Final Evaluation Report

Your Details	
Full Name	Vinicius Tirelli Pompermaier
Project Title	Assessing the vulnerability of the epigeic springtail community and its potential indicator of inorganic nutrient inputs in the central Brazilian Savannas
Application ID	28173-1
Grant Amount	£5,000
Email Address	pomper.official@gmail.com
Date of this Report	18th November 2020

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
Investigate how the addition of inorganic nutrients (N, P and N + P) and soil pH alteration (by liming) affect the taxonomic and functional composition of the epigeic springtail community				For this objective, I was able to carry out soil chemical analysis and identify the springtail morpho-species. However, I am still measuring the functional traits of the identified springtail morpho-species. I spent a lot of time to separate and counting the springtail morpho-species. Then I spent more time mounting slides for identification morpho-species (at the gender level) under the microscope. After finalising the trait measurements, I will still have to tabulate the data and analyse the functional composition of springtail assemblages.
Investigate how the addition of inorganic nutrients (N, P and N + P) and soil pH alteration (by liming) affect the trophic-niche structure of epigeic springtails				This objective has been fully achieved. Although one of the field campaigns to sample more springtails did not happen due to the pandemic (explained in item 2), the isotopic analyses were carried out successfully. I am currently writing the manuscript to publish these results.
Evaluate the potential of epigeic springtails as indicators of nutrient inputs into savanna ecosystems				This objective was partially achieved by the isotopic niche analysis of the springtail assemblages (reached by the second objective). However, this aspect will also be evaluated by the taxonomic and functional approach (in progress).

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

The unforeseen events that arose during the project were due to the pandemic. I had planned two field campaigns to sample springtails that would be used for isotopic analysis. The first campaign occurred without any problem. In the second campaign, I even installed the pitfall traps, but in the same week, the Government decreed quarantine in the city. This campaign was intended to sample more springtails to ensure that more species could be analysed. However, I was unable to

remove the traps, as the ecological station (RECOR-IBGE) closed its doors. Fortunately, this did not compromise my results, as I was still able to analyse a reasonable number of morpho-species.

Another difficulty I had due to the pandemic was the temporary interruption of laboratory activities, which hindered the separation and counting of springtail morpho-species. I got around this by taking a digital USB microscope to work at home. However, the counting rate has not been the same since then.

The last unforeseen event I had was with the institution that would carry out the isotopic analysis. The institution to which I had budgeted the analysis (Stable Isotope Facility / Department of Plant Sciences at the University of California, Davis, USA) ceased its activities due to the pandemic. I got around this problem by finding an institution in Germany that performed this service with even greater analytical precision (Center for Stable Isotope Research and Analysis, Büsgen-Institute, Georg August University Göttingen), and that did not interrupt the work. All samples I sent were successfully analysed.

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

As far as we know, this is the first work that evaluated epigeic springtail assemblages at the genus level in a central Brazilian savanna. A total of 22,225 specimens of epigeic springtails were counted, distributed in three orders, 10 families, 18 genera (*Lepidocyrtinus, Seira, Entomobrya, Lepidocyrtus, Trogolaphysa, Salina, Cyphoderus, Paracerura, Folsomides, Hemisotmin, Sourinus, Ptenothrix, Neotropiella, Pseudachorutes, Brachystomella,* and *Xenylla*) and 23 morpho-species. Of these specimens, 10,992 were captured before resuming nutrient additions (N, P, N+P and liming) and 11,233 after that. Hereafter I refer to the periods before and after the resumption of nutrient additions only as "before" and "after". In the control plots, the order Entomobryomorpha prevailed both before (56% of the total individuals captured) and after (58.9%), but before, the second most representative order was Poduromorpha (35.7%) and after was Symphypleona (29.5%). Before, the most representative family was Isotomidae (33.2%), mainly due to high representativeness of the *Paracerura* morphospecies (17.8%). After, the most representative family was Paronellidae (28.3%) due to *Salina* sp. abundance (17.7%), but in this period the greatest representativeness was of a *Sphaeridia* morpho-species (Symphypleona: Sminthurididae). This demonstrates that springtail assemblage structure changes over time, but as we evaluate the nutrient addition effect in each period using control plots, we do not consider the time effect. Below I describe the most important outcomes that I obtained from soil analysis and taxonomic and isotopic niche analysis of the springtail assemblages under the effect of nutrient addition in a tropical woodland savanna.

- Soil analyses showed that there is a residual liming effect on soil chemical factors. Even after 11 years without applying lime, the soil remained at a high pH and with high calcium and magnesium concentrations when compared to control. After the nutrient addition resumption, these differences remained in soil factors between liming and control, while other treatments partially

differed from the control in terms of organic matter factors (soil C/N and soil O.M.).

- Nutrient additions did not affect the richness and diversity of epigeic springtail assemblages. Springtails abundance was negatively and significantly affected only by liming treatment (in both periods), mainly due to a decrease in *Entomobryomorpha* abundance. One *Seira* morpho-species had its abundance decreased by liming in both periods, but there was morphospecies (*Lepidocyrtinus* sp. and *Salina* sp.) that increased in abundance after the liming resumption. Some *Symphypleona* morpho-species were negatively affected before, but not significantly after additions resumption in the N+P treatment. One *Entomobrya* morpho-species had its abundance increased by P and N+P treatment in both periods. Results showed that epigeic springtail species react differently to the nutrient additions. These changes, however, reflected in springtail assemblages with a structure significantly different from control in all treatments (N, P, N+P and liming), but more strongly in N+P and liming. These results provide us with good expectations of taxonomic use of springtails to indicate the efficiency of ecological restorations. This is because the great challenge of restoring savannas in the region occurs in soils modified by agricultural management, such as liming.
- We analysed the isotopic niche of epigeic springtail assemblages using the same composition of morphospecies in each treatment and control (*Lepidocyrtinus* sp. 1, *Lepidocyrtinus* sp. 2, *Seira* sp., *Entomobrya* sp., *Trogolaphysa* sp., *Salina* sp., *Cyphoderus* sp., *Paracerura* sp., *Hemisotoma* sp., *Sminthurinus* sp., *Bourletiella* sp., *Sphaeridia* sp., *Neotropiella* sp., and *Brachystomella* sp.), one year after nutrient additions resumption. We observed a reduction in trophic diversity of springtail assemblages in the P, N, and liming treatments, which led to a consequent increase in trophic redundancy among the morpho-species of these assemblages. However, it was in P and mainly in the N treatment where the isotopic niche of the springtail assemblages was quite reduced. Results indicate that isotopic niche analysis of epigeic springtail assemblages has enormous potential to be used as a tool for detecting nutrient inputs (e.g. atmospheric N deposition), until then for savanna ecosystems in Central Brazil.

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

There was no direct involvement of local communities in the project. However, this project has found evidence that changes in the isotopic niche of springtail assemblages can act as an indicator of nutrient entry into savanna ecosystems. The Brazilian savanna is the richest in plant species in the world and provides several ecosystem services (e.g., carbon stock, aquifer recharge, maintenance of animal biodiversity), including cultural and economic ones (extraction of medicinal and fruit plants). Most of these services, however, are threatened by the territorial advance of agricultural activities, while we still do not have good estimates of air and terrestrial pollutant deposition in this region. Studies show that entry of N and P in these savannas can alter the plant community diversity and structure and the ecosystem functioning. In this sense, consolidating the knowledge of how soil fauna responds to

these disturbances can provide us with applicable tools for detecting the conservation status of these ecosystems and assist in the implementation of public policies that guarantee the delivery of ecosystem services to society.

5. Are there any plans to continue this work?

I will defend my doctorate in February 2021. After that, I intend to submit a postdoctoral proposal to continue evaluating the potential use of soil springtails as indicators of environmental changes. I intend to continue using the functional approach, measuring the functional traits of springtails in different land uses to apply soil conservation indexes that have been increasingly consolidated in the scientific literature. I also intend to engage partnerships to expand the analysis of the isotopic niche of springtail assemblages in experiments of nutrient addition. This would help to validate my results and better understand the mechanisms behind the changes in the springtails trophic niche in the face of nutrient inputs.

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

I plan to share the results in peer-reviewed scientific journals (currently in progress), posters, and presentations at conferences. In the future, I also plan to prepare graphic materials to publicise the work to a wider audience.

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

I received the grant in October 2019, but I only started using it in January 2020 where I did my first field campaign. My forecast was to use the grant until May, but due to the difficulties faced by the pandemic situation, this extended until September 2020.

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
Garden Iron Plants Seedling Transplant Tool	6	20	+14	The product was more expensive at the time of purchase. Part of this value was to cover the freight costs.
AMT-300 4-in-1 Multifunctional Digital Soil Temperature / Moisture /pH/Sunlight	23	42	+19	The product was more expensive at the time of purchase and part of this value was to cover the freight costs.

Meter Analyzer Soil Survey Instrument				
FedEx International Priority	337	1224	+887	The export freight of samples (for isotopic analyses) had to be done by another company (DC Logistics Brasil Ltda). Samples' destination has also changed (I explain this in item 2). Part of this amount includes expenses with exchange rates and taxes. Services became more expensive due to national currency devaluation
Soil chemical analyses	253	450	+197	The service had a price adjustment. Part of this amount was used to transport the samples (£42.50). Services became more expensive due to national currency devaluation.
Total cost for the isotopic analysis of all samples (soil, leaflitter and springtails)	3891	2701	-1190	I made a large budget, as I depended on counting the sampled springtail specimens to find out how many samples, I would be able to analyse. The remainder was relocated for another purpose as agreed with the Rufford grant manager.
Food	25		-25	Field campaigns were quick and did not demand the purchase of food. Therefore, I re-allocated the budget for the cost of isotopic analysis and international freight as agreed with the Rufford grant manager.
Fuel	211		-211	I got the transport for the field campaigns with the graduate program in Ecology where I do my doctorate. Therefore, I re-allocated the budget for the cost of isotopic analysis and international freight as agreed with the Rufford grant manager.
Materials for pitfall traps (Plastic Pots with Lid 500 ml, Styrofoam plates and wooden sticks)	60		-60	As one of the field campaigns did not happen due to the pandemic, I did not need to buy this material. Therefore, I re-allocated the budget for the cost of isotopic analysis and international freight as agreed

				with the Rufford grant manager.
Eppendorf® microtubes 1,5 mL (1000 units)	12	3	-9	The amount I needed was less than initially budgeted. The remainder was relocated for another purpose as agreed with the Rufford grant manager.
Rubber Stopper Plugs for Glass Penicillin Bottles (100 units)	6		-6	Eppendorf microtubes met my demand for storing springtail specimens. I didn't need that product. Therefore, I re-allocated the budget for the cost of isotopic analysis and international freight as agreed with the Rufford grant manager.
Glass Penicillin Bottles (100 units of 50 mL)	42		-42	Eppendorf microtubes met my demand for storing springtail specimens. I didn't need that product. Therefore, I re-allocated the budget for the cost of isotopic analysis and international freight as agreed with the Rufford grant manager.
Lactic Acid, 85% (1L)	7	6	-1	The remainder was relocated for another purpose as agreed with the Rufford grant manager.
Ethanol 70% (50 bottles of 1L)	105	31	-74	As one of the field campaigns did not happen (I explain this in item 2), I did not need much 70% alcohol. The remainder was relocated for another purpose as agreed with the Rufford grant manager.
Ethanol, Absolute (6 bottles of 1L)	22	7	-15	I no longer needed absolute alcohol and then replaced it with Potassium Hydroxide (which I demanded to clear the springtail specimens for mounting slides). The remainder was relocated for another purpose as agreed with the Rufford grant manager.
Operating and Administrative Expenses - FINATEC		460	+460	Operating cost that FINATEC charged to manage the grant as agreed with the Rufford grant manager.
Ancillary Import Expenses		60	+60	
Total	**5000**	**4998**	-2	

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

I feel that the next steps are to expand studies to validate and make possible the application of these ecological analytical tools. This will necessarily have to involve expanding partnerships and training students, as well as greater community involvement. I feel that we must create a way to simply and efficiently disseminate the potential of these tools as ecological indicators of environmental quality to sensitise stakeholders and decision makers regarding better management of human activities.

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?

I have not used the Rufford logo on any material yet, but I intend to use in a presentation that I will send for the 3rd Global Soil Biodiversity Conference (https://gsb2021.ie/). However, due to the consequences of the pandemic, the conference, which would take place at the end of next year, will be held only in March 2023.

I did not publicise the Foundation during the course of the work, but the financial support by the Rufford Foundation will be properly described in the future published papers, as well as in any future presentations, technical reports, or any other kind of communication that involves this project.

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

Vinicius Tirelli Pompermaier: Applicant and project coordinator

Gabriela Bielefeld Nardoto (Advisor): Worked in the project coordination, interpretation, and discussion of results.

Gabriel Costa Queiroz (PhD in Zoology): Provided me with training in the identification of springtail morphospecies.

Bruna Raquel Winck (PhD in Soil Science): Helped me with the project design and will help to interpret the results of the functional approach.

Alex Rosa Campani: Support in field campaigns and laboratory activities.

Emanuel Messias Lima da Silva: Support in field campaigns and laboratory activities.

Giovanna Gomes Cordeiro: Support in field campaigns.

Fábio Luís de Souza Santos: Support in field campaigns.

Glauber das Neves: Support in field campaigns.

Eduardo Guimarães Santos: Support in field campaigns.

12. Any other comments?

With the budget cuts practiced in recent years in Brazil, subsidies for science are increasingly scarce and difficult to obtain. So, I would really like to thank the Rufford Foundation for the grant. Without this subsidy, I would not be able to advance in this line of research and complete a good part of the objectives that I established in my doctorate.