Final Evaluation Report

Your Details	
Full Name	Martín de Jesús Cervantes López
Project Title	The role of landscape structure and habitat quality in safeguarding amphibian and reptile diversity in cocoa agroforestry systems
Application ID	35823-2
Date of this Report	24/04/2024

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
i) Assess how local and landscape predictors affect taxonomic alpha and beta diversity of amphibians and reptiles in cocoa agroforestry systems distributed in three regions presenting contrasting land use patterns		X		This objective was partially achieved thanks to the three important activities that we successfully accomplished last year: 1) The sampling of amphibians and reptiles in each of the 30 cocoa agroforestry systems, located in three regions of southern Bahia with different land use context. 2) Field measurements of local variables at each of the cocoa sampling sites, and quantification of landscape variables using QGIS software and updated land use maps of the study region. 3) The identification and the classification of each of the amphibian and reptile species recorded in all these cocoa agroecosystems. However, it is important to mention that the present objective was partially fulfilled because we are still in the process of conducting analyses to determine the relationship between

				environmental variables and beta diversity for both taxa.
ii) Assess the effects of the landscape structure (composition and spatial configuration) and local environmental characteristics (related to management intensification) on the functional and phylogenetic diversity of amphibians and reptiles in cocoa agroforestry systems		X		This objective was also partly achieved by identifying each species, which provided us with essential information about their phylogenetic histories and functional traits. To achieve this objective, we will utilise the data on local and landscape variables previously collected for the second objective. Additionally, we will conduct analyses to explore the potential relationships between phylogenetic and functional diversity and the landscape and local variables.
iii) Assess whether taxonomic diversity can be a key predictor of the functional and phylogenetic diversity of amphibians and reptiles in regions with different contexts of land use.	X			We have not yet addressed this objective because we are currently working on the two preceding ones. Once we complete those, we will proceed with addressing this objective.

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

The most significant challenge we faced during sampling was accurately identifying amphibian and reptile species. The Atlantic Forest biome has an extraordinary diversity of amphibians and reptiles, many of which are endemic to certain parts of this biome. This great diversity often posed difficulties in identifying numerous species, especially those that are extremely rare to find in their natural habitats. However, to accurately identify all these elusive species, we photograph each individual and then utilise field guides for species identification. In addition, we enlisted the help of herpetologists who also work in the Atlantic Forest biome to corroborate the

identification of our amphibian and reptile species. Another challenge we faced during our sampling phase was the weather, which sometimes made accessing many of the farms difficult. Despite this, we managed to reach our sites, even if it meant walking a few kilometres to get there.

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

1. An important result we obtained was the record of a great diversity of amphibians and reptiles in each of the 30 cocoa agroforestry systems where in total we found 116 species and 8,299 individuals. Amphibians were the most diverse group with 74 species and 7,283 individuals, of which 62 species were found only in Brazil. In contrast, reptiles were the least diverse group with 40 species, 1,016 individuals and 12 species endemics to Brazil. Although only two of these species, the *Atractus guentheri* snake and the *Allophryne relicta* frog, are listed as threatened by the IUCN, our data indicate that cacao agroforestry systems may serve as supplemental habitats for many species of amphibians and reptiles in the Atlantic Forest. For some of these species, such as the amphibians *Nyctimantis brunoi*, *Phyllodytes melanomystax* and *Proceratophrys schirchi*, show declining population trends. And several other species from both groups are endemic to the Atlantic Forest biome, including reptiles such as *Bothrops leucurus*, *Coleodactylus meridionalis*, *Leposoma scincoides* and *Phyllopezus lutzae*, and amphibians such as *Adelophryne mucronatus*, *Gastrotheca recava*, *Bahius bilineatus*, *Physalaemus camacan*, *Trachycephalus nigromaculatus* and *Rhinella hoogmoedi*.

As we are still analysing our data, we do not have definitive results on the relationship between our diversity dimensions. However, through exploratory analyses using a single landscape variable, forest cover, we investigated the impact of this variable on the taxonomic, functional and phylogenetic diversity of amphibians and reptiles in 30 cocoa agroforests located in three different regions of the Atlantic Forest in southern Bahia. For each diversity dimension, we used true diversity indices of orders 0 and 1.

2) Our preliminary results indicate that forest cover did not affect amphibian diversity. However, we observed that cocoa agroforests in regions with high forest cover (57%) and a moderate amount of cocoa agroforest (22%) had lower taxonomic diversity (orders 0 and 1), functional richness (order 0) and phylogenetic diversity of amphibians (order 1). This result suggests that in landscapes with high forest cover, amphibians find sufficient resources in the native habitat and are less dependent on agroforests.

3) As for reptiles, forest cover significantly reduced different facets of reptile diversity in cocoa agroforestry systems. Thus, the reduction in diversity with

higher forest cover may indicate that these habitats provide necessary resources compared to agro-ecosystems. Thus, in landscapes with less forest cover, cocoa agroforests may provide additional refuge and resources, encouraging greater species accumulation, even functionally and phylogenetically more distinct.

These preliminary results underline the importance of considering landscape context when designing conservation strategies. In highly deforested areas, cocoa agroforests play a crucial role in biodiversity conservation by providing supplementary habitats that can support greater species diversity. On the other hand, in landscapes with higher forest cover, it is vital to maintain and protect native habitats, as these are sufficient to support local biodiversity.

4. What do you consider to be the most significant achievement of this work?

The main achievement of this project will be to determine how environmental variables at different spatial scales influence the taxonomic, functional and phylogenetic diversity of reptiles and amphibians. This knowledge is crucial, especially in the face of increasing rates of deforestation, as conservation efforts must go beyond the establishment of natural protected areas to include the identification of ecologically friendly matrices (such as cacao agroforestry systems) that can sustainably support biodiversity. Understanding which variables are the most significant will allow us to design better management strategies to improve habitat quality within agroforestry systems for numerous animal species.

Thus, our findings suggest that cocoa agroforests may harbour greater species diversity, including those with distinct functions and lineages, when found in more deforested landscapes. This could be because, in areas with little natural habitat, less intensive agroforests may serve as supplementary habitats, resulting in an accumulation of species.

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

The response from the workers and owners of all the cocoa farms was very positive. They always received us with kindness and showed great interest in learning about our activities and the objectives of our research. They were particularly interested in learning about the amphibian and reptile species living on their cocoa plantations, as well as their ecological importance and the benefits these species bring to their crops. We also took advantage of these conversations to learn about people's perceptions of herpetofauna, for example, many people shared with us common names of species and shared with us their experiences interacting with these species.

6. Are there any plans to continue this work?

Yes, we have plans to continue our work. Our study is part of the "Eco-nomia das Cabrucas" Project, which aims to understand the contribution of the agroforestry systems of cocoa (cabrucas) to the maintenance of native animals and plants, as well as the relationship between species diversity, ecosystem services, and local productivity of cocoa plantations. One key activity in this project, is sharing our most important findings with the workers and owners of the cocoa farms. In this sense, we will provide them with brochures featuring the names and photos of various species (such as, birds, trees, bees, wasps, dragonflies, amphibians and reptiles), along with valuable information about how cocoa agroforestry systems contribute to the conservation of biodiversity in the Atlantic Forest Biome. Additionally, we will offer suggestions to further enhance conservation efforts and demonstrate the benefits these species can provide to their cocoa crops.

In addition, based on my previous research on the role that different types of agricultural matrices, including cocoa agroforestry systems, can play in herpetofauna conservation in a tropical region of Mexico, we have future aspirations to conduct environmental education activities in Mexico. These activities aim to demonstrate to local communities the important ecological role that these agricultural matrices can have for herpetofauna. Our goal is to present the results from our current project and highlight the benefits that cocoa farmers in Brazil are experiencing by protecting and conserving biodiversity. Through this outreach initiative, we aim to inform and support stakeholders in their efforts to sustainably manage and improve their agroforestry systems to enhance wildlife conservation efforts.

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

We plan to share our results with the scientific community and ecology students through publications in international scientific journals and presentations at scientific conferences. For instance, in September 2024, we will participate in the IV Meeting

of the Brazilian Association of Ecological Science and Conservation, where we will present our most significant findings to date.

For the general public, we aim to create informative materials, such as videos, brochures. Additionally, we will engage with local communities and schools through talks and presentations to share our research with those interested in learning more. We also want to ensure that new ecology students are informed and feel welcome to conduct their thesis research in our projects.

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

The funds obtained from Rufford were used for the two field sampling seasons in 30 agroforestry systems. The first of these seasons ran from January to April 2023 and the second from September to December 2023. Although we adjusted the sampling dates slightly from those previously planned, this did not compromise the integrity of the project schedule. In addition, during the sampling period, we also organised our data in Excel, which allowed us to later identify only unknown species and perform data analysis efficiently. We are now finalising the analyses of the first and second objectives and will start writing the remaining chapters of my thesis which will be submitted to a scientific journal for publication.

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

The next steps to finalise our project are: (1) completing the analysis of my data; (2) beginning the writing of the remaining chapters of my thesis; (3) presenting our results to the owners and workers of the cocoa farms who gave us the opportunity to work there; and (4) sharing our findings with the scientific community at conferences and meetings specialising in ecology and herpetofauna in Brazil.

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, the Rufford logo has already been used in some presentations we made to some of the cocoa farm owners and workers. Also, in the note on predation between two frog species that we published in the journal Herpetology Notes (Cervantes-López et al. 2024), we included in the acknowledgements section the Rufford Foundation for the great support they gave us for our research.

Cervantes-López, M., et al. "Predation of the Black-Spotted Casque-Headed Treefrog, Trachycephalus nigromaculatus (Tschudi, 1838), by the Ocellated Treefrog,

Itapotihyla langsdorffii (Duméril and Bibron, 1841), in a cocoa agroforestry system in southern Bahia, Brazil." Herpetology Notes 17 (2024): 295-298.

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

M.Sc Martín de Jesús Cervantes López: PhD student in the postgraduate program in Ecology and Conservation at the UESC (State University of Santa Cruz) with experience in the study of herpetofauna in anthropized tropical landscapes. This project is part of his PhD thesis. He was responsible for writing the project, carrying out the sampling of amphibians and reptiles in agroforestry systems, conducting the database, and analysing this research.

Dr. José Carlos Morante Filho: Professor at UESC with 13 years of experience in bird assemblages in tropical landscapes. Contributed to Rufford-funded projects. His contribution has been to guide Martín's thesis. He is also responsible for writing the project, suggesting and discussing research analyses and is one of the coordinators of the "Economia das Cabrucas" project.

Dr. Maíra Benchimol: Assistant professor at UESC, focuses on tropical ecology and conservation. Key for idea development and manuscript creation. Previously funded by Rufford for Amazonian forest research. She is the main coordinator of the "Economia das Cabrucas" Project. And their participation has been of great importance in defining our sampling design in the study regions.

M.Sc Gabriella Alves Ferreira: PhD student in the postgraduate programme in Ecology and Conservation at UESC (State University of Santa Cruz) with experience in the study of amphibian community ecology and ecological niche modelling studies. His involvement has been in assisting with amphibian and reptile sampling and data analysis.
Undergraduate student Diego Reis: A biology student at Santa Cruz State University, he has worked as an assistant in the zoological collection of herpetofauna at the university. His assistance was crucial in the final months of sampling and in identifying several of the snake species recorded in this study.

Undergraduate student Laura Pires Miranda da Silva is pursuing a B.Sc. in Biological Sciences at UFF Universidade Federal Fluminense. She contributed to the project by measuring local environmental variables and sampling amphibian and reptile communities.

12. Any other comments?

Finally, on behalf of my team and myself, we express our gratitude to The Rufford

Foundation for the grant that enabled us to conduct our fieldwork. We also extend our appreciation for their altruistic efforts, which have facilitated various research projects on our planet. Their work has significantly contributed to nurturing future scientists and supporting biodiversity conservation.