# 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** | Camila Silveira de Souza |
| **Project title** | Network interactions in the Pantanal: preserving the interactions between native species of pollinators and plants |
| **RSG reference** | 21366-1 |
| **Reporting period** | February 2017 to February 2018 |
| **Amount of grant** | £4983 |
| **Your email address** | souza.camila.bio@gmail.com |
| **Date of this report** | 20 Feb 2018 |

**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 |
|---|---|---|---|---|
| Data collection of plant species and pollinators. | | | | We have finished collecting data and organised the material and now I am in the final analysis of the data. |
| Organization of the material in the laboratory: plants, pollinators, pollen and spreadsheets. | | | | At this stage all plant species and their pollinators were identified. The pollen slides were prepared and analysed under a microscope. The plant species were deposited in the herbarium of the Federal University of Mato Grosso do Sul. All data were organised for analysis. |
| Analysis. | | | | I started writing my PhD thesis of which this project is part. Currently I completed a chapter and submitted to the Journal of Ecology (Impact Factor: 5.431 - 2012). I began the analysis of the second and third chapter that encompasses most of the analyses on *Apis mellifera* in the Pantanal. Thus, at the end of each chapter, part of the analysis is finished, which will be done in June 2018. |
| Evaluate whether the most abundant species and/or those with more generalized characteristics have more interactions and thus contribute more to the preservation of interactions. | | | | I finished this part through partial analysis of the results obtained. We have identified some important species for the conservation and maintenance of interactions in the community. The species were classified according to their abundance (plants and pollinators), behaviour when visiting the flowers (pollinators) and floral types (plant species): type of flower, pollinators, anthesis, size and colour of the flowers. The most common species are present in the miniguide that was elaborated. In the total, the network of interactions had 80 species of pollinators and 128 species of plants. |

| | | | | |
|---|---|---|---|---|
| Investigate the role of *Apis mellifera* in pollinating native plant species in southern Pantanal and its role in network interactions. | | | | We can understand the role of this species in the Pantanal community. I am now writing the paper on the role of *Apis mellifera* in the network of interactions and comparing with other tropical areas. In general, *Apis mellifera* (honey bee) was the most frequent bee pollinator and also the most frequent among all recorded pollinators in the community. Despite this, their visiting behaviour was not efficient in all plant species resulting in thieving in some cases. |
| Dissemination of the work. | | | | We finished the mini guide with the main species of plants of the Pantanal and also a folder for the children of the region. However, we have not yet distributed to all the children in the area. We will do this in an event in April when the children return to the local school and along with the folder we will distribute honey bread for the children, besides explaining the importance of the pollination for the conservation of the Pantanal. But we already distributed some folders and mini guides to the population and felt that the receptivity was good, and the people liked the project. |

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

During the data collection one of the biggest difficulties was getting a car to take us to the study area/field station. Often some trips were cancelled at the time and had to be rescheduled for the next week. Whenever we could go together with other people to try to solve the problem. Also, during the flood season in the Pantanal in some places it was very difficult access to collect the pollinators and we had to walk for long distances in the water because the car often did not pass.

Another negative aspect is in relation to time. Often I planned to do some activities at a particular time or date but the time was sometimes short and I had to postpone or delay more with some activities that I thought would be faster, such as organising the botanical material, identifying the species and organizing the data.

For the release and delivery of the folders with the children in the study area in April 2018, we tried to deliver the folders before that date, but when we were in the study

area, most of the time the children were not having a class. The flooded period disrupted the children to go to class and with that we had to move to April 2018.

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

Because of its unique combination of dry and flooded grasslands, savannas and tropical forests, the Pantanal contains an enormous diversity of plants and animals, possibly the highest concentration of wildlife in South America (http://wwf.panda.org/what_we_do/where_we_work/pantanal/). The Pantanal wetland is recognised as a Ramsar site, that is, one wetland of International Importance (http://biodiversitya-z.org/content/ramsar-sites-wetlands-of-international-importance). Whilst large areas of the Pantanal remain pristine at the moment, the area is under pressure from increasing human activity including settlements, farming, hydroelectric power development and the planned 'hidrovia' navigation canal. Thus, I think that the most important result of the project was to have done a survey of pollinators for a long period of time for the Pantanal. With this, through the analysis of interaction networks we can observe that there are extremely important species in the community, representing a key plant species (resource for pollinators) or an important pollinator. In addition, knowing the composition of the pollinators and the plant species of the region, makes it possible now to mitigate possible conservation strategies for the area.

Among the pollinators groups, bees were the most important, especially the exotic species *Apis mellifera*, and the native species *Bombus (Fervidobombus) morio* and *Trigona spinipes*. *Apis mellifera* visited 53 species of plants (~ 9488 flowers visited) in the community during the study period. Among the species visited by *Apis mellifera*, the most frequently visited plants were also the most abundant and had the most accessible resources (nectar and pollen for example): *Cissus spinosa* (Vitaceae), *Inga vera* (Leguminosae Mimosoideae), *Ludwigia elegans* (Onagraceae), *Paullinia pinnata* (Sapindaceae) and *Richardia grandiflora* (Rubiaceae). *Apis mellifera* had adequate pollination behaviour when visiting the flowers. However, the high abundance of *Apis mellifera* and its aggressiveness in foraging resources in the flowers can inhibiting the native pollinators leading to a high competition. Thus, the management of *Apis mellifera* in the study area is an important step for the conservation of native pollinators in the Pantanal.

The oil collecting bees of the genus *Centris* and plant species that produce oil (e.g. *Byrsonima cydoniifolia* - Maliaighiaceae, *Angelonia hirta* - Plantaginaceae) represented an important mutualism in the community. This shows the importance of preserving in the fields and pastures the individuals of *Byrsonima cydoniifolia* that represents an important source of resources for the oil collecting bees in the study area. Other smaller bees like the species of *Augochlora* spp. (Halictidae family) were also abundant and important pollinators for most plant species. In relation to vertebrates, the hummingbird species *Phaetornis eurynome*, *Hylocharis chrysura* and *Eupetomena macroura* were also important pollinating agents of both ornithophilous species (*Psittacanthus cordatus*, *Helicteres guazumifolia*) and some non-ornithophilous species (*Tabebuia aurea*, *Inga vera*).

Among the plant species, *Tabebuia aurea* (Paratudo - Bignoniceae), *Richardia grandiflora* (Rubiaceae), *Pontederia cordata* (Pontederiaceae), *Paullinia pinnata* (Sapindaceae), *Ludwigia elegans* (Onagraceae), *Inga vera* (Leguminosae - Mimosoideae) and *Cissus spinosa* (Vitaceae) were the most important species for the maintenance of pollinators in the community. This is because these species have bloomed in more months or produced large quantities of flowers (resources) for the pollinators.

Finally, with this database it is possible to compare it with other data that I collected previously during the monograph and master's degree. Thus, I have been able to expand the ideas and to carry out a larger article on the temporal variation of interactions in these tropical communities, which are rich in species. This article was submitted in the Journal of Ecology and has undergone peer review.

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

This part was the one that I discovered a lot of new things. It is very interesting to see people's views of the community about the work. More than that, it is rewarding that we can spread the work and make them understand the importance of the project and why we have to preserve the pollinators. Seeing the people and children delighted with the folders and miniguides was a very big reward.

In April 2018, I will be delivering the folders for the children in the local school in the study area, and I am very anxious for the meeting. I hope that they enjoy it as much as the kids and adults in town liked. Also, it was important to see how some professors and colleagues from my university liked the idea of developing this miniguide and folder. Sometimes we forget that the main mission of our work is to divulge to preserve, and with this, in most of the time, our research is lost between scientific articles and ends up not reaching the local population, that is in the end, the most important.

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

Yes, the project is still in progress. We are now writing articles and these articles will be part of my PhD thesis that will be finalised in September 2018. In addition, we continue with pollinator collections in the study area and are also focusing on some plant species that are abundant and offer a large amount of resources to the pollinators. We have a new student, Karen Santos, who is working along with me with some important plant species in the community.

In relation to the project, we finished the first article about the interactions over time, and in the second we will explore the data obtained with the frequency of interactions between plants and pollinators and with the samples of pollen collected. And finally, we will write an article evaluating the impact of the exotic species *Apis mellifera* in the community studied.

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

We will continue distributing the folders and miniguides to the local population. In April 2018 we will have a trip to the field station to distribute the miniguides to the children of the area. In addition, we intend to expose the importance of research and conservation of pollinators in the local rural school and community near the field station (Multisserial Rural School: 1ª - 4ª series (UFMS/City Hall of Corumbá). But we have already distributed some mini guides in the city.

I have also presented the partial data of the work in a conference (Symposium on Ecology and Evolution of Plant Reproduction http://plantevol.sites.ufms.br/), and we are writing the scientific articles. We also intend to submit one further paper to WCS (Wildlife Conservation Society Brazil Program - https://programs.wcs.org/brazil/WCS-Brazil/Vision-Mission-Goals.aspx) for publication, publicizing the importance of the pollinators to supporting ecosystem processes and conserving biodiversity richness in the Pantanal. And finally, in May 2018 there will be an event where I intend to present an abstract on the first chapter of the thesis (http://www.ictp-saifr.org/workshop-on-spatial-and-temporal-dynamics-of-ecological-networks/).

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

As the grant arrived after a few exploratory data collections, I can see the difference before and after. With the grant received, the field became more productive, because we bought missing materials and we had the help of video cameras, which greatly increased the quality of the project. So, the grant intensified my fieldwork and collection because I had the autonomy to stay in the field for more time with all the necessary equipment and support. Now, I hope to conclude analyse of all data and provide all summarised results in my PhD thesis.

**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.**

| Item | Budgeted Amount | Actual Amount | Difference | Comments |
|---|---|---|---|---|
| Entomological net (4 units) | 80 | 80 | 0 | Fully spent. |
| Retractable entomological net (4 units) | 95 | 48 | +48 | We purchased only two, because the plant species in most areas were herbaceous species, not needing a retractable entomological net. |
| Digital Caliper (2 units) | 100 | 0 | +100 | We used the callipers available at the university, and this money was |

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| | | | | important to buy other laboratory utensils like slides, coverslips and reagents for the preparation of study pollen slides. |
| Cameras Sony Handycam® (5 units - more accessories: memory card, battery, charger) | 1785 | 1600 | +185 | Almost fully spent. In the final budget the cameras were more expensive and so it was not possible to buy all that we intended. So, we bought three Sony video cameras, four batteries, and four memory cards that were essential in the field to better observe the behaviour of the pollinators in the flowers through the filming. |
| Travel to BEP – Base de Estudos do Pantanal - Fuel (1400 litres) | 1158 | 1350 | -192 | During the year there was higher price difference due a variation in the tax per litre of diesel. |
| BEP - Base de Estudos do Pantanal – Help with food during hosting (12 field trips) for two or three people. | 751 | 300 | +451 | Received discount in some days each month. |
| Field guide plants and their pollinators for the Pantanal (280 copies) | 701 | 1500 | -799 | In the end, we had 2000 mini guides printed. We did a mini guide for the children of the region (1000 copies) and a mini guide for the whole community (1000 copies). |
| Tripod for video cameras (5 units) | 188 | 120 | +68 | We only bought three tripods for the cameras. |
| Rain jackets for video cameras (5 units) | 125 | 0 | +125 | It was not necessary to buy the rain jackets for the video cameras. |
| **Total** | **4983** | **4996** | **-15** | |

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

Now I am focusing on writing the articles for my PhD thesis, in order to disseminate the results of this project in scientific community. The first article is almost published (under review) and the second will focus on the role of the exotic species *Apis mellifera* in the community. The third is about the sampling methods and their implications for inferring the importance of species in the network of Pantanal interactions. For the latter, I will use two types of data: information about the identification of the pollen collected from the body of the pollinators and information on the frequency visit of the pollinators in the flowers.

In relation to the dissemination of the work, we consider educational and scientific divulgation strategies as an excellent opportunity to emphasise conservation actions with the local community. In practice, it is important to continue promoting meetings

with the population of the study site, in order to convince the local community to put into practice the actions addressed in the mini guide and folders and how to assist in the conservation of pollinators and plants in Pantanal. Through the participation of the local community, we can stimulate attitudes to maintain their life quality and local diversity.

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

Yes, we use the logo on the shirts that I made for the team during the distribution of the folders and mini guilds to the community;

I used the logo during the presentation of the preliminary results of this project in the Symposium on Ecology and Evolution of Plant Reproduction http://plantevol.sites.ufms.br/;

In submitting the first article using the project data, I mentioned my process (RSG: 21366-1) in the acknowledgements of the manuscript;

And in the folder and mini guide produced I put the Rufford logo.

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

**Professor Dr Andrea Cardoso de Araujo** – Ecologist and the project's guiding supervisor. Her expertise is on plant-animal network interactions, particularly in pollination networks. She helped me and supervise me in this project regarding the issues I wanted to answer.

**Dr Pietro K. Maruyama** - His expertise is on network interactions between plants and pollinators, pollination biology and plant reproduction. He is my co supervisor in the PhD and helped me in the questions of this project and in the writing of the first chapter of the thesis that used the data of this project.

**Karen Santos**– Laboratory colleague, started with me after the beginning of this project and helped me in the field. She also started his master's degree also working in the Pantanal in the same area of study investigating some species of plants and their pollinators.

**12. Any other comments?**

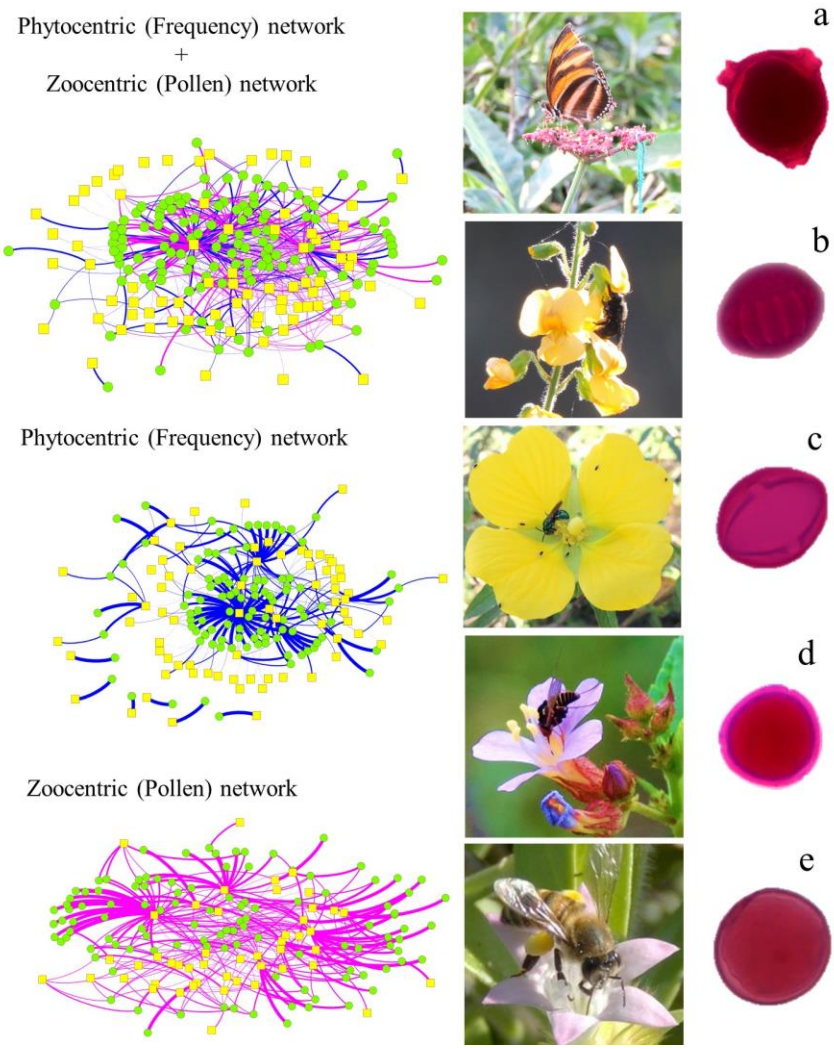
Yes, I would like to thank you for the opportunity. I am very thankful to Rufford Foundation for financial support for this project. I thought it was something very far from my reality and I never imagined receiving this help for my project. But thanks to Rufford who believed in the potential of this project I was able to go beyond my field and study. Thank you, Rufford Foundation, for the help and opportunity, I will be eternally grateful. I hope to do my best every day to publish and disseminate my work on this project.

Appendix


Photos during data collection using video cameras.



Distribution of the miniguides and folders for some people of the university. In April we will distributing the folders and miniguides to the children and local population. At the end, the copies will be enough to expand for the other places (e.g. local farms and organizations).




In the left, Phytocentric (frequency) + Zoocentric (pollen), Phytocentric (frequency) and Zoocentric (pollen) networks of interactions for the Pantanal Wetland (kamada-kawai graph). In the network, pollinators and plant species are represented by yellow boxes and green circles respectively. Thus, this figure shows the network of interactions between plants and pollinators in the Pantanal in two ways: the first with the data collected through the observation and filming of the interactions of the flowers of the plant species (Phytocentric). And the second one with the removal of pollen from the body of the pollinators that were identified with the pollen catalogue elaborated in the study area (Zoocentric). For the catalogue, we collected flowers monthly to identify the pollen types in the study area.

In the right, some plant pollinators interactions and the pollen grains of plants, (a), *Cissus spinosa* (Vitaceae) visited by butterfly *Dryadula Phaetusa*; (b) *Discolobium pulchellum* (Leguminosae) visited by the Bumblebee *Bombus morio* (c) *Ludwigia octovalvis* (Onagraceae) and Halictidae bee; (d) *Melochia simplex* (Malvaceae) visited by Bombyliidae fly and (e) *Richardia grandiflora* (Rubiaceae) visited by honey bee *Apis mellifera*.