

Final Evaluation Report

Your Details	
Full Name	Lucas Nicioli Bandeira
Project Title	Are neotropical treefrogs ecologically labile? The use of information on the evolutionary behaviour of niches in access to the impacts of climate change.
Application ID	27629-2
Grant Amount	£ 5000
Email Address	azebandeira@gmail.com
Date of this Report	October 09 th , 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
Investigation of the permanence of the ecological signal in the diversification of the genus;				Through the application of the analytical routine idealised and implemented in Abellán & Ribera (2017), we rescue the ecological signal in the diversification of <i>Pithecopus</i> . Following the adopted criterion of high similarity (or high adjustment) between the expected pattern versus the observed pattern, the results obtained with the achievement of this first objective led to the conclusion that ecology, as well as geography, had a determining role in the emergence of these treefrogs.
Preparation of the manuscript addressing the permanence of the ecological sign (henceforth the geographical) in the diversification and its importance to the mechanism of speciation and its submission in scientific journals related to the theme;				After obtaining the results from the investigation of the existence and permanence of the ecological signature throughout the evolutionary history of the species of the genus <i>Pithecopus</i> , we organised all our findings in the form of a scientific manuscript fully suitable for publication in high impact scientific journals. So far, we have three candidate magazines to receive our submission: Journal of Evolutionary Biology or Journal of Biogeography or Ecology and Evolution; magazines whose scopes fit perfectly with the theme addressed in our work.
Internship at the Macroecology and Evolution Laboratory, Department of Ecology and Evolutionary Biology, Institute of Biodiversity, University of Kansas - KU, Lawrence, USA as exchange student being overseen by PhD co-adviser A. Townsend Peterson;				The trip to the Biodiversity Institute - University of Kansas – KU, Lawrence, USA, despite being named as the backbone of this proposal, where most of the activities would be carried out, could not be carried out given the global scenario of the SARS-Covid 19 pandemic (declared on 11 March 2020). Following (CORRECTLY), among other recommendations of the World Health Organization, international transfers of people were prohibited, which

			<p>prevented (without the possibility of postponement) my going to the aforementioned university. However, it is worth mentioning that all the activities idealised and proposed with the Rufford Foundation, although with some changes, were successfully accomplished and that the results obtained deserve mention (for details see answer to question 2 below).</p>
<p>Development of the Ecological Liability Index – <i>ELI</i> & Incorporation of <i>ELI</i>, as a correction factor, in the predictions of niche models for future scenarios;</p>			<p>The study of the evolution of the niches of the species of <i>Pithecopus</i>, through the investigation of the existence of patterns consistent with the phylogenetic conservatism of niche (a study financed by my first Small Grants provided by Rufford Foundation, see www.rufford.org/lucas_nicoli_bandeira for details) and the construction of climate profiles, allowed us to conclude that the climatic requirements of these treefrogs have remained conserved throughout their evolutionary histories or, in other words, their niches are highly similar to their ancestral niche. Such information, when taken together, indicates low liability or low adaptability, information that was vital in the idealisation of <i>ELI</i>, in the construction of ecological niche models and in its projections for contrasting climatic scenarios, as well as in access to potential impacts. of climate change in these species.</p>
<p>Assessment of potential impacts of climate change on species of the genus (quantification of possible displacements, expansions or reductions of areas of occurrence);</p>			<p>To access the potential impacts of global climate change on <i>Pithecopus</i> species, we first designed the best ecological niche model calibrated for the current climate scenario for each species in eight future climate scenarios (four climate scenarios "rcp 2.6%, 4.5% , 6.0% and 8.5% "in two time periods: 2050 and 2070). That done, with the projections made and converted into binary maps, the measures "centroid displacement", "total predicted distribution area in a given climatic scenario" and "proportion of the predicted area remaining in each future</p>

			period", were taken in order to identify trends such as expansion or reduction of the species' distribution area in the future in relation to the area known in the present, displacement of the area of occurrence of one scenario in relation to the other.
Qualitative and quantitative assessment of the effectiveness of implemented biodiversity protection measures and re evaluation, based on those results, of the conservation status of each species according to the IUCN categorization.			The most direct way to access the effectiveness of conservation units - UCs (here the tested biodiversity protection measure) both in the present and in the future (in the face of the already announced climate changes with global warming) is to answer this simple question: how much of the area where a species occurs is or will it be protected within the recognised limits of UCs? Therefore, since the first of our last two objectives is to see if this measure of protection of biodiversity is indeed effective in protecting the species of <i>Pithecopus</i> , we, through a simple mathematical reason (total area predicted as presence within the UCs / total area predicted as presence * 100), we quantify how much of the area predicted as presence is and will be within the official UCs of all South American countries where these tree frogs occur. Finally, based on these robust results and with competent government agencies (at least in Brazil) as well as the IUCN governing body, we will re-evaluate the conservation status of these species in an attempt to be as faithful as possible to the real picture.

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

The main difficulty encountered arose with the advent of the global situation of the Sars-Cov-2 pandemic (new coronavirus).

On March 11 2020, the World Health Organization, in view of the accelerated increase in infected patients, deaths and affected countries around the globe, declared a state of emergency and pandemic of COVID-19, providing guidelines and highlighting measures to be taken in order to prevent the spread of the new virus and to mitigate the advance and evolution of cases and deaths in countries where the disease had already been detected and established. About 9 days after

the declaration of a pandemic by the director-general of the World Health Organization "Tedros Adhanom Ghebreyesus" (March 13, 2020), US President Donald Trump, in view of the exacerbated increase of infected and deaths in the USA, declared a state of emergency in the country. As one of the measures taken by the US Government, the president announced that he would restrict (shortly afterwards to prevent) the entry of people from other countries to the United States. Therefore, as a direct consequence of this measure correctly taken by the US Government, the initial planning proposed by me (LNB) with the notice 27629-2, namely: internship abroad at the Biodiversity Institute, University of Kansas - KU, Lawrence, USA, was greatly affected. In addition to the inability to enter the USA, my possibility of leaving Brazil has also been suspended since the Minister of Health of the Brazilian Government Luiz Henrique Mandetta, although in my view belatedly, in line with the guidelines of the World Organization of Health limited international flights which, finally, also made it impossible to carry out the aforementioned internship.

Faced with this scenario, I, together with my advisors and collaborators directly linked to this project, returned to the development of a new action plan that would guarantee the development of all activities and the fulfilment of all the objectives initially proposed. Since, in large part, the internship abroad at the University of Kansas would guarantee access to computers with a great capacity for processing analyses and access to the "cluster" for storage of large amounts of data (resources required and highlighted in the proposal), technical support via human resources for the development of codes and algorithms (i.e., programmers, scientists and computer engineers, etc.) and, more than that, it would guarantee access to invaluable theoretical support via great knowledge and experience on topics directly related to the problematic core of the my work by my tutor A. Townsend Peterson, we are looking for viable and safe alternatives that meet, even if in an unsatisfactory way, these needs.

The most viable solution found was for the need for a large-capacity computational apparatus, we decided to reallocate part of the monetary amount invested by Rufford in the project in the purchase of a computer with great processing capacity and storage capacity; for the need for technical support (human resources) and, together, for the need for theoretical support and guidance, we found it plausible (following the suggestion of the collaborator Fabricio Villalobos) to carry out an internship at the Macroecology and Evolution laboratory of the Federal University of Goiás, UFG, Goiânia, GO, Brazil. The mentioned lab is based on one of the most renowned Brazilian research institutions, and belongs to one of the most respected graduate programs in ecology in the country (concept 7 CAPES, system for evaluating courses in Brazil), with a faculty and student whose areas research activities perfectly fit our theme. We believe, without a doubt, that my permanence and immersion within that institution contributed greatly to obtaining our robust and valuable results.

Finally, even though a juggling has been done with the activities, largely modifying our previous planning, it is a pleasure to communicate that all the proposed activities have been carried out, all the objectives achieved and that our unprecedented results will greatly contribute to the understanding of emergence of these charismatic species and their conservation.

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

Our three main results with this project correspond to the results and answers obtained for each of the three questions that were initially built to head my doctoral thesis.

First, knowing that the niches of the species of *Pithecopus* have remained conserved over time has allowed us to understand holistically the geographic and phylogenetic patterns observed for the genus, which allowed, in the foreground, a theoretical basis for polishing the following questions and guiding the choice of analyses to attack them.

Second, the practical use of this information made it possible to redeem the ecological signature and disentangle the historical and ecological role in the emergence of these treefrogs (the theme addressed in the second chapter of the thesis), supporting the idea that both geography and ecology played a decisive role in the diversification of genus. Furthermore, upon learning that the niches of these species are conserved, the construction of more reliable correlative models (ecological niche models – ENMs) and projections in contrasting climatic scenarios were possible. With more robust models and, consequently, more faithful to reality, we were able to access the potential impacts of climate change clearly and objectively in *Pithecopus* (third question and chapter of the thesis), rescuing trends such as expansion, decrease and displacement of potential areas of occurrence for future climatic scenarios. In addition, with the results of this investigation, we were able to assess the efficiency of the biodiversity protection measure (i.e., efficiency of official South American conservation units). Here, it is worth noting the alarming scenario for some species described by our data; when investigating the efficiency of UCs across all South American countries where *Pithecopus* species occur, we saw that for all scenarios (from the most alarming "rcp 8.5%" to the mildest "rcp 2.6%") 10 of the 11 species investigated will have on average less than 20% of the areas predicted to be adequately protected. Only *Pithecopus hypochondrialis*, a species widely found in the Amazon basin, will present more than 30% of the appropriate area within the limits of the units.

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

We always seek to involve as many community members as possible in theoretical and practical activities directly and indirectly related to the project. Lectures were held in communities, highlighting the main points of my work, the importance of species conservation and the ecological system in which the community is inserted. As a latent theme, I tried to address how conservation would provide direct benefits to the community, such as ecotourism. Additionally, we intend to produce a herpetofauna guide (book) of some areas (covering such communities); we believe that the production of this type of document can also benefit the communities by highlighting them, its people, its diversity biological and culture.

5. Are there any plans to continue this work?

Yes, for a future not so distant, there are plans and possibilities for exploring questions related to my project or the same theme for all the species of the Phyllomedusidae family. This idea had its genesis during lively discussions with Fabricio Villalobos (project collaborator) and with Townsend Peterson (PhD co-advisor) and was fruit of the difficulties and suggestions then faced in the development of my thesis. Such ideas would be developed in a new postdoctoral level project.

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

This project has already been disseminated through three lectures given by the research leader. The first one was held at the Amazon Research Institute - INPA, Manaus, AM, Brazil in compliance with the invitation made by the coordinating team of the Ciência com Certeza -CC programme. The CC consists of a perennial cycle of lectures organised and carried out, mainly, by masters and doctoral students of the post-graduation programme in ecology of INPA that is destined to the students of this programme as well as to undergraduate and graduate students belonging to others programmes and even other state and federal institutions.

The second lecture was given to an audience composed of students of the Biological Sciences and Ecology degree course of the Universidade Federal do Amazonas - UFAM, Manaus, AM, Brazil as part of the lectures and courses offered at the biology studies week of that university.

Finally, the third one consisted of a presentation of the results of my project in a live presentation. This was organised and supported by important Brazilian and international organisations (Laboratório de Fauna e Unidades de Conservação – LAFUC, Universidade de Brasília, Brasília, DF, Brasil; Instituto Araguaia, Instituto Internacional de Educação do Brasil – IEB and, Critical Ecosystem – Partnership Fund) and was broadcast to the entire Brazilian and international academic community, as well as to the lay and sympathetic public with themes related to the evolution, biology and conservation of frogs belonging to the Phyllomedusidae family via Youtube® (link to live youtu.be/fhAu0MA52fQ), Facebook® and Instagram® (@monkeyfrog_) (which guaranteed us a high audience and greater dissemination of the works presented there). The conversation was attended by renowned researchers in the Brazilian scientific scene, who throughout their careers developed seminal work with this particular group, which guaranteed a fruitful environment for discussions, ideas and advances.

Complementary, frequent updates have been carried out in the platform of scientific dissemination Researchgate (see in https://www.researchgate.net/profile/Lucas_Bandeira?ev=hdr_xprf&_sg=BPI3CcrvfIPIme4hDFWH9KeJS4WEsHivWIViISoC3OP14Ni1LCDG87TwsZW4989krFc79RWKuSr7VR3siXgPIVv). This platform has wide acceptance in the scientific community mainly by reducing the barriers to access information, speeding the contact between researchers and accentuating debates, exchange of experiences, ideas and information. Therefore, I believe that the existence of a specific home portal about this project contributes in a robust way to its dissemination and improvement.

In addition to these vias, I will disseminate the results referring to the first chapter of my thesis at the XVI Brazilian Congress of Herpetology through a lecture and a visual presentation (poster).

Aiming to reach the non-academic population, we began in the middle of the second semester of 2019 and first semester of 2020 to establish contact with publishers of Brazilian non-scientific journals of wide access (as for example, Science Today, Super Interesting). We believe that the dissemination of information obtained through the development of the project is of general interest and should be public knowledge. In fact, we believe that the theme related to the real impacts of climate change on continental biodiversity (or at least some species belonging to it may have broad repercussions and acceptance.

Finally, we intend to reach a considerable share of the scientific community through high impact publications. In fact, the construction of the initial stages of some of the manuscripts has already begun and it is of extreme interest to the author and the other component members of his research group that the results are gradually published until the end of my PhD.

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

The amount requested from the RF was used, as justified in this report, in its entirety for the realisation of the internship at the Federal University of Goiás - UFG, GO, Brazil. All expenses related to these activities (air and land transportation, housing and food) were paid for with the amount donated. In addition, a portion referring to 20% of the total donated by the Rufford Foundation was used to purchase a computer, a device extremely necessary for the development of the proposed activities and the fulfilment of our objectives. The aforementioned institution was visited throughout the period, sequential, from February to July 2020. After adapting to the global pandemic scenario, the schedule defined (approved by my advisors and by the board of faculty members of the PPG-ECO evaluation commission, INPA) extended in 2 months to the regular size of the projects supported by the RF, but was fully complied and no more drastic changes were required which could jeopardize the activities.

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
Transport (airline and bus tickets, Uber ©)	1400	1000	-£400	<p>Since the trip to the USA was made impossible (see answer to question 2 for details) and the internship was developed in Brazil, the cost of travel was made cheaper as highlighted by the difference between what was budgeted for and what was actually used.</p> <p>As the visit wasn't pre-programmed the tickets to Goiânia, GO, Brazil in which all the activities were developed was acquired "at the last minute", which culminated in obtaining tickets with prices slightly above normal.</p>
Housing (hotels, hostels etc.)	1600	1600		<p>As for airfare / land ticket purchases, the booking of rooms in hostels or private houses (e.g. AirBnB ©) were also made at the last minute. This practice slightly burdened prices but, as we can see this variation was not as different from the initial request as I have tried to keep strictly within what was initially proposed.</p>
Alimentation (food expenses)	1500	1500		<p>As food products are subject to frequent variations anywhere in the world, our previously defined budget has undergone a variation. However, as we can see this variation was not as different from the initial request as I have tried to keep strictly within what was initially proposed.</p>
VISA fares	500		-£500	With the suspension of the

				internship at the University of Kansas in the USA, the expenses previously budgeted for the "J1" visa were not made.
Computer purchase		£900	+£900	The computational apparatus necessary for the development of numerous analyses foreseen in the project (see answer to question 2 above for details) was acquired through the purchase of an appropriate computer model. To this end, more than one budget was made in specialized stores and the purchase was made based on the amount available for that, so we stayed within the budget proposed to and sponsored by Rufford foundation.
TOTAL	5000	5000		

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

First, we see the publication of results in high-impact academic journals as a vital next step. As previously mentioned, the publication and acceptance by the scientific community of our works will be used as a measure of the success of the project and proposal. In addition, the publication of results in less formal magazines, with a larger audience, is also considered a next and important step.

Second, we will try to insert our data into public policies. Currently, ecological modelling data has been used on a large scale to support measures and guide decision-making regarding biodiversity conservation. Since our results present unprecedented information and, more than that, highly refined and reliable to the reality that these species will face soon, we believe that the realisation of this next stage is highly vital and important.

Last but not least, countless new questions arose with the development of this project! So, in the not so distant future, we will seek to develop new projects, with new groups and new partnerships, thus believing that we can increasingly contribute to the development of scientific and popular knowledge and provide means to accelerate the protection of 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?

We used the RF logo in all lectures and informal exposition of any subject related to this project. It is worth remembering that we will be grateful for the foundation in all

the publications resulting from this work and in the final written version of the doctoral thesis.

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

As mentioned in the proposal, the project was developed in collaboration with a group of researchers whose lines of research and interest align perfectly with the scope of this project. In addition, the wide experience they bring enables their execution from a theoretical-practical perspective.

Researchers are:

MSc. Lucas Nicioli Bandeira.

PhD candidate at National Institute of Amazon Research – INPA, Manaus, AM, Brazil and at Natural History Museum, Biodiversity Institute of University of Kansas – KU, Lawrence, KS, United States of America.

Status: Leader and principal investigator of the project. Lucas is the main responsible for all phases of the project.

PhD. Marina Anciaes.

Evolutionary Biology and Animal Behavior Lab. – LABECA, National Institute of Amazonian Research – INPA, Manaus, AM, Brazil.

Status: Lucas' PhD advisor.

Marina is an ornithologist with an interest in animal behavior, geographic distribution and ecology of species including conservation biology. Specifically, the researcher works and maintains under her supervision graduate students who develop issues on diversification and speciation at the ecological, behavioral and molecular levels. The professor is committed to the project since its genesis. She was responsible for valuable contributions (from suggestions on scientific literature to ideas on application of methodologies and analyses) even before the approval of the student and the research to integrate the body of students and research being carried out at PPG-ECO, INPA. As coordinator of the Laboratory of Evolutionary Biology and Animal Behaviour - LABECA, laboratory to which I belong, Marina actively contributes with new suggestions, helps in solving diverse problems and in establishing partnerships. She is an expert on the theory that supports the construction of ecological models and the application of ecological modelling methodology (methodology that is actively used in this project) and, together with the other members of the project, is responsible for the idea, improvement and construction of the index of ecological lability and the new methodology that we propose for the accomplishment of better ecological predictions for future scenarios of climatic alterations.

PhD. Fernanda de Pinho Werneck.

Adjunct researcher and vice curator of the herpetological collection of the National Institute of Amazonian Research – INPA, Manaus, AM, Brazil.

Status: Lucas' PhD co-advisor.

Fernanda's main research lines integrate ecological and evolutionary approaches to investigate the processes responsible by patterns of diversity, genetic variation and diversification of Neotropical amphibians and reptiles. Like Marina, the professor was present in the initial stages of development of this project. She was one of the members of the INPA's project selection committee that evaluated this project prior to its approval and, consequently, made numerous contributions to its improvement. Given her active participation and incisive contributions, I believe it was worth inviting her to officially be part of the research team. Fernanda has immense experience and works of the highest quality in topics such as: Phylogenetics, Phylogeography and Conservation Biology; fields closely related to the issues of my work.

PhD. Andrew Townsend Peterson. University of Kansas Distinguished Professor. Research Center – Ecology & Evolutionary Biology. KU Biodiversity Institute, Lawrence, KS, United States of America.

Status: Lucas' first stage abroad advisor and Lucas' PhD co-advisor.

Peterson's main research lines focuses on aspects of the geography of biodiversity, with a focus on tropical ornithology and systematics, distributional ecology, and disease transmission risk mapping. My group of students and colleagues is diverse and global, including people interested in the three themes of my interests, from many countries and backgrounds. Specifically, his work with the geographic and ecology of species' distributions has taken him into other fields, including conservation biology and planning as well as invasive species biology.

Here I must highlight the importance that this partnership established between my group in Brazil and the group of Professor Townsend Peterson assumes. Given the relevant role that modelling has in this project, the orientation received by me by one of the creators and most active researchers of the area (both in the improvement of the methodology, proposition of new and through the theoretical lapidation), is configured as a unique training, whose resulting learning will produced extremely positive results.

Specifically, during the three-month period corresponding to my first internship abroad Professor Townsend contributed to the development of the project in a number of ways. At the beginning, the exchange of ideas and discussions led to the definition of outstanding issues as well as to the improvement of pre-existing questions. Regarding the methodology, the modifications and suggestions were positively more incisive. For example, we decided to use the "KUENM" package for the construction of our models. Consequently, the best models for the species studied here have been constructed and will definitely lead to a more refined resolution of the issues addressed.

PhD. Fabricio Villalobos. Evolutionary Macroecology Lab., National Institute of Ecology – INECOL, Xalapa, Veracruz, México.

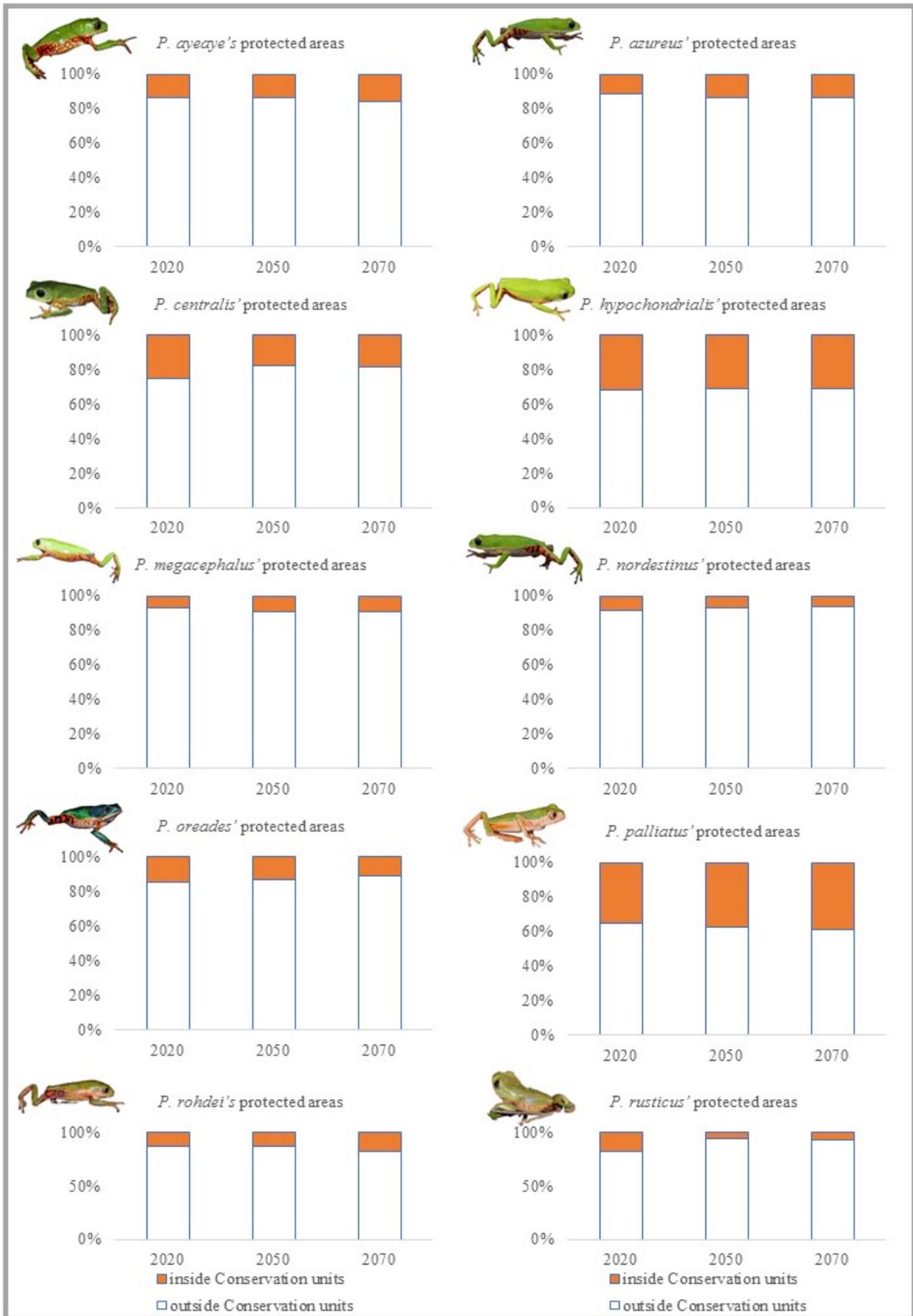
Status: project's collaborator.

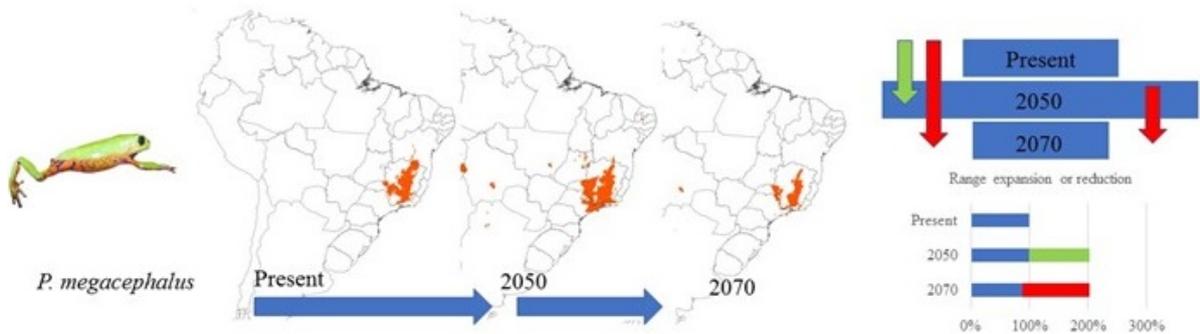
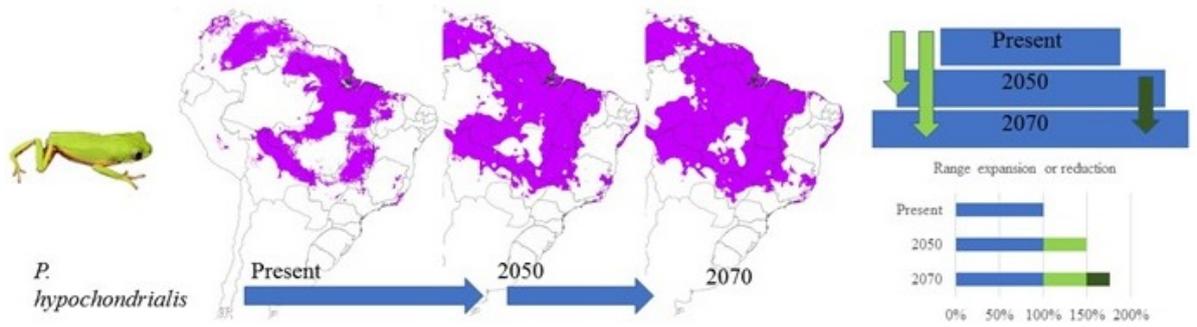
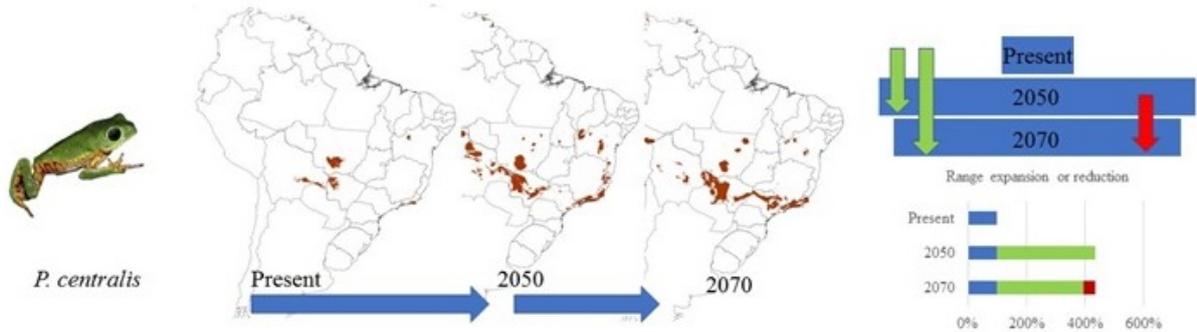
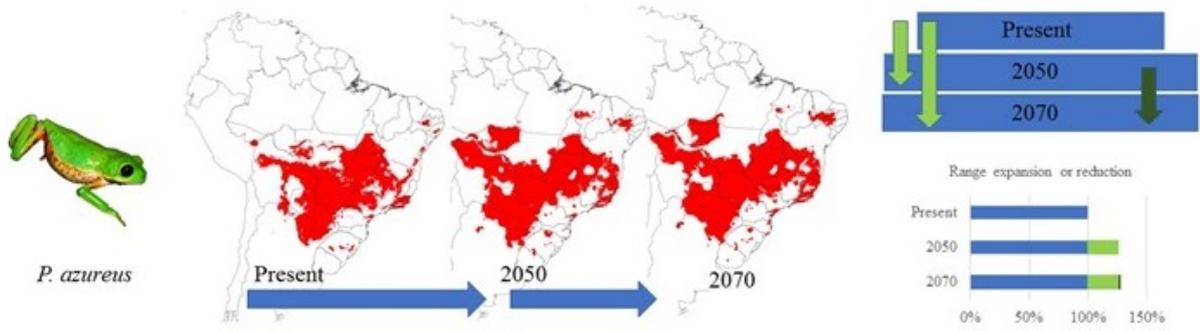
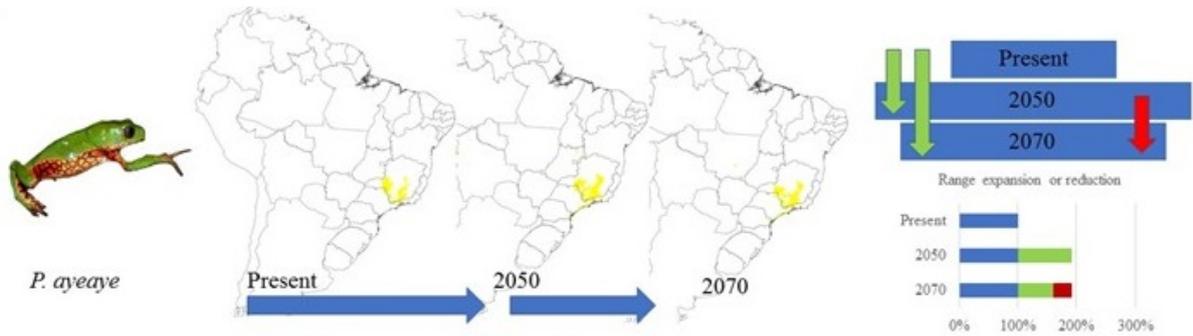
Fabrício focuses on the intersection between macroecology and macroevolution, considering macroecological patterns under an evolutionary perspective and

evolutionary patterns and processes on a spatial context. In short, he works with macroecological theory and methods integrating macroecology with phylogenetic approaches to understand geographic patterns of biodiversity. He is also part of the Ecology & Evolution and Animal Biodiversity Graduate Programs of the Universidade Federal de Goiás - UFG, GO, Brazil. In addition, Fabrício participates in the Applied Geographical Ecology group and Latin American Network for the study of Neotropical Biogeography (Red-Bion). The professor has participated in the construction and lapidation of the project, suggestion of appropriate methodologies to solve specific issues, targeting macro-evolutionary and macroecological interpretations, among others. With several works of high impact in areas such as Macroecology, Evolution, Conservation, Biogeography etc., his participation as an official member of the team of researchers of this project is more than justified. Specifically, the collaboration consists of guiding me in the "construction" of potential historical scenarios that supported my interpretations regarding the ecological-evolutionary processes that led to the diversification of my target group. In addition, how was planned and justified, I intended to do another stage abroad at the National Institute of Ecology - INECOL, Xalapa, Vera Cruz, Mexico where Fabrício is currently a professor. At this stage Fabrício would be my supervisor and the activities, briefly explained above, would be completed and, if necessary, improved.

12. Any other comments?

Again, as previously made in my first small grants, I would like to enhance the importance of The Rufford Foundation for conservation research and researchers in undeveloped countries. Especially in Brazil, we are passing by a political crisis where funds to research are been reduced, while the oxen/agricultural pressure is increasing. In this scenario, young researchers have every time fewer chances to get grants for development their researchers and carrier. So, initiatives like RF are enabling that we, in undeveloped countries, can do high level research in ecology and conservation on threatened environments and species.





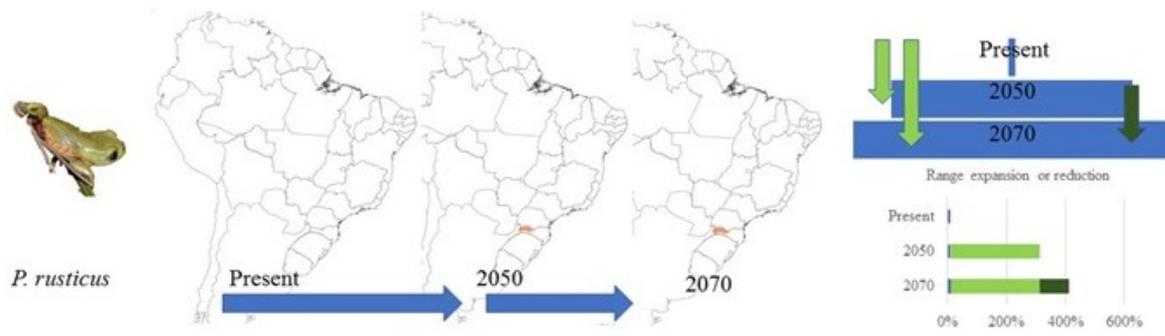
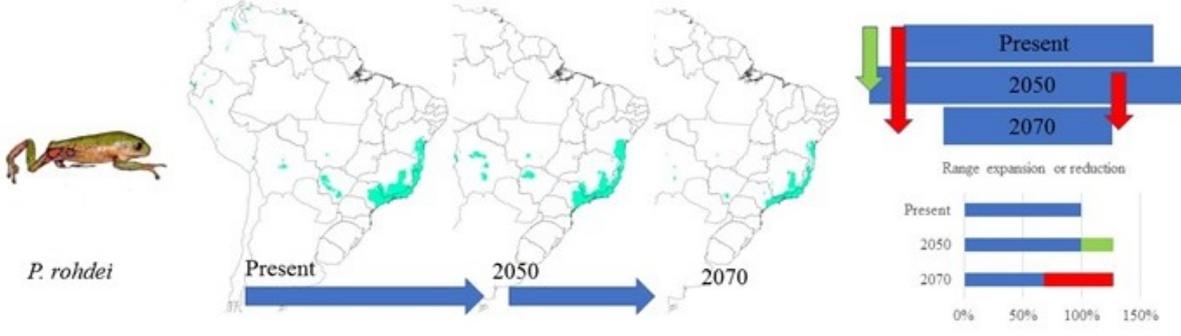
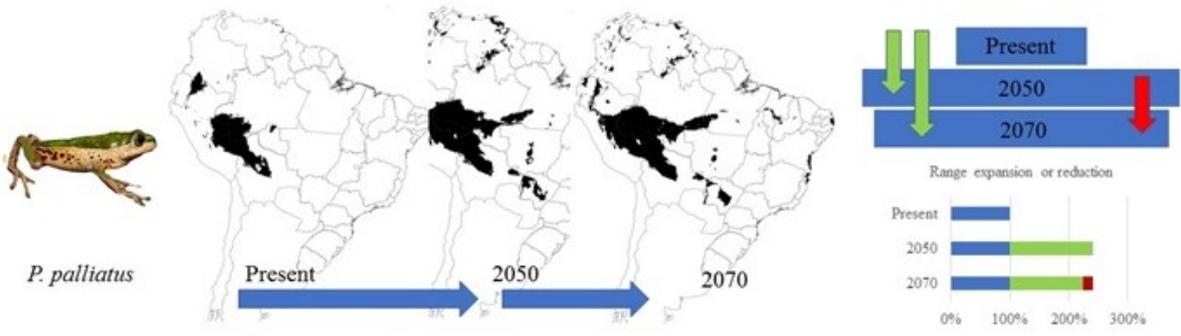
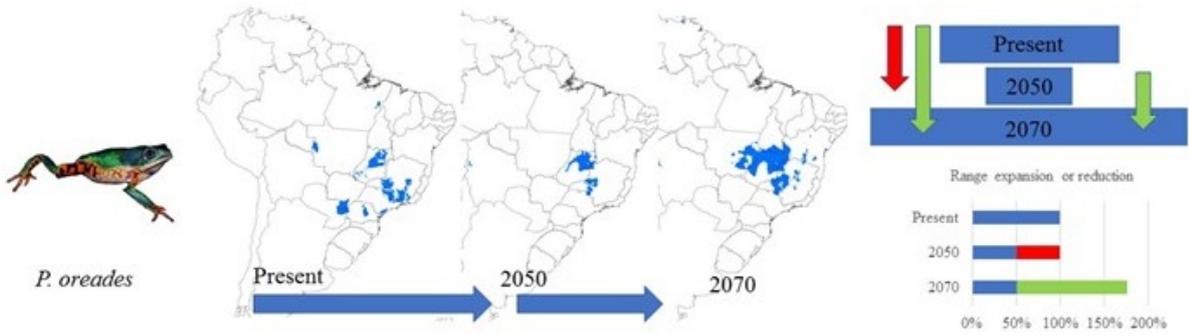


Figure Legends:

Figure 1: Compilation of the results of the analysis of expansion or reduction of potential species distributions. The maps correspond to species distribution models in three different climatic scenarios: one for the present - 2020, and two for scenarios in the future considering a milder CO₂ concentration (RCP 2.6%, IPCC) (2050 and 2070). The graphs show the addition or deletion of area in future scenarios in comparison to what is predicted for the present.

Figure 2: Percentage of areas predicted to be present in each of the three climatic scenarios considered (present - 2020, future - 2050 and 2070) to be "protected" within South American conservation units. Note that for none of the *Pithecopus* species, there are more than 40% of the assured distribution areas. Specifically, for *P. megacephalus*, *P. nordestinus*, *P. rohdei* and *P. rusticus*, there is less than 20% of what is known of their distributions (or that are predicted for the future) that will be protected; an alarming scenario as we are assessing the less drastic climate change scenario.