Final Evaluation Report

Your Details	
Full Name	José Victor Alves Ferreira
Project Title	LET IT BEe: Unveiling the Role of Cocoa Agroforests in Maintaining Multiple Dimensions of Bee and Wasp Diversity in a Global Biodiversity Hotspot
Application ID	36668-1
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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
Assessing the conservation value of shaded cocoa agroforests for the conservation of the taxonomic diversity of bees and social wasps			X	We successfully achieved this goal, and found that cocoa agroforests play a vital role for insect conservation in human-modified landscapes of southern Bahia, especially those embedded within highly forested landscapes
Investigating the role of the landscape context (specifically forest cover) as a modulator of the conservation value of agroforests			X	Regarding the landscape context, we have shown that the conservation value of cocoa agroforests is even greater in landscapes with high forest cover
Unravelling how local characteristics (diversity of shade trees, intensity of management, among others) affect the diversity of bees and wasps			X	We have also shown that changes in the local characteristics of agroforests, including management practices, affect the diversity of bees and wasps, but that increasing forest cover in the landscape or region can mitigate these effects
Evaluating the effect of landscape heterogeneity on bee and wasp diversity	X			The land use context of the landscapes sampled showed low heterogeneity, with the landscapes predominantly composed of two types of cover (forest and cocoa agroforestry). Therefore, we were unable to evaluate this landscape metric in our

				analyses.
Lectures and scientific dissemination				We organised 24 meetings with cocoa producers (totalling around 80 participants), where we presented the benefits of biodiversity for agriculture, with an emphasis on the results of our project. We also published our results in an environmental education magazine and through two videos, one of which is already available on YouTube.

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

a). The high conservation value of shaded cocoa agroforests for the diversity of bees and wasps: we found a high diversity of bees and social wasps in shaded cocoa agroforests, even compared to Atlantic Forest remnants. Furthermore, as far as we know, our study represents the first survey of bee and wasp species associated with this system, also contributing to the expansion of the known distribution for some species of social wasps, including the description of a new species of parasitoid wasp. We recorded 38 species (255 individuals) of bees and 25 species (363) of social wasps in cocoa agroforests; and 21 species (259) of bees and 17 species (167) of social wasps in forests; totalling 44 species (514) of bees and 33 species (540) of social wasps. Considering that these agroforests constitute one of the main types of land use in the southern region of Bahia, our results reinforce the role of these systems in maintaining the diversity of Hymenoptera in an especially diverse region of the Brazilian Atlantic Forest.

b). The role of landscape composition as a modulator of the conservation value of agroforests: we demonstrated that landscape composition can modulate the capacity of these systems to retain species. In this way, we demonstrated that increasing forest cover in the landscape resulted in greater similarity in the species composition of bees and social wasps in cocoa agroforests and forest remnants.

c). The negative impacts of agroforestry management can be mitigated by managing the landscape and region: these results have implications both for the conservation of local biodiversity and for cocoa production in the region. These agroforests show low productivity, in relation to average Brazilian productivity, which has been associated especially with the low frequency of management adopted by cocoa producers in southern Bahia. Thus, our results reveal that the main management practices adopted by these producers (fertelisation, pruning and

thinning, weed control, cocoa tree density) can have a low negative impact on the conservation of bee and wasp diversity if these systems are inserted in landscapes or regions with high forest cover.

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

The only problem we faced when carrying out our project was in relation to the sampling efficiency of the purchased traps. Initially, we associated the low number of bees and wasps captured with the weather conditions, since we had been through an atypical year with a lot of rain. As a result, we suspended the collections, and returned three months later. On a second sampling attempt, we noticed that the number of insects caught was higher, but still lower than expected. So we suspended the collections for a second time and considered that the sampling problem was linked to the design of the traps. We carried out several tests and realised that the traps we had bought were not performing well. We therefore asked the manufacturer to exchange the product and continued collecting data. But despite this unforeseen event resulting in a delay in our schedule, we managed to successfully complete all the activities initially planned.

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

One of the principles of our research team and the laboratory to which I belong (Applied Ecology and Conservation Lab - LEAC) is to value the participation of the non-academic community, especially cocoa farmers. In this sense, we have been proposing activities to integrate producers into the research carried out since the project was first conceived. For example, during the selection of areas and data collection, we held several conversations with cocoa farmers, in which we presented our objectives and the importance of scientific research into biodiversity conservation. After the end of data collection and analyses, we returned to the properties to talk to cocoa farmers, members of farmers' associations and students from a rural school, where we held meetings to discuss the importance of cocoa agroforestry for biodiversity conservation and ecosystem services, as well as presenting the results and conclusions of this and other sub-projects linked to the 'Eco-nomia das Cabrucas' project. The meetings were structured in a conversation format, in which we encouraged the participation of everyone present, in order to hear the experiences and perspectives of the local community in relation to cocoa production and biodiversity conservation. Furthermore, it is important to emphasise that the results of this and other projects developed by LEAC are supporting cocoa producers in the cabruca system (i.e., a system in which cocoa is grown under the shade of native Atlantic Forest trees, which consequently gives these agroforests a high conservation value) in claiming access to subsidies such as 'Payment for Environmental Services'. This programme aims to encourage the development and maintenance of systems that favour biodiversity conservation, as in the case of shaded cocoa agroforests. As an effect, this subsidy has the potential to positively

impact the conservation of local biodiversity and the economic condition of producers who choose to maintain an agroforest with characteristics favourable to biodiversity.

5. Are there any plans to continue this work?

Absolutely. One of the advantages of the Malaise trap (used in this study) is that it can capture multiple taxa. In addition, given the low cost of collecting insects, we included other collection methods in order to include other taxonomic groups. This material was stored in alcohol for later processing and identification. In fact, a master's student is currently developing her research project using some of this data. We will therefore continue with these studies in order to ensure maximum utilisation of the resources and time invested in data collection (we emphasise that we will give due credit to the Rufford Foundation for any work produced with this material, regardless of the end of the project). In addition, we intend to conduct a new study with the aim of annually monitoring insect diversity in the understory and canopy of cocoa agroforests and forest remnants, and extending our sampling to include other types of land use.

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

We have carried out several activities to disseminate our results. For the academic community, this includes the publication of five scientific articles (in addition to two others that have been submitted) in journals of high relevance to biodiversity conservation; presentations of five abstracts at two scientific congresses; and lectures to undergraduate and postgraduate students from different institutions. For non-academic audiences, we held meetings with cocoa producers, where we gave talks and presented the results obtained in our projects; we also publicised our project and results on social media (Instagram); we produced two high-quality videos, the first of which is already available on YouTube (https://www.youtube.com/watch?v=Ur3P3-Ak1MI), and the second is still being edited; and we published our results in a local magazine aimed at disseminating science to primary school students (https://drive.google.com/file/d/1rQ6MC49lNIG0AB6nwC5glyNWBD1RogHo/view).

We propose landscape and site management measures in discussions with public managers, the academic community (including published articles and participation in conferences), and also cocoa producers. Unfortunately, we cannot guarantee that such measures will be adopted. However, we perceive that cocoa producers in particular have shown great interest in our proposals, which aim to reconcile production with biodiversity conservation, demonstrating concern for the issue and ensuring support for the continuity of our research.

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

In this study we have highlighted the highly relevant role of shaded cocoa agroforests and the landscape context in which these systems are inserted for maintaining the diversity of bees and wasps. However, despite their high conservation value, these agroforests continue to be threatened by more intensive systems that are expanding rapidly in southern Bahia, such as pastures, coffee monocultures, eucalyptus monocultures and even cocoa monocultures - or full sun cocoa. In this sense, we believe it would be extremely relevant to investigate the conservation value of shaded cocoa agroforests in relation to these systems, and also start monitoring these surveyed agroforests in the long-term. Such results would substantially increase our predictive power, fostering effective management strategies to mitigate the possible losses associated with converting these agroforests into systems that possibly have a lower value for biodiversity conservation.

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?

Absolutely. Credits and acknowledgements of the Rufford Foundation's support have appeared explicitly in any and all publicity or material produced with data from this project. This includes written acknowledgements (as in the case of scientific articles and abstracts published at conferences); oral acknowledgements with the foundation's logo (as in the case of presentations and lectures); and in the video we produced to disseminate our results (https://www.youtube.com/watch?v=Ur3P3-Ak1MI).

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

José Victor Alves Ferreira: As the main researcher responsible for the project, I took part in all the stages, including planning and drafting the proposal, as well as the practical activities that involved selecting areas, organising logistics and planning data collection, processing the insects collected, curating and analysing data, writing scientific and non-scientific manuscripts, and meeting with cocoa farmers;

Dra. Maíra Benchimol (supervisor), Dr. José Carlos Morante-Filho (co-supervisor) and Dra. Danielle Storck-Tonon (co-supervisor): These three members were responsible for mentoring, supervising and actively participating in all the previously mentioned stages, as well as guiding my academic training and doctoral thesis development;

Dr. Márcio Oliveira and Dr. Alexandre Somavilla: Both researchers have significant experience in biological and taxonomic knowledge of bees and wasps, respectively. In this sense, Dr. Márcio and Dr. Alexandre were fundamental for the taxonomic identification stage of the species collected and for discussions on the biological aspects of both taxa, as well as providing all the material and structural

support (such as equipment, access to the biological collection, among others) of the Hymenoptera laboratory at the National Institute for Amazonian Research (INPA).

10. Any other comments?

The main objectives initially proposed in our research project have been successfully realised. In fact, the products and impacts generated by this research project have exceeded initial expectations. We attribute part of the success of these results to the fundamental support provided by the Rufford Foundation. In addition to the products generated, it is important to emphasise that the impacts of this support include my training as a researcher and biodiversity conservation professional. These skills acquired through the execution of this project include, for example: 1) the ability to manage time, people and financial resources; 2) participation in the supervision and training process of other professionals in the field (academic co-supervision); 3) scientific production and publications in journals of high relevance to biodiversity conservation; 4) the ability to communicate with the academic and non-academic community; 5) and the establishment of a collaborative network with other researchers and institutions. As an effect, the success of this project has certainly resulted in a positive stimulus for my training as a researcher, fostering my desire to continue producing knowledge, collaborating in the training of qualified professionals and seeking strategies and solutions to the problems associated with biodiversity conservation. I would therefore like to thank the Rufford Foundation for having believed in and supported our project.

ANNEX – Financial Report

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