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# Determination of sites of special importance for the conservation of threatened Orchid species in Colombia

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**Abstract.** Colombia is the country with the highest number of orchid species (4270), whose optimal habitat is cold and humid forests. However, the outlook for conservation is alarming, considering that deforestation is causing the loss of millions of hectares of forests. This situation has led to the existence of 206 endangered orchid species. Therefore, this research was conducted to determine Sites of Special Importance for the Conservation of Threatened Orchid Species in Colombia (SSICO), through an analysis of their spatial and altitudinal distribution using various databases, to make a selection of nature reserves on a municipality scale, using Marxan software, and employing relevant parameters (richness, rarity, and IUCN category).

Furthermore, the results were later compared with the Protected Areas System, determining their coverage to propose SSICOs. 674 records of the presence of threatened orchids in 277 municipalities were obtained. Urrao, Abrego, and Frontino were the areas with the greatest richness and rarity. Marxan selected 47 municipalities located mostly in the Andes region, and four SSICOs were prioritized, which are located in the Antioquia, Norte de Santander, Nariño and Putumayo provinces. These SSICOs, in addition to being points of great biodiversity, are areas with special socio-economic characteristics that influence the management of natural resources. These areas require timely attention, research, and intervention by environmental authorities because of their importance for conserving orchids and Andes Forests.

**Keywords:** Andes Forest; Biodiversity; Marxan; Orchidaceae; Protected areas.

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## Introduction

Megadiverse countries are those that host the highest biodiversity index on Earth, measured by the total number of species in a country, the degree of endemism of those species, and their high taxonomic levels (Mittermeier *et al*., 1999). The Centre for Environmental Conservation Monitoring, an agency in the United Nations Environment Programme, has identified 18 megadiverse countries located mainly in Southeast Asia and the Americas, characterized by having more than 70% of the planet biodiversity on 10% of its surface. Within these countries, Colombia contains the largest number of species per unit area on the planet, making it the second most megadiverse country after Brazil (LMMC, 2019). In its territory, there are regions such as the Andes Mountain Range and the Biographical Chocó, considered as Hot Spots. These are conservation priority zones due to their high species richness, in terms of levels of endemism, the number of rare, threatened species, in relatively small areas that face important threats of habitat loss (Reid, 1998).

These characteristics of great biodiversity result from the privileged geographic location of the country and its enormous environmental heterogeneity. Currently, Colombia is estimated to be the country with the highest number of orchid species globally, with 4270 species grouped into 274 genera, of which 71% contain fewer than ten species, half of the Colombian orchid species being grouped into only nine genera. *Epidendrum* is the richest genus (527 species), followed by *Lepanthes* (361 spp.) and *Stelis* (276 spp.) (Betancur *et al*., 2015). Over the last few years, publications in which new species are described continue to appear (e.g., Szlachetko & Kolanowska, 2019, 10 species). Orchids are among the largest and most diverse families of angiosperms, characterized by being in almost all terrestrial ecosystems and being of great ecological, social, and economic importance, both locally and internationally.

As for the social component, since ancient times, orchids have been recognized by different cultures as plants with ornamental, medicinal, edible, aromatic, aphrodisiac, narcotic, and spiritual uses (Arditti, 1992). In Colombia, the indigenous communities assign them many of said uses, particularly the latter ones. Currently, they are mainly used for ornamental purposes, and the main crops are found in the departments of Antioquia, Boyacá, Caldas, Cauca, Cundinamarca, Quindío, Risaralda and Valle del Cauca (Betancur *et al*., 2015). In economic terms, the export of orchids in 2010 represented a national income of about 120000 US (flowers are difficult to export due to the restrictions of

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the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)) whose main destinations are Germany, Australia, Canada, United States, France, and Japan (Cárdenas & Rodríguez, 2011).

As far as important ecological characteristics are concerned, it is worth highlighting that orchids are plants with "*stress tolerance*" adaptation strategies, which live with some limiting environmental factor; for example, most epiphytes tolerate a degree of water scarcity could be detrimental to many other plants. Simultaneously, their habitats are often deficient in mineral nutrients (Arditti, 1992). Another outstanding attribute is their ability to develop symbiotic relationships with fungi and ants. Most orchids will not germinate without mycorrhizae and in adulthood, their relationship with ants allows them to be healthier plants and suffer less in periods of drought. The last ecological characteristic to add is that they are CAM (Crassulacean Acid Metabolism) type plants. These plants' stomas open at night, when the atmospheric humidity is much higher, and the carbon dioxide is fixed and stored as malic acid. During the day, carbon dioxide is released and used in photosynthesis, reducing water and respiratory carbon dioxide loss. In addition, epiphytes fix the carbon dioxide that the forest canopy produces and, when water is abundant, function as C3 plants (Dressler, 1982).

The optimal habitats for South American epiphytic orchids ids are the cold and humid cloud forests (Andes forests), as they show greater abundance and maximum diversity (Grentry & Dodson, 1987). Between 60% and 73% of orchids in Colombia grow in the Andes forests, representing only between 3 and 4% of the national territory (Betancur *et al*., 2015). However, the outlook for orchid conservation is alarming considering that millions of hectares of forests are being lost annually to deforestation, especially for establishing crops, livestock, timber extraction, urban development, mining, and oil exploration (Doumenge *et al*., 1995). This situation of habitat loss has led to the current existence of 206 species of threatened orchids in the country, registered in the Red Book of Colombian Plants (Calderón-Sáenz, 2006), in Administrative Ruling 1912 of the Ministry of Environment and Sustainable Development (2017) and protected by CITES.

In 2015, the Ministry of Environment and Sustainable Development and the National University of Colombia developed the Plan for the Study and Conservation of Orchids in Colombia. They analyzed the importance and current situation of this family of plants, making a general diagnosis of the more than 4000 species of orchids registered in the country, to develop an action plan for their conservation (Betancur *et al*., 2015).

It is clear that orchids are key elements in the conservation of biodiversity; they are emblematic plants in the country and are being seriously threatened by human activity. Their conservation must combine habitat protection with greater insight into the species and their distribution, evaluate orchid flowers in different regions, develop databases, and generate distribution maps. There is also a need for involving users of local resources in said species and ecosystem conservation projects, dissemination activities, and the creation of information networks (Orejuela-Gartner, 2012). Their knowledge of local resources and ecosystem dynamics can complement that of scientists in conservation efforts. In addition, the involvement of these stakeholders can also improve incentives for the ecosystem (Schultz *et al*., 2007).

For these reasons, it might be hypothesized that, since the Andes forest is the main habitat for the different orchid families in Colombia, improving the knowledge about the population distribution of threatened orchid species in the country and determining strategic areas for their conservation will contribute to the preservation of the Andes forests, the maintenance of natural flows, the interspecific relationships and the services provided by these ecosystems. This study's main objective is to determine the Sites of Special Importance for the Conservation of Threatened Orchid Species in Colombia (SSICO). To do this, the current geographic distribution of these species was determined firstly. Secondly, the municipalities of the greatest importance for their conservation were defined, and finally, an initial proposal for the SSICO was made.

## Material and Methods

### Study area

Colombia is located in the intertropical fringe of the world. Its territory has an extension of 1.141.748 continental km² and 988.000 maritime km²; it is framed within the 12°30'40'' N (Punta Gallinas, Guajira) and 4°13'30'' S (Amazon river) and between 66°50'54'' W of the Greenwich meridian (Guainía province) and 79°01'23'' W to the west of that meridian in Punta Manglares (Nariño province). The fundamental element that configures Colombia's biophysical system is the Andes mountain range, which reaches its highest degree of structural complexity. To the south of Colombia, the Andes are divided into three mountain ranges, generating a complex orographic system that conditions the biophysical characteristics of the territory. With elevations up to 4200 m, the Western mountain range is detached from the central mountain range in the southwest of the country; the Central mountain range is the highest elevation and expands southwards into the eastern mountain range of Ecuador; its northern end is the Serranía de San Lucas. In addition, the Eastern mountain range is the widest of the three and comparatively the lowest, having its north end in the Serranía del Perijá on the border with Venezuela (Rangel *et al*., 2011).

The orography and the location of the country determine the differences of the climate, producing five large geographic regions, which are characterized by their physiography, climate, vegetation, and soils. These are (Guhl, 2016):

1. The Caribbean region is located in the north of the country. It is characterized by its plains and low mountains that do not exceed a mean altitude of

300 m, with climates from arid to semi-humid and a mean temperature between 27-20 ºC. As it is the mouth of the main rivers in the country, most of its soils are of alluvial origin.

2. The Pacific region, with humid and super humid climates. Its rainfall reaches 10.000 mm per year. It is located to the west of the national territory, characterized by mighty rivers and low altitudes combined with small foothills such as the Serranía del Baudó. Its main ecosystem is the Tropical Rainforest.
3. The Andes region, on which the three mountain ranges of the Andes and the main rivers of the country (Magdalena river and Cauca river) extend, generates a high variety of climates that goes from the low and warm zones up to the high summits. 70% of the population inhabits this region, including most economic activities.
4. The Orinoco region, characterized by extreme events of drought and humidity throughout the year, is located to the east of the country. Their most characteristic ecosystems are the South American savannahs and the foothills.
5. The Amazon region, with a humid climate characteristic of the Amazon rainforest, is located in the south of Colombia. Its main rivers, Caquetá and Putumayo, flow into the Amazon, generating floodable areas at certain times of the year. It is the region of the country with the smallest population and mostly belonging to indigenous communities.

In order to preserve the strategic country ecosystems, the Protected Areas National System was created, which includes all protected areas of public, private or community governance, and national, regional, or local management, which total 309236.68 km$^2$ representing 14.52% of the national territory (maritime and terrestrial) (Parques Nacionales Naturales, 2010). Figure 1 shows the country's geographical regions, along with the distribution of the Protected Areas National System.

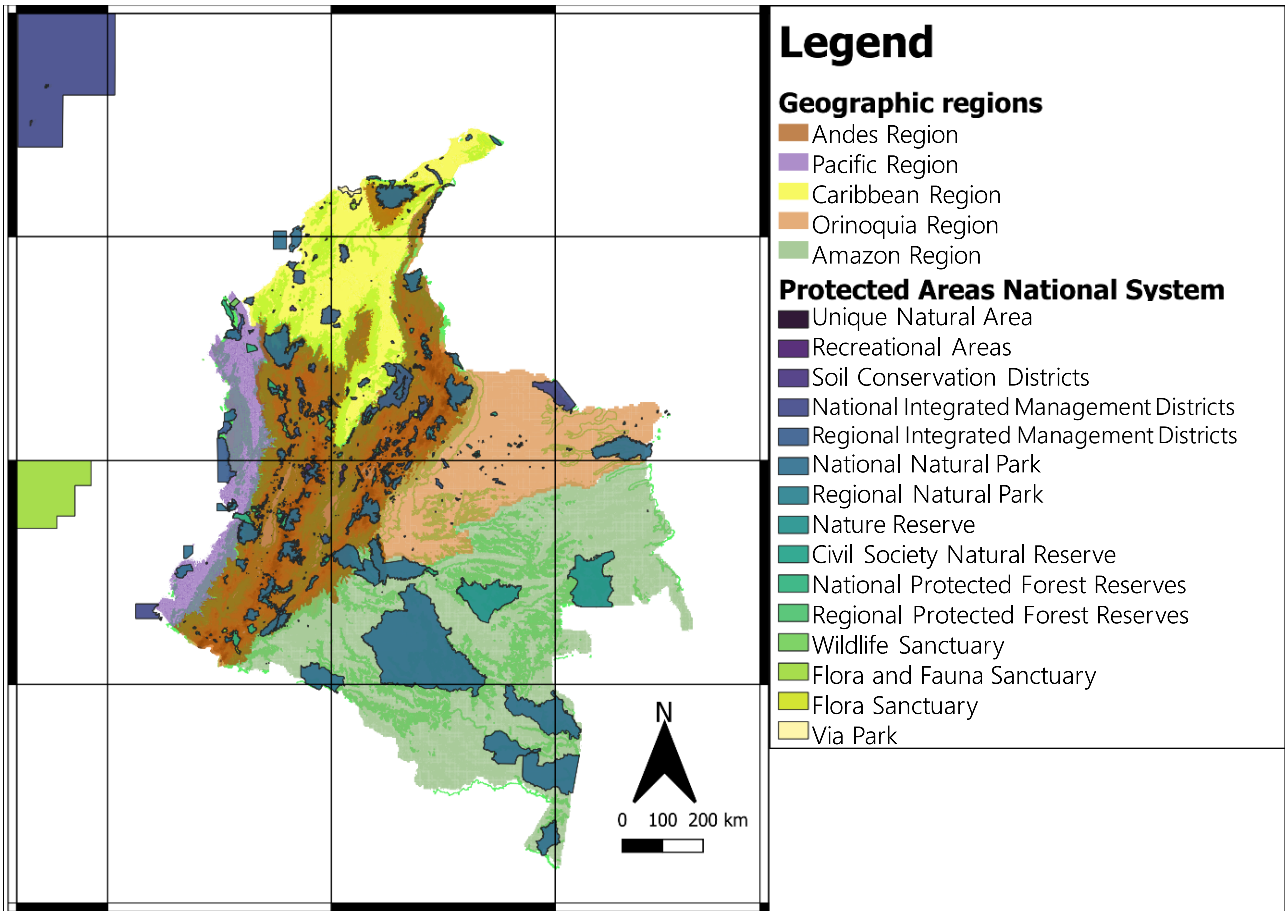


Figure 1. Map of the geographical regions of Colombia and the Protected Areas National System.

**Geographical distribution of endangered orchid species determination**

**Data collection**

Following the information provided by Volume 6 in the Red Book of Colombian Plants - Orchids, the technical categorization sheets (according to IUCN) for the 207 threatened orchid species in the country were obtained. Six orchids are Critically Endangered, 64 Endangered, and 137 are Vulnerable (Calderón-Sáenz, 2006). It was first necessary to update the nomenclature of the orchids since 33 species currently have a different name from the one recorded in the book. In addition, *Masdevallia expansa* is nowadays considered synonymous with *Masdevallia caudata*

Lindl. In the book, they are registered as two different species. For this reason, the number of threatened species was reduced to 206, according to the current nomenclature. The list of threatened orchid species with their present nomenclature, author, and IUCN category is shown in Appendix 1.

From this list and following the indications of Martínez-Hernández *et al*. (2011), a chorological database was compiled corresponding to the distribution of these species; these data were obtained from different sources of information. First of all, the records of identified species in three online databases, GBIF (GBIF.org, 2019), Epidendra (University of Costa Rica, 2012), and Tropics (Missouri Botanical Garden, 2019) were gathered. Afterwards, books at the provincial level (Castellanos-Castro & Torres-Morales, 2018) (Idárraga *et al*., 2011), peer-reviewed scientific papers (Viveros & Higgins, 2007; University of Costa Rica, 2012; Yepes-Rapelo *et al*., 2015; Martínez *et al*., 2016) and different volumes of the Orchidology Colombian Society Journal (Sánchez, 1993; Vélez De Vill, 2015; Villegas, 2015, 2016; Ordóñez-Blanco, 2017; Posada, 2018) were consulted, obtaining 674 records of presence (the presence matrix can be found in Appendix 2).

Due to the heterogeneity in the spatial scale of the records obtained (most of them did not have coordinates), it was necessary to determine a geographical reference unit that would maintain the same spatial scale in all the records and facilitate subsequent mapping. This unit was the figure of the municipality since these have an established delimitation and allow for the incorporation of records without specific coordinates.

### Richness, rarity, and altitudinal distribution

The information in the database was organized into a matrix with columns for plant taxa and rows for the 277 municipalities, where the value of (1) would indicate the presence of the species and (0) their absence. Then, species richness was calculated as the sum of species present in each municipality. And finally, continuous rarity was calculated. This parameter tried to measure the proportion of rare species (species with limited biogeographic distribution) present in a municipality and was obtained by adding the inverse of the number of records by localities where each species was found (Martínez-Hernández *et al*., 2009). These results were expressed in a geographic information system (QGIS Development Team, 2019), based on the shapefile of the Colombian municipalities obtained from the SIAC Geo service portal (2019). It is necessary to highlight that due to the lack of information about the chorological data of the species analyzed, there may be an underestimation of the presences and absences considered.

Additionally, altitudinal distribution analysis of the orchids studied was conducted, by using the mean altitude value over which each of these species occurs, to determine their altitudinal distribution by genus through a box plot, using Microsoft Excel. Finally, to determine whether there was a correlation between the municipalities' altitude and richness and rarity, an elevation profile was carried out in the municipalities with threatened orchids (277), using QGIS, to establish an approximation of their maximum and minimum altitude. With the values obtained, the mean altitude and the altitudinal variation (subtraction between the maximum and minimum altitude) were ascertained. These four altitude variables were used as independent variables, while richness and rarity were assumed as dependent variables. To know the distribution type (normal or non-normal), a normality test was applied (Kolmogorov-Smirnov Test; $P > 0.05$)) (Rahbek, 1997).

As these variables presented a non-normal distribution, Spearman's Rho correlation coefficient ($p<0.05$) was implemented to co-relate the four altitude variables with the municipalities' richness and rarity (Stevens, 1992). The statistical analyses were performed with the aid of IBM SPSS software.

## The most important municipalities for the conservation of endangered orchid species

### Marxan: Reserves selection

Marxan was used for reserve selection. This software was specifically designed to determine areas that should be preserved according to biodiversity records. Marxan assists in designing nature reserves systems that encompass several management units addressing specific conservation problems using a set of ecological, social, and economic criteria (Mendoza-Fernández *et al*., 2010). It selects planning units according to targets, goals, and software settings. Targets could be any type of spatial information, including ecological systems or species occurrences (Loos, 2011). Goals represent the amount of each target that is required in the solution. Marxan uses a heuristic algorithm called "*simulated annealing*" that achieves near-optimal results in less time than would be required by optimization algorithms (Angelis & Stamatellos, 2004).

Before executing the software, a species-specific value (the species penalty factor) must first be entered. For this reason, and to compare different Marxan results, in the first analysis, all species were assigned the same value (1). Then, the process was repeated assigning a penalty factor directly proportional to the degree of the threat specified in Volume 6 of the Red Book of Colombian Plants – Orchids. Following Mendoza-Fernández *et al*. (2010), a scale was established based on the criterion of "Extent of occurrence" used by the IUCN (2001), where a value of 100 was assigned to species cataloged as "Vulnerable," 5000 to those "Endangered" and 20000 to taxa in the "Critical Endangered" category. For each run, an ideal number of iterations needed to be used, which depends largely on the number of planning units. 10000 iterations were implemented in the two runs, following Pérez-García *et al*. (2007).

Marxan offers two results for the two selections made: Best Solution and Summed Solution. The Best Solution includes only the planning units selected in the run that had the lowest overall objective function cost (Loos, 2011). The Summed Solution is a count of the number of times planning units are included in the solutions that result from each iteration of the software (Ball *et al*., 2009). This result provides an index of each site's irreplaceability, which is defined as a frequency of site selection in the overall number of Marxan iterations (Pressey & Taffs, 2001).

The results were represented in the geographic information system used previously. Finally, the geographic units were selected that would have obtained 10000 iterations in the Summed Solutions and that would have been /chosen by the Best Solution, with and without a penalty factor. These final geographic units (municipalities prioritized) were represented in the Great Biomes of Colombia shapefile, to compare their distribution.

### Priority sites for orchid conservation identification

### Distribution of the municipalities prioritized by Marxan in the current System of Protected Areas

Colombia's Protected Areas National System defined two categories for classification. The first one consists of the Public Protected Areas (National Parks System, Protected Forest Reserves, Regional Natural Parks, Integrated Management Districts, Soil Conservation Districts and Recreation Areas) which are characterised by being administered by different state institutions and by the level of restrictions on economic activities. The second category corresponds to Private Protected Areas, composed of Civil Society Natural Reserves, private property that is voluntarily ceded by their owners to transform them into natural reserves (Anon., 2010). This system has geographic information available to the public, and from there, the shapefile of Single Registry of Protected Areas (RUNAP) used in this section was obtained.

The layer of protected areas was superimposed on the layer of municipalities prioritised by the reserve selection (Marxan) to determine the percentage of the area of the municipalities covered by any protection figure.

### Selection of priority sites for orchid conservation

Adapting the methodology used by Forero-Medina & Joppa (2010), the protection criteria, degree of transformation of the land cover, and the number of threatened species were used to determine the biomes of national priority for conservation in Colombia. Two of these criteria (level of protection and number of threatened species) were used to select specific areas over which, this study considers, it is necessary to create conservation plans and/or figures to achieve the maintenance and protection of the threatened orchid species in the country and its ecosystems. From the municipalities prioritized in the reserves selection, groups of municipalities were chosen whose percentage of coverage by protected areas was less than 17%, which could be grouped by proximity and that together, each group added a richness equal to or greater than ten and a minimum rarity of 6.9. These values correspond to the lower limits of the second category of these variables' classification (Figures 3 and 4). These areas are called Sites of Special Importance for the Conservation of Threatened Orchids in Colombia (SSICO).

## Results and Discussion

### Distribution and biodiversity parameters

### Distribution

The 206 threatened orchid species were distributed throughout 277 municipalities that were part of 21 country provinces, including the capital city. The majority of municipalities with threatened orchid species were located in the Andes region (83.1%), followed by the Pacific region (8.7%). The Caribbean, Orinoco, and Amazon regions were poorly represented (8.2%). Figure 2 shows the municipalities with the presence and absence of the species analyzed.

### Diversity parameters (richness, continuous rarity, altitudinal range)

The average number of threatened orchids per municipality was 2.43, while the highest record was 26 in the municipality of Urrao, Antioquia province. Of the 277 municipalities, only Urrao, Abrego and Ocaña had values between 16 and 26, which was the richest range, while 163 municipalities only had one species. The spatial representation of this result is shown in Figure 3.

Concerning continuous rarity, the average value per municipality was 0.75. The municipality with the highest value was again Urrao with 11.54, followed by Toledo (7.71) and Abrego (7.30), while 16 other municipalities had the lowest value of rarity (0.045). The municipalities with the highest richness and rarity values are located in the Andes region with mean altitudes ranging from 1350 to 2050 m asl. Figure 4 shows the map of rarity for threatened orchid species in Colombia. The richness and rarity values for each municipality analyzed (277) is shown in Appendix 2.

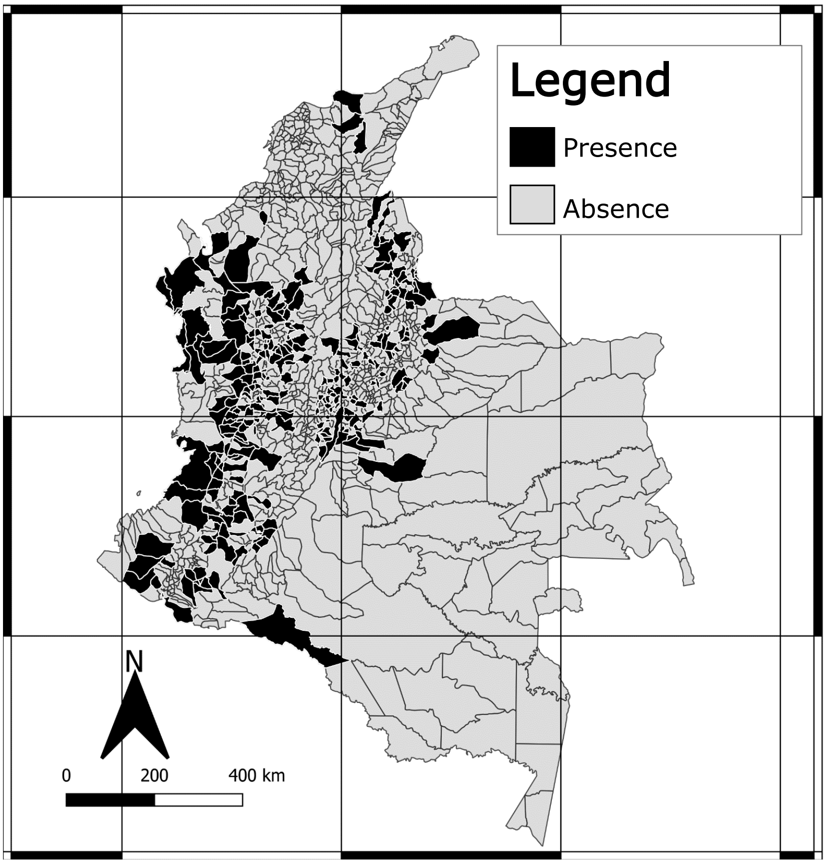


Figure 2. Distribution of threatened orchids in Colombia at the municipal level. The municipalities in black indicate the presence of the orchid species analyzed. The municipalities in grey indicate the absence of these species.

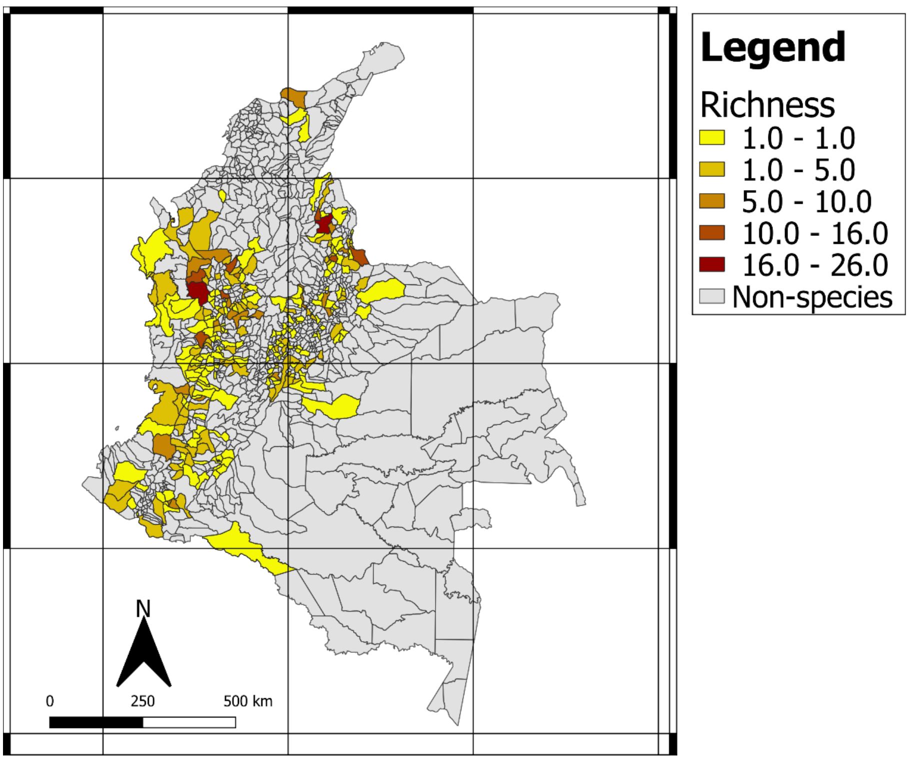


Figure 3. Map with richness ranges for threatened orchid species in Colombia at the municipal level.

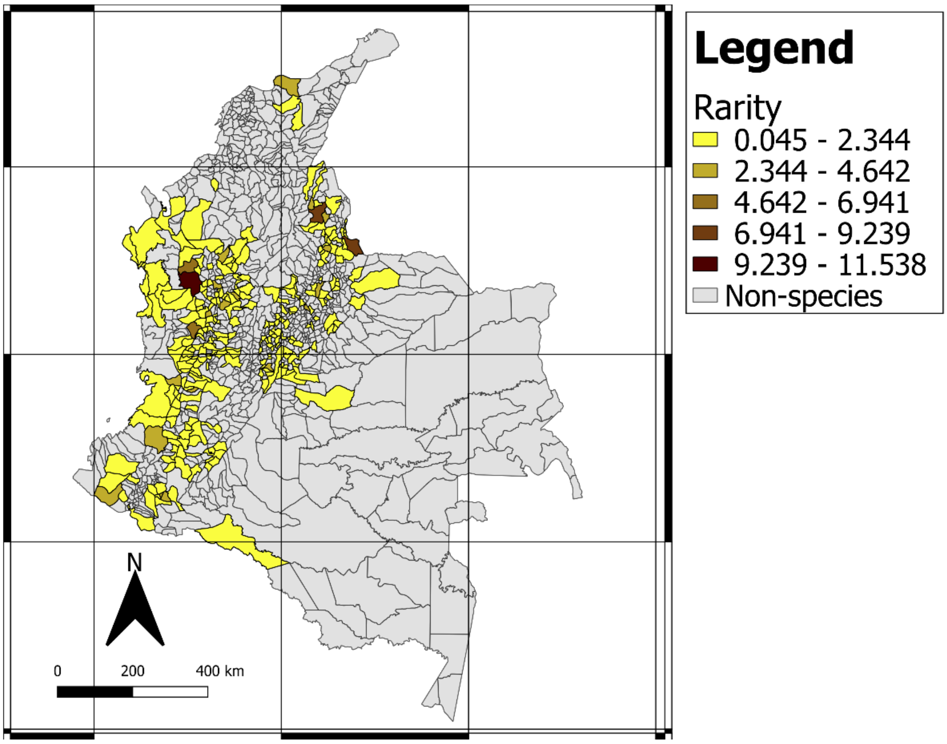


Figure 4. Map with rarity ranges for threatened orchid species in Colombia at the municipal level.

For discussion purposes, it is necessary to emphasize that species such as *Masdevallia caudata* Lindl, *Cattleya quadricolor* Lindl. ex Bateman, *Cattleya trianae* Linden & Rchb. f. and *Oncidium alexandrae* (Bateman) M.W. Chase & N.H. Williams, all categorized as "Endangered", currently have a wider geographical distribution, compared to what is recorded in the Red Book of plants of Colombia (Calderón-Sáenz, 2006). It is possibly due to two reasons. The first is the increase in research related to orchid inventories at a provincial level, as is the case in the Santander province where a List of Flora Orchidaceae was made (Martínez *et al*., 2016) with emphasis on its endemic species. Likewise, in the Cundinamarca province, public institutions (Humboldt Institute José Celestino Mutis Botanical Garden, Corpoica) and private entities (Pontifical Javeriana University) developed research where the richness and diversity of orchids in this province were determined (Castellanos-Castro & Torres-Morales, 2018). Another example is the study carried out in the province of Valle del Cauca in which the current and potential distribution map of *Cattleya quadricolor* Lindl. ex Bateman was generated. The ecological and demographic conditions in its habitat were also evaluated; threats, and drivers of change were identified and a management plan was generated (Reina-Rodríguez & Ospina-Calderón, 2013) as well.

The second reason is the increase in research on ex-situ conservation measures, whose main objective is to propagate the seeds and raise the plants in nurseries to a stage where they can be reintroduced into wildlife areas within their original range. The first example of this is the study carried out by the José Celestino Mutis Botanical Garden and the National University of Colombia in which a non-symbiotic propagation of *Masdevallia caudata* Lindl obtained by different methods of natural or artificial pollination was carried out (Ordoñez-Blanco, 2013); another example of ex-situ research is the non-symbiotic germination of seeds and in vitro propagation of *Cattleya trianae* Linden & Rchb. f., developed by researchers from the Francisco de Paula Santander University (Salazar Mercado & Vega-Contreras, 2017); and the germination and in vitro development of *Cattleya mendelii* Dombrain and *Cattleya quadricolor* Lindl. ex Bateman where an in vitro culture protocol was established for both species (Díaz-Álvarez *et al*., 2015).

Another way of analyzing the distribution of threatened orchid species is according to their altitude. Grouping all the species in their corresponding genera (Figure 5), a high variability can be observed in some of them, as is the case of *Masdevallia* that has species living from 600 to 3600 meters above sea level. On the other hand, four genera are represented by only one species (*Comparettia, Diodonopsis, Embreea,* and *Guarianthe*).

The distribution quartiles of 11 out of the 16 genera are found between 800 and 2800 meters above sea level, bringing together 92.2% of the total species analyzed. The low and medium orobiomes of the Andes (Andes forest) are to be found within these altitudes, which are ecosystems defined by the presence of mountains conditioning the water regime and vegetation. Their average temperatures vary between 12 and 20°C (Fonseca & Torres, 2007).

As for rarity, there was a low, positive, and significant correlation with maximum altitude ($p<0.05$) and a better correlation with altitudinal variation ($p<0.001$). No correlation was found among the minimum altitude of municipalities and richness and rarity variables (Table 1).

Table 1. Correlation coefficients (Spearman-Rho) of the altitude variables (maximum, minimum, mean, and variation altitude) with the richness and rarity at the municipal scale. Significant values in bold; **, significant correlation at 0.01 level (bilateral); *, significant correlation at 0.05 level (bilateral).

| Dependent variable | | Independent variable | | | |
|---|---|---|---|---|---|
| | | Max Altitude | Min Altitude | Mean Altitude | Altitudinal variation |
| Richness | Correlation coefficient | 0.225** | -0.069 | 0.119* | 0.292** |
| | Sig. (bilateral) | **0.000** | 0.253 | **0.047** | **0.000** |
| | N | 277 | 277 | 277 | 277 |
| Rarity | Correlation coefficient | 0.170** | -0.115 | 0.076 | 0.225** |
| | Sig. (bilateral) | **0.004** | 0.055 | 0.208 | **0.000** |
| | N | 277 | 277 | 277 | 277 |

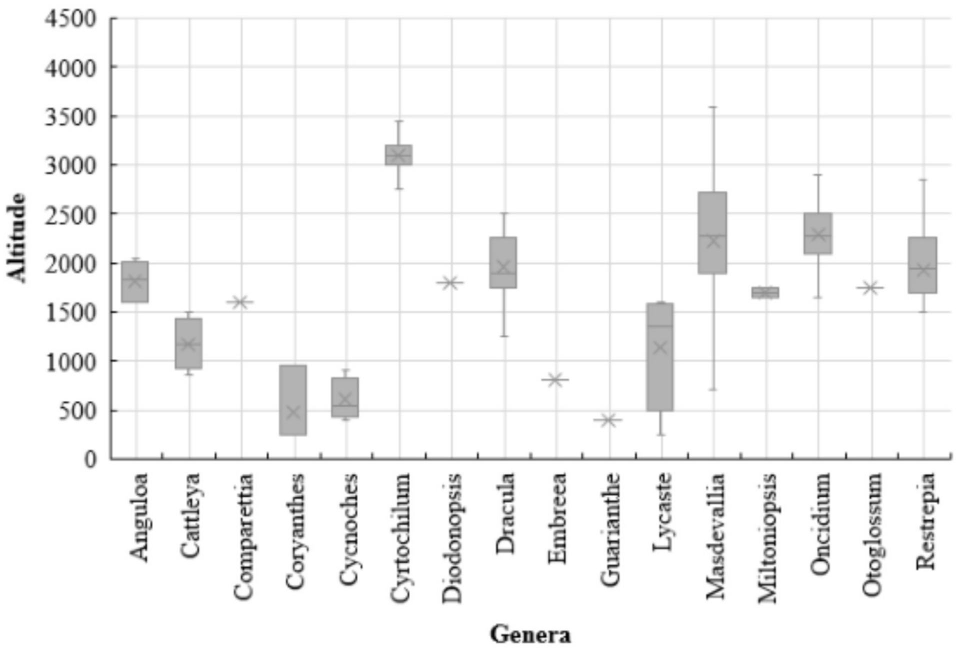


Figure 5. Box plot showing the average altitude distribution (y-axis) of the orchid genera analyzed (x-axis). Boxes comprise the two central quartiles, and whiskers indicate the 10th and 90th percentiles; correlations were also searched for between the altitudinal distribution of municipalities and richness and rarity variables. It was found that there was a low, positive, and significant correlation between richness and the municipalities' average altitude of ($p<0.05$). A moderate, positive, and significant correlation was between richness and the maximum altitude ($p<0.001$); and between this same variable and altitudinal variation ($p<0.001$) (Table 1).

**Reserve selection at the municipal level**

With the two selections made by Marxan (Figure 6), the first without and the second with a penalty value, the municipalities of the greatest importance for the protection of orchid species were obtained. The second selection of reserves, which weighed species according to their degree of threat, selected 11 different municipalities in its Best Solution compared to the first, and the Summed Solution assigned its maximum value to fewer municipalities (47 vs 49). Marxan results for the 277 municipalities with records can be found in Appendix 2.

Those municipalities were selected that would have been listed by Marxan in the two Best Solutions and that would have obtained the highest value of iterations (10000 iterations) in the two Summed Solutions, as priority municipalities. A total of 47 municipalities that met the above mentioned criteria at the same time presented the highest values of wealth and rarity. Each selected municipality was associated with the Colombian biome to which it belongs (Table 2).

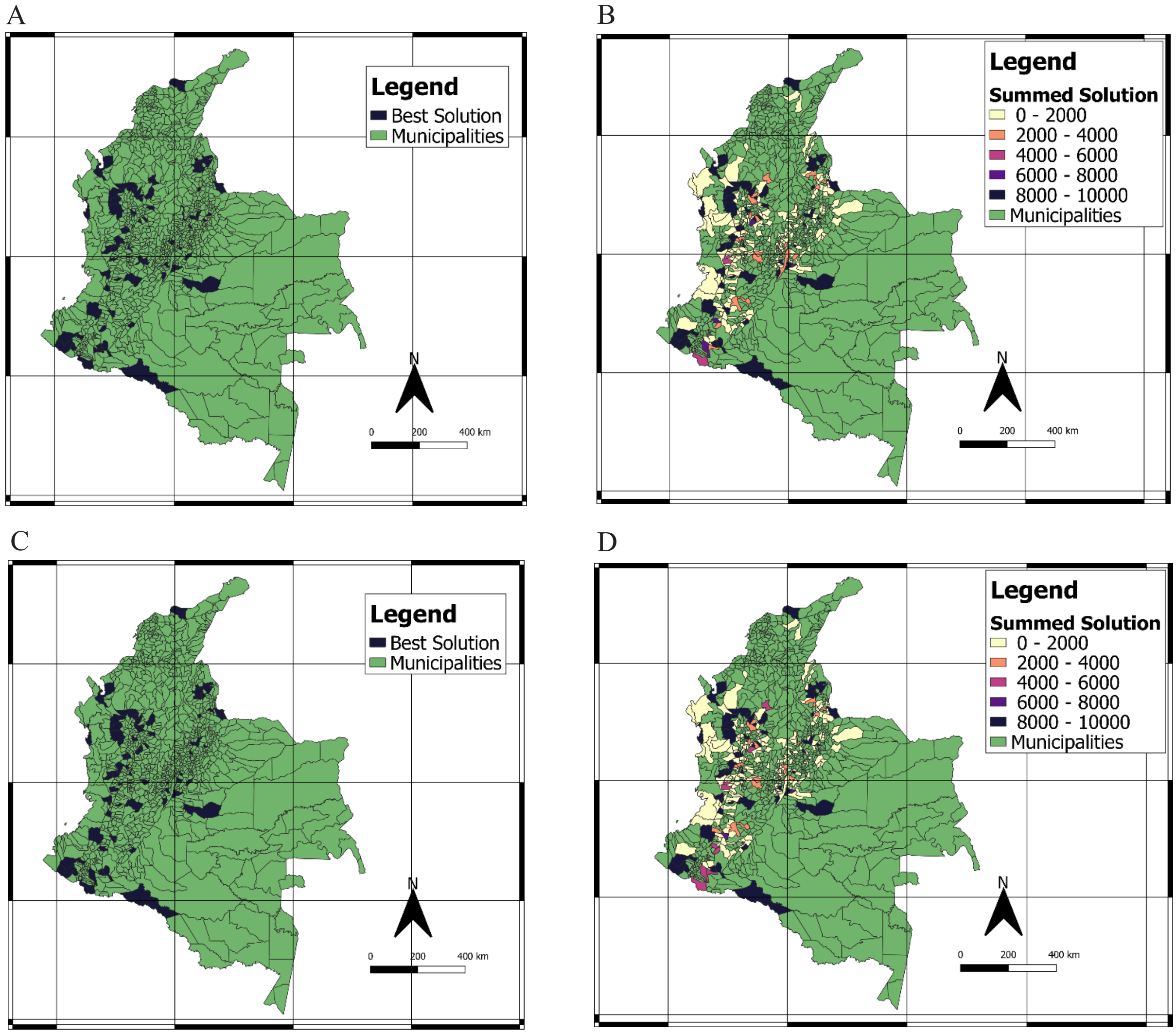


Figure 6. Marxan solutions are represented as follows: A, Best Solution without penalty factor at municipality level; B, Summed Solution without penalty factor; C, Best Solution with penalty factor; D, Summed Solution with penalty factor.

As can be seen, the first ten municipalities selected, which correspond to the highest values of wealth and rarity, are distributed in six departments: Antioquia (Urrao, Frontino, and Yarumal), Norte de Santander (Abrego and Toledo), Risaralda (Pueblo Rico), Putumayo (Sibundoy and San Francisco), Valle del Cauca (Darién) and Cauca (El Tambo), all of them are located in the Tropical Humid Zonobiome Orobiome. The 47 selected municipalities only represented 16.9% of the total number of municipalities with records (277) and were home to 81.1% of the threatened orchids. Figure 7 shows the spatial distribution of the 47 municipalities selected as priorities with their respective numeration according to their priority (numeration assigned in Table 2).

To approximate the biomes cited in Table 2, it is necessary to state that the tropical humid zonobiome, also called Tropical Humid Forest, is one of the nine zonal biomes defined by Walter (1977). It is characterised by greater rainfall than 2000 mm/year, a high percentage of humidity, a predominance of oxisol soils, and by being found only in latitudes between 10°N and 10°S. In Colombia, this biome has subdivisions determined by precipitation and altitude. The Tropical Humid Zonobiome Orobiome, also called the Andes Forest, where 33 of the 47 selected municipalities were located (70.21%) lies within these divisions. This biome can be classified into three main zones according to altitude: low mountain zone (500–1800 m asl), medium mountain zone (1800–2800 m asl), and high mountain zone (2800–4500 m asl). There are also other classifications of orobiomes that are not directly related to elevation above sea level but which are determined by factors such as soil nutrient deficiency, salinity, and flooding, as is the case with the Azonal Orobiome of the Tropical Humid Zonobiome and the Pedobiome of the Tropical Humid Zonobioma defined by a characteristic soil type within azonal vegetation (Fonseca & Torres, 2007). Figure 8 shows the spatial distribution of the 47 municipalities selected as priorities in the different Colombian biomes.

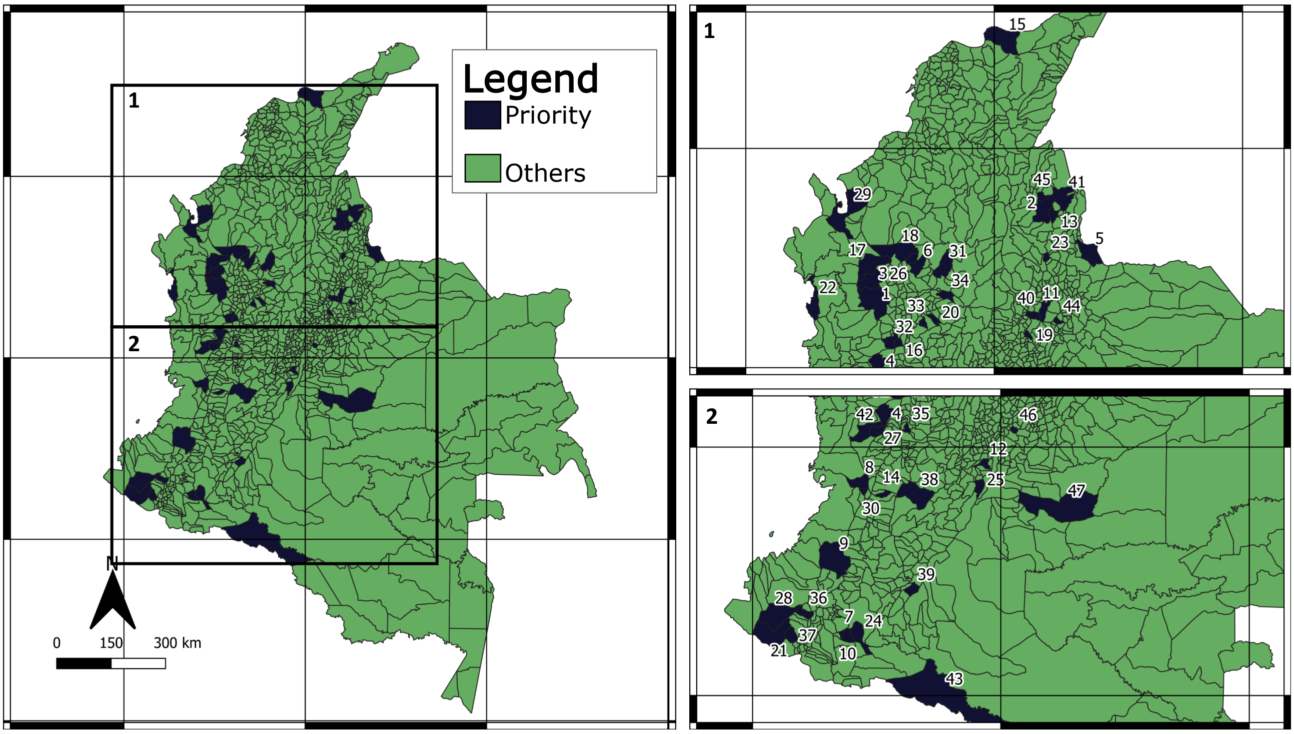


Figure 7. Distribution map of the municipalities selected as priorities.

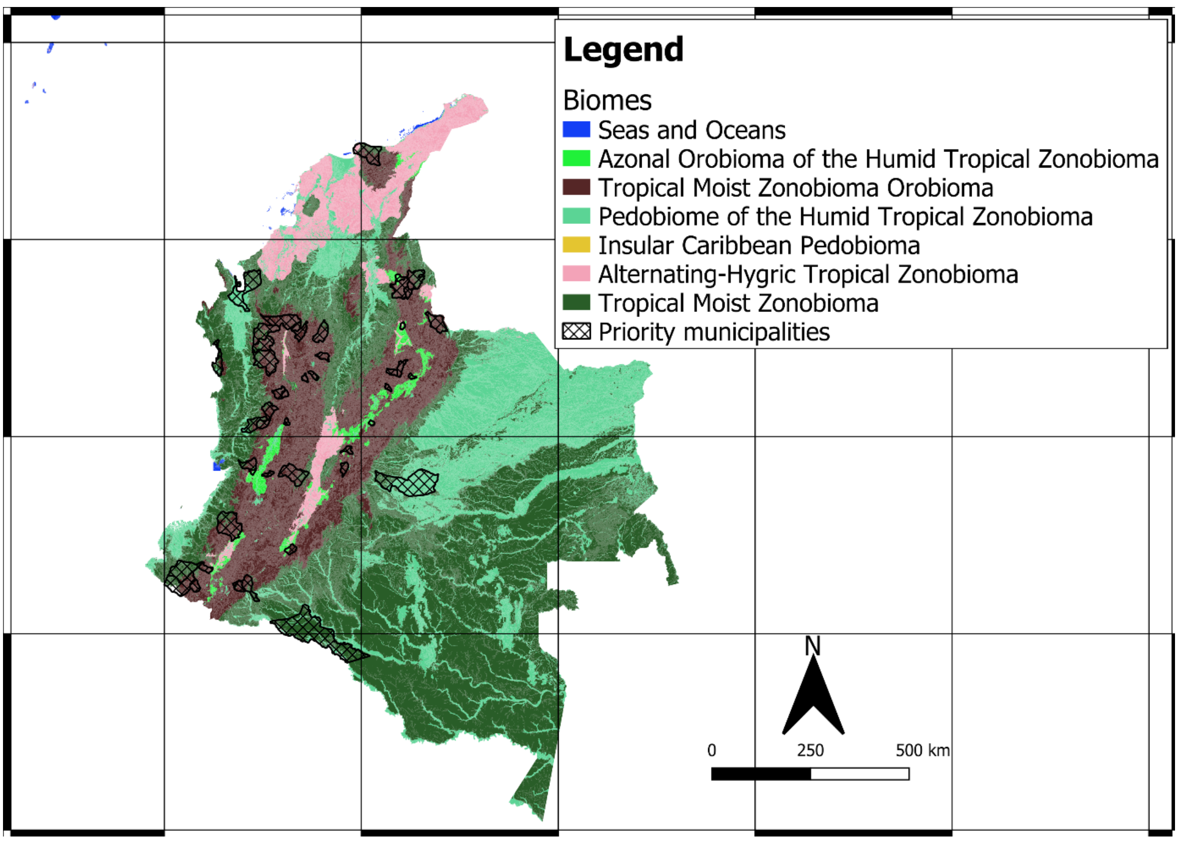


Figure 8. Distribution map of the municipalities selected as priorities in Colombian biomes.

Table 2. Values (and priority) of richness (R.), rarity, first reserve selection BSolution1 (Best Solution) and SSLON1 (Summed Solution) and second reserve selection BSolution2 (Best Solution) and SSLON2 (Summed Solution) for the 47 municipalities with the highest level of endangerment (N°) in Colombia. Bsolution1 and Bsolution 2 have a value of 1 for all cases; SSLON1 and SSLON2 have a value of 10000 in all cases.

| °N | Code | Municipality | Province | R. | Rarity | Biome |
|---|---|---|---|---|---|---|
| 1 | 5847 | Urrao | Antioquia | 26 | 11.54 | Tropical Moist Zonobiome Orobiome |
| 2 | 54003 | Abrego | Norte de Santander | 22 | 7.30 | Tropical Moist Zonobiome Orobiome |
| 3 | 5284 | Frontino | Antioquia | 13 | 4.70 | Tropical Moist Zonobiome Orobiome |
| 4 | 66572 | Pueblo Rico | Risaralda | 12 | 4.82 | Tropical Moist Zonobiome Orobiome |
| 5 | 54820 | Toledo | Norte de Santander | 11 | 7.71 | Tropical Moist Zonobiome Orobiome |
| 6 | 5887 | Yarumal | Antioquia | 11 | 3.85 | Tropical Moist Zonobiome Orobiome |
| 7 | 86749 | Sibundoy | Putumayo | 9 | 3.84 | Tropical Moist Zonobiome Orobiome |
| 8 | 76126 | Darien | Valle del Cauca | 9 | 3.41 | Tropical Moist Zonobiome Orobiome |
| 9 | 19256 | El Tambo | Cauca | 8 | 4.18 | Tropical Moist Zonobiome Orobiome |
| 10 | 86755 | San Francisco | Putumayo | 8 | 4.06 | Tropical Moist Zonobiome Orobiome |
| 11 | 68167 | Charala | Santander | 8 | 2.90 | Tropical Moist Zonobiome Orobiome |
| 12 | 25290 | Fusagasuga | Cundinamarca | 8 | 2.78 | Tropical Moist Zonobiome Orobiome |
| 13 | 54871 | Villa Caro | Norte de Santander | 7 | 3.37 | Tropical Moist Zonobiome Orobiome |
| 14 | 76306 | Ginebra | Valle del Cauca | 6 | 4.36 | Tropical Moist Zonobiome Orobiome |
| 15 | 47001 | Santa Marta | Magdalena | 6 | 2.83 | Tropical Moist Zonobiome Orobiome |
| 16 | 5364 | Jardin | Antioquia | 6 | 2.73 | Tropical Moist Zonobiome Orobiome |
| 17 | 5234 | Dabeiba | Antioquia | 6 | 2.09 | Tropical Moist Zonobiome |
| 18 | 5361 | Ituango | Antioquia | 6 | 2.07 | Tropical Moist Zonobiome Orobiome |
| 19 | 15051 | Arcabuco | Boyacá | 5 | 3.17 | Tropical Moist Zonobiome Orobiome |
| 20 | 5197 | Cocorna | Antioquia | 5 | 3.03 | Tropical Moist Zonobiome Orobiome |
| 21 | 52612 | Ricaurte | Nariño | 5 | 2.53 | Tropical Moist Zonobiome |
| 22 | 27075 | Bahia Solano | Choco | 5 | 2.01 | Tropical Moist Zonobiome |
| 23 | 68001 | Bucaramanga | Santander | 4 | 1.62 | Pedobiome of the Humid Tropical Zonobiome |
| 24 | 86001 | Mocoa | Putumayo | 3 | 2.00 | Tropical Moist Zonobiome Orobiome |
| 25 | 25120 | Cabrera | Cundinamarca | 3 | 1.13 | Tropical Moist Zonobiome Orobiome |
| 26 | 5107 | Briceño | Antioquia | 3 | 1.67 | Tropical Moist Zonobiome Orobiome |
| 27 | 27660 | San Jose del Palmar | Choco | 2 | 1.50 | Tropical Moist Zonobiome |
| 28 | 52079 | Barbacoas | Nariño | 2 | 1.50 | Tropical Moist Zonobiome |
| 29 | 5837 | Turbo | Antioquia | 2 | 1.33 | Tropical Moist Zonobiome |
| 30 | 76606 | Restrepo | Valle del Cauca | 2 | 1.14 | Azonal Orobiome of the Humid Tropical Zonobiome |
| 31 | 5031 | Amalfi | Antioquia | 2 | 1.07 | Tropical Moist Zonobiome Orobiome |
| 32 | 5034 | Andes | Antioquia | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |
| 33 | 5400 | La Union | Antioquia | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |
| 34 | 5670 | San roque | Antioquia | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |
| 35 | 66440 | Marsella | Risaralda | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |
| 36 | 52418 | Los Andes | Nariño | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |
| 37 | 52435 | Mallama | Nariño | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |
| 38 | 73168 | Chaparral | Tolima | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |
| 39 | 41319 | Guadalupe | Huila | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |
| 40 | 68770 | Suaita | Santander | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |
| 41 | 54720 | Sardinata | Norte de Santander | 1 | 1.00 | Humid Tropical Zonobiome |
| 42 | 27491 | Novita | Choco | 1 | 1.00 | Humid Tropical Zonobiome |
| 43 | 86573 | Puerto Leguizamo | Putumayo | 1 | 1.00 | Humid Tropical Zonobiome |
| 44 | 15087 | Belen | Boyaca | 1 | 1.00 | Azonal Orobiome of the Humid Tropical Zonobiome |
| 45 | 54398 | La Playa | Norte de Santander | 1 | 1.00 | Azonal Orobiome of the Humid Tropical Zonobiome |
| 46 | 25326 | Guatavita | Cundinamarca | 1 | 1.00 | Azonal Orobiome of the Humid Tropical Zonobiome |
| 47 | 50689 | San Martin | Meta | 1 | 1.00 | Tropical Moist Zonobiome Orobiome |

The Andes forests are key ecosystems for maintaining and improving the threatened orchid populations in Colombia. Thanks to their unique conditions of high humidity, unseasonal temperatures, constant altitudinal gradient and specific forest structure (microclimatic variation given by the vertical gradient in the forest canopy) (Krömer *et al*., 2007), which allow for the development of a wide variety of vascular epiphytes, a wide variety of orchid species can be found in these forests, including those analysed in this study (Zuleta *et al*., 2016).

Previous research on the importance of Andean forests in orchid conservation indicates that the most likely future scenario is that these ecosystems will continue to fragment (Reina-Rodríguez *et al*., 2017). Therefore, orchid species will have a more restricted habitat and endangered species will increase in number (Parra Sánchez *et al*., 2016). However, the role of small reserves, where strategic sites are selected, will be key in maintaining this diversity and should be taken into account for future conservation strategies.

## Priority Conservation Areas

### Distribution of threatened orchid species in current protected areas

By superimposing the layer of municipalities with the presence of orchids on the layer of the National System of Protected Areas, it was possible to determine that out of the 192750.5 km$^2$, which comprise the approximate total area of the municipalities, only 33774.9 km$^2$ of this territory has some type of protected area, representing 17.5% of the total. Concerning the municipalities selected as priorities in the previous objective, these add up to an approximate area of 59836.8 km$^2$ of which 9.6% belong to the Protected Areas System.

On the other hand, the municipalities without records of threatened orchid species occupy approximately 948998 km$^2$, whose 16.24% belong to a protected area. This proportion is similar to the percentage of total terrestrial protected areas distributed throughout the country, 16.28% (Parques Nacionales Naturales, 2010).

### Priority areas

According to the characteristics of the municipalities selected as priorities, four SSICOs located in the Andean region (Figure 9) were proposed, distributed among four provinces and 13 municipalities. A brief description of these SSICOs is presented below. In this description, some of their socio-economic characteristics were added, since these factors influence the management of natural resources. Thus, it is necessary to know them to understand each site's context better and take advantage of them to create effective conservation policies.

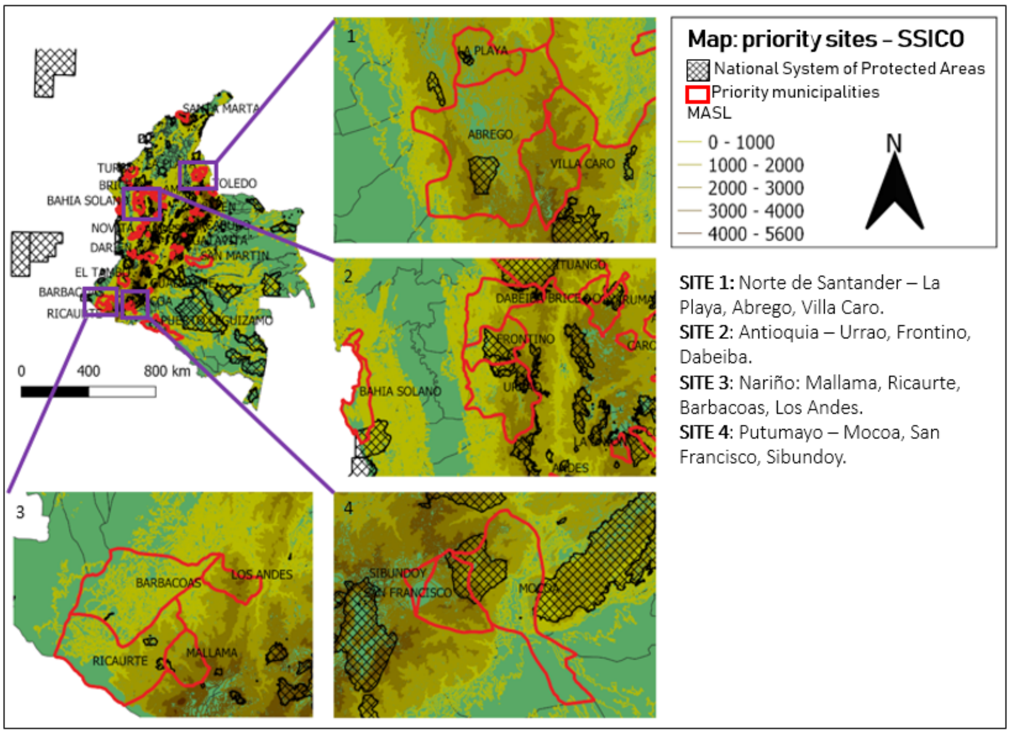


Figure 9. Map of Sites of Special Importance for the Conservation of Threatened Orchids in Colombia. A nationwide map is presented, followed by a zoom on the four SSICOs, with their corresponding enumeration.

SSICO 1. Area composed of municipalities of La Playa, Abrego, and Villa Caro, located in the north of the country in the department of Norte de Santander. Together, they are home to 27 species of threatened orchids grouped into six genera, three of which belong to the *Oncidiinae* subtribe (*Oncidium, Miltoniopsis,* and *Cyrtochilum*), two to the *Pleurothallidinae* subtribe (*Masdevallia* and *Restrepia*), one to the *Laeliinae* subtribe (*Cattleya)* and one to the *Maxillariinae* subtribe (*Anguloa*). Among the species found in this SSICO, *Restrepia aspasicensis*

Rchb. f. and *Masdevallia ignea* Rchb. f., are those of greatest concern since they are part of the six species that are critically endangered and have only been registered in this province.

These added up to a rarity of 11.68 and comprised an area of 217779.7 ha. The National Protective Forestall Reserve Rio Algodonal, the Quebrada Tenería National Protected Forest Reserve and the Los Estoraques Unique Natural Area are located within these municipalities. In conjunction, they total 9434.7 ha, representing only 4.3% of the whole area of the municipalities and 0.04% of the whole area in the Protected Areas System.

The three municipalities add up to a population of about 52000 inhabitants. The economy of this area is based on livestock, mining (hydrocarbons, coal, clay, limestone, and construction materials), agriculture (sugar cane, corn) and trade. According to the department's environmental authorities, these anthropic activities, added to the severe deficiencies in the exercise of territorial environmental regulation, have generated a strong tendency to the exhaustion of the natural sustenance base and an increase in the deterioration of the environmental quality in the main hydrographic basins (Anon., 2015).

SSICO 2. formed by the municipalities of Urrao, Frontino, and Dabeiba, which are part of the department of Antioquia and have a total area of 86462.1 ha. They distribute 36 of the orchid species analyzed and complete a rarity value of 18.33, achieving the highest values of the four selected zones. Twenty-nine of these species belong to the tribe *Epidendreae*, (tribe with the largest number of threatened orchid species), divided into the subtribe *Pleurothallidinae* (3 genera), in which *Masdevallia apparitio* Luer & R. Escobar is found, the only species of the SSICO in critical threat, and the subtribe *Laeliinae* (1 genus). The remaining seven species belong to the tribe *Cymbidieae*, subtribes *Oncidiinae* (3 genera) and *Laeliinae* (1 genus).

The Urrao National Protected Forest Reserve, the Orchid National Natural Park, and the Carauta National Protected Forest Reserve fall under these municipalities jurisdiction, which together makes up an area of 86462.1 ha, representing 14.9% of the total area of the zone and 0.3% of the total area in the Protected Areas System.

These municipalities are part of the Sucio River watershed, where livestock activity is predominant, with milk production standing out like that with the greatest generation of employment, followed by sugarcane cultivation and forest exploitation. Its population reaches 88000 inhabitants, and the main conflicts in the area are generated by the unequal distribution of land and the restrictive possibility of access to sustainable production techniques and land use, making it difficult to improve the quality of life and contributing to the depletion and deterioration of the regional natural environment. Added to this problem is the presence of armed groups operating outside the law, which affect all socio-cultural and economic activities of a community trying to guarantee the food security of the family group (Muñoz, 2004).

Even though the area comprises a National Natural Park, which has as one of its conservation objectives to guarantee the conservation of orchid species present in the territory, the socio-ecological problems and the limited extension of the park render its efforts insufficient (Muñoz, 2004).

SSICO 3. comprises the municipalities of Mallama, Ricuaurte, Barbacoas, and Los Andes, and is located to the southwest of the country in Nariño department. These have an area of 540725.3 ha, on which nine of the species analyzed live. They are distributed in three subtribes (*Oncidiinae, Pleurothallidinae,* and *Catasetinae*) and five genera (*Cycnoches, Miltoniopsis, Oncidium, Dracula,* and *Restrepia*), with the particular characteristic that two of them belong to the genus *Cycnoches* (*Cycnoches brachydactylon* Schltr. and *Cycnoches herrenhusanum* Jenny & G. A. Romero), the only one present in the subtribe *Catasetinae*, which indicates that it has a marked phylogenetic distinctiveness, compared to the other genera analysed in the study. These municipalities include La Planada National Protected Forest Reserve, the Nembi River Upper Basin National Protected Forest Reserve, the Maindes Civil Society Nature Reserve, the Selva Húmeda Biotope, and Pueblo Viejo. These, despite being five protected areas, only cover a total of 7583.2 ha, representing 1.2% of the territory of the municipalities and 0.03% of the whole area in the Protected Areas System.

Approximately 86000 inhabitants populate these municipalities, mostly distributed in rural areas. Their productive systems are based on peasant agriculture, small farms or "minifundios", the main crop being sugarcane, which is exploited for panela production in rudimentary mills. Yet, its yields are low due to the characteristics of the soils firstly, and secondly, because of artisanal gold mining (Anon., 2016). The area has been highly affected by guerrilla groups that generate social problems such as forced displacement and the loss of bread products. In addition, there are further environmental problems associated with the production of illicit crops and illegal mining (75 illegal mines in the municipality of Barbacoas), which generate illegal deforestation of large amounts of forest, contamination of water sources and loss of fertile land. This situation has been exacerbated by the low institutional presence in rural areas, a situation that has transformed and coerced the community and the social fabric (Cadena, 2018).

SSICO 4. includes the municipalities of Mocoa, San Francisco, and Sibundoy, is located in the department of Putumayo, and completes an area of 193634.6 ha, where 13 of the threatened species are found, adding up to a rarity of 9.90. A special feature of this SSICO is that most of its species (9 spp) are endemic to this province, four of them categorised as "vulnerable" (*Cyrtochilum melanthes* (Rchb.f. & Warsz.) Kraenzl., *Anguloa eburnean* B. S. Williams, *Dracula exasperata* Luer & R. Escobar and *Masdevallia sernae* Luer & R. Escobar) and five as "endangered" (*Dracula alcithoë* Luer & R. Escobar, *Dracula octavioi* Luer & R. Escobar, *Dracula* *sibundoyensis* Luer & R. Escobar, *Masdevallia cerastes* Luer & R. Escobar and *Dracula cochliops* Luer & R. Escobar).

Within these municipalities, the only existing protected area is the Mocoa River Upper Basin National Protected Forest Reserve with an area of 30848.7 ha, which corresponds to 15% of the total territory of the municipalities and 0.13% of the whole area in the Protected Areas System.

As Mocoa is the capital of the province, the sum of the population is the largest, reaching 111000 inhabitants among the three municipalities. Its economy is based mainly on three productive sectors: agricultural, mining, and the exploitation of forest resources. In the Sibundoy Valley, gold mining generates large revenues and, to a smaller extent, dairy farming and agriculture. In the municipality of San Francisco, clay exploitation for brick making is the main activity. In the municipality of Mocoa, agriculture is the basis of the economy, producing mainly corn, bananas, yucca, sugar cane, pineapple and citrus fruits (Anon., 2012).

The existence of areas for mining extraction generates socio-environmental conflicts. Despite its economic turnover, this activity implies the disappearance of the vegetation cover, the migration of wild fauna, the total disappearance of the soil, the generation of erosive processes and the contamination of water sources due to the increase in sediments and the dumping of Mercury, affecting the aquatic flora and fauna. What is more, the presence of drug trafficking and armed groups increases the pressure on rural communities (Anon., 2012).

In summary, the four SSICOs are composed of rural municipalities, which are difficult to access, poorly managed by public administrations and with socio-economic characteristics that make them prone to land tenure conflicts, further complicating the management and conservation of biodiversity and natural resources. These characteristics hinder the fulfilment of the Action Plan for the Study and Conservation of Orchids in Colombia, specifically in its action line 2 “To effectively conserve native Colombian orchid species, guaranteeing them in-situ conservation in adequate habitats and their ex situ reproduction for research and reintroduction purposes”.. Finally, this study considers that the main barrier to implementing this plan is that neither does legislation establish its mandatory compliance, nor are there national, regional, or local policies that incorporate it as a key element in managing the territories.

## Conclusions

Based on the analysis of the distribution of threatened orchid species in the country, with the help of Marxan and geographic information systems, the authors of this study were able to determine that the 47 municipalities with the highest values of richness and rarity have a representation in the system of protected areas of less than 17%. The majority (33 municipalities) is located in the Andes forest (Tropical Moist Zonobiome Orobiome). From these results, an approximation is put forward on possible sites of special importance for the conservation of threatened orchids in Colombia, leading to four SSICOs that combine low protection and a high number of threatened species. The environmental agencies might consider these SSICOs as priority areas or starting points to the conservation of threatened orchids. From this, protection of the Andes forest, maintenance of natural flows, and interspecific relationships and services provided by these ecosystems can also be considered.

As far as this study is concerned, this is the first national-level approach to analyze the distribution of threatened orchid species at a local scale and propose priority areas for conservation. However, the authors are aware of the need to generate more detailed studies to design proposals for articulating the new conservation areas identified with the current system of protected areas, incorporating the research results into public decision-making.

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Appendix 1. List of threatened orchid species in Colombia with their updated nomenclature. Asterics indicate names modified from the Red Book of threatened species in Colombia 2006.

| Updated Nomenclature 2019 | Red Book Nomenclature 2006 | IUCN |
|---|---|---|
| *Anguloa brevilabris* Rolfe | *Anguloa brevilabris* | EN |
| *Anguloa cliftonii* Rolfe | *Anguloa cliftonii* | EN |
| *Anguloa clowesii* Lindl. | *Anguloa clowesii* | EN |
| *Anguloa eburnea* B. S. Williams | *Anguloa eburnea* | VU |
| *Anguloa hohenlohii* C. Morren | *Anguloa hohenlohii* | EN |
| *Anguloa virginalis* Linden ex Schltr. | *Anguloa virginalis* | VU |
| *Cattleya dowiana* Bateman & Rchb.f. | *Cattleya dowiana* | VU |
| *Cattleya mendelii* Dombrain | *Cattleya mendelii* | EN |
| *Guarianthe patinii* Dressler & W.E.Higgins | **Cattleya patinii* | VU |
| *Cattleya quadricolor* Lindl. ex Bateman | *Cattleya quadricolor* | EN |
| *Cattleya schroederae* Sander | *Cattleya schroederae* | VU |
| *Cattleya trianae* Linden & Rchb. f. | *Cattleya trianae* | EN |
| *Cattleya warscewiczii* Rchb. f. | *Cattleya warscewiczii* | VU |
| *Comparettia ignea* P. Ortiz | *Comparettia ignea* | CR |
| *Coryanthes flava* G. Gerlach | *Coryanthes flava* | VU |
| *Coryanthes toulemondiana* G. Gerlach & T. Franke | *Coryanthes toulemondiana* | VU |
| *Coryanthes villegasiana* N. Peláez | *Coryanthes villegasiana* | VU |
| *Cycnoches barthiorum* G. F. Carr & Christenson | *Cycnoches barthiorum* | VU |
| *Cycnoches brachydactylon* Schltr. | *Cycnoches brachydactylon* | EN |
| *Cycnoches egertonianum* Bateman | **Cycnoches densiflorum* | VU |
| *Cycnoches herrenhusanum* Jenny & G. A. Romero | *Cycnoches herrenhusanum* | VU |
| *Dracula alcithoë* Luer & R. Escobar | *Dracula alcithoë* | EN |
| *Dracula amaliae* Luer & R. Escobar | *Dracula amaliae* | VU |
| *Dracula andreettae* Luer (Luer) | *Dracula andreettae* | VU |
| *Dracula aphrodes* Luer & R. Escobar | *Dracula aphrodes* | VU |
| *Dracula bella* (Rchb. f.) Luer | *Dracula bella* | VU |
| *Dracula bellerophon* Luer & R. Escobar | *Dracula bellerophon* | EN |
| *Dracula benedictii* (Rchb. f.) Luer | *Dracula benedictii* | VU |
| *Dracula berthae* Luer & R. Escobar | *Dracula berthae* | VU |
| *Dracula carcinopsis* Luer & R. Escobar | *Dracula carcinopsis* | EN |
| *Dracula chiroptera* Luer & Malo | *Dracula chiroptera* | VU |
| *Dracula citrina* Luer & R. Escobar | *Dracula citrina* | VU |
| *Dracula cochliops* Luer & R. Escobar | *Dracula cochliops* | EN |
| *Dracula cutis-bufonis* Luer & R. Escobar | *Dracula cutis-bufonis* | VU |
| *Dracula decussata* Luer & R. Escobar | *Dracula decussata* | VU |
| *Dracula diabola* Luer & R. Escobar | *Dracula diabola* | VU |
| *Dracula diana* Luer & R. Escobar | *Dracula diana* | VU |
| *Dracula exasperata* Luer & R. Escobar | *Dracula exasperata* | VU |
| *Dracula gigas* (Luer & Andreetta) Luer | *Dracula gigas* | VU |
| *Dracula gorgona* (H. J.Veitch) Luer & R. Escobar | *Dracula gorgona* | VU |
| *Dracula gorgonella* Luer & R. Escobar | *Dracula gorgonella* | VU |
| *Dracula insolita* Luer & R. Escobar | *Dracula insolita* | VU |
| *Dracula lehmanniana* Luer & R. Escobar | *Dracula lehmanniana* | VU |
| *Dracula lemurella* Luer & R. Escobar | *Dracula lemurella* | EN |
| *Dracula levii* Luer | *Dracula levii* | EN |
| *Dracula ligiae* Luer & R. Escobar | *Dracula ligiae* | VU |
| *Dracula minax* Luer & R. Escobar | *Dracula minax* | VU |

| Updated Nomenclature 2019 | Red Book Nomenclature 2006 | IUCN |
|---|---|---|
| *Dracula nosferatu* Luer & R. Escobar | *Dracula nosferatu* | EN |
| *Dracula nycterina* (Rchb. f.) Luer | *Dracula nycterina* | EN |
| *Dracula octavioi* Luer & R. Escobar | *Dracula octavioi* | EN |
| *Dracula ophioceps* Luer & R. Escobar | *Dracula ophioceps* | EN |
| *Dracula orientalis* Luer & R. Escobar | *Dracula orientalis* | VU |
| *Dracula ortiziana* Luer & R. Escobar | *Dracula ortiziana* | VU |
| *Dracula pholeodytes* Luer & R. Escobar | *Dracula pholeodytes* | VU |
| *Dracula posadarum* Luer & R. Escobar | *Dracula posadarum* | VU |
| *Dracula psittacina* (Rchb. f.) Luer & R. Escobar | *Dracula psittacina* | VU |
| *Dracula robledorum* (P. Ortiz) Luer & R. Escobar | *Dracula robledorum* | EN |
| *Dracula roezlii* (Rchb. f.) Luer | *Dracula roezlii* | VU |
| *Dracula sergioi* Luer & R. Escobar | *Dracula sergioi* | VU |
| *Dracula severa* (Rchb. f.) Luer | *Dracula severa* | EN |
| *Dracula sibundoyensis* Luer & R. Escobar | *Dracula sibundoyensis* | EN |
| *Dracula syndactyla* Luer | *Dracula syndactyla* | VU |
| *Dracula velutina* (Rchb. f.) Luer | *Dracula velutina* | VU |
| *Dracula verticulosa* Luer & R. Escobar | *Dracula verticulosa* | VU |
| *Dracula villegasii* Königer | *Dracula villegasii* | VU |
| *Dracula vinacea* Luer & R. Escobar | *Dracula vinacea* | VU |
| *Dracula vlad-tepes* Luer & R. Escobar | *Dracula vlad-tepes* | VU |
| *Embreea rodigasiana* (Claes ex Cogn.) Dodson | *Embreea rodigasiana* | VU |
| *Lycaste campbellii* C. Schweinf. | *Lycaste campbellii* | VU |
| *Lycaste macrobulbon* (Hook.) Lindley | *Lycaste macrobulbon* | VU |
| *Lycaste schilleriana* Rchb. f. | *Lycaste schilleriana* | VU |
| *Lycaste xytriophora* Linden & Rchb. f. | *Lycaste xytriophora* | VU |
| *Masdevallia alismifolia* Kraenzl. | *Masdevallia alismifolia* | EN |
| *Masdevallia angulifera* Rchb. f. ex Kraenzl | *Masdevallia angulifera* | VU |
| *Masdevallia anisomorpha* Garay | *Masdevallia anisomorpha* | EN |
| *Masdevallia apparitio* Luer & R. Escobar | *Masdevallia apparitio* | CR |
| *Masdevallia arangoi* Luer & R. Escobar | *Masdevallia arangoi* | EN |
| *Masdevallia assurgens* Luer & R. Escobar | *Masdevallia assurgens* | VU |
| *Masdevallia buccinator* Rchb. f. & Warsc. | *Masdevallia buccinator* | EN |
| *Masdevallia cacodes* Luer & R. Escobar 1982 | *Masdevallia cacodes* | EN |
| *Masdevallia caesia* Roezl | *Masdevallia caesia* | VU |
| *Masdevallia caudata* Lindl. | *Masdevallia caudata* Masdevallia expansa** | EN |
| *Masdevallia cerastes* Luer & R. Escobar | *Masdevallia cerastes* | EN |
| *Masdevallia clandestina* Luer & R. Escobar | *Masdevallia clandestina* | VU |
| *Masdevallia coccinea* Linden ex Lindl | *Masdevallia coccinea* | EN |
| *Masdevallia crescenticola* Lehm. & Kraenzl. | *Masdevallia crescenticola* | VU |
| *Masdevallia discolor* Luer & R. Escobar | *Masdevallia discolor* | VU |
| *Masdevallia dryada* Luer & R. Escobar | *Masdevallia dryada* | VU |
| *Masdevallia elephanticeps* Rchb. f. & Warsc. | *Masdevallia elephanticeps* | EN |
| *Masdevallia encephala* Luer & R. Escobar | *Masdevallia encephala* | VU |
| *Masdevallia falcago* Rchb. f. | *Masdevallia falcago* | EN |
| *Masdevallia fasciata* Rchb. f. | *Masdevallia fasciata* | EN |
| *Masdevallia foetens* Luer & R. Escobar | *Masdevallia foetens* | EN |
| *Masdevallia civilis* Rchb.f. & Warsz | **Masdevallia fragrans* | EN |
| *Masdevallia gilbertoi* Luer & R. Escobar | *Masdevallia gilbertoi* | EN |
| *Masdevallia heteroptera* Rchb. f. | *Masdevallia heteroptera* | VU |

| Updated Nomenclature 2019 | Red Book Nomenclature 2006 | IUCN |
|---|---|---|
| *Masdevallia hians* Linden & Rchb. f. | *Masdevallia hians* | VU |
| *Masdevallia hieroglyphica* Rchb. f. | *Masdevallia hieroglyphica* | EN |
| *Masdevallia hortensis* Luer & R. Escobar | *Masdevallia hortensis* | VU |
| *Masdevallia hylodes* Luer & R. Escobar | *Masdevallia hylodes* | EN |
| *Masdevallia ignea* Rchb. f. | *Masdevallia ignea* | CR |
| *Masdevallia indecora* Luer & R. Escobar | *Masdevallia indecora* | VU |
| *Masdevallia leontoglossa* Rchb. f. | *Masdevallia leontoglossa* | EN |
| *Masdevallia ludibunda* Rchb. f. | *Masdevallia ludibunda* | VU |
| *Masdevallia macrura* Rchb. f. | *Masdevallia macrura* | EN |
| *Masdevallia mandarina* (Luer & R. Escobar) Luer | *Masdevallia mandarina* | VU |
| *Masdevallia marthae* Luer & R. Escobar | *Masdevallia marthae* | VU |
| *Masdevallia mastodon* Rchb. f. | *Masdevallia mastodon* | VU |
| *Masdevallia medusa* Luer & R. Escobar | *Masdevallia medusa* | EN |
| *Masdevallia mejiana* Garay | *Masdevallia mejiana* | EN |
| *Masdevallia melanoxantha* Lindl. & Rchb. f. | *Masdevallia melanoxantha* | VU |
| *Masdevallia meleagris* Lindl. | *Masdevallia meleagris* | VU |
| *Masdevallia misasii* Braas | *Masdevallia misasii* | EN |
| *Masdevallia mooreana* Rchb. f. | *Masdevallia mooreana* | EN |
| *Masdevallia mutica* Luer & Escobar | *Masdevallia mutica* | VU |
| *Masdevallia navicularis* Garay & Dunst | *Masdevallia navicularis* | VU |
| *Masdevallia niesseniae* Luer | *Masdevallia niesseniae* | CR |
| *Masdevallia nivea* (Luer & R. Escobar) Luer & R. Escobar | *Masdevallia nivea* | VU |
| *Masdevallia odontocera* Luer & R. Escobar | *Masdevallia odontocera* | VU |
| *Masdevallia oscarii* Luer & R. Escobar | *Masdevallia oscarii* | VU |
| *Masdevallia os-draconis* Luer & R. Escobar | *Masdevallia os-draconis* | VU |
| *Masdevallia pachyantha* Rchb. f. | *Masdevallia pachyantha* | VU |
| *Masdevallia pachysepala* (Rchb. f.) Luer | *Masdevallia pachysepala* | EN |
| *Masdevallia pardina* Rchb. f. | *Masdevallia pardina* | VU |
| *Masdevallia pastinata* Luer 1997 | *Masdevallia pastinata* | VU |
| *Masdevallia pescadoënsis* Luer & R. Escobar | *Masdevallia pescadoënsis* | EN |
| *Masdevallia pteroglossa* Schltr. | *Masdevallia pteroglossa* | VU |
| *Diodonopsis pterygiophora* (Luer & R.Escobar) Pridgeon & M.W.Chase | **Masdevallia pterygiophora* | EN |
| *Masdevallia purpurella* (Luer & R.Escobar) Luer & R. Escobar | *Masdevallia purpurella* | VU |
| *Masdevallia racemosa* Lindl. | *Masdevallia racemosa* | EN |
| *Masdevallia renzii* Luer | *Masdevallia renzii* | VU |
| *Masdevallia rhinophora* Luer & R. Escobar | *Masdevallia rhinophora* | VU |
| *Masdevallia saltatrix* Rchb. F | *Masdevallia saltatrix* | VU |
| *Masdevallia sanctae-rosae* Kraenzl. | *Masdevallia sanctae-rosae* | VU |
| *Masdevallia schizantha* Kraenzl. | *Masdevallia schizantha* | VU |
| *Masdevallia schlimii* Linden ex Lindl. | *Masdevallia schlimii* | VU |
| *Masdevallia schmidt-mummii* Luer & R. Escobar | *Masdevallia schmidt-mummii* | EN |
| *Masdevallia scobina* Luer & R. Escobar | *Masdevallia scobina* | EN |
| *Masdevallia segurae* Luer & R. Escobar | *Masdevallia segurae* | EN |
| *Masdevallia sernae* Luer & R. Escobar | *Masdevallia sernae* | VU |
| *Masdevallia siphonantha* Luer | *Masdevallia siphonantha* | VU |
| *Masdevallia stenorhynchos* Kraenzl. | *Masdevallia stenorhynchos* | EN |
| *Masdevallia strumosa* P. Ortiz & E. Calderón-Sáenz | *Masdevallia strumosa* | VU |
| *Masdevallia sumapazensis* P. Ortiz | *Masdevallia sumapazensis* | VU |
| *Masdevallia trochilus* Linden & André | *Masdevallia trochilus* | VU |
| *Masdevallia urceolaris* Kraenzl. | *Masdevallia urceolaris* | EN |

| Updated Nomenclature 2019 | Red Book Nomenclature 2006 | IUCN |
|---|---|---|
| *Masdevallia valenciae* Luer & R. Escobar | *Masdevallia valenciae* | EN |
| *Masdevallia velella* Luer | *Masdevallia velella* | VU |
| *Masdevallia velifera* Rchb. f. | *Masdevallia velifera* | EN |
| *Masdevallia ventricularia* Rchb. f. | *Masdevallia ventricularia* | EN |
| *Masdevallia vieirana* Luer & R. Escobar | *Masdevallia vieirana* | VU |
| *Masdevallia virgo-cuencae* Luer & Andreetta | *Masdevallia virgo-cuencae* | VU |
| *Masdevallia wuellneri* P. Ortiz | *Masdevallia wuellneri* | VU |
| *Masdevallia xanthina* Rchb. f. | *Masdevallia xanthina* | VU |
| *Masdevallia zapatae* Luer & R. Escobar | *Masdevallia zapatae* | EN |
| *Miltoniopsis phalaenopsis* (Rchb.f.) Garay & Dunst. | *Miltoniopsis phalaenopsis* | VU |
| *Miltoniopsis vexillaria* (Rchb. f.) God.-Lebeuf | *Miltoniopsis vexillaria* | VU |
| *Oncidium alberti (P.Ortiz)* M.W .Chase & N.H. Williams | **Odontoglossum alberti* | VU |
| *Oncidium alvarezii* (P.Ortiz) M.W. Chase & N.H. Williams | **Odontoglossum alvarezii* | VU |
| *Oncidium aspidorhinum* (F. Lehm.) M.W. Chase & N.H. Williams | **Odontoglossum aspidorhinum* | VU |
| *Oncidium auriculatum* (Rolfe) M.W. Chase & N.H. Williams | **Odontoglossum auriculatum* | VU |
| *Cyrtochilum melanthes* (Rchb.f. & Warsz.) Kraenzl. | **Odontoglossum bachmannii* | VU |
| *Oncidium blandum* (Rchb.f.) M.W.Chase & N.H. Williams | **Odontoglossum blandum* | VU |
| *Oncidium crinitum* (Rchb.f.) M.W. Chase & N.H. Williams | **Odontoglossum crinitum* | VU |
| *Oncidium alexandrae* (Bateman) M.W. Chase & N.H. Williams | **Odontoglossum crispum* | EN |
| *Oncidium crocidipterum* (Rchb.f.) M.W. Chase & N.H. Williams | **Odontoglossum crocidipterum* | VU |
| *Cyrtochilum dipterum* (Lindl.) Kraenzl. | **Odontoglossum dipterum* | VU |
| *Oncidium gloriosum* (Linden & Rchb.f.) M.W.Chase & N.H.Williams | **Odontoglossum gloriosum* | VU |
| *Oncidium harryanum* (Rchb.f.) M.W.Chase & N.H. Williams | **Odontoglossum harryanum* | EN |
| *Cyrtochilum ioplocon* (Rchb.f.) Dalström | **Odontoglossum ioplocon* | VU |
| *Cyrtochilum ixioides* Lindl. | **Odontoglossum ixioides* | VU |
| *Cyrtochilum leucopterum* (Rchb.f.) Dalström | **Odontoglossum leucopterum* | VU |
| *Oncidium mirandum* (Rchb.f.) M.W.Chase & N.H. Williams | **Odontoglossum mirandum* | VU |
| *Oncidium naevium* (Lindl.) Beer | **Odontoglossum naevium* | VU |
| *Oncidium nevadense* (Rchb.f.) M.W.Chase & N.H. Williams | **Odontoglossum nevadense* | EN |
| *Oncidium nobile* (Rchb.f.) M.W.Chase & N.H. Williams | **Odontoglossum nobile* | VU |
| *Oncidium portmannii* (Bockemühl) M.W.Chase & N.H. Williams | **Odontoglossum portmannii* | VU |
| *Oncidium povedanum* (P.Ortiz) M.W.Chase & N.H. Williams | **Odontoglossum povedanum* | VU |
| *Oncidium praenitens* (Rchb.f.) M.W.Chase & N.H.Williams | **Odontoglossum praenitens* | VU |
| *Oncidium reversoides* M.W.Chase & N.H.Williams | **Odontoglossum reversum* | VU |
| *Cyrtochilum revolutum* (Lindl.) Dalström | **Odontoglossum revolutum* | VU |
| *Oncidium rhynchanthum* (Rchb.f.) M.W.Chase & N.H. Williams | **Odontoglossum rhynchanthum* | EN |
| *Oncidium subuligerum* (Rchb.f.) M.W.Chase & N.H. Williams | **Odontoglossum subuligerum* | VU |
| *Oncidium tripudians* (Rchb.f. & Warsz.) M.W. Chase & N.H. Williams | **Odontoglossum tripudians* | VU |
| *Oncidium wallisii* (Linden & Rchb.f.) M.W. Chase & N.H. Williams | **Odontoglossum wallisii* | VU |
| *Cyrtochilum weirii* (Rchb.f.) Dalström | **Odontoglossum weirii* | VU |
| *Otoglossum arminii* (Rchb. f.) Garay & Dunst. | *Otoglossum arminii* | VU |
| *Restrepia aristulifera* Garay & Dunst | *Restrepia aristulifera* | VU |
| *Restrepia aspasicensis* Rchb. f. | *Restrepia aspasicensis* | CR |
| *Restrepia chameleon* Luer & R. Escobar | *Restrepia chameleon* | VU |
| *Restrepia chocoensis* Garay | *Restrepia chocoensis* | VU |
| *Restrepia chrysoglossa* Luer & R. Escobar | *Restrepia chrysoglossa* | VU |
| *Restrepia cuprea* Luer & R. Escobar | *Restrepia cuprea* | EN |
| *Restrepia echinata* Luer & R. Escobar | *Restrepia echinata* | VU |
| *Restrepia echo* Luer & R. Escobar | *Restrepia echo* | VU |
| *Restrepia escobariana* Luer | *Restrepia escobariana* | VU |

| Updated Nomenclature 2019 | Red Book Nomenclature 2006 | IUCN |
|---|---|---|
| *Restrepia falkenbergii* Rchb. f. | *Restrepia falkenbergii* | EN |
| *Restrepia limbata* Luer & R. Escobar | *Restrepia limbata* | VU |
| *Restrepia metae* Luer & R. Escobar | *Restrepia metae* | VU |
| *Restrepia nittiorhyncha* (Lindl.) Garay | *Restrepia nittiorhyncha* | EN |
| *Restrepia pandurata* Rchb. f. | *Restrepia pandurata* | CR |
| *Restrepia purpurea* Luer & R. Escobar | *Restrepia purpurea* | VU |
| *Restrepia sanguinea* Rolfe | *Restrepia sanguinea* | VU |
| *Restrepia seketti* Luer & R. Escobar | *Restrepia seketti* | VU |
| *Restrepia tabeae* H. Mohr | *Restrepia tabeae* | VU |
| *Restrepia tsubotae* Luer & R. Escobar | *Restrepia tsubotae* | EN |