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Ecological fingerprints of mountain migration in wild food plants of North Macedonian and other Balkan Gorani

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Abstract

The Gorani communities of the Shar Mountain region (located at the crossroads among North Macedonia, Albania, and Kosovo) possess a rich traditional knowledge, especially on wild food plants (WFPs), home-made teas, and medicinal plants, reflecting both ecological adaptation and cultural identity. After studying the Kosovar and Albanian Gorani over the past decade, this study aimed to document and compare WFP use among these communities on the North Macedonia side, with a particular focus on patterns of continuity and divergence over time and space. Fieldwork involved ethnobotanical surveys, interviews, and participant observation, resulting in an inventory of 65 identified taxa among the Gorani of North Macedonia. A total of 96 botanical species were observed across the three communities. Species such as *Allium* spp., *Cornus mas* L., *Prunus cerasifera* Ehrh., *Rubus fruticosus* L., *Rumex patientia* L., and *Vaccinium myrtillus* L. emerged as a shared cultural core, consistently utilised for culinary purposes. Shannon diversity (H') and Pielou's evenness (J') indices revealed a combination of dominant, commonly used species and a wide array of less frequent taxa, highlighting both nutritional and cultural resilience. A comparative analysis revealed substantial overlap between the Macedonian and Albanian Gorani, reflecting shared ancestry and historical exchange. In contrast, Kosovar Gorani exhibited reduced diversity, likely due to migration, possible cultural assimilation to Serbian culture, and the depopulation of villages. Community-specific taxa illustrate localised ecological knowledge and cultural adaptation. The findings underscore the importance of WFPs as markers of Gorani identity and demonstrate how demographic and socio-political changes influence the transmission and retention of ethnobotanical knowledge. This study contributes to the understanding of biocultural diversity in Balkan Mountain communities and provides a foundation for future conservation and cultural heritage initiatives.

Keywords Gorani, Ethnobotany, Wild food plants, Wild teas, Traditional knowledge, Biocultural diversity, Human ecology, Balkans

1 Introduction

Ethnobotanical studies increasingly recognise that plant knowledge is not only a practical tool for subsistence but also a marker of cultural identity and food heritage, reflecting both ecological adaptations and socio-historical processes [1–3]. In this context, "cultural keystone species" play a central role by structuring foodways, rituals, and local economies, thereby anchoring collective memory and identity [1]. Previous research in the Balkans has highlighted substantial diversity in wild food plants (WFPs); yet comparative studies across neighbouring communities remain rare, particularly for small, dispersed minorities such as the Gorani [4–6].

One of the most promising directions in current ethnobiological research involves cross-cultural comparisons of folk food plant uses among contiguous ethnic or religious groups, or among diasporas [7–9]. Such studies offer insights into how cultural, social, and even politico-economic dynamics influence the use and preference of plant ingredients in local cuisines, even when environmental resources are similar [10, 11]. Previous studies in Eastern Europe have demonstrated that artificial borders and geopolitical changes can create cultural isolation, leading to divergence in ethnobotanical knowledge even among populations sharing the same ethnic "stock" [12].

The Gorani, a Slavic-speaking minority inhabiting the Shar Mountain region, are an exemplary case for such comparative research. The Gorani population was divided by the redrawing of borders in 1925, which placed some villages within Albania, others in Kosovo (formerly part of Yugoslavia), and the remaining villages in North Macedonia [13]. These communities have since experienced different sociopolitical trajectories: Kosovar Gorani integrated more extensively into urban networks and experienced frequent labour migration; Albanian Gorani remained highly isolated under the communist regime, particularly women; and Macedonian Gorani today live in semi-empty villages, reflecting recent depopulation trends [14]. This historical separation and contemporary demographic change make the Gorani ideal subjects for assessing continuity and change in traditional plant knowledge over space and time.

Despite their rich cultural heritage, Gorani communities remain understudied. We conducted ethnobiological fieldwork in 2012 and 2016 among Albanian (ALB) and Kosovar (KS) Gorani [11, 15]. The current study, among the last remaining two Gorani villages in North Macedonia, finally allows us to evaluate similarities and differences in WFP knowledge and use across these three groups divided by old and modern borders, which can illuminate not only ecological and nutritional strategies but also the resilience of cultural identity, mechanisms of knowledge transmission, and the influence of migration and village depopulation over the last decade.

Building on these insights, our study aimed to (i) document and analyze the wild food plants and teas used by the Gorani in North Macedonia; (ii) compare patterns of plant use and knowledge continuity across the three Gorani groups living in North Macedonia, Albania, and Kosovo; and (iii) identify key species that act as cultural keystone taxa, reflecting both ecological adaptation and the maintenance of Gorani identity. This comparative approach enables us to examine both the persistence and erosion of traditional ethnobotanical knowledge in communities influenced by isolation, migration, and demographic shifts.

2 Materials and methods

2.1 Ethnographic background

The Gorani are a small, isolated Slavic Muslim minority inhabiting the mountainous region of Gora in southern Kosovo (now part of the District of Dragash/Dragaš), as well as parts of northeastern Albania and northwestern North Macedonia. They represent a minority who were relatively recently Islamised, around the mid-19th century [16], compared with other Balkan Muslim groups. Historically, the Gorani have maintained a strong sense of cultural distinctiveness, practised strict endogamy, and preserved their unique language, locally known as Našinski (meaning "ours"). This Torlakian dialect bridges the Bulgarian Macedonian and Serbo-Croatian linguistic groups [17]. In Kosovo, the Gorani inhabit nineteen villages, while nine exist in Albania and only two remain in North Macedonia. They retain a distinct cultural identity and generally reject classification as Serbian, Macedonian, or Bulgarian. In recent census data, a few Kosovar Gorani identified as Bosniaks, likely due to local political circumstances rather than genuine ethnolinguistic affiliation. Marriage continues primarily within the Gorani community, reflecting enduring endogamy. Among Kosovar Gorani, there is widespread support for the establishment of an autonomous Gora municipality [15] reflecting aspirations for local governance and cultural conservation.

2.2 Study site and fieldwork

The Gorani territory lies within the Shar Mountain system, characterised by steep relief reaching elevations of up to 2,800 m, harsh continental winters with heavy snowfall, and high biodiversity. The region hosts around 2,000 vascular plant species, including approximately 150 endemics, as well as rare and relic plant communities [18]. The fauna consists of large mammals, including lynx, bear, chamois, wolf, and roe deer. Historically, the Gora region has been economically disadvantaged and remains among the poorest areas in Kosovo. Traditional livelihoods, centred on cattle pastoralism and seasonal labour migration, continue, with many community members working abroad in Italy, Austria, and Serbia; remittances now constitute the primary source of household income [15].

Fieldwork for this study focused on wild food plants (WFPs) and wild teas, conducted in the spring of 2025, in the two North Macedonian Gorani villages of Urvič and Jelovjane (Figs. 1 and 2), interviewing 32 study participants aged between 45 and 83 years. The first settlement still has a few hundred permanent inhabitants. In contrast, in the second, only a handful of families still reside there, with a significant number of returnees in both villages during the weekend (those who mainly work and live in other parts of NW North Macedonia) and in the summer (those migrant workers living in Western Europe). Despite Urvič being quoted in old Ottoman historical sources as early as the 15th century as a Christina Orthodox village [19, 20], according to our local oral elderly sources, both villages originated their current ethnic core from migration waves of Gorani peoples approximately two hundred years ago moving from the upper Gora region (nowadays Kosovo) and, especially, from the Borje area and its surrounding settlements (nowadays Albania). Comparative data were drawn from previous ethnobotanical studies conducted in winter 2015 among Gorani in the Gora region of Kosovo (Fig. 2) and in NE Albania (Borje/Shishtavec, spring 2012, Fig. 2), allowing a cross-regional comparison of WFP knowledge. In the comparative study in Kosovo, thirty-five

Fig. 1 Urvič village in spring 2025, seen from Jelovjane (Photo: A. Pieroni)

Fig. 2 Map of the study site showing the visited Gorani villages in North Macedonia (red circles) and the other Gorani villages, previously visited in 2012 and 2015 [15, 23]

primarily mid-aged and elderly male farmers, shepherds, and retired workers participated, with limited female involvement due to social and religious restrictions [21]. In the comparative study in Albania, forty-one informants aged 26–82 were interviewed.

In the current study in North Macedonia, participants across age groups were asked about currently foraged or remembered wild and semi-domesticated food plants (including wild vegetables, wild fruits, wild seasoning plants and wild plant additives), herbal teas, as well as about those few cultivated plants, whose food use diverged from the usual path; informants were also engaged in walks in surrounding areas, verified plant identification and ecological context for each single mentioned taxon. Informed

consent was always verbally obtained before conducting interviews, and researchers adhered to the Code of Ethics of the International Society of Ethnobiology [22].

Across all three regions, semi-structured interviews documented local plant names, used parts, local uses, and detailed preparation practices. Since in one of the comparative works (among Albanian Gorani) also medicinal plants and other home-remedies were included, only wild food plants and wild teas were included in the comparative analysis; externally used medicinal uses were excluded to ensure consistency with the two other datasets. Quoted folk plant names were compared with those arising from the previous studies of 2012 and 2015 conducted in the same area (other side of the mountain), in which we collected vouchers [23, 24] or we referred to previously collected vouchers [15]. Participants were engaged in guided walks to verify plant identification and ecological context for each taxon. Voucher specimens collected during the 2025 fieldwork are stored in the herbarium of Ca' Foscari University of Venice (UVV), bearing numbers UVVETBOT01–33, and plant identification was carried out by Prof. Renata Soukand and the last author Professor Andrea Pieroni. Quoted folk plant names were compared with those from the 2012 and 2015 studies conducted in adjacent areas, where vouchers had been collected [23, 25] or previously referenced [15]. Botanical nomenclature followed the World Flora Online database, family assignment followed the Angiosperm Phylogeny Group III (APG III) classification [26], and fungal nomenclature followed Index Fungorum (2025) [27]. Due to the absence of a standardised written Gorani language, all plant names were transliterated as heard from the study informants using the Latin alphabet.

All plant collection and identification activities complied with relevant institutional, national, and international regulations, including the International Union for Conservation of Nature (IUCN) Policy Statement on Research Involving Species at Risk of Extinction and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). No threatened or endangered species were collected without appropriate permissions. Collection of plant specimens was conducted under the permission of the Ministry of Environment and Physical Planning of the Republic of North Macedonia which authorizes the collection of non-protected wild plant material for scientific research purposes.

2.3 Data analysis

The primary objective of this study was to document and compare the use of wild food plants (WFPs) and wild teas among Gorani communities in North Macedonia (MKD), Kosovo (KS), and Albania (ALB), with a focus on identifying patterns of continuity, transformation, and potential erosion in traditional ecological knowledge.

All ethnobotanical data were compiled into a species-level database, including botanical and local Gorani names, plant parts used, preparation methods, and occurrence across the three regions. To ensure comparability, only wild food plants and wild teas were included; cultivated species and external medicinal uses were excluded. Descriptive statistics were calculated to summarise the number of species recorded per community, their distribution across plant families, and the variety of preparation methods. These analyses were performed using SAS software (version 9.4, SAS Institute, Cary, NC, USA). To assess similarities and differences among the Gorani populations, species × community occurrence matrices were constructed. Patterns of presence and absence

were visualised using a Venn diagram in R 4.4.3, allowing for the identification of species consistently used across all communities versus those unique to a specific region—hierarchical clustering of the species × community matrix grouped plants based on similarity in regional usage patterns. Principal Component Analysis (PCA) was further applied to examine the relationships among communities based on the plant parts used and citation frequency, with biplots identifying which plant parts contributed most to the variation in use. Finally, Shannon diversity (H') and Pielou's evenness (J') were calculated to quantify the diversity and distribution of plant use across commonly, rarely, and very widely cited species, providing a comprehensive assessment of ethnobotanical knowledge within and among Gorani communities. This integrated framework allows a robust evaluation of the persistence, transformation, and potential erosion of traditional ecological knowledge among Gorani communities.

3 Results

3.1 Ethnobotanical inventory of wild food plants and teas in Gorani communities

A total of 96 taxa were recorded across the three Gorani communities (MKD, ALB, and KS), reflecting a rich diversity of wild food resources used for food and beverages, particularly in the preparation of teas. These taxa include vascular plants identified at species and genus level, fungi, and one animal-derived food resource.

Several species, including *Allium* spp., *Cornus mas* L., *Prunus cerasifera* Ehrh., *Rubus fruticosum* L., *Rumex patientia* L., and *Vaccinium myrtillus* L., were shared across all communities (Table 1), highlighting a core set of culturally and nutritionally essential plants. The dataset shows that Gorani communities utilise a wide range of plant parts, leaves, fruits, roots, bulbs, flowering tops, and tubercles, demonstrating the multifunctionality of wild plants in culinary practices. Food uses were highly diverse, encompassing fresh consumption, jams, beverages (such as sok), teas, salads, and fermented products. The frequency of citation varied among species, with some plants being commonly cited (C), others rarely cited (R), and some being ubiquitous (VC), reflecting differences in local preference, ecological availability, and knowledge transmission. The MKD Gorani used 58 species, the ALB Gorani 42 species, and the KS Gorani 31 species as shown in Table 1, indicating the highest plant diversity in North Macedonia and comparatively lower diversity in Kosovo. Species overlap highlights shared traditional knowledge, whereas community-specific taxa reflect localised ecological conditions and cultural preferences. Overall, these results illustrate both the richness and the variation of ethnobotanical expertise within and among Gorani communities, providing a solid foundation for further analyses of plant use, preparation methods, and cross-community patterns.

3.2 Patterns of continuity and divergence in Gorani wild food plant knowledge

The comparative analysis of wild food plants (WFPs) among Gorani communities (Fig. 3) revealed significant variation across regions, pointing to heterogeneous knowledge systems shaped by local ecology and cultural history. The Macedonian Gorani displayed the highest number of unique taxa (31 species). The Albanian Gorani reported 21 unique taxa. The Kosovar Gorani presented 17 unique taxa, a smaller corpus that may reflect ongoing demographic dispersal, cultural assimilation, and reduced intergenerational transmission of plant knowledge, especially in the largest settlement of Restelica.

Overlap patterns are particularly informative: Macedonian and Albanian Gorani shared 13 taxa (*Carlina* sp., *Corylus avellana*, *Fragaria vesca*, *Juglans regia*, *Juniperus communis*, *Lamium* spp., *Malva sylvestris*, *Mentha spicata*, *Origanum vulgare*, *Plantago major*, *Prunus spinosa*, *Rosa canina*, *Sempervivum tectorum*), a finding that points to strong cultural continuity and historical exchange between these geographically close groups, rooted in the fact that the Macedonian Gorani villages mainly originated from migration from the Albanian Gorani villages. In contrast, overlap between Albanian and Kosovar Gorani was minimal (1 shared taxon), suggesting more fragmented cultural transmission across this boundary. At the intersection of all three groups, six resilient taxa, *Allium* spp., *Cornus mas*, *Prunus cerasifera*, *Rubus fruticosus*, *Rumex patientia*, and *Vaccinium myrtillus*, emerged as a cultural and ecological core, consistently retained despite geographic isolation, migration, and socio-religious changes.

The analysis of the frequency of citation (FC) of wild plants among the Gorani communities reveals distinct patterns in knowledge and use across the three groups. The most frequently cited category, "C" (commonly cited), accounts for 45 instances overall, with the highest number observed in the MKD community (38 taxa), followed by ALB (14) and KS (13). This indicates that a core set of plants is recognised and used across the communities, particularly in MKD. The "R" (rarely cited) category shows 39 occurrences in total, with ALB leading (22 taxa), KS with 12, and MKD with 17, reflecting the presence of less commonly specialised taxa in local use. The "VC" (very commonly cited) group comprises 12 taxa, most prominent in ALB and KS (6 each), and less so in MKD (3), representing plants known or used by the majority of the informants, which possess generalist or widespread culinary purposes. Overall, Fig. 3 highlights both the shared knowledge of widely used plants and the community-specific variations in less common plants, emphasising the role of local ecological availability and cultural practices in shaping plant use among the Gorani communities. To statistically assess whether the frequency of citation of wild plants differs among Gorani communities, we applied Pearson's Chi-squared test, which indicated a significant association between plant citation frequency and community ($X^2 = 12.88$, $df = 4$, $p = 0.0$). Given the relatively small sample sizes in some categories, Fisher's exact test was also performed, confirming a significant difference ($p = 0.0099$). To quantify the strength of this association, Cramer's V was calculated, yielding a value of 0.41, indicating a moderate association between community and frequency of citation. These results support the conclusion that Gorani communities show distinct patterns in their use and reporting of wild plants, reflecting both cultural preferences and local availability (Fig. 4).

3.3 Patterns of plant part use and diversity among Gorani communities

The PCA of plant parts used by Gorani communities highlights patterns of similarity and divergence in utilisation among the three communities (Fig. 5). The first two principal components capture the majority of the variance in the dataset, separating plant parts according to their predominant use by each community.

Points colored by community reveal that certain plant parts are primarily used in a single community: for example, leaves and common fruits such as *Cornus mas*, *Fragaria vesca*, and *Vaccinium myrtillus* cluster closely across all communities, indicating shared usage. Conversely, plant parts such as roots (*Bryonia alba*, *Chenopodium bonus-henricus*) and flowering aerial parts (*Hypericum perforatum*, *Matricaria recutita*) are more

Table 1 Wild and semi-domesticated food taxa (vascular plants identified at species and genus level, fungi, and one animal-derived resource), including food plants, insects, mushrooms, and herbal teas, quoted by Gorani communities in North Macedonia (MKD), Albania (ALB, appearing in italics), and Gorani communities in Kosovo (KS), appearing in bold

Taxon	Gorani communities			Herbarium specimen codes	Local folk name(s)	Part used	Local food use(s) and eventual medicinal perceptions or treated illnesses	Frequency of citation
	MKD	ALB	KS					
**Agaricus campestris* L.	No	No	Yes		**Pečurka**, **Šumski Šampignon**	**Fruiting body**	**Cooked**	R
Allium ampeloprasum L.	No	Yes	No	PRN-11/Pz/2No13, PRN-No9/Pz/2No13, PRN-1No/Pz/2No13	*Divlji luk*, *Kromit*	*Aerial parts*	*Tea: constipation*, *belly-ache*	R
Allium schoenoprasum L.	No	Yes	No		*Vlašec*	*Aerial parts*	*Snack*	R
Allium spp.	Yes	Yes	Yes		Divj luk	Leaves	Leaves used as seasoning (MKD, ALB, KS)	R
					Bet luk	*Bulbs*	*Tea*	R
Allium ursinum L.	Yes	No	Yes		Mečkin luk	Aerial parts	Snack	New
					Medvedži luk	**Leaves**	**Salad**	R
**Amanita caesarea* (Scop.) Pers.	No	No	Yes		**Jajčarka**	**Fruiting body**	**Cooked**	R
Anacamptis morio (L.) R.M.Bateman, Pridgeon & M.W.Chase	Yes	No	No		Plav sahlp	Tubercoles	Tea: cough, panacea	C
Arctostaphylos uva-ursi (L.) Spreng.	Yes	No	No		Mečkino grozje, Uvin čaj	Leaves	Tea: constipation, belly-ache	C
						Fruits	snack	R
Artemisia absinthium L.	Yes	No	No		Pelin	Aerial parts	Tea	R
Asphodelus albus Mill.	No	Yes	No		*Bater*, *Boter*, *Kalaviça*	*Above-ground parts*, *flowers*	*Yoghurt starter*	New
Atriplex hortensis L.	No	No	Yes		**Laboda**	**Leaves**	**Filling for börek/pita**	C
Beta vulgaris L.	No	Yes	No		*Repa*	*Aerial parts*, *Roots*	*Seasoning*	R
Black ants	Yes	No	No		Mravki	Whole body	Yoghurt starter "Black ants" refers to an edible insect historically consumed as part of the Gorani diet	Past
**Boletus* spp.	Yes	No	Yes		Pečurka	fruiting body	Cooked	New

Table 1 (continued)

Taxon	Gorani communities			Herbarium specimen codes	Local folk name(s)	Part used	Local food use(s) and eventual medicinal perceptions or treated illnesses	Frequency of citation
	MKD	ALB	KS					
					Vrgan	**Fruiting body**	**Cooked**	R
**Bovista* spp.	Yes	No	Yes		Pufka	Fruiting body	Fried	New
					Bela lutika	**Fruiting body**	**Cooked**	R
Brassica oleracea L.	No	No	Yes		**Kupus**	**Leaves**	**Lacto-fermented in brine; juva consumed**	VC
Bryonia alba L.	No	Yes	No		*Divja tikva, Tikva*	*Roots*	*Sarma*	R
**Cantharellus cibarius* Fr.	No	No	Yes		**Lisičerka**	**Fruiting body**	**Cooked**	R
Carlina sp.	Yes	Yes	No	PRN-41/Pz/2No13	Oreška	*Flowers*	*Fried*	New
					Dzindzer	Flower receptacles	Snack	R
Castanea sativa L.	Yes	No	No		Kosten	Fruits	Boiled, roasted, slatko	R
Centaurium erythraea Rafn	Yes	No	No		Crven kantarion, černo Kantarion	Flowering tops	Tea: digestive	C
Chenopodium album L.	No	No	Yes		**Divja laboda**	**Leaves**	**Filling for börek/pita**	C
Chenopodium bonus-henricus L.	No	Yes	No		*Čuen, Halvatanlia*	*Roots*	*Snack*	R
Chenopodium spp.	Yes	No	No		Divja loboda	Leaves	Pies	R
Cicer arietinum L.	Yes	No	No		Naud	Seeds	Bread yeast	C
Cornus mas L.	Yes	Yes	Yes	CAME-26,279, PRN-23/Pz/2No13, UVVETBOTMAK16	Dren	Fruits	Snack, sok, jam, oshaf	C
					Drenina	**Fruits**	**Beverage (sok)**	VC
					Dren	*Fruits*	*Bread yeast*	VC
Corylus avellana L.	Yes	Yes	No	CAME-26,242, GEO-No2NoNo39, PRN-24/Pz/2No13	Lešnik	Leaves	Sarma	R
						Kernels	Snack	C
					Lejthia	*Fruits*	*Tea: digestive*	R
Crataegus germanica (L.) Kuntze	-	No	No		Mushmulla	Fruits	Snack (also with the seeds), tea	C

Table 1 (continued)

Taxon	Gorani communities			Herbarium specimen codes	Local folk name(s)	Part used	Local food use(s) and eventual medicinal perceptions or treated illnesses	Frequency of citation
	MKD	ALB	KS					
Crataegus laevigata (Poir.) DC.	Yes	No	No			Flowering topics	Tea	C
Crataegus monogyna Jacq.	Yes	No	No		Glog	Fruits	Snack: cardiotonic	C
Dactylorhiza spp.	Yes	No	No		Sahlep	Tubercoles	Tea: cough, panacea	C
Daucus carota L.	No	No	Yes		**Sargarepa**	**Roots**	**Lacto-fermented in brine - the resulting liquid (juva) is drunk**	C
Equisetum arvense L.	Yes	No	No		Konski opaš, Konsko opavče	Aerial parts	Tea: digestive	C
Fagus sylvatica L.	Yes	No	No		Buka	Young leaves	Snack, salads	C
Fragaria vesca L.	Yes	Yes	No	CAME-26,247, GEO-No2NoNo48, UVVETBOTMAK33	Šumska jagoda	Fruits	Snack, sok, jam	C
					Jagoda	*Fruits*	*Snack, tea*	R
Geranium macrorrhizum L.	Yes	No	No	UVVETBOTMAK27	Zdravec	Leaves	Tea	R
Helianthus tuberosus L.	No	No	Yes		**Oraške**	**Tubers**	**Consumed raw as a snack**	R
Hordeum vulgare L.	No	No	Yes		**Ječmen**	**Grain**	**Roasted, in decoction**	R
Hypericum perforatum L.	Yes	No	No		Kantarion, Kantorion, Zhuto kantarion	Flowering tops	Tea; oleolite: drunk as a digestive	R
Juglans regia L.	Yes	Yes	No	CAME-26,238, PRN-4No/Pz/2No13	Oreh	Kernels	Snack, sweets	C
						Unripe fruits	Slatko	C
					Orah	*Leaves*	*Tea: digestive*	R
Juniperus communis L.	Yes	Yes	No	CAME-26,253, PRN-39/Pz/2No13, UVVETBOTMAK06	Smreka	Cones	Snack, sok: kidney, prostatitis, aphrodisiac for males	C
	Yes	Yes	No		*Smreka*	*Galbules*	*snack*	R
Lamium spp., including L. *album* L. and *L. purpureum* L,	Yes	Yes	No	UVVETBOTMAK23	Divja kopriva	Aerial parts	Tea: panacea	R
					Pieške	*Leaves*	*Snack, salads*	New
Malus domestica (Suckow) Borkh.	No	No	Yes		Jaboka	**Fruits**	**Beverage (sok)**	R

Table 1 (continued)

Taxon	Gorani communities			Herbarium specimen codes	Local folk name(s)	Part used	Local food use(s) and eventual medicinal perceptions or treated illnesses	Frequency of citation
	MKD	ALB	KS					
Malus sylvestris (L.) Mill.	Yes	Yes	Yes	CAME-26,236, CAME-26,288	Divja jabolka	Fruits	Vinegar: anti-diabetic; oshaf	C
						Fruits	Yoghurt starter	Past
					Divjačica, **Divja jaboka**, **Planinska jabuka**	**Fruits**	**Beverage (sok); fermented to vinegar; lacto-fermented**	VC
					Divja jabučica, *Šumska jabučica*	*Fruits*	*Pekmez*	C
Malva sylvestris L.	Yes	Yes	No	PRN-44/Pz/2No13, UVVETBOTMAK29	Čardarče	Root juice	Yoghurt starter	Past
					Mollagë	*Roots*	*Tea; oleolite: drunk as a digestive*	R
Matricaria chamomilla L.	Yes	No	No		Kamilica	Flowering tops	Tea	C
Mentha spicata L.	Yes	Yes	No	UVVETBOTMAK22	Menta, Lutošerče, Nana	Leaves	Seasoning, tea	C
					Nanadzik	*Leaves*	*Snack, sok, jam*	R
Morus spp.	Yes	No	No		Cernica	Fruits	Pekmez	C
Narcissus poeticus L.	No	Yes	No		*Lule shek*	*Flowers*	*Cooked*	New
Orchis mascula (L.)L.	No	Yes	No	PRN-15/Pz/11	*Kukaica*, *Salep*	*Rhizomes*	*Snack, sweets*	VC
Origanum vulgare L.	Yes	Yes	No	GEO-No2NoNo49, PRN-52/Pz/2No13	Planinski čaj	Flowering tops	Tea	C
					Šumski čaj, *Trava šumska*	*Flowering aerial parts*	*Tea*	R
Pelargonium graveolens L'Hér.	Yes	No	No	UVVETBOTMAK21	Karaifil, Kacanocveče	Leaves	Tea, slatko	R
Phaseolus vulgaris L.	No	Yes	No	PRN-62/Pz/2No13	*Fasulje*	*Fruits*	*Tea*	New
Plantago lanceolata L.	No	Yes	No	GEO-No2NoNo53	*Telenčit*	*Leaves*, *Flowers*	*Slatko*	R
Plantago major L.	Yes	Yes	No	GEO-No2NoNo43, PRN-54/Pz/2No13, UVVETBOTMAK17	Tegavic, Dzivovlak	Leaves	Tea	C
					Bukvica, *Papučica*, *Papuvčoci*, *Belesviče*	*Leaves*	*Snack, sok, tea: kidney, prostatitis, aphrodisiac for males*	R
Populus spp.	Yes	No	No	UVVETBOTMAK05	Topola	Young bark	Tea: diabetes, high cholesterol	C
Primula veris L.	Yes	No	No	UVVETBOTMAK24	Goralja	Flowers	Tea and syrup: cough (esp. for kids)	C
Prunus avium L.	Yes	No	Yes		**Trešnja**	**Fruits**	**Beverage (sok)**	R

Table 1 (continued)

Taxon	Gorani communities			Herbarium specimen codes	Local folk name(s)	Part used	Local food use(s) and eventual medicinal perceptions or treated illnesses	Frequency of citation
	MKD	ALB	KS					
					Divja čerešnja, Višna	Fruits	Snack, sok, jam	C
Prunus cerasifera Ehrh.	Yes	Yes	Yes	CAME-26,298, CAME-26,239, PRN-55/Pz/2No13, UVVETBOTMAK26	Dzenarika, Kaissi	Fruits	Sok, jam, oshaf	C
						Unripe fruits	Snack	C
					Divlia šliva, **Dženarika**	**Fruits**	**Beverage (sok); dried and consumed**	VC
					—	**Unripe fruits**	**Rennet to curdle milk**	R
					Diva sliva	*Fruits*	*Tea: cough, panacea*	R
Prunus domestica L.	No	No	Yes		**Sliva**	**Fruits**	**Beverage (sok); dried and boiled (oshaf); concentrated juice compote**	VC
					Divlia šliva, **Dženarika**	**Unripe fruits**	**Beverage (sok); fermented to vinegar**	C
Prunus spinosa L.	Yes	Yes	No	CAME-2626No	Trlinka, Trnika	Fruits	Snack, tea	C
					Beleusdre, *Trnka*	*Fruits*	*Tea*	R
Prunus spp.	No	Yes	No	CAME-263No6, PRN-58/Pz/2No13	*Kisile sliva*	*Fruits*	*Tea*, *slatko*	R
Pyrus communis L.	No	No	Yes		**Hruška**	**Fruits**	**Beverage (sok)**	C
Pyrus pyraster L.Borkh.	Yes	Yes	No	CAME-26,244	*Divlja kruška*	Fruits	*Tea*	R
					Divja khruska	Fruits	Snack, sok, jam, oshaf: digestive	C
Ribes rubrum L.	Yes	No	No	UVVETBOTMAK28	Divja ribisla	Fruits	Snack, sok, tea	R
Robinia pseudoacacia L.	Yes	No	No		Bagren	Flowers	Snack	C
Rosa canina L.	Yes	Yes	No	GEO-No2NoNo34, PRN-67/Pz/2No13, UVVETBOTMAK10	Šipunka, Trendafil	Pseudofruits	Sok, slatko, tea	Past
						Stems ("Bobojan")	Stems	R
					Šip, *Šipunka*	*Fruits*	*Tea: diabetes, high cholesterol*	VC
Rubus fruticosus L.	Yes	Yes	Yes	GEO-No2NoNo5No, PRN-65/Pz/2No13, UVVETBOTMAK03	Kapina	Fruits	Snack, sok, jam, oshaf	C
					Kapina, **Kupina**	**Fruits**	**Consumed raw; beverage (sok)**	C
					Cernica, *Kapina*	*Leaves*, *Fruits*	*Tea and syrup: cough (esp. for kids)*	R

Table 1 (continued)

Taxon	Gorani communities			Herbarium specimen codes	Local folk name(s)	Part used	Local food use(s) and eventual medicinal perceptions or treated illnesses	Frequency of citation
	MKD	ALB	KS					
Rubus idaeus L.	Yes	No	Yes	UVVETBOTMAK19	Malina	Fruits	Snack, sok, jam, oshaf	C
					Malina	**Fruits**	**Consumed raw; beverage (sok)**	VC
Rumex acetosa L.	Yes	No	No	UVVETBOTMAK32	Kiselica	Tops (stems and young leaves)	*Snacks*	C
Rumex acetosella L.	No	Yes	No		*Uthulla*	*Leaves*	*Vinegar: anti-diabetic; oshaf*	New
Rumex alpinus L.	No	Yes	No		*Liakër bjeshka*, *Liakër e egër*	*Leaves*	*Yoghurt starter*	R
Rumex crispus L.	No	Yes	No		*Šušlak*	*Leaves*	*Yoghurt starter*	R
Rumex patientia L.	Yes	Yes	Yes	CAME-26,285, UVVETBOTMAK07	Štavel	Leaves	pies, sarma	C
					Šavel, **Štavel**	**Leaves**	**Filling for börek/pita**	VC
					Štavel	*Leaves*	*Tea*	R
Rumex pulcher L.	No	Yes	No		*Kiselica*	*Leaves*	*Seasoning, tea*	R
Sambucus nigra L.	Yes	No	No		Harbus	Inflorescences	Tea, sok	C
Secale cereale L.		Yes	No	UVVETBOTMAK11	*Erš*	*Fruits, Kernels, Fruits ground into flour*	*Tea: panacea*	C
Sempervivum tectorum L.	Yes	Yes	No	GEO-No2NoNo35, PRN-71/Pz/2No13, UVVETBOTMAK13	Čuvarkuča	Leaves	Snack: digestive	R
					Bjelesnik	*Leaves*	*Snack, sok, jam, oshaf*	R
Silene vulgaris (Moench) Garcke	Yes	Yes	No	UVVETBOTMAK25	*Šripec*	*Leaves*	*Pies*	R
					Škripets	Leaves	Pies	C
Solanum lycopersicum L.	No	No	Yes		**Patlidžan**	**Fruits**	**Lacto-fermented in brine; liquid (juva) consumed**	VC
Solanum tuberosum L.	No	No	Yes		**Kompir**	**Young leaves**	**Filling for börek/pita**	R
Sonchus oleraceus L.	No	No	Yes		**Šušlak**	**Leaves**	**Filling for börek/pita**	R
Sonchus spp.	No	Yes			*Šušlac*	*Leaves*	*Snack*	R

Table 1 (continued)

Taxon	Gorani communities			Herbarium specimen codes	Local folk name(s)	Part used	Local food use(s) and eventual medicinal perceptions or treated illnesses	Frequency of citation
	MKD	ALB	KS					
Rumex spp.	No	No	Yes		**Kiselica**	**Leaves**	**Filling for yoghurt yoghurt starter**	VC
Taraxacum officinale agg.	Yes	Yes	Yes	CAME-26,289, GEO-No2NoNo44, PRN-84/Pz/2No13, UVVETBOTMAK02	Gluarče, Maslačak	Leaves	Snack, salads	C
						Flowers	Oil macerate (under sunshine): drunk for cough; "honey"=jam (cooked in sugar), tea: cough	C
					—	**Young leaves**	**Salads**	R
					Bunbarocveče, Cvetocveče	*Leaves*	*Boiled, roasted, slatko*	R
Thymus serpyllum L.	Yes	No	No	UVVETBOTMAK09	Matarka, Mačina dušnica	Aerial parts	Seasoning, tea	C
Tilia tomentosa Moench	Yes	No	No	UVVETBOTMAK04	Lipa	Flowers	Tea: belly-ache	C
Trifolium spp.	No	Yes	No	GEO-No2NoNo51, PRN-36/Pz/2No13	*Šarirulk, Šarisurke, Šariluke*	*Aerial parts*	*Tea: cough, panacea*	R
Urtica dioica L.	Yes	No	Yes	UVVETBOTMAK07	Kopriva	Leaves	Pies, cooked with rice and onions (buranje), soups	C
						Roots	Yoghurt starter (squeezed–> juice)	C
					Kopriva	**Leaves**	**Filling for pies**	VC
Vaccinium myrtillus L.	Yes	Yes	Yes	GEO-No2NoNo4No, PRN-87/Pz/2No13	Borovinka	Fruits	Sok, jam, perkmez, tea	C
						Flowering tops	Tea: appetising	C
						Leaves	Tea: bronchitis	C
					Borovnica, **Čeršune**, **Groždze**, **Zelenj čaj**	**Fruits**	**Beverage (sok); fermented and distilled in raki**	VC
					Borovnica, Čaršikle, Čeršikle, Čeršine	*Fruits*	*Snack: cardiotonic*	VC

Table 1 (continued)

Taxon	Gorani communities			Herbarium specimen codes	Local folk name(s)	Part used	Local food use(s) and eventual medicinal perceptions or treated illnesses	Frequency of citation
	MKD	ALB	KS					
Verbascum phlomoides L. and *V. thapsus* L.	Yes	No	No	UVVETBOTMAK20, 30 31	Boblak, Boblok	Flowers	Tea: cough	C
Zea mays L.	No	No	Yes		**Kukuruz**	**Grains / Flour**	**Fermented to boza (lacto-fermented beverage)**	C

New: reported by the study participants as a newly introduced custom, not present in the local traditional knowledge; Past: reported by the study participants as a past use, only present in their memory but not any more practiced; C: commonly quoted (10–40% of the study participants); R: rarely quoted (less than 10% of the informants); VC: very commonly quoted (more than 40% of the study participants); quoted local gastronomic terms: börek/pita: Balkan savory pastry made with thin dough (called yufka or phyllo) filled with meat, dairy products, or vegetables; boza: traditional cereal-based fermented beverage; juva: liquid resulting from lacto-fermenting vegetables or fruits in brine; oshaf: compote made from dried fruits simmered gently in water with sugar (sometimes without, if the fruits are sweet enough) - often flavored with cinnamon, cloves, or rosewater and served called as a refreshing drink/dessert; pekmez: fruit molasse; sarma: leaves wrapped around a rice filling; slatko: sweet fruit preserve; sok: (slightly fermented and carbonated) fruit juice. Fungal taxa are marked with an asterisk (*) to distinguish them from vascular plants

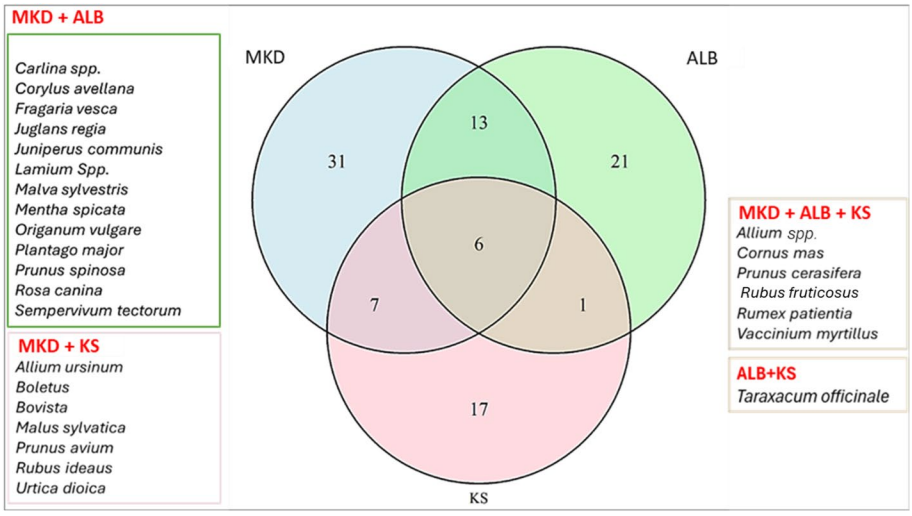

Fig. 3 Venn diagram illustrating the shared and unique wild food plants (WFPs) and mushrooms reported by Gorani communities in North Macedonia (MKD), Albania (AL), and Kosovo (KS)

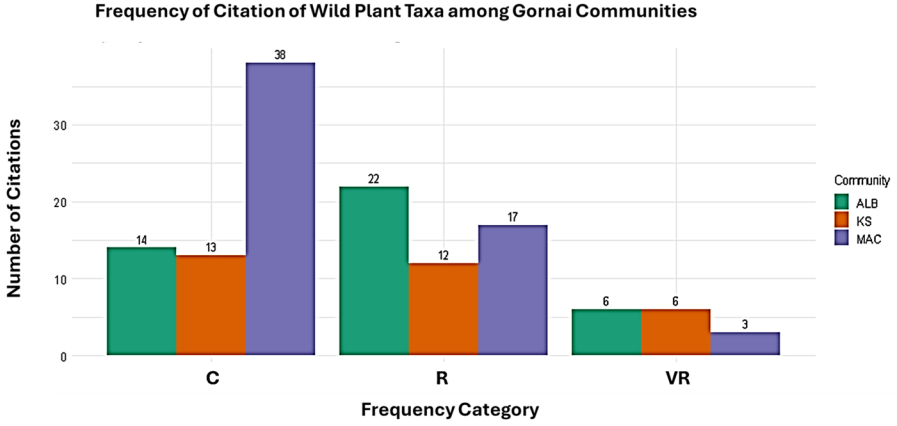

Fig. 4 Frequency of citation of the foraged wild food plants foraged and used by Gorani communities

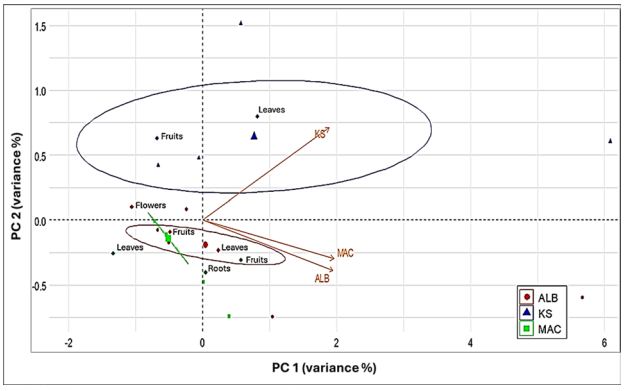

Fig. 5 Principal Component Analysis (PCA) of plant parts used by Gorani communities (*ALB* Albania, *KS* Kosovo, *MKD* North Macedonia). Each point represents a plant part, coloured according to the community that reports it most frequently. Arrows indicate the contribution of plant parts to the principal components. Ellipses show the 95% confidence area for each group of plant parts associated with the dominant community

strongly associated with specific communities (ALB or MKD), reflecting preferences and ecological availability. The biplot arrows indicate which plant parts contribute most to the variance. Leaves and fruits have longer arrows pointing to the centre, confirming their widespread use across communities. In contrast, less frequently used parts such as galbules (*Juniperus communis*) and tubercles (*Dactylorhiza* spp., *Anacamptis morio*) have shorter vectors, indicating their limited contribution to overall variation.

Overall, the PCA reveals that while there is substantial overlap in the use of leaves and fruits among Gorani communities, other plant parts exhibit community-specific practices, reflecting both ecological constraints and the cultural knowledge of wild food plants.

Shannon diversity (H') and Pielou's evenness (J') were calculated to quantify the diversity and distribution of plant use among Gorani communities. Commonly cited species (C) exhibited moderate diversity (H' = 0.97) and slightly lower evenness (J' = 0.88), indicating that a few species dominate usage in all communities. Rarely cited species (R) had the highest diversity (H' = 1.07) and high evenness (J' = 0.97), suggesting that less frequent species are more evenly distributed among the communities. Very commonly cited species (VC) also showed high diversity (H' = 1.05) and evenness (J' = 0.96), reflecting a balanced knowledge and use across communities. Overall, these indices highlight that Gorani communities maintain a rich and relatively even distribution of plant use, combining a few highly used species with a wide array of less frequently used plants, which supports both nutritional and cultural diversity (Fig. 6).

3.4 Commonly used plant species across Gorani communities

Among the wild food plants, a subset of species is consistently used across all three Gorani communities (MKD, ALB, and KS), highlighting shared traditional knowledge and culinary practices. These taxa include *Allium* spp., *Cornus mas*, *Prunus cerasifera*, *Rubus fruticosus*, *Rumex patientia*, and *Vaccinium myrtillus. Allium* is utilised in multiple ways: leaves are consumed as fresh salad or seasoning (frequency: R), bulbs are brewed for tea (R), and fruits and fruiting bodies are occasionally cooked (R), demonstrating versatile culinary and medicinal applications. *Cornus mas.* shows diverse uses across communities. Fruits are widely consumed as snacks, beverages (sok), and yoghurt starters (frequencies: C, VC, R), while kernels are eaten as snacks (C). Leaves are used for teas, digestive preparations, and salads (VC, R), and roots are occasionally prepared as oleolites or teas for medicinal purposes (R). Unripe fruits are processed into slatko (C), reflecting both nutritional and cultural food practices. *Prunus cerasifera* is primarily used for its fruits, which are processed into jams, beverages, or teas (C, VC, R). Unripe

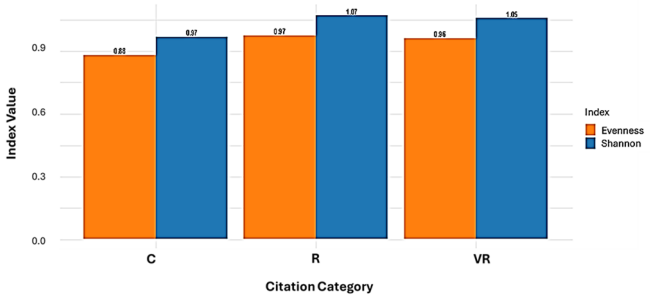

Fig. 6 Shannon diversity and evenness of plant use by citation category

fruits are also consumed as snacks or fermented into vinegar, and stems ("Bobojan") are occasionally used in cooking (R). Fruits are also used in medicinal teas to address cough, diabetes, or high cholesterol (VC, R). *Rubus fruticosum* is consistently valued for its fruits (C, VC), which are eaten raw or as beverages, jams, and oshaf. Leaves and fruits are also combined for medicinal teas and syrups, particularly for treating cough in children (R). *Rumex patientia* shows extensive culinary and medicinal use. Leaves are incorporated into pies, sarma, and pastries (C, VC), brewed as tea (R), or prepared as jams and soups (R). Flowers are used in oil macerates and jams for cough remedies (C), and roots are used as yoghurt starters (C). *Vaccinium myrtillus* is mainly consumed for its fruits, which are prepared as jams, pekmez, or medicinal teas (C, VC). Flowering tops and leaves are used in teas targeting appetite or bronchitis (C), illustrating the integration of fruits and aerial parts in traditional preparations.

Overall, the analysis of these shared taxa demonstrates that fruits and leaves are the most frequently used parts, with a broad spectrum of culinary and medicinal preparations across all three communities. The repeated use of these plant parts indicates a strong cultural consensus and ecological knowledge that maintains their importance in the Gorani diet and traditional medicine.

4 Discussion

4.1 The importance of deeply rooted food heritage

The Gorani communities of the Western Balkans maintain a rich and distinctive ethnobotanical heritage that reflects centuries of social, ecological, and historical interactions.

The pattern illustrated by the Venn diagram reveals more than a quantitative overlap in plant taxa; it mirrors the deep historical and genealogical roots of Gorani mobility across the Shar Mountain massif. The markedly higher similarity between the Macedonian and Albanian Gorani-thirteen shared wild food plant (WFP) taxa-stands in sharp contrast to the limited overlap with the Kosovar group. This asymmetry strongly supports oral historical accounts that the present-day Gorani villages of Urvič and Jelovjane in North Macedonia were founded by groups migrating two centuries ago from the Borje–Shishtavec cluster of Albanian Gorani settlements. In this sense, the ethnobotanical dataset preserves the traces of population movement and community fission much like a linguistic or genetic marker [28–30].

Such "ethnobotanical fingerprints" have been increasingly recognised in the comparative study of diasporic and mountain minorities [7, 31]. The persistence of particular plant repertoires and preparation modes, such as the use of *Sempervivum tectorum* as yoghurt starter, or *Rumex patientia* for *sarma* and pies, acts as a cultural indicator of shared ancestry. These micro-traditions are resistant to change because they are embedded in household practice, gendered transmission, and sensory memory. Thus, the close ethnobotanical resemblance between Macedonian and Albanian Gorani does not result from mere ecological similarity (the floristic composition of the upper Gora and Borje zones is nearly identical), but from the continuity of culinary cognition and ritualised plant use transported by migrating families [32, 33]. The Albanian Gorani served historically as a demographic reservoir that repopulated depopulated Macedonian slopes during Ottoman times; their plant knowledge migrated with them.

Conversely, the weaker connection with the Kosovar Gorani and its more diverging, possibly Serbian character, reflects a later period of socio-political isolation. Following

Fig. 7 A few signs that animal husbandry is still maintained in Urvič 02.05.2025 (Photo credit: R. Sõukand)

the redrawing of borders in 1925, Kosovar Gorani communities experienced urban labour migration, schooling in Serbian, and stronger integration into Yugoslav socio-economic structures, all of which contributed to cultural drift [34]. Their reduced WFP repertoire (31 species) and the loss of shared taxa typical of the Albanian–Macedonian continuum point to both ecological marginalisation and diminished intergenerational transfer of local ecological knowledge (LEK). Within the human-ecological framework, these divergences can be interpreted as adaptive responses to distinct political ecologies: the Macedonian and Albanian Gorani maintained a semi-subsistence mountain economy (Fig. 7). At the same time, the Kosovar Gorani gradually adopted market-oriented and urbanised food systems.

The ethnobotanical affinity between Macedonian and Albanian Gorani therefore functions as a biocultural remnant, a conserved set of plant-use relationships encoding the memory of migration. Within this corpus, plants such as *Juniperus communis*, *Mentha spicata*, and *Sempervivum tectorum* act as what Garibaldi and Turner (2004) [1] termed "cultural keystone species": they anchor not only diet but also identity, marking continuity between ancestral and resettled communities. The reproduction of these practices across two political borders underscores that LEK transmission may be more faithful than language or religion in reflecting historical connectivity.

From a methodological perspective, the Venn-diagram approach illustrates how quantitative ethnobotany can complement historical and linguistic reconstruction. Overlaps among communities reveal "zones of cultural inertia," where plant knowledge endures despite environmental change, aligning with oral histories such as the Gorani elders' claim that "our grandfathers came from Borje" [35–37].

More broadly, ethnobotanical similarity serves as a historical marker across the Balkans, where shared wild food species among mountain groups like the Gorani, Torbeši, and Pomaks trace past routes of migration and exchange. In this sense, plants become vehicles of collective memory [38, 39].

The proximity between Macedonian and Albanian Gorani ethnobotany shows that the Venn diagram visualises not only shared taxa but shared time a living record of movement, adaptation, and identity across the Sharr/Šar Planina.

On the other hand, all Gorani groups possess a rich ethnobotanical heritage, as reflected in the use of 96 wild food plants (WFPs) and tea species. These plants serve not only as dietary resources but also as markers of cultural identity, embedding ecological knowledge in foodways [25, 40–42]. Core taxa, including *Allium* spp., *Cornus mas*, *Prunus cerasifera*, *Rubus fruticosum*, *Rumex patientia*, and *Vaccinium myrtillus*, are consistently used across all communities, illustrating a shared "cultural core" and continuity of traditional culinary practices. Leaves and fruits dominate the repertoire due to their accessibility, multifunctionality, and integration into both nutrition and medicine. Food uses of plant roots and flowers, as well as fungi, although less widespread, provide complementary uses, highlighting specialised knowledge within individual communities [5, 43].

Certain historical food practices have disappeared or diminished, reflecting shifts in lifestyle and patterns of pastoral mobility. Yoghurt starters, such as houseleek (*Sempervivum tectorum*), sorrel (*Rumex acetosa*), and wild garlic (*Allium* spp.), were once central to traditional fermentation practices but are no longer commonly used, likely due to the reduced seasonal mobility of pastoralist groups. Similarly, young potato leaves (*Solanum tuberosum*), previously boiled as a filling for börek, represent a now-obsolete "emergency" food, illustrating how environmental constraints and historical scarcity shaped culinary innovation in isolated mountain communities [15, 44]. The disappearance of millet *Panicum miliaceum*-based millet flour in favour of corn reflects broader agricultural and ecological changes in the region. Boza remains culturally significant and continues to be produced artisanally by diasporic Gorani confectioners [45].

4.2 Patterns of diversity and ecological adaptation

Shannon diversity (H') and Pielou's evenness (J') indices show that Gorani WFP knowledge is both rich and relatively balanced. Commonly cited species exhibit moderate diversity and slightly lower evenness, suggesting dominance of a few key plants, while rarely cited taxa reflect more individual or localized knowledge. In contrast, the most frequently cited species are widely known, indicating effective cultural transmission. PCA analyses further highlight that leaves and fruits form a central, shared cluster across all communities, with plant parts such as roots (*Bryonia alba*, *Dactylorhiza* spp., *Anacamptis morio*) and flowers (*Hypericum perforatum*, *Matricaria recutita*) exhibiting residual traces of ancient herbal and ritual traditions. This duality illustrates how Gorani ethnobotanical knowledge is structured by both ecological opportunity and cultural practice, aligning with patterns observed in other Balkan Mountain communities [46].

4.3 Resilience and erosion risks

The Gorani ethnobotanical system demonstrates a dynamic balance between resilience and vulnerability. Macedonian Gorani communities exhibit the highest diversity, reflecting their relative geographic isolation and the semi-continuous nature of their cultural transmission [47]. In contrast, Kosovar Gorani show a reduced repertoire, likely influenced by migration, socio-political pressures, and cultural dilution. Albanian Gorani presents an intermediate pattern, suggesting partial retention of traditional knowledge within mixed-ethnic rural landscapes [48]. This indicates that the persistence of key WFPs across all communities' underscores both nutritional and cultural resilience, while the erosion of peripheral species signals potential risks to biocultural diversity.

From a human ecological and sustainability perspective, the Gorani case highlights three key insights: (1) biocultural resilience, as core species persist despite social and demographic change; (2) knowledge erosion risks, particularly for peripheral taxa and historically significant plants; and (3) opportunities for sustainable futures, where wild teas, fruits, and greens could support eco-tourism, specialty food production, and community-led enterprises while respecting cultural meanings [49–51]. These insights underscore how ethnobotanical knowledge mediates the relationship between humans, culture, and mountain ecosystems, providing a model for safeguarding biodiversity and culturally marginalised landscapes.

Overall, the Gorani ethnobotanical system exemplifies a human ecological story: a minority population negotiating continuity and change through plants. Core WFPs ensure subsistence and cultural cohesion, while peripheral and disappearing taxa reflect both vulnerability and adaptive innovation. Documenting this heritage not only preserves traditional knowledge but also informs broader debates on biocultural diversity, food security, and sustainable rural development in European mountain communities [1, 2].

5 Conclusion

This study provides the first systematic ethnobotanical documentation of the Gorani minority in North Macedonia, situated within a comparative framework that includes sister communities in Albania and Kosovo. The findings show that Gorani traditional plant knowledge constitutes a resilient yet dynamic corpus of local ecological knowledge (LEK), in which wild food plants (WFPs) serve as both subsistence resources and cultural symbols.

Across the three communities, 96 wild taxa were recorded, with a distinct cultural core, *Allium* spp., *Cornus mas*, *Prunus cerasifera*, *Rubus fruticosus*, *Rumex patientia*, *and Vaccinium myrtillus*, that transcends national borders and remains deeply rooted in collective memory and everyday practice. This shared botanical repertoire constitutes a biocultural nucleus that has persisted through centuries of migration, political division, and social transformation.

At the same time, regional divergences illustrate varied trajectories of cultural adaptation. The Macedonian Gorani exhibit the richest plant diversity and the most balanced knowledge distribution, reflecting semi-subsistence lifestyles and relatively intact intergenerational transmission. Albanian Gorani, although fewer in number, maintain a distinctive and conservative ethnobotany shaped by isolation and mixed-ethnic coexistence in the Borje–Shishtavec region. In contrast, Kosovar Gorani show clear signs of knowledge erosion, influenced by migration, cultural assimilation, and demographic decline. These patterns demonstrate how political borders, socio-economic pressures, and depopulation interact to reshape ethnobotanical systems in Europe's mountain peripheries.

Beyond documenting plant use, the study highlights a methodological and theoretical insight: ethnobotanical similarity can serve as a fingerprint of historical connectivity and population movement. The pronounced overlap between the Macedonian and Albanian Gorani ethnobotanies (as shown by the Venn diagram) mirrors oral accounts of ancestral migration from Borje to Urvič and Jelovjane, thus corroborating ethnographic and linguistic evidence through ecological data. In this sense, plant knowledge behaves like

an intangible genetic marker, one that transmits not through DNA but through recipes, practices, and the hands of women who continue to prepare s*arma*, *sok*, and *oshaf* in the same ways their grandmothers did. The comparative analysis, therefore, demonstrates that LEK, when studied across divided but related communities, can reveal the deep temporal structure of human mobility and adaptation.

the Gorani case illustrates the interplay between biocultural resilience and knowledge erosion. Core WFPs anchor identity and nutrition, while the disappearance of marginal taxa, such as *Sempervivum tectorum* or *Rumex acetosa* used as yoghurt starters, signals an erosion of micro-knowledge tied to pastoral mobility and women's domestic economies. These changes reflect broader socio-ecological transformations, including urban migration, reduced agricultural engagement, and declining communal foraging. Nevertheless, Gorani communities maintain a living repertoire of wild foods, demonstrating adaptive capacity and sustaining their relationship with the landscape, cultural memory, and community identity.

Future research could pursue several directions. Longitudinal ethnobotanical monitoring would allow assessment of knowledge loss or transformation over time, particularly among younger and diasporic generations. Comparative studies with neighboring Torbeši, Pomak, and Bosniak groups could identify whether similar ethnobotanical "signatures" exist among other Islamised Mountain minorities, clarifying processes of cultural convergence and divergence.

Integrating ethnolinguistic and molecular ecological approaches for example, correlating folk plant nomenclature with phylogenetic and landscape data could further illuminate the interplay between cultural memory and environmental reality. Finally, participatory initiatives to revitalize wild plant knowledge through local schools, ecotourism, and small-scale product valorization (e.g., wild teas, jams, fermented foods) could transform intangible heritage into a resource for sustainable rural development.

Overall, the Gorani ethnobotanical corpus exemplifies a resilient relational knowledge system that persists at the margins of modernity, retaining the memory of migration, coexistence, and adaptation within its culinary practices. Documenting and sustaining this knowledge provides both scientific insight and ethical guidance, affirming that cultural and biological diversity are intertwined, and that the plants of the borderlands continue to carry the stories of those who moved with them.

Author contributions

M.A.: Data Analysis, Software Analysis and Visualisation, Discussion/Conceptualisation, Writing Original Draft and Review; A.P.: Research Design, Methodology, Field Research, Data Collection, Botanical Identification, Discussion/Conceptualisation, Review, Editing, and Funding; RS: Research Design, Methodology, Field Research, Data Collection, Discussion/Conceptualisation, Review, Editing, and Funding; N.S., C.Y., J.P., A.H., A.B.: Review and Editing. B.R.: Field Research, Review, and Editing. All authors have read and agreed to the published version of the manuscript.

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Data availability

Data supporting the reported results are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The study received ethical approval from the Comitato Etico dell'Università di Scienze Gastronomiche, as documented in the official record VERBALE COMITATO ETICO 4/2024, session of 17 June 2024, 16:30. The committee, chaired by Prof. Bartolomeo Biolatti, reviewed and approved the project after discussion. All interviews were conducted anonymously, and no identifying information was recorded. The research followed the International Society of Ethnobiology (ISE) Code of Ethics (2006, with 2008 additions). (https://www.ethnobiology.net/what-we-do/core-programs/ise-ethics-program/c

ode-of-ethics/, accessed February 17, 2025). Informed consent was obtained from all individual participants included in the study. Participants were fully informed about the purpose of the research, the methods, and their rights, including the right to withdraw from the study at any time. The research followed the International Society of Ethnobiology (ISE) Code of Ethics (2006, with 2008 additions) (https://www.ethnobiology.net/what-we-do/core-programs/ise-ethics-program/code-of-ethics/, accessed February 17, 2025).

Consent for publication

Informed consent was obtained from all participants for the publication of images in which they may appear. Participants were made aware that the images would be published in the journal and gave their permission.

Competing interests

Andrea Pieroni is an Editorial Board Member of Discover Food and was not involved in the editorial handling or decision-making process for this manuscript. Mousaab Alrhmoun, Besnik Rexhepi, Naji Sulaiman, Cheikh Yebouk, Julia Prakofjewa, Avni Hajdari, Ani Bajrami, and Renata Soukand declare that they have no competing interests.

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