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A reservoir of ethnobotanical knowledge informs resilient food security and health strategies in the Balkans

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While all peoples are nested in their environments, their decisions and actions are mediated by culturally constructed values, beliefs and priorities. Ethnobotanical methods can show how different ethnic groups living within the same geographic landscape interact with environmental resources. Here, we explore the impact of culture on ethnobotanical knowledge, and practice on local food security and human health. Gora, a mountainous territory of northeastern Albania, is home to two culturally and linguistically distinct peoples: Gorani and Albanians. We investigated the divergences and convergences of ethnobotanical strategies among the groups with respect to the use of 104 plant species. Local knowledge modulated by cultural history has moulded these peoples' use of their natural environment, fostering resilience during periods of food insecurity.

Ethnobotany, the study of human interactions with plants, is relevant to many global concerns including food security, climate change, conservation biology and human health. In much of the developing world, humans rely heavily on local environmental resources, especially wild plants, for daily subsistence and health care. Traditional knowledge of these resources, passed down from generation to generation, can serve as a *reservoir of resilience* and influence group survival during periods of hardship. Ethnobotanical knowledge within a defined microsystem is represented mainly by experiential knowledge shared among community members identifying with a specific culture. Although this is influenced by introduction of outside ideas and practices, the core body of knowledge is typically linked to those resources that are most easily accessible to the local population. Divergences in knowledge and practice between two cultural groups that live within the same ecosystem are intriguing as they can provide insight into how the lens of culture can not only alter human viewpoints of the environment, but even guide human interactions with resources embedded in the ecosystem. To explore the question of what role culture plays in shaping the human–nature interface, we conducted field research in northeastern Albania, an area of the Balkans that hosts an incredibly rich repertoire of cultural, linguistic and biological diversity. Local people live in rural, isolated communities and maintain an intimate knowledge of the land and the traditional ecological resources on which they subsist. Here, we compare the ethnobotanical knowledge of two culturally and linguistically distinct groups that share the same ecological landscape, environmental resources, religion and challenging economic conditions. We apply a quantitative ethnobotanical approach to examine how culture shapes knowledge and practice concerning wild flora for household subsistence and health practices.

Fieldwork was conducted on the Albanian side of the Gora region (Kukës district, northeastern Albania, Fig. 1). Kukës district comprises 94 km^2 with an approximate population of 75,000. One-third of the population live in the city of Kukës; the remainder in 90 semi-urban and rural villages divided into 14 communes. Kukës is one of the three most economically disadvantaged districts in Albania. Along with Kurbin and Gramsh, these districts have more of the 'Very Poor and Poor, ranging from approximately 60 to 85 percent of their households' than the rest of the country[1]. This state of poverty is exacerbated by fewer sources for income and employment in the region. Since the closure of nearly all of the local mining and mineral processing facilities (for example chrome and copper), small-scale agriculture (especially potato cultivation) has become the most important economic sector[1].

In addition to Albanian communities in this region, there are a few isolated Gorani settlements. The Gorani are an ethnic minority consisting of approximately 30 000 people living in mountainous communities spread across Albania, Kosovo and Macedonia in the southwestern Balkans. The Gorani language 'našinski' is a

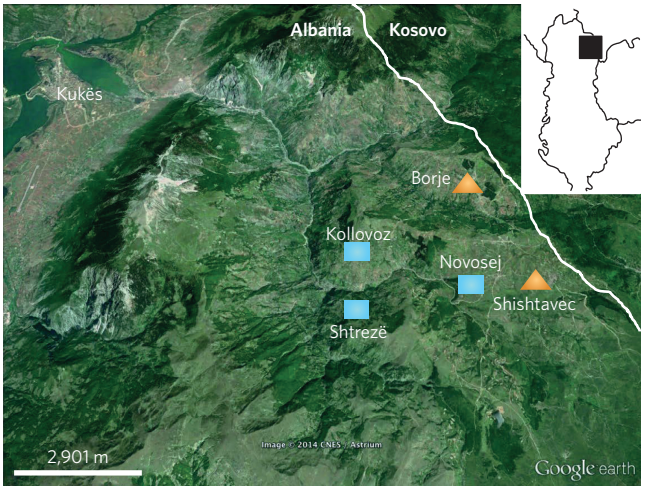

Figure 1 | Map of the study area. Image adapted from Google Earth (https://www.google.com/earth/). Albanian villages are denoted with squares, Gorani with triangles.

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Table 1 | Comparison of Gorani and Albanian plant use by informant consensus factor (F_{ic}) analysis.

Category of Use	Number of taxa (N_t)*		Number of use citations (N_{uc})		Informant consensus factor (F_{ic})†	
	Gorani	Albanian	Gorani	Albanian	Gorani	Albanian
Cardiovascular	14	10	57	40	0.77	0.77
Dermatological	20	28	125	237	0.85	0.89
Economics	18	12	74	49	0.77	0.77
Endocrinological	2	3	12	20	0.91	0.89
Ethnoveterinary	8	9	21	34	0.65	0.76
Food	41	26	176	195	0.77	0.87
Gastrointestinal	21	15	100	92	0.80	0.85
General health	28	19	154	164	0.82	0.89
Gynaecological, andrological, nephrological, and urological	13	13	41	84	0.70	0.86
Household use	5	6	17	31	0.75	0.83
Musculoskeletal and neurological	13	13	41	75	0.70	0.84
Ophthalmological	2	4	8	17	0.86	0.81
Oral and dental	4	2	14	13	0.77	0.92
Otolaryngological and respiratory	20	14	114	82	0.83	0.84
Ritual and spiritual	12	8	142	135	0.92	0.95
Total	221	182	1096	1268		

*Individual taxa may be listed in multiple use categories.
†A high F_{ic} value indicates a high rate of agreement between the informants regarding plants used for the corresponding category of use; a low F_{ic} indicates a low degree of agreement.

Torlakian transitional dialect between the Bulgarian/Macedonian language group and the Serbo-Croatian language[2]. All of the Albanian and Gorani communities included in this study identify with the Islamic faith.

Using Gorani and Albanian traditional ethnobotanical knowledge as a model, we hypothesize that two distinct cultural groups living in the same ecosystem will share a similar pattern of use of wild flora for daily subsistence and medical practices, and that distinctions will arise only for those taxa that play a key role in culture-specific ritual, food or health practices. To address this, we propose a new approach to analysing cultural importance value assignments to botanical resources with a visual matrix.

Results

A total of 104 botanical taxa, representing 42 families and 68 genera, were cited by the study participants. Data on 2,364 use citations were collected (Table 1), representing 418 plant uses for a broad spectrum of food, health, ritual and local economic purposes (Supplementary Table 1). Here, we report the findings from our statistical analysis of the ethnobotanical data reported by both groups.

Plant use analysis. We found a significant difference ($P < 0.05$) in 77 plant uses between groups, representing 43 botanical taxa. Of note, the Gorani use of *Sambucus nigra* and *Thymus pulegioides* as antitussives, *Brassica oleracea* as a savoury pie ingredient, *Nepeta cataria* as a treatment of shock, *Chelidonium majus* for warts, *Primula veris* for sale, *Prunus domestica* in health beverages, *Salix alba* for courtship and the Albanian use of *Plantago lanceolata* as a haemostatic and *Rumex pulcher* as a raw snack were all significant at a P-value < 0.001.

Informant consensus analysis. Informant consensus per group by category of use is reported in Table 1. The highest levels of consensus (informant consensus factor (F_{ic}) > 0.85) for both groups were for dermatological, endocrinological and ritual/spiritual categories. The Gorani had greater consensus regarding ophthalmological therapies ($0.86^{Gor}/0.81^{Alb}$), whereas Albanians had greater consensus in food (0.77/0.87), gastrointestinal (0.80/0.85), general health (0.82/0.89), gynaecological/andrological/nephrological/urological (0.70/0.86) and oral/dental categories of use (0.70/0.92), suggesting greater person-to-person variation in knowledge and application of traditional ecological resources among the Gorani.

Fidelity analysis. The fidelity level (FL) for every plant use is reported in Supplementary Table 1 and is based on the combined reports of both groups. As the reported species are commonly prepared in numerous ways for various purposes, the FL for most plant uses is quite low. However, there are a few instances of high FL (>80%), and these include the use of *Spinacia oleracea, Narcissus poeticus, Bunium alpinum, Carlina* sp., *Helianthus tuberosus, Lactuca sativa, Rumex acetosella, R. patientia* and *R. alpinus* as foods; various *Allium* spp. as apotropaions; *Bellis perennis* for sale to plant traders; *Ostrya carpinifolia* as a vulnerary; *Equisetum arvense* for prostate problems; *Phaseolus vulgaris, R. obtusifolius* and *Pinus nigra* as suppuratives; *Centarium erythraea* for haemorrhoids; *P. lanceolata* as a haemostatic; and *Syringa vulgaris* as a decoration.

Use-value matrix analysis. Only *Achillea millefolium* and *Sambucus ebulus* emerged in quadrant I, indicating their high value to Albanians, but not the Gorani (Fig. 2b). There were no use citations by the Gorani for *S. ebulus*, whereas for Albanians it was repeatedly cited as a valuable therapy for rheumatism, and four distinct preparations were reported. *A. millefolium*, on the other hand, was cited by both groups, but while Albanians use it for several medical applications (for example haemostatic, suppurative, toothache remedy, warts, general illness and women's blood problems), the primary use by Gorani was for sale to plant traders. On the other hand, four species emerged in quadrant VIII, indicating high value to the Gorani, but not Albanians. This included *S. nigra*, which is used by the Gorani for a diverse array of functions (for example antitussive, galactagogue, panacea, anti-inflammatory and vulnerary), whereas for Albanians, it is simply collected and sold in trade. Other species of high value to the Gorani but not Albanians included *Hypericum perforatum*, *Orchis mascula* and other terrestrial orchid species grouped under the folk generic name of '*salep*', and *S. alba*. *S. alba* emerged as a cultural keystone species for the Gorani on the basis of its use in numerous ritualistic and medicinal practices. Out of the 104 taxa documented in this study, only two species received high use-value scores in both Gorani and Albanian participants: *Rosa canina* and *Urtica dioica*. Both of these species are regularly consumed in the diet: *R. canina* as a tea or lactofermented beverage, considered useful for health promotion, otolaryngological, gastrointestinal and cardiological complaints, whereas *U. dioica* is valued for topical applications for

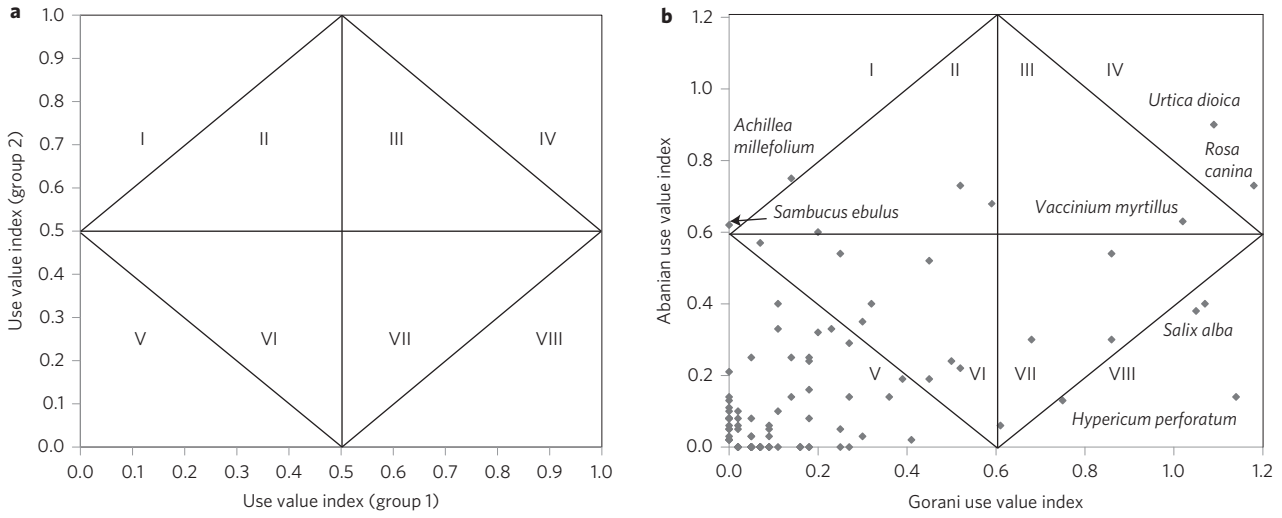

Figure 2 | Use-value matrix comparison of two groups with access to the same flora and ecological resources. a, Matrix design. Each quadrant corresponds to a specific relationship concerning plant use-value. Those plants found in quadrant I share the characteristic of a high UV_c index according to informants from group 2, with little to no value to group 1. Likewise, plants found in quadrant VIII have high UV_c indices for group 1, with little to no value to group 2. Those plants with low to moderate UV_c indices in both groups occur in quadrant V, whereas those that share high UV_c indices in both groups are found in quadrant IV. Taxa with intermediate UV_c indices can be found in quadrants II, III, VI and VII. The value of such an exercise is the rapid identification of those species that share high use-value in both groups (quadrant IV), as well as identification of divergent use-values for species (quadrants I and VIII). **b**, The use-value indices were plotted in order to compare plant rankings of Albanian and Gorani study participants. Plants in quadrant I, such as *Achillea millefolium* and *Sambucus ebulus* are highly valued by Albanians, but not the Gorani. On the other hand, *Hypericum perforatum* is highly valued by the Gorani, but not Albanians. While the majority of plants have a low (quadrant V), or intermediate (quadrants II,III, VI, VII) use-value index score, only two exhibited high rank (quadrant IV) among both the Gorani and Albanians: *Urtica dioica* and *Rosa canina*. The corresponding quadrant for each species is also listed in Supplementary Table 1.

musculoskeletal complaints and eaten as a healthy food. A full accounting of plant uses is provided in Supplementary Table 1.

Discussion

Divergences in ethnobotanical strategies. The divergences observed between Gorani and Albanian ethnobotanical knowledge and practice are in several cases linked to small differences in household economic strategies. This was most evident upon examination of plants emerging in either quadrants I or VIII in the use-value matrix analysis (Fig. 2). These quadrants are useful for identifying which taxa are highly valued by one group (for example *Achillea millefolium* and *S. nigra*), but not the other. In this instance, one group assigned high value to those plants used in household medicine, whereas the other group assigned a low value, corresponding to small-scale wild-crafting practices for sale to plant traders. Such culture-mediated distinctions between the value of traditional ecological resources for personal use (for example as a valued medicine or special food) over impersonal use (for example sale for a small economic supplement) can have a meaningful impact on resource conservation issues concerning both local species and habitats. For example, we noted alarming trends concerning the sale of wild crafted taxa to plant traders who deliver the goods to external markets. Some taxa (*Orchis* spp., in particular) collected for these purposes are listed under CITES Appendix II (ref. 3), which includes species that while not necessarily under threat of extinction, require trade controls to avoid uses that are incompatible with their survival. Although an in-depth investigation into the local economic impact of the wild plant trade was out of the scope of this study, it is noteworthy that several informants cited the importance of this practice in income supplementation, especially in the face of uncertain market prices for the potato crop. However, informants also lamented plant population declines, especially among those species used for both trade and local medicinal and/or food purposes. This issue is relevant to conservation biologists and economists alike, and certainly merits further study.

Divergences in the importance of medicinal and ritual plants were also evident. For example, Gorani communities attribute a very high value to willow trees (*S. alba*). Willow is integral to several distinct cultural practices surrounding the St George's Day festivities, and range from use in rituals for courtship, health of children, health of livestock, luck for a bountiful harvest, and evil eye amulets displayed in homes and businesses. Willow is a cultural keystone species[4] for the Gorani, and its importance is deeply embedded in local cultural practice and social identity. Beyond the cultural landscape, willow trees are also uniquely pervasive in the physical spaces throughout Gorani communities (unlike Albanian communities), and this is due to historic and current day plantings (Fig. 3).

In addition to socioeconomic drivers and ritual practices, other divergences may be explained in part by the cultural and linguistic isolation of the Gorani communities within Albania. Despite the fact that these two groups have shared the same Islamic faith for at least the past two centuries (the Gorani having been Islamicized by the Ottomans in the late eighteenth century, roughly three centuries after the Albanians), the Gorani and Albanians have lived and still mainly live apart. Intermarriages are very rare, even today. This differs from the Macedonian side of the Gora region, where Albanians and Gorani experience more frequent intermarriage and share more plant uses in common than a third ethnic group in that region (Macedonians)[5]. Isolation of these Gorani communities in northeastern Albania was further influenced by political factors over the past century, most notably the independence of Albania in 1912, which resulted in creation of today's geopolitical borderlines that separate them from the bulk of other Slavic populations.

Here, as has been documented in many other places in the world, women are largely responsible for the vertical transmission of traditional botanical knowledge[6,7]. Reduced interactions between

Figure 3 | *Salix alba* is a cultural keystone species that uniquely dominates the Gorani village landscapes. It is highly valued by the Gorani for a myriad of ritual and medicinal applications. (Photo by C.L.Q.).

Gorani and Albanian women could be responsible for fostering the development of a divergent set of ethnobotanical knowledge in these two ethnic groups, despite the fact that they have access to the same environmental resources and subsist within an environment composed of nearly identical biological environments, geologic terrains and economic stressors. Indeed, Gorani women have remained so isolated from their Albanian counterparts that the eldest are unable to communicate in Albanian, despite it being the primary language of their country.

In addition to the differences observed between the Gorani and Albanian communities in this study, it is also important to frame this within the larger context of ethnobotanical practice in the Balkans. Here, we highlight some of the most relevant differences in ethnobotanical knowledge by specific taxa:

(1) *Sambucus* spp.: The arboreal *S. nigra* is most commonly used among Gorani, as also documented in other south Slavic areas[8–10], whereas the use of herbaceous *S. ebulus* prevails among Albanians[11];
(2) *Centaurium erythraea* is commonly used as an antihaemorrhoidal therapy among Gorani;
(3) *Origanum vulgare* is emerging as a cultural keystone species[4] among northern Albanians[12];
(4) *P. lanceolata*, whose cicatrizing use is remarkably predominant among Albanians in the study area;
(5) *S. alba* is popular among Gorani for medical and ritual uses, as in other Slavic plant-based folkloric customs[13]; and
(6) The use of numerous wild fruit-based lacto-fermented 'healthy' beverages is widespread among Gorani[14].

Convergences in ethnobotanical strategies. While there are many levels of divergence in ethnobotanical strategies noted between these two ethnic groups, the predominance of high fidelity levels between the Gorani and Albanian participants for wild edible species is significant. This could be explained by the crucial role that these local environmental resources play in ensuring food security during periods of famine. Unfortunately, memories of food insecurity live brightly in much of the study population due to sporadic periods of economic strife in the 1970s and 1980s, and then again during the Balkan conflict of the 1990s. During these times, the commonly available wild foods that occur in ecotomal zones (for example stinging nettles, *U. dioica*) served as important nutritional staples in the absence of other cultivated greens. This tradition continues today, as nettles are a favoured main ingredient used as the stuffing for savoury pies, known as *byrek* or *pita,* in both populations. Likewise, a number of *Rumex* spp. are valued as wild foods by Gorani and Albanians alike (Fig. 4). Wild fruits (esp. of the Rosaceae family) are valued for applications in health beverages. For example, the dried fruits of the wild dog rose (*R. canina*) remain a favoured herbal tea ingredient, are consumed several times per week, and represent an important source of antioxidant vitamin C (ascorbic acid), polyphenolics and flavonoids[15] in the local diet.

Distinct cultural groups tend to diverge in food practices through specific cultural associations with consumable resources, and, indeed, the term 'food sovereignty' is distinguished from food security by inclusion of reference to the '… right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems'[16]. Food security, on the other hand, lacks the reference to cultural appropriateness and is instead founded on the core principles of food availability, food access (physical and economic), food utilization and stability over time[17]. Our results suggest that selective convergence in certain sets of ethnobotanical knowledge concerning wild foods can occur between ethnic groups during periods of food insecurity, and have a lasting imprint on the body of oral traditional environmental knowledge of a group. For example, in addition to those wild food taxa (*U. dioica* and *R. canina*) that ranked at the top of the use-value scores (Fig. 2b) for both Albanian and Gorani informants (quadrant IV), it is noteworthy to mention the importance of other highly valued wild edible taxa such as *Vaccinium myrtillus* (quadrant III) and other edible taxa that experienced high value in one group, but moderate in the other: *Allium sativum* (quadrant II) and *Prunus domestica* and *Cornus mas* (quadrant VII). Knowledge of these taxa is not restricted simply to the plant itself, but also encompasses the means of processing the botanical material to create long-lasting foodstuffs (for example by drying or lacto-fermenting[14]). A robust set of ethnobotanical knowledge concerning wild edible resources can serve as a reservoir of resilience for an entire community or cluster of communities, better preparing them to cope with periods of famine or staple food scarcity. Thus, while intercultural divergences may persist regarding specialized medicinal and ritual uses or sale of certain taxa, these are not topics that determine survival for an entire group. In contrast, food can determine survival of a population, and knowledge of wild edibles within an environment inhabited by different ethnic groups is less restricted by cultural boundaries.

Conclusion

Use of a variety of targeted quantitative methods in the analysis of ethnobotanical data can lead to new understandings of how people interact with plants for the purposes of food, health and survival. These tools can provide insight into the role that culture plays in guiding human interactions with environmental resources. We have described both divergent and convergent practices in ethnobotanical knowledge and practice in the two cultural groups studied,

Figure 4 | The unripe fruit of *Prunus domestica* L. is a favoured snack of Gorani and Albanian children in the region. (Photo by C.L.Q.).

linked in part to differing socioeconomic strategies and the state of isolationism of the Gorani from other Slavic populations (due to geopolitical influence) and of Gorani women from Albanians (due to marriage practices and linguistic barriers). Our hypothesis that the two groups would share a similar pattern of use of the wild flora for daily subsistence and medical practices was rejected on some levels. Our data demonstrate that a significant number of health strategies (including both the taxa cited and the manner of their use) are different in the two groups, and this is not restricted solely to those plants which play a key role in culture-specific ritual practices (for example *Salix alba*) or folk illnesses. Most interesting, however, is that the data revealed that when it comes to food security and mechanisms for coping with famine, ethnobotanical knowledge is far less restricted to specific ethnic groups, and is instead more widespread across the borderlines of gender, language and culture. In regions suffering from economic strife, poverty and hunger, such an understanding of the human–nature interface is critical to the future design of culturally appropriate, sustainable economic development and health promotion initiatives.

Methods

Ethnobotanical research. We conducted in-depth, semi-structured interviews concerning the traditional use of local ecological resources for food acquisition and production, human health strategies and other applications of economic importance in five rural communities in the Kukës district of the Gora Mountains. We interviewed 107 informants (44 Gorani and 63 Albanians, all over the age of 18) from the Gorani communities of Borje and Shishtavec, and the Albanian communities of Kollovoz, Novosej and Shtrezë, in May and June 2012. The distribution of gender was 56% female among Gorani informants and 43% female among Albanians. Interviews were conducted in either in Serbian or in Albanian, depending on which community we were visiting, with the help a simultaneous translator. Prior informed consent was always verbally obtained before conducting interviews and the ethical guidelines of the American Anthropological Association[18] were followed. During interviews, informants were asked to show the quoted plants. Digital photographs and voucher specimens were taken for all the quoted wild plants, when available. Vouchers were deposited at the Emory University Herbarium (GEO; Atlanta, GA, USA), Herbarium Universitatis Camerinensis (CAME; Camerino, Italy), and Herbarium Universiteti i Prishtinës (Prishtina, Kosovo). Taxonomic identification follows *Flora Europaea*[19] and *The Plant List*[20]. The Angiosperm Phylogeny Group III system was used for family assignments[21].

For the purpose of clarity, here we use the term '*use citation*' to refer to each mention of a plant use given by an informant. Data collected for a use citation of a given taxa included its local name(s), part(s) used, mode(s) of preparation, mode(s) of application, intended use or purpose, and information concerning the folkloric value or relevance to local traditions. The term '*plant use*' refers to either an individual use citation (from a single informant) or a group of matching use citations (provided by different informants) that maintain the same criteria for the part(s) used, mode(s) of preparation, mode(s) of application, and intended use or purpose of a given taxa. Identifying the number of *use citations* for a particular *plant use* is key to determining the fidelity level for a plant use within the study population.

Significance of plant uses. We employed Fisher's exact test to determine the significance of differences in the number of use citations (N_{uc}) for each unique plant use between groups. To do this for each use-report, we created a grid (Supplementary Fig. 1) containing the corresponding data for analysis, with a being the N_{uc} for group 1, b being the N_{uc} for group 2, c and d being the number of informants not reporting this specific use in groups 1 and 2, respectively. In each test, the column totals ($a + c$ or $b + d$) always equalled the total number of informants in each group (Gorani: 44; Albanian: 63). Data were analysed using the free statistical software 'R', with the following two lines of code:

```
>data<-matrix(c(a, b, c, d), ncol=2, byrow=T)>
>fisher.text(data)
```

The difference in N_{uc} between groups was considered statistically significant at a P-value < 0.05. The advantage of using Fisher's exact test here instead of other statistical tests (such as the Pearson's chi-squared test) is that while it is most useful for work with small sample sizes (with values of a, b, c or d being <10), it is also applicable to larger sample sizes. This approach provides a detailed evaluation of which plant uses for taxa are unique to the two groups under comparison.

Informant consensus factor. The categories selected for use in the F_{ic} analysis[22] are detailed in Supplementary Table 2. Each plant use was added to the appropriate category prior to analysis using the following formula:

$$F_{ic} = \frac{N_{uc} - N_t}{N_{uc} - 1}$$

where N_{uc} is the total number of use citations in each category and N_t is the number of taxa used in that category. High F_{ic} values (near 1.0) are obtained when one, or a few species, is reported to be used by a large proportion of informants for a particular category, whereas lower F_{ic} values indicate that informants disagree over which taxa to use. F_{ic} analysis was conducted on both the Gorani and the Albanian data sets separately for the purposes of comparison of informant consensus within each group.

Fidelity level. The Fidelity level (FL) percentage measure[23] was used to identify the central role of each reported taxa, as agreed upon by both groups. The FL was defined as the ratio of the total number of informants that independently cited a

specific plant use (N_p) and the total number of informants (N) that cited the plant for any use:

$$FL = \left(\frac{N_p}{N}\right) \times 100$$

For the purposes of identifying plant uses with the highest joint FL, the number of use citations (N_{uc}) by Gorani and Albanian informants was combined in this analysis. The main limitation of this method is that for taxa with few citations (three or fewer), the fidelity level may appear to be artificially high. Thus, taxa with only a few citations were excluded from this analysis.

Use-value for individual species. The use-value (UV_c) citation index[24] was calculated for each species and in each group. This index is useful for evaluation of the relative importance of each species based on its cited uses. Briefly, it is calculated as follows:

$$UV_c = \frac{\sum^{U_{is}}}{N}$$

where U_{is} is the sum of the total number of use citation reports concerning a given species, divided by the total number of informants (N). Although traditionally this index has been used for comparison of plant use within the same sample population, we propose a new method for using this tool to compare relative plant importance between two groups (see below).

Use-value matrix design and analysis. We designed a new approach for the comparative analysis of how use-values differ in two well-defined groups. The UV_c data for each group were plotted using a standard scatterplot, with group 1 (Gorani) data corresponding to the x-axis and group 2 (Albanian) data to the y-axis.

Quadrants were created as an overlay on the scatterplot data. The point of intersection was located at ($UV_{max}/2$), with UV_{max} equal to the maximum UV_c value identified (from either one of the two groups under study). For example, if the maximum use-value (UV_{max}) is equal to 1, then the quadrants should intersect at ($UV_{max}/2$), or 0.5 in this example, on the x- and y-axes. The UV_{max} may be greater than 1.0 in a data set if individual informants cite multiple uses for the same species. The four quadrants were subdivided to create a final total of eight regions, numbered I–VIII (Fig. 2a).

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Author contributions

C.L.Q. and A.P. conceived and designed the study, performed the interviews, and analysed the data. C.L.Q. wrote the paper and A.P. provided revisions.

Additional information

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Competing interests

The authors declare no competing financial interests.