Cultural Importance Indices: A Comparative Analysis Based on the Useful Wild Plants of Southern Cantabria (Northern Spain)[1]

Javier Tardío*[,2] and Manuel Pardo-de-Santayana[3]

[2]Instituto Madrileño de Investigación y Desarrollo Rural, Agrario y Alimentario, Apdo. 127, 28800, Alcalá de Henares, Madrid, Spain
[3]Departamento de Biología (Botánica), Universidad Autónoma de Madrid, c/ Darwin 2. Campus de Cantoblanco, 28049, Madrid, Spain
*Corresponding author; e-mail: javier.tardio@madrid.org

Cultural Importance Indices: A Comparative Analysis Based on the Useful Wild Plants of Southern Cantabria (Northern Spain). This paper compares four indices based on informant consensus. Each index aims to assess the cultural significance of plant species and is suitable for statistical testing of different hypotheses. For the comparison, we used data concerning plants traditionally used in the Campoo area of southern Cantabria in northern Spain. Our results show a positive and significant correlation between the number of uses (NU) and the frequency of citation (FC) of the species. It seems to be a general rule that the more versatile a plant, the more widespread its usefulness. In addition, NU is highly influenced by the number of use-categories in the study. Consequently, an objective index must rely on FC more than NU. We propose the use of the cultural importance index (CI), which is defined as the summation of the informants' proportions that mention each of the uses of the species. The CI index is highly correlated with FC and, although it also considers diversity of use, each use-category is conveniently weighted by the number of informants mentioning it. Despite the use of cultural significance indices being questioned, we believe that indices based on in-depth, semi-structured interviews are still very useful for compilation studies of passive knowledge, such as most ethnobotanical works conducted in the last three decades in Europe.

Key Words: Quantitative ethnobotany, cultural importance index, traditional knowledge, Spain.

Introduction

Since the first use of the term "quantitative ethnobotany," coined by Prance et al. (1987), there has been growing interest in improving the traditional compilation-style of ethnobotanical studies by incorporating quantitative research methods in data collection, processing, and interpretation of results (Höft et al. 1999). One key issue relating to these studies is the relative importance of plant taxa to different human groups by elaborating indices of cultural significance or use values for plants.

There have been different approaches regarding measurement (Hoffman and Gallaher 2007). Some authors have developed indices based on the researcher's subjective allocation of the importance of each use. Turner (1988) defined the cultural significance index (CSI) as the sum of different values obtained for each use of a plant. These values were obtained by a product of different figures estimated for "quality of use," "intensity of use," and "exclusivity of use" for each species. Other authors have followed the same system with some modifications. Stoffle et al. (1990) added a variable to measure present use. Pieroni (2001) created a specific cultural food significance index (CFSI) for wild food plants. Besides frequency of use, it takes into account other variables such as frequency of quotation of the species, availability,

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the part of the plant used, multifunctional food use, taste score appreciation index, and its medicinal use. Silva et al. (2006) proposed a new way of calculating the CSI by simplifying the alternatives for each variable and adding a term that measures the degree of consensus among informants. Recently, a slightly altered CFSI has been utilized by Garibay-Orijel et al. (2007) for evaluating edible mushrooms in Mexico. Nevertheless, even the latter indices are influenced in some way by research value judgments. They have to be calculated with parameters, such as frequency of use, quality of use, plant availability, and taste, all of which must be obtained through specific interviews or subjective estimations.

However, the most popular indices are based on "informant consensus," i.e., the degree of agreement among the various interviewees (Albuquerque et al. 2006). They are founded on the reasonable assumption that the greater the salience of a given plant or use in the community, the more likely it is to be mentioned. Phillips (1996) pointed out that these procedures tend to be more objective as they are designed to reduce researcher bias in attributing relative importance. One of the simplest and most widely employed indices is the frequency of citation (or frequency of quotation), i.e., the number of informants that mention a useful species. Adu-Tutu et al. (1979) used this index to evaluate the relative importance of the different species used as a chewing stick in Ghana. Some authors utilize the frequency of citation for the species as useful (Bonet and Vallès 2002; Ladio and Lozada 2001; Lozada et al. 2006). For others, the frequency of citation specifically refers to each plant-use considered (Bonet et al. 1992; Bonet and Vallès 2003; Camejo-Rodrigues et al. 2003; Pardo-de-Santayana et al. 2005; Pieroni et al. 2005; Tardío et al. 2005). The latter value, which is also called "number of use-reports," is widely used by authors who followed the Informant Consensus Factor (Canales et al. 2005; Case et al. 2006; Kufer et al. 2005; Monteiro et al. 2006) defined by Heinrich et al. (1998). This factor is based on a previous ratio created by Trotter and Logan (1986) for assessing the importance of medicinal plants used for certain ailments. Recently, Moerman (2007) used a similar analysis for the medicinal flora used by native peoples of North America, providing a critical perspective on this "informant consensus analysis" for the detection of medicinal plants with pharmacologically active products. He demonstrates with several examples that, due to the placebo effect, many plants with low indices of global consensus can heal by their meaning to the particular cultural group.

In contrast, other researchers have developed indices of relative importance based only on the diversity of plant uses, independent of informant consensus. Prance et al. (1987) constructed their use value index as a sum of uses for every species, using a value of 1 for major uses and 0.5 for minor uses. More recently, following the same system, Bennett and Prance (2000) defined the relative importance index for a medicinal plant as a mean between the number of pharmacological properties and the number of body systems it affects.

In order to obtain a more objective index, Phillips and Gentry (1993a) modified the index of Prance et al. (1987) by including the number of informants citing a given plant-use. Their use-value (UV) index for species "s" is defined by the following formula (simplified by Rossato et al. 1999 and Albuquerque et al. 2006).

$$\mathrm{UV_s} = \sum U_i/N \qquad (1)$$

where U_i is the number of different uses mentioned by each informant i and N is the total number of informants interviewed in the survey. In their original formulation, Phillips and Gentry (1993a) also considered the number of times that each informant referred to a given species and the denominator was N_s, i.e., the total number of informants interviewed for species "*s*."

On the basis of the abovementioned index of Bennet and Prance, Pardo-de-Santayana (2003a) developed a relative importance index (RI), also used by San Miguel (2004) and Carvalho (2005), which takes into account both the number of informants who mention the useful species and the different uses for it. This index is the mean value of the relative frequency of citation ($\mathrm{RFC_{max}}$) and the relative number of uses of the species. This relative number of uses is calculated as well as a mean of the relative number of use-categories ($\mathrm{RNU_{max}}$) and the relative number of subcategories ($\mathrm{RNUSub_{max}}$) in which the species is classified. All these relative numbers were calculated by dividing each figure by the maximum value of each addend.

Recently, Reyes-García et al. (2006) proposed using an integrated index called "total value" to estimate the significance of plant species for humans. This is the sum of three values obtained along three different dimensions: "cultural value" that was obtained with free-listing interviews, "practical value," with observational data, and "economic value," taking into account the price (real or estimated) of the ethnospecies. This "cultural value" multiplicative index takes into consideration frequency of citation and versatility of the species and its formula is explained in the Material and Methods section of this study.

The existence of several indices based on "cultural consensus" and the need to evaluate the cultural importance of the different species in our ethnobotanical studies led us to conduct a comparative analysis to choose the most suitable index. As we were not totally convinced with any of the existing indices, we constructed the cultural importance index (CI), which could be regarded as a simplification of the cultural value of Reyes-García et al. (2006) and eventually as a redefinition of the Phillips and Gentry's use-value (Phillips and Gentry 1993a). This paper aims to present and evaluate this index and to compare it with other indices, discussing their advantages and disadvantages. To do so, we rely on the information about wild plants traditionally used in the Campoo area of northern Spain, the result of a research project for compiling the useful plants in this area (Pardo-de-Santayana 2003a).

Material and Methods

Survey Area

The Campoo region, which is in the south of northern Spain's Cantabria Province, is on the border between the Mediterranean and Eurosiberian floristic regions (Fig. 1). It covers 1,000 km^2 at an average altitude of 800 m on the southern slopes of the Cantabrian Range. Cuchillón peak reaches 2,222 m. Although the climate over most of the Cantabria region is oceanic, some drier areas in the Campoo have a summer dry period lasting up to 2 months. Mean annual rainfall in the study area is about 1,000 mm, ranging from 1,900 mm on the highest peaks to 767 mm in the drier southern areas. The landscape includes a mosaic of meadows, forests, moorland, rivers, and high mountain vegetation growing on varied geological materials and soils. Several types of oak forests predominate. *Quercus pyrenaica* covers most of the area although it is more dominant to the south. *Q. robur* and *Q. petraea*

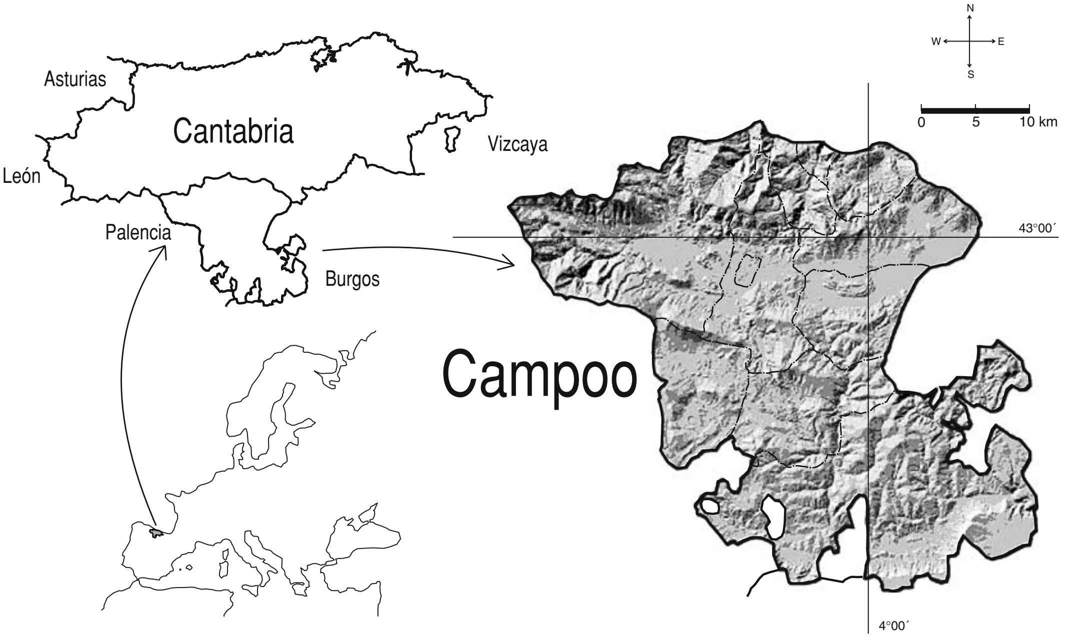

Fig. 1. Study area location.

are more common in the central and northern areas whereas *Q. faginea* and *Q. ilex* are established in the warmer parts. In addition, *Fagus sylvatica* or *Betula alba* forests are common in the moister areas.

This region includes Saja-Besaya Natural Park, as well as other proposed protected areas, such as the Ebro Reservoir, River Ebro Canyon, and the Hijedo Forest.

The population of the area is around 23,000, half of which live in the town of Reinosa. Until 1970, the Campoo economy was based on agriculture, cattle breeding, and a number of minor activities. While the household economy was largely subsistence-based, additional income was derived from the sale of animals, eggs, butter, and handicrafts. Low salaries meant that even people working in factories combined wage labor with cattle raising. Many wild plants were gathered for a range of different purposes. They were used to meet material needs such as food, fodder, health, firewood, and construction materials. They also were used in religious celebrations, as ornamentals, and for other symbolic aspects of culture. A profound transformation of the economy has occurred since 1970s. Mechanization and intensification of agricultural practices and the transition to a market economy has led to basic economic, social, and environmental changes. Fields of cereals and grains (for bread), pulse crops, and potatoes have been replaced by cattle pasture and many harvesting practices have been abandoned.

Ethnobotanical Methodology

An ethnobotanical survey was conducted in the Campoo area between 1997 and 2000 (Pardo-de-Santayana 2003a) to compile the knowledge of plants that were employed in the area in the last century. Information was obtained through 117 semi-structured, in-depth interviews of 107 people (age range of 35–93 years, mean age 68 years). Open questions were asked about the plants used in the area. Similar questions were posed to every informant in order to compile the full knowledge of each informant in the different contexts of plant use (e.g., health, food). Key informants with a sound traditional knowledge of useful wild plants were sought—mostly elderly people who had lived and worked in the region for many years. Interviews were conducted in informants' homes, a familiar and spontaneous setting. When possible, walks in the countryside were organized to collect plant specimens and to complete the list of plant uses known by the informant. Open questions were asked about the plants used or managed in the past and nowadays. Notes on these conversations were recorded in a notebook, though most interviews were taped and subsequently transcribed. Voucher specimens were deposited at the herbarium of the Royal Botanical Garden of Madrid, CSIC (MA).

With regard to plant identification, we sought to relate folk names and scientific botanical names of the species. Although we identified all the plant species, and most of them presented a one-to-one correspondence, in cases of under-differentiation, we used the botanical genus. For instance, *Equisetum* sp. pl. (*species pluribus*) refers to *Equisetum arvense* L. and *E. telmateia* L., since both can be included in the same folk species. In the case of "robles" referring to deciduous oaks, there were differences among informants (Pardo-de-Santayana 2003b). Some people considered them as a unique folk species (*Quercus* sp. pl.), whereas others differentiated among the various botanical species. Botanical species names were assigned only in the latter cases.

Although a more detailed classification based on informants' categories was used in the original work, for this study, data were grouped into 10 broad categories (see Table 1) that as far as possible reflect emic categories. The category of "medicinal" includes plants used for both human and animal diseases. "Technology and craft" covers plants used for making objects (e.g., basketry,

Table 1. Number of use-reports (UR) and percentage of use categories.

Categories (Codes)	Number of UR	Percentage
Medicinal (MED)	505	21
Human food (HF)	432	18
Animal food (AF)	431	18
Technology and craft (TECH)	341	14
Weeds (WEE)	178	7
Firewood (FW)	162	7
Symbolic uses (SYM)	137	6
Ornamental (ORN)	79	3
Toxic (TOX)	59	2
Others (OTH)	50	2
Total	2374	100

wood for tools or construction), dye and aromatic plants, and plants used for hunting birds. "Symbolic uses" include plants used in festivities, rituals, religious events, and children's games. Toxic plants consist of those considered inedible for humans and animals as well as ichthyotoxic plants. Finally, the category "Others" covers species for smoking, hedges, and as rootstocks.

Data Analysis

All the ethnobotanical indices are founded on the basic structure of the ethnobotanical information: "informant i mentions the use of the species s in the use-category u." The event resulting from the combination of these three variables has been defined as a use-report (UR; Kufer et al. 2005). In a particular survey that yields NS species (s_1, s_2,..., s_{NS}), with a total number of use-categories NC (u_1, u_2,..., u_{NC}) and N informants (i_1, i_2,..., i_N), UR_{sui} can reach the value of 1 when a combination exists or 0 when this combination is not mentioned. These ethnobotanical data can be grouped in different manners fixing one or two of the variables. For studying the cultural importance of plants, one of the most commonly used tools is the total number of use-reports (UR) for each species, i.e., fixing the variable *s*. This can be mathematically expressed as

$$UR_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui}. \qquad (2)$$

First, we sum the UR of all the informants (from i_1 to i_N) within each use-category for that species (s); i.e., the number of informants who mention each use-category for the species. Second, we sum all the UR of each use-category (from u_1 to u_{NC}).

In this paper, we have compared the importance of each species using the following four indices: relative frequency of citation (RFC), relative importance index (RI), cultural value index (CV), and cultural importance index (CI).

Relative Frequency of Citation (RFC)

This index, which does not consider the variable *u* (use-category), is obtained by dividing the number of informants who mention the use of the species, also known as frequency of citation (FC), by the number of informants participating in the survey (N). Using the same terminology, the numerator can be seen as the summation of the UR of all the informants interviewed for the species without considering the use-category.

$$RFC_s = \frac{FC_s}{N} = \frac{\sum_{i=i_1}^{i_N} UR_i}{N} \qquad (3)$$

For example, *Acer campestre* was reported as useful by 9 out of 107 informants; hence, $RFC_{Acer\ campestre} = 9/107 = 0.08$. This index theoretically varies from 0, when nobody refers to the plant as useful, to 1 in the unlikely case that all the informants would mention the use of the species.

Relative Importance Index (RI)

Created by Pardo-de-Santayana (2003a), this index takes into account only the use-categories—not the subcategories—using the following formula.

$$RI_s = \frac{RFC_{s(max)} + RNU_{s(max)}}{2} \qquad (4)$$

where $RFC_{s(max)}$ is the relative frequency of citation over the maximum, i.e., it is obtained by dividing FC_s by the maximum value in all the species of the survey $[RFC_{s(max)} = FC_s/\max(FC)]$, and $RNU_{s(max)}$ is the relative number of use-categories over the maximum, obtained dividing the number of uses of the species $\left(NU_s = \sum_{u=u_1}^{u=u_{NC}} UR_u\right)$ by the maximum value in all the species of the survey $[RN_{s(max)} = NU_s/\max(NU)]$.

In the former example, *Acer campestre* was mentioned as useful by 9 informants while the maximum number of informants citing any species was 42 (*Quercus* sp. pl.). It was employed in four different use-categories (technology and craft, animal food, firewood, and symbolic uses). The maximum number of use-categories mentioned for a species in the survey was nine (*Crataegus monogyna*). Subsequently, $RI_{Acer\ campestre} = [9/42 + 4/9]/2 = 0.33$. The RI index theoretically varies from 0, when nobody mentions any use of the plant, to 1 in the case where the plant was the most frequently mentioned as useful and in the maximum number of use-categories.

Cultural Value Index (CV)

This index, developed by Reyes-García et al. (2006), is calculated using the following formula.

$$CV_s = \left[NU_s/NC\right] \times \left[FC_s/N\right] \times \left[\sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui}/N\right] \quad (5)$$

where the first factor is the relationship between the number of different uses reported for the species ("ethnospecies" in the original work) and the total number of use-categories considered in the study (NU_s divided by NC). The second factor is the relative frequency of citation of the species (previously defined). Finally, the third factor is the sum of all the UR for the species (defined at the beginning of this section), i.e., the sum of number of participants who mentioned each use of the species, divided by N. These three factors are then multiplied together.

In our example, as pointed out before, *Acer campestre* was employed in four out of ten different use-categories considered (4/10). It was mentioned as useful by 9 out of 107 informants interviewed (9/107). Finally, seven informants reported this species as used in the category of technology and craft, three used the species as animal food, two as firewood, and one reported using the species for symbolic uses, while the total number of participants in the survey was 107. Hence, $CV_{\text{Acer campestre}} = [4/10] \times [9/107] \times [7/107 + 3/107 + 2/107 + 1/107] = 0.00409$. The theoretical maximum value would be reached when all the factors reached their maximum; in the unlikely case that all the informants would mention the use of the species (FC_s=N) in all the use-categories considered in the survey (NU_s=NC), the first two factors would be equal to 1 and, as will be explained in the following index, the third factor would be the total number of different use-categories (NC). Therefore, this index varies as well from 0 to NC.

Cultural Importance Index (CI)

The cultural importance index (CI) is defined by the following formula.

$$CI_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui}/N \quad (6)$$

This index, the third factor of the previously defined CV index, also can be seen as the sum of the proportion of informants that mention each species use. As explained in our example of *Acer campestre* for the previous index, $CI_{\text{Acer campestre}} = 7/107 + 3/107 + 2/107 + 1/107 = 0.065 + 0.028 + 0.019 + 0.009 = 0.121$. This additive index takes into account not only the spread of the use (number of informants) for each species, but also its versatility, i.e., the diversity of its uses. The theoretical maximum value of the index is the total number of different use-categories (NC), reached in the unlikely case that all the informants would mention the use of the species in all the use-categories considered in the survey, i.e., ten in our study. In the case of species with only one use, this index would be equal to RFC.

Another important property of the CI index is that each addend is a measure of the relative importance of each plant use. In the aforementioned example, it can be seen that the most important use of *Acer campestre* is in the use-category of technology and craft as it was cited by 6.5% of the informants, followed by its use for animal food (2.8%), for firewood (1.9%), and for symbolic uses (0.9%).

It is worth noting that the total figure of the CI index is identical to the simplified formula for the UV index, although both indices are defined in different ways. Following the same notation we have previously used, the UV index can be defined by the following formula.

$$UV_s = \sum_{i=i_1}^{i_N} \sum_{u=u_1}^{u_{NC}} UR_{iu}/N \quad (7)$$

where it can be seen that we are summing the same data (UR_s), but grouping them in a different manner. In the case of CI index, we first sum the

UR grouping by uses (the sum of the informants who cited each given use) and then we sum all these UR. However, in the case of the UV index, we first sum the UR grouping by informants (the sum of the uses cited by each informant) and then we sum all these data. Obviously, they yield the same result because we are adding the same events (UR_s). For example, *Acer campestre* was described as useful by nine informants, but the sum of UR is 13, being the informants who mentioned each use-category 7+3+2+1. The same result is obtained by summing the UR grouping by informants (3+4+6), since one informant cited three uses (three uses), two mentioned two (four uses), and six mentioned one (six uses). Finally, the denominator of the UV formula also could be the same if we consider that all the participants in the survey have been interviewed for all the species, as it is in the simplified formula of UV (Eqs. 1 and 7).

Like other authors (Albuquerque et al. 2006; Estomba et al. 2006; Monteiro et al. 2006), we used the Spearman correlation coefficient to compare the various indices since all the variables considered are not distributed normally. However, when the Pearson correlation coefficient is used, the results are exactly the same, presenting very similar figures.

Results and Discussion

Table 2 shows the contribution of each use-category to the total cultural importance index (CI) of the 25 most relevant and useful species in the Campoo area. The folk species of *Quercus* sp. pl. ("robles" in Spanish), which includes all the citations (FC=42) that could not be assigned to a certain botanical species, is the most culturally significant according to the CI index. It has a CI index value of 0.60, which would as high as 0.88 if we included the 41 citations (57 use-reports) that clearly were assigned by the informants to the species: *Quercus pyrenaica* (22 citations, 28 use-reports), *Q. petraea* (10, 14), *Q. faginea* (5, 9) and *Q. robur* (4, 6), all of which also were called "robles." As Table 2 indicates, the timber of these oak species is mainly used for technology and craft, (CI_{TECH}=0.20) or as firewood (CI_{FW}=0.11) and their leaves and acorns for animal feed (CI_{AF}=0.20). Other minor uses were also mentioned. As pointed out in the description of the survey area, they are the dominant species in the landscape, especially *Q. pyrenaica*.

The second species in the ranking is *Crataegus monogyna* (CI=0.52). As the figures for CI index components in Table 2 indicate, its use was cited by several informants in nine out of the ten categories. The most important is human consumption of the fruit (CI_{HF}=0.16), followed by tool making (CI_{TECH}=0.09), leaves and fruit as animal food (CI_{AF}=0.07), and as a rootstock for grafting fruit trees (CI_{OTH}=0.07).

In the case of ties, the species quoted by a greater number of informants (higher FC) has been assigned the first position in the ranking. That is the case of *Corylus avellana*, *Sambucus nigra*, and *Ulmus minor*, all with 48 use-reports and hence the same CI index value (0.45); however, they were mentioned by 37, 36, and 30 informants, respectively.

Interestingly, the 25 species with the highest CI index value include ten trees, five shrubs, and ten herbs, the first seven taxa being trees, as shown in Table 2. The differences among the mean CI index value of trees, shrubs, and herbs have been tested by pairs with the non-parametric test of Mann–Witney ($p<0.05$). The mean CI index value for trees (0.18±0.03) is significantly higher than that for shrubs (0.10±0.03; $p=0.03$) and herbs (0.06±0.02; $p=0.00$). Nevertheless, the mean CI index value for shrubs is not significantly higher than the one for herbs ($p=0.06$) at the same level of significance. Although not completely accepted for all the use-categories and regions (Albuquerque and Lucena 2005; Stepp and Moerman 2001), the salience and usefulness of trees and shrubs over that of herbaceous plants has been noted frequently (e.g., Berlin 1992; Moerman 1994). According to Moerman (1994), a tree, with a high number of distinct parts (wood, bark, leaves, fruits, seeds, roots, etc.) is more likely to be a medicinal plant than herbaceous plants. In our opinion, this rationale can be extrapolated to the overall uses of a plant. More complex plants, such as trees and shrubs, are more likely to be useful plants (sometimes with several uses) than herbaceous plants. Our group found similar results in a historical and literary study of the plants mentioned in the complete works of Cervantes (Pardo-de-Santayana et al. 2006).

Comparing Different Indices

Table 3 shows a comparison with the other three indices described in the "Material and

TABLE 2. CULTURAL IMPORTANCE INDEX (CI) OF THE 25 MOST RELEVANT SPECIES OF THE CAMPOO AREA, WITH THE CI COMPONENT OF EACH USE-CATEGORY.

Species	AF	HF	MED	TECH	FW	ORN	SYM	TOX	WEE	OTH	Total CI
Quercus sp. pl.	0.20	0.01	0.04	0.20	0.11			0.01		0.04	0.60
Crataegus monogyna Jacq.	0.07	0.16	0.03	0.09	0.02	0.03	0.04	0.03		0.07	0.52
Fagus sylvatica L.	0.05	0.06	0.01	0.17	0.14		0.01	0.05		0.03	0.50
Ilex aquifolium L.	0.19		0.01	0.13	0.05	0.02	0.07	0.01			0.47
Corylus avellana L.	0.07	0.12	0.04	0.19	0.02		0.01	0.01			0.45
Sambucus nigra L.		0.07	0.27	0.08			0.03				0.45
Ulmus minor Mill.	0.24			0.15	0.05		0.01				0.45
Origanum vulgare L.		0.19	0.23								0.42
Rubus ulmifolius Schott	0.05	0.21	0.07	0.05	0.01		0.01		0.02	0.01	0.42
Urtica dioica L.	0.09	0.03	0.22	0.02				0.01	0.04		0.41
Rosa sp. pl.	0.07	0.21	0.09	0.03							0.40
Prunus spinosa L.	0.04	0.23	0.05	0.04					0.01	0.03	0.39
Fraxinus excelsior L.	0.12		0.03	0.16		0.01	0.07				0.39
Pteridium aquilinum (L.) Kuhn	0.02			0.09	0.14		0.02	0.03		0.08	0.38
Rumex acetosa L.		0.33					0.02		0.01		0.36
Populus nigra L.	0.17			0.10	0.03		0.05	0.01			0.36
Chamaemelum nobile (L.) All		0.06	0.24	0.01			0.01				0.32
Salix sp. pl.	0.03		0.02	0.16	0.06		0.04			0.02	0.32
Asphodelus albus Mill.	0.20		0.02		0.03				0.06		0.30
Ulex gallii Planch.	0.07				0.13		0.01		0.02	0.04	0.27
Genista florida L.	0.04			0.07	0.12	0.01	0.03				0.27
Carduncellus mitissimus (L.) DC.	0.02		0.24								0.26
Malva sylvestris L.		0.02	0.22				0.01		0.01		0.26
Equisetum sp.pl.	0.02		0.18						0.07		0.26
Quercus pyrenaica Willd.	0.07			0.11	0.07		0.01				0.26

AF Animal food, *HF* human food, *MED* medicinal, *TECH* technology and craft, *FW* firewood, *ORN* ornamental, *SYM* symbolic uses, *TOX* toxic, *WEE* weeds, *OTH* others.

Methods" section, indicating species ranking based on each index and the three basic values of the study, i.e., frequency of citation (FC), number of use-reports (UR) and number of uses (NU) for each species. As mentioned, except for FC, which only considers the spread of knowledge of useful plants (number of people that mention them as useful), the other indices also take into account multiplicity of use (number of use-categories mentioned for a species).

There are appreciable differences in species ranking yielded by the various indices set out in Table 3. Although the first two species are the same in all of them, the order varies depending on the chosen index. The RI and CV indices place *Crataegus monogyna* in first position because these two indices assign greater importance to the multiplicity of uses and the species was mentioned in a higher number of use-categories (NU=9). In our opinion, *Quercus* sp. pl. logically should be considered the most important as they predominate in the landscape and are mentioned by a higher number of informants.

Table 3 also indicates that whereas *Fagus sylvatica* is in twelfth position when only number of informants is considered, i.e., the FC index, it rises to the third position when diversity of uses is taken into account with the CI index (or the CV index) and to the 6th on the basis of the RI index.

TABLE 3. EVALUATION OF USEFUL PLANTS OF THE CAMPOO AREA, USING FOUR QUANTITATIVE INDICES. LIST OF THE FIRST 20 SPECIES FOLLOWING THE CI INDEX AND PLANT RANKING, BASED ON EACH INDEX.

	Basic values			Indices				Ranking			
Species	FC	UR	NU	CI	RFC	RI	CV	CI	RFC	RI	CV
Quercus sp. pl.	42	64	7	0.60	0.39	0.89	1.64E−01	1	1	2	2
Crataegus monogyna Jacq.	38	56	9	0.52	0.36	0.95	1.67E−01	2	2	1	1
Fagus sylvatica L.	31	54	8	0.50	0.29	0.81	1.17E−01	3	12	6	3
Ilex aquifolium L.	36	50	7	0.47	0.34	0.82	1.10E−01	4	4	5	4
Corylus avellana L.	37	48	7	0.45	0.35	0.83	1.09E−01	5	3	4	5
Sambucus nigra L.	36	48	4	0.45	0.34	0.65	6.04E−02	6	5	10	9
Ulmus minor Mill.	30	48	4	0.45	0.28	0.58	5.03E−02	7	14	16	11
Origanum vulgare L.	36	45	2	0.42	0.34	0.54	2.83E−02	8	6	19	18
Rubus ulmifolius Schott	33	45	8	0.42	0.31	0.84	1.04E−01	9	8	3	6
Urtica dioica L.	32	44	6	0.41	0.30	0.71	7.38E−02	10	9	7	7
Rosa sp. pl.	29	43	4	0.40	0.27	0.57	4.36E−02	11	15	17	14
Prunus spinosa L.	32	42	6	0.39	0.30	0.71	7.04E−02	12	10	8	8
Fraxinus excelsior L.	32	42	5	0.39	0.30	0.66	5.87E−02	13	11	9	10
Pteridium aquilinum (L.) Kuhn	23	41	6	0.38	0.21	0.61	4.94E−02	14	22	12	12
Rumex acetosa L.	36	38	3	0.36	0.34	0.60	3.58E−02	15	7	14	17
Populus nigra L.	28	38	5	0.36	0.26	0.61	4.65E−02	16	16	11	13
Chamaemelum nobile (L.) All	31	34	4	0.32	0.29	0.59	3.68E−02	17	13	15	16
Salix sp. pl.	23	34	6	0.32	0.21	0.61	4.10E−02	18	23	13	15
Asphodelus albus Mill.	25	32	4	0.30	0.23	0.52	2.80E−02	19	18	21	19
Ulex gallii Planch.	22	29	5	0.27	0.21	0.54	2.79E−02	20	25	18	20
Genista florida L.	19	29	5	0.27	0.18	0.50	2.41E−02	21	30	23	23
Carduncellus mitissimus (L.) DC.	26	28	2	0.26	0.24	0.42	1.27E−02	22	17	31	29
Malva sylvestris L.	25	28	4	0.26	0.23	0.52	2.45E−02	23	19	22	22
Equisetum sp. pl.	24	28	3	0.26	0.22	0.45	1.76E−02	24	21	28	26
Quercus pyrenaica Willd.	22	28	4	0.26	0.21	0.48	2.15E−02	25	26	25	24

CI=cultural importance, RFC=relative frequency of citation, RI=relative importance, CV=cultural value, FC=frequency of citation, UR=number of use-reports, NU=number of uses.

The same occurs to *Ulmus minor*, which changes from the fourteenth with the FC to the seventh position based on the CI index.

Some extensively used species, such as *Origanum vulgare* (mentioned by 36 informants) but with few uses (two, condiment and medicine), are underestimated when using the CV and RI indices, reaching the eighteenth and ninteenth positions, respectively, instead of the eighth (see Table 2) with the CI index.

Prunus spinosa is another example of excessive importance being assigned to diversity of uses as a result of the RI and CV indices. It ranks eight with both instead of thirteenth based on the CI index because, although six uses were mentioned for the species, some are not very widespread in the population with only few citations (see Table 2).

The CV index is obtained by multiplying the relative values of frequency of citation of the species (FC/N), number of uses (NU/NC), and number of use-reports (UR/N). In our opinion, this index gives excessive weight to diversity of use since UR measures both FC and NU and, being multiplicative, the effect is amplified. The RI index is the mean between the relative FC and the relative NU, but, as indicated below, the latter two are positively correlated; hence, it overweights the multiplicity of uses. However, although the CI index also considers diversity of use, each use-category is conveniently weighted by the number of informants who mentioned it. These uses only influence the final result when they are mentioned sufficiently, i.e., the uses are widespread in the population.

The descriptive statistics of the results obtained using the different indices and basic values are shown in Table 4. The RI index tended to overrate the species (mean=0.21, standard deviation=

Table 4. Descriptive statistics of the results obtained with four quantitative indices (N=268).

	Basic values			Indices			
	FC	UR	NU	CI	RFC	RI	CV
Mean	7.2	8.9	2.2	0.08	0.07	0.21	0.01
Minimum	1	1	1	0.01	0.01	0.07	8.73E–06
Maximum	42	64	9	0.60	0.39	0.95	0.17
Standard deviation	8.8	12.0	1.5	0.11	0.08	0.18	0.02
Percent variation	122	135	69	135	122	85	317

CI=cultural importance, RFC=relative frequency of citation, RI=relative importance, CV=cultural value, FC=frequency of citation, UR=number of use-reports, NU=number of uses.

0.18) in relation to other indices. The reason is that the relative frequency of citation and the relative number of use-categories are normalized by dividing by the maximum value, ranging from 0.07 to 0.95. On the contrary, the CV index assigned the lowest values (mean=0.01, standard deviation=0.02). Although the authors of this index (Reyes-García et al. 2006) defined it as we have calculated, they normalized it by dividing it by the mean. In that case, the CV index varies from 0.00 to 24.20 (mean=1, standard deviation=3.17).

Table 5 shows the Spearman correlations among all the variables. All the correlations are significant at $P<0.05$ ($n=268$), some being stronger than others. An interesting point that appears to corroborate these data is that the frequency of citation is not completely independent of use diversity. The correlation index between the FC and NU is quite high (0.73), meaning that a versatile species is more likely to be mentioned by a higher number of informants. This relationship also is shown in the scatter plot of Fig. 2.

Regarding differences among the indices, RI and CV have the highest correlations with the number of uses, and hence with the number of categories considered. The choice of categories is rather subjective and depends on the criterion of the researcher. The criterion can be more synthetic or more analytical by choosing a lower or higher number of use-categories, respectively. Therefore, it can be stated that indices that depend more on the number of informants who mentioned the usefulness of the species (such as FC) or, at least, on the number of use-reports (such as CI) are more objective than those influenced more by the number of use-categories.

Table 5 also shows that the CI and FC indices are highly correlated (0.99). It may appear that this close correlation is due to the large number of species whose use is included in only one use-category (121, 45.1%) since, in those cases, the FC and CI indices attain the same value. Nevertheless, this close correlation persists (0.98) if, in the analysis, only the 147 plants with two or more uses are considered. In addition, most (84%) useful plants in the Campoo area have few uses (three or less); only 16% of the species have more than three. However, among the 25 species with a higher CI index, only 4 have three uses or less (*Origanum vulgare*, *Rumex acetosa*, *Carduncellus mitissimus*, and *Equisetum* sp. pl., see Table 3). Similarly, using an index that does not consider the diversity of uses (FC), only six species with three uses or less appear among the 25 most important plants. They are the same aforementioned taxa, as well as *Gentiana lutea* and *Inula* sp. pl.

The latter analysis shows that, in general, the more versatile a plant the more widespread the knowledge of its usefulness, as is shown in Fig. 2. This fact means that although we would use an index that does not explicitly include the diversity of uses of the plant, like the FC, this variable is

Table 5. Spearman rank order correlations among all the variables: basic values and indices.

	UR	NU	RFC	CI	RI	CV
FC	0.99	0.73	1.00	0.99	0.94	0.98
UR		0.78	0.99	1.00	0.97	0.99
NU			0.73	0.78	0.90	0.84
RFC				0.99	0.94	0.98
CI					0.97	0.99
RI						0.99

All the correlations are significant at $P<0.05$ ($n=268$).

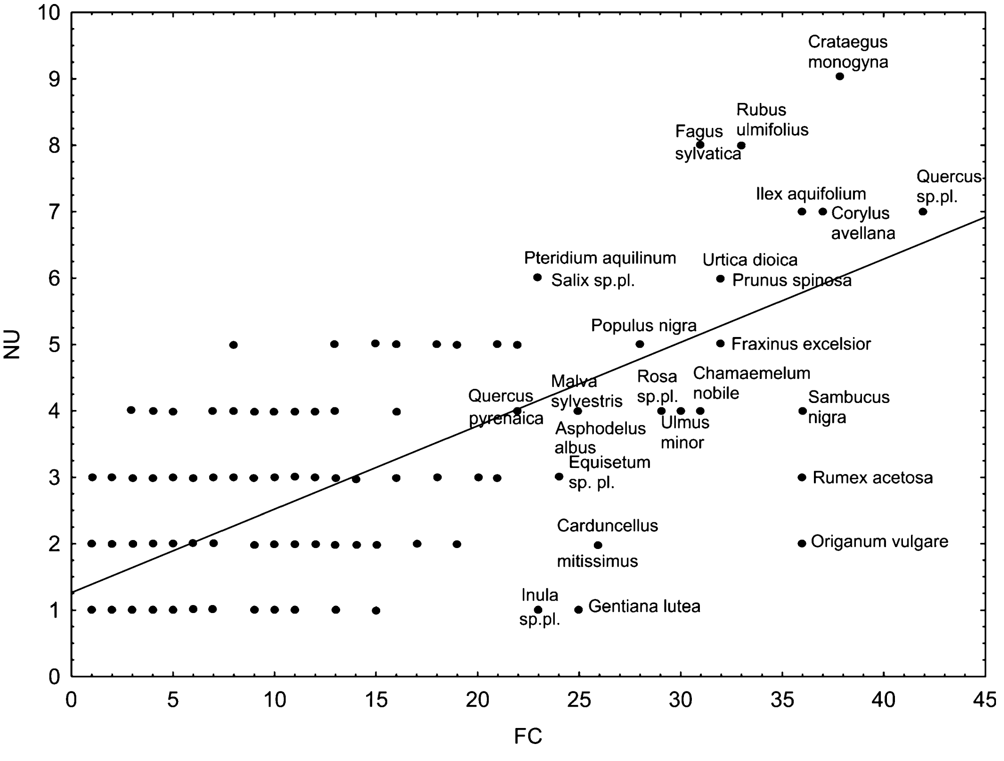

Fig. 2. Relationship between the number of use-categories for each species (NU) and frequency of citation (FC), i.e., the number of informants mentioning the species as useful. Each *dot* represents one species, but only the most important ones are labeled.

implicitly contained in the number of informants that mention the plant as useful. Nevertheless, if we want to increase the differentiation of plants by their multiplicity of uses, we highly recommend the use of the CI index because it is the most objective of the indices that include this variable. The number of informants that mentioned it weights each use and only the most cited will influence the final figure.

Finally, another important advantage of the CI index is that it is valid for comparing the botanical knowledge of different regions studied with a varying number of interviewees (Pardo-de-Santayana et al. 2007). This is because the CI index measure is independent of the number of informants, the denominator of the index. That is not the case of the RI index, which is relative to the maximum value of frequency of citation and the maximum value of use-categories and so is only valid for comparison with the useful plants in the same survey. The same reasons could be argued for the CV index when the authors normalized it by dividing it by the mean value in order to calculate their "total value" (Reyes-García et al. 2006).

Interest of Using a Cultural Importance Index

As stated in the Introduction, including quantitative methods in ethnobotany as a way of improving the traditional compilation-style has been commented upon repeatedly (e.g., Höft et al. 1999; Phillips 1996; Prance et al. 1987). Phillips and Gentry (1993a, b) demonstrated that several hypotheses could be tested statistically using their use-value index. Many other authors have followed the same technique, introducing minor modifications (Byg and Balslev 2001; Galeano 2000; Kristensen and Balslev 2003; Rossato et al. 1999). All the same advantages of using their indices in statistical analysis can be attributed to all the cultural significance indices employed in this paper.

Some authors have expressed misgivings regarding the interest of a cultural value index. Reyes-García et al. (2006) stated that the cultural value of a plant species, obtained through interviews using a free-list method, does not necessarily correspond to its practical value, using observational data. They found that some species frequently mentioned in interviews, are rarely used at present because they were exploited almost to extinction.

All of the aforementioned reasoning must be taken into account for studying present uses of plants (active uses). This kind of cultural significance index does not, in all cases, measure which plants people habitually use; rather, it measures knowledge about their use (passive knowledge). In addition, data obtained using in-depth, semi-structured interviews gather a greater proportion of informant knowledge than those involving free-list methods, which work better for present uses. That is the case of this survey and most of the ethnobotanical studies conducted recently in Europe (e.g., Carvalho 2005; Lastra 2003; Pieroni 1999; San Miguel 2004). Therefore, in our opinion, such indices based on the results of semi-structured interviews still can be very useful for studies whose general aim is to compile a record of passive knowledge rather than data on active plant use.

Furthermore, it has been stated that indices based on "cultural consensus" do not take into consideration relevant cultural aspects such as intensity, types, and multiplicity of uses; role in narratives, ceremonies, or in symbolism; naming and terminology in a language (Albuquerque et al. 2006; Garibaldi and Turner 2004). In our opinion, however, the cultural consensus methods based on citation frequency reflects most of these variables since, according to them, the most relevant plants will be the ones most often cited in comprehensive ethnobotanical surveys made with in-depth, semi-structured interviews. The case of *Gentiana lutea* in the Campoo area is an interesting example of a culturally important plant (26th and 20th in the ranking of CI and FC indices, respectively) that is not frequently used. Its rhizomes, which are chiefly used as an *apéritif* for children and for digestive disorders, can be preserved easily for long periods; most informants have or have had the plant at home.

Another important question regarding the use of the CI index is the ability to discover patterns of agreement and disagreement in plant knowledge. The global value of the CI index value of a plant in a particular human population does not discriminate whether it is a central plant for a particular category or a more diversified one. For example, *Corylus avellana* and *Ulmus minor* have the same total CI index value (0.45), but the number of informants mentioning them is quite different (37 versus 30) as is the number of use-categories (7 versus 4). However, this analysis is possible using the CI index value components of each use-category (Table 2). In this example, it is possible to say that *Ulmus minor* is the most important plant as an animal food, while the use of its wood is also considered important in the area but less than *Corylus*. The agreement or disagreement in the use of a plant in a particular culture also could depend on the geographical focus of the survey. A plant with a low consensus (and subsequently a low CI index value) in the whole survey area could be a very important plant for the people of a few municipalities. That is the case of *Viburnum lantana* (CI, 0.18), which is a widespread species whose fruits were appreciated only in some villages of the center and west of the Campoo (Pardo-de-Santayana et al. 2005). The same idea was mentioned by Moerman (2007) who makes note of some meaningful medicinal plants that are utilized only by a few cultures of native North Americans. However, the CI index can be used to compare the plant knowledge among different cultures (Pardo-de-Santayana et al. 2007) and to study the intracultural differences if some subgroups are previously established. It can be said that the CI index is an efficient tool for highlighting those species with a high-agreement for the survey culture and so to recognize the shared knowledge of these peoples.

The last question we raise is the use of the term "cultural importance" for the index. Heinrich et al. (1998) explain that "culturally important plants are those that are used by a large number of people for the same category of use," assuming the idea of cultural consensus for evaluating the importance of plants for people. According to Albuquerque et al. (2006), the terms "cultural importance" and "relative importance" usually are used interchangeably in the literature to refer to the importance of certain plants to a given culture. However, the term "relative importance" was used first by Bennett and Prance (2000) for defining an index that takes into account only the number of uses. For all the above reasons, we considered the term "cultural importance" appropriate for the proposed index.

Cultural Importance Versus Use Value

As previously explained, although they are defined in different ways (the CI index is the sum of the proportions of informants cognizant of each use-category, whereas the UV index is the average number of use-categories for a certain plant per informant), the result of both indices is the same. The latter is better suited to an ecological approach seeking to evaluate natural resources. Obviously, this was the aim of Prance et al. (1987) in the first definition of the UV index and of Phillips and Gentry (1993a) in their subsequent modification of the index. By contrast, the way of grouping the results of the CI index corresponds with an interest in detailing the specific uses of plants that better reflect the cultural aspects of plant utilization. In fact, ethnobotanical publications usually present plant uses in tables or catalogs where the information is grouped by species, indicating their particular uses, and commonly the number of informants who mentioned them. This way of grouping is much more reasonable for evaluating the importance of each plant species by its cultural consensus. Nevertheless, the mode that the UV index uses to group plant-uses better suits a study for comparing the differences of plant-use knowledge among informants, i.e., intracultural variation.

Another reason for grouping results in the manner of the CI index is that the different uses of a plant are intrinsic characteristics of the species and are derived from the physical or chemical properties observed by humans. However, the number of uses attributed by an informant to a plant is intrinsic to people's knowledge.

Finally, using published works as a basis for comparative studies of the cultural importance of plants among different regions is only possible with a CI index, not with a UV index, because the number of uses that each informant attributes to each species is not usually published. What is frequently presented is the number of informants who mentioned a particular use (or number of reports for the use-category). For those papers, it is possible to determine the total number of use-reports (UR) for the species (sometimes this datum also is presented) and dividing it by the total number of informants to calculate the CI index. In other works, only the number of informants who mentioned the species as useful (FC) is shown. Bearing in mind the relationship between this figure and the number of uses discussed earlier, we recommend the direct use of the FC or, for comparative purposes, the relative frequency of citation (RFC), dividing it by the total number of informants.

Conclusions

The traditional compilation style used extensively in ethnobotany does not allow the identification of the relative importance of different plant species in the cultures surveyed. Several kinds of quantitative indices have been developed for measuring the cultural value of useful plants, allowing different hypotheses to be tested statistically.

If we accept that culture is a shared system of knowledge and competence among a group of people, most central aspects of culture will be widely shared by its members (e.g., Pelto and Pelto 1975; Wan et al. 2007). Hence, a culturally important plant can be defined as a species desired, preferred, or with an affective evaluation by most members of this culture. An indirect measure of the perceived cultural importance is therefore the extension of its knowledge. In our opinion, indices of cultural importance based on "informant consensus" are more objective because they reduce researcher bias in the attribution of the relative importance of plants.

It is commonly assumed that the cultural importance of a plant depends on the number of informants who mention its usefulness (FC) and on the number of uses (NU). Diverse indices have considered both variables, such as the UV index (Phillips and Gentry 1993a), the RI index (Pardo-de-Santayana 2003a), and the CV index (Reyes-García et al. 2006). However, NU is highly influenced by the number of use-categories considered in the study, according to the researcher's wider or narrower criteria in defining them. In addition, as our results confirm, there is a positive correlation between NU and FC that probably can be stated as a general rule: the more versatile a plant, the more widespread is its usefulness. That is, those versatile plants with several uses are generally more familiar to people than those with only one use. Consequently, to achieve a more objective index, we must rely more on FC than on NU. Except for FC, CI is the index with the lowest correlations with NU.

The cultural importance index (CI) proposed in this paper is strongly correlated with FC and, although it also considers the diversity of uses, each use-category is conveniently weighted. The index considers the contribution of each use-category according to the number of informants mentioning them and only widespread uses significantly influence the final result. However, other indices, such as RI or CV, overestimate the multiplicity of uses at the cost of informants' opinions.

The CI index is an efficient tool for highlighting those species with a high-agreement for the culture of the whole survey area and so to recognize the shared knowledge of these people. This does not mean that plants with low indices are always less interesting. The knowledge about useful plants is not homogenously distributed and the intracultural differences can be studied considering several subgroups. The CI index also can be used to compare the plant knowledge among different cultures (Pardo-de-Santayana et al. 2007).

The decomposition of the CI index in the components of each use-category also allows the analysis of the relative importance of plants in the different categories. The analysis of useful plants of only one wider category, such as edible plants, is also possible with the CI index utilizing other narrower use-categories, such as vegetables, fruits, or condiments (Pardo-de-Santayana et al. 2007).

The CI index can be employed to test statistically different hypotheses, such as the greater salience and usefulness of trees over shrubs and herbs, demonstrated with the data of the present ethnobotanical survey in the Campoo area. It can be considered as a redefinition of the use-value of Phillips and Gentry (1993a), grouping the information in a more reasonable way for most ethnobotanical studies, i.e., by plants and use-categories. That manner better reflects the cultural aspects of plant utilization and makes possible comparative studies of cultural importance of plants among different regions based on published works. However, this numerical identity can be considered a new advantage of using the CI index because it makes possible comparisons with many ethnobotanical works that have used the UV index.

Despite the use of cultural significance indices being questioned, we believe that indices based on in-depth, semi-structured interviews still can be very useful in analyzing passive knowledge, such as most of the ethnobotanical studies conducted in the last three decades in Europe. We propose the use of the CI index, which we believe is the most objective of the indices based on informant consensus that also consider the diversity of uses.

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