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RESEARCH ARTICLE

Traditional uses of medicinal plants in Pirot District (southeastern Serbia)

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Abstract This study provides information on plants used for medicinal purposes in Pirot District (southeastern Serbia). The population of 157 villages in four municipalities of Pirot District (631 informants) completed questionnaires about the knowledge and use of medicinal herbs; the questionnaires included information about respondents and specific issues related to the applications of medicinal herbs. There were 4817 URs (use reports) on plants used for different ailments classified in various categories. The informant consensus factor (ICF) for the most frequently reported taxa and a comparison of nationality and gender in the use of plants for most frequent medical indications were calculated by ICF analysis. The overlap of plant taxa and URs recorded for three ethnic groups (Serbian, Bulgarian, and Roma) in the study area is also presented. Multivariate correspondence analysis was performed. A total of 182 medicinal plant taxa belonging to 68 families were recorded, of which 53 are included in European Pharmacopoeia 10.2. The most frequently mentioned families were Lamiaceae (1322 URs), and Compositae (899 URs).

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Hypericum perforatum and *Matricaria chamomilla* were the most used plant species. Aerial parts and leaves were the most frequently used plant parts. Infusion and oil extracts were the most reported preparations of medicinal herbs. Among 14 categories, respiratory (1235 URs), and digestive (911 URs) groups of diseases were the most frequently reported. Data on the knowledge and use of medicinal plants in Pirot District could be a good starting point for further ethnopharmacological investigations.

Keywords Pirot District · Traditional use · Medicinal plants · Ethnobotanical survey · Balkan Peninsula

Abbreviations
UR Use report
URs Use reports

Introduction

The Balkan region has a long tradition of plant use for ethnopharmacology and other purposes (Zlatković et al. 2014; Matejić et al. 2020). Serbia, situated in the central part of the Balkan Peninsula, is characterized by great floristic diversity (Jarić et al. 2015). With its abundant plant species, Serbia is classified as one of the 158 world biodiversity centers (Jarić et al. 2015). Ethnobiological research conducted in the Balkans in the past fifteen years has also reported a rich biocultural diversity and remarkable vitality of traditional knowledge of the local medicinal flora in investigated areas (Pieroni et al. 2013).

Medicinal plant use has been the main form of traditional medical practice, particularly in the developing world. The people of southeast Europe, including the Balkans and Serbia, have been practicing phytotherapy, which differs from conventional medicine (Džamić and Matejić 2017). According to Živković et al. (2020), the simultaneous use of herbal preparations and conventional drug therapy in these areas is widespread.

Ethnobotanical investigations have a role in preserving traditional phytotherapeutic knowledge and building a basis for further research (Jarić et al. 2015). In the Western Balkan regions, ethnobotanical research has been carried out in the past fifteen years in Albania (Pieroni et al. 2005, 2014, 2015; Pieroni 2008; Mullalija et al. 2021), Bosnia and Herzegovina (Šarić-Kundalić et al. 2010; Saric Kundalic et al. 2016), Montenegro (Menković et al. 2011), Serbia (Pieroni et al. 2011; Jarić et al. 2007, 2015; Popović et al. 2012; Šavikin et al. 2013; Zlatković et al. 2014; Janaćković et al. 2019; Marković et al. 2021a, b; Matejić et al. 2020; Živković et al. 2020, 2021), Macedonia (Pieroni et al. 2013; Rexhepi et al. 2013), Kosovo and Metohija (Mustafa et al. 2012a, b, 2015, 2020) and Greece—Central Macedonia (Tsioutsiou et al. 2019). Their research aimed to collect and preserve knowledge on the traditional uses of medicinal plants, primarily in rural populations.

Serbian rural areas are spread over about 85% of the country, with 41.8% of the total Serbian population living in villages (Dajić Stevanović et al. 2014). Rural areas have often been treated as an obstacle to the fast development of the national economy. According to the same authors, rural regions in Serbia have tremendous biodiversity and are rich in natural resources, traditional heritage, and ethnobotanical knowledge. The poverty level is highest in the rural regions of southeastern Serbia (Matejić et al. 2020; Živković et al. 2020), including the study area of Pirot District. Villagers do not have access to adequate medical care, and as a result, their first choice of healthcare is medicinal plants (Matejić et al. 2020). Most of the population firmly believes in the power of medicinal plants as remedies for different medical conditions, and they usually use natural herbal medicines (Jarić et al. 2015).

It is worth noting that Pirot District is rich source for many medicinal plants, as recorded in previous research in this area. Milojević and Mihajlov (1985) found 208 species of medicinal herbs. On Mt. Vidlič, which is found in the study area, Marković et al. (2019) recorded 264 medicinal plants and 60 aromatic plants (Marković et al. 2009). In Pirot District, a list was made of 326 herbs considered official or used in folk medicine (Marković et al. 2010, 2020c).

Some regions in Europe remain poorly explored from an ethnobotanical perspective, despite their high floristic and vegetation diversity. New ethnobotanical investigations are needed to supplement existing knowledge.

The present study aimed to record the profile of all medical uses per herbal medicine in rural areas of Pirot District (southeastern Serbia) to provide essential ethnomedical data. Furthermore, this

investigation can supplement the data on the use of medicinal plants from previous research from the Balkans. Therefore, it is crucial to answer the questions presented in the paper:

1. Which are the most commonly used medicinal plants in the investigated area,
2. Which indications are commonly treated,
3. Are there any differences in medicinal plant use between the Serbian, Bulgarian, and Roma populations,
4. Comparison of results with previously published ethnomedicinal data collected by researchers from surrounding territories in Serbia and the Balkan Peninsula, and
5. Note new uses of medicinal plants in Pirot District not previously recorded in neighboring regions.

Materials and methods

Research area

The area of Pirot District is located in southeastern Serbia (42.863′ N–43.403′ N and 22.117′ E–23.006′ E). It comprises four municipalities Pirot, Bela Palanka, Babušnica, and Dimitrovgrad. The investigated area covers 2761 km^2 (Pirot District GIS 2019) at elevations from 239 to 2169 m, and the total number of inhabitants is 92,479 (Marković et al. 2021a, b).

The research area is situated in a temperate continental climatic zone. Sub-mountain and mountain climate conditions are recorded at higher altitudes in the mountain region of the research area (Marković et al. 2010). Mt. Stara Planina and Mt. Suva Planina, which belong to the Carpatho-Balkan arc, are the largest natural objects in the investigated region, with significant medicinal herb resources (Marković et al. 2010, 2021a, b). Part of Mt. Stara Planina is found in the Pirot and Dimitrovgrad municipalities.

According to the botanical classification, the studied area belongs predominantly to the forest communities *Carpinetum orientalis serbicum*, *Quercetum frainetto-cerridis*, and *Fagetum moesiacae montanum* (Marković et al. 2015a, 2018). The vegetation patterns of dry grasslands and rocky grounds rich in medicinal plants were investigated by Marković et al. (2015b). These investigation also testify to rare botanical taxa that are characteristic of mountain steppes, such as *Adonis vernalis*, *Anemone montana*, and *Paeonia tenuifolia*, making this area particularly attractive from the aspect of botanical diversity.

Population and unique language dialect

The ethnic structure of the Pirot District population is heterogeneous. According to the official 2011 census, the nationalities include Serbs (83.7%), Bulgarians (7.1%), Roma (4.7%), and others (4.5%) (Statistical Office of the Republic of Serbia 2011). In the municipalities of Pirot, Bela Palanka, and Babušnica, the predominant nationality is Serbs, while in the municipality of Dimitrovgrad, the dominant ethnic group is Bulgarian (Marković et al. 2021a, b). In Pirot District, as well as in other regions of Eastern Balkans—southeastern Serbia, northeastern Macedonia, and western Bulgaria, a distinct ethnographic group, "Shopi" or "Torlaci", is found (Panajotović 2007; Stojković 2010; Krstić 2019, 2020). Torlak, as the name of a regional group, is associated with a dialect (Krstić 2019). This term is derived from the South Slavic word "tor" (sheepfold), as sheep farming was the dominant activity in the past (Šubarević et al. 2015).

Serbian, the official language in Serbia, belongs to the South Slavic group of languages. According to Matejić et al. (2020), the language in eastern and southeastern Serbia is divided into two different groups of dialects, "timočko-lužnički" and "svrljiško-zaplanjski." The dialect of people in Pirot District is a specific variant of the "timočko-lužnički" dialect. It belongs to the Balkan Slavic linguistic area, with Serbian, Bulgarian, and Macedonian. The dialect of the people in this area is a variant of the Shtokavian, or Torlakian, dialect, with many unique and archaic words. UNESCO classified it as an endangered language (Panajotović 2007). According to the same author, the separation of Shtokavian dialects, including Torlakian, from the other neighboring South Slavic dialects can be explained by the migratory routes of different Slavic tribal groups in the past. The language of the people in the villages of Pirot District has many specific and old native words, including the local names of plants. Milojević and Mihajlov (1985) noted 788 native folk names of 208 medicinal plant

species, and most of them reflect the unique characteristics of the Pirot District dialect.

Ethnopharmacological survey

The local population from villages in the four municipalities of Pirot District was interviewed between 2017 and 2019. A semi-structured questionnaire was completed by 631 informants from 157 villages (65 villages in the municipality of Pirot, 36 villages in Bela Palanka, 32 villages in Babušnica municipality, 24 villages in the municipality of Dimitrovgrad). A study-area map showing the villages visited is given in Fig. 1.

Interviews were conducted with 337 men and 294 women, aged 16–88, living in Pirot District. Data inventoried from the informants were the local names of used plants, the ailments treated with plants, which plant parts are used, how they are prepared, and whether internal or external administration is applied. Interviews with the informants mainly focused on wild rather than cultivated plants. The informants were asked to show dried plant material or fresh plants from natural habitats in the vicinity of their homes (forests, meadows, dry pastures, rocky grounds). Many had transplanted wild plants into their gardens for medicinal purposes. Besides wild flora, some respondents reported using cultivated plant species from their gardens to treat various ailments.

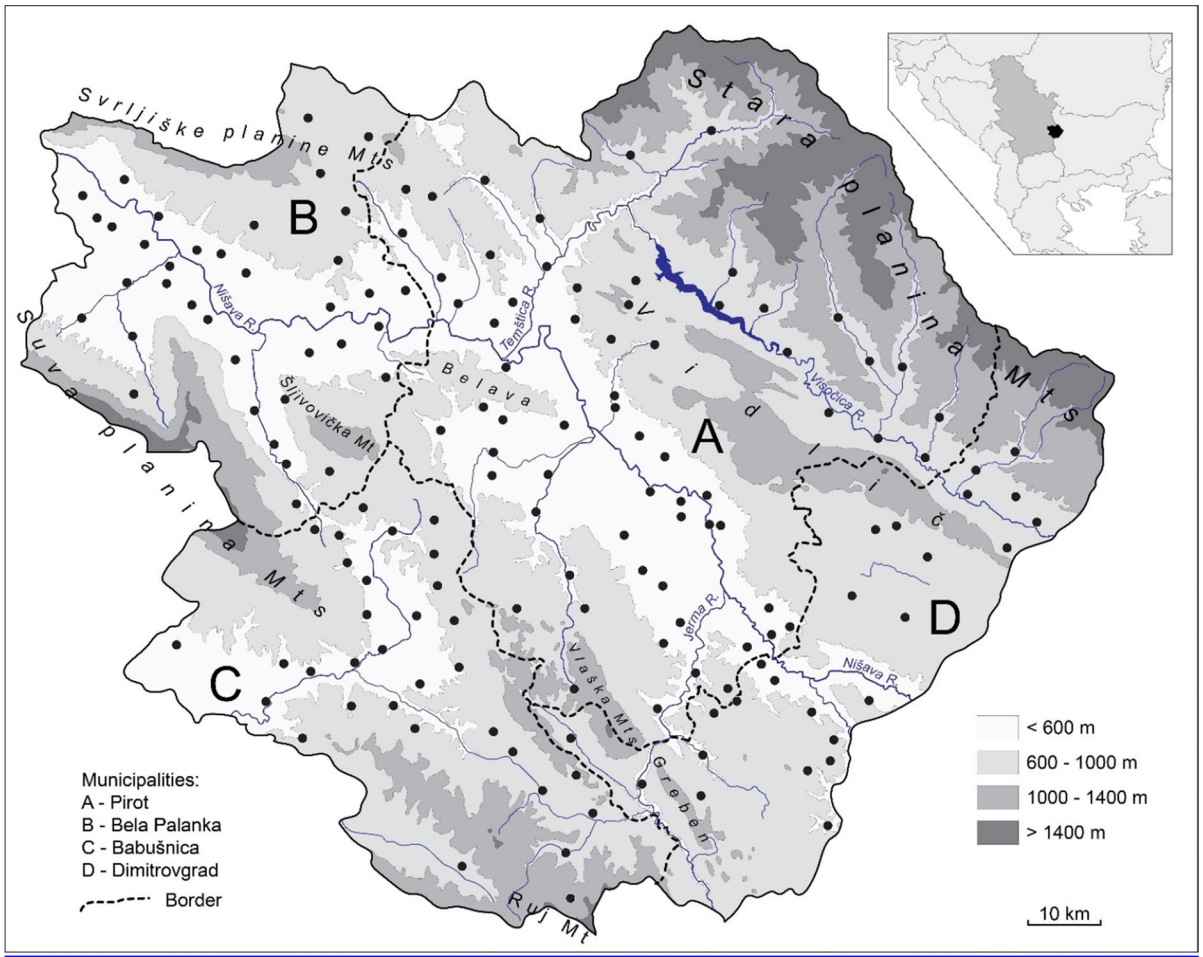


Fig. 1 A map of Pirot District showing mountains and waterbodies, and villages (black dots) visited in the scope of ethnobotanical interviews in four municipalities

Answers from the questionnaire were systematized by alphabetization of municipalities and villages. Questionnaire data and notes with observations and recipes for medicinal plant preparations of plant species obtained during the field survey are deposited in the Herbarium Moesiacum Niš (HMN), the herbarium of the Faculty of Sciences and Mathematics, University of Niš.

The plant species reported and collected during the interviews were identified according to Josifović (1970–1986), Jordanov (1963–1979), and Tutin et al. (1964–1980, 1993). The plants were classified by taxonomic nomenclature following the checklist from The Plant List database (http://www.theplantlist.org/). The species collected during the research were deposited in the abovementioned HMN herbarium. Inventory voucher numbers are given in Supplement 2 (Table 2). The following identified species: *Alchemilla flabellata* Buser, *Crocus tommasinianus* Herb., *Euphrasia stricta* D. Wolff, *Thymus praecox* Opiz. subsp. *jankae* (Čelak) Jalas, *Ulmus glabra* Huds., and *Verbascum phlomoides* L., are given at genus level in the table as other species from the same genera in the study area can be used with almost the same effect. The respondents did not differentiate between the species of recorded genera and used them in the same way.

Data analysis

The results are summarized and arranged in alphabetical order of plant taxa (Supplement 2, Table 2). The URs were organized into one of the 14 categories. The variance was calculated for used plants according to the total number of informants and URs per species (Weckerle et al. 2018).

The informant consensus factor (ICF) according to Trotter and Logan (1986) for the most frequently reported taxa was calculated for analyzing the collected data of Pirot District as a whole and for each of the four municipalities. The taxa ratio is the percentage of URs reported for the most frequently used plants.

Plant uses by nationality and gender were compared using ICF analysis. The overlap of plant taxa reported during the ethnobotanical survey by three ethnic groups (Serbian, Bulgarian, and Roma) in Pirot District is graphically represented. The overlap of URs for comparing the three ethnic groups is also graphically represented (Fig. 4).

Statistical analysis

The Chi-square test

The Chi-square (χ^2) test was applied to compare the distribution of plant use among the different groups of informants. SPSS statistical software (version 20.0) was used for statistical analysis, at a significance level of $p < 0.05$.

Multivariate correspondence analysis

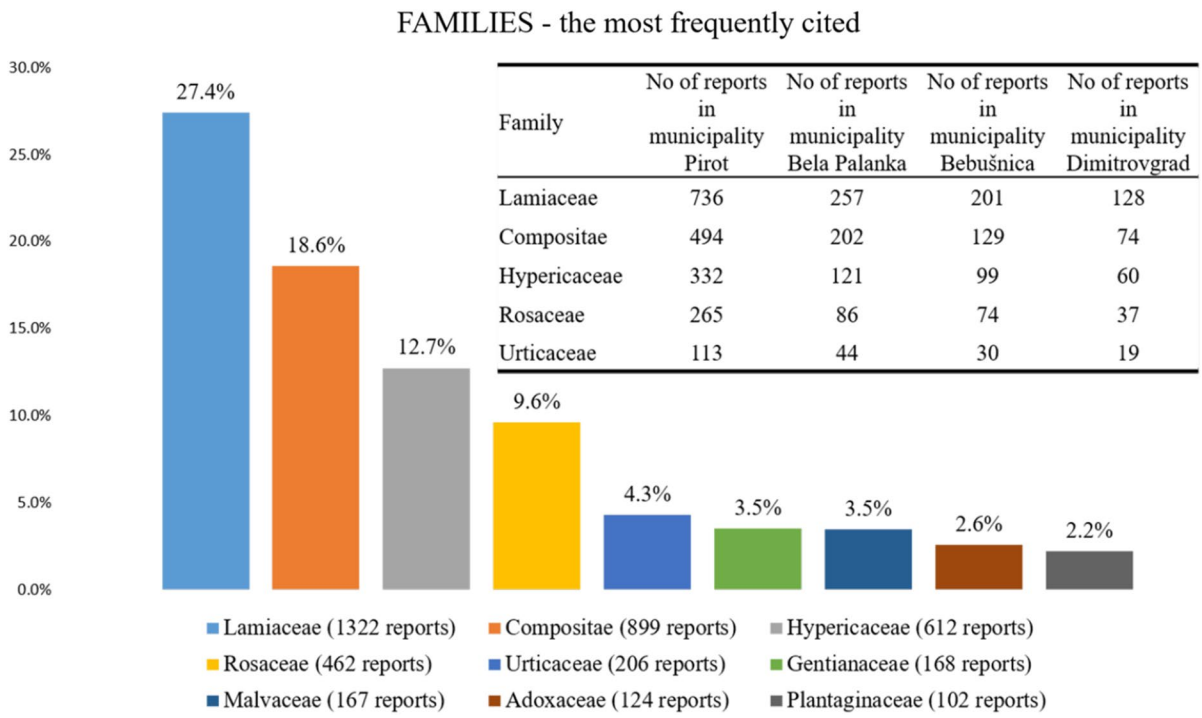
For multiple correspondence analysis (MCA) and plot production, the R-CRAN environment with 'FactoMineR' and 'ggplot2' libraries was used. Multivariate correspondent techniques (Rohlf 1998) were applied to indicate potential connections among variables, observing the state of their grouping in a graph. The output of this multivariate analysis shows the coordinates of the row (respondents) and column (character states) on correspondence axes displayed on the scatter plot (Zlatković et al. 2014).

Results

Quantitative analyses

The number of interviewed populations with ethnic composition and number of URs and comparison with the total number of rural inhabitants of Pirot District (according to the 2011 census) are given in Supplement 1 (Table 1). Our results showed that 182 plant taxa are used to treat various ailments and diseases by the human population (4817 URs). The results are given in Supplement 2 (Table 2), with information on each plant species mentioned during the research. The species were classified into 68 families. The greatest number of species were in the Rosaceae (22 plant species), Lamiaceae (21 plant taxa), Compositae (15 species), and Apiaceae (9 species) families. Families such as Lamiaceae, Compositae, Hypericaceae, Rosaceae, Urticaceae, Gentianaceae, Malvaceae, Adoxaceae, and Plantaginaceae were most widely reported (Fig. 2).

The majority of plant taxa are herbaceous (73.6%), followed by trees (19.8%) and shrubs (6.6%). The most frequently used plant parts were the aerial parts (48.3%, 2328 URs), leaves (19.9%, 959 URs), floral



Family	No of reports in municipality Pirot	No of reports in municipality Bela Palanka	No of reports in municipality Bebušnica	No of reports in municipality Dimitrovgrad
Lamiaceae	736	257	201	128
Compositae	494	202	129	74
Hypericaceae	332	121	99	60
Rosaceae	265	86	74	37
Urticaceae	113	44	30	19

Fig. 2 The most frequently reported families of medicinal plants in Pirot District and four municipalities

structures (16.8%, 809 URs), fruit (7.1%, 343 URs), and underground parts (4.8%, 233 Urs). Bark was used in a low percentage (1.1%, 52 URs).

Plants used to treat diverse ailments are prepared and administered in different forms. Tea or water extraction, infusions, decoctions, and macerates were the usual modes of preparation. Relatively common were oil extracts, extracts in alcohol, fresh leaves applied or eaten (depending on the species), compresses, and fresh juice (Fig. 3). Most plants were used for internal oral absorption (84.2%, 4,056 URs), with fewer used for external application (15.8%, 761 URs).

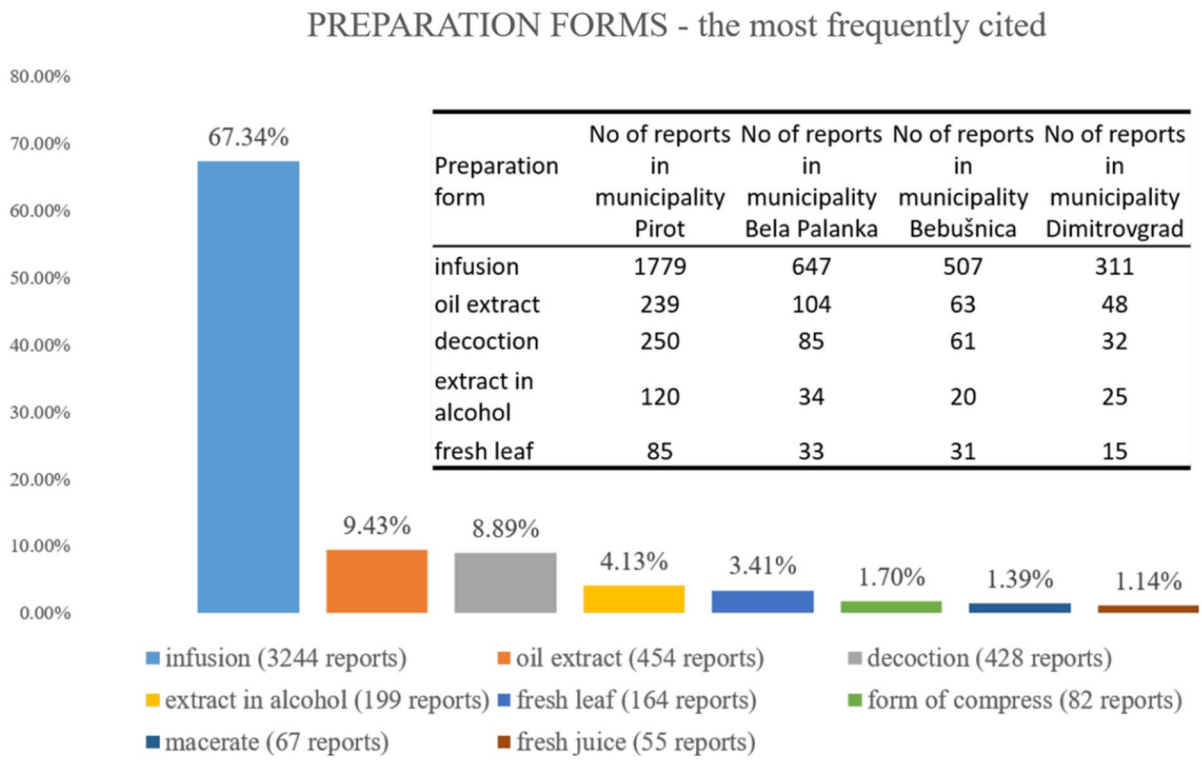
The groups of diseases and predominantly used plant taxa

During our study, it was noted that Pirot District inhabitants most often used the following plant taxa: *Hypericum perforatum* (612 URs, 12.7%), *Matricaria chamomilla* (381 URs, 7.9%), species from the genus *Thymus* (359 URs, 7.5%), *Mentha* x *piperita* (351 URs, 7.3%), and *Achillea millefolium* (245 URs, 5.1%) (Supplement 2, Table 2).

The plant taxa most utilized in each municipality and groups of ailments treated are presented in Table 1. The use categories were created based on biomedical criteria. The primary reported groups of ailments were Rs—respiratory system diseases (1235 URs, 25.6%), Dg—digestive diseases (911 URs, 18.9%), Dm—dermatology (612 URs, 12.7%), and Cd—cardiovascular diseases (482 URs, 10.0%), Nr—nervous system diseases (274 URs, 5.7%), If—infectious diseases (274 URs, 5.1%), Pr—preventive (238 URs, 4.9%), Ur—urinary (229 URs, 4.7%), and Vr—various (228 URs, 4.7%). The less reported groups of ailments were Rp—reproductive diseases (107 URs, 2.2%), En—endocrine (104 URs, 2.2%), Dp—depurative (52 URs, 1.1%), Ca—cancerous diseases (51 URs, 1.1%), and Au—autoimmune diseases (47 URs, 0.9%).

The respiratory group of diseases (Rs) includes the following primary reported symptoms: common cold, cough, and sore throat. The most commonly used plant taxa for treating respiratory system diseases were species from the genera *Thymus*, *Matricaria chamomilla,* and *Sambucus nigra.*

The digestive group of ailments (Dg) includes the most frequent indications of gastric problems in



Preparation form	No of reports in municipality Pirot	No of reports in municipality Bela Palanka	No of reports in municipality Bebušnica	No of reports in municipality Dimitrovgrad
infusion	1779	647	507	311
oil extract	239	104	63	48
decoction	250	85	61	32
extract in alcohol	120	34	20	25
fresh leaf	85	33	31	15

Fig. 3 The most frequently reported forms of medicinal plant preparation in Pirot District and four municipalities

general, stomachache, diarrhea, and appetite loss. The most frequently used plants for treating these were *Mentha* x *piperita*, *Achillea millefolium*, and *Hypericum perforatum*.

The most frequently treated conditions in the dermatology group of disease (Dm) were wounds and burns. The respondents mainly reported using *Hypericum perforatum*, *Plantago major*, and *Matricaria chamomilla* for this group of diseases.

High blood pressure and anemia were the primary reported indications in the cardiovascular group of diseases (Cd). Plants with the highest number of URs for this group of diseases were *Urtica dioica, Crataegus pentagyna, Pyrus pyraster*, and *Prunus spinosa*.

During interviews, it was clear that the inhabitants of Pirot District villages most often used medicinal plants rather than seeking help at healthcare facilities. Residents of the different municipalities mainly use various medicinal plant taxa for treating the following group of ailments: Pr, Ur, Rp, En, and Au. In Pirot, Bela Palanka, and Babušnica, the most frequently used plants for Pr were *Rosa canina*, *Urtica dioica*, species from the genus *Thymus*, and *Achillea millefolium*. In contrast, *Gentiana cruciata* and *Urtica dioica* were commonly used in Dimitrovgrad. The urinary group of diseases (Ur) in Pirot was mainly treated using *Petroselinum crispum*, in Bela Palanka—*Arctostaphylos uva-ursi*, *Equisetum arvense*, Dimitrovgrad—*Hypericum perforatum*, and *Petroselinum crispum. Arctostaphylos uva-ursi* was most commonly used in Bela Palanka compared with the other municipalities, as its populations are found on Mt. Suva Planina, located in Bela Palanka. *Vaccinium vitis-idaea* is a substitute for *Arctostaphylos uva-ursi* in the villages on Mt. Stara Planina. People usually use these plant species that are widespread around their villages. In Pirot, reproductive diseases (Rp) were mainly treated with *Agrimonia eupatoria*, while the other municipalities used *Achillea millefolium*. In Pirot, the endocrine (En) and autoimmune (Au) groups of diseases were usually treated using *Gentiana cruciata* and *Symphytum officinale*, respectively. In contrast, these two groups of diseases were treated using several different plant species in the other municipalities (Table 1).

Table 1 Plant taxa most utilized for ethnopharmacological indications in each treatment category in Pirot District (full data in Supplement 6)

Group	URs	Reports ratio (%)	No of taxa	ICF	Taxa most used (number of URs)	Taxa ratio (%)
Respiratory	1235	25.64	66	0.95	*Thymus* spp. (235), *Matricaria chamomilla* (193), *Sambucus nigra* (108)	43.40
Digestive	911	18.91	63	0.93	*Mentha* x *piperita* (277), *Achillea millefolium* (104), *Hypericum perforatum* (103)	53.13
Dermatology	612	12.7	41	0.93	*Hypericum perforatum* (383), *Plantago major* (67), *Matricaria chamomilla* (31)	78.57
Cardiovascular	482	10.01	68	0.86	*Urtica dioica* (131), *Crataegus pentagyna* (74), *Pyrus pyraster* (40), *Prunus spinosa* (32)	57.47
Nervous system diseases	274	5.69	31	0.89	*Melissa officinalis* (100), *Thymus* spp. (50), *Mentha* x *piperita* (21), *Tilia cordata* (21)	70.07
Infectious	247	5.13	25	0.90	*Salvia officinalis* (126), *Matricaria chamomilla* (42), *Sempervivum tectorum* (29)	79.76
Preventive	238	4.94	40	0.84	*Rosa canina* (43), *Urtica dioica* (35), *Thymus* spp. (22), *Achillea millefolium* (21)	50.84
Urinary	229	4.75	46	0.80	*Petroselinum crispum* (33), *Equisetum arvense* (29), *Vaccinium vitis-idaea* (21)	36.24
Reproductive	107	2.22	50	0.54	*Achillea millefolium* (10), *Hypericum perforatum* (9), *Agrimonia eupatoria* (6), *Epilobium parviflorum* (6)	28.91
Endocrine	104	2.16	47	0.55	*Gentiana cruciata* (8), *Helianthus tuberosus* (8), *Centaurium erythraea* (7), *Taraxacum campylodes* (7)	28.85
Depurative	52	1.08	24	0.55	*Allium ursinum* (5), *Gentiana cruciata* (5), *Taraxacum campylodes* (5), *Urtica dioica* (4)	36.54
Cancerous diseases	51	1.06	19	0.64	*Chelidonium majus* (16), *Gentiana cruciata* (13), *Persicaria bistorta* (4)	64.71
Autoimmune diseases	47	0.98	27	0.43	*Symphytum officinale* (7), *Rosmarinus officinalis* (5), *Urtica dioica* (5)	36.17

ICF informant consensus factor

Of 182 plant taxa reported in the study, 101 (55.5%) were reported only by Serbs, 12 (6.6%) only by Bulgarians, 41 (22.5%) were used by both Serbs and Bulgarians, and 8 (4.4%) were used by Serbs and Roma. In contrast, 20 (11.0%) were used by Serbs, Bulgarians, and Roma (Fig. 4a). Of the total URs (4,817), 321 (6.7%) were recorded only by Serbs, 20 (0.4%) only by Bulgarians, 1119 (23.2%) by Serbs and Bulgarians, 74 (1.5%) by Serbs and Roma, and 3,283 (68.1%) URs by Serbs, Bulgarians, and Roma (Fig. 4b).

Informant consensus factor for groups of ailments by nationality and gender

A comparison of the number of plant taxa, the number of URs, and the ICF between gender and among nationalities is shown in Table 2. The highest consensus (ICF > 0.90) was among the Serbs for the respiratory, digestive, and dermatology groups of diseases. The Serbs had a more significant ICF for all groups of ailments, suggesting a more homogeneous knowledge about the use of medicinal plants among Serbs compared to Bulgarians and Roma. However, there is no uniformity in the number of respondents by nationality, which is a shortcoming of the presented study. Many more Serbs than Bulgarians and Roma

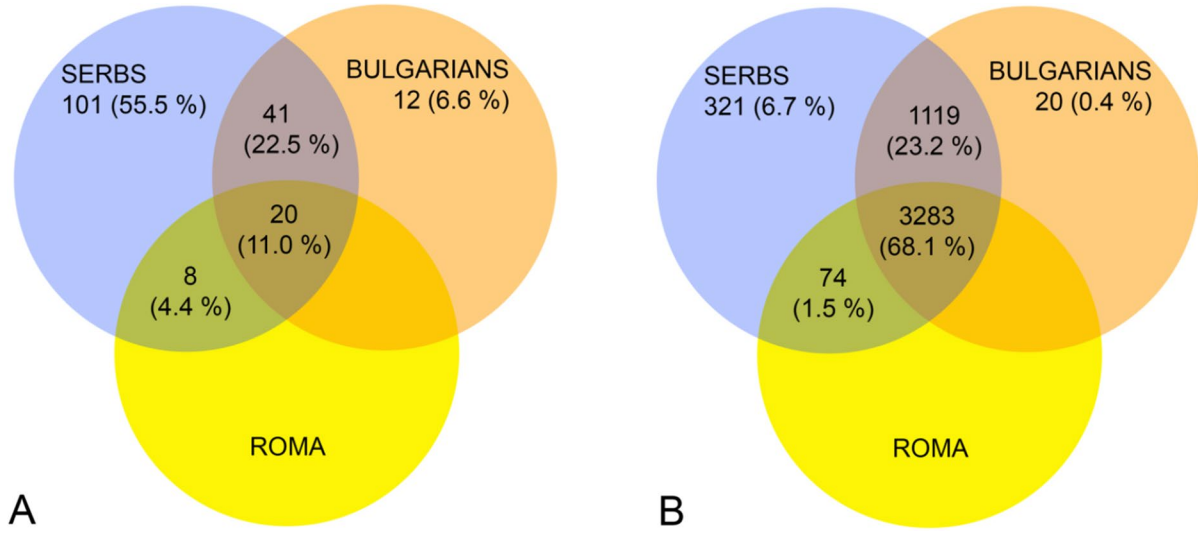


Fig. 4 The overlap of plant taxa (A) and overlap of URs (B) recorded and used by three ethnic groups in Pirot District

were interviewed. The ICF depends on big data and a considerable number of use reports. It behaves erratically when there are only a few URs per category of use, making the comparison of values between such uneven samples inconclusive. In future ethnopharmacological research, we should have sample uniformity by nationality.

In general, men had a greater consensus for Ca, Pr, Ur, Vr, En, and Au groups of ailments, while women had a greater consensus for Dg, Nr, If, Rp, Dp, and Ca groups. Men and women had the same ICF for Rs and Dm. Men knew more different plant taxa used against most of the groups of diseases, except for cancerous and autoimmune diseases.

Serbian, Bulgarian, and Roma males knew more different plant taxa used against Rs, Ca, If, Rp, En, and Dp groups of ailments than females. Serbian women knew more different plant taxa used against the various autoimmune groups of ailments. In contrast, Bulgarian women knew more different plant taxa used against Dg, Dm, Nr, and Ur groups of ailments.

The results showed that men and women did not differ in the number of used taxa. However, in a few cases, Roma women (and men) did not use plants for Pr, Ur, Vr, Rp, Dp, and Au. In two cases, statistical analysis was not applicable.

The number of URs by ethnic groups demonstrated differences by gender in Rs, Dm, and Cd treatment. As mentioned above, in fewer cases, Roma women (and men) did not use plants (Pr, Ur, Vr, Rp, Dp, and Au) (Table 2).

The results of multivariate qualitative analyses

The results of the applied multivariate correspondence analysis showed a potential correlation among at least some of the eight variables tested: (1) gender, (2) age, (3) nationality, (4) family, (5) administration mode, (6) part used, (7) preparation form, and (8) group of diseases. The correspondent analysis results indicated statistical connections among the two groups of analyzed variables, regardless of the age cohort or gender of informants, clustered around (I) Au, and (II) Dm groups of disease (Fig. 5):

(I) Treatment of autoimmune diseases (Au), i.e., arthritis or rheumatic pain: use of dry rhizome (DRHY) or compress (COM) of plant species from the families

(II) (a) Rutaceae (RUT)—*Citrus trifoliata*, (b) Hippocastanaceae (HIP)—*Aesculus hippocastanum*, (c) Dioscoreaceae (DIO)—*Dioscorea communis*, (d) Boraginaceae (BOR)—*Symphytum officinale*, and (e) Oleaceae (OLE)—*Syringa vulgaris*.

(III) Treatment of dermatology diseases (Dm): external use of oil extract (OILEX) of plant

Table 2 Comparison of gender and nationality for groups of ailments by informant consensus factor analysis

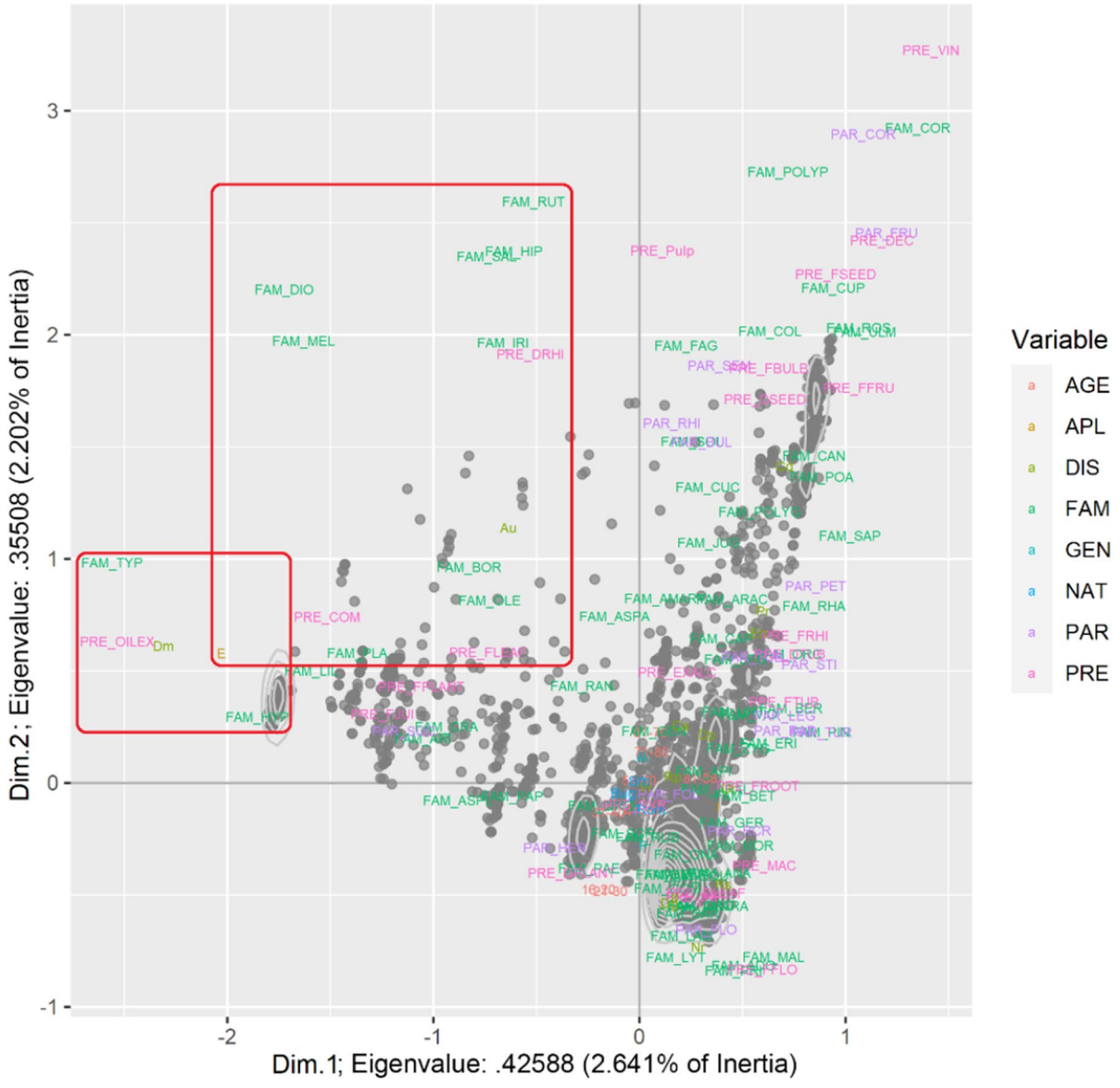
Group of ailments	Sex	Number of used plant taxa					Number of URs					ICF*			
		SER[a]	BUL	ROM	Test and Sig	No of different taxa	SER	BUL	ROM	Test and Sig	Σ	SER	BUL	ROM	Σ
Rs	Male	48	25	9	Chi-square = 2.263 $p = 0.323$	55	533	108	21	Chi-square = 15.191 $p < 0.001$	662	0.91	0.78	0.60	0.92
	Female	44	22	3		48	497	73	3		573	0.91	0.71	0.00	0.92
	Σ	54	51	9		66	1030	181	24		1235	0.95	0.83	0.65	0.95
Dg	Male	47	14	7	Chi-square = 1.489 $p = 0.475$	50	385	42	13	Chi-square = 5.611 $p = 0.060$	440	0.88	0.68	0.50	0.89
	Female	45	15	3		47	418	49	4		471	0.89	0.71	0.33	0.90
	Σ	61	22	7		63	803	91	17		911	0.93	0.77	0.63	0.93
Dm	Male	26	6	3	Chi-square = 1.039 $p = 0.595$	29	278	40	9	Chi-square = 7.101 $p = 0.028$	327	0.91	0.87	0.75	0.91
	Female	25	7	1		27	250	34	1		285	0.90	0.82	0.00	0.91
	Σ	37	10	3		41	528	74	10		612	0.93	0.88	0.78	0.93
Cd	Male	45	20	6	Chi-square = 3.838 $p = 0.147$	51	231	59	10	Chi-square = 9.279 $p = 0.009$	276	0.81	0.82	0.44	0.82
	Female	41	11	1		43	180	24	2		206	0.78	0.56	1.00	0.80
	Σ	60	20	6		68	411	59	12		482	0.86	0.67	0.55	0.86
Nr	Male	23	4	3	Chi-square = 1.047 $p = 0.592$	23	106	6	5	Chi-square = 5.767 $p = 0.055$	117	0.78	0.40	0.50	0.81
	Female	21	5	1		21	141	15	1		157	0.86	0.71	0.00	0.87
	Σ	31	6	4		31	247	21	6		274	0.88	0.75	0.40	0.89
If	Male	20	4	3	Chi-square = 0.480 $p = 0.786$	21	102	9	4	Chi-square = 3.036 $p = 0.219$	115	0.81	0.56	0.33	0.82
	Female	15	3	1		15	124	7	1		132	0.89	0.67	0.00	0.89
	Σ	24	4	3		25	226	16	5		247	0.90	0.80	0.50	0.90
Pr	Male	31	10	–	Chi-square = 0.273 $p = 0.602$ wo. ROM	32	109	18	–	Chi-square = 2.954 $p = 0.086$ wo. ROM	127	0.72	0.47	–	0.75
	Female	29	7	–		31	103	8	–		111	0.73	0.14	–	0.72
	Σ	39	11	–		40	212	26	–		238	0.82	0.60	–	0.84
Ur	Male	37	7	2	Chi-square = 0.717 $p = 0.397$ wo. ROM	38	101	13	3	Chi-square = 0.149 $p = 0.700$ wo. ROM	117	0.64	0.50	0.50	0.84
	Female	26	8	–		27	101	11	–		112	0.75	0.30	–	0.77
	Σ	44	10	2		46	202	24	3		229	0.79	0.61	0.50	0.80
Vr	Male	44	15	4	Chi-square = 2.64 $p = 0.104$ wo. ROM	49	102	18	4	Chi-square = 1.477 $p = 0.224$ wo. ROM	124	0.57	0.18	0.00	0.61
	Female	46	7	–		47	94	10	–		104	0.52	0.33	–	0.55
	Σ	64	17	4		69	196	28	4		228	0.68	0.41	0.00	0.70
Rp	Male	27	5	3	Chi-square = 0.041 $p = 0.840$ wo. ROM	31	49	5	3	Chi-square = 0.016 $p = 0.898$ wo. ROM	57	0.46	0.00	0.00	0.46
	Female	25	4	–		27	45	5	–		50	0.45	0.25	–	0.47
	Σ	45	8	3		50	94	10	3		107	0.53	0.22	0.00	0.54

Table 2 (continued)

Group of ailments	Sex	Number of used plant taxa					Number of URs					ICF*			
		SER[a]	BUL	ROM	Test and Sig	No of different taxa	SER	BUL	ROM	Test and Sig	Σ	SER	BUL	ROM	Σ
En	Male	32	1	–	NA	32	51	1	–	NA	52	0.38	0.00	–	0.70
	Female	31	–	–		31	52	–	–		52	0.41	–	–	0.41
	Σ	47	1	–		47	103	1	–		104	0.55	0.00	–	0.55
Dp	Male	18	6	1	Chi-square = 0.321	22	26	6	1	Chi-square = 0.072	33	0.32	0.00	0.00	0.34
	Female	10	2	–	$p = 0.571$ wo. ROM	11	16	3	–	$p = 0.789$ wo. ROM	19	0.40	0.50	–	0.44
	Σ	21	6	1		24	42	9	1		52	0.51	0.38	0.00	0.55
Ca	Male	11	–	–	NA	11	22	–	–	NA	22	0.52	–	–	0.52
	Female	11	2	–		11	26	3	–		29	0.60	0.50	–	0.64
	Σ	19	2	–		19	48	3	–		51	0.62	0.50	–	0.64
Au	Male	14	3	–	Chi-square = 0.380	15	19	3	–	Chi-square = 0.391	22	0.28	0.00	–	0.33
	Female	17	2	–	$p = 0.537$ wo. ROM	19	23	2	–	$p = 0.532$ wo. ROM	25	0.27	0.00	–	0.25
	Σ	25	4	–		27	42	5	–		47	0.41	0.25	–	0.43

[a]Nationality codes, SER—Serbian, BUL—Bulgarian, ROM—Roma, *ICF—Informant Consensus Factor, wo.—without, NA—statistical testing not applicable

Groups of diseases: Au—autoimmune diseases, Ca—cancerous diseases, Cd—cardiovascular, Dg—digestive, Dm—dermatology, Dp—depurative, En—endocrine, If—infectious, Nr—nervous system diseases, Pr—preventive, Rp—reproductive, Rs—respiratory, Ur—urinary, Vr—various



species from the families Hypericaceae (HYP)—*Hypericum perforatum* and Typhaceae (TYP)—*Typha latifolia*.

The results of multivariate techniques indicated treatment methods that are common or widely applied in the researched area. However, these analyses may also highlight specific or even unusual indications from the analyzed data, unusual species, or parts of the plant in use and treatments, which will be further discussed in the following chapter.

Discussion

Of the 182 plant taxa used to treat various ailments and diseases in Pirot District, 53 species are included in the European Pharmacopoeia (European Pharmacopoeia 10.2, 2020) (Supplement 2, Table 2).

The ethnomedicinal application of the most frequently used plant taxa in Pirot District was previously described by Stankov Jovanović et al. (2018), Marković (2019), and Marković et al. (2020a, b, c). St. John's wort (*Hypericum perforatum*), used in human and veterinary ethnopharmacology, was

◂**Fig. 5** The results of correspondence analysis. Variables: AGE—Age, APL—Application, DIS—Disorder, FAM—Family, GEN—Gender, NAT—Nationality, PAR—Part used, PRE—Preparation, APL—Application, I—Internal, E—External, DIS—disorder, Au—Autoimmune diseases, Ca—cancerous diseases, Cd—cardiovascular diseases, Dg—digestive diseases, Dm—dermatology diseases, Dp—depurative, En—endocrinology, If—infectious diseases, Nr—nervous system diseases, Pr—preventive, Rs—respiratory diseases, Ur—urinary diseases, FAM—Family: ADO—Adoxaceae, AMARA—Amaranthaceae, MARY—Amarylidaceae, ANA—Anacardiaceae, API—Apiaceae, ARAC—Araceae, ARAL—Araliaceae, ARI Aristolochiaceae, ASPA—Asparagaceae, ASPL—Aspleniaceae, BER—Berberidaceae, BET—Betulaceae, BOR—Boraginaceae, BRA—Brassicaceae, CAN—Cannabace, CAP—Caprifoliaceae, CAR—Caryophyllaceae, COR—Corylaceae, COL—Colchicaceae, COM—Compositae, COR—Cornaceae, CRA—Crassulaceae, CUC—Cucurbitaceae, CUP—Cupressaceae, DIO—Dioscoreaceae, DRO—Droseraceae, EQU—Equisetaceae, ERI—Ericaceae, FAG—Fagaceae, GEN—Gentianaceae, GER—Geraniaceae, HIP—Hippocastanaceae, HYP—Hypericaceae, IRI—Iridaceae, JUG—Juglandaceae, LAM—Lamiaceae, LEG—Leguminosae, LIL—Liliaceae, LYT—Lythraceae, MAL—Malvaceae, MEL—Melanthiaceae, MOR—Moraceae, OLE—Oleaceae, ONA—Onagraceae, ORC—Orchidaceae, ORO—Orobanchaceae, PAE—Paeoniaceae, PAP—Papaveraceae, PIN—Pinaceae, PLA—Plantaginaceae, POA Poaceae, POLYG—Polygonaceae, POLYP—Polypodiaceae, RAN—Ranunculaceae, RHA—Rhamnaceae, ROS—Rosaceae, RUB—Rubiaceae, RUT—Rutaceae, SAL—Salicaceae, SAP—Sapindaceae, SCR—Scrophulariaceae, SOL—Solanaceae, TYP—Typhaceae, ULM—Ulmaceae, URT—Urticaceae, VER—Verbenaceae, VIO—Violaceae, ZYG—Zygophyllaceae, PAR—Part used, BUL—Bulbus, COR—Cortex, FLO—Flos, FOL—Folium, FRUC—Fructus, HER—Herba, LEG—Legumen, PET—Petiolus, RAD—Radix, RHI—Rhizoma, RCR—Rhizoma cum radicibus, SEM—Semen, STI—Stigmata, SUC—Succus, TUB—Tuber, TUR Turio, PRE—Preparation, COM—Compress, DEC—Decoction, DLEAF—Dry leaf, DPLANT—Dry plant, DRHI—Dry rhizome, DSEED—Dry seed, DTUB—Dry tubers, EXALC—Extract in alcohol, FBULB—Fresh bulb, FFLO—Fresh flower, FFLU—Fresh fruit, FJUI—Fresh juice, FLEAF—Fresh leaf, FPLANT—Fresh plant, FRHI—Fresh rhizome, FROOT—Fresh root, FSEED—Fresh seed, FTUB—Fresh tubers, INF—Infusion, MASC—Macerate in water, OILEX—Oil extract, PULP—Pulp, SYR—Syr, VIN—Vinega

reported by 90.5% of respondents (Stankov Jovanović et al. 2018). According to Marković et al. (2020a), 383 respondents reported using chamomile (*Matricaria chamomilla*) in human and veterinary ethnopharmacology. Marković et al. (2020c) recorded the use of the following plant species from the genus *Thymus* in Pirot District: *T. longicaulis*, *T. praecox* subsp. *jankae*, *T. praecox* subsp. *polytrichus*, *T. pulegioides* subsp. *panonicus*, *T. pulegioides* subsp. *pulegioides*, *T. odoratissimus* and *T. striatus.* The authors reported that the use of these *Thymus* taxa in the folk medicine of the study area could be interpreted identically because the respondents did not know the differences between the taxa, considering them to be the same species.

The General Medicine Department in Pirot municipality noticed the following most common groups of diseases among the population of Pirot District: respiratory group of diseases (19.3%), circulatory system group of diseases (18.8%), and musculoskeletal system and connective tissue group of diseases (10.3%) (Institute of Public Health Pirot 2016). Treatment of the respiratory and cardiovascular groups, but also digestive and dermatology groups of diseases were the most frequently reported by informants in our study.

Comparative ethnopharmacological analysis in the Balkan region

Balkan Peninsula ethnobotanical field research has been conducted in the last 15 years in Serbia, Bulgaria, Bosnia and Herzegovina, Albania, Northern Macedonia, Montenegro, and Croatia. A comparison of plant uses in Pirot District and the mentioned ethnobotanical research in neighboring Balkan regions (1–24) is presented in the last column of Supplement 2 (Table 2). In the same place, the results of plant use in our research were also compared with that from books of herbal medicine in Bulgaria: 25. Nedelcheva (2012), and Serbia: 26. Gostuški (1973), 27. Sarić (1989), 28. Tucakov (1990), 29. Tasić et al. (2001), 30. Marković et al. (2020c), 31. Ratknić et al. (2021).

The names and uses of taxa from the mentioned genera with similar effect and purpose in neighboring Balkan regions (with numbers 1–24) and books of herbal medicine (with numbers 25–31), marked with a symbol (⁎) in the last column of Supplement 2 (Table 2), are reported in Supplement 3 (Appendix 1 of Table 2).

In our survey, *Allium cepa* and *A. sativum* were reported less frequently than in other ethnopharmacological research in the Balkans. A possible reason is that interviews focused on wild rather than cultivated plants.

A comparative review of plant uses in Pirot District and previously conducted ethnobotanical field research in surrounding regions in the Balkans (1–24)

is presented in Supplement 7 (Table 5). The ethnopharmacological uses of 129 plant taxa were different and new compared to other research in neighboring Balkan regions, including uses reported in previously published books in Serbia dedicated to herbal medicine (Supplement 2, Table 2). These results can be considered new uses of the presented study (the symbol ◙ indicates that the plant taxa were not mentioned in previous ethnobotanical field research in neighboring areas during the last two decades). The list of plant taxa with different uses compared to other research in neighboring Balkan areas is given in Supplement 4 (Appendix 2 of Table 2). However, other literature from the Balkan Peninsula and research from outside the Balkans have not been considered in this comparison. For this reason, our comparative review cannot be precise in numerical terms and depends on the selected literature.

Correspondence analysis reflects the common ethnopharmacological practice in the study area, indicating connections among plant species and their use in traditional medicine. Some of the most frequent uses in Pirot District, but also in the broader area of the Balkans, refer to the use of compresses made from the underground parts or fruits, rarely flowers, of *Citrus trifoliata, Aesculus hippocastanum, Dioscorea communis, Symphytum officinale,* and *Syringa vulgaris* in treating autoimmune diseases, i.e., rheumatic pain or arthritis. Also, the frequent external use of oil extracts from the upper parts and inflorescences of *Hypericum perforatum* and *Typha latifolia* rhizome in treating dermatology diseases is indicated.

The seeds of *Aesculus hippocastanum* have been widely used across the Balkan Peninsula, including the study area, for the treatment of arthritis (Šavikin et al. 2013; Jarić et al. 2015; Mustafa et al. 2020; Łuczaj et al. 2021), joint pains (Kozuharova et al. (2013), and gout (Gostuški 1973; Tucakov 1990), while the use of lemon fruits against rheumatic pain has only been reported in the monograph of Gostuški (1973). The external application of *Dioscorea communis* rhizome has been popular in the traditional medicine of Serbia and several neighboring countries against joints inflammations and rheumatism (Jarić et al. 2007; Łuczaj et al. 2021), sciatica (Jarić et al. 2007), as well as exostoses, a benign outgrowth of cartilaginous tissue on bone, in Bulgaria (Kozuharova et al. 2013). The use of *Symphytum officinale* for bone cell recovery, against joint and rheumatic pain, and joint swelling, as reported in this study, is similar to the common uses of its preparations in other regions (Pieroni et al. 2011; Popović et al. 2012; Kozuharova et al. 2013; Živković et al. 2020). The external use of *Syringa vulgaris* preparations, as reported for treating rheumatic pain by several informants, could be more specific to the study area. Although rare in traditional medicine, this use is also recorded by Gostuški (1973) and Jarić et al. (2015). As expected, external uses of *Hypericum perforatum* in the form of an oil extract have been widely reported for a spectrum of skin disorders, burns, and wounds. The use of *Hypericum* oil for different cutaneous problems is common in households and clinics across the region as well as the rest of Europe, which is also mentioned in the EMA report (Pieroni et al. 2015; Janaćković et al. 2019; Łuczaj et al. 2021).

According to the results of the applied multivariate techniques, ethnopharmacological practices from the study region generally indicate similar applications of the given species in the wider area, as confirmed by other research conducted in the Balkan Peninsula. As an exception, the use of *Typha latifolia* rhizome for treating burns is different compared to the other Balkan regions, representing a specific and less known use from Pirot District. As stated above, Mustafa et al. (2020) reported the use of *T. latifolia* pollen powder for treating skin cuts, while Gescher and Deters (2011) have described the potential for the use of *T. latifolia* fruit extracts as wound-healing agents. However, to our best knowledge, the use of the oil extract from its rhizome for treating burns has not been previously reported.

In the investigated area, 11 plant species were not reported by respondents from other regions of the Balkan Peninsula during the last two decades, and seven of them have not been reported in any of the research on the Balkans or in books of herbal medicine in Serbia and Bulgaria (they are in bold in the following list): *Artemisia alba, Drosera rotundifolia, Dysphania ambrosioides, Laburnum alpinum,* ***Paeonia peregrina, Salvia nemorosa, Salvia sclarea, Scilla bifolia, Seseli rigidum,*** and ***Stellaria graminea***. These results suggest an adaptation to local flora or, to some extent, the singularity of knowledge about medicinal plants in Pirot District compared to other Balkan regions. On the other hand, it is worth noting that the mentioned 11 plant species received mostly one UR per indication of use and can be categorized as artifacts or outliers. Also, one

respondent reported using *Aesculus hippocastanum* in nutrition. This could be an artifact or the result of a mix-up with *Castanea sativa*.

A. alba uses were also reported in an old Bulgarian medicinal book (Nedelcheva 2012). The uses of *D. rotundifolia, D. ambrosioides,* and the similar taxon *Laburnum anagyroides* (*L. alpinum* in our study) were described in books dedicated to herbal medicine in former Yugoslavia and Serbia. Gostuški (1973) wrote that *D. ambrosioides* was used to treat intestinal parasites, i.e., roundworms in humans, while in our study, *D. ambrosioides* was mentioned for treating diarrhea. The uses of *D. ambrosioides* reported in herbal medicine books were similar to the results of our investigation. According to Łuczaj et al. (2022), the medicinal uses of *D. ambrosioides* were recorded in different local pharmacopeias worldwide as an anthelmintic drug and for treating indigestion and dyspepsia. *D. rotundifolia* was described as a medicinal plant by Gostuški (1973), Sarić (1989), Tucakov (1990), and Marković et al. (2020c) for treating infectious diseases followed by coughing: bronchitis, asthma, and tuberculosis. The reported use of *D. rotundifolia* against tuberculosis was the same as in our investigation.

In addition, three of the 11 mentioned species are cultivated: *Dysphania ambrosioides, Fagopyrum esculentum,* and *Laburnum alpinum*. The other herbs are wild plant species, of which *Drosera rotundifolia* and *Paeonia peregrina* are species strictly protected by national legislation (Official Gazette of the Republic of Serbia 2016).

The aerial parts of *Artemisia alba* in Pirot District are soaked in alcohol to be used for improving appetite and are said to improve the immune system. Three Bulgarian respondents in the presented study reported these uses. The use of *Artemisia alba* was mentioned in "Canon Prayer to St. Ivan Rilski and Medicinal Text", part of Bulgarian early printed literature (Nedelcheva 2012). It was used in the form of a vinegar-based mixture for general body strengthening.

The use of *Scilla bifolia* bulbs in the present study for the external treatment of chest pain is also new. Investigations into this species are minimal, and when studied in terms of active principles, it could be considered an easily accessible resource (Balasoiu et al. 2014). *S. bifolia* is used outside the Balkans. According to Turker and Usta (2008), only insignificant antibacterial activity was observed in *S. bifolia* from Turkey. The underground parts of *S. bifolia* in Romania are administered internally as a tea against cough (Balasoiu et al. 2014), similar to the use reported in our study.

The fresh leaf of *Salvia sclarea* was reported to be used for wounds. A compress from the roots of *Seseli rigidum* was mentioned for wound treatment, while its alcohol extract is credited with benefits in treating cancers.

The population of Pirot District prepares an infusion from the aerial parts of *Dysphania ambrosioides* for the treatment of diarrhea in the following way: boiling water is poured over the dried and chopped plant and left to steep for some time. The same procedure is used to prepare *Fagopyrum esculentum* leaves for use against high blood pressure and for body cleansing, *Laburnum alpinum* leaves for treating constipation, the aerial parts of *Salvia nemorosa* against stomach problems and sore throat, and the aerial parts of *Stellaria graminea* for treating cough.

The uses of 14 medicinal plants were not previously reported in ethnobotanical research in the Balkans apart from our investigation of Pirot District and Serbian books of herbal medicine (Supplement 5: Appendix 3 of Table 2):

We compared our results with Bulgarian data (Kozuharova et al. 2013, 2014; Koleva et al. 2015) (Supplement 2, Table 2). In ethnobotanical research on the Balkan Peninsula, the uses of the following plants are unique to Pirot District (present study) and Bulgaria:

- *Allium schoenoprasum*—against hypertonia,
- *Cottinus coggygria*—for gynecological problems, i.e., genital infections,
- *Geranium macrorrhizum*—against hypertonia.

We compared our results with an ethnobotanical study from Croatian islands (Łuczaj et al. 2021) (Supplement 2, Table 2). *Satureja montana*, *Teucrium chamaedrys*, and *T. montanum* are widely used in Croatia (and Herzegovina) for various ailments. The uses of *S. montana* against common cold, *T. chamaedrys* for diabetes, and *T. montanum* for body cleansing on the Adriatic islands in Croatia (Łuczaj et al. 2021) were identical to those of our study.

Comparative analysis with regions of Greece and Turkey

Publications from some regions of Greece and Turkey reported several medicinal plants mentioned in our study with similar uses. Comparisons of our results with those of research from Greece and Turkey are presented below.

Based on literature data, Vokou et al. (1993) studied the traditional medicinal plant use in Zagori, a group of villages in the mountainous area of Epirus, northwest Greece. They found the following medicinal plants, also reported in our study, with the most frequent traditional uses by group of ailments (Table 1): *Sambucus nigra* (respiratory), *Urtica dioica* (cardiovascular system), *Achillea millefolium* (digestive system), *Arctostaphylos uva-ursi* (urinary system complaints), *Hypericum perforatum* (skin diseases), *Tilia tomentosa* (similar to the taxon in our study *T. cordata*, for nervous diseases), *Salvia officinalis* (infectious diseases). The interview-based study of Malamas and Marselos (1992) at the same locality in Greece reported the same results for uses of the following plants: *S. nigra*, *U. dioica*, *A. millefolium, H. perforatum*, and the similar taxon *T. tomentosa*, in line with our study. *Matricaria chamomilla*, *Hypericum* spp., and *Salvia* spp. were the taxa with the highest use-value in herbal markets with traditional recipes at Peloponnisos in southern Greece (Petrakou et al. 2020), and these taxa were also reported with similar applications in the present study.

Uzun and Koca (2020) determined that *Urtica dioica*, *Thymus* spp., and *Mentha* x *piperita* have broad traditional uses in the herbal markets of Kahramanmaraş (Turkey). These taxa are also mentioned in our study, with some identical uses of *U. dioica* for hair care, wounds, diabetes, hemorrhoids, and rheumatism, *Thymus* spp. against stomachache, headache, indigestive, cough, bronchitis, and nervous disorders, and *Mentha* x *piperita* against stomachache, cold, and headache. *Rosa canina* and *U. dioica* were the medicinal plants widely used by the local people of Maden District (Cakilicoglu et al. 2011) and Elazığ (Hayta et al. 2013), located in the eastern Anatolia region of Turkey. Our study reported these two plants with identical uses: *R. canina* against the common cold and influenza, and *U. dioica* against the common cold, diabetes, and rheumatism. *Artemisia absinthium*, *Melissa officinalis*, *Tussilago farfara*, and *U. dioica* were the most frequently used in Sakarya province in northwest Turkey (Uzun et al. 2004), and are also reported with similar uses in our study.

Local knowledge and knowledge from herbal medicine books

Some of the recorded uses in our study could be affected by literature. The wide use of *Epilobium parviflorum* by people in the study area for prostate may be from reading books by the herbalist Marie Treben. The research of Sõukand et al. (2020) aimed to understand the increase in interest in using plants from the genus *Epilobium* in various countries. They report there is a chance that plants from this genus could prove to be clinically safe for treating prostate diseases, but this has yet to happen. Ethnobotanical research should differentiate between local traditional knowledge and the widespread knowledge reported in scientific literature, popular books on plant use, and the media (Leonti 2011). Herbal medicine, documented through field research, shows a strong relationship with written herbal knowledge, and science-generated herbal knowledge is filtered down to the popular level (Leonti and Verpoorte 2017). The commonly used medicinal plant taxa in Pirot District (*Hypericum perforatum, Matricaria chamomilla*, *Thymus* spp., *Mentha* x *piperita*, and *Achillea millefolium*), but also most of the other plant species, have mainly similar uses to those found in herbal medicine books in Serbia (Gostuški 1973; Sarić 1989; Tucakov 1990; Tasić et al. 2001; Marković et al. 2020d; Ratknić et al. 2021) (Supplement 2, Table 2). Also, the overlap in the use of plants in our study with the ancient written sources about herbal medicine in Bulgaria (Nedelcheva 2012) has been recorded, such as the use of *Artemisia alba* for general body strengthening, *Juglans regia* for treating cough and skin infections, *Salvia officinalis* against headache, and *Petroselinum crispum* for treating urinary tract infections, especially difficulty in urinating. Rostafiński was the first in the nineteenth century to formulate the idea that folk herbal knowledge may be recycled from books (Köhler 2015; Łuczaj et al. 2022). According to Rostafiński, the knowledge about plants that is widespread among village populations was not local in origin but derived from ancient knowledge acquired through the Christian culture and books on herbal medicine (Köhler 2015).

Conclusion

The presented study identified plant taxa used by the population in Pirot District. Results showed that out of 182 plant taxa locally used for medicinal purposes, *Hypericum perforatum*, *Matricaria chamomilla*, species from the genus *Thymus*, *Mentha* x *piperita*, and *Achillea millefolium* were the best known and most commonly used. Infusions were the most common form of preparation. The most frequently reported families were Rosaceae, Lamiaceae, and Compositae. Treatment of respiratory, digestive, dermatology, and cardiovascular groups of diseases was the most frequently reported by informants.

Correspondence analysis showed that the use of medicinal plants in Pirot District is primarily similar to that of other parts of the Balkan Peninsula and Europe. As an exception, the underground parts of the species *Typha latifolia* are used for burns, unlike reports from other research mentioning the use of pollen powder or the fruits of this plant for similar skin problems.

The local population's knowledge of traditional herbal medicine used in the study area could be a basis for future research. Further investigations are needed to prove the efficacy of herbal remedies. These investigations could deal with the biological activities of the mentioned plant taxa, their chemical composition, pharmacological application, antimicrobial and antiviral activity, and clinical evidence of their action.

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Declarations

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