The Rufford Foundation
Final Report

Congratulations on the completion of your project that was supported by The Rufford Foundation.

We ask all grant recipients to complete a Final Report Form that helps us to gauge the success of our grant giving. The Final Report must be sent in **word format** and not PDF format or any other format. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work. Please be as honest as you can in answering the questions – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please complete the form in English and be as clear and concise as you can. Please note that the information may be edited for clarity. We will ask for further information if required. If you have any other materials produced by the project, particularly a few relevant photographs, please send these to us separately.

Please submit your final report to jane@rufford.org.

Thank you for your help.

Josh Cole, Grants Director

Grant Recipient Details	
Your name	Ingrid de Mattos
Project title	Small mammal responses to fragmentation and habitat loss in the Brazilian Cerrado
RSG reference	24992-1
Reporting period	2018 - 2019
Amount of grant	£4,979
Your email address	mtt.ingrid@gmail.com
Date of this report	31/01/2020

1. Please 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
Evaluate whether richness and taxonomic/functional diversity patterns are better predicted by landscape configuration (fragment size and isolation) or habitat amount				The data collected is sufficient to achieve this goal and answer the questions related to it. With a capture success of 4.53%, we captured 1328 individuals from 16 species through the 36 patch study sites. With these data I am currently performing analyses to fulfil this objective.
Understand the role of fragment quality in maintaining small mammal abundance and diversity				The data collected is sufficient to achieve this goal and answer the questions related to it. I am currently performing analyses to fulfil this objective.
Verify whether fragmentation acts like an abiotic filter to functional traits, as well as to phylogenetic groups				The data collected is sufficient to achieve this goal and answer the questions related to it. I am currently performing analyses to fulfil this objective.
Elucidating how trophic relations in communities surviving in this changing environment are affected by fragmentation				I decided to evaluate changes in trophic relations in the fragmented landscapes using only one species as a model - the most abundant species, the didelphid marsupial *Gracilinanus agilis.* Consequently, I did not consider all registered species of communities as idealised in the original project. So, this goal was modified from the original community perspective to a population perspective. This decision was taken under the following arguments: communities (each study site or fragment) had very different species composition. These differences in species abundance and composition impairs comparisons of community-wide metrics of isotopic niche between sites; in addition, total

				project funding could not afford isotopic analyses (at a cost of $10 per sample) for all captured individuals (1328 individuals). *Gracilinanus agilis,* an arboreal marsupial, was the only species that was captured in almost all sites and was the most abundant species in the study (n = 839 individuals; representing 63% of captures). So, it was selected as a model to answer the questions about the effects of fragmentation, habitat loss, and habitat quality on trophic relations (based on isotopic niche metrics).
5)Identify which species´ characteristics are associated with vulnerability/ resilience to landscape fragmentation.				The data collected is sufficient to achieve this goal and answer the questions related to it. I am currently performing analyses to fulfil this objective.

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled (if relevant).

There were some unforeseen difficulties related to time spend in the field and access to sampling sites, described above.

Whenever I started fieldwork in late April 2018, while preparing sampling transects in forests and perceiving which would be the main time needed to check traps, mark and measure captured animals based on the high local capture success rate found, I realised that sampling 45 sites with two sampling transects each would be too time consuming, which meant that I would have to spend more time in the field than was predicted, incurring extra costs with gasoline, meals and lodging. So, I redesigned sampling scheme and decided to sample 36 sites with one transect each, doubling sampling effort per transect (now 80 traps per transect each capture night).

Furthermore, I had a time delay to conclude fieldwork because there was a delay in the release of Goiás state governmental environmental licence needed to sample two sites located in a state conservation reserve (Jaraguá State Park, Goiás). These are important sites because, as big nature reserves, they represent least modified environments and are considered reference areas for regional species pool. I only completed sampling scheme in these areas in late December 2019, although sampling in the remaining sites were concluded in late August 2019.

Finally, on the course of fieldwork periods we lost two sampling sites (one in the third and the other one in the fourth campaign) because farmers decided not to allow us to work in their lands anymore for personal reasons.

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

I am currently analysing collected data, and final analytical outcomes are about to be concluded and will be informed to RSG.

Fieldwork was conducted in four campaigns of around 60 days each, from April 2018 to December 2019, totalling around 240 fieldwork days. We established a capture effort of 45,120 trap x nights, one of the highest capture efforts implemented in a study of small mammals in the Brazilian cerrado. In the course of the study we captured 1328 individuals, recaptured 737 times, and recorded a total of 16 small mammal species (five marsupials and 11 rodents). Additionally, the extensive sampling of this work contributed to fulfil sampling gaps of small mammal diversity and species distribution in the Brazilian cerrado in studied regions of Goiás state.

From the results of analysed data, a very important finding was that trophic diversity (evaluated as Standard Ellipse Area corrected for small samples) of the didelphid marsupial species *Gracilinanus agilis* was not affected by patch size nor by the percentage of natural cover in the landscape scale (15000 ha), contradicting our expectations. However, populations consumed predominantly invertebrates in all fragments (indicated by high values of $\delta^{15}N$) and fragment size positively affected $\delta^{15}N$ values, which means that in bigger fragments *G. agilis* occupied higher trophic levels. Additionally, the marsupial consumed food resources that were mostly from forests (C3 plants), irrespective to fragment size, context of habitat loss and habitat quality, with low assimilation of pasture matrix resources (C4 grasses). Thus, we found that *Gracilinanus* is a forest dependent species, despite its ability to survive in small, isolated and low habitat quality fragments. These results reveal that despite *G. agilis´*s tolerance to fragmentation and habitat loss, it is a forest specialist species, an omnivore-insectivore forest consumer (as indicated by other studies on its diet). Thus, results suggest that this species plays a fundamental role in the maintenance of forest trophic dynamics in small fragments, dispersing native forest plant species, and most of all predating native forest arthropods. *Gracilinanus* was the most abundant species found in highly fragmented sites, being strictly dependent of forest resources.

Regarding habitat quality, the didelphid marsupial occupied slightly higher trophic positions in higher habitat quality fragments - forests with higher complexity structure - and *G. agilis* practically did not feed on resources from the pasture matrix, relying on forest food resources, no matter how low habitat quality was. Overall assimilated trophic diversity was greater in patches of higher habitat quality, suggested by higher values of isotopic niche ellipses, standard ellipse areas, as well as the other isotopic niche metrics ($\delta^{15}N$ range, $\delta^{13}C$ range and Standard Ellipse Area corrected for small samples) the more complex and less disturbed the patches were.

With these partial results we conclude that maintaining habitat quality is essential to conserve trophic relations in semi-deciduous forest ecosystems in the Brazilian cerrado. Small mammals might respond differently to habitat quality, patch size/isolation or landscape changes, depending on the dimension of biodiversity evaluated. With actual results we conclude that *G. agilis* populations have their trophic ecology affected by changes in habitat scale and patch scale. Remaining analyses will answer the questions about the effects of fragmentation and habitat loss over other dimensions of biodiversity.

We strongly recommend that farmers and land managers adopt strategies that conserve forest structure complexity and maintain higher habitat quality, such as preventing cattle access to forest patches as well as avoiding fires entering forest patches. These are essential management strategies for conserving ecosystem trophic relations of small mammals, therefore preventing collapse of food webs in fragmented landscapes. Moreover, we indicate studies on fragmentation and habitat loss to consider changes in habitat quality as significant consequences of fragmentation and habitat loss.

4. Briefly describe the involvement of local communities and how they have benefitted from the project (if relevant).

Local communities (especially farmers) had the opportunity to know part of the small mammal biodiversity they hold and protect within the legal reserves inside their land holdings. I presented them some captured animals on the course of the study. Also, I explained them the ecological role of these animals for maintaining balance of ecosystems (as seed disperses, arthropod predators, as prey for predators), breaking down myths and false ideas about these animals. Finally, the involvement with local people from farms and villages gave me the opportunity to perform environmental education raising awareness of the importance to conserve biodiversity and how it relates to the conservation of natural resources such as water. Moreover, there were some field assistants that were from local communities.

5. Are there any plans to continue this work?

I plan to continue this work to completely evaluate the effects of fragmentation, habitat loss and habitat quality in trophic diversity under the community-wide perspective, as originally planned. Now that I have fur samples collected from the 1328 individuals captured, I would have a consistent amount of samples to answer the questions, for both rodents and marsupials but I would have to search for funding to perform so many laboratorial isotopic analyses.

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

I plan to share the results of my work with academy by presenting my PhD thesis in July 2020, also publishing each chapter on indexed journals that deal with conservation biology and landscape management. Moreover, I plan to present results to farmers in order to help them implementing management strategies that improve conservation of native vegetation of legal reserves of their land holdings,

consequently contributing to the conservation of small mammals and ecological similar species groups. For this, I will suggest to local government environmental secretaries to schedule an appointment with farmers so we can discuss the results of this work.

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

The Rufford Foundation grant was used over the fieldwork campaigns (April/June 2018, August/October 2018, February/April 2019 and June/August 2019). Fieldwork comprised around half of the time devoted to the project, but now that I have collected all the necessary data, I am analysing it and writing the PhD thesis to present it to the university in late July 2020.

8. Budget: Please 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.

Notes on the budget: After making adjustments to make project´s cost go down [for example, 1) changing experimental design to reduce the number of sampled areas – 45 to 36 forests; 2) not renting a car and using my own personal car; 3) in some areas, we asked farmers to camp in farms for free to reduce lodging costs; and so on...], project´s total expenditure was 7384 £. I got funding grants from Rufford Small Grants (4,979 £), Latin American Student Field Research Award (1,500 USD) and University of Brasília (568 £), totalling a grant amount of 6,700 £. Consequently, I had a lack of funds to cost basic field needs such as meals, lodging, gasoline and car maintenance. It means I had to reorganise the total amount of grants to fund fieldwork item needs (shown in the following table for Rufford grant amount) and laboratorial expenses in order to make it possible to conclude the fieldwork and project´s data collection. So, there are some differences between budgeted and actual expenditure for some items, as shown below.

Item	Budgeted Amount	Actual Amount	Difference	Comments
Lodging	365	1365	+1000	To sample forest patches located in the municipality of Pirenópolis- GO, I had to pay for lodging for me and the team from the second field campaign on. In the first campaign we had borrowed a house to stay in, but the houseowner could not lend us the house anymore. So, I had to spend more with lodging than previously expected.
Car rental	952		-952	I could not get enough funding to rent a

				car, so I used my own car in the fieldwork. Consequently, I rearranged the budgeted amount for car rental partially to cost gasoline expands, an item that was not budgeted before in Rufford Application, and meals.
Car maintenance	675	675		
Meals	452	1452	+1000	Costs with meals were high, partially because we could not daily cook after fieldwork to make meals less expensive than buying dinner. In addition, I took 2 field assistants to work with me instead of one, so captures and collection of environmental data could be done in time. However, taking one extra field assistant means extra costs with meals.
Gasoline		751	+751	I added this item in the expenditure of RSG (and added it here in final report, making an alteration in the budgeted items shown in the application) because the few other funds I got could not cover all the costs with gasoline. Gasoline´s price increased a lot on the course of fieldwork period (over one year and a half). So costs with this item was high.
Local salaries (field assistants)	716		-716	As I could not get other funding than Rufford Small Grants (4,979 £), Latin American Student Field Research Award (1500 USD) and University of Brasília (£ 568), I had a lack of funds to cost basic field needs such as meals, lodging, gasoline and car maintenance. It means I had to reorganise the total amount of grants to fund fieldwork expenses. So, I also rearranged the amount previously destinated to payment of local salaries for field assistants for costing part of meals and lodging. Fortunately, I found many volunteers to be field assistants, most of them were undergraduate biology students from Brasília -DF, Brazil, and from local communities.

Isotope analysis	1819	736	-1083	Isotopic analyses were performed in January-February 2019, so it means I only used samples from the first and second field campaigns. We chose that moment to perform the preparation of samples because laboratorial results could take up to 5 months to be returned to us. So, I could not wait until the end of fieldwork to perform isotopic analyses. At that time, the rarefaction curves of sampling were not yet stable, and there would still be some species to be added to the curve on the ahead samplings. So, at that time I had not yet samples from all the detected community. Additionally, community composition differed a lot between forest patches and this difference make it difficult to compare trophic diversity between communities as a result of fragmentation. Moreover, the only species that was registered in almost all study sites was the marsupial *Gracilinanus agilis*, so it was a good model to test shifts in trophic ecology because of fragmentation and habitat loss. In this context, I decided (together with my advisor) to focus on the evaluation of changes in isotopic ecology of populations of the didelphid marsupial *G. agilis* in the fragmentation gradient instead of investigating trophic changes under a community wide approach. For this, we chose 98 samples of *G. agilis* individuals from sampled patches to analyse isotopic contents. Consequently, I spent less than planned with isotopic analysis (total expenditure was 736 £ from a total predicted amount of 1,819 £ from RSG). I used the remaining amount originally destinated to isotopic analyses to help affording costs with lodging, meals and gasoline.
TOTAL	**4979**	**4979**	**0**	*Current exchange rate: 5.43 Brazilian reais to 1 Pound sterling.

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

The important next steps are to publish the results in important journals that deal with conservation biology and landscape management, contributing and reinforcing the scientific arguments on the protection of environmental legislation of native vegetation, countering the actual politics in Brazil that aim at eroding environmental politics in order to guarantee interests of agribusiness sectors.

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

Yes, I used the Rufford Foundation logo in oral presentations I have made on the course of the project at the University of Brasília, and whenever I was asked about the project´s funding, I disseminated the information that Rufford Small Grants was the main funding I received for performing my PhD research.

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

Name	Role in the project
Ingrid de Mattos	PhD student responsible for the project, coordination and execution of the project (experimental design, fieldwork, analyses, writing)
Dr. Jader Marinho-Filho	PhD advisor
Dra. Gabriela Bielefeld Nardotto	Scientific collaborator on the theme of isotopic ecology and isotopic analysis
Dra. Bárbara Zimbres	Scientific collaborator on the theme of landscape ecology and landscape analysis
Dra. Juliana Fernandes Ribeiro	Scientific collaborator on the theme of mammal ecology, isotopic analysis and statistical analysis
Artur Rodrigues, Daniele Cristina Barcelos, Flávia Luanne M. Barreto, Thais Camilla Damaceno Alves, Edwilson Miranda Barbosa, Jéssica Luiza Rodrigues de Amorim, Erick Madson, Cícera Vanessa Feitosa Morais, Adriano Paiva, Bruno Augustus Peña Corrêa, Mariza Mendanha, Flávio Müller, Jaine de Andrade Nascimento, Gabriel Amaral, Ana Carolina Rodrigues Nogueira Cavalcante, Hiugue Takashi, Raphael Armani, Fernando de Castro, Carolina Tarouco, Brenda Adelinne Sousa de Souza, Antônio Lucas Pereira	Field Assistants helped with trapping animals in the field also collecting environmental data on forest structure and food availability.

de Sousa, Júlio Campos e Silva, Eric Scaramello, Hicaro Corado Batista, Karolayne Cardoso Fernandes, Welita dos Reis Alves, Débora Marques de Lima, Cristiano Machado Lins da Silva.	

12. Any other comments?

There are still many data to analyse, therefore I will send RSG complements of the outcomes of this work as soon as I present my PhD thesis in early July 2020.

I would like to thank Rufford Foundation for the funding. Without this grant it wouldn´t be possible to collect the data to perform fieldwork and isotopic analysis of my PhD thesis. Rufford funded about 67 % of my project. In Brazil we are facing a terrible political crisis with devastating consequences for education and research and technology. So, Brazilian universities are lacking financial support such as research scholarships for graduate students and research funds for developing scientific projects.

Gracilinanus agilis (Didelphimorphia: Didelphidae). It is an arboreal forest specialist marsupial species. It was the most abundant species registered in the study. © Ingrid de Mattos.

Marmosa murina (Didelphimorphia: Didelphidae). It is an arboreal forest specialist marsupial species. It was a rare species in the study, captured only in bigger fragments. © Ingrid de Mattos.

Rhipidomys macrurus (Rodentia: Cricetidae). A forest specialist, locally abundant arboreal and frugivore rodent species registered in the study.

Me registering body measurements of the rodent species Calomys expulsus (Rodentia: Cricetidae) during fieldwork. © Welita dos Reis Alves.

Representation of the typical studied landscapes: forest remnant patches immersed in pasture matrix. Landscape in municipality of Jesúpolis, Goiás State, Brazil. © Bruno Augustus Peña Corrêa.