Conservation of medicinal germplasm: a proposal to establish priorities based on conservation biology and ethnobotanical criteria

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Research

Abstract

Background. This study focused to assess the overall status of the *ex-situ* collection of medicinal plant germplasm and propose management objectives based on ethnobotanical theory and conservation biology at the Germplasm Bank of the Facultad de Agronomía in Uruguay (BGFAgro).

Methods. Reviewing the passport data of 3646 BGFAgro database accessions, we were able to identify 47 species with medicinal uses and pertinent historical information. A total of 37 medicinal plant species germination capacities were tested using accessions from these taxa. We used a logistic function to search the putative variations in germination capacity. To establish criteria for conservation priority, the frequency distribution of families, species, and associated uses was examined along with correspondence analysis.

Results. Asteraceae and Leguminosae are the families with the highest number of medicinal species, and the years 1997 and 1998 had the highest number of conserved accessions. After 14 years of entrance into the collection, the germination values dramatically decline. There are 14 uses related to medicinal species that exhibit varying degrees of versatility, redundancy, and exclusivity. The most common uses are for the Symptoms and conditions of undefined origin and Digestive system.

Conclusions. The collection needs support to reach international standards. We show a priority list of species based on ethnobotanical and conservation biology criteria as where to start to enhance *ex situ* and biocultural conservation tools.

Keywords: Medicinal plants, germplasm banks, *in situ-ex situ* conservation, ethnobotanical, viability.

Background

Since time immemorial, the world's population has used medicinal plants for the treatment of ailments and healthcare. Plants have been the primary source of new drugs worldwide, and it is estimated that 40% of synthetic medicines contain compounds derived from their secondary metabolites. According to the World Health Organization (WHO), 11% of the 252 drugs available to treat major human diseases are considered essential and originate from medicinal plants (WHO 2015). However, in the current context of climate change and the impact of various threats such as extreme drought events, habitat fragmentation, invasive species, and usage pressure, the preservation of this resource is at risk (Hamilton 2008). It is important to highlight that the global demand for this resource increases exponentially year after year (Kaky & Gilbert 2019, Zisca *et al.* 2009).

In Uruguay, since the early 19th century, various authors have described the medicinal botanical flora used by rural populations. Among them, the pioneering work of Dámaso Antonio Larrañaga in 1815, the reports on the medicinal properties of native plants by Mariano Berro in 1899, and a large number of studies in the 20th and 21st centuries stand out (e.g., Alonso Paz *et al.* 2008, Arrillaga de Maffei 1969, Bertucci *et al.* 2008, Castiñeira Latorre *et al.* 2018, 2020, Costa & Cairoli 1959, Dabezies 2011, Davies 2004, del Puerto 2011, Dellacassa *et al.* 2005, Gómez *et al.* 2016, Hernández 2011, Lombardo 1967, 1973, Parrillo *et al.* 1999, Pereda Valdés 1943, Priore *et al.* 1989, Rettaa *et al.* 2012, Tabakián 2016). The contribution of Alonso Paz *et al.* (2008) represents the first work that emphasizes the rational use of medicinal plants in Uruguay. On the other hand, Castiñeira Latorre *et al.* (2020) evaluate the resilience of botanical medical systems, warning that a possible change could affect their stability, resulting in the loss of species and associated knowledge. These works show the medicinal botanical richness of the country and how the utilitarian value of species combines with intangible elements related to symbolism and spirituality. These aspects contribute to both the maintenance of identity and the stability of the botanical medical system (Castiñeira Latorre *et al.* 2020, Cristancho & Vining 2004, Garibaldi & Turner 2004). Available information indicates that the majority of users of medicinal plants obtain them directly by themselves or through markets, and in both cases, the plants are collected from nature (Castiñeira Latorre *et al.* 2018). Since all the medicinal plants used in our country are harvested from wild environments, the pressure on the resource threatens the permanence of natural populations. This pressure on medicinal plants can be mitigated through conservation programs *in situ* (e.g., in protected areas), *ex situ* (e.g., botanical gardens and germplasm banks), mixed methods (*in situ-ex situ*), and good cultivation practices programs (Heywood & Dulloo 2005). The work carried out by Davies (2004) on the domestication and cultivation of medicinal and aromatic species has been an important precedent for future development. Although species conservation is most effective through the management of populations in their natural environments (*in situ*), *ex situ* techniques are complementary conservation tools (Liu *et al.* 2018). In this sense, plant germplasm banks, responsible for maintaining collections of biological material including spores, tissues, and seeds capable of transmitting hereditary characteristics from one generation to another, are considered important supply sources of genetic resources (Smith *et al*. 2003). They thus become true repositories, essential for contributing to restoration and maintenance programs for threatened populations in their natural environments (Bacchetta *et al.* 2008, Hernández Bermejo 2007, Liu *et al.* 2018).

The collection of the Germplasm Bank of the Faculty of Agronomy (BGFAgro)- Universidad de la República (UdelaR) in Uruguay (WIEWS Code URY002) is composed of seeds that safeguard the genetic information of key taxa for the nation. It originated from collections made in the 1940s by the botanist Prof. Bernardo Rosengurtt, a pioneer in the study of natural grasslands in Uruguay (Rosengurtt 1944). The collection was significantly expanded through subsequent contributions with the focus on forage species in the 1960s, 1980s, and 1990s through a variety of projects with external funding (from organizations such as the Organization of American States, the Plant Genetic Research Institute, the Swedish Agency for Research in Developing Countries, and the United Nations Development Programme). A robust research program has also been formed in natural grasslands, which has aided in the expansion of the collection of grasses (Bayce Muñoz 1984, Glison *et al*. 2023, Speranza 2009; Speranza & Malosetti 2007; Speranza *et al*., 2003). Other phytogenetic resources that were considered important for conservation were also included, such as plants crops, landraces and native species with food, medicinal, and aromatic uses (Berretta *et al*. 2007, Davies 2004, Galván *et al*. 2005, Vilaró *et al*. 2020). Currently, BGFAgro conserves seeds from approximately 4,000 accessions in cold storage and preserves 23% of the estimated richness of medicinal botanical species in the country (Castiñeira Latorre *et al*. 2018, 2020). Ensuring the long-term viability of germplasm is crucial for the proper conservation of these seeds. They should be stored at low temperatures in cold rooms, and periodic viability tests and germination trials are necessary. However, viability tests have not yet been conducted on the preserved medicinal germplasm. In this context, conducting germination tests will allow us to assess the seed conservation status, identify associated gaps, and expand the collection through the adoption of innovative methods and approaches to management (Krause *et al*. 2006). To achieve this, the intention is to incorporate plant germplasm from medicinal species that represent a true biocultural reservoir due to their cultural value and ecosystem function (Hernández Bermejo 2007).

Establishment of ex situ/in situ management priorities for medicinal plants.

Modern germplasm banks align their objectives with the guidance provided by the United Nations Convention on Biological Diversity, the Global Strategy for Plant Conservation, and the Food and Agriculture Organization of the United Nations (FAO) (Jackson & Kennedy 2009). In this regard, the Millennium Seed Bank (MSB) has been coordinating the *ex situ* conservation objectives of 80 countries since 2000, contributing to the systematic evaluation of collections and their programs for the restoration and recovery of crop species, wild crop relatives, and species important for ecosystem maintenance. The seeds are preserved in the collections of the country of origin, and backup copies are stored at the Millennium Seed Bank (MSB), with these actions being managed by the Royal Botanic Gardens (RBG) at Kew (Griffiths *et al*. 2015). In South America, for example, Chile conserves 20% of the endemic and endangered species in the banks of the National Institute of Agricultural

Research and deposits duplicate in the MSB (León-Lobos *et al*. 2010). At the forefront of this effort is the 'Svalbard Global Seed Vault', located on the island of Spitsbergen within the Norwegian Svalbard archipelago, near the North Pole. The greatest collection of agriculturally significant seeds in the world is kept in this facility with the main objective of preserving and securing the future supply of food for the entire planet. The vault preserves duplicates of plant germplasm collections from various regions, including Latvia, Morocco, China, Taiwan, the USA, the Netherlands, Israel, Poland, Zambia, India and Italy (Svalbard Global Seed Vault 2023).

Moreover, there are other regional and local initiatives that channel their conservation efforts towards broader objectives beyond agri-food value, including the preservation of plant germplasm of rare, endemic, or endangered species (Grammont *et al*. 2006, Liu *et al*. 2018, Vincent *et al.* 2015). Examples of this can be found in germplasm banks in Europe, including the ENSCONET network comprised of 24 European germplasm banks, coordinated by KEW, as well as in the Spanish National Strategy for Plant Conservation (MAGRAMA 2014), the Spanish Plant Genetic Resources Center, the César Gómez Campo genebank at the Polytechnic University of Madrid, and the Agrifood Research and Technology Center of Aragón. Additionally, the network of seed banks integrated into the Ibero-Macaronesian Association of Botanical Gardens (REDBAG) also preserves seeds of wild relatives of food and forage crops as part of their efforts to conserve threatened plant species. These initiatives are based on criteria that consider the level of threat and levels of endemism, providing essential guidelines for seed collection and preservation (Rubio Teso *et al*. 2018). The global commitment to ensuring the diversity of food crops and prioritized species for biodiversity conservation is evident, with significant efforts being directed towards this purpose. Emerging programs are being developed with criteria of social or cultural relevance, considering emblematic species for human communities (e.g., *Leontopodium alpinum* Cass in Alpine regions, *Dracaena draco* L. in the Canary Islands, or *Cedrus libani* A. Rich in Lebanon, as well as landrace potato collections *Solanum tuberosum* L. in Colombia (Buchetta *et al*. 2008, Manrique-Carpintero *et al.* 2023). Furthermore, some of these programs are specifically focused on preserving species with medicinal value (ICAR 2023, Grace *et al.* 2010). Finally, progress in *ex situ* conservation is significant, although the major challenge remains to establish systematic assessments to identify information gaps in collections of emblematic species and set priorities in line with available human and financial resources (Griffiths *et al*. 2015).

Ethnobotanical criteria

Versatility and availability hypothesis, use value, and key cultural species.

Several ethnobotanical theories can help guide conservation actions and priorities for medicinal plants in a germplasm bank (Gaoue *et al*. 2017, Lucena *et al*. 2007, Santoro *et al*. 2018). In this sense, we could consider the versatility hypothesis, which posits that medicinal plants are incorporated into pharmacopeias after having been previously explored as food, aromatic, and ornamental plants (Alencar *et al*. 2010, Bennett & Prance 2000). This hypothesis is related to another one on resource availability, which argues that species primarily used for therapeutic treatments are abundant and accessible (Lucena *et al*. 2007). Consequently, there is a higher likelihood of these species being encountered and recognized, thereby increasing the chances of experimentation and their inclusion in local pharmacopeias (Lozano *et al*. 2014). Both contributions derived from ethnobiological theory can be tested using the species' use value index (VU) (Albuquerque *et al.* 2015).

On the other side, the idea of "cultural keystone species," proposed by Garibaldi and Turner (2004), which derives from the concept of "ecological keystone species" by Paine (1969), was adapted to study cultural systems in general and medicinal botanical systems in particular. It assumes that certain species contribute to maintaining their stability and resilience (Castiñeira *et al*. 2020, Cristancho & Vining 2004, Garibaldi & Turner 2004, Santoro *et al*. 2007). In this regard, the species included in pharmacopeias have specific attributes (e.g., flavor, color) associated with attracting human attention and causing adjustment to their search, experimentation, and use behavior (Albuquerque *et al*. 2015, 2017, Gaoue *et al*. 2017).

Model of utilitarian redundancy and prominent species

Finally, the Model of Utilitarian Redundancy (MRU), based on Walker's ecological redundancy hypothesis (1992) and related to the functional redundancy of ecosystem components from a biological perspective, has been adapted to socioecological systems. This model represents how various medicinal plants are used to address similar therapeutic goals, thus allowing for an interpretation of their cultural significance. From the perspective of biocultural conservation, redundant species contribute to the stability of medicinal botanical systems (Albuquerque 2013, Albuquerque & de Oliveira 2007; Albuquerque *et al*. 2015, 2017, Nascimento *et al*. 2015).

Our objective is to conduct germination tests on medicinal species accessions and evaluate their conservation status in the main Germplasm Bank of Uruguay. We suggest using criteria based on an ethnobotanical and biological conservation theoretical framework to manage the collection of medicinal accessions based on the gaps that have been identified. This will allow us to formulate collection and conservation strategies to safeguard both the genetic heritage and associated knowledge. To achieve this, we suggest a list of priority taxa that need to be rejuvenated and conserved. In the future, we hope that this collection will become a valuable tool for programs aimed at the reintroduction and strengthening of populations of strategic health value for Uruguay.

Materials and Methods

Ethnobotanical information

Ethnobotanical information on medicinal plants and associated traditional knowledge was obtained using proxy methods since the BGFAgro lacks passport data for species with this type of information. For this purpose, we relied on the studies conducted by Castiñeira *et al*. (2018) and the database available in the Medicinal Plant Thesaurus of the Faculty of Chemistry at UdelaR (Piastri 2023). The work of Castiñeira *et al*. (2018) represents a significant sample of the diversity of medicinal plants used by rural communities in Uruguay. The study area is an important reservoir of biodiversity (Brussa & Grela 2007; Soutullo *et al*. 2013), categorized by UNESCO as a Biosphere Reserve, specifically under the name 'Bioma Pampa Quebradas del Norte' (Fig. 1), which includes the protected area 'Valle del Lunarejo' in the Rivera Department. The population in this region is an amalgamation of diverse Amerindian, European, and African cultures (Bonilla *et al*. 2004), consisting of descendants of native peoples (mainly Guaraní natives), Spaniards, Basques, French, Germans, and West Africans (Curbelo 2003; González & Rodríguez Varese 1990), creating a multicultural context (*sensu* Martínez *et al.* 2006). The mentioned work employed basic ethnobotanical methodology, such as snowball sampling, semi-structured interviews, field trips with medicinal plant sellers to natural harvesting sites, and the participant observation technique/strategy (Albuquerque *et al.* 2014; Cunningham 2001; Newman 2010; Noy 2008). A total of 44 interviews were conducted, and the information gathered was decoded. A careful interpretation of the interviewees' perceptions regarding diseases, treatments, and the use of plants (emic categories) was conducted. This process led to the creation of a categorization (etic categorization) to facilitate subsequent analyses (Albuquerque *et al*. 2014). It's important to note that the methodological approach adheres to the ethical principles of the International Society of Ethnobiology (ISE 2014).

Botanical accessions

During the period of June-August 2022, a review of the passport information was conducted for a total of 3646 accessions contained in the database of BGFAgro. Forty-seven taxa from various locations in Uruguay with medicinal uses were identified (Castiñeira Latorre 2018, Piastri 2023). To determine the phytogeographical origin of the species, the database of the Darwinion Botanical Institute, Flora of the Southern Cone, Catalog of vascular plants was consulted (see www.darwin.edu.ar), considering the native and adventitious categories. The threat status of the species was assigned following Marchesi *et al.* (2013). The botanical nomenclature was verified using the database of the International Plant Names Index (IPNI 2023).

Seed germination trials

Seeds in optimal phytosanitary conditions were selected, contained in heat-sealed aluminum pouches, and stored in a refrigerated chamber at 5°C. Seed germination trials were conducted for all accessions. Each accession presented variability in the number of seeds, which was quantitatively analyzed to extract a quantity that would allow for future germination assays. The accessions correspond to collections made in wild environments during the years 1979, 1982, 1983, 1985, 1991, 1992, 1993, 1994, 1996, 1997, 1998, 2000, 2003, and 2021. The germination assays followed manuals on germination procedures for related taxa (ISTA 2015, 2017, 2020). The following parameters were determined for all assays: a) Germination capacity, expressed as a percentage of germinated seeds; b) Delay in germination, represented by the time (in days) required for the first germination; c) the T50 value or the precise time to reach 50% of the final germination capacity (*sensu* Côme 1970). When a germination protocol was not available, the vitality of the batch was estimated based on the number of non-germinated seeds. The seeds were placed in petri dishes on filter paper soaked in distilled water and placed in the incubation chamber at a constant temperature (25°C) and controlled lighting (12 hours of light). Germination development was observed weekly. To prevent desiccation and maintain optimal health status, regular moisture control and observation with binocular magnifying lenses were conducted to detect the presence of fungi.

Statistical analyses

A logistic function was fitted to explore a putative change in the germination capacity. This statistical tool will allow estimating the maximum time, on average for all species in the germplasm bank, that seeds remain viable for germination. Which is a relevant parameter for the management of the genebank. This logistic function, is a symmetrical function that allows for the estimation of three parameters: two asymptotes (lower asymptote: minimum germination percentage, upper asymptote: maximum germination percentage) and the inflection point (50% drop in the germination percentage), as well as the significance of each parameter. The logistic function fitting was performed using the "drm" function and the packages "drc", "nlme", and "aomisc" (Onofri 2020; Pinheiro *et al.* 2022; Ritz *et al.* 2015). We conducted a correspondence analysis to explore the relationship between the medicinal species present in the BGFAgro and the reported medicinal uses for those species (Zuur *et al.*, 2007). In this way, we can categorize the priority of the species based on their degree of versatility and redundancy (Albuquerque & Oliveira 2007). The correspondence analysis was conducted using the packages "FactoMineR" (Le *et al.* 2008) and "factoextra" (Kassambara & Mundt 2020) and visualized using the "gplots"package (Warnes *et al.* 2022). All analyses and figures were performed using the statistical software R (R Core Team 2022) along with the RStudio interface (RStudio Team 2019).

Results

Taxonomic diversity

Of the total germplasm present in the BGFAgro, the presence of 3,837 accessions preserved at 4°C and -20°C is reported, corresponding to 333 taxa. Among these, 46 taxa have medicinal uses, and germination analyses were conducted for a total of 37 taxa. The remaining taxa were discarded due to the presence of fungi during the assay development. A period of 18 years, from 2003 to 2021, is reported without the introduction of medicinal plant accessions. In descending order, the years with more than one medicinal taxon collected were 1998 with 11 species, 1996 with 8 species, 1997 with 5 species, and 1994 with 4 species. The period between 1997-1998 had the highest number of incorporated medicinal species (Table 1). The families with the highest number of recorded species in the sample, in descending order, were Asteraceae (8 species), Leguminosae (8 species), Lamiaceae (4 species), and Poaceae (3 species), while the remaining families were represented by one species (Fig. 1).

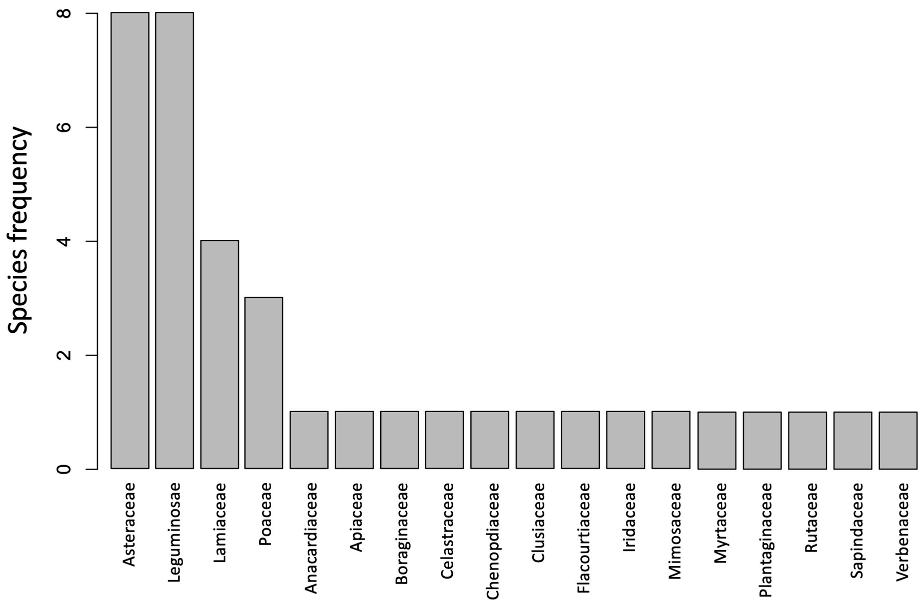

Figure 1. Species frequency per botanical family.

Survey of medicinal germplasm

The categorization system allowed for a reduction in the number of medicinal uses, improving the interpretation of the results (Table 2). The species with the highest number of uses are: *Stenachaenium campestre* Baker (uses=9); *Baccharis trimera* (Less.) DC., *Achyrocline flaccida (*Weinm.) DC.*, Achyrocline saturejoides* (Lam.) DC. (uses=8); *Apium leptophyllum* (Pers.) F.Muell. (uses=7); *Maytenus ilicifolia* Mart. Ex Reissek and *Schinus molle* L. (uses=6); *Mentha pulegium* L. and *Mentha rotundifolia* (L) Huds. (uses=5); *Chenopodium ambrosioides* L.*, Eugenia uniflora* O.Berg*, Heliotropium amplexicaule* Vahl*, Phaseolus vulgaris* L. (uses=4); *Casearia sylvestris* Sw., *Dodonaea viscosa* Jacq. (uses=3); *Desmodium incanum* (G.Mey.) DC., *Desmanthus virgatus* (L.) Willd., *Eupatorium buniifolium* Hook. & Arn., *Hordeum vulgare* L.*, Phaseolus lunatus* Haberle, *Plantago tomentosa* Lam., *Prosopis nigra* Hieron.*, Sorghastrum pellitum* (Hack.) Burkart and *Trichocline incana* Cass. (uses=2); *Acacia bonariensis* Gillies, *Aloysia gratissima* (Gillies & Hook.) L.D.Benson, *Arachis hypogaea* L., *Cypella herbertii* Herb.*, Gaillardia megapotamica* Baker, *Galega officinalis* L.*, Hedeoma multiflora* Benth., *Hypericum perforatum L.*, *Rhynchosia senna* Gillies ex Hook. & Arn., *Stevia rebaudiana* (Bertoni) Bertoni, *Ocimum selloi* Benth.*, Zanthoxylum fagara* L. and *Zea mays* L. (uses=1) (Table 1; Fig. 2).

Table 1. The species that have undergone germination tests are identified by the following information: Family; Species; Common name; Origin (Adventitious (A), Native (N)); Year (year of collection); % (germination percentage); Assay (duration in days); Presence of fungi (*); Uses; Threat (YES (X), NOT (-) *sensu* Marchesi *et al*. 2013) and Priority for rejuvenating the collection. Description of uses: 1) Circulatory system; 2) Digestive system; 3) Genitourinary system; 4) Respiratory system; 5) Endocrine-metabolic system; 6) Immune system; 7) Nervous system; 8) Musculature and skeleton; 9) Skin and subcutaneous tissue; 10) Parasitic diseases; 11) Infectious diseases; 12) Tumoral diseases; 13) Symptoms and states of undefined origin; 14) Antidote-antiophidic

Family	Species	Vernacular names	Origin	Year	%	Test	Uses	Threat	Priority
Anacardiaceae	*Schinus molle* L. (*)	Anacahuita	N	1996	100	11	2; 3; 4, 6, 7; 12	-	High
Apiaceae	*Apium leptophyllum* (Pers.) F.Muell.	Apio silvestre	A	1998	23	20	2; 3; 6; 7; 9; 13; 10	-	-
Asteraceae	*Achyrocline saturejoides* (Lam.) DC.	Marcela	N	1996	0	32	1; 2; 3; 4; 6; 7; 9; 13	-	High
	Achyrocline flaccida (Weinm.) DC.	Marcela	N	1996	0	32	1; 2; 3; 4; 6; 7; 9; 13	-	High
	Baccharis trimera (Less.) DC.	Carqueja	N	1996	0	32	1; 2; 3; 5; 6; 7; 9; 13	-	-
	Eupatorium buniifolium Hook. & Arn.	Chirca	N	1997	0	32	2; 13	-	-
	Gaillardia megapotamica Baker	Botón de oro	N	1998	66	21	9	X	High
	Stenachaenium campestre Baker	Arnica de campo	N	1998	43	14	1; 2; 3; 4; 6; 8;9; 12; 13	-	High
	Stevia rebaudiana (Bertoni) Bertoni	Stevia	N	1991	0	28	5	-	-
	Trichocline incana Cass.	—	N	1997	0	11	2; 13	X	High
Boraginaceae	*Heliotropium amplexicaule* Vahl (*)	—	N	1998	0	14	2; 3; 11; 13	-	High
Celastraceae	*Maytenus ilicifolia* Mart. ex Reissek	Congorosa	N	1996	10	14	1; 2; 7; 9; 11; 13	-	-
Chenopdiaceae	*Chenopodium ambrosioides* L.	Paico	A	1997	0	32	3; 13; 14	-	-
Clusiaceae	*Hypericum perforatum* L.	Hyperico	A	1998	20	20	7	-	-
Flacourtiaceae	*Casearia sylvestris* Sw.	Guazatunga	N	1996	0	32	11; 13;14	-	High
Iridaceae	*Cypella herbertii* Herb. (*)	Lirio	N	1998	0	32	13	-	-
Lamiaceae	*Hedeoma multiflora* Benth.	—	N	1998	76	14	13	-	-
	Mentha pulegium L.	Menta	A	2000	21	32	2; 3; 9; 11; 13	-	-
	Mentha rotundifolia L.(*)	Menta	A	1997	0	27	2; 3; 9; 11; 13	-	-
	Ocimum selloi Benth.	—	N	1997	0	20	13	-	-
Leguminosae	*Acacia bonariensis* Gillies (*)	Acacia	N	1992	0	14	13	-	-
	Arachis hypogaea L.	Maní	N	2021	90	20	13	-	-
	Desmodium incanum (G.Mey.) DC.	—	N	1982	53	20	9; 13	-	-
	Galega officinalis L.	—	A	1994	100	7	2	-	-

	Phaseolus lunatus Haberle	Porotos	N	1994	10	20	2; 11	-	-
	Phaseolus vulgaris L. (*)	Porotos	N	1994	50	20	2; 3; 13; 9	-	-
	Prosopis nigra Hieron. (*)	Algarrobo negro	N	1993	10	32	2; 3	-	-
	Rhynchosia senna Gillies ex Hook. & Arn. (*)	Porotillo	N	1994	0	32	13	-	-
Mimosaceae	*Desmanthus virgatus* (L.) Willd.	—	N	1979	20	14	2; 3;	-	-
Myrtaceae	*Eugenia uniflora* O.Berg	Pitanga	N	1996	0	32	2; 3; 9; 13	-	High
Plantaginaceae	*Plantago tomentosa* Lam.	Llantén	A	1996	0	20	2; 10	-	-
Poaceae	*Hordeum vulgare* L.	Cebada	A	2003	100	20	7; 13	-	-
	Sorghastrum nutans subsp. pellitum (Hack.) Burkart	Avenilla	N	1983	0	20	11; 13;	-	-
	Zea mays L.	Maíz	N	1985	0	32	3	-	-
Rutaceae	*Zanthoxylum fagara* L.	—	N	1998	0	20	13	-	-
Sapindaceae	*Dodonaea viscosa* Jacq.	Chirca de monte	N	1998	0	20	10; 11; 13	-	-
Verbenaceae	*Aloysia gratissima* (Gillies & Hook.) L.D.Benson	Cedrón del monte	N	1998	3	20	13	-	-

Table 2. Herbalist at the Biosphere Reserve, UNESCO, "Bioma Pampa-Quebradas del Norte" Rivera Departament, Uruguay. Species, scientific name to which ethnospecies belong; vernacular names. Origins whether native or alien species; Uses, uses assigned to medicinal plants; Ab, abortive; Al, alcoholism; An, antiseptic; Bo, bone; Can, cancer; Car, cardiovascular; De, dermatological; Ea, ear-nose-throat; G, gastrointestinal; Hae, haematological; Hai, hair; Im, immunological-allergic; Inf, infections; Li, liver; Ma, magical; Mem, memory; Met, metabolic; Mo, mouth; Ne, nervous; Nu, nutricional; Pai, pains; Par, parasites, Ren, renal; Rep, reproductive; Res, respiratory; SI, slimming; The, thermoregulator; Ve, vesicle; Vi, vipers; Wo, wounds. The species conserved in the BGFAgro collection are presented in parentheses with an asterisk. Adapted from Castiñeira Latorre (2018).

Species	Vernacular names	Origins	Uses
Adoxaceae			
Sambucus australis Cham. & Schltdl.	Sauco	native	Ea, Res
Alismataceae			
Echinodorus grandiflorus (Cham. & Schltdl.) Micheli	Sombrero de cuero	native	De, Bo, Inf, Met, Nu, Ren, Res
Amaranthaceae			
Guilleminea densa (Willd. ex Roem. & Schult.) Moq.	Yerba del pollo	native	G, Ea, Res
Amaryllidaceae			
Allium cepa L.	Cebolla	alien	Ea, Res
Allium sativum L.	Ajo	alien	Car, Inf, Met, Nu, Par, Res, Vi
Anacardiaceae			
Schinus molle L. var. Molle (*)	Anacahuita	native	Im, Ea, Res
Annonaceae			
Annona muricata L.	Graviola	alien	Can, Car, G, Ne
Apiaceae			
Pimpinella anisum L.	Anis	alien	G, Inf, The
Apium graveolens Cham.	Apio	alien	An, Mo, Car
Eryngium pandanifolium Cham. & Schltdl.	Caraguata	native	Li, Ren
Eryngium sp.	Cardo	native	G, Ne, The
Foeniculum vulgare Mill.	Hinojo	alien	G, Ne, Rep
Aquifoliaceae			
Ilex paraguariensis A. St.-Hill	Yerba mate	native	Met
Araliaceae			
Panax ginseng C.A. Mayer	Ginseg	alien	Im, Met, Nu, Rep
Aspleniaceae			
Asplenium ceterach L.	Doradilla	alien	Car, G, Rep
Asteraceae			
Acanthospermum australe (Loefl.) Kuntze	Yerba de la oveja	native	Li, Rep
Achillea millefolium L.	Milenrama	alien	G
Achyrocline satureioides (Lam.) DC. (*)	Marcela	native	An, Car, G, Li, Im, Ma, Met, Nu, Ea, Ren, Res
Acmella decumbens (Sm.) R.K. Jansen var. *decumbens*	Barba de indio	native	G, Ren
Arctium lappa L.	Bardana	alien	An, G, Her

Arnica montana L.	Arnica	alien	Ab, De, Pai, Hae, Bo, Im, Nu, Rep
Artemisia absinthium L.	Ajenjo-Losna	alien	G, Li, Ea, Par, Rep, Res
Baccharis articulata (Lam.) Pers.	Carqueja blanca	native	SI, Car, G, Hae, Li, Met, Nu, Ren
Baccharis trimera (Less.) DC (*)	Carqueja	native	SI, An, Car, G, Li, Met, Rep, Ve
Conyza bonariensis L.	Carnicera	native	G, Wo, Li, Ren
Cynara scolymus L.	Alcachofa	alien	G, Li, Ren
Lactuca sp.	Lechuga	alien	Ne
Matricaria chammomilla L.	Manzanilla	alien	Rep
Matricaria recutita L.	Manzanilla	alien	Hai, Car, De, G, Ne, Rep,
Mikania glomerata Spreng.	Guaco	native	Oi
Mikania periplocifolia Hook. ARN	Guaco	native	Ea, Res
Moquiniastrum polymorphum (Less)	Cambará	native	Res
Pluchea sagittalis (Lam.) Cabrera	Yerba lucera	native	G, Hig
Stenachaenium sp. Baker (*)	Arnica	native	Ab, An, Mo, Can, De, Pai,G, Hae, Wo, Bo, Inf, Im, Ea, Ren, Rep, Res
Stevia rebaudiana (Bertoni) Bertoni (*)	Stevia	alien	Nu
Tanacetum vulgare L.	Palma imperial	alien	G, Wo, Li, Par, Ve
Taraxacum officinale G, Weber ex F.H. Wigg.	Diente de león	alien	Si, An, Li, Bo, Inf, Met, Nu, Ren, Ve
Xanthium spinosum L. var *spinosum*	Cepa caballo	native	Li, Res
Boraginaceae			
Borago officinalis L.	Borraja	alien	The
Lithospermum sp	Siete sangrias	alien	Car, Hae, Met, Nu
Symphytum officinale L.	Confrei	alien	An, Can, G, Her
Brassicaceae			
Nasturtium officinale W. T. Aiton	Berro	alien	Ne
Bromeliaceae			
Bromelia balansae Mez	Bananinha do mato	native	Li, Res
Tillandsia recurvata L.	Epilobio	native	Rep
Cactaceae			
Opuntia brasiliensis (Willd.) Haw	Yurunibeba	native	Pai, G, Ve
Caricaceae			
Carica papaya L.	Papaya, mamón	native	Inf
Celastraceae			
Maytenus ilicifolia Mart. ex Reissek (*)	Congorosa	native	Al, Car, G, Hem
Cervantesiaceae			
Jodina rhombifolia (Hook. & Arn.) Reissek	Sombra de toro	native	Al, Car, G, Hae, Wo, Li, Im, Met, Nu, Ren, Rep
Chenopodiaceae			
Dysphania ambrosioides (L.) Mosyakin & Clemants (*)	Paico	native	G, Hig
Convolvulaceae			

Ipomoea batata (L.) Lam	Boniato	alien	Met
Cucurbitaceae			
Cucurbita pepo L.	Zapallo	alien	G
Dryopteridaceae			
Rumohra adiantiformis (G. Forst.) Ching	Calaguala	native	Pai, Li, Bo, Ren
Ebenaceae			
Diospyros inconstans Jacq.	Caki	native	G
Ephedraceae			
Ephedra tweediana Fisch. & C.A. Mey emend. J.H.Hunz	Cola de caballo	native	An, Li, Inf, Im, Met, Nu, Ren, Ve
Equisetaceae			
Equisetum giganteum L.	Cola de lagarto	native	Ren, Rep
Euphorbiaceae			
Euphorbia serpens Kunth var. *serpens*	Yerba meona	native	Ren
Manihot esculenta Crantz	Mandioca	native	Car, Pai, G
Fabaceae			
Bauhinia forficata Link ssp. *pruinosa* (Vogel) Fortunato & Wunderlin	Pata de vaca	native	Car, Met, Nu, Ren, Rep
Caesalpinia echinata Lam.	Palo Brasil	native	De
Cassia angustifolia Vahl	Sene	alien	G
Erythrina crista-galli L. var. *leucochloa* Lombardo	Ceibo	native	Wo, Res
Otholobium glandulosum (L.) J.W. Grimes	Culé	alien	G
Ginkgoaceae			
Ginkgo biloba L.	Ginkgo	alien	Car, Hae, Me
Hypericaceae			
Hypericum connatum Lam.	Yerba del toro	native	Ne
Hypericum perforatum L.	Hiperico	native	G, Ne
Iridaceae			
Sisyrinchium vaginatum Spreng. ssp. *vaginatum*	Cambaracito	native	Mer, Ea, Ren, Res
Juglandaceae			
Carya illinoinensis (Wangenh.) C. Koch	Nuez de Pecan	alien	Met, Nu
Labiataceae			
Origanum vulgare L	Oregano	alien	G, Met, Res
Lamiaceae			
Hyptis radicans (Pohl) Harley & J.F.B. Pastore	Ortelan	native	De, G, Pa
Lavandula angustifolia Mill.	Lavanda	alien	Pai, Ne
Marrubium vulgare L.	Marrubio	alien	Sl, G, Li, Met, Nu, Rep, Res
Melissa officinalis L.	Melisa	alien	Pai, Ne
Mentha aquatica L.	Menta/Levante	alien	G, Im, Ma, Met, Ne, Ea,
Mentha spicata L.	Menta	alien	G, Ma, Ne

Mentha x *piperita* L.	Menta	alien	Oi
Rosmarinus officinalis L.	Romero	alien	Car, Pai, G, Ma, Met, Nu, Rep, Res
Thymus vulgaris L.	Tomillo	alien	Res
Lauraceae			
Cinnamomum amoenum (Nees) Kosterm.	Garuvá	native	G
Cinnamomum sp.	Canela	alien	G, Met, Ne, Nu, Rep, Res
Laurus sp.	Laurel	alien	Ne, Nu, Res
Persea americana Mill.	Palta	alien	G, Ren
Loranthaceae			
Tripodanthus acutifolius (Ruiz & Pav.) Tiegh.	Yerba del pajarito	native	G, Hae, Wo, Inm
Lythraceae			
Cuphea carthagenensis (Jacq.) J.F. Macbr.	Escobilla	alien	Car, Hem
Cuphea fruticosa Spreng.	Siete sangrias	native	Car, Hae, Wo, Met, Nu, Ren
Punica granatum L.	Granada	alien	G
Malvaceae			
Malva sylvestris L.	Malva	alien	An, Mo, De, G, Wo, Inf, Im, Ea, Ren, Rep
Modiola caroliniana (L.) G. Don	Mercurio	native	De, Her
Meliaceae			
Melia azedarach L.	Paraiso	alien	De
Menispermaceae			
Cissampelos pareira L.	Oreja de tigre	native	Li, Ren
Monimiaceae			
Peumus boldus Molina	Boldo	alien	G, Li, Ve
Moraceae			
Dorstenia brasiliensis Lam.	Higuerrilla	alien	Wo, Res
Morus alba L.	Mora	alien	Met, Ne, Ren, Rep, Res
Myrtaceae			
Blepharocalyx salicifolius (Kunth) O. Berg	Arrayan	native	Car, Pai, G, Hae, Li, Nu, Ren, Res, Ve
Campomanesia xanthocarpa O. Berg var *littoralis* (D. Legrand)	Guabiroba	native	Mer, Nu, Ren
Eucalyptus globulosus St. -Lag	Eucalypto	alien	Res, The
Eugenia uniflora L. (*)	Pitanga	native	Pai, G, Nu, Oi
Eugenia uruguayensisCambess.	Guayabo blanco	native	Wo, Pa
Myrceugenia eusoma (O. Berg) D.Legrand	Murta	native	G, Li, Res
Myrrhinium atropurpureum Schott var. *octandrum* Benth.	Palo de fierro	native	Im, Met, Nu
Psidium carrleianum Sabine	Azará	native	G, Wo, Met, Ren, Ve
Oleaceae			
Fraxinus excelsior L.	Fresno	alien	Hem
Olea europaea L.	Olivo	alien	Car
Onagraceae			

Epilobium parviflorum Schreb.	Epilobio	alien	Rep
Parmeliaceae			
Usnea sp	Yerba de la piedra	native	An, Mo, Ren
Passifloraceae			
Passiflora caerulea L.	Burucuya	native	Ne, Nu
Passiflora edulis Sims	Maracuya	alien	Ne
Turnera diffusa Willd.	Damiana	alien	Met
Phyllanthaceae			
Phyllanthus niruri L.	Quebra pedra	native	Ren, Rep, Ve
Phyllanthus sellowianus (Klotzsch) Mull.Arg.	Sarandi blanco	native	Hae, Mer, Nu
Phytolacca dioica L.	Ombú	native	G
Piperaceae			
Piper mikanianum (Kunth) Steud. var. *mikanianum*	Paiparoba	native	Ab, G, Hem
Plantaginaceae			
Plantago tomentosa Lam. ssp. *tomentosa* (*)	Llantén	native	An, Mo, Can, G, Wo, Li, Inf, Im, Nu, Ea, Ren, Ve
Plumbaginaceae			
Limonium brasiliense (Boiss.) Kuntze	Baicuru	native	G
Poaceae			
Cymbopogon citratus (DC.) Stapf	Pasto limón	alien	Ne
Sorghastrum pellitum (Hack.) Parodi	Cola de zorro	native	Ren
Zea mays L. (*)	Barba de choclo	alien	Inf, Ren,
Polygonaceae			
Polygonum punctatum Elliott	Yerba del bicho	native	De, G, Inm
Polypodiaceae			
Microgramma vacciniifolia (Langsd. & Fisch.) Copel.	Suelda-consuelda	native	Bo, Met, Nu
Pontederiaceae			
Pontederia cordata L. var. *cordata*	Sombrero de cuero	native	Pai, Hu
Ranunculaceae			
Clematis bonariensis Juss. ex. DC.	Barba de viejo	native	De, Wo, Vi
Rhamnaceae			
Discaria americana Gillies & Hook.	Quina de campo	native	Si, Hai, G, Ren, The
Scutia buxifolia Reiss.	Coronilla	native	Car, Hae, Met, Nu, Ren
Rosaceae			
Eriobotrya japonica (Thunb.) Lindl.	Nispero	alien	Res
Prunus subcoriaceae (Chodat & Hassl.) Koehne	Duraznero	alien	G, Pa
Rubiaceae			
Uncaria tomentosa (Willd. Ex Roem. & Schult.)DC.	Uña de gato peruana	alien	An, Bo, Inm
Rutaceae			
Citrus aurantium L.	Limera	alien	Car, G, Ne

Citrus limon (L.) Osbeck	Limón	alien	Car, Pai, G, Hae, Met, Ne, Nu, Ea, Ren, Res
Citrus sp.	Lima	alien	De, Pai, G, Wo, Inf, Ne, Ea, Res
Ruta chalepensis L.	Ruda	alien	Ab, Car, Pai, Ma, Par, Ren, Rep, Vi
Salicaceae			
Banara tomentosa	Guazatunga	native	De, Pai, Vi
Casearia decandra Jacq.	Guazatunga	native	An, De, Vi
Casearia sylvestris Sw. var. *sylvestris*	Guazatunga	native	An, De, Pai, Wo, Bo, Inf, Vi
Saliz humboldtiana Willd.	Sauce	native	Do
Sapindaceae			
Aesculus hippocastanum L.	Castaño de la India	alien	Car
Allophylus edulis (A. St.-Hill., A. Juss. & Cambess.) Hieron. Ex Niederl.	Chal chal	native	Hig
Paullinia cupana Kunth	Guarana	alien	Mem, Met, Un
Schisandraceae			
Illicium verum Hook.f.	Anís estrellado	alien	G, Ne
Simarubaceae			
Quassia amara L.	Cedro santo	native	Met, Nu, Pa
Smilacaceae			
Smilax campestris Griseb.	Zarzaparrilla	native	An, Hae, Wo, Inf, Im, Met, Nu
Solanaceae			
Atropa belladonna L.	Bella dona	alien	G
Cestrum euanthes Schltdl.	Guazatunga	native	De, Vi
Datura arborea L.	Floripón	alien	Res
Nicotiana glauca Graham	Palam-palam	native	Her
Solanum paniculatum L.	Yurubeba	native	G
Solanum tuberosum L.	Papa	alien	Do
Tilaceae			
Luchea divaricata Mart	Francisco Álvarez	native	Hem
Tilia cordata	Tilo	alien	Car, Ne, Ea, Res
Tropaeolaceae			
Tropaeolum majus L.	Taco de reina	alien	Met, Nu
Urticaceae			
Urtica dioica L.	Ortiga	alien	Hai, Res, The
Verbenaceae			
Aloysia citrodora Palau	Cedron	native	An, Mo, G, Ne, Res, The
Aloysia gratissima (Gillies & Hook. ex Hook.) Tronc. var. *gratissima*	Cedron del monte	native	G, Ne, Ea, Res
Lantana montevidensis (Spreng.) Briq	Salvia	native	An, Mo, Inf, Ea, Ren, Res

Lippia alba (Mill.) N.E.Br. ex Britton & P. Wilson var. *alba*	Salvia	native	G, Oi
Salvia officinalis L.	Salvia	alien	G, Inf, Ea, Par, Ren, Resp
Violaceae			
Anchietea pyrifolia (Mart) G. Don	Cipó suma	native	Bo, Vi
Vitaceae			
Cissus verticillata (L.) Nicolson & C.E. Jarvis	Insulina vegetal	native	Met, Nu
Zingiberaceae			
Zingiber officinale Roscoe	Gengibre	alien	Res

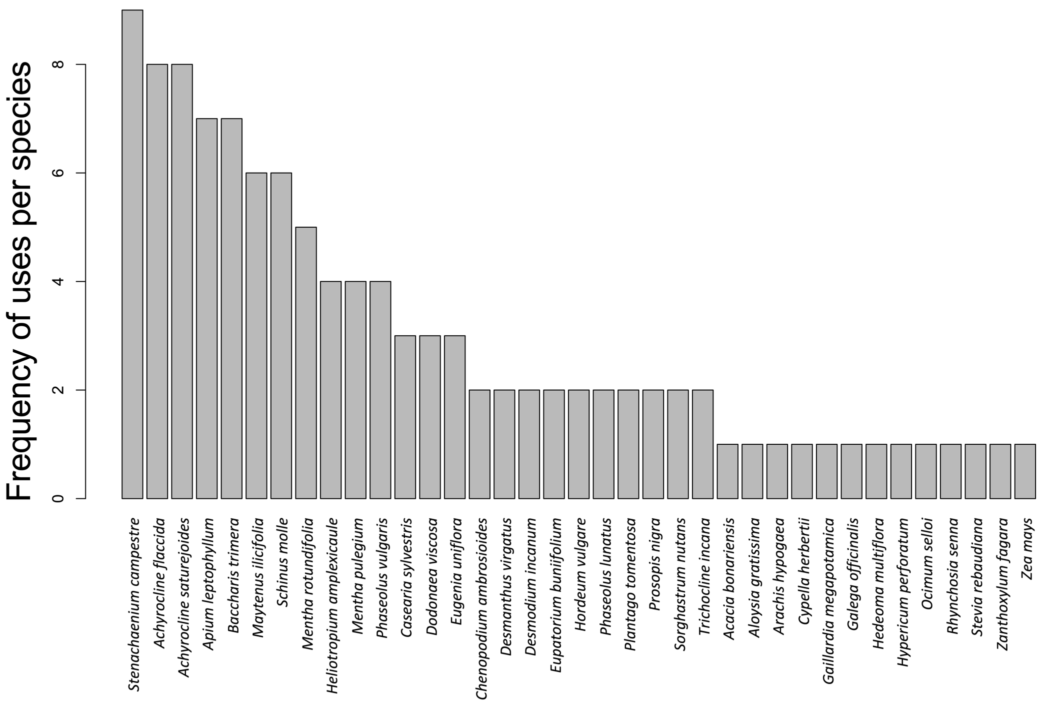

Figure 2. Frequency of medicinal uses per species.

The medicinal uses with the highest number of species are as follows: Symptoms and conditions of undefined origin (24 species); Digestive system (19 species); Genitourinary system (15 species); Skin and subcutaneous tissues (12 species); Infectious diseases (8 species); Nervous system (8 species); Parasitic diseases (3 species); Respiratory system (4 species); Immune system (6 species); Circulatory system (5 species); Endocrine and metabolic system (2 species); Tumorous diseases (2 species); Antidote-antiophidic (2 species); Musculature and skeleton (1 species). Out of the total of 37 species, 29 are of native origin and 8 are adventitious (Table 1).

Viability of the accessions.

The logistic regression shows a significant fit of the inflection parameter of the function in the year 2007 ($t_{(91,3176; 35)}$; $p<0.001$) (Fig. 3). This result indicates that germination values decrease drastically after 14 years of entry into the collection. The correspondence analysis based on the matrix of species in relation to their medicinal uses accounted for 35.5% of the system's variance (dimension 1: 19.4%, dimension 2: 16.1%) described in the first two dimensions (Figure 4). Most of the species and medicinal uses have low weight in these two dimensions: Symptoms and conditions of undefined origin, Digestive system, Genitourinary system, Skin and subcutaneous tissues, indicating high redundancy (i.e., several species treating the same symptoms, utilitarian redundancy model, see Albuquerque & Oliveira 2007). On the other hand, there are plants with high specificity. A strong association is observed between *S. rebaudiana* with Endocrine and metabolic system, *C. sylvestris* and *C. ambrosioides* with Antidote-antiophidic. Lastly, it is worth mentioning *S. campestre*, which, although a versatile species (i.e., the same species treats different symptoms, see Albuquerque & Oliveira 2007), is the only one associated with the treatment of Musculature and skeleton and with S. molle the only ones that treat Tumor diseases (Figure 4).

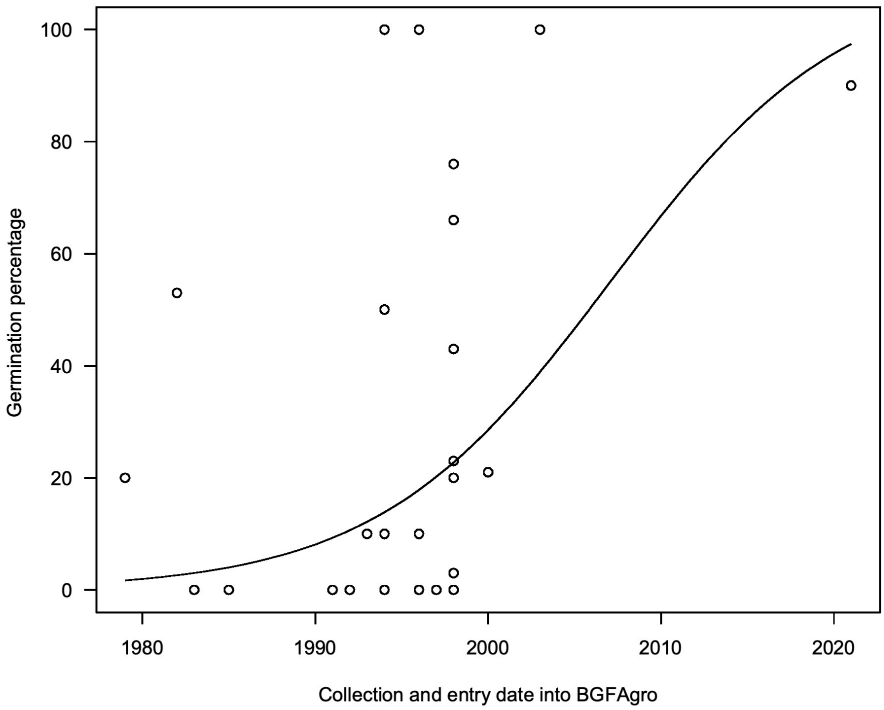

Figure 3. Logistic adjustment of the germination percentage as a function of the collection and entry date (in years) into BGFAgro.

Discussion

The main biome of the country is represented by species that make up the Pampas of the Río de la Plata, which are characterized by a predominance of herbaceous vegetation and grasslands (Cabrera & Willink 1973; Morrone 2001). A significant collection of seeds from these species is preserved in BGFAgro. The high representativeness of the Asteraceae, Leguminosae, and Poaceae families in the collection shows the abundance of these species in natural fields and also highlights the significant efforts made to improve forage species. In addition to the intrinsic value of the seeds available in the BGFAgro, the database provides a broad view of species distribution in the territory. In temporal terms, records dating back to the 1970s are available, while in spatial terms, representations of all 19 Departments of Uruguay are included. The passport information provides precise knowledge of taxonomic and geographical data, reaching the level of locality, with corresponding geographical coordinates, latitudinal data, and habitat type (Hernández Bermejo 2007).

Analyzing the temporal information has allowed us to detect that the highest number of entries of medicinal plant accessions directly correspond to specific projects funded from abroad (e.g., "Development of the Medicinal and Aromatic Plants Sector in Uruguay" funded by the European Union and the Project "Phytogenetic Resources of Native Species. Collection, Conservation, Taxonomic and Biological Studies" - FPTA Project No. 137 INIA-CNFR, Davies & Villamil (2004), also recording a period of 18 years without the entry of medicinal plant accessions. The identification of the strong association between the entry of accessions and specific externally funded projects reflects the dependency and highlights that Uruguay has not been able to efficiently implement the recommendations of the United Nations Convention on Biological Diversity and the Global Strategy for Plant Conservation in terms of *ex situ-in situ* conservation (DINAMA 1999, 2000, Haywood & Dulloo 2005, Jackson & Kennedy 2009).

The germination tests conducted on medicinal taxa show low seed quality for the conserved batches, and the probability of germination declines drastically after 14 years, resulting in the loss of genetic information for the taxa. The low seed viability and longevity compromise the objectives of the BGFAgro germplasm bank. The problems with longevity are strongly related to the procedures at the time of seed collection, and therefore, their long-term conservation capacity is compromised (Bacchetta *et al.* 2008, Griffiths *et al*. 2015). At the same time, to achieve better germination results, it is necessary to increase the sanitary control of the seeds upon entry into the bank. In this study, we discarded 17% of the material due to the presence of fungi. The need to develop an effective conservation protocol for each taxon, carry out collection campaigns, cultivate the plants in a laboratory or botanical garden, and efficiently manage a seed bank is emphasized, contributing to the completion of the plant's vegetative and reproductive development cycle (Griffiths *et al*. 2015, Hernández Bermejo 2007). This aspect is of particular interest for the development of plans for the reintroduction or reinforcement of populations of medicinal plants under strong harvest pressure (Hamilton 2008, Liu *et al.* 2018).

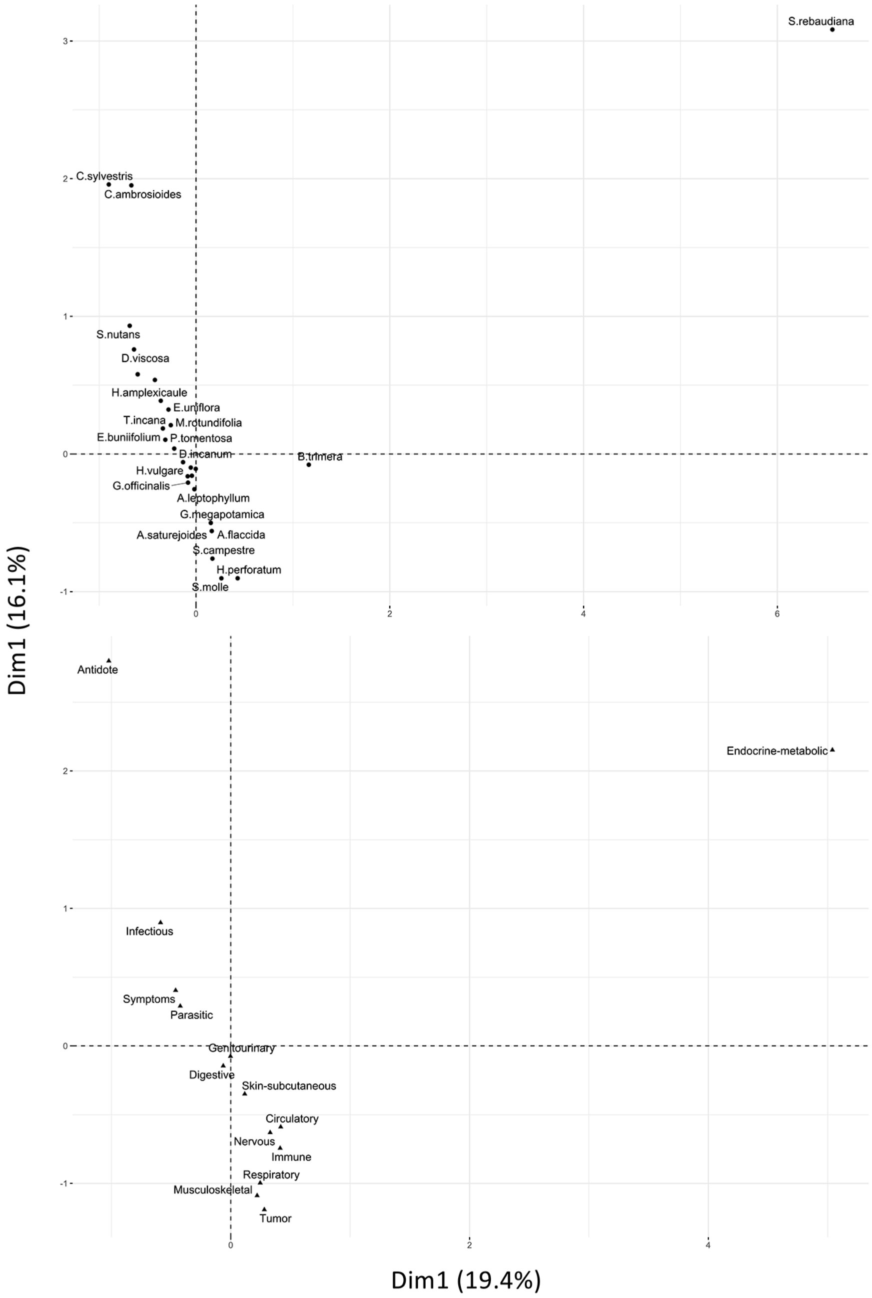

Figure 4. Correspondence analysis generated from the matrix of medicinal plants and medicinal uses. Where dimension 1 (Dim1) accounts for 19.4% of the variation and dimension 2 (Dim2) accounts for 16.1%. The upper figure represents the medicinal plants variable, and the lower figure represents the medicinal uses variable.

The original conservation criteria of the BGFAgro prioritized the collection of natural grassland and forage species, later included collections of commercial cultivars and landrace varieties (e.g., *Arachis hypogaea*; *Phaseolus* spp.; *Zea mays*) (Berretta *et al.* 2007). Today, the BGFAgro is developing criteria to establish conservation strategies for wild, ornamental, and medicinal species. Currently, the collection preserves 23% of the estimated medicinal botanical species richness of the country (*sensu* Castiñeira Latorre *et al*. 2018), see supplementary material), as germination values tend to be below 50%, these values cannot satisfy the requirements of an international germplasm bank (Griffiths *et al*. 2015). This reinforces the urgency of establishing an *ex situ* conservation program with management tools that contribute to fulfilling Uruguay's commitments under the Convention on Biological Diversity (CBD) and the Nagoya Protocol, regarding the conservation of biocultural diversity (*sensu* Gavin *et al*. 2015). It is necessary to rejuvenate the current collection of seed medicinal plants, and in this sense, ethnobotanical criteria (e.g., versatility and redundancy) can be valuable tools to contribute to the efficient planning of future plant germplasm collection campaigns (Griffiths *et al*. 2015).

Based on the principles of ethnobotanical theory, versatile and readily available species, including those considered cultural keystone species, were incorporated into local pharmacopeias after undergoing periods of experimentation and knowledge transmission (Albuquerque *et al*. 2015, 2017, Alencar *et al*. 2010, Bennett & Prance 2000, Gaoue *et al*. 2017, Lucena *et al*. 2007). These species are currently considered safe for therapeutic treatments and provide stability to medicinal botanical systems. In the current context of climate change, habitat fragmentation, and ecosystem transformation, these species and associated knowledge are particularly vulnerable (Castiñeira *et al*. 2020). A proposal for *ex situ* conservation that prioritizes their preservation can contribute to maintaining the resilience of these systems in the face of disturbance events (Albuquerque & de Oliveira 2007, Castiñeira *et al*. 2020, Cristancho & Vining 2004, Ferreira *et al*. 2012, Garibaldi & Turner 2004, Santoro *et al*. 2007).

Within this framework, a tentative list of medicinal species to be considered would include rescuing the genetic and phenotypic heterogeneity of populations that include taxa with a high degree of versatility and redundancy, while, on the other hand, considering other taxa with highly specific functions. For example, *Schinus molle* show a high degree of versatility in its uses related to diseases with high prevalence and low severity for the studied populations (e.g., digestive system) (Castiñeira *et al*. 2018; Molares & Ladio 2008; Santoro *et al*. 2015). It is also of interest for the search for new compounds due to its action on the Immune system and Tumor-related diseases (Piastri 2023). Another example is the *ex situ* conservation of *Achyrocline saturejoides* and *A. flaccida*, native species with high versatility in traditional uses and associated with redundant treatments. This conservation would allow for the preservation of wild populations that are currently threatened by intense harvesting pressure and the maintenance of diverse therapeutic functions (Soutullo *et al*. 2013). From another perspective, species like *G. megapotamica* can be considered specific for certain treatments (Skin and subcutaneous tissue). Including them as priorities contributes to the conservation of particular therapeutic targets and the knowledge associated with cultural management and preparation practices. Both species are classified as priority for conservation due to the drastic reduction in the size of their populations in the territory (Marchesi *et al.* 2013). Finally, the application of strategies that integrate ethnobotanical and conservation biology criteria facilitates the establishment of priorities within a germplasm bank (as defined by Grammont & Cuarón 2006), ensuring the long-term availability of genetic material for ecosystem restoration and contributing to the maintenance of botanical medicinal systems (Gavin *et al.* 2015, Kaky & Gilbert 2019).

Conclusions

Uruguay has a valuable diversity of medicinal plants that is closely tied to the resilience of botanical medical systems, the maintenance of health, and the identity of the most vulnerable rural populations. However, concerns exist regarding the persistence of these resources in the actual context of climate and environmental changes, which could lead to the loss of species and associated knowledge.

The Germplasm Bank of the Faculty of Agronomy (BGFAgro) it is a powerful tool to promote and make *ex situ* conservation. However, in this study, we found that the BGFAgro has some limitations that should be highlighted. Firstly, it conserves a fragmented collection of medicinal seed samples, which does not fully represent the total richness of medicinal plants present in the country. Furthermore, these seeds were introduced into the BGFAgro due to incidental collection campaigns that were not primarily focused on the conservation of medicinal phytogenetic resources. Although the preserved material provides passport data with georeferenced, ecological, and temporal information, unfortunately, it does not include information related to the traditional use of these species in the localities where they were collected. To address this gap, we had to apply to proxy methods, relying on findings from other studies (Castiñeira Latorre *et al*. 2018) and the Medicinal Plant Thesaurus of the Faculty of Chemistry at UdelaR (Piastri 2023).

The results of the seeds germination trials indicate that the preserved material has a low germination capacity. This could be due to various factors such as insufficient knowledge about the seeds' specific physiological characteristics, specifically their developmental stage and dormancy, problems with cleaning the material when it was added to the collection, and difficulties in maintaining optimal conditions during the conservation process in cold storage rooms.

Despite these limitations, our results are consistent and emphasize the urgent need to address the lack of *ex situ* conservation tools in our country regarding medicinal phytogenetic resources. They also underscore the importance of implementing changes to align with international standards established for germplasm banks. We consider these challenges as opportunities to take new measures that reduce the identified gaps and promote the creation of effective *ex situ* conservation management programs. To prioritize *ex situ* conservation programs for medicinal phytogenetic resources, we propose using criteria that integrate ethnobotanical and conservation biology theories.

Declarations

Ethics statement: Not applicable.

Consent for publication: Not applicable.

Availability of data and materials: All accessions are preserved in the Banco de Germoplasma de Facultad de Agronomía, Montevideo, Uruguay.

Competing interests: The authors declare that they have no competing interests.

Author contributions: ECL conducted the research work and data analysis and wrote the first draft of the manuscript. AC contributed to the statistical data analysis. RV collaborated with the germination trials and methodology in the germplasm bank. All authors read, revised, reviewed and approved the final draft of the manuscript.

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