Native Useful Plants of Chile: A Review and Use Patterns

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Native Useful Plants of Chile: A Review and Use Patterns. We compiled an inventory of the uses of the native flora of Chile by extracting uses cited in the literature until 2015. The inventory reported use citations for a total of 995 species of useful vascular plants (23% of Chile's flora). These data were used to test the hypothesis that some plant families are overrepresented (overused) for some use categories. We used two statistical approaches: a Bayesian and an imprecise Dirichlet model (IDM). Families with a higher number of useful species are Asteraceae, Poaceae, Fabaceae, and Solanaceae. However, according to both the Bayesian and IDM approaches, the Grossulariaceae, Myrtaceae, Lamiaceae, Nothofagaceae, Salicaceae, Rosaceae, and Bromeliaceae are overrepresented. We found 501 species with medicinal uses, 228 with edible uses, 341 used for animal fodder, 300 considered ornamental, 102 used as dyes, 89 for ritual purposes, 75 for timber, and 51 species as a source of fiber. Over 43% of the useful species are endemic to Chile, and 4.7% are threatened. Our results indicate that the plant families of Chile with greater species richness are more likely to have a higher number of useful plants. However, some families tend to be overrepresented and others underrepresented within the different use categories, suggesting a non-random taxonomic distribution pattern of flora use.

Plantas nativas utilizadas en Chile: revisión y patrones de uso. En este trabajo se realizó una recopilación bibliográfica de los usos de la flora nativa de Chile publicados en la literatura hasta el año 2015. La revisión arrojó referencias de usos para 995 especies vasculares nativas (23% de la flora de Chile). Con esta información se puso a prueba la hipótesis que ciertas familias están sobre representadas en ciertas categorías de usos. Para ello se utilizó estadística Bayesiana y un modelo de distribución impreciso de Dirichlet (IDM por su sigla en ingles). Como resultado las familias taxonómicas con mayor cantidad de especies utilizadas son Asteraceae, Poaceae, Fabaceae y Solanaceae. Sin embargo, de acuerdo al análisis Bayesiano e IDM, especies pertenecientes a las familias Grossulariaceae, Myrtaceae, Lamiaceae, Nothofagaceae, Salicaceae, Rosaceae, y

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Bromeliaceae estarían sobre representadas en distintas categorías de uso. En total se registraron 501 especies con uso medicinal, 228 con uso comestible, 341 utilizadas como forraje para animales, 300 utilizadas como ornamentales, 102 con uso tintóreo, 89 utilizadas con fines rituales, 75 utilizadas como fuente de madera, y 51 como fuente de fibra. Más del 43% de las especies útiles son endémicas de Chile y el 4,7% se encuentra bajo alguna categoría de amenaza. Los resultados indican que las familias botánicas con mayor número de especies tienen un mayor numero de especies útiles. Sin embargo, algunas familias están sobre representadas y otras sub representadas dentro de las distintas categorías de uso, sugiriendo un patrón de distribución no aleatorio de los usos de la flora de Chile.

Key Words: Useful plants, ethnobotany, traditional knowledge, South America, Chile.

Introduction

The flora of Chile includes over 4500 taxa (Marticorena 1990; Rodríguez et al. 2018; Zuloaga et al. 2008), is highly endemic (ca. 50%) (Cowling et al. 1996; Marticorena 1990), and is increasingly under threat (Olson and Dinerstein 1998).

Chilean people have a long history of using native plants, and many indigenous groups still continue to use these plants for their subsistence (Barreau et al. 2016; De Mösbach 1992; Smith-Ramirez 1996; Villagrán and Castro 2004), generating a large body of local plant knowledge. In this work, "useful plant" is defined as a plant used by people, according to Hill (1937).

The first Spanish exploratory voyages in southern South America recorded valuable information on the use of native plants by indigenous people, prior to Chile's Spanish colonization (e.g., Bivar in the 16th century; Ovalle and Rosales in the 17th century) (Marticorena and Rodríguez 1995). Since 1753, botanical explorations began to provide descriptions and records of the flora of Chile that gradually enriched the available information on uses and applications (e.g., Molina, Gay, and Phillippi and Reiche in the 19th century, among others) (Marticorena and Rodríguez 1995). Anthropological and ethnobotanical studies in Chile, initiated at the end of the 20th century, compiled valuable and detailed information about the uses of native plants by local communities. These ethnobotanical studies focused particularly on indigenous communities in the north of Chile (Aldunate et al. 1981, 1983; Cárdenas 1998; Castro et al. 1982; Munizaga and Gunkel 1958; Plath 1968; Serracino et al. 1974; Villagrán et al. 1998a, b, 1999, 2003; Villagrán and Castro 1999, 2004), the Mapuches from Southern Chile (Bragg et al. 1986; De Mosbach 1992; Gumucio 1999; Gusinde 1936), local communities on the islands of the Chiloé Archipelago (Chaer and Jerez 1999; Meza and Villagrán 1991; Villagrán et al. 1983), and some communities in Patagonia (Martínez Crovetto 1968, 1982; Massardo and Rozzi 2006).

Since the 1960s, some of the traditional knowledge associated with native plants began to be assessed through bioassays that characterized the metabolites and molecules responsible for their uses (see Arnason et al. 1995; Echeverría and Niemeyer 2012; Niemeyer 1995). As a result, several compounds have been identified with potential use for the pharmaceutical, cosmetic, food, agricultural, and environmental industries (CORFO 2007).

While information about the botanical resources of Chile and their traditional and current use may be documented in some areas, it is vastly dispersed and inadequately synthesized. Many publications have been limited to a few indigenous groups or localities, to specific use categories, and by the heterogeneous methodological approaches of diverse research fields (e.g., botany, biology, anthropology, chemical, and conservation biology, among others). Furthermore, some publications, such as unpublished theses, dissertations, government agency documents, and technical reports, are not widely accessible. Hence, the scattered data prevent a proper understanding of the current state of knowledge of Chile's flora, limiting both the analysis of plant use patterns and comparative analyses with other floras.

Since 2007, the Plant Genetic Resources Program of Chile (by the Instituto de Investigaciones Agropecuarias (INIA)) has been developing a database of all native useful plant species, with the aim of compiling the state of current knowledge of uses to first allow information access and collaboration among researchers, planners, policy makers, and indigenous populations (Ningthoujam et al. 2012). It will also support the protection of indigenous knowledge against erroneous IP claims (Gaudillière 2014) and help prioritize the collection of seeds. Last, it will contribute towards informed decision-making for a sustainable use of endangered species (Moerman et al. 1999; Smith et al. 2000).

Additionally, an analysis of the useful plants at the national level can also improve our understanding of large-scale patterns, i.e., discerning which plant families have a higher richness of useful species and which are overrepresented in proportion to their number of total species (useful and non-useful). These findings can provide information on the selection of useful plants made by humans across different cultures and regions (Moerman et al. 1999), guide bioprospecting efforts towards the groups of species that are more likely to yield new drugs or functional foods (Zhu et al. 2011), and contribute to the understanding of traditional knowledge itself (Saslis-Lagoudakis et al. 2012).

Diverse studies have shown that useful plants are not randomly distributed across floras and families (Forest et al. 2007; Lukhoba et al. 2006; Moerman 1991; Moerman et al. 1999; Weckerle et al. 2011, 2012). Some higher plant groups, like families, tend to be overrepresented in terms of a specific use category and others underrepresented. A taxonomic pattern has been detected in studies on medicinal plants. Here, medicinal plants were found to be overrepresented in some taxa compared to a random distribution of medicinal plants in the existing flora (Leonti et al. 2003; Moerman 1991; Moerman et al. 1999; Weckerle et al. 2011, 2012).

Phylogenetic patterns have been investigated for medicinal plants, food plants, and "economic plants" (Ernst et al. 2016; Forest et al. 2007; Lukhoba et al. 2006; Saslis-Lagoudakis et al. 2011, 2012; Şerban et al. 2008). Researchers found that each of the use categories investigated was phylogenetically clumped (Forest et al. 2007; Lukhoba et al. 2006; Saslis-Lagoudakis et al. 2012; Şerban et al. 2008), and these clusters occurred in distinctive parts of the phylogeny for each use category (Forest et al. 2007).

In sum, while there is evidence for a taxonomic and a phylogenetic pattern in useful plants, most studies have been done on medicinal plants and have not examined the total spectrum of use categories.

In this review of the native useful flora of Chile, we compiled the state of current knowledge of plant uses with the following aims: (i) to analyze the data to determine the categories of plant uses with higher species richness, (ii) to analyze the data according to the families with higher species richness for each use category, and (iii) to test the hypothesis that, while overall the number of useful plant species in families is proportional to the family species richness, some plant families are overrepresented for some use categories. In other words, some families have a higher number of useful plant species than expected if all families had the same likelihood of having useful plant species.

Materials and Methods

Assessment of Chile's Flora as a Baseline for this Study

The total flora of Chile, its origin, endemism, and the nomenclature of its taxa were based and assessed on the catalogue of the flora of Chile by Rodríguez et al. (2018), with a total list of 4262 species (excluding subspecies or varieties) belonging to 169 families. For conservation status information, we employed the official classification developed by the Ministry of the Environment following the procedures suggested by IUCN (Ministerio del Medio Ambiente 2012).

Literature Search and Data Extraction

We extracted plant "use-citations" from all the studies conducted in Chile, reporting useful plants that we found during our literature review, and we compiled this information (including references) in a database of the useful plants of Chile (see Electronic Supplementary Material (ESM) Appendix 1; all database and references are available in the Figshare repository https://figshare.com/s/85d4b8cc58ba6286b796). In this paper, we use the term "use-citation" to refer to the description of a specific use for a plant species.

To start, we reviewed classic natural history texts (e.g., Muñoz 1975; Reiche 2013; Rosales 1877, among others), ethnobotanical studies of Chile's flora (e.g., Aldunate et al. 1981, 1983; Bragg et al. 1986; Cárdenas 1998; Castro et al. 1982; Gumucio 1999; Gusinde 1936; Meza and Villagrán 1991; Munizaga and Gunkel 1958; Plath 1968; Serracino et al. 1974; Villagrán and Castro 1999, 2004; Villagrán et al. 1983, 1998a, b, 1999, 2003), and books about useful plants (e.g., Juliet 1962; Montes and Wilkomirsky 1985; Muñoz et al. 1981, among others). Then, we conducted a literature search in the databases of the libraries of INIA (Agricultural Research Institute, Chile) and Memoria Chilena (National Library) and by searching in Google Scholar and Web of Science (WOS). The literature search included journal articles, botanical reviews, and available university theses. In the literature search, we first used a list of relevant keywords. We used combinations of "Chile," "ethnobotany," "traditional ecological knowledge," "local ecological knowledge," "plant uses," "medicinal plants," "edible plants," "ornamental plants," "timber plants," etc., in both English and Spanish. We then conducted a second search in the ISI Web of Knowledge (until 2015) limited to the species listed in the sources found in the first search (plant names and synonyms). We reviewed a total of 718 publications (see ESM Appendix 1; all database and references are available in the Figshare repository https://figshare.com/s/85d4b8cc58ba6286b796). To maintain the categories used in the major Chilean ethnobotanical studies, we classified plant uses according to a modified version of the classification by Villagrán and Castro (2004). We expanded their classification system with additional use categories to provide a more precise and complete representation of the biocultural diversity of Chile (for future users of this data). Therefore, the information on plant uses extracted from the literature was compiled in a database according to 20 use categories described in Table 1.

Data Analysis

To test the hypothesis that the number of useful plant species in families is *overall* proportional to the family species richness, we ran negative binomial linear regressions with the number of total species for each family as the independent variables, and as dependent variables, we used the following: (a) the total number of useful plant species for the corresponding family and the number of useful plant species for (b) medicinal plants, (c) fodder, (d) ornamental, (e) food, (f) dye, (g) fiber, (h) sources of timber, and (i) rituals. We used negative binomial models as these are more appropriate for count data that do not follow a normal distribution (O'Hara and Kotze 2010).

We also tested the hypothesis that some plant families are overrepresented in terms of useful plant species richness, i.e., that useful plants are not randomly distributed across plant families, but that some families are more likely to have more useful plant species even when controlling for the total number of species per family. When we use the terms "overrepresented" or "underrepresented," we mean as compared to the random distribution of useful plant species across families.

To test the hypothesis that some plant families are overrepresented in the number of useful plant species in Chile's flora, we used two statistical approaches: a Bayesian approach and an imprecise Dirichlet model (IDM). The Bayesian approach considers that there is some uncertainty on the number of useful plants for a region, i.e., that ethnobotanical surveys are never complete (Leonti et al. 2012), but assumes that the overall flora of the region has been identified. The IDM approach also considers that there is uncertainty in the number of useful plants for a region but removes the assumption that the overall flora for the same region is known and allows for (some) uncertainty of the flora (Weckerle et al. 2012). Generally, the IDM approach leads to more conservative results than the Bayesian approach (Weckerle et al. 2012). Specifically, small plant families are more likely to result as being overrepresented with the Bayesian approach than with the IDM approach. We decided to use both methods and compare results, as the debate on which of the two methods is more appropriate for this type of analysis is still open.

Limitations of this Study

In spite of our extensive search, there may be some omissions in our literature search, mainly due to the records of the works of the first chroniclers, botanical reviews, university theses, technical reports, and "gray literature" archived in libraries' databases that are not systematized in a rigorous and standard way, as the records of scientific papers in WOS. Another limitation could be related with nomenclature changes, synonyms, varieties, subspecies, and merged species, some of which may not have been considered. Also, the geographically heterogeneous distribution of ethnobotanical studies may lead to a bias in the taxa with the higher number of useful plants, by giving more weight to taxa that are present in regions where more studies have been conducted.

Results

In this review, we found more than 1200 records of useful vascular plant species. However, considering the current nomenclature (Rodríguez et al. 2018) and correcting by synonymy, our record was reduced to 995 species (23% of Chile's flora) belonging to 462 genera and 137 families (the database supporting the analysis of this article is available in ESM Appendix 1 and Figshare repository https://figshare.com/s/85d4b8cc58ba6286b796). Of the 995 species with known uses, 43% are endemic to Chile ($n = 429$) and 4.7% are included in one of the threatened categories, which is equivalent to 11% of

TABLE 1. USE CATEGORIES FOR CHILEAN USEFUL FLORA, DEFINITION OF EACH CATEGORY, AND THE SPECIES NUMBER REPRESENTED IN EACH CATEGORY.

Use	Classification criteria	No. of species	% of total Chilean flora
Medicinal	Species reported as medicinal in ethnobotanical studies, reported in books or book chapters about medicinal plants, or described for the treatment of a certain disease or ailment by Chilean people in natural history or botanical texts	501	11.8
Fodder	Species reported as fodder in ethnobotanical studies or reported as consumed by livestock in botanical or agronomical texts	341	8.0
Ornamental	Species reported as used in gardens and parks, used as greenery, cultivated and sold in Chilean nurseries, and used to decorate ceremonies, and those that have been used in breeding for ornamental purposes	300	7.0
Edible	Species reported as edible in ethnobotanical studies, reported in books or book chapters on edible plants, or described as consumed by Chilean people in natural history, botanical, or anthropological texts (can be fresh, cooked, roasted, dehydrated, or in form of jam, beverages, infusions, and condiments)	228	5.3
Dye	Species reported as plant dyes in ethnobotanical studies, reported in books or book chapters about plant dyes or textile art, or described as used by local people for dye in natural history, botanical, or anthropological texts	102	2.4
Rituals	Species reported for rituals in ethnobotanical studies, reported in books or book chapters about magical plants, or described in botanical or anthropological texts as used by people in ceremonies, rituals, or against spells and enchantments in natural history, botanical, or anthropological texts	89	2.1
Timber	Species reported as sources of timber in ethnobotanical studies, reported in books or book chapters about timber sources, or described as timber used by people (can be furniture, interiors, drawers, sculptures, among others) in botanical or anthropological texts	75	1.8
Fiber	Species reported as sources of fiber in ethnobotanical studies or used by people to make baskets, ropes, roofs, or mattress in botanical or anthropological texts	51	1.2
Craft/utilitarian	Species with reports of use to manufacture craft utility objects, for example sticks for knitting, bows and arrows, necklaces and crafts, presses, toys, among others, in natural history, botanical, or anthropological texts	41	0.9
Cosmetics	Species reported in anthropological, botanical, or phytochemical texts as used in cosmetics; for example, for hair washing, to make facial tonics, tattoos, body paintings, or used in the cosmetics industry	32	0.8
Beekeeping	Species from which monofloral honey is obtained according to Montenegro et al. (2008)	30	0.7
Detergent	Species reported as detergent or reported as used for laundry in natural history, ethnobotanical, botanical, or phytochemical texts	24	0.5
Construction	Species reported in ethnobotanical studies, books, or book chapters of useful plants of Chile, as used in construction. Includes woods and fiber plants	20	0.5

TABLE 1. (CONTINUED).

Use	Classification criteria	No. of species	% of total Chilean flora
Agricultural-ecological	Species with reports of use to improve the agricultural land, or as host of edible parasitic plants, in natural history, agronomical, ethnobotanical, or botanical texts	14	0.3
Fuel (carbon)	Species with reports of use as charcoal or fuel (does not include firewood) in anthropological or botanical texts	14	0.3
Tanning	Species with reports of use in tannery, in natural history, anthropological, botanical, or phytochemical texts	10	0.2
Biopesticide	Species reported as biopesticide or used by people for pest control or insect repellent, in natural history, anthropological, botanical, or phytochemical texts	8	0.2
Musical	Species reported in ethnobotanical, anthropological, or botanical texts as used in the manufacture of musical instruments. For example, stems or hollow reeds to make traditional flutes, soft woods for making guitars, etc.	6	0.1
Phytoremediation	Species with reports of use in sewage treatment or that grow in sites of high concentrations of metals, contaminated sites, or mine tailings, in agronomical, botanical, or phytochemical texts	5	0.1
Others	Species that could not be classified in the previous categories (other materials, chemicals)	11	0.2

the total number of threatened species of Chile's flora.

A total of 887 species (89.2%) had between one and three use categories, whereas the remaining 108 (11%) had more than four different use categories. Based on the number of species belonging to each use category, categories with a higher number of species are medicinal, fodder, ornamental, and food, followed by dyes, rituals, timber, and source of fiber (Table 1).

Negative binomial linear regressions analysis showed that the number of useful plants in plant families are overall proportional to the family species richness, as we found a significant relationship between species richness and the dependent variables (Table 2). Additionally, to check the influence of outliers, we ran the same regression after dropping large plant families (with more than 200 species) and we obtained similar results except for the *p* value of the timber category that became higher than 0.05 after dropping the three families with more than 200 species.

Table 3 summarizes the results of both the Bayesian and IDM approaches for the use categories with most useful species and compares the overrepresented families with the families with the higher number of useful species. The complete results of the IDM and Bayesian analysis are available in ESM Appendix 2.

Discussion

The percentage of useful species is similar to that of the useful flora in other Latin American countries such as Mexico (23.4%) (Caballero, personal communication) and Ecuador (30%) (De la Torre et al. 2008). It should be noted that there are numerous exotic wild plants incorporated into traditional Chilean knowledge and also there are Chilean native plants that are traditionally used in foreign countries but are not counted or considered in this survey. For example, in a recent study on the wild edible species of a Mapuche community, 28% of the mentioned species were exotic (Barreau et al. 2016) and the percentage could be much larger outside the indigenous groups (Kujawska et al. 2017).

Regression analysis confirmed our hypothesis that, overall, families with greater species richness are more likely to have a higher number of useful plants, either as total uses or as categories of use. However, the Bayesian and IDM analyses, for each use category and for all the uses aggregated, show that some families are outliers of this overall pattern and tend to be overrepresented in comparison to the expected number of species if these were proportional to the family species richness. This finding is in accordance with the findings of previous studies (de Medeiros

TABLE 2. RESULTS OF THE NEGATIVE BINOMIAL REGRESSION ANALYSIS.

Dependent variable	Independent variable	*p* value	Coefficient	Observations
Number of useful species	Species richness	***	0.0139	200
Number of medicinal species	Species richness	***	0.0104	200
Number of edible species	Species richness	***	0.0131	200
Number of fodder species	Species richness	***	0.0211	200
Number of ornamental species	Species richness	***	0.0079	200
Number of dye species	Species richness	***	0.0068	200
Number of timber species	Species richness	*	0.0046	200
Number of fiber species	Species richness	***	0.0141	200

According to this model, one additional species in the species richness of a family corresponds to a percentage increase of the dependent variable equal to $(e^{coeff} - 1) \times 100$ (McCullagh and Nelder 1989)
$^{***}p < 0.001$

et al. 2013; Leonti et al. 2003; Moerman 1991; Moerman et al. 1999; Weckerle et al. 2011, 2012; Zhu et al. 2011) and supports the idea that the useful plants of the Chilean flora are not randomly distributed across taxonomic families. Instead, the useful plants of Chile tend to be concentrated in some taxonomic groups either when considering all uses or each use separately. It is probable that some botanical families have characteristics and properties that make them more likely to have species that are useful for a specific use category. For example, plant families with higher alkaloid content are more likely to have more medicinal species.

In our review, we found that the four main use categories were medicinal, fodder, ornamental, and edible, which constituted 70% of total uses. Here, we will focus our discussion on these main categories; additionally, we will also include timber use, due to its economic and conservation relevance.

Medicinal is the use category with the most species, with a similar percentage to that found for floras in other North and South American countries, such as Argentina (14%; Barboza 2009), Mexico (7%; Caballero et al. 1998), Colombia (10–14%; Fonnegra and Jiménez 2007), Ecuador (≈ 18%; De la Torre et al. 2008), and the USA (13%; Moerman 1998). According to our review in the WOS database (i.e., for scientific journals), more than 60% of Chile's plant species with medicinal uses have yet to be bioprospected. Thus, there is immense potential to continue research of promising leads from natural products.

In our analysis, we found that Lamiaceae, Linaceae, Proteaceae, Cunoniaceae, Rhamnaceae, Rosaceae, and Myrtaceae are overrepresented among medicinal species. Lamiaceae are usually herbaceous species, rich in essential oils, and other secondary compounds with organoleptic and medicinal properties. These characteristics have often been associated with medicinal plants (Ramasubramania Raja 2012). This family is also overrepresented in other medicinal floras (Lagoudakisa et al. 2011; Moerman et al. 1999; Thomas et al. 2011). Similarly, Myrtaceae are often rich in essential oils, which may have antimicrobial effects (Stefanello et al. 2011). Cunoniaceae and Rosaceae, rich in tannins, may have a wide range of pharmacological effects like antibacterial, antiviral, immunomodulation, and anti-inflammatory (Gurib-Fakim 2006; Macákova et al. 2014). Moreover, cyanogenic glycosides and tannins are prevalent in Rosaceae (Gurib-Fakim 2006) and Linaceae (Vetter 2000). In species belonging to the Proteaceae family, research has found that metabolites of the naphthoquinones type have antibacterial and cytotoxic properties and have been used as pulmonary bronchodilators and antitussives (Erazo et al. 1997). Rhamnaceae species are widely used in traditional medicine to reduce inflammation, fever, and convulsions; to relieve pain; and for the treatment of viral infections (Alarcón and Céspedes 2015; Kundu et al. 1989; Lee et al. 2003). In the Chilean Rhamnaceae, alkaloids and penta-cyclic triterpenes, responsible for its biological activity, have been isolated (Alarcón and Céspedes 2015). Unsurprisingly, the families with the greatest number of Chilean medicinal species, such as Asteraceae, Fabaceae, and Solanaceae, are among the families with the higher number of approved drugs in the world (Zhu et al. 2011). However, none of the overrepresented families recorded in our review are among the most important families in terms of drug discovery (Zhu et al. 2011). Thus, it would be interesting to further investigate these families for biologically active compounds.

TABLE 3. FAMILIES WITH THE HIGHER NUMBER OF SPECIES AND OVERREPRESENTED FAMILIES FOR EACH USE CATEGORY.

Use category	Species	Genera	Families	Families with the higher number of species (top 5)	The number of useful species per family	Overrepresented families
All uses	995	462	137	Asteraceae	155	Grossulariaceae
				Poaceae	89	Myrtaceae
				Fabaceae	55	Lamiaceae
				Solanaceae	46	Nothofagaceae
				Apiaceae	27	Salicaceae
						Rosaceae
						Bromeliaceae
Medicinal	501	289	114	Asteraceae	113	Lamiaceae
				Fabaceae	26	Linaceae
				Solanaceae	18	Proteaceae
				Lamiaceae	16	Cunoniaceae
				Apiaceae	15	Rhamnaceae
						Rosaceae
						Myrtaceae
Edible	228	142	72	Cactaceae	19	Grossulariaceae
				Asteraceae	18	Ericaceae
				Apiaceae	14	Myrtaceae
				Fabaceae	13	Cactaceae
				Grossulariaceae	9	Anacardiaceae
						Bromeliaceae
						Berberidaceae
Fodder	341	178	59	Poaceae	76	Poaceae
				Asteraceae	66	
				Fabaceae	29	
				Solanaceae	27	
				Cyperaceae	14	
Ornamental	300	188	91	Asteraceae	19	Salicaceae
				Fabaceae	13	Nothofagaceae
				Poaceae	12	Proteaceae
				Solanaceae	12	Myrtaceae
				Myrtaceae	11	Lycopodiaceae
						Lauraceae
						Escalloniaceae
						Elaeocarpaceae
						Monimiaceae
						Gesneriaceae
						Berberidaceae
						Anacardiaceae
						Cunoniaceae
						Dicksoniaceae
Dye	102	80	47	Asteraceae	14	Proteaceae
				Fabaceae	8	Cunoniaceae
				Solanaceae	6	Loranthaceae
				Proteaceae	4	Zygophyllaceae
				Berberidaceae	4	Anacardiaceae
						Berberidaceae
						Krameriaceae
						Araliaceae
						Nothofagaceae
Rituals	89	72	53	Asteraceae	10	Philesiaceae

TABLE 3. (CONTINUED).

Use category	Species	Genera	Families	Families with the higher number of species (top 5)	The number of useful species per family	Overrepresented families
				Solanaceae	9	Araliaceae
				Hymenophyllaceae	4	
				Ericaceae	3	
				Apiaceae	3	
Timber	75	57	32	Fabaceae	10	Nothofagaceae
				Nothofagaceae	8	Podocarpaceae
				Myrtaceae	6	Proteaceae
				Podocarpaceae	4	Cupressaceae
				Proteaceae	4	Cunoniaceae
						Lauraceae
						Myrtaceae
Fiber	51	36	19	Cyperaceae	14	Juncaceae
				Poaceae	7	Lardizabalaceae
				Juncaceae	6	Cyperaceae
				Bromeliaceae	4	Luzuriagaceae
				Asteraceae	3	Bromeliaceae

The edible species represent about 5% of the Chilean flora, a percentage similar to the one found in other countries such as Spain (5.9%; Tardío et al. 2006), Slovakia (3%; Łuczaj 2012), Ethiopia (6.8%; Lulekal et al. 2011), and Ecuador (9.2%; Vanden Eynden and Cueva 2008). We found that the Grossulariaceae, Ericaceae, Myrtaceae, Cactaceae, Anacardiaceae, Bromeliaceae, and Berberidaceae are overrepresented among edible plants. These families hold species with fleshy fruits. Species of these families (with the exception of Cactaceae) are widely distributed in central–south Chile, overlapping the area where the Mapuche culture developed. This original culture has broad traditional ecological knowledge of edible native plants from these ecosystems (see De Mösbach 1992 as well as Meza and Villagrán 1991).

Most species classified as being used as fodder in our review come from ethnobotanical studies in the Altiplano, north Chilean Andes (Villagrán and Castro 2004), where local communities developed an agro-pastoral economy, with emphasis on sheep and domesticated camelid stockbreeding (Abbasi et al. 2013). Many of the species identified as cattle fodder are consumed in vast amounts, as a result of extensive grazing, for example in transhumance traditionally practiced in north and central Chile (Bahre 1979). However, most of these species have not been evaluated as fodder species, and they are not even cultivated for this purpose.

We found that Poaceae is overrepresented among fodder plants. Poaceae are herbaceous with few toxic compounds, which make them ideal candidates for fodder plants.

In the case of ornamental species, among the overrepresented ornamental families, Proteaceae, Lauraceae, Myrtaceae, Cunoniaceae, Monimiaceae, Lycopodiaceae, and Dicksoniaceae have attractive foliage and are used as greenery products. Salicaceae, Nothofagaceae, Myrtaceae, Anacardiaceae, Escalloniaceae, Elaeocarpaceae, and Berberidaceae are important ornamental trees and shrubs in Chile and other parts of the world due to their beauty and rapid growth (Hoffmann 1998; Montenegro and Timmermann 2000; Teiller 2008).

The use of native woods began to decrease in the 1960s with the expansion of commercial forestry plantation, mostly in *Pinus radiata* D. Don and later *Eucalyptus globulus* Labill (Armesto et al. 2010). To date, plantations of native species for forestry purposes are scarce. Nevertheless, until today in rural areas, high-productivity native renewal forests are still very important materials for house construction and manufacturing handicrafts (Catalán et al. 2006). Nothofagaceae, Podocarpaceae, Proteaceae, Cupressaceae, Cunoniaceae, Lauraceae, and Myrtaceae are overrepresented among the species used for timber. Indeed, most of the native forests of Chile are dominated by *Nothofagus* species (Ramírez 1987). Hence, these species have traditionally been used by local communities as an important natural resource and attract great interest in forestry, mainly due to their higher growth rates and the value of their wood (Avilés and Henle 1994). In particular for raulí (*Nothofagus alpina* [Poepp. & Endl.] Oerst), a large number of studies have been conducted to investigate the management of renewals and establishment of plantations under pure and mixed conditions (Donoso and Soto 2010). Cupressaceae and Podocarpaceae are among the native conifers. Podocarpaceae holds the higher number of species (five species; Marticorena 1990), and timber from Cupressaceae species is one of the most durable woods, which is easily worked and very valuable. For the Myrtaceae family, their tree timber species are characterized as being very hard and are frequently used for the construction of beams, posts, and tool handles. Finally, Chilean Proteaceae, Cunoniaceae, and Lauraceae timber is soft, light, and of great value, widely used in construction and for internal uses such as decoration and furniture and for manufacturing some musical instruments. Among the Proteaceae, the most important is *Gevuina avellana* Molina, of which there are multipurpose plantations (mixed production of fruits, leaves, honey, and wood). Although this species has been scarcely studied, there are some experimental essays that highlight its productive potential (Donoso and Soto 2010). The Proteaceae family appears overrepresented in our review for many types of use, emphasizing the multiple purposes and huge value of its six native species in Chile.

Conclusions

Plant families in Chile with greater species richness are more likely to have a higher number of useful plants. However, some families tend to be overrepresented and others underrepresented within the different use categories, suggesting that people's use of the flora in Chile follows a non-random taxonomic distribution pattern. This study showed that this taxonomic pattern, at the level of the families, could be found in many of the main use categories of its native flora.

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