

Final Evaluation Report

Your Details	
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Project Title	The black-lion-tamarin Leontopithecus chrysopygus as seed disperser and its role in forest regeneration
Application ID	29108-1
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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
functional redundancy of the black-lion-tamarin (BLT) as seed disperser with other mammals and birds				three groups of BLTs, from the start of their daily activities until their return to the sleeping tree. We performed the follow up of the groups in two Atlantic Rainforest areas in the State of São Paulo (Brazil), resulting in 1,056 hours of sampling effort. Through our fieldwork, we determined the plant species dispersed by the BLTs. Then, we combined our data with all other data on frugivory and dispersion which were available in the literature for this species (BLT). Concurrently, we created a database with the sympatric species of mammals and birds which inhabit each studied area. We gathered information on frugivory of the other animal species from data papers (e.g., Atlantic frugivory: a plant-frugivore interaction data set for the Atlantic Forest, Bello et. al. 2017), and from articles and theses available in digital platforms (e.g., Google Scholar, Scielo, Capes). Subsequently, we filtered these records into potential dispersal interactions. We considered a potential interaction if the animal species was able to swallow and defaecate the whole seed. With this information, we created a binary matrix of interactions, with the BLT and the other sympatric animal species (that interact with the same plant species dispersed by the BLTs) in one level, and the plant species in the other level. Finally, we performed analyses of ecological networks, where we assessed different structural parameters of the networks. To do this, we used the software R (2020) with the



		Bipartite package.
Characterize the primary dispersion performed by the BLTs		We assessed the characteristics of the fruits and their seeds (dispersed by the BLTs) and compared whether the primary dispersion carried out by the BLTs varies according to the habitat where the groups are found (continuous forest, continuous forest with edge effect, and riparian forest). To accomplish that, we performed the data collection on the field, alongside the data collection of the first objective we described above. We collected the behaviours using the scan sampling method (Altmann, 1974) each 5 minutes, and for frugivory we used the all-occurrence sampling method (Altmann, 1974). In cases of defaecation records, we noted the time and counted the number of dispersed seeds, and also measured their length and width. Whenever possible, we identified the dispersed seeds on the field. For each dispersion event, we estimated the straight line distance between the defaecation coordinates and the coordinates of the possible mother tree. We used Anova tests to compare the number and size of the dispersed seeds between groups. To determine the spatial distribution of fruit trees used as resources by the BLTs, we used the aggregation index as a proxy, calculated by means of the function "clarkevans.test" in the software R.
Evaluate if the dispersion performed by the BLT is non-random, conferring better germination and recruitment success for the dispersed plants		In the same areas, we built experiments of plant recruitment on the field, in January 2020. Using a plant species widely consumed by the BLTs, <i>Inga</i> <i>marginata</i> , we compared recruitment success based on three treatments: (1) defaecation sites of the BLTs (dispersion by the BLT); (2) random sites (random dispersion); (3) under the mother tree (no dispersion). In half the experiments of the treatment (1), we tested the effect of the secondary dispersion (i.e.,



	the dispersion carried out by coprophagous beetles) by burying the seeds into different depths: 1, 3 and 5 cm. We used 60 seeds per treatment, with 180 seeds per area, making a total of 540 seeds. All the experiments were protected by vertebrate exclusion cages. To turn feasible the monitoring of the seedlings, we tied up the seeds with clear nylon threads of approximately 25 cm, which ended with a piece of coloured paper containing an identification number. At each sampled point of the three
	treatments, we measured the canopy cover and the forest litter, to link the
	micro-habitat characteristics. In
	performed an inspection of the
	experiments, measuring and counting the number of saplings that survived, to
	compare between treatments and areas.

2. Describe the three most important outcomes of your project.

a). Our findings show that the disperser role performed by the BLTs vary according to the environmental context. Contrary to the expectations, in a preserved area that maintains its original fauna (Morro do Diabo State Park), the species performed a very complementary role, by consuming and dispersing plant species that are little used by other frugivores. As for the defaunated area (Rio Claro Farm), the more generalist feeding behaviours of the animals resulted into greater functional redundancy. The record that the BLTs show a differential selection of resources according to the area is unprecedented for the species.

b). The habitat in which the groups of BLTs are found seems to modulate the resting time and the time and way the individuals move, which consequently influences the distance in which the seeds are dispersed in the areas. However, contrary to the expectations, even shorter dispersal distances did not lead to more aggregated distributions of dispersed seeds in the areas. In our study, the dispersal pattern observed in a disturbed area was like that observed in a continuous forest habitat, which suggests that the effectiveness of the species as a disperser remains even in altered habitats.

c). The primary dispersion carried out by the BLTs increased the recruitment success of seedlings, while the secondary dispersion significantly decreased the seed predation by invertebrates. Therefore, our findings show that the diplochoric system we evaluated here (BLTs plus coprophagous beetles), potentially characterises a



directed dispersal. Since the post-dispersion largely influences the effectiveness of a primary seed disperser, from this result, we emphasise the importance of integrating secondary dispersion data in the comprehension of the effect of frugivores as dispersers in the plant communities.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

Our main difficulty was to proceed with this project in a Covid-19 pandemic scenario. The project has started in October 2019 and was scheduled to end in September 2020. However, in March 2020, with the spread of SARS-CoV-2 in Brazil, the areas we developed the fieldwork (Morro do Diabo State Park, in Teodoro Sampaio, São Paulo, and Rio Claro Farm, in Lencóis Paulista, São Paulo) were closed, both for visitation and research. Due to the lack of information about the disease, there were doubts among the scientific community, mainly about the possibility of transmission to the animals, and that was particularly troubling, considering that we studied primates, which are animals phylogenetically close to us. During almost 1 year, we could not access the areas, which caused the project to be extended, and part of the methodology to be adapted, so that the initial objectives of the project could be achieved. The main change was related to the objective "Evaluate if the dispersion performed by the BLT is non-random, conferring better germination and recruitment success for the dispersed plants". In principle, the experiments would be inspected monthly, to monitor the seed germination and the subsequent seedling recruitment. After that, we intended to replicate the experiments with other plant species, besides Inga marginata. We built the experiments in January-February 2020. In March, we would go to the field to perform the first monitoring of the seeds. However, with the park and the farm closed, we had to cancel this field campaign, and for months we did not know when or whether would be possible to inspect our experiments. So, to not lose our experiments that were already on the field, we modified the methodology and turned the experiments to recruitment instances, and no more of germination. Also, we have adapted our questions and hypotheses accordingly. We decided to not replicate the experiments with another plant species, since the project depended on the conclusion date of my doctorate. Another difficulty is that we had planned the presentation of our results to the general public, in lectures and meetings. With social isolation, we had to adapt the presentations to the virtual modality.

4. Describe the involvement of local communities and how they have benefitted from the project.

During our field campaigns, different field assistants, and some local community residents, helped us to open trails through the forest, follow the groups and collect data, and in return they were paid per diems. We also used part of the resources of the project with maintenance costs in the cities, such as feeding and lodging. As other students from the lab went with us to the field campaigns, which occurred periodically, by doing our research in these cities that are not essentially touristic, we indirectly helped the local economy. Furthermore, most of the people we interacted with in these cities were unaware of the presence of the BLT in the region. By talking to them about our study, and about the presence of the BLT and the threats to



which the animal species are subject, seems to have started in these people the interest in conservation, and although they did not become environmental activists, we believe that small changes certainly started there. The fact that other students went to the field with us is very important, because some of them did not have any funding. This enabled a mutual aid, because they helped us in data collection, while also developed their own projects. Through the knowledge generated from our projects, we are able to advance in the environmental education area, spreading information about the species among school students and universities. In the future, we intend to organise an event about the BLT, with lectures and dissemination of our results to the general public.

5. Are there any plans to continue this work?

From this study, others are being generated already. Through the monitoring of the BLT groups, and the identification of the plant species the BLTs consume and disperse, it was possible to create an illustrated botanical identification guide. The work was developed by a scientific initiation student under my supervision and is available for use by everyone in the laboratory of Primatology at the UNESP of Rio Claro (São Paulo). I consider this guide one of the most important results of this project. From this, it will be easier for other researchers to identify what the BLTs are consuming and dispersing. From the data we collected on the field, we identified 89 plant species, which are currently composing the guide. The idea is to update the guide periodically, if new plant species are identified as part of the diet of the BLT. Besides the unfolding of this project that will be studied by other students of the laboratory, I will stay in the academic area. After the publication of the results, we obtained here, I hope to develop new projects that help in the conservation of the neotropical primates.

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

I am already sharing the results of this project in different ways. So far, I have presented the results in six abstracts at five national and international congresses. Through lectures, I have also shared the preliminary results to the students of biology graduation at the Taubaté University (UNITAU - São Paulo), and to the managers and employees from the environmental area of the Duratex and Suzano enterprises (owners of the Rio Claro Farm). Moreover, I have shared partial reports with these enterprises and with the Forestry Foundation of the State of São Paulo, responsible for managing the Morro do Diabo State Park. I sent to the managers of each area a copy of the PhD thesis and made myself available to discuss and present the results. Furthermore, my PhD thesis, which was structured into four chapters, resulted from this project. Each chapter will become a scientific article, which will be submitted for publication in international journals. One of these articles is already ready and I expect that in the next few months all the articles will be submitted.

Presentations that resulted from this Project (Figure 1):

(2019) XIV Brazilian Congress of Ecology. Presented in oral format: "The black-liontamarin *Leontopithecus chrysopygus* as a seed disperser and its role on forest regeneration".



(2019) XVIII Brazilian Congress of Primatology. Presented in oral format: "Habitat loss, edge effect and the seed dispersal service by the black-lion-tamarin".

(2021) Virtual Meeting ATBC (Association for Tropical Biology and Conservation). Presented in oral and virtual format: "The role of an endangered small-bodied primate species as a seed disperser in the Atlantic Rainforest".

(2021) XV Brazilian Congress of Ecology. Presented in oral format: "The role of the black-lion-tamarin *Leontopithecus chrysopygus* in two seed dispersal networks with different environmental contexts".

(2022) XIX Brazilian Congress of Primatology. Presented in oral format: "Influence of fruit and seed characteristics on the interaction network of black-lion-tamarin, plant species and other Atlantic Rainforest vertebrates".

(2022) XIX Brazilian Congress of Primatology. Presented in oral format: "black-lion-tamarins and coprophagous beetles: the diplochory effect on plant recruitment".

(2022) PhD Thesis. Presented in oral and virtual format: "Effectiveness of the blacklion-tamarin *Leontopithecus chrysopygus* as a seed disperser and its role on forest regeneration".







Figure 1. Disclosing the results of this project. Above, at the XIV Brazilian Congress of Ecology. Below, defending my PhD Thesis.

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

Firstly, disseminating the results generated throughout this project. I plan to dedicate myself in the next months to publishing the articles, presenting the results to the involved parts, participating in events, and giving lectures to students. Knowing the plant species that are dispersed by the BLT and shared with other animal groups, may help to delimit which ones could be used in reforestation programs of the areas, including the creation of ecological corridors, to establish larger areas of continuous forest. Therefore, I see the dissemination of the results as a possibility to transform theory into practical conservation actions. Secondly, the continuation of the studies with BLTs (which is already being carried out by the laboratory of Primatology at the UNESP of Rio Claro) and the integration of these studies. We hope that the data generated here could be combined with data from other studies which address, for example, the genetic health of the populations, enabling a safer management, translocation, and reintroduction of the groups, if necessary.

8. 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?

I have used the Rufford Foundation logo at the end of every oral presentation, in a special acknowledgment slide. Also, I mentioned The Rufford Foundation and the project number in the abstracts that were submitted to the scientific events. In the papers that I am preparing for publication, the Rufford grant will always be mentioned. From this project resulted the elaboration of the botanical guide, which, although for use of the laboratory, it also contains the Rufford Foundation logo on its back cover as a project supporter (Figure 2).







Guia de identificação de espécies vegetais consumidas/dispersadas pelo mico-leão-preto







Poliana Rezende Chagas e Anne Sophie de Almeida e Silva

Figure 2. Cover and back cover of the identification guide of the plant species that are consumed/dispersed by the black-lion-tamarin.



9. Provide a full list of all the members of your team and their role in the project.

PhD Anne Sophie de Almeida e Silva - Main researcher. I was responsible for the project elaboration, writing, data collection and analysis. I was also responsible for searching fundings, dissemination and presentation of the results at the events.

PhD Laurence Culot - Advisor. She was the one who supervised and directed my project, assisted in the theoretical conceptualization and in the analysis's delineation, as well as in the review of the project, PhD thesis and articles.

PhD Lisieux Franco Fuzessy – Co-advisor. She was responsible to help me in the analyses, especially those related to the theory of ecological networks. She helped me to delineate two of the four chapters of my PhD thesis and has reviewed the text of these chapters.

Marco Antonio Rovida Junior - Fixed field assistant. He was present on every field campaign, being responsible for opening the trails through the forest and helping to locate and follow up the groups, as well as contributing to data collection.

Umberto Cotrim Barcos - Fixed field assistant. He was present on the initial field campaigns, where he helped us to open trails and follow up the groups.

Eventual field assistants - People from the local communities who helped us by performing the same functions as the fixed assistants. One of these local assistants helped us to build the experiments of plant recruitment at the Morro do Diabo State Park.

Geovana Fernandes Zangarini - Graduation student co-advised by me. She helped us to build the experiments of plant recruitment at the Rio Claro Farm.

Poliana Rezende Chagas - Graduation student advised by me. She was responsible for developing under my supervision the guide of plant species consumed and dispersed by the BLTs. She helped searching for information and images, as well as in compiling the data and organizing the guide.

10. Any other comments?

I would like to thank The Rufford Foundation for trusting me and in the project. Without this grant it would be unfeasible to carry out the fieldwork, given the high costs of travel and stay in the areas where we collected the data. In the last years, successive cuts to science in Brazil have made it even more difficult to get support for research in the country, especially for conservation of the biodiversity. This is because environment conservation is not a priority for the current government, which deals with environmental issues with negligence. As post-graduate students, we are eligible to receive a scholarship from the government, by means of the university. However, since the amount of the scholarship is low, what we receive is spent entirely on housing, food, and transport. So, to develop our research, we need to search for other funding, which is scarce in the country. Many of us do not get



neither the scholarship nor the funding and abandon the course, along with the dream of doing science in Brazil. So, I am very grateful for the opportunity that The Rufford Foundation has given me. If today I am a PhD and can share what I have learned with the BLTs, it is because I had support.

To The Rufford Foundation, thanks so much!

Literature cited

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