# UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

**Colegio de Ciencias Biológicas y Ambientales**

## Preliminary taxonomical and conservation analyses of the *Porroglossum* Schltr. genus, Echidna section in Ecuador

.

**Alisson Betsabeth Fierro Minda**

**Biología**

Trabajo de fin de carrera presentado como requisito
para la obtención del título de
Bióloga, concentración en Biodiversidad y Conservación

Quito, 21 de mayo de 2021

# UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

**Colegio de Ciencias Biológicas y Ambientales**

**HOJA DE CALIFICACIÓN**
**DE TRABAJO DE FIN DE CARRERA**

**Preliminary taxonomical and conservation analyses of the *Porroglossum* Schltr. genus, Echidna section in Ecuador**

**Alisson Betsabeth Fierro Minda**

| | |
|---|---|
| **Nombre del profesor, Título académico** | **Gonzalo Rivas-Torres, Ph, D.** |

Quito, 21 de mayo de 2021

# © DERECHOS DE AUTOR



Nombres y apellidos: Alisson Betsabeth Fierro Minda

Código: 00201126

Cédula de identidad: 1750449884

Lugar y fecha: Quito, 20 de mayo de 2021

# AGRADECIMIENTOS

Agradezco infinitamente a Gonzalo Rivas quien fue mi director de este trabajo y en especial a Luis Baquero, por su valiosa ayuda a lo largo del mismo. Igualmente quiero agradecer a Janeth Santiana, Leonardo Zurita y Diego Andrade por toda su ayuda en esta investigación.

A mi mamá por su constante apoyo, paciencia y amor, por criarme y realizar innumerables sacrificios con el fin de garantizar mi bienestar.

A mis amigas Alissen Haro, Paola Espinosa y Martina Albuja porque me ayudaron mucho más de lo que creen y la gratitud que les tengo supera lo que logro expresar con palabras.

A la naturaleza por crear seres tan sorprendentes y a mí, en nombre del amor propio, por hacer este trabajo posible.

# ACLARACIÓN PARA PUBLICACIÓN



# UNPUBLISHED DOCUMENT

# RESUMEN

El género *Porroglossum* Schltr. (Orchidaceae) se caracteriza por la presencia de un labelo móvil que se cierra al ser estimulado. Una de las secciones más notables de este género es la sección Echidna, la cual es fácilmente diferenciada por la presencia de un pedúnculo floral pubescente. Sin embargo, poco se conoce sobre la taxonomía, distribución y ecología de este grupo. El objetivo de este estudio fue generar información relevante para la sección Echidna. Para cumplir este objetivo, se generaron los siguientes resultados: un dendrograma creado a partir una matriz de rasgos usando características taxonómicas relevantes, permitió conocer que preliminarmente, se diferencian 3 grupos que comparten rasgos que los discriminan taxonómicamente; usando un análisis de PCA, se pudo determinar preliminarmente que cada especie puede ser diferenciada por medio de las características de tres órganos principales: sépalos, labelo y pedúnculo; finalmente, mediante modelamiento de nicho climático potencial, se pudo entender que, en principio, el nicho potencial de las especies registradas en Ecuador está amenazado principalmente por actividades mineras, lo cual pone en amenaza su conservación. Justamente, un análisis de conservación utilizando la herramienta GeoCAT, permitió determinar de manera inicial, que las especies evaluadas se encuentran en alguna categoría de amenaza según la UICN. En conclusión, si bien los resultados aquí presentados son un gran paso hacia el conocimiento de este grupo, es imperante recolectar más información a nivel poblacional de estos taxones, así como recopilar más datos ecológicos y de distribución, que permitan realizar entre otros, análisis moleculares para entender sus relaciones filogenéticas.

**Palabras clave:** conservación, ecología, nicho climático potencial, *Porroglossum echidna, Porroglossum hystrix, Porroglossum muscosum*.

# ABSTRACT

The genus *Porroglossum* Schltr. (Orchidaceae) is characterized by the presence of a mobile labellum that snaps shut when stimulated. One of the most notable sections of this genus is the Echidna section, which is easily differentiated by the presence of a pubescent floral peduncle. However, little is known about the taxonomy, distribution, and ecology of this important group. Therefore, the general objective of this study was to generate relevant information for the Echidna section. To achieve this objective, the following results were generated: a dendrogram generated from a matrix of traits using relevant taxonomic characteristics, allowed to know that three groups are preliminary differentiated, which share traits that differentiate them taxonomically; using a PCA analysis, it can be preliminarily determined that each species can be differentiated through the characteristics of three main organs: sepals, labellum and peduncle; finally, by modeling the potential climate niche of the Ecuadorian species, it was possible to understand initially, that the potential ecological niche of the species recorded in Ecuador is threatened mainly by mining activities, which additionally threatens their conservation. Precisely, a spatially explicit conservation analysis using the GeoCAT tool, made possible to initially determine that the evaluated species are in some category of threat under IUCN. In conclusion, although the results presented here are a great step towards understanding this group, it is still imperative to collect more individuals in the field, in addition to information related to relevant ecological and biogeographic information for these species, which among others, allow to carry out molecular analyzes to understand the phylogenetic relationships and biogeographic patterns of this group.

**Key words:** Conservation, ecology, orchids, orchid taxonomy, *Porroglossum echidna, Porroglossum hystrix, Porroglossum muscosum*, potential climatic niche.

**TABLA DE CONTENIDO**

# ÍNDICE DE FIGURAS

# INTRODUCTION

The genus *Porroglossum* Schlr. was described by Rudolf Schlechter in 1920, however, the first species of this taxon was located in the *Masdevallia* Ruiz & Pav genus (in year 1855), and described as *M. echidna* by Ludwig Reichenbach (1861). Following these historical events, in 1925 Kraenzlin decided not to recognize the *Porroglosum* group and reduced it to a synonymy of the section Echidna, located within this later group in his monograph of *Masdevallia* (Kraenzlin, 1925). Finally, in 1987 and after significant changes in the group, Carlyle Luer published a monography of *Porroglossum* that included 25 species (Luer, 1987), which also incorporated taxa from previously known *Masdevallia*.

Presently, there are 54 species of this genus, distributed in the Andes of Colombia, Ecuador, and Peru mainly. Only two species of the group are recorded in other South American countries, one in Venezuela and another one in Bolivia. Ecuador seems to be the center of diversification for the genus, mainly because >70% of the described species are found in that country, specifically in the northwest and southeast slopes of the Andes, more specifically in the Cutucú and Condor mountain ranges of Morona Santiago and Zamora Chinchipe provinces (Baquero et al., 2020).

The species of *Porroglossum* are recognized for a mobile labellum that snaps shut when stimulated by pollinators, and the presence of an erect anther as its most remarkable characteristics. This combination of features are unique for the whole Pleurothallidinae subfamily, except for one species in *Stelis* Sw. (Orchidaceae), and one other in *Specklinia* Lindl (Orchidaceae) (Baquero et al., 2020). The genus *Porroglossum* has two subgenera: *Eduardii* and *Porroglossum*; and the later has three sections: Echidna, Tortae and Porroglosum. A characteristic that is present in some species of the Echidna section, that may help to recognize them, is the presence of a pubescent floral peduncle. Initially, there are only two species with this characteristic and within the Echidna section: *P. echidna* and *P. muscosum*. (Luer, 1987).

It is important for context and this work, to mention that, when *P. muscosum* was described in the year 1987, four different illustrations were needed to define its phenotype (Luer, 1987); but later in 1988, one of these illustrations was described as *P. hystrix*. This later species can be distinguished from *P. muscosum* by its smaller flowers with slender tails and verrucose sepals (Luer, 1988). For instance, the variety of the phenotypes of *P. muscosum* create taxonomic inconsistences that make the identification of this species to be difficult.

Later in 2006, Luer described *P. parsonsii*, a species without collection data, obtained from an unknown collector (Luer, 2006). The last additions to the Echidna section occurred in 2011, when Luer described *P. apolae* (Luer & Sijm), *P. dejonghei* (Luer & Sijm) and *P. myosurotum* (Luer & Hirtz) (Luer, 2011). In addition, a new species named “sp nov. ined.” which is in process of being recognized as a new taxon within Echidna section, has been included in this study, and as far as known, may count as the latest taxonomic addition to the group.

In spite of the general and overall importance to generate significant knowledge of an important taxonomic group such as Orchidaceae, and the relevant taxonomic work regarding the species of the Echidna group -that still needs to be resolved, very little is known about their taxonomic relationships (based in traits differences), ecology, distribution and conservation in all the countries that record these orchids, and in Ecuador particularly. This is why, here I aimed to generate relevant (taxonomic, geographic and conservation) information about the Echidna section of the *Porroglossum* Schlr. genus. Particularly, I wanted to first, understand the taxonomic relationships (here, the taxonomic relationships are defined as groupings based on the traits from Annex B) between the species of this group; second, resolve the taxonomic inconsistencies around *Porroglossum muscosum* for Ecuador; third, predict the climatic niche of the Echidna section species located in Ecuador; and fourth, make notes of the conservation status for this group. Finally, and for this last objective, using the biogeographic data generated here, I also specifically analyzed the endangered and conservation status for the species of this section found in Ecuador.

# METHODS

## Study area

There are six species of *Porroglossum* sec. Echidna recorded and described for South America, and distributed through Venezuela, Colombia, Ecuador and Peru. However, only 4 of them have data regarding collections details, including georeferenced locations. (Figure 1). *P. hystrix* has only been recorded in Ecuador; *P. echidna* and *P. muscosum* have been collected in Ecuador and Colombia (however *P. muscosum* has been reported in Venezuela as well). In addition, *P. apoloae*, *P. dejonghei* and *P. parsonsii* do not have further collection information than its country of provenance that is Ecuador - for the first two species- and Colombia, for the last species respectively (Annex A). Finally, a seventh species, defined here as "sp nov. ined." is in the process to be described and it is so far, only recorded in Ecuador. For this study, only only *P. echidna*, *P. hystrix* and *P. muscosum* were selected for the analyses presented below. This means specifically, that this investigation focuses in the species located in Ecuador mainly (excluding the new species mentioned before).

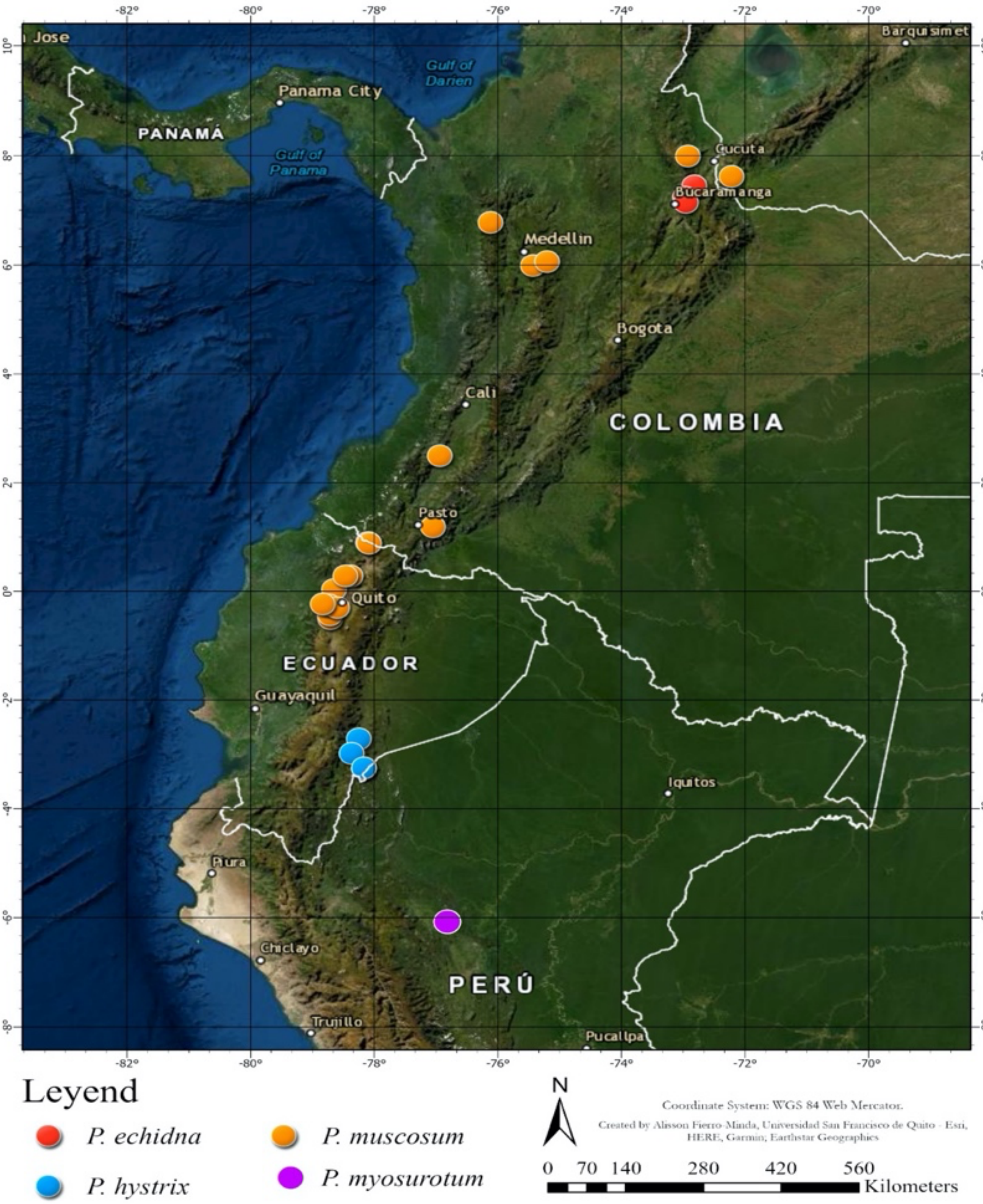


**Figure 1.** Distribution of the Echidna' section species that present collection data. The species *P. apoloae*, *P. dejonghei*, *P. parsonsii* and the new species under description (sp nov. ined.) are not included.

It must be said that that most of the areas where these species can be found in Ecuador are located inside mining zones, specially *P. hystrix* at the south of the country; the same situation occurs with *P. echidna* and *P. muscosum*, both found at the north, where there is a large amount of mining concessions. The governmental protected areas, complemented with the privately protected forest zones, cover a significant area of the country; however, they may not protect the relevant areas that could aid for the conservation of these species (Figure 2).

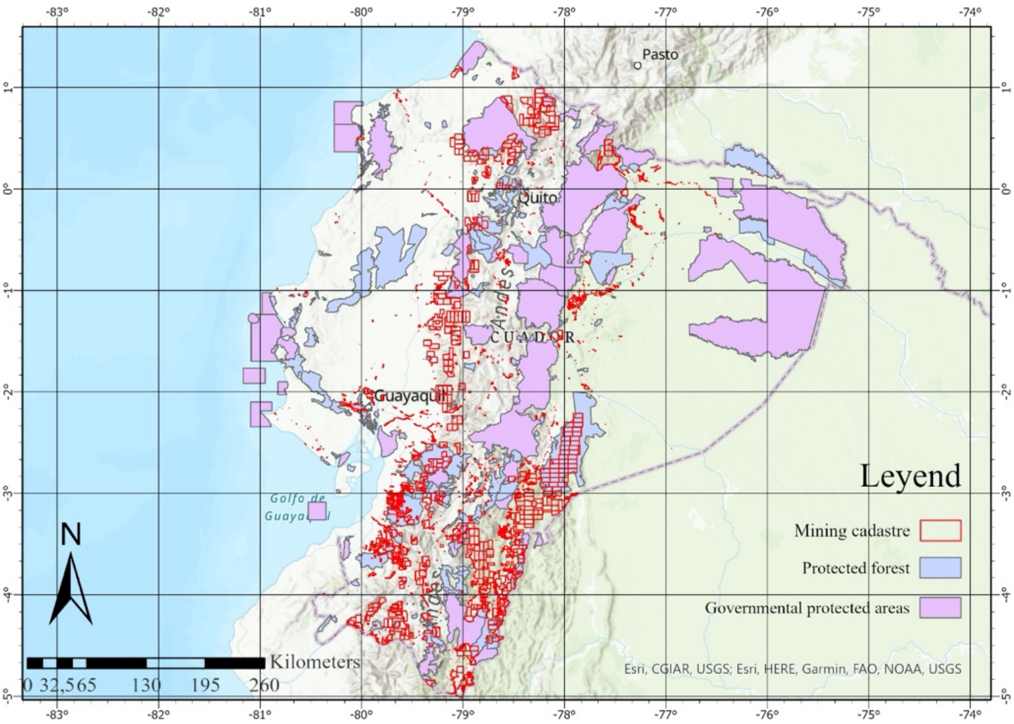

**Figure 2.** Map of the mining cadaster, protected forest and governmental protected areas of Ecuador.

**Data collection**

No field collections and material were obtained for this project, so no collection permits were needed. The collection data and information related to traits for each species, was obtained primarily from the original species descriptions (i.e papers, books and journals) and [www.tropicos.org](http://www.tropicos.org) specimens' database (retrieved April-22-2021). Ecuador, the target country of this present study, is also where most of the Echidna section species are located (n=5), but almost half of these species (n=2), don't have any information related to distribution or locations of these organisms for that country. In this context, only species with collections data available for Ecuador (*P. echidna*, *P. hystrix* and *P.*

*muscosum*) were able to be included in the biogeographic analysis presented below (Figure 3).

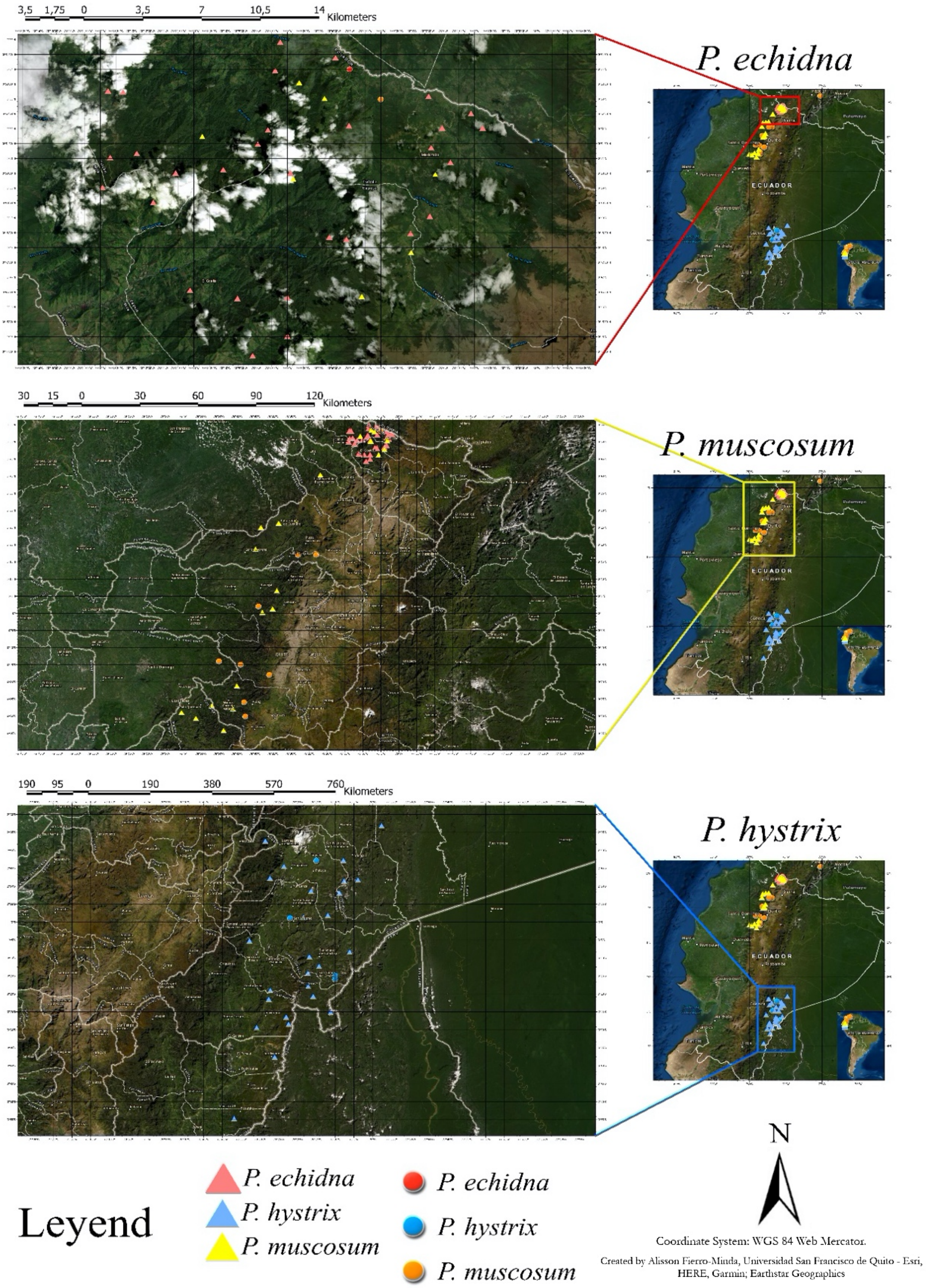


**Figure 3.** Artificial and real collection points for the Ecuadorian species of the Echidna section (Orchidaceae) used in this study. The triangles represent the artificial points, while the circles represent the real locations for the species denoted in the legend.

Due to the limited coordinates that were obtained by the primary sources mentioned above, artificial coordinates were created for every species in Ecuador; resulting in 29 artificial coordinates for *P. apoloae*, 26 for *P. hystrix* and 21 for *P. muscosum* (Figure 3). In total, real (obtained from www.tropicos.org and original descriptions) and artificial geographic points added up to 30 coordinates for each species. These artificial points were created with the help of Luis Baquero, specialist for the family in Ecuador, who located artificial points using his expertise and the following criteria: closeness to the real coordinate, altitude, presence of protected areas and presence of protected forest (Annex C). Mechanically speaking, points were created using spatial tools on ArcGIS (patch 3 ver. 2.7.1) software and following the criteria mentioned before to generate a shapefile that was later combined with the original coordinates/collection points. That resulting shapefile was later exported as a .csv file to be used in other software as explained in the following sections.

In order to know the altitude and the coordinates for each point obtained and used in this study, the web page gps-coordinates.net (retrieved in 31-03-2021) was used for such purpose. Additionally, information regarding protected areas inclusion and remnant forest associated with each record, was obtained and proved by the map layers archived under the “Sistema Nacional de Área Protegida SNAP” and “Bosque y Vegetación Protectora” projects, that can be downloaded from http://ide.ambiente.gob.ec/mapainteractivo/ and visualized using ArcGIS software as well. Some records and coordinates generated as previously specified, were not located into a protected area (especially the ones at the south of the country), because of the small extension of these protected zones mainly. The artificial locations generated in this study followed the next importance order, that is also related to a prediction of where the species might be regarding know information from true collections: first, closeness to the real coordinates; second, altitude; third, presence of protected areas; and fourth, presence of protected forest.

**Understanding the taxonomic relationships of the Echidna section (Dendrogram)**

Using the resulting traits matrix, obtained from the quantitative and qualitative characteristics of every species description and other sources described before (Annex B), a dendrogram was obtained. All the traits included in the mentioned matrix were used for this purpose, with the exemption of flower coloration of each species. Also, the qualitative characteristics were transformed into numeric values (i.e. small=1, medium=2, large=3). The data set, managed in R Studio (ver. 1.2.5033), was prepared using *readxl* (Wickham et al., 2019), *ade4* (Dray et al., 2020) and *vegan* (Oksanen et al., 2020) packages. To create a dendrogram, the UPGMA (Unweighted Pair Group Method using Arithmetic Average) clustering method was performed using *cluster* (Maechler et al., 2021) and *gclus* (Hurley, 2019) packages under the same mentioned open software.

**Resolving the taxonomic inconsistences of the Echidna section (PCA)**

To examine the influence of the taxonomical variables (Annex B) in the species differentiation, a Principal Component Analysis (PCA) was performed (using RStudio ver. 1.2.5033). An outgroup was included for this purpose as a “taxonomic control”, to highlight the similarities between the species of the Echidna group. The outgroup species used here was *Masdevallia picturata* Rchb. f., that was selected due to the molecular closeness of this genera to *Porroglossum* Schlr. shown by McDaniel (2019). To visualize the different traits used in the mentioned matrix and understand its influence to spatially and statistically place the species in the PCA, the vectors of this graphic interface were activated according to instructions under package *ggfortify* (Horikoshi et al., 2020). The vectors shown in resulting figures, represent every taxonomical characteristic from

Annex B that influence the spatial statistical closeness for all the analyzed species. All of the traits compiled in Annex B were included in this analysis, due to the lack of reported specific traits that may help to discriminate for the identification of each Echidna' section species.

**Climatic niche prediction of the *Porroglosum* species recorded in Ecuador (MaxEnt)**

The variables used here to calculate the climatic niche of the three speies of this group recorded in Ecuador, were obtained from the Worldclim website (http://www.worldclim.org/current), which is the main source of this kind of abiotic variables for MaxEnt modeling (Ciss et al., 2019). The historical monthly weather data of WorldClim only includes three variables: minimum temperature, maximum temperature and precipitation. For this study, only the temperature variables and elevation at a spatial resolution of 2.5 minutes (~21km$^2$) were included. Additionally, only WorldClim data from the year 2018 onwards, was selected and used here, because first, it was the most recent year available in this platform for the regions of interest; and second, due to the large amount of information that was needed to process climatic data from previous years (that may exceed the last of this thesis project).

These three variables obtained from WorldClim, were transformed to raster layers (using ArcGIS Pro patch 3 ver. 2.7.1), in order to show data only from Ecuador. After that, all raster layers were ready to analyze in the modeling software MaxEnt (ver. 3.4.3), which takes the artificial and real locations (Annex C) and the raster layers (WorldClim) to estimate the density of plant presences in a grid cell (Merow et al., 2013). The grid cell size for this analysis was 0,026 degree units. The modeling result generates a map of the potential climatic niche for the species *P. echidna, P. hystrix* and *P. muscosum* (see Data Collection section for more details about species selection).

**Making notes of the conservation status of the *Porroglosum* species recorded in Ecuador (GeoCAT)**

The Geospatial Conservation Assessment Tool-GeoCAT (http://geocat.kew.org/) use occurrence data, to perform semi-automated IUCN Red List assessments and analyses, in order to ease the process directed to assess the conservation status of target species (Bachman et al., 2011). Here, this tool was used to predict the possible conservation status of *P. apoloae*, *P. hystrix* and *P. muscosum*, using only records from www.tropicos.org (Annex D). Ecological information and the genus' expert opinion was relevant to analyze each threatening status obtained from GeoCAT. Parameters to perform such analysis were set under criterion B (that includes the summary of five criteria) used to evaluate threatening categories (more details in IUCN Standards and Petitions Committee, 2019 http://cmsdocs.s3.amazonaws.com/RedListGuidelines.pdf) using this tool. This criterion is a strong predictor for the extinction risk of a taxon, that is based on the evaluation of the species geographic range (Le Breton et al., 2019).

## RESULTS

**Understanding the taxonomic relationships of the *Porroglossum* species (Orchidaceae) within the Echidna section**

In order to answer the first objective of this investigation, the resulting dendrogram obtained for that purpose (Figure 4, UPGMA cophenetic=0.728; where 1 is an excellent representation of the reality based in the model information), allowed to recognize three main groups organized according to similarities and dissimilarities of their traits: the first, composed by *P. apoloae* and *P. myosurotum*; the second, which is the larger one and includes two subgroups *P. dejonghei* related to *P. parsonsii* and the "sp nov. ined." related to *P. hystrix*; and finally, in a third cluster, *P. echidna* and *P. muscosum* are placed together.

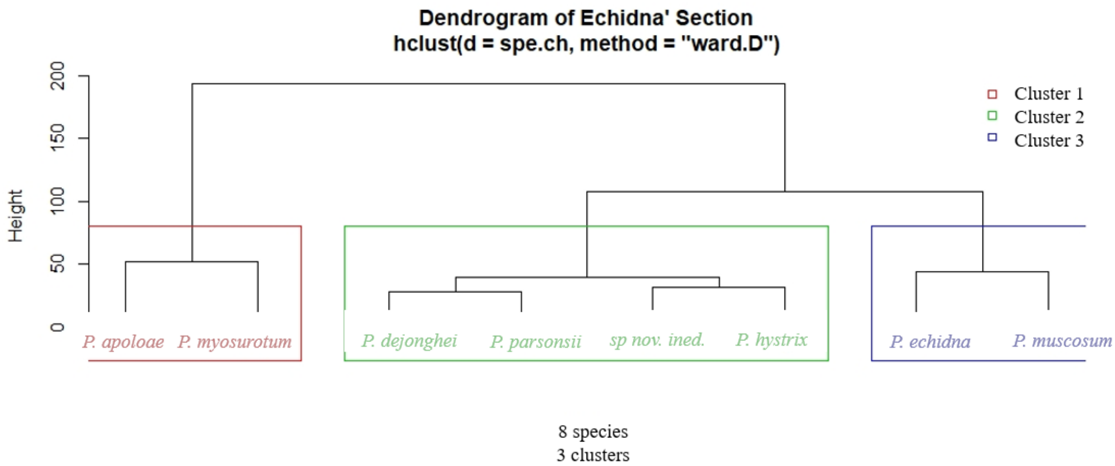


**Figure 4.** Dendrogram of Echidna section. Each number represents a species, 1 is *Porroglossum apoloae*, 2 is *P. dejonghei*, 3 is *P. echidna*, 4 is *P. hystrix*, 5 is *P. muscosum*, 6 is *P. myosurotum*, 7 is *P. parsonsii* and 8 is a new inedited *Porroglossum* species (sp nov. ined).

**Resolving the taxonomic inconsistencies around *Porroglossum muscosum* for Ecuador**

To answer the second objective of this study, the resulting PCA (variance of 39.23% for PC1 and 19% for PC2, meaning 58.23% is the maximum variance that the data allow to explain using this analysis), allowed to asses that 3 clusters can be identified, grouping the target species in the following way: *P. apoloae* near to *P. myosurotum* in the first cluster*; P. dejonghei, P. hystrix, P. parsonsii* and sp nov. ined.in the second cluster; and *P. echidna* with *P. muscosum* in the third cluster. These clusters, formed after the PCA ordered the mentioned species according to their statistical (and trait) differences, is in congruency with the cluster (Figure 5) also obtained in this study.

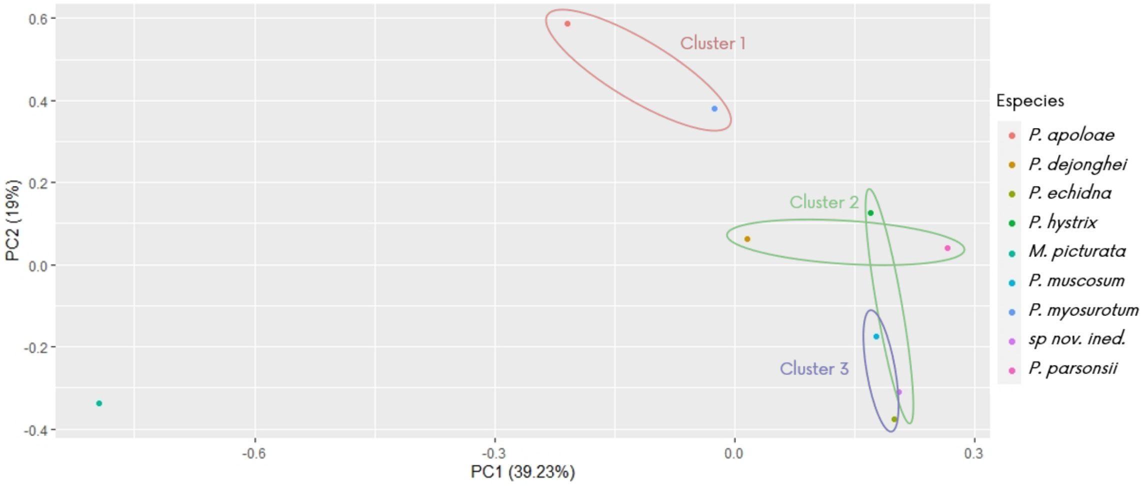

**Figure 5.** Principal Component Analysis (PCA) that used artificial ellipses to obtain the clusters presented in this diagram. The artificial ellipses shown here are presented for visual purposes (i.e to group them according to proximity); meaning they do not denote statistical grouping and support.

The second figure of this analysis (Figure 6) was generated as a complement of the abovementioned PCA, shows vectors for all traits used in this analysis in order to provide a visual aid regarding the taxonomic characteristics that better explain the ordination observed in Figure 5. Among those traits represented as vectors, three principal groups of characteristics should be noted, which are related to three organs: sepals, labellum and peduncle (Figure 6). It is also important to highlight among this result, that the importance of the excrescences of these two last organs (labellum and peduncle) is notorious, and as shown by corresponding vectors lengths shown in Figure 6. The column shape presents a long vector too, but the importance of this trait must be associated with the differences between genus *Porroglossum* Schlr. and *Masdevallia* Ruiz & Pav., more than the differences within the species of the Echidna section, as all the species of the group have the same column shape length.

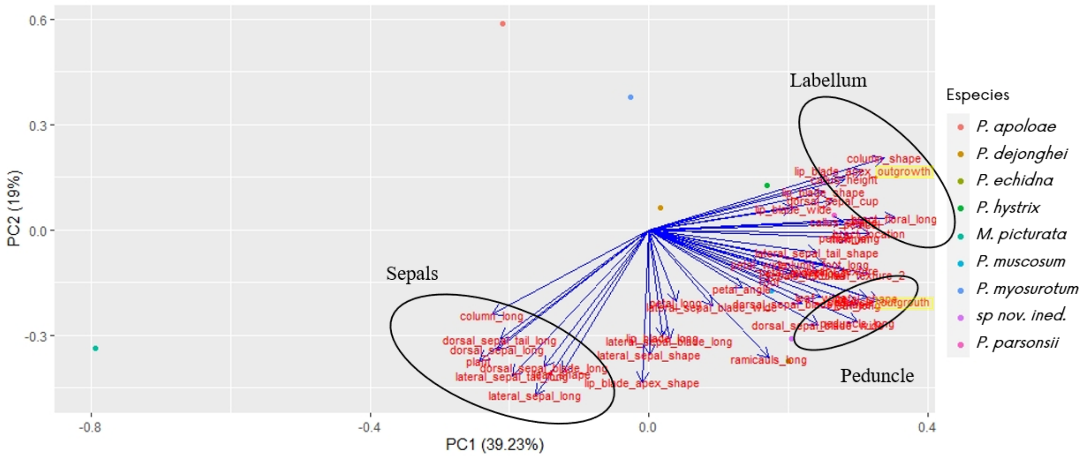

**Figure 6.** Vectors from the Principal Component Analysis (PCA) from every characteristic listed in the traits matrix-Annex B. Each vector represents a characteristic of Annex B and the names highlighted in yellow represent the characteristics related to the excrescences of the labellum and peduncle.

## Climatic niche predictions for the three *Porroglossum* species of the Echidna section (Orchidaceae) occurring in Ecuador

To answer the third objective of this research, three predictive climatic niche models were obtained with a training AUC of 0.997 for *P. echidna;* 0.980 for *P. hystrix* and; 0.989 for *P. muscosum*. The resulting maps (Figure 7) show the predictive climatic niche for each of the three species. The warmer colors show the areas where the probability of occurrence of a suitable climatic niche for the species is greater, while the areas with colder colors are those where the probability of occurrence of a “proper” climatic niche is lower.

A more suitable climatic niche for *P. echidna* is principally defined in the Andean foothills located at the northwestern part of the country, specifically from Carchi (in the north) to Cotopaxi (south) provinces. However, it is important to notice that at the eastern side of the Andean mountain range, the obtained models show there is at least a 50% chance to also find a suitable climatic niche for this species, more specifically near the frontier between Sucumbíos province and Colombia (Figure 7a). On the other side, *P.*

*hystrix* predicted climatic niche distributes around the Condor mountain range located in the southeast part of the country (with more than a 85% probability), but it also extends through the central and northern Amazon foothills (in the provinces of Napo, Pastaza and Tungurahua) with a 20-30% chance for presence of suitable conditions in those sites. The predicted climatic niche of this species also includes (with a 50% chance) Morona Santiago and Zamora Chinchipe provinces (in addition to the Condor cordillera also recorded within those political limits). The central and south areas of Morona Santiago is where the probabilities to find the best climatic niche for this species are higher (Figure 7b). The predicted climatic niche for *P. muscosum* shows a high suitability in the Andean foothills located mainly within Carchi and Cotopaxi provinces; however, Imbabura province shows the areas with the highest probabilities to find the species. It is also important to highlight that according to the modelling techniques used here, suitable climatic niches for *P. muscosum* to occur, are even found in the forests around Quito, the capital of Ecuador, that is highly urbanized (Figure 7c.). Finally, is also relevant to notice that there is a minimum chance to find appropriate climatic niches of *P. muscosum* in the eastern side of the northern Andes of Ecuador, or in the same areas where *P. echidna* climatic conditions are better for the presence of this later taxa.

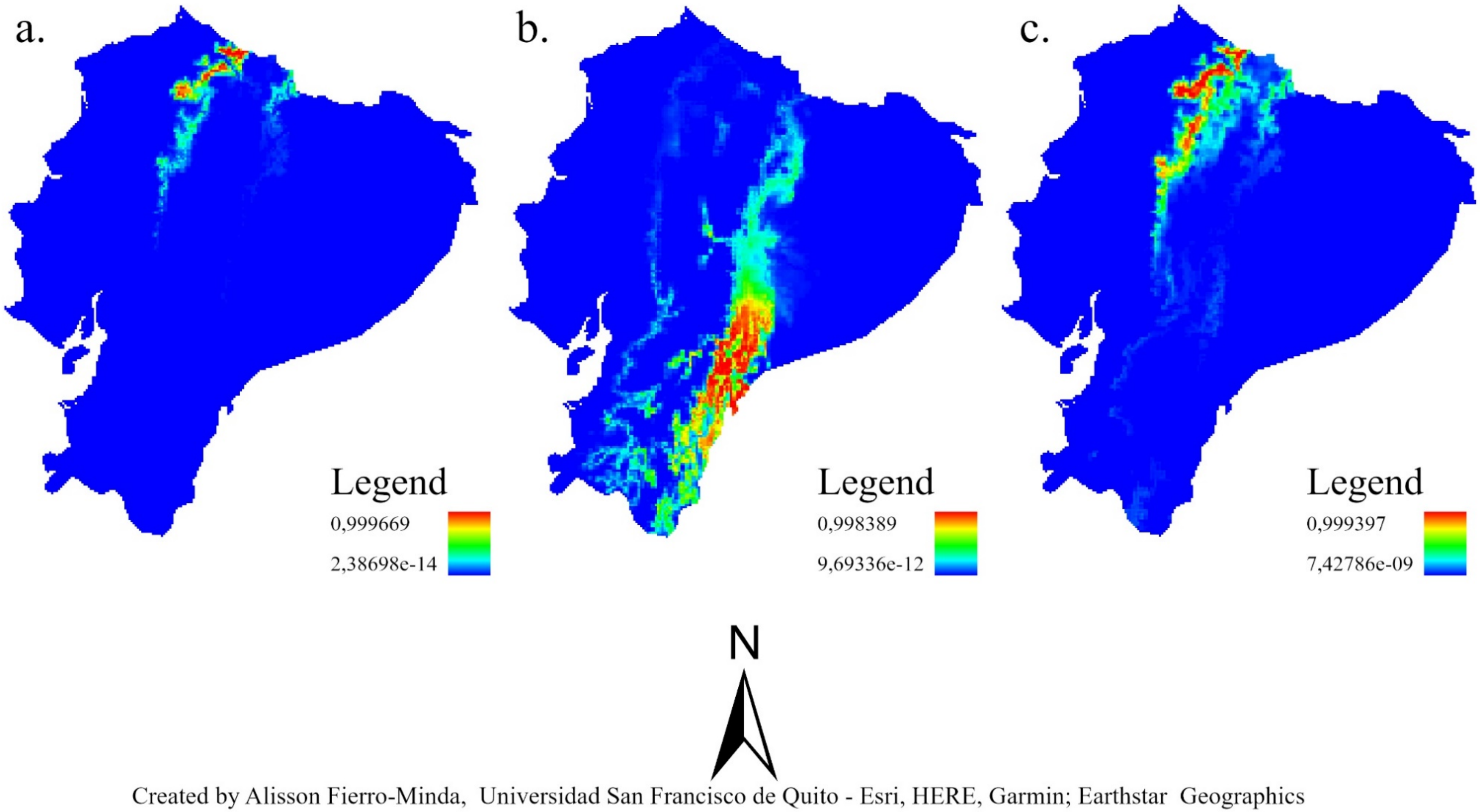


**Figure 7**. MaxEnt climatic niche modelling for the Ecuadorian species of the Echidna (Orchidaceae) section: a. *Porroglossum echidna* located at the north, b. *P. hystrix* located at the south and c. *P. muscosum* located at the north. Warmer colors show the areas with better predicted climatic conditions for these species, while colder colors show the opposite.

**Conservation status analysis for Echidna section species found in Ecuador.**

To answer this fourth and final objective of this study, two standardized measurements: the Area of Occupancy (AOO) and the Extent of Occurrence (EOO), were calculated using GeoCAT tool (http://geocat.kew.org). To calculate AOO, GeoCAT evaluates and includes in the analysis the fact that species usually don't occur throughout its whole EOO, because of the presence of unoccupied or unsuitable habitats. The area of occupancy-AOO then, is defined as the smallest (2km grid size recommended - IUCN Standards and Petitions Committee, 2019) zone in which a taxon can inhabit within its EOO. On the other hand, Extent of Occurrence-EOO is the area contained inside the smallest polygon (where no internal angle is greater than 180 degrees) that encompass all the occurrences of a species (IUCN, 2012; Joppa et al., 2016).

The calculated EOO for *P. echidna* was 0 $km^2$ while its AOO was 4 $km^2$. These results might be explained by the fact only one real occurrence was used for this particular species and analysis. Additionally, there are many ongoing mining concessions operating in the vicinities of this occurrence, that in the end, may affect such calculations too. These results help to set the threatening category for *P. echidna* as "Critically Endangered B1ab(iii); B2ab(iii)".

For *P. hystrix* on the other hand, the calculated EOO was 537,038 $km^2$, while its AOO was 12 $km^2$; which places this species as "Endangered B1ab(iii); B2ab(iii)" according to GeoCAt and IUCN definitions. This categorization also takes into account the metal mining around its distribution area and the lack of protected zones at the south of the country.

Finally, *P. muscosum* was placed under the same category as *P. hystrix*; however, its EOO is 2196,441 $km^2$ and its AOO is 32 $km^2$, which are the largest AOO and EOO values respectively, for all the three taxa analyzed here.

## DISCUSSION AND CONCLUSIONS

### Understanding the taxonomic relationships of the Porroglossum species (Orchidaceae) within the Echidna section

The dendrogram obtained here, and used to answer objective one, explains how the species are grouped, based on the morphological characteristics of these plants. However, these relationships don't seem to be related to the geographical distances recorded between of every species. Further collections are needed to explore if these kinds of patterns remain when more individuals are included in posterior analyses.

Results from the principal components analysis (PCA) also allowed to preliminarily understand that three organs are the most important for species differentiation and can be used as diagnosis traits in the future, these organs are: labellum, peduncle and sepals. It is suggested that for future similar analyses to include quantitative measurements of these traits like excrescences of the peduncle and labellum, which seem to have an important role for plant distinction.

### Resolving the taxonomic inconsistencies around *Porroglossum muscosum* for Ecuador

The synonymized species *P. apoloae* Luer & Sijm and *P. myosurotum* Luer & Hirtz, are clearly related, but should not be treated as the same taxa, according to the preliminary results presented here. Their main difference lies in the length of the peduncle; in *P. myosurotum* this organ is almost three times longer. Other reason for this species separation is the labellum shape, in *P. apoloae* it is triangular while for *P. myosurotum* is spathulate. The sepals shape is really similar in length and wide when both species are compared, which only differs in ~1mm between both of them. However, the petals of both species show remarkable and unique characteristics for each of them, such as the rounded apex and the acute angled lobe in the upper margin of *P. apoloae*; as well as the clavate apex and the absence of lobes in the margins of *P. myosurotum*.

In Icones Pleurothallidinarum IV (Luer, 1987) the manuscript describing taxa within this group, one of the four illustrations from the original description of *P. muscosum*, clearly doesn't correspond to this species. This conclusion is reached based on the characteristics of the sepals, labellum and peduncle that were found and used in this study, and later directly contrasted with the mentioned publication. For instance and after a short analysis on this regard, the illustrations plates numbered as 2941 (Annex E) and 4304 (Annex F) that are part of the species description (Luer, 1987), show similarities that can help to recognize *P. muscosum*. First, the peduncle length, which is longer in comparison with the plant' height for both illustrations (but not for plate number 8714; Annex G); second, the labellum shape for illustration plates 2941 and 4304 that is spathulate, while the labellum shape of illustration plate 8714 is obovate; third, the outgrowth in the labellum of illustration plates number 2941 and 4304 is small, almost pilosus, but for the last illustration (8714), it is ciliate; and fourth, the sepals described in illustration plate 8714 are slightly smaller than the ones in the other illustrations. Is important to mention that all these plates, and the described inconsistencies, belong to one publication and the same description, showing the difficulties that arise when describing new species, since there may be phenotypes that can be easily misidentified by researchers.

**Climatic niche predictions for the three *Porroglossum* species of the Echidna section (Orchidaceae) occurring in Ecuador**

In relation to the climatic niche models presented here, is important to emphasize that resulting maps might not reflect accurately where these species can be actually located, as only 3 variables (minimum temperature, maximum temperature and elevation) due to time constrains, where used in this study.

However, when the maps obtained here showing the predicted climatic niches are analyzed for the three taxa recorded in Ecuador, it is almost striking how the lack of protected areas (that can include the potential climatic niches of the analyzed species) is almost generalized. For example, in *P. echidna* and *P. muscosum* predicted climatic niche models, only one governmental protected area, the Cotacachi Cayapas National Park, was intersecting those potential niches. However, on the other hand, it is also important to mention that Reserva Dracula, a private protected area of primary forest and located at the northern part of the country, intersects with a significant portion of the calculated potential niches of both *P. echidna* and *P. muscosum*. A similar pattern, where the mentioned protected area intersects with *P. hystrix* which is endemic for Ecuador, also can be observed.

**Conservation status analysis for Echidna section species found in Ecuador**

Finally, it is important to mention that for the preliminary results regarding conservation status of the target taxa, more collections are also necessary to better estimate in the future the EOO and AOO for the species used in this investigation. Additionally, most of the collected information used here is coming from old records, (i.e. the year 2001 records the most recent collection for *P. hystrix*, Tropicos.org, 2021b; while the year 1973 records the only time when *Porroglossum echidna* was collected, Tropicos.org, 2021a; and 1989 the last time *P. muscosum* was recorded in the wild, Tropicos.org, 2021c). There is a collection of *P. muscosum* from 1990, but it was not included in these analyses due to its lack of coordinates, collection number and collector full name (Tropicos.org, 2021c). In spite of the limited number of collections used in this study, is important to clarify that also other investigations (de Siqueira et al., 2009; Hernandez et al., 2006; Guisan et al., 2006; Williams et al., 2009) have used very few samples for similar objectives as the ones presented here, that can be a normal caveat when working with rare species in the wild. These investigations also agreed that the methods used here for assessing threats and to provide a conservation category to rare taxa, can be used as valid mechanisms for that purpose.

In general, the preliminary data presented here, provide a good baseline information to start understanding important patterns regarding the taxonomy, distribution and conservation status of this important group. However, future and follow-up studies are also needed, in order to provide more complete information that can help to delineate, among others, proper managerial plans that seek to preserve these unique organisms.

**REFERENCES**


Bachman, S., Moat, J., Hill, A., Torre, J., & Scott, B. (2011). Supporting Red List threat assessments with GeoCAT: Geospatial conservation assessment tool. *ZooKeys*, *150*, 117-126. https://doi.org/10.3897/zookeys.150.2109

Baquero, L. E., Fierro-Minda, A., & Yeager, J. (2020). A new species of Pleurothallidinae (Orchidaceae) from the south-east of Ecuador. *Lankesteriana*, 129-136. https://doi.org/10.15517/lank.v20i2.41722

Ciss, M., Biteye, B., Fall, A. G., Fall, M., Gahn, M. C. B., Leroux, L., & Apolloni, A. (2019). Ecological niche modelling to estimate the distribution of Culicoides, potential vectors of bluetongue virus in Senegal. *BMC Ecology*, *19*(1), 45. https://doi.org/10.1186/s12898-019-0261-9

de Siqueira, M. F., Durigan, G., de Marco Júnior, P., & Peterson, A. T. (2009). Something from nothing: Using landscape similarity and ecological niche modeling to find rare plant species. *Journal for Nature Conservation*, *17*(1), 25-32. https://doi.org/10.1016/j.jnc.2008.11.001

Dray, S., Dufour, A.-B., Thioulouse, and J., Jombart, with contributions from T., Pavoine, S., Lobry, J. R., Ollier, S., Borcard, D., Legendre, P., & Chessel, S. B. and A. S. B. on earlier work by D. (2020). *ade4: Analysis of Ecological Data: Exploratory and Euclidean Methods in Environmental Sciences* (1.7-16) [Computer software]. https://CRAN.R-project.org/package=ade4

Guisan, A., Broennimann, O., Engler, R., Vust, M., Yoccoz, N. G., Lehmann, A., & Zimmermann, N. E. (2006). Using Niche-Based Models to Improve the Sampling of Rare Species. *Conservation Biology*, *20*(2), 501-511. https://doi.org/10.1111/j.1523-1739.2006.00354.x

Hernandez, P. A., Graham, C. H., Master, L. L., & Albert, D. L. (2006). The effect of sample size and species characteristics on performance of different species distribution modeling methods. *Ecography*, *29*(5), 773-785. https://doi.org/10.1111/j.0906-7590.2006.04700.x

Horikoshi, M., Tang [aut, Y., cre, Dickey, A., Grenié, M., Thompson, R., Selzer, L., Strbenac, D., Voronin, K., & Pulatov, D. (2020). *ggfortify: Data Visualization Tools for Statistical Analysis Results* (0.4.11) [Computer software]. https://CRAN.R-project.org/package=ggfortify

Hurley, C. (2019). *gclus: Clustering Graphics* (1.3.2) [Computer software]. https://CRAN.R-project.org/package=gclus

IUCN. (2012). IUCN Red List Categories and Criteria: Version 3.1. Second edition. Gland, Switzerland and Cambridge, UK: IUCN.

IUCN Standards and Petitions Committee. (2019). Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Committee. Downloadable from http://www.iucnredlist.org/documents/RedListGuidelines.pdf.

Joppa, L. N., Butchart, S. H. M., Hoffmann, M., Bachman, S. P., Akçakaya, H. R., Moat, J. F., Böhm, M., Holland, R. A., Newton, A., Polidoro, B., & Hughes, A. (2016). Impact of alternative metrics on estimates of extent of occurrence for extinction risk assessment. *Conservation Biology: The Journal of the Society for Conservation Biology*, *30*(2), 362-370. https://doi.org/10.1111/cobi.12591

Le Breton, T. D., Zimmer, H. C., Gallagher, R. V., Cox, M., Allen, S., & Auld, T. D. (2019). Using IUCN criteria to perform rapid assessments of at-risk taxa. *Biodiversity and Conservation*, *28*(4), 863-883. https://doi.org/10.1007/s10531-019-01697-9

Luer, C. A. (1987). *Icones Pleurothallidinarum IV*. Systematics of the genus *Porroglossum*. *Monographs in Systematic Botany from the Missouri Botanical Garden*, 24, 25–90.

Luer, C. A. (1988). *Icones Pleurothallidinarum V*. Systematics of *Dresslerella* and *Scaphosepalum*. Addenda to *Porroglossum*. *Monographs in Systematic Botany from the Missouri Botanical Garden*, 26, 108–109.

Luer, C. A. (2006). *Icones Pleurothallidinarum XXVIII*. A reconsideration of *Masdevallia*, and the systematics of *Specklinia* and Vegetatively similar taxa (Orchidaceae). Addendum to *Porroglossum*. *Monographs in Systematic Botany from the Missouri Botanical Garden*, 105, 253–254.

Luer, C. A. (2011). Miscellaneous New Species in the Pleurothallidinae (Orchidaceae) Excluding Species from Brazil. *Harvard Papers in Botany*, 16(2), 341–345.

Kraenzlin, F. (1925). Monographie der Gattungen Masdevallia, *Lothiania, Scaphosepalum, Cryptophoranthus* & *Pseudoctomeria*. Repert. Spec. nov. Regni Veg. Beih. 34:1-240

Maechler, M., original), P. R. (Fortran, original), A. S. (S, original), M. H. (S, Hornik [trl, K., maintenance(1999-2000)), ctb] (port to R., Studer, M., Roudier, P., Gonzalez, J., Kozlowski, K., pam()), E. S. (fastpam options for, & Murphy (volume.ellipsoid({d >= 3})), K. (2021). *cluster: «Finding Groups in Data»: Cluster Analysis Extended Rousseeuw et al.* (2.1.1) [Computer software]. https://CRAN.R-project.org/package=cluster

Merow, C., Smith, M. J., & Silander, J. A. (2013). A practical guide to MaxEnt for modeling species' distributions: What it does, and why inputs and settings matter. *Ecography*, *36*(10), 1058-1069. https://doi.org/10.1111/j.1600-0587.2013.07872.x

Oksanen, J., Blanchet, F. G., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., Minchin, P. R., O'Hara, R. B., Simpson, G. L., Solymos, P., Stevens, M. H. H., Szoecs, E., & Wagner, H. (2020). *vegan: Community Ecology Package* (2.5-7) [Computer software]. https://CRAN.R-project.org/package=vegan

Reichenbach, E. (1861). *Masdevallia*. Walpers Ann. Bot. Syst. 6:195

Tropicos.org. (2021a). *Porroglossum echidna* (Rchb. f.) Garay. Missouri Botanical Garden. https://www.tropicos.org/name/23510028

Tropicos.org. (2021b). *Porroglossum hystrix* Luer. Missouri Botanical Garden. https://www.tropicos.org/name/23517318

Tropicos.org. (2021c). *Porroglossum muscosum* (Rchb. f.) Schltr. Missouri Botanical Garden. https://www.tropicos.org/name/23510093

Wickham, H., Bryan, J., attribution), Rs. (Copyright holder of all R. code and all C. code without explicit copyright, code), M. K. (Author of included R., code), K. V. (Author of included libxls, code), C. L. (Author of included libxls, code), B. C. (Author of included libxls, code), D. H. (Author of included libxls, & code), E. M. (Author of included libxls. (2019). *readxl: Read Excel Files* (1.3.1) [Computer software]. https://CRAN.R-project.org/package=readxl

Williams, J. N., Seo, C., Thorne, J., Nelson, J. K., Erwin, S., O'Brien, J. M., & Schwartz, M. W. (2009). Using species distribution models to predict new occurrences for rare plants. *Diversity and Distributions*, *15*(4), 565-576. https://doi.org/10.1111/j.1472-4642.2009.00567.x

**ANNEX A. DATA COLLECTION AVAILABLE FOR THE ECHIDNA'S SECTION SPECIES.**

| Species | Country | Province | Location | Altitude | Collector | Collection number | Herbarium |
|---|---|---|---|---|---|---|---|
| *P. apoloae* | Ecuador | - | - | - | Sijm | 20110703 | mo |
| *P. dejonghei* | Ecuador | - | - | - | Sijm | 20110709 | mo |
| *P. echidna* | Colombia | Ocaña | Alto de San Francisco | - | Wagener | - | w |
| | Colombia | Ocaña | - | - | Kalbreyer | 458 | w |
| | Colombia | Santander north | Alto de San Francisco | 2600 | Luer | 10256 | mo |
| | Colombia | Santander north | Paramo de Jurisdicciones | 3130 | Luer | 6561 | sel |
| | Colombia | Santander south | Bucaramanga - Berlin | 3200 | Luer | 7607 | sel |
| | Ecuador | Carchi | Maldonado | 2100 -2200 | Nielsen et al | 6042 | aau |
| *P. hystrix* | Ecuador | Morona Santiago | Valle del Paute | 2200 | Luer | 13384 | mo |
| | Ecuador | Morona Santiago | Limón | 1000 | Luer | 3630 | sel |
| | Ecuador | Morona Santiago | Limón Indaza | 2000 | Lou Jost et al | 3105 | mo, qcne |
| | Ecuador | Morona Santiago | Limón Indaza | 2000 | Lou Jost et al | 3134 | qcne |
| *P. muscosum* | Colombia | Antioquia | Vía Frontino - Medellin | - | Shuttleworth | - | w, k |
| | Colombia | Antioquia | La Ceja | 2000 - 2400 | Lenmann | 3198 | g |
| | Colombia | Antioquia | Fontino | 1600 | Luer | 4304 | sel |
| | Colombia | Antioquia | Cocorna - Quebrada Guarindo | 1800 | Luer | 2941 | sel |
| | Colombia | Cauca | Munchique | 2000 - 2300 | Lenmann | 2810 | g |
| | Colombia | Santander north | Alto de Santa Inez | 2500 | Luer | 8714 | sel |
| | Colombia | Putumayo | La Cocha - Sibundoy | 2700 | Luer | 3094 | sel |
| | Ecuador | Imbabura | Vía Otavalo - Apuela | 2000 | Luer et al | 3938 | sel |
| | Ecuador | Pichincha | Corazón - Río Silante | 2000 | luer | 9823 | mo |
| | Ecuador | Pichincha | Guajalito | 2000 | luer | 9823 | mo |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Ecuador | Pichincha | Nono | 2000 | Cerón et al | 5956 | mo, qcne |
| | Ecuador | Pichincha | Aloag | 2000 | Luer et al | 12073 | mo |
| | Ecuador | Carchi | Maldonado | 1900 | Dalström & Höijer | 1244 | mo |
| | Ecuador | Pichincha | Chiriboga | 1900 | Luer & Benigno Malo | 1749 | sel |
| | Ecuador | Imbabura | Otavalo – Cuicocha | 2600 | Dalström | 451A | sel |
| | Ecuador | Pichincha | Lloa | 2200 | Luer & Hirtz | 13702 | mo |
| | Venezuela | Tachira | Quinimari River | 2500 | Duntesrville | 1143 | - |
| *P. myosurotum* | Peru | Amazonas | Moyabamba | - | Hirtz | 8611 | mo |
| *P. parsonsii* | Colombia | - | - | - | Luer | 20985 | mo |
| *sp. nov. ined.* | Ecuador | Carchi | Tufiño | - | - | - | - |

**ANNEX B. CHARACTERISTICS IN CM OF EVERY ECHIDNA' SECTION SPECIES**

| species | plant | root | ramicauls_long | leaf_long | leaf_wide | petiole_long | peduncle_long | bract_floral_long | pedicel | ovary_long |
|---|---|---|---|---|---|---|---|---|---|---|
| *apoloae* | 1.00 | 1.00 | 8.50 | 32.50 | 6.00 | 12.50 | 22.50 | 4.00 | 5.00 | 4.00 |
| *dejonghei* | 1.00 | 1.00 | 15.00 | 65.00 | 6.50 | 20.00 | 100.00 | 5.00 | 10.00 | 6.00 |
| *echidna* | 2.50 | 3.00 | 42.50 | 95.00 | 12.50 | 27.50 | 150.00 | 6.50 | 7.50 | 5.00 |
| *hystrix* | 1.50 | 1.00 | 22.50 | 75.00 | 13.50 | 27.50 | 135.00 | 4.50 | 5.00 | 4.50 |
| *muscosum* | 2.00 | 2.00 | 25.00 | 95.00 | 14.00 | 25.00 | 170.00 | 6.00 | 7.00 | 5.50 |
| *myosurotum* | 1.00 | 1.00 | 10.00 | 50.00 | 5.00 | 20.00 | 70.00 | 5.00 | 6.00 | 3.00 |
| *parsonsii* | 2.00 | 4.00 | 11.00 | 60.00 | 15.00 | 10.00 | 120.00 | 5.50 | 7.00 | 5.00 |

| species | dorsal_sepal_long | dorsal_sepal_blade_long | dorsal_sepal_blade_wide | dorsal_sepal_tail_long | dorsal_sepal_cup | lateral_sepal_long | lateral_sepal_blade_long | lateral_sepal_blade_wide | lateral_sepal_tail_long | mentum |
|---|---|---|---|---|---|---|---|---|---|---|
| *apoloae* | 13.00 | 5.00 | 5.00 | 8.00 | 2.00 | 13.00 | 5.50 | 4.00 | 7.50 | 3.00 |
| *dejonghei* | 23.00 | 9.00 | 5.50 | 13.00 | 5.00 | 19.00 | 9.00 | 8.00 | 10.00 | 4.00 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *echidna* | 32.00 | 7.00 | 6.00 | 25.00 | 5.00 | 32.50 | 7.50 | 8.00 | 25.00 | 5.00 |
| *hystrix* | 14.00 | 5.50 | 6.00 | 8.50 | 3.50 | 14.00 | 5.00 | 6.00 | 9.00 | 2.00 |
| *muscosum* | 27.50 | 7.50 | 5.50 | 20.00 | 2.50 | 28.00 | 8.00 | 5.50 | 20.00 | 2.50 |
| *myosurotum* | 14.00 | 6.00 | 5.00 | 8.00 | 4.00 | 14.00 | 6.50 | 4.00 | 7.50 | 3.00 |
| *parsonsii* | 21.00 | 7.00 | 6.00 | 14.00 | 4.00 | 24.00 | 10.00 | 5.00 | 14.00 | 6.00 |

| species | petal_long | petal_wide | labellum_blade_long | labellum_blade_wide | column_long | column_foot_long | leaf_shape | leaf_texture | peduncle_outgrouth | bract_location | ovary_texture |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *apoloae* | 3.50 | 1.00 | 4.00 | 3.75 | 2.00 | 3.50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *dejonghei* | 5.00 | 0.50 | 5.00 | 4.00 | 4.00 | 5.00 | 2.00 | 2.00 | 2.00 | 2.00 | 1.00 |
| *echidna* | 4.00 | 1.30 | 8.00 | 4.00 | 3.00 | 8.00 | 3.00 | 3.00 | 3.00 | 3.00 | 2.00 |
| *hystrix* | 5.00 | 1.00 | 5.50 | 3.50 | 3.00 | 8.00 | 3.00 | 2.00 | 3.00 | 3.00 | 3.00 |
| *muscosum* | 4.75 | 1.25 | 4.75 | 3.75 | 2.50 | 5.00 | 3.00 | 3.00 | 3.00 | 3.00 | 4.00 |
| *myosurotum* | 5.00 | 1.40 | 5.00 | 3.25 | 3.00 | 3.00 | 2.00 | 1.00 | 1.00 | 4.00 | 2.50 |
| *parsonsii* | 5.00 | 2.00 | 4.00 | 2.00 | 2.00 | 4.00 | 1.00 | 4.00 | 3.00 | 5.00 | 5.00 |

| species | sepals_texture | dorsal_sepal_blade_shape | lateral sepal shape | lateral_sepal_tail_shape | petal_shape | petal_midvein | petal_angle | labellum_blade_shape | labellum_blade_apex_shape | labellum_blade_apex_outgrowth | callus_height | callus_shape | column_shape |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *apoloae* | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *dejonghei* | 1.50 | 2.00 | 2.00 | 2.00 | 1.50 | 1.00 | 0.00 | 2.00 | 2.00 | 1.00 | 1.00 | 2.00 | 1.00 |
| *echidna* | 2.00 | 2.00 | 3.33 | 3.00 | 3.00 | 1.00 | 0.00 | 3.00 | 3.00 | 1.00 | 2.00 | 1.00 | 1.00 |
| *hystrix* | 3.00 | 1.00 | 1.00 | 1.50 | 3.00 | 1.00 | 0.00 | 3.00 | 2.00 | 1.50 | 2.00 | 3.50 | 1.00 |
| *muscosum* | 4.00 | 2.00 | 1.00 | 1.50 | 3.50 | 1.00 | 0.00 | 4.00 | 3.00 | 1.00 | 1.00 | 3.00 | 1.00 |
| *myosurotum* | 1.00 | 2.00 | 1.00 | 4.00 | 1.00 | 1.00 | 0.00 | 5.00 | 2.00 | 1.00 | 2.00 | 1.00 | 1.00 |
| *parsonsii* | 3.00 | 2.00 | 3.66 | 5.00 | 2.00 | 0.00 | 1.00 | 4.00 | 1.00 | 2.00 | 2.00 | 3.00 | 1.00 |

## ANNEX C. ARTIFICIAL AND REAL DATA FROM *Porroglossum muscosum*, P. *echidna* and *P. hystrix.*

| ID | LAT | LON |
|---|---|---|
| *P. muscosum* | 0.7727654051410090 | -78.0935380034666000 |
| *P. muscosum* | 0.7974823224750580 | -78.0671021514159000 |
| *P. muscosum* | 0.8839903341645030 | -78.1134507231932000 |
| *P. muscosum* | 0.0070074322098852 | -78.6325547270995000 |
| *P. muscosum* | -0.4623097557595530 | -78.7688538604003000 |
| *P. muscosum* | -0.3510760031932730 | -78.7511727385741000 |
| *P. muscosum* | 0.4492025373630180 | -78.4765145354491000 |
| *P. muscosum* | 0.4189910024929480 | -78.6389061980467000 |
| *P. muscosum* | 0.3146230385582370 | -78.6636254363280000 |
| *P. muscosum* | 0.4395897894153010 | -78.5571953826171000 |
| *P. muscosum* | 0.6744112920772270 | -78.3642479949217000 |
| *P. muscosum* | 0.8385052096163550 | -78.1301018767577000 |
| *P. muscosum* | 0.8927440120703250 | -78.1270119719725000 |
| *P. muscosum* | 0.8412514965656220 | -78.0542275481444000 |
| *P. muscosum* | 0.8625351544046910 | -78.1788537078124000 |
| *P. muscosum* | 0.0234968373929683 | -78.5849246217598000 |
| *P. muscosum* | 0.1113650732747470 | -78.5653601943979000 |
| *P. muscosum* | -0.4476609868509610 | -78.8667554071131000 |
| *P. muscosum* | -0.5679955243601120 | -78.8126027282405000 |
| *P. muscosum* | -0.5089224860651960 | -78.9405999692119000 |
| *P. muscosum* | -0.4804797152500000 | -79.0073335734792000 |
| *P. muscosum* | 0.8833333000000 | -78.0833333333333 |
| *P. muscosum* | 0.2833333000000 | -78.3833333333333 |
| *P. muscosum* | 0.2833333000000 | -78.4666666666666 |
| *P. muscosum* | -0.0333333000000 | -78.6500000000000 |
| *P. muscosum* | -0.2333333000000 | -78.8333333333333 |
| *P. muscosum* | -0.2500000000000 | -78.7333333333333 |
| *P. muscosum* | -0.3000000000000 | -78.6000000000000 |
| *P. muscosum* | -0.4333333000000 | -78.7166666666666 |
| *P. muscosum* | -0.4468366244858 | -78.7185714550781 |
| *P. echidna* | 0.77161097851497 | -78.16008148193350 |
| *P. echidna* | 0.867216527305795 | -78.050540557227400 |
| *P. echidna* | 0.776235229935249 | -78.185382144541500 |
| *P. echidna* | 0.842005051742294 | -78.193056056014700 |
| *P. echidna* | 0.866120379650699 | -78.143723767972900 |
| *P. echidna* | 0.842005051742294 | -78.131664764229400 |
| *P. echidna* | 0.852966583177075 | -78.213885244299000 |
| *P. echidna* | 0.915446704173192 | -78.137146129567400 |
| *P. echidna* | 0.906677628357059 | -78.107546756742300 |
| *P. echidna* | 0.805831781515264 | -78.110835575945100 |

| | | |
|---|---|---|
| *P. echidna* | 0.888043271980317 | -78.229233067245200 |
| *P. echidna* | 0.850670945161237 | -78.228071955350400 |
| *P. echidna* | 0.856163499878253 | -78.056410578397200 |
| *P. echidna* | 0.884999281877223 | -78.057783869412900 |
| *P. echidna* | 0.739445099714662 | -78.151854303983200 |
| *P. echidna* | 0.867148585656364 | -78.028944758084700 |
| *P. echidna* | 0.843805240776735 | -78.167647150662900 |
| *P. echidna* | 0.847924664867802 | -78.046110895780100 |
| *P. echidna* | 0.804670497357425 | -78.101729181912900 |
| *P. echidna* | 0.868521719145500 | -78.100355890897200 |
| *P. echidna* | 0.817715454446556 | -78.057097223905100 |
| *P. echidna* | 0.750430499260179 | -78.133314875272200 |
| *P. echidna* | 0.858223205871268 | -78.149107721951900 |
| *P. echidna* | 0.875387379092271 | -78.035124567655100 |
| *P. echidna* | 0.887402253692048 | -78.221205500272200 |
| *P. echidna* | 0.833849947922469 | -78.232191828397200 |
| *P. echidna* | 0.772057923612158 | -78.133314875272200 |
| *P. echidna* | 0.808103384873877 | -78.067396906522200 |
| *P. echidna* | 0.899417089266470 | -78.139838007596500 |
| *P. echidna* | 0.825439422259312 | -78.205069330838700 |
| *P. hystrix* | -2.731752200000000 | -78.257178611111100 |
| *P. hystrix* | -2.998418900000000 | -78.373845277777700 |
| *P. hystrix* | -3.266666700000000 | -78.166666666666600 |
| *P. hystrix* | -3.250000000000000 | -78.166666666666600 |
| *P. hystrix* | -3.297197656477080 | -78.286485391162000 |
| *P. hystrix* | -3.417839808143830 | -78.186235147021300 |
| *P. hystrix* | -2.863865811706790 | -78.147782998583800 |
| *P. hystrix* | -3.086038993390530 | -78.546037393115100 |
| *P. hystrix* | -3.138147089429170 | -78.102464395068200 |
| *P. hystrix* | -2.551105371500510 | -77.961015420458800 |
| *P. hystrix* | -2.855636326978850 | -78.274125772021300 |
| *P. hystrix* | -3.160086565610580 | -78.280992227099500 |
| *P. hystrix* | -3.357520595165460 | -78.460893350146300 |
| *P. hystrix* | -3.626185672964890 | -78.434800820849500 |
| *P. hystrix* | -3.439773130664860 | -78.383989053271300 |
| *P. hystrix* | -3.343811161133420 | -78.264512734912000 |
| *P. hystrix* | -2.809001471453120 | -78.127183633349500 |
| *P. hystrix* | -2.795284981642050 | -78.455400186083800 |
| *P. hystrix* | -2.622443732756430 | -78.475999551318200 |
| *P. hystrix* | -2.712982703282540 | -78.129930215380700 |
| *P. hystrix* | -2.803514894818570 | -78.065385537646300 |
| *P. hystrix* | -2.740417426933940 | -78.393602090380700 |
| *P. hystrix* | -2.976329438480840 | -78.307084756396300 |
| *P. hystrix* | -2.968100776525210 | -78.198594766162000 |
| *P. hystrix* | -3.203964123344260 | -78.238420205615100 |

| | | |
|---|---|---|
| *P. hystrix* | -3.316391718866870 | -78.454026895068200 |
| *P. hystrix* | -3.236871058718130 | -78.287858682177600 |
| *P. hystrix* | -3.911212208680150 | -78.614701943896300 |
| *P. hystrix* | -3.489121256267100 | -78.514451699755700 |
| *P. hystrix* | -3.472672167193540 | -78.373002725146300 |

**ANNEX D. DETAILED COLLECT DATA FOR *Porroglossum echidna*, *P. hystrix* and *P. muscosum*.**

| sp | province | location | latitude | longitude | alture (msnm) | collector | n_collect | institution | date |
|---|---|---|---|---|---|---|---|---|---|
| *P. echidna* | Carchi | Maldonado | 0.9000000000000 | -78.1000000000000 | 2100 - 2200 | L.B. Holm-Nielsen, S. Jeppesen, B. Løjtnant & Benjamin Øllgaard | 6042 | aau | 20-may-73 |
| *P. hystrix* | Morona Santiago | Valle del Paute | -2.7166667000000 | -78.2500000000000 | 2200 | Luer | 13384 | mo | 16-may-88 |
| *P. hystrix* | Morona Santiago | Limón | -2.9833333000000 | -78.3666666666666 | 1000 | Luer | 3630 | sel | 12-dic-78 |
| *P. hystrix* | Morona Santiago | Limón Indaza/Macas | -2.2666667000000 | -78.1666666666666 | 2000 | Lou Jost, David A. Neill, Paul E. Berry & José M. Manzanares | 3105 | mo, qcne | 21-mar-01 |
| *P. hystrix* | Morona Santiago | Limon Indaza | -3.2500000000000 | -78.1666666666666 | 2000 | Lou Jost, David A. Neill, Paul E. Berry & José M. Manzanares | 3134 | qcne | 21-mar-01 |
| *P. muscosum* | Imbabura | Otavalo - Apuela | 0.2833333000000 | -78.3833333333333 | 2000 | Luer et al | 3938 | sel | 8-feb-79 |
| *P. muscosum* | Pichincha | Corazón - Río Silante | -0.4468366244858 | -78.7185714550781 | 2000 | Lenmann | 315 | g | ene-88 |
| *P. muscosum* | Pichincha | Guajalito | -0.2333333000000 | -78.8333333333333 | 2000 | Luer et al | 9823 | mo | 31-mar-84 |
| *P. muscosum* | Pichincha | Nono | -0.0333333000000 | -78.6500000000000 | 2000 | Carlos E. Cerón, Fernando Hurtado & J. Regalado | 5952 | mo, qcne | 19-ene-89 |
| *P. muscosum* | Pichincha | Aloag | -0.4333333000000 | -78.7166666666666 | 2000 | Luer et al | 12073 | mo | 1-mar-86 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *P. muscosum* | Carchi | Maldonado | 0.8833333000000 | -78.0833333333333 | 1900 | Stig Dalström & T. Höijer | 1244 | mo | 17-feb-89 |
| *P. muscosum* | Pichincha | Vía a Chiriboga | -0.2500000000000 | -78.7333333333333 | 1900 | Luer & Benigno Malo | 1749 | sel | 19-jul-77 |
| *P. muscosum* | Imbabura | Otavalo - Cotacachi | 0.2833333000000 | -78.4666666666666 | 2600 | Stig Dalström | 451A | sel | 15-ene-83 |
| *P. muscosum* | Pichincha | Lloa | -0.3000000000000 | -78.6000000000000 | 2200 | Luer & Hirtz | 13702 | mo | 28-may-88 |

**ANNEX E. ILLUSTRATION NUMBER 2941 FROM THE ORIGINAL DESCRIPTION OF *Porroglossum muscosum***



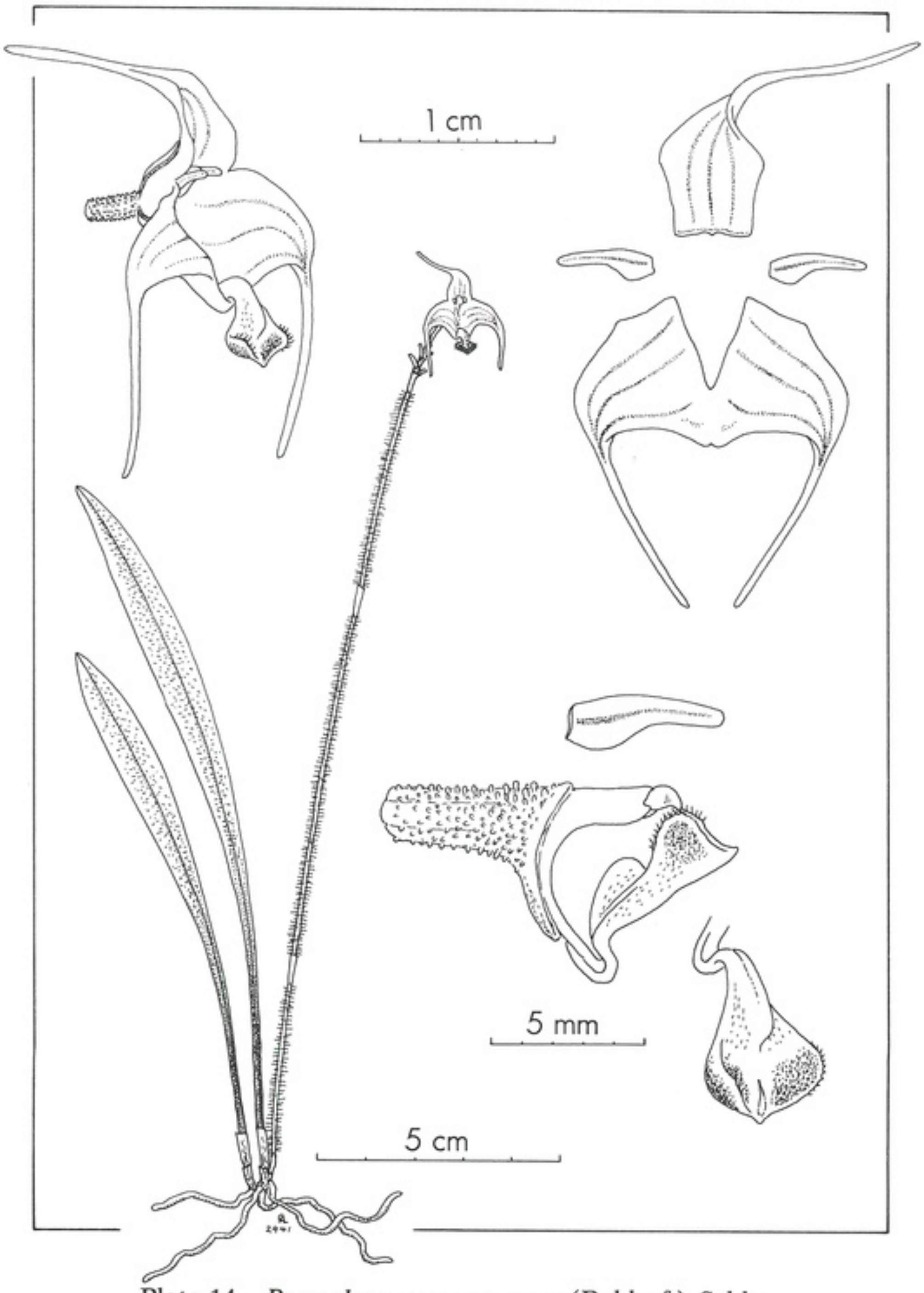


Plate 14. *Porroglossum muscosum* (Rchb. f.) Schltr.

## ANNEX F. ILLUSTRATION NUMBER 4304 FROM THE ORIGINAL DESCRIPTION OF *Porroglossum muscosum*

SYSTEMATICS OF PORROGLOSSUM 65

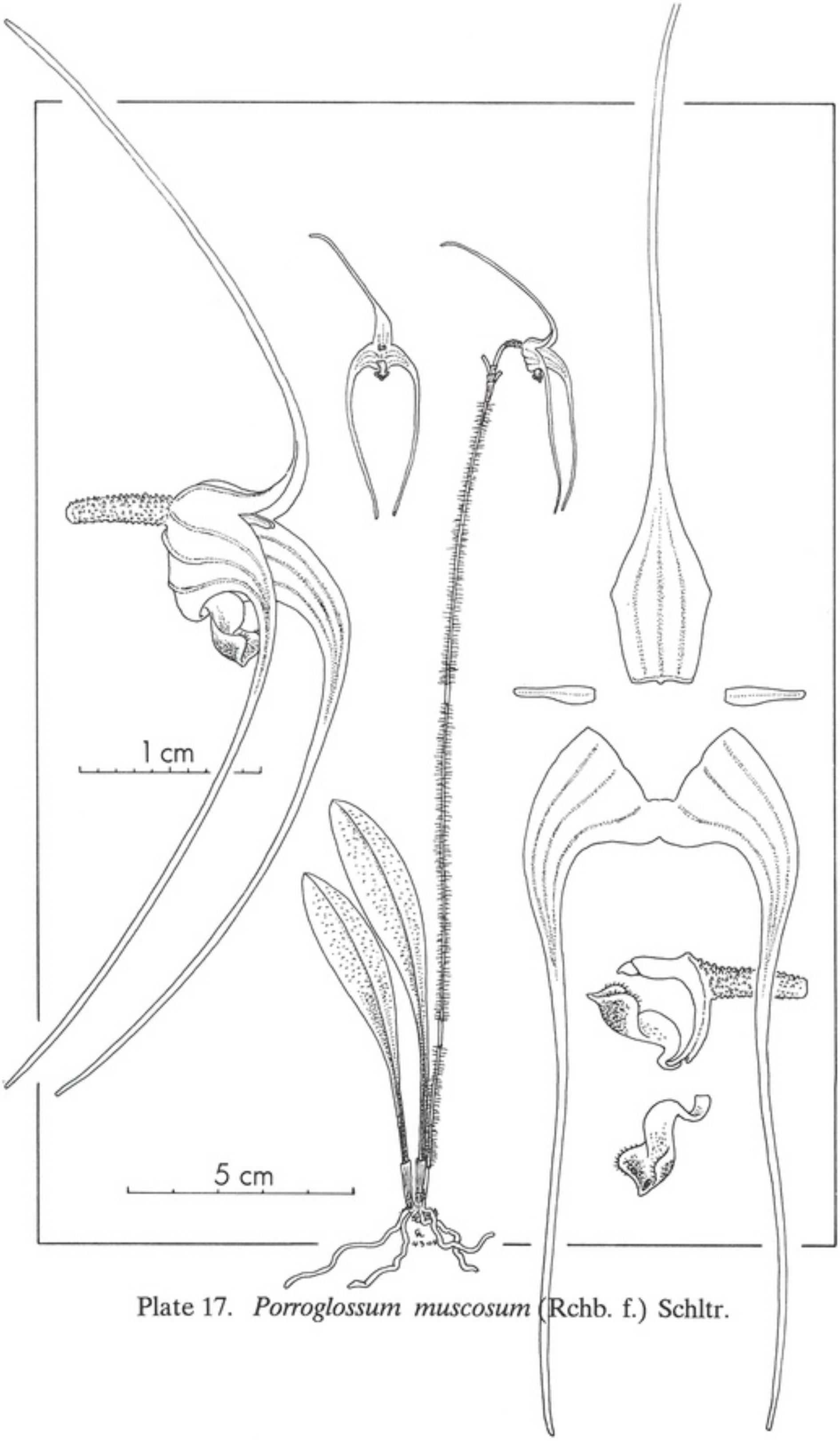


Plate 17. *Porroglossum muscosum* (Rchb. f.) Schltr.

## ANNEX G. ILLUSTRATION NUMBER 8714 FROM THE ORIGINAL DESCRIPTION OF *Porroglossum muscosum*

SYSTEMATICS OF PORROGLOSSUM 63

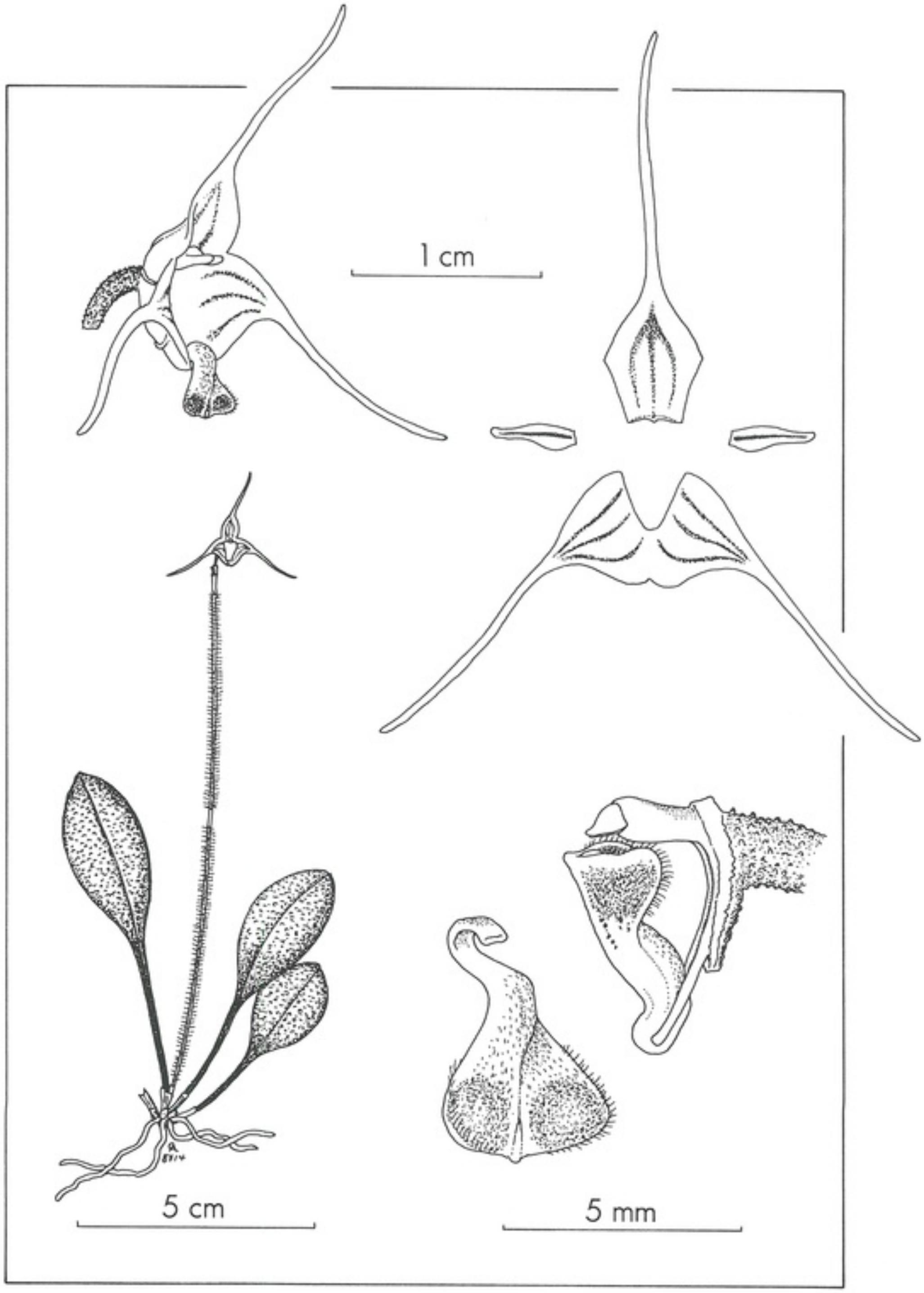


Plate 15. *Porroglossum muscosum* (Rchb. f.) Schltr.