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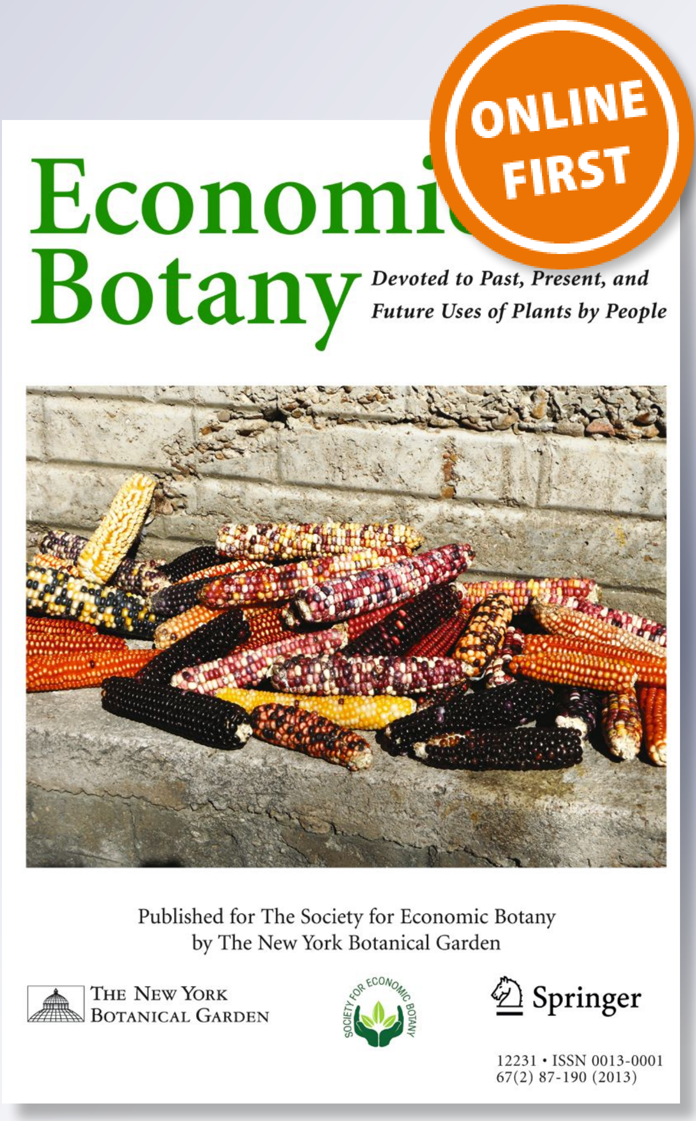

The Use of "Use Value": Quantifying Importance in Ethnobotany

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The Use of "Use Value": Quantifying Importance in Ethnobotany. Use value (UV) is an index widely used to quantify the relative importance of useful plants. It combines the frequency with which a species is mentioned with the number of uses mentioned per species, and is often used to highlight prominent species of interest. However, high-UV species are often disproportionately cultivated species, with wild-collected plants ranking lower. To better understand this pattern, and to determine if it is present in the broader ethnobotanical literature, we reviewed an array of papers with results on UV and cultivation status, and we analyzed in depth data from two large ethnobotanical studies in the Republic of Georgia in the Caucasus. In addition to looking for differences in UV by cultivation status, we compared the two best-populated categories of use (medicinal and food uses) and the components of UV (relative frequency of citation and number of uses mentioned per species). We found that UV was higher in cultivated plants than wild plants in both the Caucasus datasets and the 17 studies overall. Medicinal plants did not exhibit this trend, as medicinal wild plants had marginally higher UV than medicinal cultivated plants. Relative frequency of citation had a substantial effect on UV, in contrast to number of uses mentioned for a given plant. In sum, UV seems subject to some obscured biases which are important to consider in the context of each study.

Key Words: Quantitative ethnobotany, importance index, use value, cultivation, wild collection.

Introduction

Ethnobotanical studies often seek to identify and evaluate the plant species that are most important to a given culture (Albuquerque et al. 2006; Dudney et al. 2015). Beyond the direct relevance to understanding cultural value systems, in order to draw broader conclusions about ethnobotanical knowledge across cultures, we must be able to measure ethnobotanical knowledge in a consistent way (Reyes-Garcia et al. 2007; Turner 1988). The relative ethnobotanical importance of plants is also pertinent to conservation biology (under the presumption that the most important species may be subjected to the greatest harvesting pressure) and may inform new drug discovery from ethnobotanically useful species (Albuquerque et al. 2006; Byg and Balslev 2001; Morvin Yabesh et al. 2014). With these and other benefits in mind, quantitative importance metrics have been utilized more frequently in the field of ethnobotany in the past 30 years (Phillips 1996). These metrics are most valuable when clearly understood (Hoffman and Gallaher 2007) and when

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matched with appropriate theoretical questions (Gaoue et al. 2017).

Among the quantitative techniques that have come into favor, the use value (UV) index proposed by Phillips and Gentry (1993) has been widely used to quantify the relative importance of species (Albuquerque et al. 2006). In addition to the formula published by Phillips and Gentry (1993), a simplified version of the original equation, modified by Rossato et al. (1999), is often employed, where use value is calculated with the formula $UV = \Sigma U_i/n$. Here, U_i is the number of uses mentioned by each informant for a particular species, and n is equal to the total number of informants (Albuquerque et al. 2006; Bussmann et al. 2016a, b, 2017a, b, 2018; Rossato et al. 1999). For instance, if in a two-informant study one informant mentions five uses for a particular plant, and the other informant mentions three uses for the same plant, the UV of the species is equal to four (eight mentions / two informants). The original formula by Phillips and Gentry (1993) allowed for multiple interviews per informant to be considered in the calculation, whereas the simplified version by Rossato et al. (1999) presumes only one interview per informant (Albuquerque et al. 2006). Several variations of this formula are employed to assess some measure of relative importance (Medeiros et al. 2011), but common to most are two basic components: the number of uses of a particular species (Npu) and the relative frequency of citation (Rfc), that is, the proportion of informants citing a species as useful. An increase in either will necessarily drive a higher ΣU_i and therefore a higher species UV.

UV is considered to be effective at determining which plants are considered most useful to a particular group of people, evaluating potential uses of a plant, and determining the extent of knowledge about it within the group (Albuquerque et al. 2006; Morvin Yabesh et al. 2014; Phillips and Gentry 1993). However, it has been observed that in some cases managed or gardened plants score particularly higher in UV than do wild plants (Bussmann et al. 2016a, b, 2017a, b, 2018; Thomas and Van Damme 2010).

This could be because cultivated plants are preferred (or perceived to be more useful) in comparison to wild plants. Cultivated plants may require less knowledge to exploit, in contrast to wild plants which must be located and distinguished from similar taxa (Sõukand et al. 2017). It may also be that plants that have more uses or are more widely known are those most likely to be brought into cultivation or management (Fuller et al. 2014). Further, social-ecological coadaptation (through domestication processes, landscape modification, and cultural transmission) may lead to an increased or persistent usefulness of plants once in cultivation (Harris 1989; Larson et al. 2014).

However, wild plants may also be preferred. Wild collection allows access to a great diversity of plants, including species not amenable to cultivation, and in the absence of the investments of time and space necessary for cultivation. Further, even for species that are both collected from the wild and cultivated, wild populations may be preferred based on chemical qualities or cultural values. For example, in China, wild ginseng roots are up to ten times more valuable than cultivated ones because the perceived medicinal value is higher (Schippmann et al. 2002).

Although it is widely recognized that there are diverse ways in which species or populations may be "wild" or "cultivated" (including various degrees of affiliation, toleration, management, and domestication [Conklin 1961; Ford and Nigh 2009; Harris 1989; Smith 2011]), several ethnobotanical studies which record UV also characterize species as "wild" or "cultivated" within their geographic areas of study. This characterization may be recorded as a binary distinction (as in Ahmad et al. 2015, Bibi et al. 2014, Egea et al. 2016) or as part of a more complex classification, including specifying plants that are grown in gardens, purchased, imported, native, endemic, or naturalized (as in Khan et al. 2015, Nunkoo and Mahomoodally 2012, Samoisy and Mahomoodally 2016).

We therefore raise the questions: Is there a larger pattern in this literature showing that the UV is generally higher for cultivated rather than wild plants? If so, which components of UV (number of uses of a particular species or number of informants citing a plant as useful) are more likely to relate to cultivation? Through a broad analysis of results within the existing literature, paired with an in-depth analysis of data from an ethnobotanical survey across the Republic of Georgia, we attempt to answer this question.

Methods

To locate studies that utilize UV as proposed by Phillips and Gentry (1993), we conducted a SCOPUS search of the search terms "ethnobotany" and "use value," resulting in 217 documents. These results were further narrowed by selecting studies that contained (1) a full species list including UV and (2) an indication, for each species, of whether it was wild or gardened/cultivated, (3) had more than 100 informants, and (4) were available online and in English. This resulted in 17 studies (Table 1), from which we constructed a database of species, UV, and information about cultivation or wildness (Electronic Supplementary Material [ESM]; Table 1). To this, we added data from two studies conducted in the Republic of Georgia, the first conducted in 2013–2015 (Bussmann et al. 2016a, b) and the second in 2016–2018 (Bussmann et al. 2017a, b; Bussmann et al. 2018). These two Caucasus datasets broadened the resulting comparison to 19. Because for these latter two studies we had access to the plant-use report data of individual informants (rather than the commonly published results of UV scores aggregated at the level of species), they also allowed a more in-depth exploration of the components of UV. Species names and authorities were reviewed and standardized using the Tropicos plant database (www.tropicos.org).

As distributions of UV values varied greatly among different studies, we standardized UV within study. Each species UV was scaled and centered by subtracting the mean study UV and then dividing by the standard deviation, using the base package in R (version 3.5.0, R Core Team 2018).

In order to test for differences in UV of cultivated and wild plants, we created a variable "wildness" for each species within each study. The majority of species within studies were considered either wild or cultivated (Table 1), and so had, respectively, a wildness of 1 or 0. For species within studies reported as both wild and cultivated, we assigned a value of 0.5. Finally, in the two Caucasus studies for which we had access to multiple individual reports for each species, we divided the number of individual wild reports of a species by the total number of individual wild and cultivated reports for that species, so that wildness could vary continuously from 0 to 1. We tested for a general pattern across the 19 studies by constructing a linear mixed-effects model using the R package nlme (Pinheiro et al. 2018) with scaled UV (UV_s) as a function of wildness, keeping study as the random effect.

To characterize differences among studies, individual Wilcoxon tests were performed comparing UV_s between wild and cultivated plants in each study (ignoring plants that fell between). Results of these tests indicated studies for which UV_s was significantly higher in cultivated than in wild species or vice versa. As species lists overlapped across many of the studies in our sample, we also asked whether the UV_s of a species which was recorded as wild in some studies and cultivated in others differed depending on its wildness. For this subset of 213 species reported in more than one study, we performed a paired Wilcoxon test comparing the mean UV_s of wild reports to the mean UV_s of cultivated reports for each species.

To determine if the UV-wildness trend observed in the earlier Caucasus data (Bussmann et al. 2016a, b, 2017a, b) was replicated in the data collected subsequently (Bussmann et al. 2018), we fitted a linear model of UV as a function of wildness on both datasets separately. To determine whether either of the components of the UV index (the number of uses of each plant, Npu, or the relative frequency of citation, Rfc) was differentially driving the relationship between UV and wildness, we fit separate linear models of Npu and Rfc as a function of wildness for each of the Caucasus studies. Finally, to characterize whether the relationship between UV and wildness differs among major categories of use, we fit separate linear models of UV as a function of wildness within the two most reported categories within the Caucasus data—food plants (504 reports) and medicinal plants (220 reports).

Results

Across the 19 studies considered (17 resulting from the literature search, and the 2 Caucasus datasets), UV ranged from 0.005 to 6.63, and UV_s ranged from − 2.24 to 7.48 (excluding six species UV values reported as 0 in the source studies; Electronic Supplementary Material [ESM]). All studies had a higher percentage of wild plants mentioned than cultivated plants (Table 1).

In analyses across the 19 studies, a linear mixed-effects model using UVs as a function of wildness showed a higher UV_s for plants that were cultivated rather than collected wild (a difference of 0.34 UV_s between cultivated and wild, $p < 0.001$). Within this overall cross-study relationship, studies differed in the degree and direction of the relationship. Five studies showed a significant negative mean difference in UV_s between wild and cultivated plants (following the overall model), two studies showed a significant positive mean difference, and 12 studies showed no significant difference (Table 2, Fig. 1). For the 213 species that were indicated as wild in some studies and cultivated in others, the paired Wilcoxon test showed no significant difference in

TABLE 1. STUDIES INCLUDED IN META-ANALYSES.

Citation	Location	Informants (*N*)	Species (*N*)	Scope of uses	Cultivation/wildness status of plants mentioned (%)			
					Wild	Cultivated	Both	Other
Ahmad et al. 2015	Pakistan	120	46	Medicinal, for treatment of hypertension	83	17	0	0
Bibi et al. 2014	Pakistan	255	58	Medicinal	86.2	12.1	0	1.7
Caucasus Study 1	Republic of Georgia	168	482	All uses	56.2	16.6	27	0.2
Caucasus Study 2	Republic of Georgia	79	401	All uses	47.6	20.2	31.2	1
Faruque et al. 2018	Bangladesh	174	159	Medicinal	81.1	18.9	0	0
Güzel et al. 2015	Turkey	211	202	Medicinal	85.2	14.8	0	0
Hayta et al. 2014	Turkey	136	74	Medicinal	83.8	16.2	0	0
Khan et al. 2015	Bangladesh	185	71	Medicinal	70.4	28.2	1.4	0
Mahmood et al. 2013	Pakistan	203	71	Medicinal	78.9	21.1	0	0
Nunkoo and Mahomoodally 2012	Mauritius	307	39	Medicinal, for infectious disease	28.2	12.8	15.4	43.6
Polat et al. 2015	Turkey	128	70	Medicinal	80	20	0	0
Samoisy and Mahomoodally 2016	Rodrigues	122	80	Medicinal	56.4	28.2	15.4	0
Sargin 2015	Turkey	178	159	Medicinal	83.6	16.4	0	0
Sargin et al. 2015	Turkey	201	141	Medicinal	87.2	7.8	5	0
Telli et al. 2016	Algeria	324	67	Medicinal, for treating diabetes	61.2	35.8	3	0
Umair et al. 2017	Pakistan	201	85	Medicinal	75.3	14.1	10.6	0
Vitalini et al. 2013	Italy	104	66	Medicinal and food	90.9	9.1	0	0
Yaseen et al. 2015	Pakistan	530	87	Medicinal	71.3	12.6	16.1	0
Zahoor et al. 2017	Pakistan	400	96	Medicinal	90.6	9.4	0	0

mean UV_s among studies that considered a species wild versus those that considered it cultivated.

The linear model showed a significant, negative relationship in the newly collected Caucasus dataset (– 0.07 difference in UV between completely cultivated and completely wild species, $p < 0.01$, adjusted $R^2 = 0.02$; Fig. 2), replicating the relationship observed in the previously collected Caucasus data (– 0.14 difference in UV between completely cultivated and completely wild species, $p < 0.001$, adjusted $R^2 = 0.09$; Fig. 2). Considering the Caucasus datasets together, the separate linear models of the components of UV showed that Npu is higher in wild plants (0.28 difference between wild and cultivated, $p < 0.01$, adjusted $R^2 = 0.015$), while Rfc is higher in cultivated plants (– 0.10 difference between wild and cultivated, $p < 0.001$, adjusted $R^2 = 0.077$), which suggests that the overall trend in UV with wildness is driven by Rfc (Fig. 3). Within the subset of reports of plants used for food, the overall trend in UV recurred (– 0.12 difference in UV between completely cultivated and wild species; Fig. 4), while within the subset of reports of plants used for medicine, the linear model showed the inverse relationship, with marginal statistical significance (0.02 difference in UV between completely cultivated and wild species, $p = 0.056$; Fig. 4).

Discussion

The objectives of this study were to determine if a pattern is present in the ethnobotanical literature in which UV is higher in cultivated than wild species of useful plants, and to investigate which components of UV might be driving this relationship. This pattern can be seen in the literature surveyed, including studies with a variety of geographic locations, study designs, and numbers of species considered, suggesting that the pattern may hold true across the broader ethnobotanical literature. When studies were analyzed individually, however, we

TABLE 2. MEAN DIFFERENCE IN SCALED USE VALUE (UV_S) BETWEEN WILD AND CULTIVATED PLANTS IN EACH STUDY (STUDY DETAILS IN TABLE 1)

Citation	Mean difference in UVs between wild and cultivated plants	Significance
Hayta et al. 2014	– 1.18	< 0.001
Umair et al. 2017	– 0.92	0.01
Polat et al. 2015	– 0.60	0.03
Mahmood et al. 2013	– 0.52	0.11
Bibi et al. 2014	– 0.51	0.4
Sargin et al. 2015	– 0.40	0.04
Samoisy and Mahomoodally 2016	– 0.25	0.12
Khan et al. 2015	– 0.25	0.36
Caucasus Study 1	– 0.24	< 0.001
Yaseen et al. 2015	– 0.16	0.41
Faruque et al. 2018	– 0.14	0.33
Nunkoo and Mahomoodally 2012	– 0.12	0.35
Caucasus Study 2	– 0.06	0.16
Zahoor et al. 2017	0.00	0.94
Güzel et al. 2015	0.07	0.26
Sargin 2015	0.08	0.24
Telli et al. 2016	0.14	0.56
Vitalini et al. 2013	0.34	0.01
Ahmad et al. 2015	1.02	0.01

found several instances where UV was significantly higher in wild species than in cultivated ones, which suggests that there are cases in which wild plants are more useful (or more well known) than cultivated ones, and vice versa.

This could be the result of study parameters or of actual cultural differences in the knowledge of useful wild plants. There is evidence to suggest that the use of wild edible species has fallen out of favor in some cultures, due to a loss of traditional knowledge among younger generations and negative associations with collecting wild plants in the older generation (as it can be reminiscent of past food insecurity; Hadjichambis et al. 2008; Quave and Pieroni 2015). Additionally, rapid development in areas inhabited by indigenous people is contributing to the loss of wild habitats and traditional knowledge of them; as viable ecosystems are being converted to agricultural land, many useful plants are removed and become more difficult to locate and therefore utilize (Ramirez 2007). If knowledge of wild plants is less resilient to these changes—perhaps because it represents connections with specific wild environments rather than the "constructed" niche of

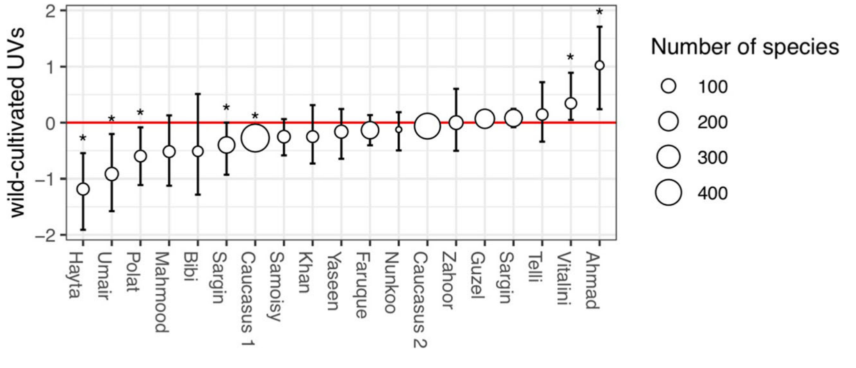

Fig. 1. Mean difference in scaled use value (UV_s) between wild and cultivated plants in each study (Table 1, Table 2). Error bars represent 95% confidence intervals; asterisks indicate results that are independently significantly different than zero ($p < 0.05$).

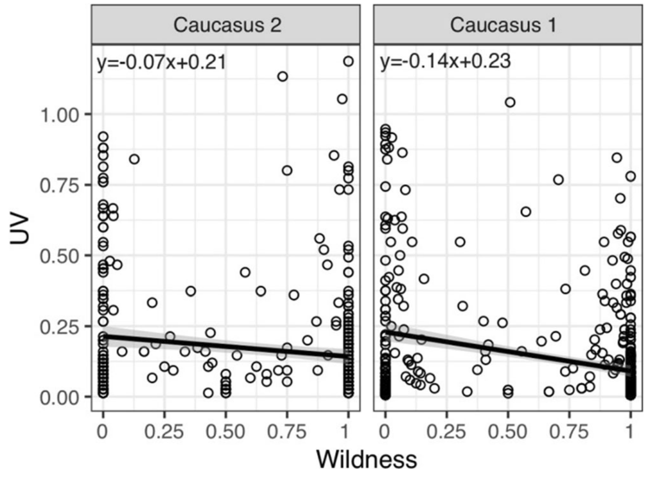

Fig. 2. Use value (UV) as a function of wildness in the new Caucasus dataset and previous Caucasus dataset. UV decreases as the likelihood that a plant is collected from the wild increases.

cultivation (Rowly-Conwy and Layton 2011; Smith 2011), or simply because of the much larger number of wild plants than cultivated—knowledge loss could explain the pattern we observe.

Among plants used for food, cultivated plants have a higher UV, while among medicinal plants, wild plants have a marginally higher UV; this may be related to economic opportunities. Most species of medicinal plants are thought to be wild collected (Hamilton 2004), and in many countries, the wild harvest and sale of medicinal plants is a significant source of income for the poor who do not have access to farmland (Hamilton 2004; Schippmann et al. 2002). It has been suggested that the total number of medicinal and aromatic plant species used worldwide is more than 50,000, while less than a few hundred are currently in cultivation for commercial production (Schippmann et al. 2002). In order to successfully commercialize cultivated medicinal plants, various obstacles must be overcome, such as lack of quality planting material, poor development, and unorganized markets

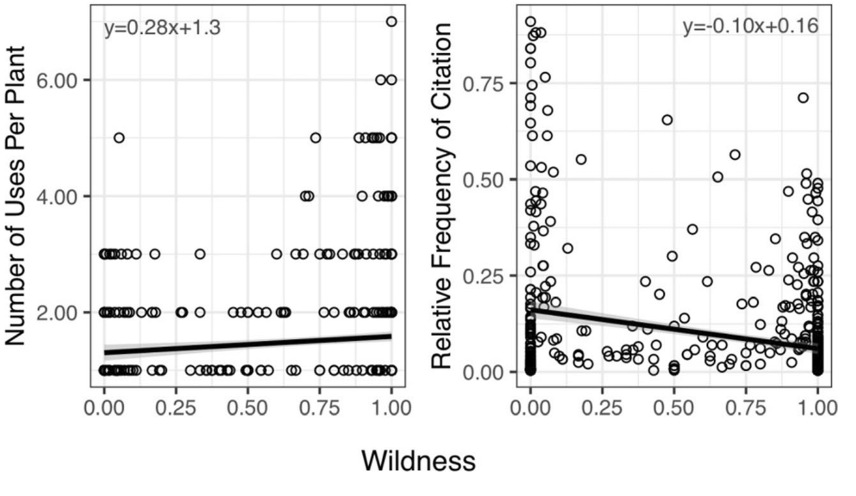

Fig. 3. Components of use value (Npu, number of uses / plant and Rfc, relative frequency of citation) as a function of wildness.

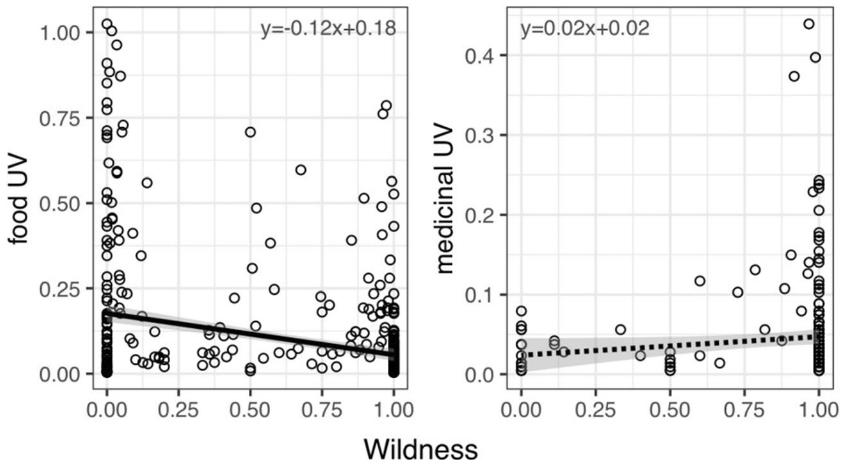

Fig. 4. Use value (UV) as a function of wildness in medicinal plants and food plants. In food plants, cultivated plants have a higher UV (solid line, $p < 0.005$), while in medicinal plants, wild plants have a marginally higher UV (dotted line, $p = 0.057$).

(Ramakrishnappa 2002). Overall, the wild collection of medicinal plants may presently be favored over cultivation (Schippmann et al. 2002) or simply more feasible than cultivation (Ramakrishnappa 2002). This difference among use categories that we quantify within the Caucasus dataset may also explain some of the differences among studies that we observe. Different studies had different use scopes—most dealt with medicinal plants only, but some with a broader set of uses and others with a narrower set of specific medicinal treatments. However, a pattern is not immediately clear here, as studies of all scopes were found to have significantly negative or significantly positive wild-cultivated UVs (Tables 1 and 2, Fig. 1).

We did not find a significant difference in UV between species that are considered wild in some cases and cultivated in others, which perhaps suggests that the qualities that make these plants useful are less subject to cultural understandings of a plant as "wild" or "cultivated," and instead related to biological or biocultural factors which make these species good candidates for food, medicine, or other uses (Garnatje et al. 2017).

It has been suggested that UV places more emphasis on plants which have many uses, even if these species are not well known (Albuquerque et al. 2006; Silva et al. 2006). Our results from the Caucasus study show the opposite trend, as wild plants tend to have *more* uses than cultivated plants yet have lower UV. In our case, UV seems to be mostly driven by species which are well known (are mentioned by more informants / high Rfc) rather than those that are most "useful" (have the greatest number of uses / high Npu), suggesting that the most important components of UV may vary across different study parameters.

It seems that, overall, UV is useful in determining some measure of relative usefulness; however, it is not clear that the index universally paints an accurate picture about which plants are most useful, or one that is consistent among studies. In addition to possibly favoring those species which are well known, rather than have the most uses, another disadvantage (noted by Albuquerque et al. 2006) is that this index does not distinguish between past use, present use, and general knowledge about a given species. Similarly, the delineation of use categories (subject to the author's judgment) can affect the resulting UV and suggests that this index is susceptible to biases that may not be clear to authors or audiences of ethnobotanical studies.

Conclusions

Analysis of UV, its components, and its relationship to wild and cultivated plants shows that the results of using this index may be biased in ways that are not immediately apparent. Overall, UV seems to exhibit a pattern in which cultivated plants are favored over wild plants, but significant differences among studies remain. Additionally, while UV, at least in name, seeks to rank quantitatively the plants that are most useful to a group of informants, it may in fact conflate the uses of a plant with the breadth of its knowledge. Given our results, it is important that researchers keep in mind that while quantitative ethnobotany seeks to utilize statistical methods and other quantitative tools to increase the scientific rigor of the discipline, indices such as UV have limitations in the way they can assess data objectively. With these limitations in mind, and in agreement with prior calls for clarity and rigor in the choice and employment of quantitative methods in ethnobotany (Gaoue et al. 2017; Hoffman and Gallaher 2007), it may be preferable in certain cases to present simple and easy-to-interpret statistics (such as the number of uses and frequency of reports for given plants) instead of compound and more-difficult-to-interpret metrics that may operate differently in different systems. It is important to also consider the way that methodological differences may be contributing to subjective results, particularly delineation of use categories. In conclusion, the push for quantitative methods, including UV, has resulted in data that can be clearly analyzed using statistical methods, although the problem of subjectivity is unresolved. More investigation may be necessary to determine why cultivated plants might be favored over wild plants, and which component of UV has the greater influence on final results.

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