La Granja:
Revista de
Ciencias de la Vida

pISSN:1390-3799; eISSN:1390-8596

https://doi.org/10.17163/lgr.n42.2025.01

Special Issue / Edición Especial

Dynamics of Water and the Páramos

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CHARACTERIZATION OF ANDEAN WILD FRUIT TREES AS AN ENVIRONMENTAL CONSERVATION STRATEGY IN THE EASTERN MOUNTAIN RANGE OF PÁRAMO, COLOMBIA

CARACTERIZACIÓN DE FRUTALES SILVESTRES ANDINOS COMO ESTRATEGIA DE CONSERVACIÓN AMBIENTAL EN EL PÁRAMO DE LA CORDILLERA ORIENTAL, COLOMBIA

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Received on July 30th, 2024. Accepted, after revision on April 22nd, 2025. Published on September 1st, 2025.

Abstract

The páramos are ecosystems between 3,2000 and 4,900 meters above sea level. Currently, in Boyacá, the páramos are undergoing mining, deforestation, cattle ranching, and conservation of various plant species, as well as the declaration of nature reserves that strengthen nature ecotourism. The objective of the research was to characterize trees, shrubs, and vines of native fruit tree species, as well as to record the status of the use of fruit-type plant species and the knowledge held by the community in the department of Boyacá. Transect methodologies were applied, with the creation of square plots according to the type of forest and shrub cover. Additionally, an inventory of fruit tree species was conducted, along with photographic records with identification by expert taxonomists and specialized botanical catalogs. As a result, 48 species were recorded in 14 botanical families among the identified plants. The most diverse family in number of genera and species is Ericaceae with 12 species, Rosaceae with 8 species, Solanaceae and Passifloraceae with 3 species, Myrtaceae with 2 species and 6 families with one species. Likewise, the categorization and community information processes were systematized in categories of ethnobotanical use, for example: medicinal, tinctures, juices and conservation. Other species with nutritional functions were identified, for which a descriptive photographic botanical catalog was prepared. Conclusion: It is important to educate the community, as well as organize paramo rangers, to allow the conservation, diversification and use of products and by-products of the páramo.

Keywords: Biodiversity, native fruits, productive systems, botany.

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Resumen

Los páramos son ecosistemas comprendidos entre 3200 m.s.n.m, y 4900 m.s.n.m. Actualmente, en Boyacá se presentan en los páramos procesos de explotación minera, deforestación, ganadería y conservación de varias especies de plantas, así como declaratorias de reservas naturales que permiten fortalecer el ecoturismo de naturaleza. El objetivo de la investigación fue realizar la caracterización de árboles, arbustos y lianas de especies de frutales nativos, además registrar el estado del uso de especies vegetales de tipo frutales y del conocimiento que tiene la comunidad en el departamento de Boyacá, se aplicaron metodologías de transeptos, con realización de parcelas cuadradas, según el tipo de cobertura de bosques y arbustales. Adicional, se realizó el inventario de las especies de frutales, el registro fotográfico con la identificación por expertos taxónomos, catálogos especializados en botánica. Como resultado; se registraron 48 especies en 14 familias botánicas, entre las plantas identificada. La familia más diversa en número de géneros y especies es ericaceae con 12 especies, rosaceae 8 especies, solanaceae y passifloraceae con 3 especies, myrtaceae con 2 especies y 6 familias con una especie. Así mismo se sistematizaron los procesos de categorización e información comunitaria en categorías de uso etnobotánico, ejemplo: medicinal, tinturas, jugos y conservación identificaron otras especies con funciones alimentarias por lo que se elaboró un catálogo botánico fotográfico descriptivo. Conclusión; es importante educar a la comunidad, así como organizar guarda páramos, para permitir la conservación, la diversificación y el aprovechamiento de productos y subproductos del páramo.

Palabras clave: Biodiversidad, frutas nativas, sistemas productivos, botánica.

Suggested citation: Galvis Rueda, M. and Torres-Torres, M. (2025). Characterization of andean wild fruit trees as an environmental conservation strategy in the Eastern Mountain Range of Páramo, Colombia. *La Granja: Revista de Ciencias de la Vida.* Vol. 42(2):11-21. https://doi.org/10.17163/lgr.n42.2025.01.

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1 Introduction

Plant diversity in the paramo is a key element to be characterized, despite the fact that, as noted by Hofstede et al. (2003), the number of genera and species identified as endemic in paramo ecosystems is relatively low. However, the known values for the number of endemic species are significantly high. One possible explanation for this phenomenon is the relatively recent geological emergence of this ecosystem, which may have led to specialization at the species level rather than at the genus level. For example, the ericaceae family in neotropical forests is among the most representative, mainly inhabiting montane forests. It is currently represented by approximately 46 genera and 900 species, with about 94% of them being endemic (Kron et al., 2002).

This research aims to characterize and document native fruit-bearing plants and proposes strategies for their conservation within Andean systems. Fieldwork methodologies included the establishment of twelve square plots for plant inventories, taking into account shrub and forest cover across different altitudinal transects in the Guantiva-La Rusia paramo complex, located in the western corridor of Boyacá.

Among other aspects, the study addresses the need to identify wild native fruit species that play a fundamental role in ecosystem dynamics and are associated with specific territorial areas. This implies that the ecological benefits of these fruit species promote ecosystem balance and serve as a food source for members of food webs, such as consumers (Parada-Quintero et al., 2012). Therefore, this descriptive and experimental research will enhance opportunities for collaboration with local rural communities in the paramos.

Fruits are among the most commonly consumed food items both in the rural areas under study and globally, particularly in the Andean region of Latin America (Sanjinés and Øllgaard, 2006), as exemplified by the ericaceae family, whose distribution aligns with the findings of the present study.

2 Materials and Methods

This research was conducted to characterize and document native Andean fruit species with the goal of promoting their conservation. A mixed-methods approach and a systematic descriptive methodology were adopted, establishing twelve inventory plots based on vegetation research methods by Rangel and Velázquez (1997). These plots considered shrub and natural forest coverage along altitudinal transects in the Guantiva-La Rusia paramo complex, covering the municipalities of Cómbita, Sotaquirá, Paipa, and Duitama, Boyacá.

The study titled *"Characterization of Wild Fruit Species as a Conservation Strategy for the Páramo in Boyacá"* involved inventory and documentation, including photographic records of the species and their fruits. To identify their uses, direct dialogue with communities near the paramo was essential (Galvis-Rueda and Torres-Torres, 2017).

2.1 Research Approach:

The investigation was based on a mixed-methods design, representing a set of systematic, empirical, and critical processes involving the collection and analysis of both quantitative and qualitative data. This integrated analysis enhances the understanding of the studied phenomenon (Hernández-Sampieri and Mendoza, 2018). According to Creswell (2013) and Lieber and Weisner (2010), as cited in Hernández-Sampieri and Mendoza (2018), mixed methods incorporate numerical, textual, and visual data to explore complex problems.

2.2 Research Paradigm:

The research was grounded in a socio-critical paradigm, characterized by self-reflection and driven by community needs as the basis for knowledge construction (Alvarado and García, 2008).

2.3 Study Population:

A sample of 80 adult participants was convened, 20 from each municipality. In Cómbita, participants were from the Laguna community and El Valle Regional Park; in Sotaquirá, from the central area and Avendaños village; in Paipa, from Los Medios and Palermo villages, including Ranchería Municipal

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Park; and in Duitama, from communities bordering the Andalucía Forest Reserve. The Tibairá Corporation participated with five members, alongside 15 farmers from La Quinta and Santana villages, all of whom carry out agricultural activities in the paramo under study.

2.4 Research Phases:

Phase 1 –Action Plan Formulation:

Following Latorre (2003), an action plan was developed with flexible and context-adaptable components for information gathering and critical reflection.

Phase 2 –Botanical Identification of Fruit Trees:

Collected specimens were dried and identified at the Instituto de Ciencias Naturales (ICN) of the National University of Colombia or at UPTC in Tunja. Taxonomic identification followed Cronquist (1981) and used sources such as the Alexander von Humboldt Virtual Herbaria. Each specimen received a collection label with essential field data. Identifications were verified with experts using the most current taxonomic revisions and the Colombian National Herbarium (COL), accessed virtually.

Inventory and Cataloguing:

A photographic catalog of fruit species in the natural reserves and study area was compiled to facilitate recognition. This included ethnobotanical information on local uses, morphological and botanical descriptions, among other traits.

Phase 3 –Ethnobotanical Use Analysis:

A detailed activity plan was implemented, incorporating ethnobotanical categorization based on the Kew-Colplanta database (Sánchez et al., 2021). Twenty interviews were conducted in each municipality (80 in total), targeting adult residents with influence in the forest reserves. Interviewees identified wild fruit species and their uses—such as food or pigment extraction—contributing to a more comprehensive catalog. The work was supported by specialized texts like *Descriptive Botany of Tropical Crops* (León, 1987).

Phase 4 –Field Observation and Community Engagement:

Field observations were conducted on farms to gather evidence and assess direct dialogue with local farmers. These observations were planned and systematically recorded to address the core research questions, particularly concerning paramo preservation challenges identified by the community.

Phase 5 –Participatory Reflection and Conservation Planning:

Following the Action Research model (Kemmis and McTaggart, 1988), reflection focused on evaluating the outcomes of community-driven conservation efforts. The study led to the proposal of a mid-term conservation strategy: the design of a nursery in the Duitama–Río Surba region. This initiative aims to support the propagation of native species as a response to the impacts of climate change and frequent wildfires in high mountain ecosystems.

2.5 Data Analysis:

The qualitative data analysis process followed the framework described by Rodríguez et al. (2005), involving the systematic organization and interpretation of information to identify relationships, meanings, and conclusions.

3 Results and Discussion

In the paramo and the study region, a total of 48 species were recorded, grouped into 14 families (Table 1), of these, 99% correspond to species native to Colombia and distributed throughout South America, while 1% are introduced species, either cultivated or naturalized; which coincides with the research of Aguilera-Arango et al. (2020). A total of 45 species were found between 2,900 and 3,600 meters above sea level, each with some traditional use or potential for food or medicinal purposes. Of these, 40 species exhibit potential for ecological restoration and water resource conservation.

From a conservation perspective, several shrub and tree species are proposed as candidates for conservation targets due to their rarity, degree of threat, overexploitation, or endemism. Two species—*Greigia stenolepis* and *Passiflora tripartita*—are

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documented under the conservation status of Least Concern (LC), though they are categorized as having some level of threat (Morales, 2001).

In comparison, the work by González (2014), *Illustrated Guide to the Plants of the Municipality of Villa de Leyva and Surrounding Areas*, is highly comprehensive, listing 1,293 species of native vascular plants and other exotic species cultivated for edible or ornamental purposes. The current list shares approximately 90% of its species with González's work, while also contributing new records and ethnobotanical uses relevant to the region of the Eastern Cordillera.

Table 1. Ethnobotanical use of families and Species with Edible Fruits from the *Paramo* of the Western Corridor Guantiva-La Rusia, Boyacá.

Common name	Family	Scientific name	Ethnobotanical uses
Piñuela, piña de páramo	Bromeliaceae	*Greigia stenolepis* L.B.Sm.	Berry fruit; edible seeds, juice preparation, laxative medicinal use.
Papayuela	Caricaceae	*Vasconcellea pubescens* (A.DC.) Badillo	Fruit used as food; prepared in various ways including aromatic waters, preserves, and papain production.
Guatila	Cucurbitaceae	*Sechium edule* (Jacq.) Sud.	Used as a vegetable, edible fruit and other parts. Phytotherapeutic potential as antibacterial agent.
Anise grape	Ericaceae	*Cavendishia bracteata* (Ruiz & Pav. ex J. St.-Hil.) Hoerold	Fruits used for food, sweets, and jams.
Camarera grape	Ericaceae	*Macedonia rupestris* (Kunth) A.C. Smith	Fruits used for food, sweets, wine, jams, medicinal and culinary applications.
Grape	Ericaceae	*Macleania pubiflora* Benth.	Edible fruit.
Small grape	Ericaceae	*Cavendishia pubescens* (Kunth) Hemsl	Edible fruit, potential use in food and cosmetic industries.
Paramo grape	Ericaceae	*Disterigma alaternoides* (Kunth) Nied	Edible fruit.
Grape	Ericaceae	*Psammisia macrophylla*. (Kunth) Klotzsch.	Edible fruit.
Grape	Ericaceae	*Thibaudia floribunda* Kunth	Human food used in juices, sweets, and jams.
Grape	Ericaceae	*Gaylussacia buxifolia* Kunth.	Edible fruit in juices, sweets, and jams.
Pachim	Ericaceae	*Plutarchia coronaria* (Hook.fil.) A.C.Sm	Fruit used for juice, syrup, and liquor.
Agraz, Mortiño	Ericaceae	*Vaccinium floribundum* Kunth.	Human food, used in juices, sweets, and jams. Antioxidant properties.
Páramo agraz	Ericaceae	*Vaccinium meridionale* Swartz	Fruit used for juices, jams, sauces, and wines. Antioxidants present.
Reventadera	Ericaceae	*Pernettya prostrata* (Cav.) DC.	Medicinal plant, fruit used for tinctures, ethanolic extracts used for anti-inflammatory, antioxidant, and antibacterial properties.
Small grape	Ericaceae	*Cavendishia nitida* (Kunth) A.C. Sm	Edible fruit.
Grape	Ericaceae	*Cavendishia cordifolia* (Kunth) Hoerold	Edible fruit, used in jams, wines, nectars, juices, candies.
Camarera	Ericaceae	*Themistoclesia dependens* (Benth.) A.C. Sm.	Edible fruit.

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Camarera grape	Ericaceae	*Psammisia graebneriana* Hoerold	Edible fruit.
Barejon, small grape	Grassulariaceae	*Ribes andicola* Jancz.	Edible fruit, used to make jams, also used to treat undiagnosed conditions.
Arrayan	Myrtaceae	*Myrcianthes rhopaloides* (Kunth) McVaugh	Fruits and leaves used to prepare colada (traditional beverage).
Wild Arrayan	Myrtaceae	*Ugni myricoides* (Kunth) O.Berg	Wild fruit is edible.
White Arrayan	Myrtaceae	*Myrcianthes leucoxyla* (Ortega) McVaugh	Edible fruit.
Curuba	Passifloraceae	*Passiflora tripartita* (Juss.) Poir.	Edible fruit and pulp used in agro-industrial products like beverages, ferments, ice creams, and juices.
Curuba	Passifloraceae	*Passiflora mollissima* (Kunth) L. H. Bailey.	Edible fruit and pulp used in agro-industrial products like beverages, ferments, ice creams, and juices.
Canelón	Piperaceaea	*Peperomia subspathulata* Yunck.	Aromatic plant; used in infusions for stomach, head, tooth pain, nerves, bruises, burns. Whole plant used as poultice, purgative, and for deafness.
Cherry	Rosaceae	*Prunus serotina subsp. capuli* (Cav.) McVaugh	Edible fruit; used for juices, medicinal, bark, leaves, and fruit have commercial value. Expectorant, sedative, stimulant.
Uche, cerezo	Rosaceae	*Prunus buxifolia* Koehne	Fruits are edible (seeds); used as human food.
Mortiño	Rosaceae	*Hesperomeles goudotiana* (diciembre.) Killip.	Fruits used for juices, jams, and wines.
Mortiño	Rosaceae	*Hesperomeles heterophylla* (Ruiz & Pav.) Gancho	Fruits used for human consumption; juices, jams, wines.
Blackberry	Rosaceae	*Rubus urticifolius* Poir.	Fruits used for juices, jams, medicinal, and wine making.
Castilian blackberry	Rosaceae	*Rubus bogotensis* Kunth	Fruits used for human consumption; juices, jams.
Morón	Rosaceae	*Rubus nubigenus* Kunth	Fruits used for human consumption; juices, jams.
Blackberry	Rosaceae	*Rubus robustus* C. Presl	Fruits used for human consumption; juices, jams.
Blackberry	Rosaceae	*Rubus compactus* Benth	Fruits used for human consumption; juices, jams.
Blackberry, morón	Rosaceae	*Rubus glaucus* Benth	Fruits used for human consumption; juices, jams, medicinal, and wine making.
Mortiño	Rosaceae	*Hesperomeles ferruginea* (Kunth) Lindl.	Fruits used for human consumption; juices, jams.
Native strawberry	Rosaceae	*Fregaria vesca* L.	Wild strawberry used for food, juices, jams, medicine; alcoholic drinks made with aguardiente.
Rojitos, pennyroyal	Rubiaceae	*Nertera granadensis* (Mutis ex L. f.) Druce	Fruit used as food, medicinal, used to treat heart conditions.
Native lulo	Solanaceae	*Solanum quitoense* Lam.	Fruit used in traditional beverages like canelazo, colada morada, and chicha.

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Goldenberry	Solanaceae	*Physalis peruviana* L.	Food and laxative; supports bone and cartilage health, prevents diseases like osteoporosis; used in traditional drinks.
Tomatillo	Solanaceae	*Solanum sisymbrifolium* LAM.	Ripe fruit edible in various preparations; medicinal; ethanolic extract has genotoxic effects.
Mashua	Tropeliaceae	*Tropaeolum tuberosum* Ruiz y Pavón	Used in traditional highland cuisine; medicinal use for liver and kidney ailments.
Grape vine	Vitaceae	*Cissus alata* Jacq.	Green fruits stewed as vegetable; medicinal use for bruises and hematomas.
Paramo chili, cinnamon	Winteraceae	*Drimys granatensis* Mutis ex L.f	Spicy fruit used in food; traditional uses include as a laxative, emmenagogue, and anthelmintic.

As a result of the inventory, more than 15 tree species were documented (Figure 1), including *Hesperomeles goudotiana* and *Hesperomeles heterophylla* (commonly known as mortiño), *Myrcianthes leucoxyla* (arrayán), and *Prunus serotina* (cherry). Shrub species such as *Macleania rupestris* and *Macleania pubiflora* (uva camarona see Figure 2) species investigated by Acero and Bernal (2003), *Cavendishia pubescens* (uvita), and other fruit-bearing shrubs including *Disterigma alaternoides, Psammisia macrophylla, Thibaudia floribunda, Gaylussacia buxifolia, Plutarchia coronaria, Vaccinium floribundum* and *Vaccinium meridionale* (agraz or mortiño), *Pernettya prostrata* (reventadera), as well as various Rubus species (*R. urticifolium, R. bogotensis, R. nubigenus, R. robustus*, all known as wild blackberries), were recorded.

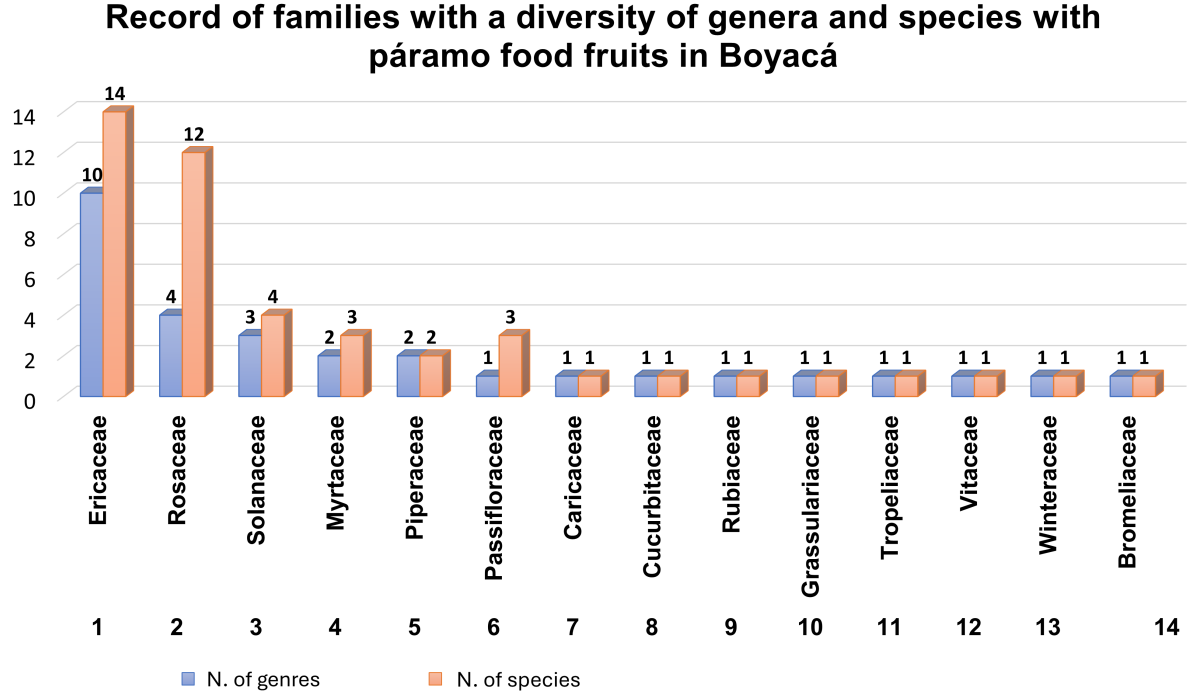

Figure 1. Record of Plant Families with Diversity of Genera and Edible Fruit-Bearing Species in the Paramo of the Western Corridor, Guantiva-La Rusia Complex– Boyacá.

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Additionally, species such as *Vasconcellea pubescens* (papayuela), *Solanum quitoense* (wild lulo), *Physalis peruviana* (cape gooseberry), *Solanum sisymbriifolium* (tomatillo), *Passiflora tripartita* (curuba) recognized as a promising crop (Casierra-Posada et al., 2017), *Cissus microcarpa* (a fruiting liana), *Sechium edule* (chayote, guatila), *Ribes andicola* (barito from the Grossulariaceae family), and *Greigia stenolepis* (piñuela from the Bromeliaceae family) were included.

This process also involved learning techniques related to fruit collection, seed scarification and preparation, germinator construction, and sexual and asexual propagation (e.g., stem cuttings), specifically for species such as *Drimys granadensis* (paramo chili), *Peperomia subspathulata* (canelón), and *Tropaeolum tuberosum* (cubio, mashua).

The presence of 15 species from the Ericaceae family, whose fruits—particularly those of the genera *Macleania, Cavendishia, Disterigma, Plutarchia*, and *Vaccinium*—are consumed, illustrates a remarkable diversity of edible plants with a long-standing tradition of use in the Duitama region. This cultural practice is closely linked to the traditions of paramo communities, as also documented in Peru by researchers such as Huamantupa-Chuquimaco et al. (2021). In Colombia, these species—commonly known as *uva camarona* or *uva de monte*—are currently being studied for their pulp production potential and transformation into value-added products such as jams and preserves.

Figure 2. Photograph and Description of *Uva Camarona* (spanish version) and its use.

In the study of edible fruit-bearing plant species from various families (see Table 1) which coincides with research by Coimbra-Molina (2014), conducted in the western corridor of the Guantiva-La Rusia páramo in Boyacá, it was found that the vegetative cover supports high plant diversity. This includes shrubs, trees, and herbaceous species distributed across 14 botanical families. The family Ericaceae showed the highest genetic diversity with 14 species across 10 genera this coincide with Castro et al. (2023), followed by Rosaceae with 12 species and 4 genera, Solanaceae with 4 species and 3 genera, and both Myrtaceae and Passifloraceae with 2 species each and which hold potential benefit (Rodríguez-Castillo and Melgarejo, 2015). Eight other families were represented by a single genus and species

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each. These findings align with previous research by Rangel (2000) on plant diversity in Colombia, particularly in high Andean zones and dry to subhumid *paramo* ecosystems, where Ericaceae and Rosaceae dominate due to their high number of genera and species in fruit trees (Fischer et al., 2022).

The Ericaceae and Rosaceae family represent the most diversified groups of plants originating from the Neotropics (Kron et al., 2002). Their diversification is closely associated with specific habitats that require distinct abiotic conditions, which change rapidly along altitudinal gradients. These conditions include variations in soil nutrient availability, precipitation regimes, humidity, temperature, photoperiod, and soil water content, all of which are interrelated with their seed dispersers and pollinators (Cáceres et al., 2014).

In terms of the recorded families and species diversity, the distribution is represented as percentages of the total sample. Plants bearing fruits of alimentary value in the paramo (Quevedo-Rubiano et al., 2021) are dominated by the Ericaceae family, comprising 33%, followed by Rosaceae at 24%, Solanaceae at 9%, Myrtaceae and Passifloraceae each at 7%, and Piperaceae at 4%. Eight additional families -Bromeliaceae, Grossulariaceae, Caricaceae, Cucurbitaceae, Rubiaceae, Tropaeolaceae, Winteraceae, and Vitaceae- are each represented by 2% of the species (Figure 1).

Furthermore, it was confirmed that several of these species play an important role in the conservation of micro-watersheds, as observed in Río de Piedras in Cómbita, Río Sotaquirá, and Río Surba in Duitama, Boyacá. As an Educational Strategy for conservation a Wild Fruit Catalog could be designed. The Figure 2 shows an example with the informative sheet of *Uva Camarona* a kind of wild grape.

4 Conclusions

Based on the work conducted, it can be stated that the *paramo* under study functions as a biological corridor with high potential for native fruit biodiversity, especially when compared to other high Andean areas in Colombia. Among the recorded plant families, Ericaceae and Rosaceae are the most prominent, both exhibiting a significant diversity of edible fruits (Diago and Castro, 2021) with various ethnobotanical applications.

The rural communities of the region display a rich pluricultural knowledge base. Through dialogue with these communities, it was established that ethnobotanical uses are primarily managed and transmitted by women (70%), who are also the main users of wild fruits from shrubs and trees -such as agraz (*Vaccinium meridionale*) same contribution by Becerra et al. (2022), lulo (*Solanum quitoense*), anise grape (*Cavendishia bracteata*), curuba (*Passiflora mollissima*), cherry known as *capulí in spanish* (*Prunus serotina subsp*), pachin (*Plutarchia coronaria*), and mortiño (*Hesperomeles heterophylla*) -mainly for the preparation of juices and jams. In contrast, men (30%) tend to use these same plants and other trees for the construction of living fences.

Finally, it is crucial to implement community education programs and to organize local *paramo* guardianship groups to ensure the conservation, diversification, and sustainable use of *paramo* products and by-products, thereby maintaining biodiversity for present and future generations.

Acknowledgements

We extend our sincere gratitude to the community boards of Cómbita, the Río de Piedras Aqueduct Management Board in Sotaquirá, the Ecoam Foundation, and the community board of Vereda Los Medios in the municipality of Paipa and Palermo. We also thank the Tibairá Foundation –Duitama, Julián Barbosa and Cristina Arias, MICRAM Uptc Research Group, Professor Javier Molano Malaver, José Fernando Ramírez Bermúdez, and the rural community of Vereda La Quinta and Santana, Duitama-Boyacá.

Authors' contribution

M.G.C.: Conceptualization, data processing, research, methodology, original draft, writing - review and editing. M.T.T.: Conceptualization, research, methodology, project management, writing - original draft, writing -review and editing.

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