

Final Evaluation Report

We ask all grant recipients to complete a project evaluation that helps us to gauge the success of your project. This must be sent in **MS Word and not PDF format**. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please DO NOT fill in and submit this form until the project has been completed.

Complete the form in English. Note that the information may be edited before posting on our website.

Please email this report to jane@rufford.org.

Your Details	
Full Name	DIEGO ALEJANDRO ESQUIVEL MELO
Project Title	Conserving invisible species: revealing cryptic diversity in the neotropical bat genus <i>Lophostoma</i>
Application ID	40548-1
Date of this Report	Jan 06, 2026

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
<p>1. Generate a comprehensive list of valid taxa for the genus <i>Lophostoma</i>, along with distributional and ecological data.</p>				<p>This objective was fully achieved through an integrative taxonomic, phylogenetic, and biogeographic assessment of the genus <i>Lophostoma</i>. By combining DNA sequences generated through this project with publicly available molecular data, we reconstructed a robust genus-level phylogeny that clarifies species limits and reveals previously unrecognized evolutionary lineages. As a direct outcome, the number of recognized species in <i>Lophostoma</i> is expected to increase from eight currently accepted taxa to eleven, with the formal description of new species now in progress, including one species endemic to Colombia.</p> <p>The resources provided by this project were essential to assemble a sufficiently comprehensive dataset to resolve long-standing taxonomic uncertainties and uncover cryptic diversity within the genus. This included museum visits, the examination of voucher specimens, and the application of modern molecular and analytical tools. Together, these approaches allowed us to integrate genetic, geographic, and ecological information, resulting in updated distribution maps and ecological summaries for all species.</p>

			<p>To ensure broad dissemination and long-term utility, this updated taxonomic and ecological framework is being incorporated into the genus-level chapters of <i>Mammals of Middle and South America: Chiroptera</i>, making the information generated by this project accessible and usable for future research, conservation planning, and policy-oriented applications.</p>
<p>2. Perform an assessment of the conservation status of <i>Lophostoma</i> bats, including information on threats, and potential conservation measures.</p>			<p>This objective was met through a comprehensive and integrative evaluation of the conservation status of bats in the genus <i>Lophostoma</i>. As part of an ongoing contribution to the book <i>Mammals of Middle and South America: Chiroptera</i>, we are preparing the genus-level chapters for <i>Lophostoma</i>, where each species is assessed using up-to-date taxonomic, geographic, ecological, and conservation information. These assessments synthesize existing knowledge and new evidence generated through this project, including refined distributional data, updated taxonomic hypotheses, ecological traits, and documented threats such as habitat loss, landscape modification, and climate-related pressures. Importantly, drawing on our previous work and results supported by the Rufford Foundation, we explicitly discuss how cryptic diversity and unresolved taxonomy influence current conservation assessments, highlighting where</p>

			<p>formally recognized species may mask multiple vulnerable evolutionary lineages. For each species, we outline current and potential conservation measures, including research priorities, habitat protection needs, and management recommendations. Together, these contributions provide the most up-to-date and policy-relevant assessment of <i>Lophostoma</i> conservation status to date, while also ensuring that this information is disseminated in an authoritative reference widely used by scientists, conservation practitioners, and decision-makers.</p>
<p>3. Understand how to incorporate cryptic species into conservation plans and policies, not only for <i>Lophostoma</i> bats but for other groups of cryptic species as well.</p>			<p>This objective was achieved by explicitly linking cryptic diversity to conservation risk, prioritization, and policy-relevant metrics. Through a continental-scale assessment of Neotropical bats, we demonstrated that a substantial proportion of currently recognized species harbor cryptic lineages that are already exposed to severe anthropogenic pressures and climate-driven habitat loss. By integrating molecular species delimitation with spatial analyses, human modification indices, IUCN status, and future climate projections, we showed that many cryptic lineages occur within taxa presently classified as Least Concern and are therefore invisible to existing conservation frameworks.</p> <p>Crucially, we translated cryptic diversity into actionable conservation units by identifying priority species complexes and</p>

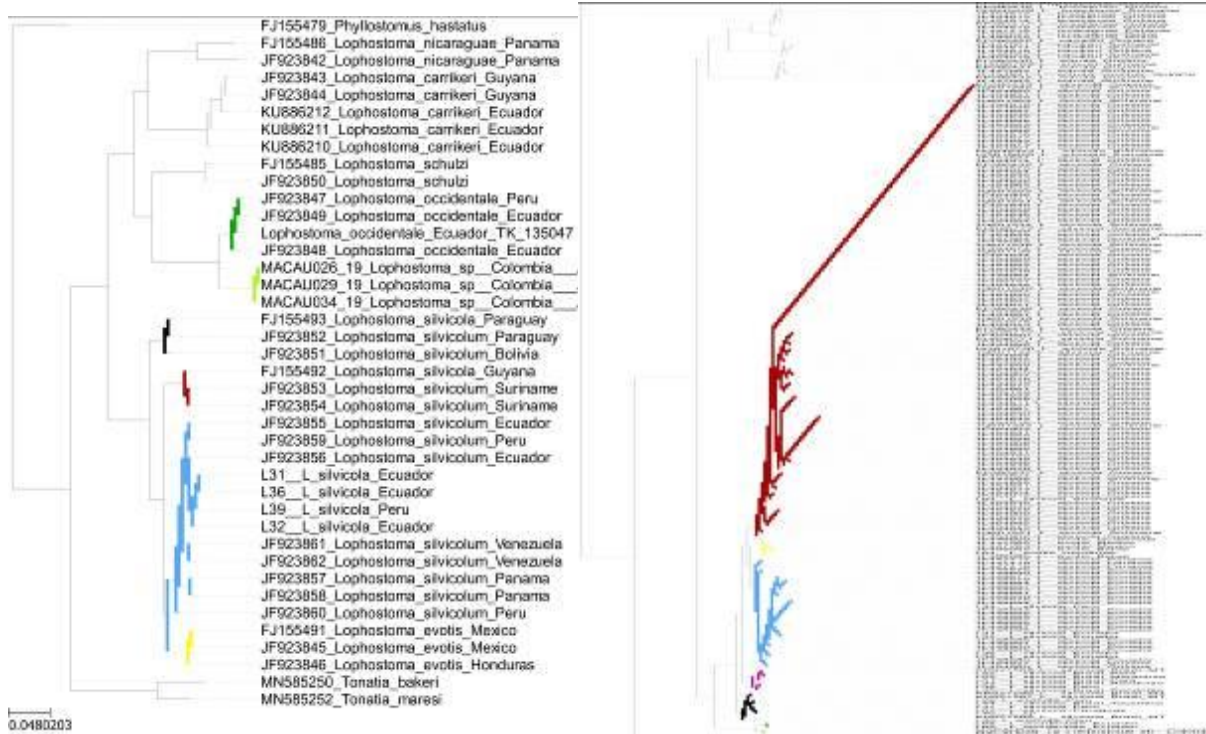
			<p>geographic hotspots where undescribed diversity coincides with high current and future threat levels. This framework allows cryptic species to be proactively incorporated into conservation planning before formal taxonomic description, providing a mechanism for precautionary inclusion in environmental assessments, protected-area design, funding allocation, and policy discussions. Although developed using <i>Lophostoma</i> and other bat taxa, the approach is explicitly transferable to other groups affected by cryptic diversity. The full set of results supporting these conclusions is currently under peer review at <i>Nature Communications</i> and is expected to be shared publicly once the manuscript is accepted.</p>
<p>4. Develop a protocol for studying cryptic diversity in neotropical bats that is informative for both scientists and decision-makers.</p>			<p>We fulfilled this objective by developing and implementing a transparent, reproducible, and decision-oriented protocol for detecting, mapping, and prioritizing cryptic diversity in Neotropical bats. The protocol integrates widely available molecular data (COI barcodes), conservative multi-method species delimitation, spatial bias correction, ecological niche modelling, and threat integration into a single analytical pipeline. A central innovation is the Hidden Species Richness (HSR) index, which corrects for uneven sampling effort and accessibility while enabling robust spatial comparisons among regions.</p>

			<p>Importantly, the protocol bridges scientific rigor and policy relevance. For scientists, it provides a standardized roadmap for identifying cryptic species complexes and guiding integrative taxonomic research. For decision-makers, it delivers clear and interpretable outputs-including priority species complexes, conservation urgency rankings, and geographically explicit hotspots-that can be directly incorporated into conservation planning and resource allocation. This protocol and its results are currently undergoing peer review at <i>Nature Communications</i>, and we anticipate disseminating them broadly once the article is formally accepted.</p>
<p>5. Design guidelines for the development of conservation plans aimed at protecting <i>Lophostoma</i> bats and their habitats.</p>			<p>This objective was partially achieved. Although we did not produce a standalone set of formal conservation guidelines specifically dedicated to <i>Lophostoma</i>, the project generated the scientific foundation required to develop such guidelines in a rigorous and evidence-based manner. Through the preparation of the manuscript currently under peer review at <i>Nature Communications</i> and the ongoing book chapters for <i>Mammals of Middle and South America: Chiroptera</i>, we incorporated concrete recommendations, conceptual frameworks, and analytical protocols relevant to the conservation of <i>Lophostoma</i> and other taxa affected by cryptic diversity. These include</p>

			<p>guidance on identifying conservation-relevant lineages, prioritizing populations and regions under high threat, and integrating taxonomic uncertainty into conservation planning.</p> <p>The original intention was to synthesize these peer-reviewed outputs into practical, species-specific conservation guidelines for <i>Lophostoma</i>, designed for use and dissemination among local landowners, protected-area managers, and conservation practitioners. However, given that several key publications are still in advanced stages of peer review and revision, we considered it scientifically premature to finalize and distribute such guidelines before the formal publication of the underlying results. The development of dedicated <i>Lophostoma</i> conservation guidelines therefore represents a direct and well-defined next step emerging from this project, to be implemented once the current publications are formally accepted and publicly available.</p>
<p>6. Generate Tools as brochures, posters, talks and presentations to improve awareness on bat, and biodiversity as a whole, conservation in local</p>			<p>We successfully met this objective by developing and implementing a broad suite of outreach and educational activities. In addition to producing brochures, posters, and visual materials, we delivered targeted talks and presentations to multiple audiences, including school</p>

<p>communities, staff of protected areas and the general public.</p>			<p>communities, early-career and young researchers, and undergraduate students at Universidad EAFIT (Medellín), Universidad Nacional (Bogotá), and Universidad del Rosario (Bogotá). We also engaged directly with key stakeholders, such as staff from botanical gardens and protected areas. Collectively, these actions strengthened awareness of bats and biodiversity conservation and fostered dialogue among local communities, academic groups, and conservation practitioners.</p>
--	--	--	---

Objective 1.



Phylogeny of the genus *Lophostoma* based on COI (right) and cytochrome b (left) sequences, incorporating data generated by this project and sequences from public databases. These phylogenies are in preparation for publication as part of a taxonomic study of the genus, including the description of new species.

Objective 2.

SPRINGER NATURE Meteor

Prof. Diego A. Esquivel

Projects Help

Mammals of Middle and South America: Chiroptera

My Tasks My Chapters Table of Contents

Search chapter Show Filter

TITLE	DUE DATE	STATUS
Pygmy Round-eared Bat <i>Lophostoma brasiliense</i> W. Peters, 1866 ID: 292 by Esquivel, D., Bianchi, F., Velazco, P., Ramos ...	2026-01-02 (revision)	Revision Requested
Mesoamerican Round-eared Bat <i>Lophostoma micropus</i> (G. G. Goodwin, 1942) ID: 295 by Esquivel, D., Bianchi, F., Velazco, P., Ramos ...		In Review
White-throated Round-eared Bat <i>Lophostoma silvicolu</i> d'Orbigny, 1836 ID: 299 by Esquivel, D., Bianchi, F., Velazco, P., Ramos ...		In Review

Show rejected and withdrawn chapters 1 - 3 of 3 Page 1 of 1

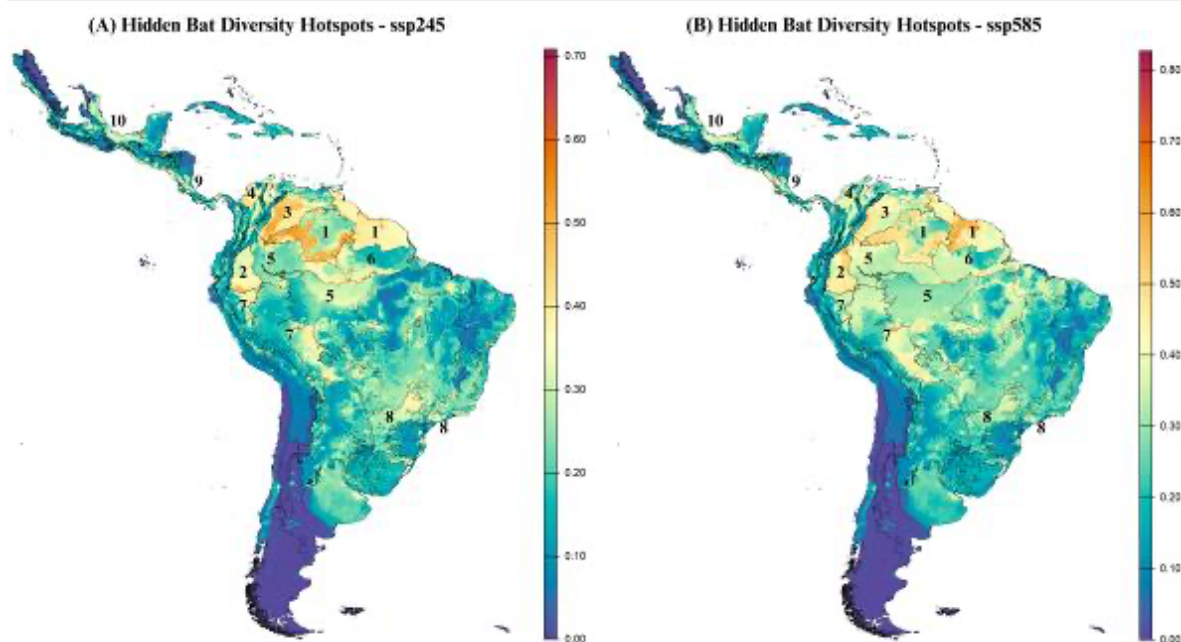
Project overview

■ In Review
2 chapters, 66%

■ Revision Requested
1 chapters, 33%

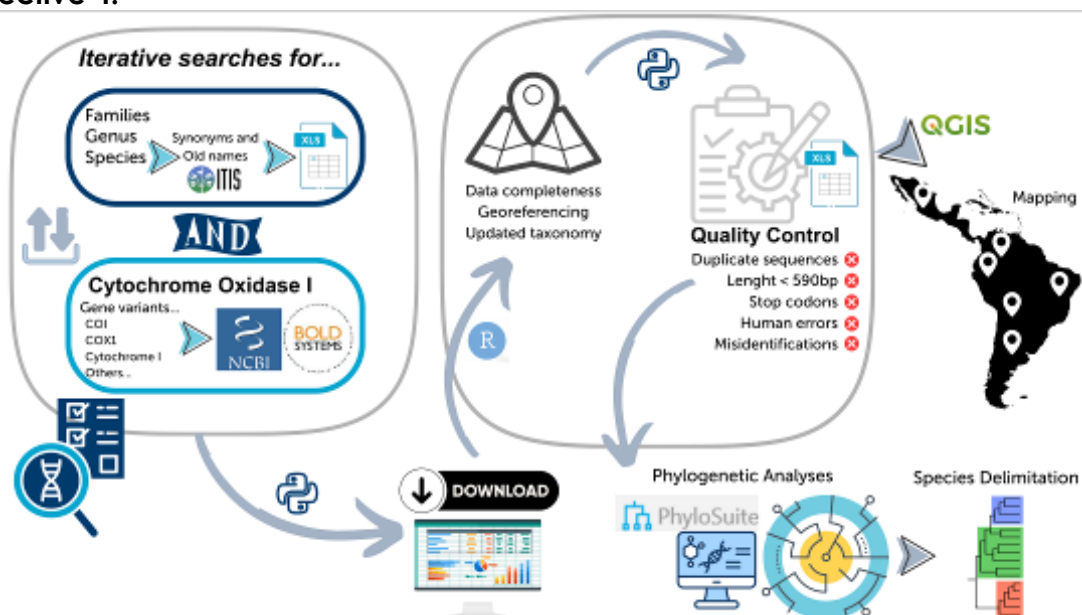
Editorial platform showing the preparation and peer-review status of genus-level chapters for *Lophostoma* in **Mammals of Middle and South America: Chiroptera**, which synthesize current knowledge on taxonomy, distribution, ecology, threats, and conservation measures for each species.

Objective 3.

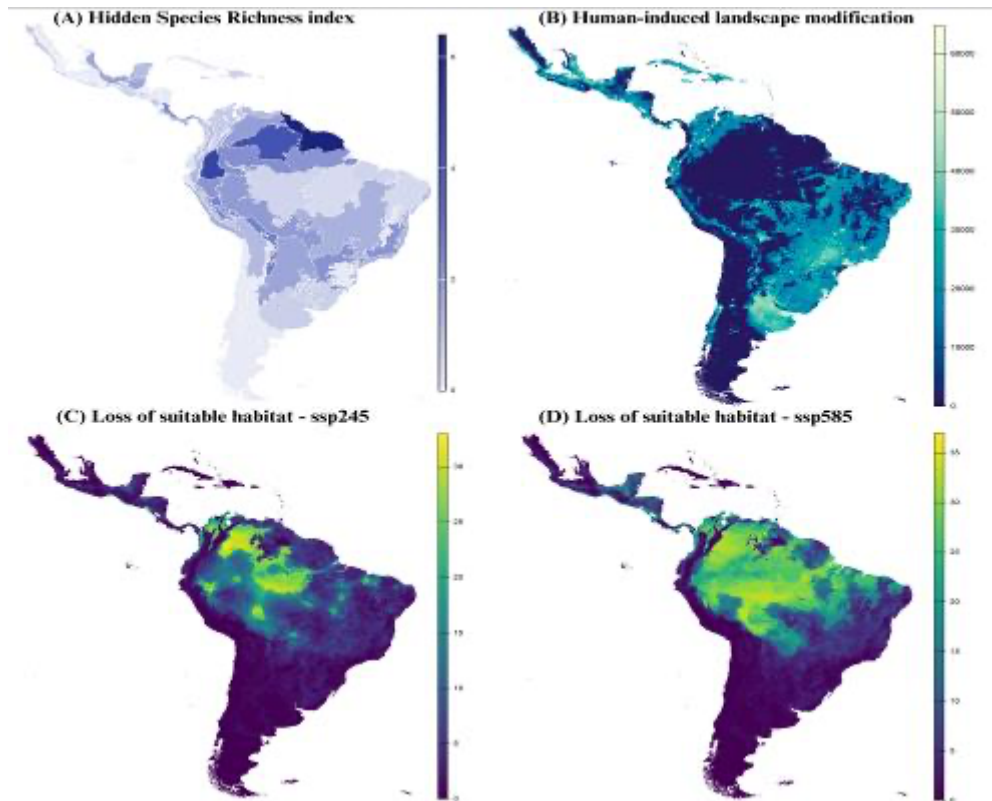


Hidden diversity hotspots for Neotropical bats. A. Hotspots under SSP245, where values from 0.00 (blue) to 0.70 (red) represent a composite value integrating Hidden Species Richness (HSR) index, human impact, and projected habitat suitability loss by 2070. B. Hotspots under SSP585, where values from 0.00 (blue) to 0.80 (red) show increased vulnerability in northeastern South America and parts of Central America under more extreme climate projections. Higher values (warmer colors) indicate areas of maximum conservation urgency. Numbers represent the 10 main hotspots for hidden bat diversity in the Neotropics.

Objective 4.



Pipeline proposed to include cryptic/hidden species into conservation plans.



Three different layers for modelling hidden diversity hotspots. A. Hidden Species Richness (HSR) index showing areas of potential undescribed bat diversity. B. Human-induced landscape modification intensity. C. Projected loss of suitable habitat for bat species complexes under SSP245 climate scenario (moderate emissions). D. Projected loss of suitable habitat under SSP585 climate scenario (high emissions).

Objective 6. Collection of activities and promotional items from the Project.



Educational workshops and outreach talks conducted with undergraduate and school students promoting awareness of bats and biodiversity conservation.

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

a) Resolution of cryptic diversity and taxonomic clarification in *Lophostoma*.

The project generated the most comprehensive taxonomic and phylogenetic assessment of the genus *Lophostoma* to date. By integrating newly generated molecular data with publicly available sequences, museum specimens, and geographic information, we clarified species limits and uncovered substantial cryptic diversity. As a direct outcome, the number of recognized species in *Lophostoma* is expected to increase from eight to eleven, with formal descriptions currently in preparation, including a species endemic to Colombia. This work resolves long-standing taxonomic uncertainty and provides a solid, evidence-based framework for future research and conservation action.

b) Development of a transferable framework to integrate cryptic species into conservation planning

A major conceptual outcome of the project was the development of a reproducible and policy-relevant framework for incorporating cryptic species into conservation assessments. By combining species delimitation, spatial analyses, human impact metrics, and climate-change projections, we identified continental-scale hotspots of hidden bat diversity and areas of highest conservation urgency. This approach demonstrates how cryptic lineages, often overlooked under current conservation categories, can be translated into actionable conservation units. The framework, currently under peer review at *Nature Communications*, is broadly applicable beyond bats and provides a possible solution to integrating hidden biodiversity into conservation planning and decision-making.

c) Translation of scientific results into accessible knowledge and capacity building

The project ensured that its scientific outputs extend beyond academia through multiple dissemination and capacity-building pathways. Updated taxonomic, ecological, and conservation information for *Lophostoma* is being incorporated into the authoritative reference *Mammals of Middle and South America: Chiroptera*, ensuring long-term accessibility. In parallel, the project engaged students, local communities, and conservation stakeholders through talks, workshops, educational materials, and social media outreach. These activities increased awareness of cryptic biodiversity, strengthened local capacity, and fostered early engagement with conservation initiatives, laying the groundwork for sustained conservation impact beyond the life of the project.

Our fieldwork and the outreach activities also generated some quantitative outputs. Our bat surveys were conducted using eight mist nets across four study areas for a total of 20 sampling nights, resulting in the capture of 125 bats representing 24 species. Tissue samples from the uropatagium were collected from all individuals for genetic analyses. We also visited 10 scientific collections, where approximately 600 specimens were examined and measured. Outreach activities included five educational workshops in local schools reaching 72 students, two workshops with approximately 30 undergraduate biology students, and one workshop with private landowners managing conservation-relevant areas.

Educational materials were also distributed, including approximately 45 project t-shirts provided to landowners, brochures for school teachers, and two educational posters left in schools, along with teaching materials (e.g., silhouettes and masks) designed so that teachers can independently replicate the educational activities involving bats in the future.

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

During the course of the project, several unforeseen difficulties arose, primarily related to regulatory processes and logistical constraints associated with molecular work. One major challenge was the time required to obtain collecting permits from governmental authorities, as well as import permits for tissue samples from international museum collections for DNA extraction and sequencing. These legal and administrative procedures were beyond the direct control of the project team and took substantially longer than anticipated. The only viable way to address this issue was to comply fully with the regulations and wait for formal approvals, which inevitably caused delays in data generation and, consequently, in the completion of some project outputs and the submission of this final report.

A second challenge involved limitations in lab facilities. To overcome this constraint, we actively sought and established collaborations with laboratories and researchers in Colombia who had the necessary facilities and materials. These collaborations allowed us to complete the molecular component of the project successfully while also strengthening our professional network and fostering long-term research partnerships. Although these difficulties slowed the project timeline, they ultimately led to a more collaborative and resilient research framework, ensuring that the core scientific objectives were met despite the initial setbacks.

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

Our project created meaningful connections with local communities in our study areas. We recognized that lasting conservation depends on people understanding and valuing the biodiversity around them.



Community engagement activities: educational activities with local communities.

We worked closely with the Bahía Solano Botanical Garden, an institution that plays a vital role in the region's communities. We socialized our work with the garden staff, sharing the sampling methodologies employed and explaining the importance of bats for the ecosystem. This exchange allowed the staff to understand the value of cryptic bats present in their areas and how they can contribute to their monitoring and conservation.

We developed field demonstrations with undergraduate students from Universidad EAFIT – Medellín, where we showed practical sampling methodologies they can apply in their own research. These practical sessions provided direct experience with field techniques that are rarely accessible in classroom settings.



Field training sessions with undergraduate students from Universidad EAFIT at Bahía Solano Botanical Garden: demonstrating mist net setup, bat handling techniques and conducting nocturnal surveys.

Schools became another important focus of our outreach. We visited schools throughout Chocó, adapting our presentations to different age groups, from 8-10-year-old children just beginning to understand ecology, to 13-15-year-old youth ready for more complex conservation concepts. We also connected with sixth-grade students from schools in cities in other departments, explaining why cryptic bat diversity matters and how these species fit into the broader ecosystem.

To support these educational efforts, we developed materials aimed at schools, including informative posters with educational content about cryptic diversity and the importance of bats. Additionally, we produced t-shirts and stickers that help give visibility to these organisms in daily life in different community spaces where their presence increases awareness about bat conservation in the region.



T-shirts featuring species from the project for the local community.

Additionally, we established a volunteer program to review specimens in scientific collections. This opportunity allowed an undergraduate student to gain real research experience, learn proper specimen handling, and understand how museum collections contribute to scientific discovery.



¿Te gustan las colecciones y la taxonomía?
¿Quieres desarrollar tu trabajo de grado en este campo?

KURUPIRA
¡Buscamos!
PASANTE, TESISISTA O VOLUNTARIOS

Para apoyar un proyecto de taxonomía de murciélagos en desarrollo y liderar su propio proyecto de investigación en este campo

Ofrecemos

- Recursos económicos para realizar visitas a colecciones
- Equipos básicos para las actividades de investigación
- Apoyo académico en todas las fases de tu proyecto
- Oportunidad de aprender nuevas técnicas en taxonomía

Requisitos

- Estudiante de Biología
- Vivir en Bogotá
- Compromiso y responsabilidad
- Habilidades de redacción de artículos científicos o disposición para aprender

Interesados enviar hoja de vida y carta de intención al correo: serva.kurupira@gmail.com

Volunteer work in scientific collections: student training in specimen handling and curation procedures

Through all these activities, we have built something that extends far beyond data collection. Investing in community engagement is an effective conservation strategy. When local communities, especially young people, see themselves as part of the scientific process and understand the unique biodiversity in their own region, they become advocates and guardians. This is how conservation becomes sustainable, ensuring that communities have both the knowledge and motivation to protect what makes their region irreplaceable.

5. Are there any plans to continue this work?

Yes. There are clear and well-defined plans to continue this work. In the short term, we will finalize and publish the manuscripts currently in advanced stages of peer review, including the taxonomic revisions, species descriptions, and the conservation framework addressing cryptic diversity in Neotropical bats. These publications will provide the scientific basis for developing applied conservation guidelines for *Lophostoma* and for extending the approach to other bat groups and cryptic taxa in the region.

In parallel, we are actively advancing the analysis of whole-genome data generated for all species of *Lophostoma*. This ongoing work will allow us to address deeper questions on the evolutionary history, biogeography, and conservation genomics of the genus and is expected to result in additional high-impact publications. Beyond research outputs, we plan to strengthen collaborations with local institutions, protected-area managers, and communities in key regions to translate these findings into monitoring initiatives and conservation actions. Together, these efforts ensure that the project represents not an endpoint, but a foundation for a sustained and expanding research and conservation program.

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

We've designed our dissemination approach to reach everyone from specialist researchers to local communities who live alongside these bats every day.

On the scientific side, we submitted our main findings to *Nature Communications* on July 11, 2025. The manuscript has already passed the initial editorial screening and completed the first round of peer review, we're currently working through the second round of revisions, which is an encouraging sign that the work is resonating with the reviewers. All our datasets will be openly available so other researchers can use it, apply it, and spread it. Once I finish my doctoral thesis in June 2026, the full document will be archived in the Universidade Federal do Rio Grande do Sul repository at <https://lume.ufrgs.br> this way, anyone interested can access the complete methodology and detailed results. Throughout this research, we've been actively sharing our work at academic venues. I presented several *Talks* hosted by PPGBAN (Biology Program) - UFRGS which sparked great discussions with colleagues working on similar questions. Also, I defended my doctoral qualification exam on May 12, 2025 which was open to the public and it was evaluated by a distinguished committee: Ludmilla Aguiar, Renan Maestri, and Felipe Ribeiro, all recognized Brazilian experts. Their feedback really helped shape the direction of the research.



PhD candidacy examination in Biology, including some results from the project.

Beyond academia, we've given talks to local communities and students in Bogotá D.C./Universidad Nacional de Colombia and Universidad del Rosario, also in Medellín/Universidad EAFIT, and Bahía Solano/Secondary schools, Bahía Solano/Botanical garden, and Bahía Solano/skateholders, explaining why these cryptic bat species matter and how their conservation connects to the health of local ecosystems. These conversations have been incredibly rewarding, people are genuinely fascinated once they learn about the hidden diversity right in their own backyards, and several community members have expressed interest in helping with future monitoring efforts. In this sense, we also generated a short field guide to the bats of Bahia Solano for local stakeholders, with images of bats present in their territories. In addition, we developed and teaching two courses on "Introduction to Ecological Niche Modelling" for more than 25 people. It felt important to pass along these technical skills to the next generation of researchers who'll continue this kind of work.



Outreach materials disseminated through social media, including a bat guide for Bahía Solano shared with local landowners.

Moving forward, we're working on additional papers for specialized journals and planning to create materials that conservation practitioners and park managers can actually use on the ground. The goal has always been to make sure this research doesn't just sit on a shelf somewhere, it needs to inform real conservation decisions.

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

Looking ahead, the most important next steps focus on consolidating this project into a long-term scientific and conservation trajectory. In the immediate future, I aim to complete my doctoral thesis using the data generated with the support of the Rufford Foundation, ensuring that the taxonomic, phylogenetic, and conservation results are fully synthesized and made publicly available through peer-reviewed publications and my dissertation. These outputs will provide a durable scientific baseline for future work on *Lophostoma* and other cryptic bat groups in the Neotropics.

In the medium term, I plan to pursue postdoctoral research that builds directly on this project, expanding the genomic, evolutionary, and conservation dimensions of the work. The whole-genome datasets already generated will be central to this next phase, allowing more detailed investigations into evolutionary history, biogeography, adaptation, and conservation genomics. Equally important, this project has reinforced my commitment to field-based research and to working closely with local communities and conservation practitioners. The combination of rigorous science, fieldwork, and community engagement proved both scientifically productive and personally meaningful, and I intend to continue integrating these components in future projects. Overall, the next steps involve scaling up the scientific scope, strengthening applied conservation outcomes, and maintaining strong connections between research, fieldwork, and the people who share their landscapes with this biodiversity.

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?

The Rufford Foundation was acknowledged in all oral presentations delivered at academic venues. The Foundation was also credited in our manuscript submitted to Nature and will be acknowledged in the doctoral thesis to be deposited in the Universidade Federal do Rio Grande do Sul repository at <https://lume.ufrgs.br>. Through our educational outreach activities and community engagement efforts that reached hundreds of students and community members across, The Rufford Foundation's support for conservation research gained significant visibility in the region. Additionally, the Foundation's logo was incorporated into all educational and outreach materials developed for the project, ensuring widespread recognition of their commitment to supporting conservation science in the Neotropics.

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

- **Diego Alejandro Esquivel:** I serve as the Principal Investigator and project coordinator, having originally developed this research as part of my PhD thesis. I oversee all stages of the project, including conceptual design, field implementation, and overall project management.
- **Maria Joao Ramos Pereira:** Assistant Professor at the Zoology Department, UFRGS, Brazil. Research advisor and supervisor of my thesis and of the proper development of this project. Her role included the formulation of the different project phases, as well as supervision and follow-up of the proposed objectives.
- **Anderson Feijó:** Assistant Curator at the Field Museum of Natural History, and co-advisor of my thesis. He advised on multiple stages of the project and facilitated, through a grant, my visits to U.S. scientific collections, which enabled the collection of critical *Lophostoma* data at the American Museum of Natural History, the Smithsonian Institution, and the Field Museum.
- **Burton Lim:** Assistant Curator at the Royal Ontario Museum, Canada. Project collaborator. His assistance was invaluable in providing bat tissue samples collected by him and his team in the Guianas and Ecuador, as well as in facilitating access to additional tissues from other regions of the Neotropics.
- **Paúl M. Velazco:** A recognized expert in the systematics and taxonomy of Neotropical bats and a leading specialist on the genus *Lophostoma*. He assisted with the collection of morphological data and provided guidance during key stages of the project.
- **Camilo Salazar:** Professor at the Universidad del Rosario, Colombia. Expert in genetics. He advised on the methodological aspects of molecular analyses and provided access to his laboratory for DNA extractions and PCR work.

10. Any other comments?

We extend our sincere gratitude to The Rufford Foundation for their financial support, which made this research possible. Their commitment to supporting conservation science has been instrumental in advancing our understanding of cryptic bat diversity in the Neotropics. This funding enabled us not only to conduct rigorous field research but also to engage meaningfully with local communities, ensuring that conservation efforts are grounded in both scientific evidence and community participation. The

Rufford Foundation's investment in this project represents an investment in the long-term conservation of Neotropical biodiversity.

ANNEX – Financial Report
[Intentionally removed]