weed removal project for another year (2021 – 2022). But a transfer to Vashist will likely be necessary in order to continue the project.

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

The results of the dietary study on *M. fascicularis* were presented at the National Parks and Conservation Service (NPCS) head office in October 2020. Our extensive report for The Rufford Foundation will also be shared with the NPCS because they are responsible for the coordination of macaque capture activities around Mauritius.

Furthermore, I plan on publishing the results of the dietary study on macaques in an academic journal. We also managed to publish the results of our first study on the potential competition between *P. niger* and *M. fascicularis* this year in the *Journal of Mammalogy*. We made a little promotional video on twitter that included camera trap footage of bats and macaques to draw attention to the article.

Moreover, I plan to become more involved in dissemination of information to a broader audience. There is an urgent need to close the growing gap between academics and the general public in Mauritius. There are plans to film a new documentary on invasive primates in Mauritius. I have been in contact with the film makers who have great ideas about addressing the conservation issues in Mauritius and making this information accessible to the general public.

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

We originally aimed to complete the macaque dietary study in December 2020, which was achieved. However, the weed removal project was supposed to end in April 2020. Even though the pandemic caused a slight delay in the transfer of funds to the bank account of the Ecosystem Restoration Alliance, there was no delay in our field activities. However, there was inter-annual variation in fruiting patterns, resulting in delayed flowering of species after we finished weed removal in July - August 2020. Therefore, to successfully compare fruit and flower production for all species between pre- and post-weeded conditions, our research assistant Vashist will continue monitoring fruit drop until October 2021.

**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
Accommodation at £100 /month for 9 months	900	900		
Living allowance at £200 /month for 9 months	1800	1800		
Transport at £200 /month for 9 months	1800	1800		
Fuel at £600 for 9 months	600	600		
Staff salaries for weeding at £50 a day (expected 30 days)	1500	1000		Fewer staff were hired, and volunteers were recruited
Field assistant at £300 per month for 5 months	1500	2000		Assistant was hired for 10 months for £200 per month (4 - 6 hours of work per week)
<b>TOTAL</b>	<b>8100</b>	<b>8100</b>		

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

It will be valuable to trial thermal infrared imaging with drones to estimate population size of macaques in Mauritius. Furthermore, to continue the study on weed removal, it may be necessary to transfer the project to our research assistant Vashist, so he can potentially incorporate it in his PhD.

However, the most important step to deal with invasive plants and macaques in Mauritius is to raise awareness among the general public. Awareness raising campaigns should not be limited to ecosystem damage by invasive macaques but should also cover ecosystem impacts of other invasive animals and invasive plants. Most invasive plants are considered 'Mauritian' by the majority of people. It is also essential to encourage people to engage with local wildlife conservation organisations so they can learn about their unique wildlife. Outdoors's activities, such as hiking, are common recreational activities for Mauritians. Many people are nature loving, but they lack the knowledge to distinguish between native and invasive flora and fauna. If people were more aware of their conservation issues and learn about their native wildlife and vegetation, they would probably be more willing to support various conservation efforts around the island. Encouraging publication by local researchers in local magazines and newspapers and providing assistance to local journalists or documentary film makers that want to cover wildlife issues will be essential to make information more accessible to the general public in Mauritius.

**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?**

The Rufford Foundation logo was used when the preliminary results of our dietary study on macaques were presented at the National Parks and Conservation Service head office in October 2020.

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

**Professor Gareth Jones** – Gareth was the main supervisor of the study.

**Dr Ryszard Oleksy** (Ecosystem Restoration Alliance, Indian Ocean) – Ryszard is the director of the Ecosystem Restoration Alliance (ERA) and was a co-supervisor of this study. Additionally, he provided necessary transport and field equipment.

**Ismael Janoo** (Conservation biologist at ERA): Ismael was hired to assist with weed removal. His experience with weed removal and extensive plant knowledge were of great help.

Vashist Seegobin (PhD student in ecology at the University of Mauritius): Vashist assisted with data collection for the weed removal study from October 2020 until December 2020 and was hired to independently collect data for the same study from January 2021 until October 2021.

**12. Any other comments?**

None.