

Comparative study of regional ethnobotany in Andean Region

Juan Carlos Carrasco-Baquero

juancarlos.carrasco@espoch.edu.ec

Escuela Superior Politécnica del Chimborazo

Zbynek Polesny

Czech University of Agriculture

Daisy Carolina Carrasco-López

Escuela Superior Politécnica del Chimborazo

Fernando Romero-Cañizares

Universidad de Salamanca (USAL)

Josué Bonilla

Escuela Superior Politécnica del Chimborazo

Verónica Lucía Caballero-Serrano

Escuela Superior Politécnica del Chimborazo

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Abstract

One of the primary goals of ethnobotany is to document traditional plant knowledge before it is lost. However, the extent of ethnobotanical research and the comprehensiveness of existing knowledge across cultural groups in the northern and central Andes remain poorly understood. To address this gap, we combined field research conducted in Ecuador with a comprehensive review of ethnobotanical literature from Colombia, Ecuador, Peru, and Bolivia.

Our analysis compiled records for 162 plant species belonging to 55 families and 30 orders, encompassing twelve use categories. Asteraceae was the most represented family, while medicinal use was the dominant ethnobotanical category in Ecuador (69.1%), Colombia (45.7%), Peru (51.2%), and Bolivia (37.7%). Notably, the second most frequent category was “no record,” indicating substantial gaps in the documentation and transmission of traditional knowledge.

Comparative analyses revealed a high degree of similarity in plant use among countries. Ecuador shared the highest number of species with Peru (115 species; 70.99%), followed by Colombia (105 species; 64.81%) and Bolivia (102 species; 62.96%). Moreover, all species recorded in Colombia, Peru, and Bolivia were also documented in Ecuador.

These findings demonstrate the existence of a broadly shared ethnobotanical heritage across the Andean region and highlight the urgency of strengthening efforts to document, preserve, and revitalize traditional knowledge systems that are increasingly threatened by cultural and environmental change.

1. Introduction

Plants sustain terrestrial ecosystems and provide the resources necessary for the survival of most life forms on Earth (Kor et al., 2021). Beyond their ecological functions, plants supply essential goods such as food, medicines, construction materials, and fuel, thereby supporting human well-being and ecosystem services worldwide (Millennium Ecosystem Assessment, 2005; Kier et al., 2020; Pironon et al., 2024). These long-standing interactions between people and plants have generated extensive bodies of traditional knowledge that constitute the foundation of ethnobotanical research.

Globally, more than 40,000 useful plant species have been documented, each associated with at least one recorded human use (Diazgranados et al., 2020). However, despite their ecological and cultural importance, approximately 40% of plant species are threatened with extinction, raising concerns not only about biodiversity loss but also about the erosion of traditional knowledge linked to plant resources (Brummitt et al., 2015; Corlett, 2016; Nic Lughadha et al., 2020).

The tropics represent the world's principal reservoir of plant diversity, harbouring nearly two-thirds of all angiosperm species (Corlett, 2016; Pimm & Joppa, 2018). This pattern is also evident in ferns, bryophytes, and liverworts, which reach their greatest diversity in tropical regions (Geffert et al., 2013; Carreño-Rocabado et al., 2016; Chen et al., 2019). Among tropical regions, the Andes stand out as one of the most biologically diverse areas on the planet. Colombia, Ecuador, Peru, and Bolivia encompass a substantial proportion of global biodiversity and include two internationally recognised biodiversity hotspots: the Chocó-Darién and the Tropical Andes (Myers et al., 2000; UN-WCMC, 2014). The latter has been identified as a global centre of biological diversity and endemism (Gonda, 2020).

The exceptional biological richness of the Andes is closely linked to a remarkable diversity of cultures and traditional ecological knowledge. Since the first human settlements in the region during the early Holocene, plants have played a central role in subsistence, medicine, rituals, and environmental management (Haas, 2023; Enciso et al., 2020; Le Neün et al., 2023). These interactions have shaped complex knowledge systems regarding the use and management of plant resources. In Ecuador alone, approximately 5,172 useful plant species have been recorded, with medicinal, construction, food, and cultural uses representing the most important categories (De la Torre et al., 2008; Herrera-Feijoo et al., 2023).

The biological and cultural diversity of the Tropical Andes has stimulated a growing number of ethnobotanical studies and collaborative initiatives such as the Latin American Ethnobotanical Group (GELA) (Albuquerque et al., 2013; Paniagua-Zambrana et al., 2020). Nevertheless, most ethnobotanical research has been conducted at local or national scales, limiting broader comparisons among Andean countries. As a result, regional patterns of plant use, knowledge sharing, and cultural convergence remain insufficiently understood.

Comparative ethnobotanical studies offer valuable opportunities to identify common and distinctive patterns of plant use, assess the influence of ecological and cultural factors on traditional knowledge systems, and support conservation planning in regions where biological and cultural diversity are closely intertwined. Despite the global significance of the Tropical Andes, comprehensive comparative assessments of ethnobotanical knowledge across Andean countries remain scarce.

Against this backdrop, this study addresses the following questions: (1) How do plant-use patterns in Ecuador compare with those of ecologically and culturally related Andean countries such as Colombia, Peru, and Bolivia? (2) What similarities and differences exist in the ethnobotanical knowledge of these regions? and (3) How can this information contribute to biodiversity conservation and sustainable resource management?

Accordingly, the objective of this study was to compare ethnobotanical plant-use patterns among Ecuador, Colombia, Peru, and Bolivia in order to identify shared and unique elements of traditional knowledge, assess regional similarities in plant use, and generate information relevant to biodiversity conservation and sustainable resource management.

2. Materials and Methods

2.1. Study Area

The study encompassed four countries located within the Tropical Andes biodiversity hotspot: Ecuador, Colombia, Peru, and Bolivia (Fig. 1). These countries were selected because they share a common Andean biogeographic context, high levels of biological and cultural diversity, and a long history of interactions between human societies and plant resources. Together, they represent one of the most important regions in the world for the conservation of biodiversity and traditional ecological knowledge.

The principal geographic, ecological, and ethnobotanical characteristics of the four countries are summarised in Table 1.

Table 1
Structure geographic, ecological, and ethnobotanical characteristics of the four countries

Variable	Ecuador	Colombia	Peru	Bolivia
Area (km²)	256,370	1,141,748	1,285,216	1,098,581
Population (millions)	18	53	35	12
Elevation range (m)	0–6,310	0–5,775	0–6,768	90–6,542
Plant species richness	~ 17,000–20,000	~ 26,000–30,000	~ 19,000–25,000	~ 15,000–20,000
Endemic plant species	~ 4,000–4,500	~ 6,000–8,000	~ 5,300	~ 2,500–3,000
Endemism (%)	~ 27%	~ 25%	~ 27%	~ 15–18%
Useful plant species reported	> 4,500	7,472	> 5,000	> 3,000
Dominant ethnobotanical uses	Medicinal, food, construction, fuelwood	Medicinal, food, materials, forage	Medicinal, ritual, food, construction	Medicinal, food, fuelwood, materials
Principal ethnic groups	Kichwa, Shuar, Achuar, Waorani, Cofán, Secoya	Wayuu, Embera, Nasa, Kogi, Tikuna, Misak	Quechua, Aymara, Asháninka, Shipibo-Conibo, Awajún	Quechua, Aymara, Guaraní, Chiquitano, Mojeño

2.2. Collection of ethnobotanical data in Ecuador

Ethnobotanical fieldwork was conducted between 2023 and 2024 in the province of Chimborazo, Ecuador. All research activities adhered to the Code of Ethics of the International Society of Ethnobiology. Eight of the province's ten cantons were surveyed: Alausí, Colta, Chambo, Chunchi, Guamote, Guano, Penipe, and Riobamba. These cantons are dominated by high-Andean ecosystems, including páramo, sub-páramo, and montane forest. The cantons of Pallatanga and Cumandá were excluded because they are located within the subtropical zone of Chimborazo Province.

Participants were selected using purposive and snowball sampling techniques (Tongco, 2007). Ethnobotanical information was collected through semi-structured interviews conducted after obtaining the informed verbal consent of each participant. Interviews were carried out in households and agricultural fields and were directed primarily to household heads (male or female). When household heads were unavailable, interviews were conducted with another adult household member (≥ 18 years old) (Posel, 2001; Budlender, 2003; Kothari, 2004). The number and distribution of participants are presented in Table 2.

Interviews were conducted in Spanish and focused on documenting local knowledge regarding plant species, including vernacular names, plant parts used, and associated uses. Whenever possible, respondents provided fresh plant material to facilitate species identification. All information was recorded in electronic databases and subsequently organised into a comprehensive inventory of taxa, plant parts, and use categories.

Plant identification and nomenclature followed the *Catálogo de Plantas Vasculares del Ecuador* (Jørgensen & León-Yáñez, 1999), the *Enciclopedia de las Plantas Útiles del Ecuador* (De la Torre et al., 2008), the *Libro Rojo de las Plantas Endémicas del Ecuador* (León-Yáñez et al., 2011), and the Ecuadorian Biodiversity Information System (MAE, 2025). Scientific names and taxonomic status were subsequently verified using the World Flora Online database.

Table 2
Social and geographical characteristics of the study districts in Ecuador

Canton	Elevation (meter above sea level)	Number of interviews	Gender (male/ female)	Age groups 20–40/ 40–60/ above 60	Arrival in the area	Matrimonial system	Social subsistence
Alausí	2,340	35	15/20	20–40/ 40–60/ above 60	Autochthonous	Endogamy	Farmers, Livestock keepers Government employees Micro-entrepreneurs.
Colta	3,210	46	19/27	40–60/ above 60	Autochthonous	Endogamy	Farmers, Livestock keepers Government employees
Chambo	2,740	40	27/13	20–40/ 40–60/	Autochthonous	Endogamy	Farmers, Livestock keepers Government employees Micro-entrepreneurs.
Chunchi	2,720	23	12/11	20–40/ 40–60/ above 60	Autochthonous	Endogamy	Farmers, Livestock keepers Government employees Micro-entrepreneurs.
Guamote	3,030	36	15/21	20–40/ 40–60/	Autochthonous	Endogamy	Farmers, Livestock keepers Government employees
Guano	2,720	24	11/13	20–40/ 40–60/ above 60	Autochthonous	Endogamy	Farmers, Livestock keepers Government employees Micro-entrepreneurs.
Penipe	2,480	18	7/11	40–60/ above 60	Autochthonous	Endogamy	Farmers, Livestock keepers Government employees Micro-entrepreneurs.
Riobamba	2,754	140	50/90	20–40/ 40–60/ above 60	Autochthonous	Endogamy	Farmers, Livestock keepers Government employees Micro-entrepreneurs.

2.3. Collection of bibliographic data from Peru, Colombia and Bolivia

The compilation of ethnobotanical information followed established methodological principles for ethnobotanical research, including the documentation of plant species, their uses, cultural significance, and associated traditional knowledge (Given & Harris, 1994; Martins et al., 2022). Particular emphasis was placed on generating a standardized database that would allow comparisons among countries.

A comprehensive literature review was conducted to compile ethnobotanical information from Colombia, Peru, and Bolivia. Sources included floristic inventories, ethnobotanical surveys, floras, plant-use guides, scientific articles, books, technical reports, and biodiversity databases. Only publications containing verifiable information on plant species and their documented uses were considered.

For Colombia, information was obtained from published floristic and ethnobotanical studies, as well as national biodiversity databases (Rangel, 2015; Instituto Amazónico de Investigaciones Científicas [SINCHI], 2016; Fajardo-Gutiérrez et al., 2020; SIB Colombia, 2020; Bernal et al., 2023). For Peru,

information was compiled from ethnobotanical inventories and studies on useful plants (Bussmann & Sharon, 2006, 2009; León et al., 2006; Rodríguez, 2008). For Bolivia, data were obtained from floristic and ethnobotanical publications addressing the use of native plant resources (Beck, 2001; Macía et al., 2005; Vidaurre & Paniagua, 2006; Meneses et al., 2013).

For each source, information was extracted on species identity, plant family, vernacular names (when available), use categories, and documented ethnobotanical applications. The resulting database was standardized using accepted taxonomic references to facilitate comparisons among countries and to identify regional patterns in plant use and traditional knowledge.

No temporal restrictions were imposed, and all available sources meeting the inclusion criteria were considered.

2.4. Data Analysis

2.4.1. Data Organization and Coding

A total of 162 ethnobotanical records corresponding to useful plant species documented in Ecuador, Colombia, Peru, and Bolivia were compiled for analysis. Each species was classified according to twelve use categories defined by the World List of Useful Plant Species (Diazgranados et al., 2020): (1) medicinal, (2) food, (3) materials, (4) social uses, (5) fuel, (6) vertebrate food, (7) invertebrate food, (8) environmental uses, (9) additives, (10) beekeeping, (11) toxic uses, and (12) no reported use.

Ethnobotanical information was transformed into a binary presence–absence matrix in which rows represented species and columns represented use categories. A value of 1 indicated the presence of a documented use, whereas a value of 0 indicated its absence. Binary matrices are widely employed in ethnobotanical and ecological studies because they facilitate comparisons among taxa and regions using categorical data (Hammer et al., 2001; Legendre & Legendre, 2012).

To evaluate broader taxonomic patterns, species-level information was subsequently aggregated at the family level. Following taxonomic standardization and data verification, 138 botanical families were retained for analysis. This family-by-use matrix constituted the basis for the subsequent multivariate analyses.

2.4.2. Jaccard Similarity Index (JI)

To evaluate similarities in the occurrence of useful plant species among Ecuador, Colombia, Peru, and Bolivia, a binary presence–absence matrix was constructed in which species occurrence within each country was coded as 1 (present) or 0 (absent).

Species similarity between countries was quantified using the Jaccard Similarity Index (JI), a widely used measure in floristic and ethnobotanical studies (Jaccard, 1901; Magurran, 2004):

$$JI = a / (a + b + c)$$

where *a* is the number of species shared by two countries, *b* is the number of species exclusive to the first country, and *c* is the number of species exclusive to the second country.

The index ranges from 0 (no similarity) to 1 (complete similarity). Pairwise similarity values were visualized using a heatmap to facilitate comparisons among countries and identify patterns of ethnobotanical affinity (Legendre & Legendre, 2012).

2.4.3. Multivariate Analysis: Logistic Biplot

Patterns of ethnobotanical use were explored using Logistic Biplot analysis, a multivariate ordination technique specifically developed for binary data (Galindo-Villardón, 1986; Vicente-Villardón, 2010a; Hernández et al., 2019). The analysis was performed using the family-by-use presence–absence matrix and implemented in the MULTIBILOT software environment.

Logistic Biplot allows the simultaneous representation of observations (botanical families) and variables (use categories) in a reduced-dimensional space, thereby facilitating the interpretation of relationships between taxa and ethnobotanical uses. The method models the probability of occurrence of each use category as a function of latent dimensions extracted from the data matrix.

The resulting factorial plane was used to identify groups of botanical families exhibiting similar ethnobotanical profiles, evaluate associations between particular families and use categories, and detect patterns of specialization or generalization in plant use. Interpretation followed the criteria proposed by Vicente-Villardón (2010b) and Greenacre (2017), whereby distances among families reflect similarities in ethnobotanical profiles and the orientation of variable vectors indicates the strength and direction of associations with use categories.

2.4.4. Hierarchical Cluster Analysis

To complement the ordination analysis and identify groups of botanical families with similar ethnobotanical characteristics, a Hierarchical Cluster Analysis (HCA) was performed using the coordinates obtained from the Logistic Biplot ordination.

Clusters were generated using Ward's minimum variance method, which minimizes within-group variation while maximizing differences among groups (Murtagh & Legendre, 2011). The resulting dendrogram was examined to determine the principal clusters of botanical families sharing similar ethnobotanical use profiles.

Cluster membership was subsequently projected onto the Logistic Biplot factorial plane, enabling the simultaneous visualization of botanical families, use categories, and cluster structure. This integrated approach facilitated the identification of functional groups of plant families and improved the interpretation of multivariate patterns of ethnobotanical use across the Andean region.

3. Results

3.1. Demographic Characteristics and Traditional Knowledge of Participants in Ecuador

A total of 362 participants were interviewed across eight cantons of Chimborazo Province, Ecuador. The distribution of participants was as follows: Alausí (35; 9.67%), Colta (46; 12.71%), Chambo (40; 11.05%), Chunchi (23; 6.35%), Guamote (36; 9.94%), Guano (24; 6.63%), Penipe (18; 4.97%), and Riobamba (140; 38.67%) (Table 2). Participants represented diverse occupational groups, including farmers, livestock producers, public-sector employees, artisans, and micro-entrepreneurs.

Women accounted for 56.91% of respondents, whereas men represented 43.09%. A considerable proportion of female participants were dedicated primarily to household activities. Participants also exhibited a wide range of educational backgrounds and age groups.

Traditional ethnobotanical knowledge varied among respondents. Older participants generally reported a greater diversity of plant uses and demonstrated broader knowledge of medicinal species than younger participants. This pattern was particularly evident in the cantons of Riobamba, Alausí, and Guano. Likewise, respondents with lower levels of formal education frequently reported a greater number of ethnomedicinal uses and traditional practices associated with local plant species.

Overall, the interviews revealed substantial traditional knowledge regarding the identification and use of medicinal plants, although notable differences were observed among demographic groups.

3.2. Diversity and Use of Plant Resources

A total of 162 useful plant species belonging to 55 families and 30 taxonomic orders were recorded across the four Andean countries included in this study (Appendix 1). These species were associated with a broad range of ethnobotanical uses, encompassing eleven use categories: medicinal, food, materials, social, fuel, vertebrate food, invertebrate food, environmental, additives, beekeeping, and toxic uses. In addition, a number of species lacked documented ethnobotanical uses and were classified as “no reported use” (Table 3).

The compiled dataset revealed a diverse and complex ethnobotanical system in which several species were associated with multiple use categories. Following data standardization, species classified exclusively as “no reported use” were excluded from subsequent multivariate analyses to facilitate the evaluation of ethnobotanical patterns among countries.

Table 3
Percentages of usage categories by country

Use category	Ecuador	Colombia	Perú	Bolivia
No recorded use	0%	34%	25%	40%
Environmental	2%	2%	3%	4%
Medicinal	69%	46%	51%	38%
Toxic	0%	0%	1%	1%
Social	5%	0%	2%	1%
Materials	6%	5%	7%	5%
Fuel	1%	1%	0%	1%
Beekeeping	1%	0%	1%	1%
Invertebrate feed	2%	1%	0%	0%
Vertebrate feed	4%	2%	1%	3%
Additive	2%	3%	1%	1%
Food	9%	7%	9%	6%

3.3. Comparative Analysis of Plant Uses

The distribution of ethnobotanical use categories showed both similarities and differences among Ecuador, Colombia, Peru, and Bolivia (Fig. 2). Medicinal use was the dominant category in all four countries, accounting for the highest number of recorded species. Ecuador registered the largest number of medicinal plants (112 species), followed by Peru (83), Colombia (74), and Bolivia (61).

Food use represented the second most common category across the region. Ecuador and Peru each recorded 14 food species, while Colombia and Bolivia registered 12 and 10 species, respectively. Material uses were also well represented, particularly in Peru (12 species), followed by Ecuador (9 species) and Colombia and Bolivia (8 species each).

Less frequent categories exhibited a more restricted distribution. Beekeeping uses were documented in Ecuador, Peru, and Bolivia but were absent from the Colombian dataset. Toxic plants were reported only in Peru and Bolivia. Social uses were relatively uncommon and were concentrated mainly in Ecuador (8 species) and Peru (3 species), with only one species recorded in Bolivia and none in Colombia.

The number of species classified as having no documented use varied among countries. Bolivia recorded the highest number of species in this category (65 species), followed by Colombia (55), Peru (40), and Ecuador (33).

Overall, medicinal plants constituted the most representative ethnobotanical category across all countries, followed by food and material uses. Although the relative importance of minor use categories varied among countries, the general distribution of plant uses showed a high degree of similarity throughout the Andean region.

3.4. Similarity of Ethnobotanical Knowledge Among Andean Countries

The Jaccard similarity analysis revealed a high degree of similarity in the use of plant species among the four Andean countries studied (Fig. 3). Jaccard index values ranged from 0.52 to 0.71, indicating moderate to high levels of species sharing among countries.

The highest similarity was observed between Ecuador and Peru ($JI = 0.71$), which shared 115 species. Ecuador also exhibited high similarity values with Colombia ($JI = 0.65$; 105 shared species) and Bolivia ($JI = 0.63$; 102 shared species). These results indicate that Ecuador shared the greatest number of ethnobotanically documented species with the other countries included in the analysis.

In general, all pairwise comparisons showed similarity values greater than 0.50, demonstrating substantial overlap in the useful plant species recorded across the Andean region. The heatmap further illustrates these patterns, highlighting the strong floristic and ethnobotanical affinities among the countries studied (Fig. 3).

Table 3
Comparative analysis of the use of species in the of Ecuador, and similar regions in Colombia, Peru, and Bolivia

Common name	Scientific name	Type of plant	Ethnobotanical use by country				Part of the plant used			
			Ecuador	Colombia	Peru	Bolivia	Ecuador	Colombia	Peru	Bolivia
Sin sin	<i>Podocarpus sprucei</i>	T	Medicinal	No recorded use	No recorded use	No recorded use	L			
Apiecillo	<i>Cyclospermum leptophyllum</i>	H	Medicinal	No recorded use	Materials	No recorded use	L		S,L	
Apio	<i>Apium graveolens</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	R,L,Se	S,L	L	F
Cilantro	<i>Coriandrum sativum</i>	H	Medicinal	Additive	Medicinal	No recorded use	S,L,F	S,L	L	
Eneldo	<i>Anethum graveolens</i>	H	Medicinal	Additive	Medicinal	No recorded use	L,F,Se	L	Se	
Zanahoria	<i>Daucus carota</i>	H	Medicinal	Additive	No recorded use	Food	R,S,L	R		F
Pumamaqui	<i>Oreopanax ecuadorense</i>	T	Medicinal	No recorded use	No recorded use	No recorded use	L			
Cabuya	<i>Furcraea bedinghausii</i>	H	Materials	Medicinal	Materials	Environmental	L	L	S,L	S
Cabuya Negra	<i>Agave americana</i>	H	Medicinal	Materials	food	Materials	S,L	L	S,L	L
Sabila	<i>Aloe vera</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	L	L	L	L
Achicoria	<i>Hypochaeris sessiliflora</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	R	L	L	S
Ajenjo	<i>Artemisia absinthium</i>	H	Medicinal	food	Medicinal	Medicinal	S,L	S,L	L	S
Azulina	<i>Aristeguietia glutinosa</i>	S	Medicinal	No recorded use	Medicinal	Materials	L		S,L	L
Canayuyo	<i>Sonchus oleraceus</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	R,S,L,F	L,F	L	L
Cashamarucha	<i>Xanthium strumarium</i>	H	Medicinal	Medicinal	Medicinal	No recorded use	L	L	L	
Chilca Blanca	<i>Baccharis dracunculifolia</i>	S	Medicinal	Environmental	Medicinal	Medicinal	L,F	S,L	L	L
Chilca negra	<i>Baccharis latifolia</i>	S	Medicinal	Medicinal	Environmental	Materials	S,L	L	S,L	L
Chuquiragua Peruana	<i>Chuquiragua insignis</i>	S	Medicinal	No recorded use	Medicinal	No recorded use	F			
Chuquiragua	<i>Chuquiragua jussieui</i>	Sh	Medicinal	Medicinal	No recorded use	No recorded use	S,L,F	S,L		
Hierba del ángel	<i>Chromolaena collina</i>	S	Medicinal	Medicinal	No recorded use	No recorded use	S,L			
Lechuga	<i>Lactuca sativa</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	S,L,F	L	L,F	L
Manzanilla	<i>Chamaemelum nobile</i>	C	Medicinal	Medicinal	Medicinal	Medicinal	S,L,F	R,S,L,F	S,F	S
Marco	<i>Ambrosia arborescens</i>	S	Medicinal	Materials	Medicinal	No recorded use	L,Fr,Se	L	S,L	
Margarita de la sierra	<i>Gaillardia cabreriae</i>	Sh	Medicinal	food	Medicinal	No recorded use	L,F	L	F	
Ñachag	<i>Bidens andicola</i>	H	Medicinal	No recorded use	Medicinal	Medicinal	L,F		S,F	F
Romerillo	<i>Bidens pilosa</i>	H	Medicinal	No recorded use	No recorded use	No recorded use	L,F			
**A=Aquatic; C =Creeping; Cl=Climbing; E=Epiphytic; H=Herbaceous; Sh=Semi-shrubby; S=Shrubby; T=Tree-like										
R=Root; S=Stem; L=Leaves; F=Flowers; Fr=Fruits; S=Seeds; O=Others										

Common name	Scientific name	Type of plant		Ethnobotanical use by country				Part of the plant used			
				Ecuador	Colombia	Peru	Bolivia	Ecuador	Colombia	Peru	E
Romerillo del paramo	<i>Diplostephium antisanense</i>	S	Medicinal		No recorded use	No recorded use	No recorded use	S,L			
Santa María	<i>Pyrethrum parthenium Sm.</i>	H	Social		No recorded use	No recorded use	Social	R,S,L,Fr			S
Taraxáco	<i>Taraxacum officinale</i>	H	Medicinal		Medicinal	Medicinal	Medicinal	R,L	R	R	F
Aliso marítimo	<i>Alysum maritimum</i>	H	Medicinal		Environmental	Environmental	Food	L,F	F	L,Fr	L
Berro amargo	<i>Cardamine hirsuta</i>	C	Medicinal		food	food	Food	L	S,L	S	L
Berro de agua	<i>Nasturtium officinale</i>	H	Medicinal		Medicinal	food	Food	S,L	L	L	S
Col	<i>Brassica oleracea</i>	H	Medicinal		Medicinal	food	No recorded use	S,L	L	S,L	
Nabo	<i>Brassica rapa</i>	H	Medicinal		No recorded use	Medicinal	Medicinal	R,L,F		R	L
Mashua	<i>Tropaeolum tuberosum</i>	C	Medicinal		Medicinal	food	No recorded use	S,L,Fr	Fr	L,F	
Ataco morado	<i>Amaranthus asplundii</i>	H	Medicinal		food	Additive	Medicinal	R,L,F,Fr	S	S,L	L
Escancel	<i>Aerva sanguinolenta L.</i>	H	Medicinal		Medicinal	No recorded use	Medicinal	S,L	L		L
Escancel morado	<i>Alternanthera pubiflora</i>	H	Medicinal		Medicinal	Medicinal	Medicinal	L	L	S,L	L
Lengua de vaca	<i>Rumex obtusifolius</i>	H	Medicinal		Medicinal	Materials	Medicinal	L	R,L	S	S
Paico	<i>Chenopodium ambrosioides</i>	H	Medicinal		No recorded use	Medicinal	Additive	S,L,Se		S,L	L
Quinhuilla	<i>Chenopodium album</i>	H	Medicinal		No recorded use	No recorded use	No recorded use	S,L			
Quinoa	<i>Chenopodium quinoa</i>	H	food		No recorded use	No recorded use	No recorded use	S,L,Fr,Se			
Remolacha	<i>Beta vulgaris</i>	H	Medicinal		Medicinal	food	Medicinal	R,S	R	R,L	F
Sangorache	<i>Amaranthus hybridus</i>	Sh	Medicinal		No recorded use	No recorded use	No recorded use	S,L			
Melloco	<i>Ullucus tuberosus</i>	H	Medicinal		food	Materials	Medicinal	R,L	R,L	S,L	S
Tuna	<i>Opuntia ficus-indica</i>	S	Invertebrate feed		Medicinal	Medicinal	No recorded use	S	L	L,Fr	
Lancetilla	<i>Commelina diffusa</i>	H	Medicinal		No recorded use	Medicinal	No recorded use	F		L	
Shansa	<i>Coriaria ruscifolia</i>	S	food		No recorded use	No recorded use	No recorded use	F,Fr,Se			
Pepino	<i>Cucumis sativus</i>	Cl	food		food	Medicinal	No recorded use	Fr	Se	Fr	
Sambo	<i>Cucurbita ficifolia</i>	C	Medicinal		No recorded use	No recorded use	No recorded use	L,Fr,Se			
Zapallo	<i>Cucurbita maxima</i>	C	Medicinal		Medicinal	Medicinal	Environmental	L,F,Fr,Se	Fr,Se	S,L,F	S
Cipres común	<i>Cupressus sempervirens</i>	T	Medicinal		Medicinal	Medicinal	No recorded use	L,Fr	L	L	
**A=Aquatic; C =Creeping; Cl=Climbing; E=Epiphytic; H=Herbaceous; Sh=Semi-shrubby; S=Shrubby; T=Tree-like											
R=Root; S=Stem; L=Leaves; F=Flowers; Fr=Fruits; S=Seeds; O=Others											

Common name	Scientific name	Type of plant	Ethnobotanical use by country				Part of the plant used			
			Ecuador	Colombia	Peru	Bolivia	Ecuador	Colombia	Peru	E
Ciprés de California	<i>Crupressus macrocarpa</i>	T	Medicinal	No recorded use	No recorded use	No recorded use	S,L			
Sauco negro	<i>Sambucus nigra</i>	S	Medicinal	Medicinal	Medicinal	Medicinal	S,L,F,Fr	F,Fr	S	S
Valeriana	<i>Valeriana officinalis</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	R	R,L	L	F
Cola de Caballo	<i>Equisetum arvense</i>	S	Medicinal	Medicinal	Medicinal	Medicinal	S,L	S	S	S
Agraz silvestre	<i>Vaccinium meridionale</i>	S	Medicinal	Additive	Social	Food	L	L,Fr	S,L	L
Hierba de San Pedro	<i>Primula officinalis</i>	H	Medicinal	No recorded use	No recorded use	Medicinal	R,L,Se			L
Tora	<i>Escallonia myrtilloides</i>	T	Medicinal	No recorded use	No recorded use	Fuel	S,F,Fr			S
Acacia o botón de oro	<i>Acacia dealbata</i>	T	Medicinal	Materials	Medicinal	Environmental	F,Se	S	S,L	S
Alfalfa	<i>Medicago sativa</i>	H	Medicinal	Medicinal	Environmental	Vertebrate feed	S,L,F	L	R,S,L	S
Alverjana	<i>Lathyrus latifolius</i>	H	food	No recorded use	Medicinal	Medicinal	Fr		F	S
Alverjilla	<i>Lathyrus odoratus</i>	CL	Medicinal	food	food	Additive	L	Fr	Fr	L
Chocho	<i>Lupinus mutabilis</i>	H	Medicinal	Medicinal	Environmental	Food	S,Se	L	R,S	F
Chocho silvestre	<i>Lupinus tricolor</i>	H	Fuel	Medicinal	food	Environmental	S	L,Se	Fr	S
Fréjol	<i>Phaseolus vulgaris</i>	Cl	food	food	Vertebrate feed	Medicinal	Fr,Se	L,Fr	Fr	S
Guarango	<i>Caesalpinia spinosa</i>	H	Environmental	No recorded use	Materials	No recorded use	S,L		Se	
Habas	<i>Vicia faba</i>	T	food	Additive	No recorded use	Food	L,Fr,Se	F		F
Llin llín	<i>Senna multiglandulosa</i>	T	Medicinal	No recorded use	No recorded use	No recorded use	S,L,F,Fr			
Lotera	<i>Lotus uliginosus</i>	H	Vertebrate feed	Vertebrate feed	No recorded use	Vertebrate feed	S,L	L		S
Retama amarilla	<i>Spartium junceum</i>	S	Social	No recorded use	Medicinal	No recorded use	S,L,F		R,L	
Retama blanca	<i>Retama monosperma</i>	S	Fuel	No recorded use	Medicinal	No recorded use	S		S,L,F	
Retamilla	<i>Cytisus monspesulanus</i>	S	Social	No recorded use	No recorded use	No recorded use	S,F			
Trebol blanco	<i>Trifolium repens</i>	C	Vertebrate feed	No recorded use	Medicinal	Vertebrate feed	R,L,F		S,L,F	F
Trébol rojo	<i>Trifolium pratense</i>	C	Environmental	No recorded use	No recorded use	Medicinal	L			F
Trinitaria	<i>Otholobium munyense</i>	H	Medicinal	No recorded use	No recorded use	No recorded use	L,F			
Aliso	<i>Alnus acuminata</i>	T	Materials	Medicinal	Medicinal	Medicinal	S,L	L	L	S
Laurel de cera	<i>Morella pubescens</i>	T	Medicinal	Materials	Environmental	Materials	S,L	Fr	L,F	F
**A=Aquatic; C =Creeping; Cl=Climbing; E=Epiphytic; H=Herbaceous; Sh=Semi-shrubby; S=Shrubby; T=Tree-like										
R=Root; S=Stem; L=Leaves; F=Flowers; Fr=Fruits; S=Seeds; O=Others										

Common name	Scientific name	Type of plant	Ethnobotanical use by country				Part of the plant used			
			Ecuador	Colombia	Peru	Bolivia	Ecuador	Colombia	Peru	E
Lana del pobre (Musgo)	<i>Rigodium implexum</i>	C	Medicinal	Environmental	Medicinal	No recorded use	S	R	R,L	
Acanto	<i>Acanthus mollis</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	L,F	L,F	R	L
Cholán	<i>Tecoma stans</i>	T	Medicinal	No recorded use	No recorded use	No recorded use	L,F			
Borrajá	<i>Borago officinalis</i>	H	Beekeeping	Medicinal	Medicinal	Medicinal	F	L,F	L	L
Hierba buena	<i>Mentha spicata</i>	H	Medicinal	Medicinal	Materials	No recorded use	L	L	L	
Menta	<i>Mentha x piperita L.</i>	Sh	food	Medicinal	Additive	No recorded use	L	L	L	
Menta de caballo	<i>Mentha longifolia</i>	H	Medicinal	Medicinal	No recorded use	Medicinal	S,L	L		L
Muña	<i>Minthostachys mollis</i>	S	Environmental	No recorded use	Medicinal	No recorded use	S,L		L,F	
Orégano	<i>Origanum vulgare</i>	Sh	Additive	Medicinal	Medicinal	No recorded use	L,F	L	L	
Romero	<i>Rosmarinus officinalis</i>	S	Medicinal	Medicinal	Medicinal	Medicinal	S,L,F	L,F	L	S
Salvia real negra	<i>Salvia sagittata</i>	H	Social	Medicinal	Medicinal	Materials	S,L,F	L	R,S	L
Toronjil	<i>Melissa officinalis</i>	S	Medicinal	Medicinal	Medicinal	Medicinal	S,L,F	S,L	L	L
Cymbalaria	<i>Cymbalaria muralis</i>	H	Medicinal	Medicinal	No recorded use	No recorded use	L	F		
Llantén macho	<i>Plantago major</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	R,L	R	L	L
Matico	<i>Buddleja globosa</i>	S	Medicinal	Medicinal	Medicinal	No recorded use	S,L,F	S,L	L,F	
Quishuar	<i>Buddleja incana</i>	T	Social	No recorded use	Medicinal	No recorded use	S,L,F		L,F	
Cedrón	<i>Aloysia citrodora</i>	S	Medicinal	Medicinal	Medicinal	Medicinal	L,F	F	L	S
Verbena	<i>Verbena littoralis Kunth</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	S,L,F	L	F,Fr	L
Calicanto del japon	<i>Chimonanthus praecox</i>	S	Medicinal	No recorded use	Beekeeping	No recorded use	F		L,F	
Ishpingo	<i>Ocotea quixos</i>	T	Medicinal	Medicinal	Medicinal	No recorded use	L,F	S,L	L	S
Laurel	<i>Laurus nobilis</i>	T	Additive	Medicinal	Medicinal	Medicinal	S,L	L	L,Fr	L
Lirio de Pascua	<i>Lilium longiflorum</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	S,F	F	L	L
Lechero blanco	<i>Euphoria laurifolia Lamb</i>	S	Medicinal	No recorded use	Toxic	No recorded use	L			S
Granadilla	<i>Passiflora ligularis</i>	Cl	food	Medicinal	Medicinal	Medicinal	Fr	L,F		L
Taxo	<i>Passiflora mollissima</i>	Cl	food	No recorded use	No recorded use	No recorded use	L,Fr			
Chancapiedra	<i>Phyllanthus niruri L.</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	S,L	L	S,L	L
Motilon	<i>Hyeronima macrocarpa</i>	T	Materials	food	Materials	No recorded use	S,F	L,F	S	
**A=Aquatic; C =Creeping; Cl=Climbing; E=Epiphytic; H=Herbaceous; Sh=Semi-shrubby; S=Shrubby; T=Tree-like										
R=Root; S=Stem; L=Leaves; F=Flowers; Fr=Fruits; S=Seeds; O=Others										

Common name	Scientific name	Type of plant	Ethnobotanical use by country				Part of the plant used			
			Ecuador	Colombia	Peru	Bolivia	Ecuador	Colombia	Peru	Bolivia
Alamo blanco	<i>Populus alba</i>	T	Materials	Materials	Materials	Medicinal	S	S	S	L
Alamo negro	<i>Populus nigra</i>	T	Medicinal	Materials	Medicinal	Fuel	L	S	S,L	S
Sauce blanco	<i>Salix alba</i>	T	Medicinal	No recorded use	No recorded use	No recorded use	S,L,F,Fr			
Sauce llorón	<i>Salix babylonica</i>	T	Materials	Invertebrate feed	Materials	Environmental	S,L	R,S	S	S
Malva común	<i>Malva sylvestris</i>	T	Medicinal	Medicinal	Medicinal	No recorded use	L,F	S,L	L	
Tilo	<i>Tilia</i>	T	Medicinal	No recorded use	Medicinal	Food	L,F		F	F
Arrayán	<i>Myrtus communis</i>	T	Invertebrate feed	Medicinal	Medicinal	Medicinal	Fr	L	S,L	L
Arrayán negro	<i>Myrcianthes rhopaloides</i>	T	Medicinal	Medicinal	Medicinal	Medicinal	S,L,F	L	S	L
Eucalipto	<i>Globulus Labill</i>	T	Medicinal	Medicinal	Materials	Medicinal	S,L	L	L,F	L
Eucalipto blanco	<i>Eucaliptus globulus</i>	T	Medicinal	Medicinal	Materials	Medicinal	S,L,F	L	L	S
Aretillos	<i>Fuchsia loxensis</i>	S	Medicinal	Medicinal	Medicinal	Beekeeping	L,F	L	S,L	F
Ocas	<i>Oxalis tuberosa</i>	C	food	No recorded use	No recorded use	Medicinal	R,F			L
Pino chino	<i>Pinus patula</i>	T	Materials	No recorded use	Medicinal	No recorded use	S			S
Pino insigne	<i>Pinus radiata</i>	T	Materials	No recorded use	Medicinal	No recorded use	L			S
Achupalla	<i>Puya clavata-herculis</i>	H	Medicinal	food	Materials	Medicinal	L,F	L	S,L	L
Huicundo	<i>Tillandsia spp</i>	E	Medicinal	No recorded use	No recorded use	No recorded use	S,L,F			
Musgo, salvaje	<i>Tillandsia recurvata</i>	E	Social	No recorded use	No recorded use	No recorded use	L,F			
Totora	<i>Scirpus californicus</i>	A	Materials	No recorded use	Medicinal	No recorded use	S,L			S
Avena	<i>Avena sativa</i>	H	Vertebrate feed	Medicinal	Medicinal	Food	R,S,L,F	S,L	L,Se	S
Carrizo	<i>Phragmites australis</i>	A	Social	Medicinal	Social	Materials	S,L	S,L	S	S
Cebada	<i>Hordeum vulgare</i>	H	Medicinal	Medicinal	food	Medicinal	S,Se	Se	S,L	S
Grama	<i>Cynodon dactylon</i>	H	Medicinal	Medicinal	Medicinal	Medicinal	R,S,L	L	S,L	S
Gramalote	<i>Axonopus scoparius</i>	H	Medicinal	Vertebrate feed	No recorded use	No recorded use	L	R,S,L		
Hierba luisa	<i>Cymbopogon citratus</i>	H	Medicinal	Medicinal	Medicinal	No recorded use	L	S,L	L	
Kikuyo	<i>Pennisetum clandestinum</i>	C	Environmental	No recorded use	No recorded use	No recorded use	R,S,L			
Maíz	<i>Zea mays</i>	H	food	Materials	food	Medicinal	S,Fr	Fr	R,S,L,F,Fr	L
Paja brava	<i>Stipa ichu</i>	H	Medicinal	No recorded use	Medicinal	Vertebrate feed	R,L		L	F
Paja chamik	<i>Calamagrostis intermedia</i>	H	Vertebrate feed	No recorded use	Medicinal	Materials	S,L		S	F
**A=Aquatic; C =Creeping; Cl=Climbing; E=Epiphytic; H=Herbaceous; Sh=Semi-shrubby; S=Shrubby; T=Tree-like										
R=Root; S=Stem; L=Leaves; F=Flowers; Fr=Fruits; S=Seeds; O=Others										

Common name	Scientific name	Type of plant		Ethnobotanical use by country				Part of the plant used			
				Ecuador	Colombia	Peru	Bolivia	Ecuador	Colombia	Peru	E
Pajilla	<i>Stipa plumeris</i>	H	Social		No recorded use	Medicinal	No recorded use	L		R,L	
Sigze	<i>Cortadeiría nitida</i>	H	Medicinal		No recorded use	No recorded use	Materials	S,L,F			S
Trigo	<i>Triticum vulgare</i>	H	food		Medicinal	Medicinal	No recorded use	F	S,L	Se	
Culantrillo de pozo	<i>Adiantum capillus-veneris</i>	H	Medicinal		Medicinal	Medicinal	No recorded use	S,L	S	S,L	
Amapola	<i>Papaver somniferum</i>	H	Medicinal		No recorded use	food	Medicinal	Fr		F,Se	F
Amapola silvestre	<i>Papaver rhoeas</i>	H	Social		Medicinal	No recorded use	Medicinal	F	L,F		L
Higo	<i>Ficus carica</i>	T	Medicinal		Medicinal	food	Medicinal	L,Fr	S,L,F	Fr	L
Morera	<i>Morus nigra</i>	T	food		Vertebrate feed	Medicinal	Environmental	Fr	S,L,F	L	L
Árbol de papel	<i>Polylepis reticulata</i>	T	Materials		Fuels	Medicinal	Vertebrate feed	S,L	S	S,L	S
Cadillo	<i>Acaena ovalifolia</i>	Sh	Vertebrate feed		Medicinal	Medicinal	Medicinal	S,L	L	S,L	L
Capulí	<i>Prunus serotina</i>	T	Medicinal		Medicinal	food	Medicinal	L,F,Fr	L,F	Fr	S
Durazno	<i>Prunus persica</i>	T	Medicinal		Medicinal	No recorded use	Food	F,Fr	L		F
Fresa	<i>Fragaria vesca</i>	H	Medicinal		Medicinal	No recorded use	Medicinal	R,L	L		L
Frutilla	<i>Fragaria</i>	H	food		food	Medicinal	No recorded use	Fr	L,Fr	Fr	
Mora	<i>Rubus ulmifolius</i>	S	Medicinal		Materials	Medicinal	Medicinal	L,F	L,F,Fr	L	L
Mortiño Verdadero	<i>Hesperomeles goudotiana</i>	T	Additive		No recorded use	Medicinal	Medicinal	Fr		S,L	L
Nigua	<i>Margyricarpus pinnatus</i>	T	Medicinal		No recorded use	No recorded use	Medicinal	R,S,L,Fr			L
Yagual	<i>Polylepis incana</i> Kunth	S	Medicinal		No recorded use	No recorded use	No recorded use	L			
Ortiga Blanca	<i>Urtica leptophylla</i>	H	Medicinal		Medicinal	Medicinal	No recorded use	R,S,L	L	S,L	
Ortiga negra	<i>Urtica dioica</i>	H	Medicinal		Medicinal	Medicinal	Medicinal	S,L	L	L	L
Molle	<i>Schinus molle</i>	T	Medicinal		food	Medicinal	Medicinal	S,L,Fr	S,L,Se	S,L	F
Ruda	<i>Ruta graveolens</i>	Sh	Medicinal		Medicinal	Medicinal	No recorded use	S,L,F	L,F	S,L,F	
Guanto	<i>Brugmansia arborea</i>	T	Medicinal		No recorded use	Social	Medicinal	S,L,F		L,F	L
Hierba mora	<i>Solanum nigrum</i>	H	Medicinal		Medicinal	Medicinal	Toxic	R,S,L	L,Fr	S,L,Fr	L
Papas	<i>Solanum tuberosum</i>	H	Medicinal		No recorded use	Medicinal	Medicinal	R,L		R	F
Sauco blanco	<i>Solanum barbulatum</i>	S	Invertebrate feed		Medicinal	Medicinal	No recorded use	S,L	L,Fr	S,L	
Sauco negro	<i>Cestrum peruvianum</i>	T	Medicinal		Medicinal	Medicinal	Medicinal	R,S,L,Fr			L
Tomate de árbol	<i>Solanum betaceum</i>	T	Medicinal		No recorded use	food	No recorded use	L,Fr		Fr	
**A=Aquatic; C =Creeping; Cl=Climbing; E=Epiphytic; H=Herbaceous; Sh=Semi-shrubby; S=Shrubby; T=Tree-like											
R=Root; S=Stem; L=Leaves; F=Flowers; Fr=Fruits; S=Seeds; O=Others											

Common name	Scientific name	Type of plant		Ethnobotanical use by country				Part of the plant used			
			Ecuador	Colombia	Peru	Bolivia		Ecuador	Colombia	Peru	E
Uvilla	<i>Physalis peruviana</i>	S	Medicinal	Medicinal	No recorded use	No recorded use		R,S,L,F,Fr	L,Fr		
**A=Aquatic; C =Creeping; Cl=Climbing; E=Epiphytic; H=Herbaceous; Sh=Semi-shrubby; S=Shrubby; T=Tree-like R=Root; S=Stem; L=Leaves; F=Flowers; Fr=Fruits; S=Seeds; O=Others											

3.5. Comparative analysis of plant part used

The distribution of plant parts used for medicinal purposes showed a consistent pattern across the four Andean countries analyzed (Fig. 4). Leaves were the most frequently utilized plant part in all countries, followed by stems, while flowers, roots, fruits, and seeds were used less frequently.

Ecuador recorded the lowest proportion of leaf use among the countries studied, although leaves still represented the most commonly used plant part (37% of reported uses). Stems and flowers accounted for 23% and 18% of uses, respectively. In contrast, Colombia exhibited the highest proportion of leaf use (51%), followed by stems and other plant structures.

Similar patterns were observed in Peru and Bolivia, where leaves accounted for 45% and 48% of reported uses, respectively. In both countries, stems represented the second most frequently used plant part, accounting for approximately 24–27% of uses. Flowers, roots, fruits, and seeds each represented less than 12% of reported uses.

Overall, the results indicate a high degree of consistency in the selection of plant parts used for medicinal purposes across the Andean region, with leaves and stems representing the dominant plant structures in all four countries (Fig. 4).

Appendix 2 summarizes the principal similarities and differences among the study countries with respect to the ethnobotanical use of plant species according to the plant parts utilized.

3.6. Comparative analysis of ethnobotanical uses by plat family

The 162 recorded plant species were distributed among 55 botanical families, with Asteraceae, Fabaceae, Lamiaceae, Poaceae, and Solanaceae representing the families with the highest number of ethnobotanically useful species across the four Andean countries (Fig. 5).

Asteraceae was the most represented family in terms of medicinal species, recording 18 medicinal uses in Ecuador, 13 in Peru, and 9 in Colombia. Fabaceae and Poaceae also exhibited a high diversity of documented uses, including medicinal, food, and material applications. Lamiaceae and Solanaceae similarly contributed a substantial number of species associated primarily with medicinal uses.

Medicinal use was the dominant category across most botanical families and countries. Ecuador recorded the highest number of medicinal-use reports, followed by Peru, Colombia, and Bolivia. Food and material uses were also widely represented, particularly within Fabaceae, Poaceae, and Agavaceae.

Several families were associated with less frequent use categories. Environmental uses were recorded in families such as Cupressaceae, Cactaceae, and Rosaceae, whereas beekeeping uses were documented in Boraginaceae and Onagraceae. Social uses were reported in a smaller number of families, including Poaceae and Solanaceae.

Overall, the results indicate that a relatively small number of botanical families account for a large proportion of the ethnobotanical uses documented in the four Andean countries, with medicinal applications representing the most common use category across the taxonomic groups analyzed.

3.7. Multivariate Analysis of Ethnobotanical Uses

The Logistic Biplot analysis revealed clear differences among countries in the relative importance of ethnobotanical use categories (Fig. 5). Ecuador was primarily associated with medicinal, social, and vertebrate/invertebrate food uses, whereas Colombia showed a stronger association with food and additive uses. Peru was more closely related to material uses, while Bolivia was associated with toxic, environmental, and beekeeping uses. The first two factorial axes accounted for 70% of the total variability, indicating that the ordination adequately represented the main patterns of ethnobotanical use among countries.

The analysis of relationships among use categories revealed several distinct patterns (Fig. 6). Vertebrate food, invertebrate food, fuel, and environmental uses were positively associated and clustered together within the ordination space. In contrast, toxic, beekeeping, additive, and food uses formed a separate group located in the opposite sector of the factorial plane. Medicinal use appeared relatively isolated from the remaining categories, indicating a weak association with other use types in the dataset.

The first two axes of this ordination explained 26% of the total variability, reflecting the complexity of relationships among ethnobotanical use categories and the multidimensional nature of plant use patterns across the Andean region.

The vertebrate and invertebrate food, fuel, and environmental uses show stronger correlations among themselves and appear to be opposed to toxic, apicultural, additive, and edible uses. The medicinal use is practically independent of all others, acting as a unique trait that tends to exclude additional uses when present. The X and Y axes together explain 26% of the total variance.

Peru, Colombia, and Ecuador form a compact group that tends to differentiate from Bolivia, sharing medicinal, edible, environmental, and animal feed uses particularly highlighting the families Apiaceae, Brassicaceae, Papaveraceae, Plantaginaceae, Lauraceae, Myricaceae, Verbenaceae, and Salicaceae. Notably, the families whose use is exclusively medicinal form a consolidated cluster composed of Myrtaceae, Fabaceae, Solanaceae, Amaranthaceae, Lamiaceae, Poaceae, and Rosaceae across all four countries analyzed. The X and Y axes explain 83% of the total variance (Fig. 7).

3.8. Hierarchical cluster analysis (HCPC)

Hierarchical Cluster Analysis identified three major groups of species according to their ethnobotanical use profiles (Fig. 8). The clusters were clearly differentiated within the multivariate space, indicating distinct patterns of plant use across the Andean region. Cluster 1 comprised species primarily associated with medicinal, food, and additive uses. These species represented the most direct contributions to human health and nutrition and formed the largest concentration of ethnobotanical records. Cluster 2 grouped species associated mainly with social, fuel, and material uses. This cluster included plants used in cultural practices, household activities, and the provision of construction materials and energy resources. Cluster 3 contained species linked to environmental, beekeeping, toxic, and unreported uses. Compared with the other groups, these species occupied a more distinct position within the ordination space and were characterized by less frequent or more specialized use categories.

The dendrogram revealed substantial separation among the three clusters, reflecting differences in ethnobotanical use profiles. Species associated with medicinal uses were particularly distinct from those grouped within environmental and unreported-use categories. The projection of clusters onto the factorial plane further highlighted the functional differentiation of species according to their documented ethnobotanical uses (Fig. 8).

4. Discussion

The comparative analysis of ethnobotanical knowledge across Ecuador, Colombia, Peru, and Bolivia highlights the strong biocultural relationships that Andean communities maintain with plant resources. Despite differences in geography, cultural history, and ecosystem composition, the four countries exhibited remarkably similar patterns of plant use, reflecting the persistence of shared traditions and knowledge systems throughout the Tropical Andes.

Medicinal use emerged as the dominant ethnobotanical category in all countries, confirming the central role of traditional medicine in Andean societies. Species such as *Podocarpus sprucei*, *Cyclospermum leptophyllum*, *Apium graveolens*, *Coriandrum sativum*, *Anethum graveolens*, *Daucus carota*, *Oreopanax ecuadorense*, *Furcraea bedinghausii*, and *Agave americana* continue to be widely used for health-related purposes. Similar patterns have been documented throughout the Andes, where medicinal plants represent one of the most important components of traditional ecological knowledge and cultural identity (Paniagua-Zambrana et al., 2020; Rivero-Guerra, 2021).

The predominance of medicinal plants likely reflects the interaction of multiple factors. Traditional knowledge remains actively transmitted within many rural and indigenous communities, particularly through oral traditions and intergenerational learning (Tene et al., 2007). Furthermore, the extraordinary floristic diversity of the Tropical Andes provides access to a wide range of species with recognized therapeutic properties, promoting the development of sophisticated ethnomedical systems (Bussmann & Paniagua-Zambrana, 2022; Sánchez-Capa et al., 2023). The maintenance of home gardens and traditional agroecosystems further contributes to the conservation and continued use of medicinal plants by integrating cultivated and wild species within the same management system (Cocarico et al., 2025).

The high similarity observed among countries, particularly between Ecuador and Peru, suggests the existence of a common ethnobotanical heritage across the Andean region. Historical exchanges among Andean populations, combined with the continuity of mountain ecosystems and shared cultural traditions, have likely facilitated the circulation and preservation of plant knowledge over long periods. Nevertheless, country-specific patterns were also evident. Colombia showed a stronger association with food and additive uses, reflecting the importance of traditional agricultural systems and locally managed food resources (Romero et al., 2020; Galvis-Tarazona et al., 2022). In contrast, Bolivia exhibited a greater representation of environmental and beekeeping uses, highlighting the role of plants in ecosystem management and ecological services within high-Andean landscapes (AART, 2018; Bussmann & Paniagua-Zambrana, 2022).

The analysis of plant parts used revealed a consistent preference for leaves throughout the four countries. Similar findings have been reported in numerous ethnobotanical studies worldwide, where leaves are favored because they are readily accessible, renewable, and frequently contain high concentrations of secondary metabolites (Cabrera-Amaya et al., 2017; Perafán & Paz, 2024). Their harvesting generally has a lower impact on plant survival than the collection of roots or whole plants, making leaf-based medicinal practices more compatible with sustainable resource use.

The predominance of the families Asteraceae, Fabaceae, Lamiaceae, Poaceae, and Solanaceae further reflects patterns commonly observed in ethnobotanical research across tropical and temperate regions. These families are among the most species-rich groups of vascular plants and contain numerous taxa with medicinal, nutritional, and material uses (Gras et al., 2021). Their repeated occurrence in the four countries analyzed underscores their importance in shaping regional ethnobotanical knowledge and highlights their potential value for future conservation and sustainable development initiatives.

Multivariate analyses provided additional insights into the organization of ethnobotanical knowledge. The Logistic Biplot revealed that medicinal and food uses were the principal dimensions structuring variation among countries, whereas categories such as beekeeping, toxic, and additive uses occupied more distinct positions within the ordination space. These results suggest that medicinal and food uses constitute the core components of ethnobotanical knowledge systems, while other categories represent more specialized domains of plant use.

Similarly, Hierarchical Cluster Analysis identified three major functional groups of species: (i) medicinal, food, and additive species; (ii) social, material, and fuel species; and (iii) environmental, beekeeping, toxic, and unreported-use species. This classification supports the idea that ethnobotanical knowledge is structured according to functional domains rather than being distributed randomly among plant species. Comparable patterns have been described in Quechua and Aymara communities, where plants are frequently classified according to their practical and cultural roles in daily life (Bussmann & Paniagua-Zambrana, 2022; Cocarico et al., 2025).

Overall, the results demonstrate that the Andean region retains a rich and highly structured body of ethnobotanical knowledge despite ongoing social and environmental change. The strong convergence in plant uses across countries, together with the persistence of culturally significant medicinal species, highlights the importance of preserving traditional knowledge as an integral component of biodiversity conservation. Strengthening documentation efforts, promoting intergenerational knowledge transmission, and integrating ethnobotanical knowledge into conservation and rural development strategies will be essential for safeguarding the region's biocultural heritage.

A particularly important finding of this study is the high degree of ethnobotanical similarity observed among Ecuador, Colombia, Peru, and Bolivia. Jaccard similarity values exceeding 0.50 in all pairwise comparisons indicate that these countries share a substantial proportion of useful plant species and associated traditional knowledge. The strongest relationship was observed between Ecuador and Peru, which shared more than 70% of the recorded species. Furthermore, all species documented in Colombia, Peru, and Bolivia were also represented in the Ecuadorian dataset.

These findings suggest that the Tropical Andes function not only as a biodiversity hotspot but also as a reservoir of shared biocultural knowledge. The continuity of Andean ecosystems, combined with centuries of cultural exchange among indigenous and rural populations, has likely facilitated the persistence and dissemination of ethnobotanical knowledge throughout the region. While previous studies have largely focused on local inventories or individual communities, the present research demonstrates that ethnobotanical knowledge can also be understood as a regional phenomenon characterized by both cultural continuity and local adaptation.

The multivariate analyses further support this interpretation. The Logistic Biplot revealed that medicinal and food uses constitute the principal dimensions structuring ethnobotanical knowledge across countries, whereas environmental, beekeeping, and toxic uses occupy more specialized positions within the ordination space. Likewise, the hierarchical clustering identified functional groups of species that transcend national boundaries, suggesting that Andean communities organize plant knowledge according to comparable utilitarian and cultural criteria. Together, these results indicate that ethnobotanical knowledge in the Tropical Andes exhibits a coherent regional structure rather than a collection of isolated local traditions.

From a conservation perspective, these findings are particularly relevant. The observed convergence in plant use implies that the erosion of traditional knowledge in one region may represent the loss of knowledge shared across a much broader biocultural landscape. Consequently, conservation strategies should move beyond species protection alone and incorporate the preservation of traditional knowledge systems, local management practices, and mechanisms of intergenerational knowledge transmission. Such an approach would contribute not only to biodiversity conservation but also to the safeguarding of the cultural heritage that has historically shaped human–plant relationships throughout the Andes.

The present study demonstrates that ethnobotanical knowledge across the Tropical Andes is characterized by both remarkable continuity and regional specialization. Despite differences in geography, culture, and ecosystem composition, Andean communities share a common core of plant knowledge centered on medicinal, food, and material uses. At the same time, local adaptations have generated distinctive ethnobotanical practices that reflect the ecological and cultural particularities of each country.

By integrating comparative ethnobotany, similarity analysis, Logistic Biplot ordination, and hierarchical clustering, this research provides a regional-scale perspective on the organization of traditional plant knowledge in the Andes. These findings reinforce the importance of considering biocultural heritage as a fundamental component of conservation planning and sustainable development policies. Future research should expand this comparative framework to additional Andean regions and cultural groups to better understand how traditional knowledge evolves in response to ongoing environmental and socioeconomic change.

5. Conclusions

Plants sustain all terrestrial ecosystems on Earth. They provide the structure and resources necessary for other organisms to survive and support a multitude of human uses essential to life. However, despite their importance, plant conservation has not generated the sense of urgency or funding that drives animal conservation, even though plants are just as important to us.

Many species are still unknown to science. Perhaps one-third of all terrestrial plants are threatened with extinction, including many that have not been described or, although they have been, lack sufficient data.

Traditional conservation efforts have often relied on the separation between human societies and nature. This had led to exclusionary protected areas, with numerous instances of restrictions on the use of natural resources and the displacement of local communities. In this context, it is important and urgent to understand how communities and populations use their resources and how, by understanding their importance, they can drive relevant conservation programs by applying use-based conservation approaches. Therefore, none of these problems are inherently unsolvable, and all the shortcomings could be remedied. We know how to do it, but we are currently not doing enough.

This study provides a comparative assessment of ethnobotanical knowledge across four Andean countries Ecuador, Colombia, Peru, and Bolivia revealing a high degree of similarity in the traditional use of plant resources throughout the region. A total of 162 useful plant species belonging to 55 families and 30 taxonomic orders were documented, demonstrating the remarkable biological and cultural richness of the Tropical Andes.

Medicinal use emerged as the dominant ethnobotanical category in all countries, highlighting the continued importance of traditional medicine in Andean communities. Food and material uses constituted the second most important categories, while environmental, beekeeping, and social uses reflected more specialized dimensions of plant knowledge. Leaves were consistently the most frequently used plant part, and families such as Asteraceae, Fabaceae, Lamiaceae, Poaceae, and Solanaceae played a central role in regional ethnobotanical practices.

The high similarity observed among countries, particularly between Ecuador and Peru, indicates the existence of a shared biocultural heritage that transcends national boundaries. Multivariate analyses further revealed that ethnobotanical knowledge is structured around distinct functional domains, with medicinal and food uses forming the core of traditional plant-use systems across the Andes.

These findings demonstrate that the Tropical Andes represent not only a global center of biodiversity but also a reservoir of traditional ecological knowledge. The preservation of this knowledge is essential because it contributes to cultural identity, local livelihoods, sustainable resource management, and biodiversity conservation. Consequently, conservation strategies should incorporate both biological and cultural dimensions, promoting the documentation, transmission, and application of traditional knowledge alongside the protection of plant diversity.

Future research should expand comparative ethnobotanical analyses to additional Andean regions and cultural groups, allowing a more comprehensive understanding of the processes that shape the evolution, persistence, and transformation of traditional plant knowledge in the face of environmental and socioeconomic change.

Ultimately, safeguarding Andean plant diversity requires safeguarding the traditional knowledge systems that have shaped and conserved these resources for generations, reinforcing the inseparable link between biological and cultural diversity.

Declarations

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Data Availability: The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethical. We confirm that all procedures involving human participants in this study (fieldwork, interviews, and observations) were conducted in accordance with the ethical guidelines of the Chimborazo Higher Polytechnic School. Informed consent was obtained from all participants.

Consent for Publication. We confirm that we have obtained written consent for publication.

Consent to Participate. We confirm that we have obtained verbal or written consent from all research participants.

Competing interests. The authors declare no competing interests.

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Figures

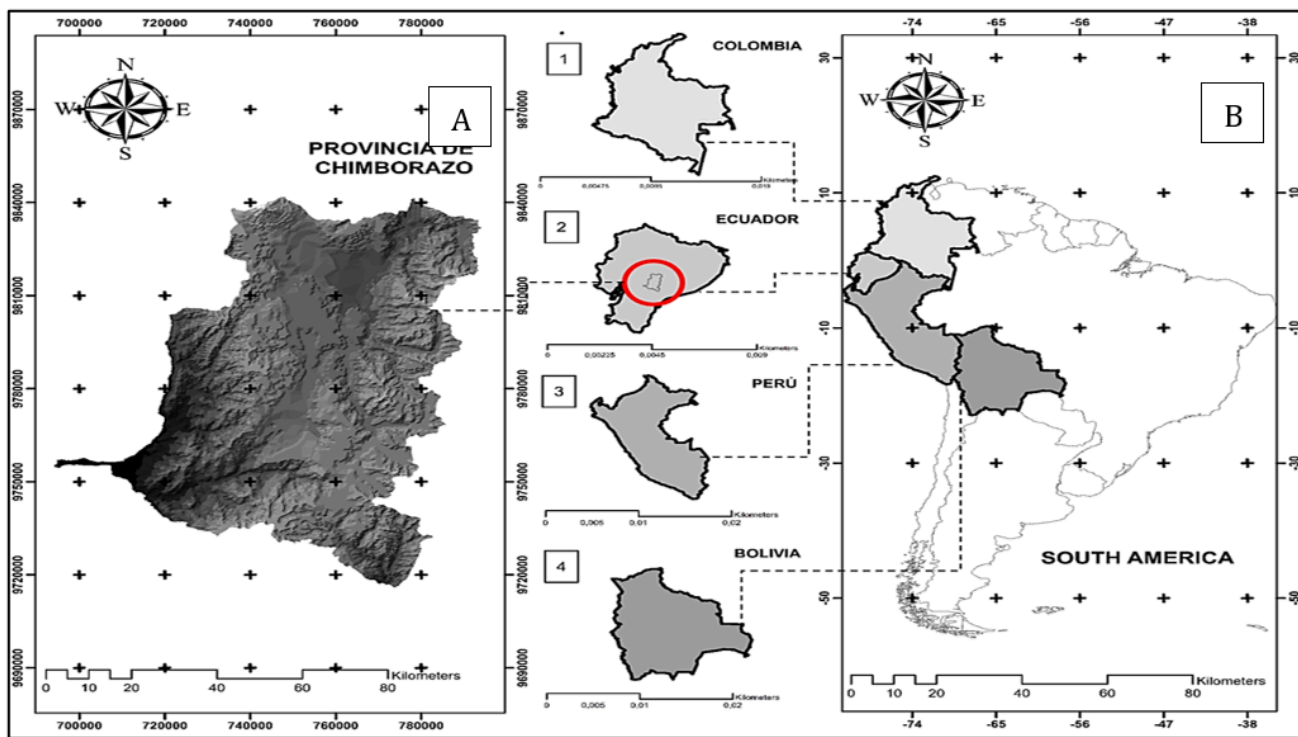


Figure 1

Map of the study area. (A) Location of Chimborazo Province – Ecuador (B) Location of the study countries: 1. Colombia, 2. Ecuador, 3. Peru, 4. Bolivia.

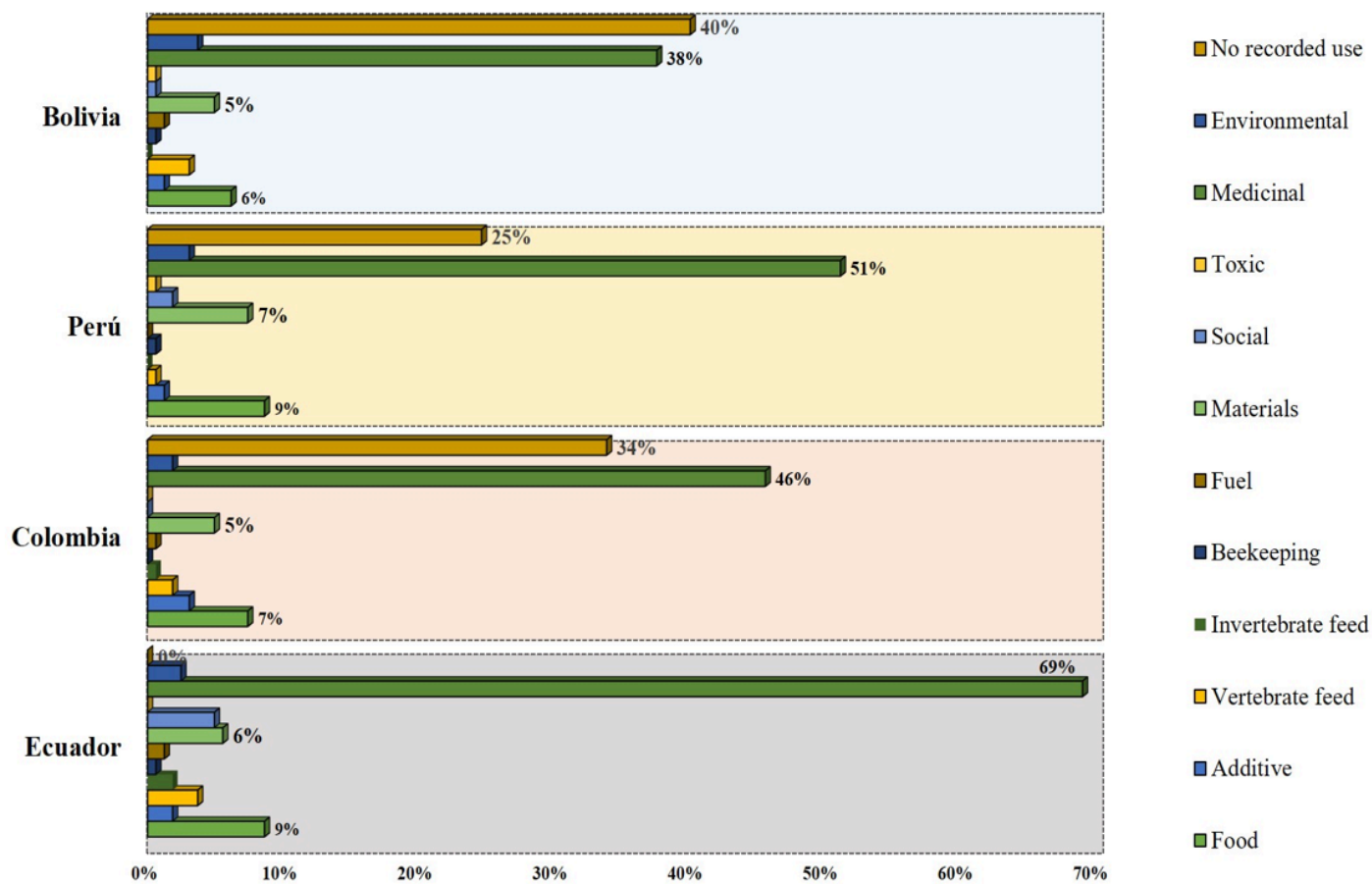


Figure 2

Types of use (%) of species recorded in Ecuador, Colombia, Peru, and Bolivia

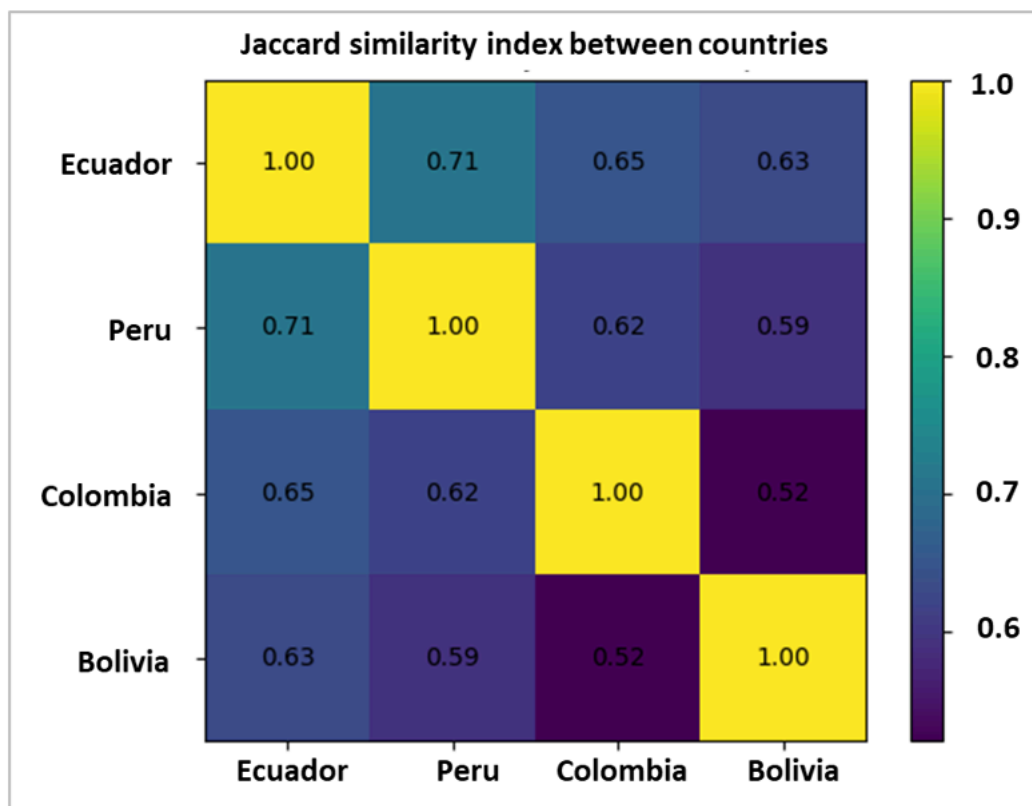


Figure 3

Jaccard similarity index of ethnobotanical species among Ecuador, Peru, Colombia, and Bolivia. Higher values indicate greater similarity in shared species use.

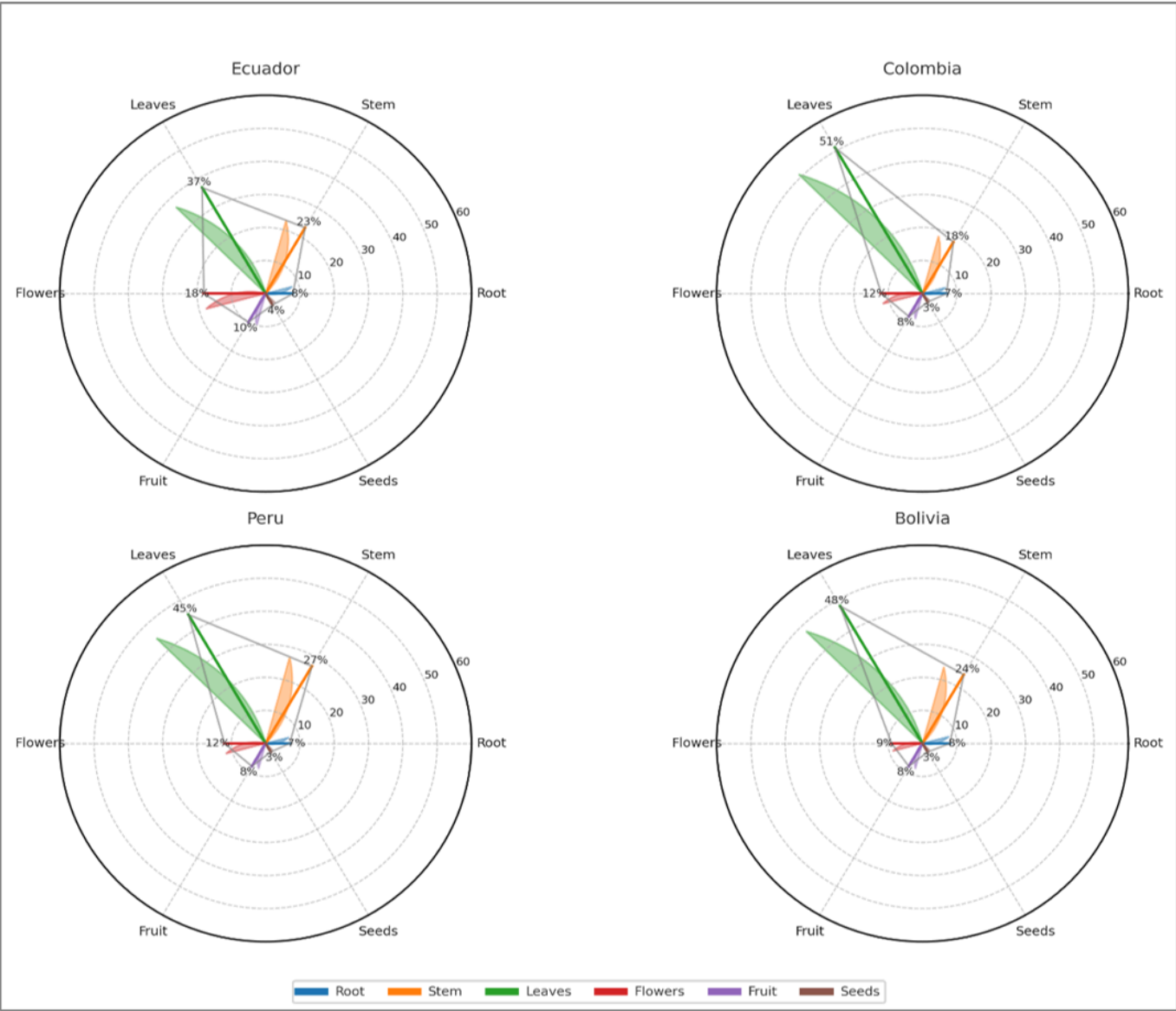


Figure 4

Parts used from registered species (%), in Ecuador, Colombia, Peru, and Bolivia

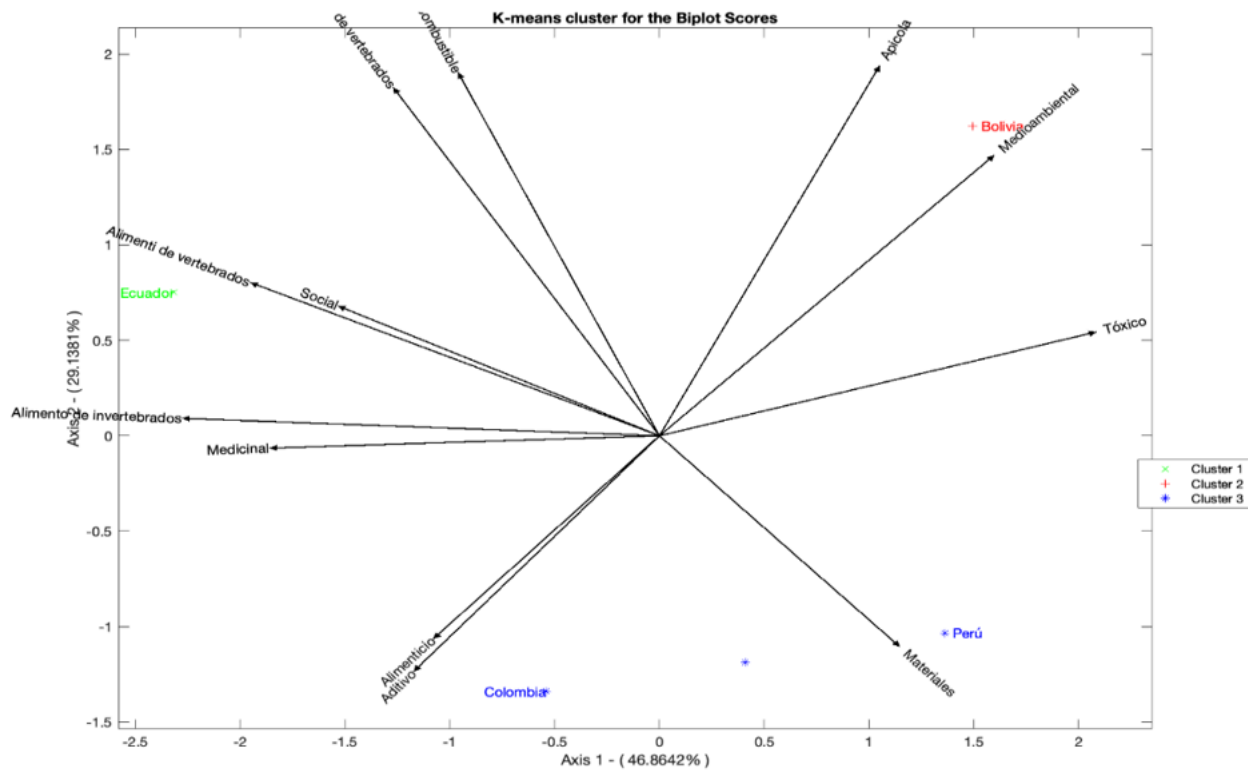


Figure 5

Logistic Biplot of ethnobotanical use categories by country.

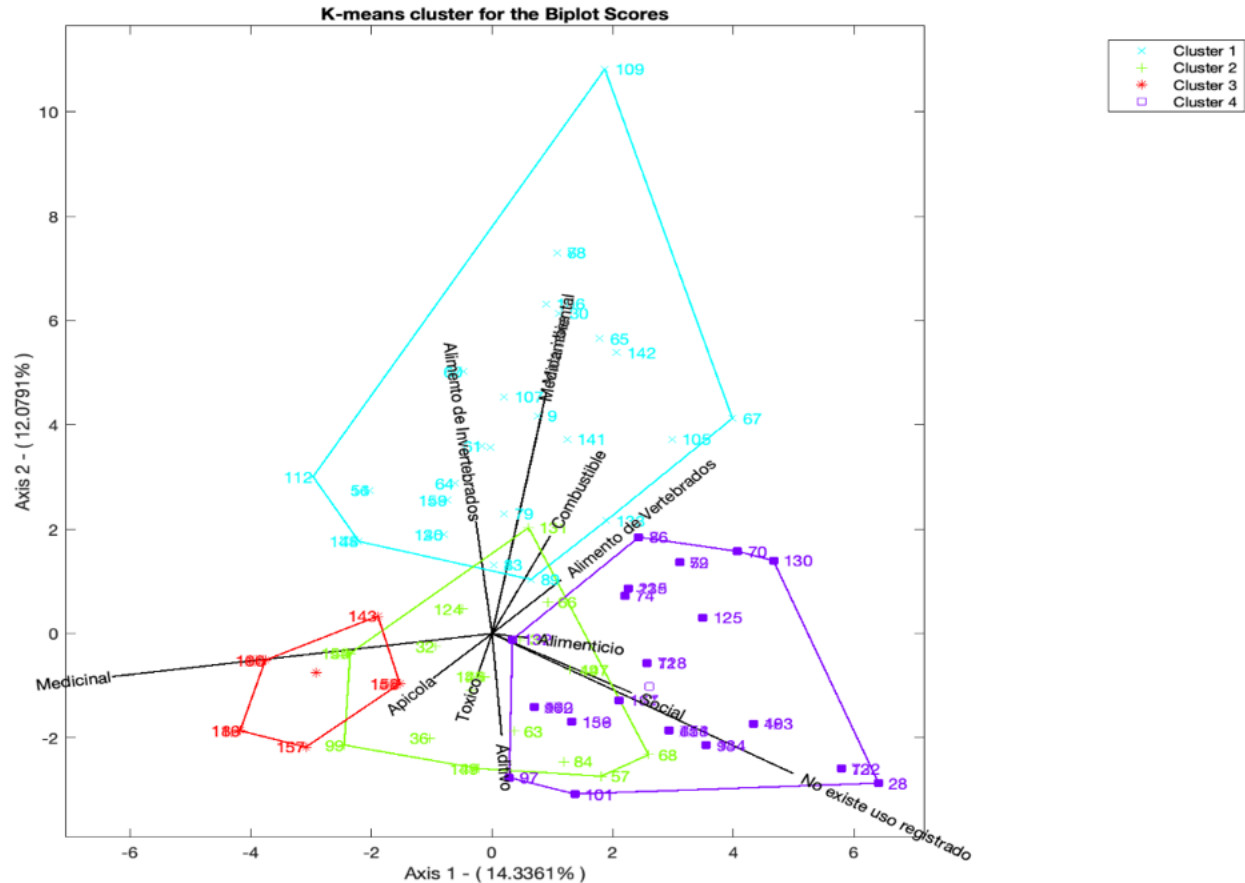


Figure 6

Relationships among ethnobotanical use categories based on Logistic Biplot analysis.

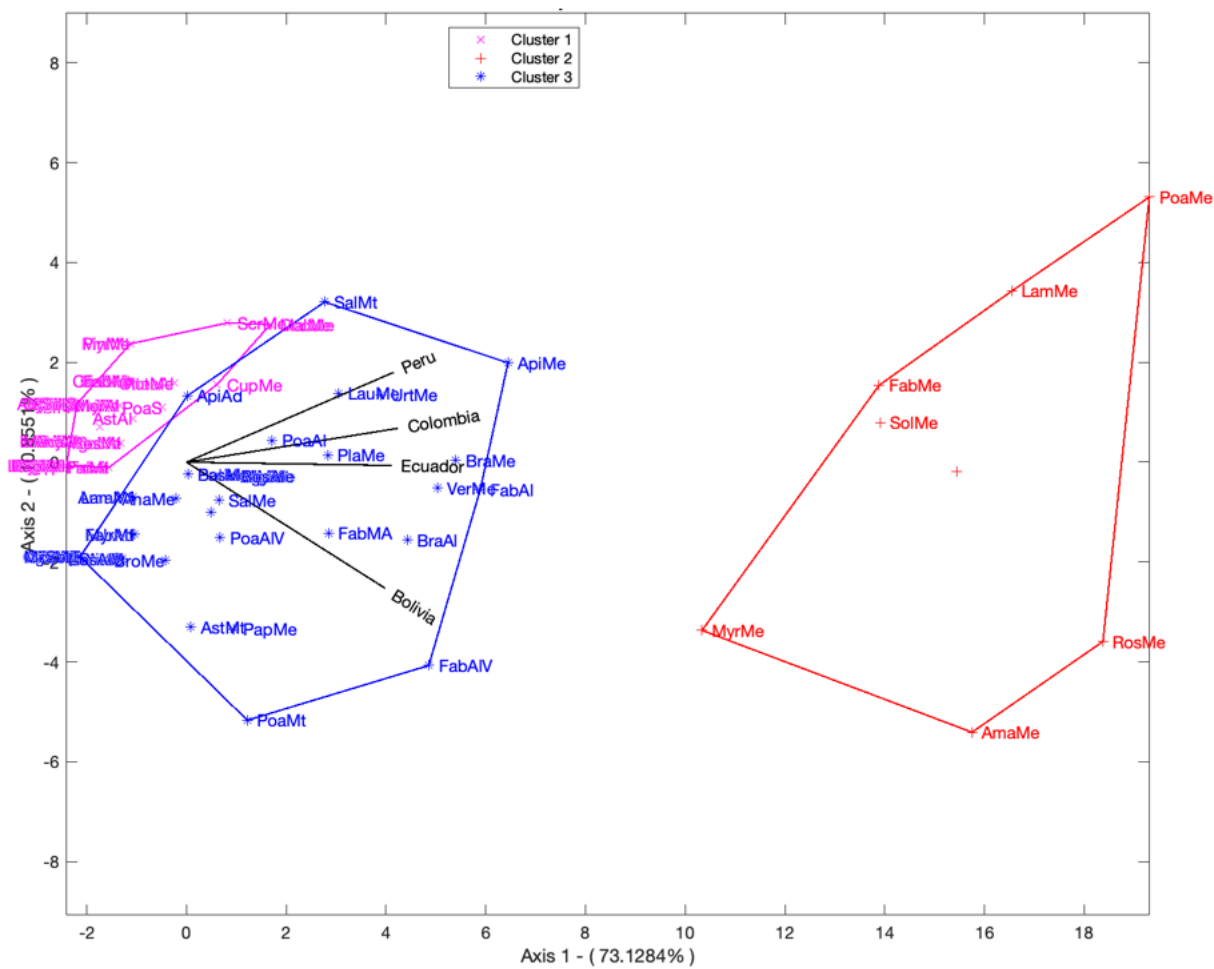


Figure 7

Usage correlations by family

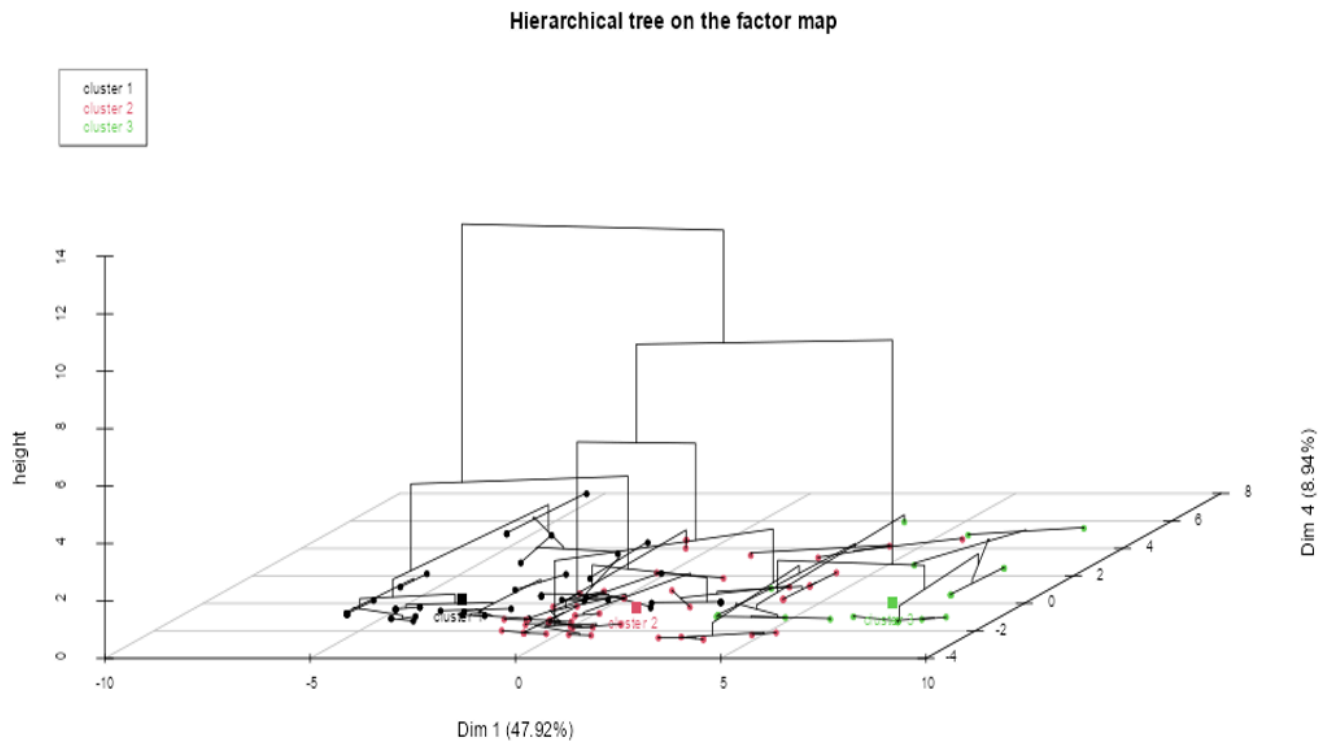


Figure 8

Hierarchical cluster analysis by species