

Final Evaluation Report

Your Details	
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Project Title	Conservation support for endemic and threatened cacti species in the Brazilian Caatinga
Application ID	29813-2
Grant Amount	£ 5991
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Date of this Report	November 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
Reproductive phenology				<p>We monitored monthly the flowering and fruiting of four cacti species. Our data shows three <i>Melocactus</i> species with continuous flowering and fruiting periods with peaks during the dry and rainy seasons. The columnar cactus <i>Pilosocereus chrysostele</i> exhibited continuous flowering and sub-annual fruiting patterns. The phenological monitoring of <i>M. lanssensianus</i> individuals were carried out in the field, while <i>M. conoideus</i>, <i>M. ferreophilus</i>, and <i>P. chrysostele</i> individuals were monitored in the cactarium collection.</p>
Pollination, floral biology and breeding systems				<p>During the phenological monitoring, there was no record of either flowers or buds of <i>M. lanssensianus</i> on the cephalium surface, confirming complete cleistogamy. Cleistogamy is a type of autogamy in which unopened flowers are capable of autonomous self-pollination resulting in fruit and seed set. Some floral traits of <i>M. lanssensianus</i> were analysed (e.g. colour, length, diameter, anther height, stigma height, ovary length, stamen number, ovule number, ovary diameter). We also evaluated floral traits of <i>P. chrysostele</i>, as well as period and duration of anthesis, odour emission, pollen viability and stigma receptivity, breeding system experiments, and nectar dynamics. This species is self-incompatible, neither spontaneous nor manual self-pollination treatments formed fruits. We did not carry out focal observations of <i>P. chrysostele</i> floral visitors in the field due to limited access to study area I.</p>
Frugivory and seed dispersal				<p>We evaluated fruiting phenology, fruit traits, and seed dispersal of <i>M. lanssensianus</i> over 1-year period. We recorded frequency of frugivore visits and their dispersal distance, and then tested</p>

			their effectiveness as seed dispersers by assessing the effect of passage through the digestive tract on germination success of seeds.
Focal observations and camera trap (monitoring of visitors)			With a sampling effort of 48 camera days (daytime and nighttime) and 116 hours of focal observations, we recorded 76 interactions between Tropicuridae lizards and <i>Melocactus</i> .
Identification of visitors			<i>M. lanssensianus</i> produces cleistogamous flowers that are not exposed on the cephalium surface, thus no floral visit was observed. Their fruit visitors were identified, including two lizard species. No potential pollinators were recorded on flowers of <i>P. chrysostele</i> in the individuals of Cactarium Guimarães Duque. We recorded florivory events by <i>Trigona spinipes</i> . We also recorded two species of birds consuming pulp and seeds (<i>Coereba flaveola</i> and <i>Paroaria dominicana</i>).
Germination experiments			We conducted several germination experiments with <i>M. conoideus</i> , <i>M. ferreophilus</i> and <i>M. lanssensianus</i> . The effect of storage time was analysed by comparing stored seeds (T-1year; T-6 months) and recently collected seeds (T-zero). We calculated germinability (%), mean germination time (MGT), emergence rate index (ERI) and synchronisation index (SI). Our preliminary results show that from one year of storage, the seeds show loss of viability and that the highest germination rates of greater than 80 % were reported under 12/12h light and 25 °C temperature (<i>M. conoideus</i>) and 12/12 light and 30 °C (<i>M. ferreophilus</i> and <i>M. lanssensianus</i>).
Seed collection			The Seed Collection of Brazilian Semiarid Cacti was created in June 2020. Currently, the collection stores more than 10,000 seeds of 31 cacti species from the Brazilian caatinga.
Seedling bank			The seedling bank was implemented in January 2021. We are currently monitoring the seedling recruitment of three <i>Melocactus</i> species.
Publications and scientific divulgation			We published two papers and a third is accepted in peer-reviewed journals. We

				<p>also produced promotional materials with ecological information about the studied species. This material is already available to local community, students, teachers, farmers and stakeholders.</p>
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2. Please explain any unforeseen difficulties that arose during the project and how these were tackled.

There has been a delay in receiving funding. The NGO Associação Plantas do Nordeste (APNE) reported several difficulties in carrying out the operation, bank bureaucracy and difficulties due to the closed bank agency, and the absence of employees at the bank agency due to the COVID-19 pandemic. The Rufford paid the grant on 10th February 2020, but the transfer of the resource was completed only on March 26th. In this time, the COVID-19 pandemic scared the whole world. The governor of Paraíba state declared lockdown and quarantine periods (<https://portalcorreio.com.br/estado-decreta-calamidade-publica-na-pb-para-combater-coronavirus/>), thus delaying my schedule of related fieldwork activities.

We report the Rufford by e-mail according with recommendations "Important Message Regarding the COVID-19 Pandemic" in the website, specifically the topic 6 "Grantees should contact the Foundation if there are delays in implementing their project due to the COVID-19 pandemic." The data collection started in late May 2020 and complied with all security protocols. Due to the COVID-19 pandemic, we were also unable to access study area I where *P. chrysostele* population occurs. Only ongoing projects (PhD dissertations and master thesis) were allowed to be conducted in the area. Therefore, we carried out flowering and fruiting monitoring, floral biology, and breeding systems evaluations with 10 reproductive individuals of *P. chrysostele* conserved in the Cactarium Guimarães Duque. We also monitored reproductive phenology of *M. conoideus* (six reproductive individuals) and *M. ferreophilus* (12 reproductive individuals) in the cactarium. We concentrated our fieldwork activities in Study Area II where *M. lanssensianus* population occurs. In this place, we were authorised to conduct the study in compliance with all safety protocols.

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

I believe that the three most important outcomes of the project were:

- We evaluated the reproductive phenology, fruit traits and seed dispersal of the endangered globose cactus *Melocactus lanssensianus* in the Brazilian caatinga over a 1-year period. We confirm complete cleistogamy of *M. lanssensianus* flowers. Among *Melocactus* spp. cleistogamy is rare, cross-pollination by hummingbirds is the common mode of pollination for their conspicuous tubular flowers. This reproductive strategy may be influenced by ecological factors, ensuring the reproductive success in altered, stressful and unpredictable environments. We observed seed dispersal by two lizard species (*Tropidurus semitaeniatus* and *T. hispidus*). In 116 h of focal observations, lizards made 76 visits during different times of day, with a mean dispersal distance of 5 m. Both lizard species showed more frugivory

interactions in the dry season, with peak visits in water-stressed months. Fleshy fruit availability throughout a year is an important resource for lizard energy and water requirements, especially in seasonal environment as occurs in the caatinga. Germination experiments reveal that 85% of seeds found in the lizard's faeces germinated when compared to 41% in the control treatment. *M. lanssensianus* depends on lizards for an efficient seed dispersal service, such that lizards are essential to ensure reproductive success and survival of this endangered cactus species. We highlight the relevance of studies addressing reproductive biology aspects to assist conservation actions. This study was published in the journal *Plant Ecology*. I also wrote an article with Pierre J. Braun (researcher who described *M. lanssensianus*). He is an expert on ecology, threats, and conservation of Cactaceae. The paper will be published in December 2021 and addresses history, distribution, ecology, threats, and conservation of *M. lanssensianus*. Braun mentioned that as soon as the COVID-19 situation in Brazil improves, he wishes to return for the next field trip and invited me to meet him one day in Paraíba. I hope that after this meeting we will carry out other actions to conserve this endangered globose cactus.

- The Seed Collection of Brazilian Semiarid Cacti was created in June 2020. We collected 250 fruits from cacti species both in the field and the cactarium from June 2020 to August 2021. All seeds were removed and subjected to asepsis conditions. After such procedure, seeds were stored in the seed collection according to specialised methodology already described in the literature. Currently, the seed collection includes 10,696 seeds from 31 species and 11 genera, maintained in the cold chamber at the Molecular Biology Laboratory at INSA. The most representative genera in the seed collection are *Melocactus*, *Tacinga* and *Pilosocereus* with 16, four and three species, respectively. The seed collection database includes ID number, species, sampling area, date of collection and storage, collector, number of fruits, and amount of seeds/fruit. We have already started germination experiments evaluating seed viability of *Melocactus* spp.
- Currently, we are monitoring the recruitment of 550 seedlings of three threatened *Melocactus* species in the seedling bank. There are 142 individuals of *Melocactus conoideus* (Critically endangered - CR), 48 of *M. ferreophilus* (Critically endangered - CR), and 360 of *M. lanssensianus* (Endangered - EN). We evaluate weekly seedling survivorship and seedling growth. After 18 months (July 2022), we will start an ecological restoration program to recover the *M. lanssensianus* population in its natural habitat.

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

Although the pandemic has affected some scheduled activities, we seek alternatives to interact with the local community while respecting all safety protocols. We participated in live and radio programmes (e.g., Rádio Marquesa, Rádio Morada do Sol, Rádio CBN) to discuss conservation of biodiversity. During our talks, we highlighted that the participation of the population is very important for the maintenance of species in their natural habitat. In the Caiçara municipality, many

residents admire the Pedra do Pão Açúcar. We emphasise that in addition to the historical and cultural aspects, this area houses a unique biodiversity that makes it even more special. One especially touching experience after one of the programmes was when a resident of Caiçara was waiting for me to return a *Melocactus* that he had removed from the study area. We provide online lectures at several schools. In some, we were invited to participate in-person in the future. We contacted and received help from a teacher named Jocelino Lima to distribute scientific and promotional materials. He is the Director of NGO Atitude. The NGO acts in the Caiçara, Tacima, and Logradouro municipalities, encouraging reading through a solidarity library. We donated several materials to the library. The distribution of the memory card game to students, teachers, and the local community (children, young, adults and old-aged) has made many peoples aware of the importance of conservation related to plant species and associated fauna (e.g., pollinators, seed dispersers). This game gathers information about 18 cacti species that occur in the caatinga, including the columnar cactus *P. chrysostele* (Near Threatened - NT) and the globose cactus *M. lanssensianus* (Endangered - EN). Copies of the game were sent to 30 public schools in Paraíba. The game is a fun tool that makes it possible to address ecological and biodiversity conservation aspects.

5. Are there any plans to continue this work?

Yes. Currently, I am a researcher at the Program of Institutional Training (PCI) at the National Institute of the Semiarid. My PCI scholarship extends until March 2023. I will continue my studies addressing reproductive ecology aspects and conservation actions for cacti species in the Brazilian Caatinga, with special attention to the *Melocactus lanssensianus* population because its situation is more worrying than we imagined when we began this study. We will start an ecological restoration program to recover the population in its natural habitat. The population recorded in Paraíba state is distributed on the Pão de Açúcar Ranch, Tacima municipality. Pão de Açúcar Ranch has 200 ha, dominated by caatinga vegetation and three granitic outcrops, also known as inselbergs, at least 500 m apart from each other. Locally, we detect that the main disturbances faced by this species are garbage, invasive grasses, mining, livestock animals (e.g., goats and cattle), intentional fires and motocross. Additionally, for over 100 years, on August 15th, a religious celebration of “Nossa Senhora da Assunção day” occurs, including mass, cultural presentations and cultural shows. Thousands of people climb the inselbergs for devotion and at the end of the celebration there was the habit of setting fire to the vegetation. In fact, during the sampling, we observed bromeliads and cacti burned in different areas of the rocky outcrops. In the highest outcrop, there were no reproductive individuals of *M. lanssensianus*, solely seedlings and young plants, a clear consequence of anthropogenic disturbances. Given the context of a disturbed ecosystem associated with reduced population size and restricted distribution, it is clear that *ex situ* and *in situ* conservation support are urgent.

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

We have already started disseminating our results through the publication of scientific articles. We have also shared our results through presentations about threats to cacti species and how we can help preserve them with students, teachers, and farmers in the Caiçara, Tacima, and Logradouro municipalities and

cactarium visitors at INSA. We presented a lecture at SNCT (Semana Nacional Ciência e Tecnologia), a national event promoted by Ministry of Science, Technology and Innovations of Brazil. We expect to publish another scientific article in peer-reviewed journals and write popular science articles. Some copies of the memory card game and a leaflet were sent to NGO Associação Plantas do Nordeste (APNE) for distribution and divulgation of the project. We are also sending our findings to stakeholders, but due COVID-19 we are unable to schedule meetings.

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

The grant was used since the first month for the planning and preparation of sampling equipment. The grant made it possible to intensify my fieldwork sampling because I had the autonomy to stay in the field, especially during the fruiting peaks of the *M. lanssensianus*. Furthermore, receiving the grant was essential for acquiring consumables for germination experiments and field assistance. I hope to conclude analysis of all data of germination experiment, monitoring seedling recruitment, and provide a summarised result in papers, reports, and promotional materials.

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
Fuel (990 liters)	728	770	+ 42	During the year there was a price difference due a variation in the tax per litre of gasoline.
Lodging + food (90 days)	2970	3070	+100	Spent a little more money than initially considered. Additional costs with personal protective equipment for COVID-19 (alcohol 70%; alcohol gel, masks, face shield, gloves).
Digital Caliper	30	30		Fully spent.
Retractable entomological net	80	80		Fully spent.
Cameras with sensor	630	630		Fully spent. We also have bought light traps equipment.
Tripod for video cameras	45	45		Fully spent.
Rechargeable Batteries	80	80		Fully spent.

AA + Battery Charger				
External HD	50	50		Fully spent.
Tweezers	110	110		Fully spent.
Microsyringe	60	60		Fully spent.
Refractometer	50	50		Fully spent.
Germination experiments, consumables	304	304		Fully spent.
Field guide (300 copies)	310	170	-140	We produced a memory card game and an informative leaflet with field information about cacti-lizard interaction. We printed 1,000 copies of the leaflet. We spent less money than initially considered. Therefore, the money was used to buy personal protective equipment for COVID-19 and fund the difference in fuel costs. Additionally, the printing of 500 copies of the memory card game was paid with funding research from the INSA and FINEP partnership. 500 copies R\$ 3.789,50 = £ 642
Management overheads and administrative cost – (NGO) 10% of project value	544	544		Fully spent.
TOTAL	5991	5993		Local exchange in March 26, 2020 1 £ sterling = 5,90 Real Brazil/BRL Total: £ 5.991,00 = R\$ 35.352,37 after bank discounts rates

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

Some initiatives have been conducted through reproductive ecology studies, educational activities, and the distribution of promotional materials to students, teachers, and the local community. We will continue interacting with the population. Environmental education initiatives have a complementary and important role in the conservation of biodiversity. Furthermore, we are monitoring the recruitment of 60 seedlings of *M. lanssensianus* obtained from germination experiments and 300 seedlings obtained from *in vitro* propagation (in partnership with Pollyana Silva). These seedlings are in the seedling bank of the botanical collection of Cactarium Guimarães Duque (INSA) and will be used to start an ecological restoration program to recover the *M. lanssensianus* population of Paraíba in their natural environment. Additionally, we scheduled at least two field collections per year to increase the seed collection. We are also writing the

manuscript "Ex situ conservation of *Melocactus*". This paper documents the *Melocactus* species preserved in the *in vivo* and *in vitro* collections of the Cactarium. We also provide germination and *in vitro* propagation protocols for conservation of 11 threatened *Melocactus* species.

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, I did. The Rufford Foundation logo was used in all my activities. The Rufford reference was cited in the text of newspaper reports (e.g. Jornal a União 2020), papers, and disclosure materials on the institutional website and other websites of regional relevance (e.g. Agência Eco Nordeste). Additionally, we have mentioned the foundation in interviews on radio programmes and slides of online lectures. Rufford has also been acknowledged as a funding source in all published (Plant Ecology: Seed dispersal of *Melocactus lanssensianus*; Brazilian Journal of Development: Inventory, challenges and perspectives of the Cactarium Guimarães Duque) and accepted papers (Kakteen und andere Sukkulente - DKG German Cactus Society: *Melocactus lanssensianus* in Paraíba: history, distribution, ecology, threats and conservation) as well as in the printed promotional materials (memory card game and leaflet). The publication of the memory card game was highlighted on the social medias pages of the Ministry of Science, Technology and Innovations of Brazil.

- Link to the Journal a União 2020: <https://auniao.pb.gov.br/servicos/arquivo-digital/jornal-a-uniao/2020/abril/a-uniao-26-04.2020/view>
- Link to Radio interview CBN: <http://cbnjoapessoa.com.br/#!/meio-ambiente-como-as-lagartos-podem-ser-importantes-para-os-cactos-que-estao-ameacados-de-extincao/>
- Link to Radio interview Programa Atitude: https://www.facebook.com/watch/live/?ref=watch_permalink&v=234448358063638
- Link to Agência Eco Nordeste: <https://agenciaeconordeste.com.br/projeto-de-conservacao-das-cactaceas-do-semiarido-brasileiro-tera-financiamento-exterior/>
- Link to INSA website: <https://www.gov.br/mcti/pt-br/rede-mcti/insa/assuntos/noticias/processo-de-dispersao-de-sementes-de-cactacea-ameacada-de-extincao-e-tema-de-artigo-publicado-pelo-insa-mcti>
- Link to Insa website: <https://portal.insa.gov.br/noticias/1509-projeto-de-conservacao-de-cactaceas-de-pesquisadora-do-insa-sera-financiado-por-instituicao-britanica>

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

Carlos Alberto Lins Cassimiro - INSA/ National Institute of Semi-arid. He participated in the field trips and he is the main person responsible for germination experiments. He has experience with handling of cacti, and assisted me in acclimatization of seedlings.

Pollyana Karla da Silva - INSA/ National Institute of Semiarid. She is responsible for Plant Tissue Culture Laboratory and *in vitro* propagation of *M. lanssensianus*.

Ricardo Koroiva - UFPB/ Federal University of Paraíba. Technical support on field activities and help me to writing the papers.

Frans Pareyn - APNE / Associação Plantas do Nordeste. Financial managing support.

Cesar Augusto Melo - APNE / Associação Plantas do Nordeste. Financial managing support.

Fabiane Rabelo da Costa Batista - INSA/ National Institute of Semiarid. Coordinator of the Biodiversity Department at INSA. She has an important role in reviewing the scientific materials.

12. Any other comments?

I am very grateful to The Rufford Foundation for funding this research project and supporting conservation initiatives of threatened cacti species in the Brazilian caatinga. Without this funding, this work would be unfeasible, especially in these challenging times due to the COVID-19 pandemic. Our results have been frequently highlighted in the local media. The dissemination and interest of the local community increases the hope of reaching governments and stakeholders and advancing in conservation actions for caatinga's biodiversity. On behalf of all the collaborators and cacti species from the Brazilian semiarid region, I would like to express my appreciation.

FIGURES





Sampling activities in the field.



Cleistogamic flowers of *M. lanssensianus* (left) and consumption of fruits by *T. semitaeniatus* (right).



Material distribution with students and teachers. Left to right: Tamires (student), Jocelino Lima and Iara Rocha (teachers).



Scientific disclosure with political authorities in the Cactarium Guimarães Duque.

The Rufford Foundation logo on page of the leaflet.



The Rufford Foundation logo on box and cards of the memory cards game.



Participation in the radio program.



Threats to natural population of *M. lanssensianus*: motocross activities (left) and intentional fire (right).



Seed collection of Brazilian Semiarid Cacti species and seedling bank.