

Final Evaluation Report

| Your Details | |
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| Full Name | Gabriel Felipe Peñaloza Bojaca |
| Project Title | Diversity and distribution of the <i>Dendroceros</i> genus in Brazil and Colombia, implications for the conservation of montane forests in tropics |
| Application ID | 27208-1 |
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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 |
|---|--------------|--------------------|----------------|--|
| To compare the material collected with original material for the taxonomic determination of these new specimens | | | | It was possible to compare the collected material with Type specimens from national and international herbaria (CANB, CHR, CONC, CONN, DUKE, G, NY, S herbaria, acronyms according to <i>Index Herbariorum</i>). |
| To confirm the presence of the species reported years ago in the ecosystem, improving data on the current conservation status of each species | | | | We confirm the presence of the three species of <i>Dendroceros</i> (<i>D. crispus</i> ; <i>D. crispatus</i> ; <i>D. breutelii</i>) for Brazil and Colombia. Moreover, we managed to extend the range of distribution of these three species in the ecosystems studied. We also recorded and expanded the previous records of other hornworts species in these two countries. |
| To know the current state of diversity of the group, increasing previous information of/on the diversity of their ecosystems | | | | We expanded the distribution range of <i>Dendroceros</i> species and other hornworts to Brazil and Colombia. For example, in Colombia individuals of the genus <i>Dendroceros</i> were recorded for three new departments (RIS, BOY, CAQ). |
| To collect ecological data of the group to establish criteria on the state of conservation of the genus | | | | It was possible to increase the numbers of records of the group in these two countries, which is a first step to knowing the conservation status. However, to develop a reliable assessment of the conservation status of the <i>Dendroceros</i> genus in these ecosystems, it is necessary to continue exploring new locations, to establish a definitive concept. |

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

The three main achievements of our project were:

- a).** Confirm the presence of *Dendroceros crispus* (Sw.) Nees, *Dendroceros crispatus* (Hook.) Nees and *Dendroceros breutelii* Nees in Brazil and Colombia, in addition to

recognising their altitudinal distribution range that covers 800 - 2300 m above sea level, in cloud forests and the Atlantic Forest.

b). We expanded the range and distribution records of *Dendroceros* species and increased the information on other genera of this group such as *Anthoceros*, *Nothoceros*, *Phaeoceros* and *Phaeomegaceros* (Fig. 1), by visiting new areas where there was previously no information of hornworts in Brazil and Colombia.

c). Likewise, this project allowed us to recognise ecological characteristics of hornworts in their natural habitat (e.g., preferred habits, humidity and exposure to light), which were poorly known. This knowledge encouraged novel research questions that were or are being analysed and replicated in the laboratory. For example, contrasting responses between life stages (gametophyte vs sporophyte), species of the same genus, and hornwort genera to desiccation factors. They will allow us to study the ability of these plants to respond to dry periods. Helping to understand the ecological dynamics of hornworts and their ecosystems, as well as contributing to the conservation and preservation of vegetation, as well as allowing the improvement of mitigation measures against environmental impacts such as climate change.



Figure 1 Hornworts genera in the Brazilian Atlantic Forests and the Colombia Cloud Forests. A: *Dendroceros*; B: *Nothoceros*; C: *Anthoceros*; D: *Phaeoceros*.

The most significant achievement of this work is to provide information to the diversity, ecology, and conservation of *Dendroceros* species, as well as to the other genera of hornworts present in the cloud forests and the Atlantic Forest. In this forest formation, the presence of these plants can help to improve the tools for environmental protection and conservation (Fig. 2A, B). Additionally, this work

provided important information that potentially can be used in environmental education processes with the community for protection of forests, water, air, and animals (Fig 2C).



Figure 2 activities in field. A: exploring new habitats with hornworts; B: processing of collected samples; C: Interactions with community.

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

Our project involved a large amount of time in the field, visiting different locations. This activity was divided into two stages. The first phase of field work was completed between January and February 2020, before the COVID-19 pandemic. We visited four locations in the Brazilian Atlantic Forest, in three conservation units: 1) Serra dos Órgãos National Park; 2) Serra da Bocaina National Park; and 3) Serra do Mar State Park, where we went to two sites, Núcleo Itutinga-Pilões and Núcleo Santa Virginia. A fourth location, Serra da Mantiqueira Park, was included in our original proposal. However, due to transportation and lodging difficulties, the visited and the work had to be cancelled.

Next, we had planned field visits in Colombia for June 2020. Unfortunately, this trip was not possible due to the COVID-19 pandemic, and the sanitary protection measures and restrictions applied worldwide. To solve this problem and to thoroughly develop our project, we rescheduled our activities, postponing our trip to Colombia to 2021 and contacting our collaborators in that country to carry out these field surveys. Finally, we were able to visit regions where these types of plants had never been sought. We visited three locations in the department of Antioquia (municipality of San Pedro de los Milagros, Quebrada Sucia; municipality of San Luis, Quebrada Belen; and in the municipality of Sabaneta, in the La Romera Ecological Park) and one area in the department of Cundinamarca (municipality of Zipacon).

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

The recognition of hornwort species in their environments and the possibilities to share this knowledge by producing and distributing educational material to expand the knowledge that the communities have about bryophytes and, specifically, about hornworts. This could be developed with local population who accompanied

us during the field expeditions. We showed and explained to them where to find and how to recognise these plants, along with the benefits that they can get by protecting them. Additionally, we shared educational material with the natural parks and ecological reserves that were visited. For those purposes, we will send an electronic link with a video, and scholar an educational activity which presents, in a non-technical language, information about hornworts and their relationship with cloud forests and the Atlantic Forest.

Bellow, we present a list of the visited areas for which we will share the video (link the Spanish version: <https://youtu.be/F67bg2UCKFY>; and the Portuguese version: <https://youtu.be/gAKFUWY2LKY>). Likewise, this will be shared by different social networks such as YouTube, Facebook, and Instagram.

1. Serra dos Órgãos National Park (BR).
2. Serra da Bocaina National Park (BR).
3. Serra do Mar State Park, Núcleo Itutinga-Pilões (BR).
4. Serra do Mar State Park, Núcleo Santa Virginia (BR).
5. La Romera Ecological Park (COL).

Additional places:

6. Três Picos State Park (BR).
7. Desengano State Park (BR).
8. Tijuca National Park (BR).
9. Tinguá Biological Reserve (BR).



Figure 3 Examples of locations visited in the Brazilian Atlantic Forests and the Colombia Cloud Forests. A: Serra do Mar State Park, Núcleo Santa Virginia (BR); B: Serra da Bocaina National Park (BR); C-D: La Romera Ecological Park (COL).

5. Are there any plans to continue this work?

Yes, I have plans to continue working with *Dendroceros* and hornworts. Thanks to Rufford's funding, we have made important advances in understanding the diversity, distribution, and ecology of hornworts. But there are still locations that need to be explored in the Neotropics, where I hope to continue searching for these plants. Furthermore, new research questions are emerging with the implementation of new technologies (e.g., genomics, proteomics and epigenomics). These new tools when implemented with approaches such as stress tolerance, reproductive biology, cyanobacterial plant symbiosis, microbiome, among others, can potentially help answering multiple ecological enigmas of the evolution, reproduction, propagation, or even interaction of these plants with their environment. I expect to address some of these questions in an upcoming post-doctorate or when I start my work as a professor with a research group.

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

The different results produced in/by this project are being shared through published scientific articles (new occurrence of a hornwort for Colombia - Doi: 10.5252/cryptogamie-bryologie2020v41a9; new record of a hornwort for Brazil (Doi:10.1080/03736687.2021.1942590) and a video). In addition, a paper on the ecological characteristics of *Dendroceros* and their resistance to drought stress in cloud forests is under submission in a scientific journal. Likewise, a video was published online on the different social platforms about the importance of *Dendroceros* and bryophytes in general in the cloud forests of Colombia and the Atlantic Forest in Brazil.

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

An important next step may include the development of studies of diversity of hornworts and bryophytes in areas poorly or no studied in Brazil and Colombia, increasing the knowledge about the ecology, reproduction, propagation, and interaction of this group. Key factors to understand the plant composition and its relationship with it will allow the construction of a better and a more efficient plant environmental management in highly threatened areas, such as improving the conservation programmes of the protected areas in these two countries. Further, the information produced will help the integration of the community in the conservation processes, by building new mechanisms for protection and preservation of these plants, with a responsible and sustainable use.

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?

During the project, I presented works on the diversity of *Dendroceros* and hornworts in Brazil and Colombia different conferences at congresses, symposiums, and workshops. For example, in 2021 the "Bryophytes, lichens, and northern ecosystems in a changing world"; "Conversatorio Briología Colombiana" international event; the "Primer conversatorio colombiano de briología" in Colombia; the course "Afinal, qual é a utilidade das briófitas" offered in the Postgraduate Program in Plant Biology at the Universidade Federal de Minas Gerais, and "III Simpósio de Botânica Aplicada" for university students in Brazil. The Rufford Foundation logo was used as one of the main funding agencies for this project and was highlighted as a potential funding agent for research with an emphasis on conservation. Additionally, in the two published articles (Doi: 10.5252/cryptogamie-bryologie2020v41a9; 10.1080/03736687.2021.1942590), as well as in the two others in the process of being submitted to indexed journals, the foundation was acknowledged for its financial support.

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

Gabriel Felipe Peñaloza Bojacá (Principally researcher): I had a responsibility to coordinate this project. For example, I ordained the logistic to travel in the differences places to collected sampling in Brazil and Colombia. Moreover, I was

responsible to sampling, morphological/taxonomical identification, like in the conceptualize the aims, hypotheses, methodology and written of the papers.

Adaíses Simone Maciel da Silva (Professor of the Department of Botany - Universidade Federal de Minas Gerais): She is expert in Biology of Bryophytes and helped me in coordinate project, an interpret the ecology of Dendroceros, sampling and experimental methods. In addition, she has collaborated with the papers, especially of aims, hypotheses, methodology and written revision.

Juan Carlos Villarreal (Professor of the Department of Botany - The Laval University, Canada): He is a hornworts' expert in the world and has helped to confirm taxonomical determination and to interpret the morphological/ecological characteristics of the genus. In addition, he has collaborated with the construction of the papers, especially in structure of aims and written revision.

Mateus Fernandes and Cíntia Araújo were important in the laboratory support, during the process of identification and processing of the testimonial material that was deposited in the BHCN herbarium of the Universidade Federal de Minas Gerais.

10. Any other comments?

Finally, I would like to acknowledge the opportunity provided by The Rufford Foundation in funding this exciting project. The grant received allowed me to improve different skills such as responsibility, leadership, teamwork, project management, communication, among others. Those are essential factors to continue working and researching for the benefit of the care and conservation of nature.