South African Journal of Botany 137 (2021) 278–289

Contents lists available at ScienceDirect

South African Journal of Botany

journal homepage: www.elsevier.com/locate/sajb

Ethnoveterinary knowledge in Pirot County (Serbia)

Marija S. Marković[a,*], Dejan S. Pljevljakušić[b], Biljana M. Nikolić[c], Dragoljub L. Miladinović[d], Mrdjan M. Djokić[a], Ljubinko B. Rakonjac[c], Vesna P. Stankov Jovanović[a]

[a] University of Niš, Faculty of Sciences and Mathematics, Višegradska 33, Niš 18000, Serbia
[b] Institute for Medicinal Plants Research "Dr. Josif Pančić", Tadeuša Koščuška 1, Belgrade 11000, Serbia
[c] Institute of Forestry, Belgrade, Kneza Višeslava 3, Beograd 11030, Serbia
[d] University of Niš, Faculty of Medicine, Department of Pharmacy, Bulevar Dr. Zorana Đinđića 81, Niš 18000, Serbia

ARTICLE INFO

Article History:
Received 3 August 2020
Revised 14 October 2020
Accepted 20 October 2020
Available online 5 November 2020

Edited by LJ McGaw

Keywords:
Pirot County
Ethnoveterinary knowledge
Balkan peninsula

ABSTRACT

This paper provides essential information on medicinal plant uses in the veterinary ethnopharmacology of Pirot County in Eastern Serbia, known as a relatively isolated, multiethnic, and a traditional agricultural area. The aim of the study was to collect, analyze, and evaluate the medicinal plants' ethnoveterinary knowledge in a Pirot County (2761 km^2, total 92,479 inhabitants, of which 34,672 in the rural area). The local inhabitants of the rural area were interviewed by a semi-structured questionnaire to determine how many of them are familiar with the plants' application in veterinary ethnopharmacology. Interviews were conducted in four municipalities of the Pirot County, where the samples of the local rural population included 631 respondents (mean age 50; 45.59% women, 53.41% men) at 144 sites, of which 148 respondents from 92 villages reported the use of plants in veterinary medicine. The data are presented in a tabular manner and include scientific and local names, the part used, pharmaceutical form, therapeutic indication, and mode of administration, followed with several reports. Furthermore, most frequently reported taxa are systemized for each therapeutic group municipality-wise with calculated informant consensus factor. A comparison with previously published data collected from surrounding territories on the Balkan Peninsula was performed by considering the Jaccard index. The survey revealed 192 plants used by the local population for various health indications, of which 46 species were reported for use in veterinary medicine. Plants reported for the treatment of health issues in livestock (206 reports) were distributed in 30 families out of which the main ones being Asteraceae (8 species), Lamiaceae (4 species), Rosaceae (4 species) and the most abundant were Asteraceae (43 reports), Hypericaceae (28 reports), Polygonaceae (26 reports) and Ranunculaceae (23 reports). The most frequently used plants in veterinary ethnopharmacology were *Cichorium intybus, Hypericum perforatum,* and *Rumex patientia*. Aerial plant parts were exploited more frequently than underground parts. The mode of administration was primarily oral in the water extract form. The primary reported therapeutic groups were diarrhea (98 reports), wounds (27 reports), dermatological diseases (scabies and pediculosis) (14 reports), and elevated temperature (10 reports). The use of 22 plant species was not reported in other ethnoveterinary surveys in the Balkan Peninsula. Knowledge of plants for veterinary use is still constrained among the population of the rural parts of Pirot County. The study identified plant species used by the local population to deal with health issues in domestic animals. The presented findings of this study can be a good starting point for new phytopharmacological investigations in the veterinary domain.

1. Introduction

Ethnopharmacological surveys are a crucial starting point in the development of drugs from natural sources. The knowledge of the use of biological resources for medicinal purposes was transmitted from one generation to another. The information obtained on traditional knowledge of use, wildcrafting, and preservation of medicinal plants facilitates research for new drugs, and the time effectiveness of drug development programs (Said et al., 2002).

The medicinal plants are being used for treating various disorders and diseases around the world for centuries, particularly in

Abbreviations: QF, quotation frequency; FIC, informant consensus factor; DG, digestive; DM, dermatology; IF, infectious; RP, reproductive; RS, respiratory; VR, various; I, internal; E, external; No., number; SER, serbian; BUL, bulgarian; ROM, roma; HMN, Herbarium Moesiacum Niš; EV, Ethnoveterinary

* Corresponding author. University of Niš, Faculty of Sciences and Mathematics, Višegradska 33, 18000 Niš, Republic of Serbia, Tel.: + 38118533015.
E-mail addresses: marijam@pmf.ni.ac.rs (M.S. Marković), dpljevljakusic@mocbilja.rs (D.S. Pljevljakušić), smikitis@gmail.com (B.M. Nikolić), dragoljub.miladinovic@medfak.ni.ac.rs (D.L. Miladinović), mrdjandjokic@pmf.ni.ac.rs (M.M. Djokić), ljrakonjac@yahoo.com (L.B. Rakonjac), sjvesna@pmf.ni.ac.rs (V.P. Stankov Jovanović).

https://doi.org/10.1016/j.sajb.2020.10.025
0254-6299/

developing countries. More than 80% of the world's population, mostly in poor and less developed countries, depend on traditional medicine (Wanzala et al., 2005). The use of medicinal plants is not restricted to human disease treatment but also widely used for the treatment of animal diseases (Lans et al., 2007a; Kunwar and Bussmann, 2008). Ethnoveterinary medicine encompasses the knowledge, skills, methods, practices, and beliefs about traditional health treatments of animals (McCorkle, 1986).

In the developing countries, the rural inhabitants rely on ancestral indigenous knowledge to control various animal diseases, such as diarrhea, wounds, colds, worms, and reproductive disorders with the medicinal plant (Akerreta et al., 2010). The same authors wrote that an only small portion of this traditional knowledge has been documented in most of the countries. Nevertheless, in recent years, increasing attention has been paid to local veterinary practice and therapeutic value (Akerreta et al., 2010; Davidović et al., 2011, 2012; Kubkomawa et al., 2013; Šubarević et al., 2015; González et al., 2020). Most of this knowledge is preserved in the elderly community members and unfortunately often disappeared as they die, and studies in veterinary ethnopharmacology could save this knowledge from extinction (Gradé et al., 2009; Akerreta et al., 2010).

The reasons for utilizing knowledge and skills in traditional veterinary medicine are primarily economic. Over the last decades, a usual practice in livestock production was the use of antibiotics as growth promoters, which were applied in doses smaller than therapeutical (Davidović et al., 2011). The frequent and uncontrolled use of antibiotics and antiparasitics has led to the emergence of resistance, which contributes to the popularity of veterinary ethnopharmacology. Moreover, some medicines happened to be economically unprofitable for administration, such as antiviral drugs and cytostatics (Lans et al., 2007b). Due to the contemporary trends of healthier food production, better raw materials for clothing, cost-effectiveness, and more significant environmental conservation, veterinary ethnopharmacology is gaining importance in the last decades (Kubkomawa et al., 2013).

Ethnobotanical data provide a basis for further validation of practices and plant uses in the context of a professional approach to ethnoveterinary medicine (Muhammad et al., 2005; Akerreta et al., 2010). Besides, the obtained results can use for new scientific studies. A diverse or extensive collection of medicinal plant species, which can be used in veterinary medicine, and the knowledge concerning their medicinal use in function as the raw material for such research are considered (Akeretta, 2010). Ethnoveterinary knowledge could constitute a fundamental step for the discovery and isolation of natural extracts from plants in the search for new and low-cost drugs (González et al., 2020).

The rural regions of Southeast Europe and central part of Balkan Peninsula represent the unique territories for ethnobotanical studies, thanks to the spacious mountainous area, which has been recognized as regions of abundant bio and ethnic diversity (Tsioutsiou et al., 2019). So far, there is sparse ethnobotanical evidence for East Serbia (Balkans, southeastern Europe) (Janaćković et al., 2019). In Serbia, the level of poverty is the highest in eastern and southeastern regions, where the economy is reduced to small-scale agriculture (Matejić et al., 2020; Živković et al., 2020). These regions have been under economic impoverishment and depopulation for decades, influencing the disappearance of traditional knowledges (Živković et al., 2020). In the part of the territory covered by the current research, herbal resource assessments, used in human medicine, were previously carried out. Mihajlov and Milojević (1985) were given the pharmacognosy map data of the Pirot's environment. In this research, 208 species of medicinal plants and 788 local names have been recorded, where most of them were described by the characteristics of the language of this region itself (Milojević and Mihajlov, 1985). According to Ranđelović et al. (1991), a list of 93 medicinal plants for the subregion Pirot was compiled. There are 60 aromatic plants noticed on Vidlič mountain (Marković et al., 2009). In Pirot County, Marković et al. (2010) made a list of 326 herbs whose drugs are officinal or are used in traditional medicine. Stankov Jovanović et al. (2018) reported that the most widely used medicinal plant in Pirot County is St. John's Wort (*Hypericum perforatum* L.).

Several of the previously conducted ethnobotanical surveys in Serbia have targeted traditional knowledge of the use of plants in human diseases treatment (Jarić et al., 2007, 2014, 2015; Zlatković et al., 2014; Janaćković et al., 2019; Matejić et al., 2020; Živković et al., 2020), but these authors, except paper Janaćković et al., 2019, which mentioned *Glechoma hederacea* L. (Lamiaceae), which shoots are given to horses against intestinal parasites, *Helleborus odorus* Waldst. & Kit. (Ranunculaceae), used against fever and pain of sick animals, and *Hypericum perforatum* L. (Hypericaceae), used for animal skin protection and against liver fluke, did not report the use of any plant for the treatment of animal diseases. Šubarević et al. (2015) were studied the knowledge of ethnoveterinary medicine in four villages from the eastern part of Stara Planina Mts in the Dimitrovgrad municipality, where this survey pointed out the specificity and importance of knowledge concerning the geographic places and determined the applicability of knowledge in veterinary medicine.

The lack of the regional knowledge base concerning medicinal plants, which can be used in veterinary ethnopharmacology, will severely limit the potential of ethnopharmacology for drug discovery. Therefore, we conducted an ethnobotanical study in Pirot County (Eastern Serbia) intending to preserve the share of this knowledge. The prime goal of our study was to collect and conserve the knowledge of traditional uses of wild medicinal plants in veterinary ethnopharmacology by the local population in the County. The survey results present the tracheophyte resources still used, or that have been used until the last decades, for the health care and comfort of domestic animals in this rural and underdeveloped region of Serbia.

2. Materials and methods

2.1. Study area

Pirot County is a region situated in the central part of the Balkan Peninsula, on the border between Serbia and Bulgaria. Studied area of the County covers 2761 km^2 (Pirot County GIS, 2019) (42.863′ N – 43.403′ N and 22.117′ E – 23.006′ E). The investigated area is located at elevations 239 to 2169 m. It includes the following mountain ranges: the south slope of the Stara Planina Mts, the western and central part of Vidlič, Belava, Sedlar, Vlaška Mts (Pirot municipality), Šljivovička Mt and Svrljiške Mts (Bela Palanka municipality), the eastern slopes of the Suva Planina Mts and western slopes of Ruj Mt. (Babušnica municipality), the Greben Mt and eastern slopes of Vidlič Mt (Dimitrovgrad municipality). The mentioned mountain areas are rich in wealth and diversity of medicinal plant species (Marković et al., 2009, 2010, 2019b; Zlatković and Bogosavljević, 2014). The most significant natural object in the area is Stara Planina Mts that dominates the relief of the County, but it also represents the wealthiest mountain in terms of resources of medicinal plants as well as flora and vegetation in general (Mijović et al., 2007; Marković et al., 2010).

The climate is temperate continental (Petrović 1998), and the transitional climatic variations to sub-mountain and mountain climate at altitude over 600 m (Vidanović, 1960). The community of *Carpinetum orientalis serbicum* Rudski 1949 can be found on steep slopes, at the altitudes of 400 to 600 m (Marković et al., 2015a). Community of *Quercetum frainetto-cerridis* Rudski 1949, formed at the altitudes 400 to 1000 m, mostly in the south exposures. The upper region of the mountains, at the altitudes 900 to 1300 m, is covered by community of *Fagetum moesiacae montanum* Jov. 1953 (non Rudski 1949) (Marković et al., 2018). Many types of meadows and shrub-like vegetation of the rocky slopes were formed over the vast area of eroded slopes (Marković et al., 2015b). They are essential as a source

of medicinal (Marković et al., 2010) and especially aromatic plants (Marković et al., 2009).

2.2. Localities, the population of the study area and data collection

The population surveyed is conveniently divided into samples by four municipalities: Pirot, Bela Palanka, Babušnica, and Dimitrovgrad. It is a typical traditional, rural and underdeveloped region of Serbia.

The total number of inhabitants of the Pirot County, according to population census 2011, was 92,479, of which 83.7% were Serbs, 7.1% Bulgarians, 4,7% Roma, and 4.5% the other nationalities (Statistical Office of the Republic of Serbia, 2011). In the municipality Pirot, according to that census, Serbs was in the majority, i.e., 91.9%, also in municipality Bela Palanka (85.7%) and in municipality Babušnica (88.8%). On the contrary, in the municipality Dimitrovgrad, the ethnic group of Bulgarians was in the majority (52.5%). That group of respondents, which are situated in the eastern part of Dimitrovgrad (Bulgarian-Serbian border), are a particular ethnic population group named "Shopi" (Stojković, 2010). They live in the territory in western Bulgaria, northeastern Macedonia, and southeastern Serbia. Another name for these peoples, "Torlaci," indicated sheep farming as their dominant activity (Šubarević et al., 2015). Their culture, way of life, treatment, and cultivation of animals in the Stara Planina Mts are exceptional. They have assimilated parts of Bulgarian culture and Bulgarian language due to the proximity of the border with Bulgaria (Svetieva, 2005). According to Krstić (2019), for East Balkans, the term Torlaks or “Torlaci" is associated with a dialect and used to refer to the Vlachs, nomadic stockbreeders, who are also called “Crnovlnci”.

Of the number of inhabitants in Pirot County, 37.49% live in rural areas or villages, which are the target group of our investigation. In the Pirot municipality, 20.6% of people live in rural areas, in Bela Palanka municipality 32.8%, in Babušnica municipality 62.6%, in Dimitrovgrad municipality 37.9%. In villages, which are covered by the research, older people are in the majority, because of the migration to the closest town, which is a growing trend in majority European countries in the last decades (Jarić et al., 2007, 2014, 2015; Zlatković et al., 2014; Janaćković et al., 2019). During our study period, we have found that the elder members of the population have more excellent knowledge upon the utilization of medicinal plants in comparison to the younger generation. The younger generations showed less interest in traditional practices. The average age of respondents who have mentioned the use of plants in veterinary ethnopharmacology was about 55 years.

An ethnobotanical survey was based on information collected during the fieldwork in 2017. The survey was conducted using a semi-structured questionnaire and participant observation as well as guided tours to the locations where the informants usually collect medicinal plants. Information gathered in the form of a questionnaire provided valuable data and insight into medicinal plants' knowledge and original ways of use among the local community at Pirot County. The questionnaire about knowledge and use of medicinal plants included inhabitants of 144 villages of the Pirot County, of which, 32 villages in the municipality of Babušnica, 37 villages in the municipality of Bela Palanka, 25 villages in the municipality of Dimitrovgrad and 65 villages in the municipality of Pirot. A total of 631 people was surveyed, of which 337 were male and 294 female, age range 16–88 (Stankov Jovanović et al., 2018; Marković, 2019a). Most of the respondents belonged to the Serbian nationality (532), while others were Bulgarians (84) and Roma (15). The ethnic composition of the interviewed population and comparison with the total number of rural inhabitants in Pirot County and four municipalities are given in Table 1.

Most respondents were engaged in agriculture and livestock breeding. Their knowledge of medicinal plant uses was based on a tradition, inherited from their ancestors. In direct interview each respondent was asked a list of questions. Respondents were asked to list the plants that they collect in the County for medicinal purposes. They were also asked for the information on using medicinal plants in veterinary ethnopharmacology: which part of the plant shows the medicinal effect, form of preparation and administration, and finally to specify medicinal uses in the treatment of different health issues in livestock. Of the total number of the interviewed population, respondents from 92 villages mention the use of plants in veterinary ethnopharmacology. Distribution of localities visited in the scope of ethnobotanical interviews, and local people's knowledge of the use of medicinal plants in veterinary ethnopharmacology is given in Fig. 1. The population of studied villages mainly consists of animal husbandry and agriculture (Vidanović, 1955, 1960). The villages are located at different elevations (265 to 1175 m a.s.l.). They are relatively small in terms of their given area and the number of inhabitants. The average values of altitudes of villages, in which the local people have mentioned the use of plants in veterinary ethnopharmacology, for all four municipalities is 533.25 m. The highest altitudes

Table 1
Overview of the interviewed rural population by nationality and gender in the Pirot County with the share of ethnoveterinary data.

		Census data[a]				Interviewed				EV knowledge[c]				EV reports[d]			
Municipality/County	Sex	SER[b]	BUL	ROM	Σ	SER	BUL	ROM	Σ	SER	BUL	ROM	Σ	SER	BUL	ROM	Σ
Pirot	male	9152	97	353	9846	163	2	4	169	29	-	1	30	47	-	1	48
(rural)	female	8645	76	345	9297	158	1	2	161	42	-	-	42	59	-	-	59
	Σ	17,797	173	968	19,143	321	3	6	330	71	-	1	72	106	-	1	107
Bela Palanka	male	1910	1	100	2090	60	-	4	64	17	-	-	18	22	-	1	23
(rural)	female	1701	1	101	1893	61	-	-	61	18	-	-	18	22	-	-	22
	Σ	3611	2	201	3983	121	-	4	125	35	-	1	36	44	-	1	45
Babušnica	male	3403	327	112	3984	50	10	3	63	8	2	2	12	11	2	3	16
(rural)	female	3216	272	91	3722	37	7	-	44	12	1	-	13	16	1	-	17
	Σ	6619	599	203	7706	87	17	3	107	20	3	2	25	27	3	3	33
Dimitrovgrad	male	464	1139	3	1996	2	38	1	41	-	8	1	9	-	10	1	10
(rural)	female	534	916	5	1844	1	26	1	28	-	6	-	6	-	9	-	10
	Σ	998	2055	8	3840	3	64	2	69	-	14	1	15	-	19	1	20
Pirot County	male	14,929	1564	568	17,916	275	50	12	337	54	10	5	69	80	12	6	98
(rural)	female	14,096	1265	542	16,756	257	34	3	294	72	7	0	79	97	10	-	107
	Σ	29,025	2829	1110	34,672	532	84	15	631	126	17	5	148	177	22	6	205

[a] Data according to the 2011 census (Statistical Office of the Republic of Serbia, 2011).
[b] Nationality codes, SER - Serbian, BUL - Bulgarian, ROM - Roma.
[c] EV knowledge - number of respondents with knowledge about ethnoveterinary use of plants.
[d] EV reports - number of reports about ethnoveterinary use of plants.

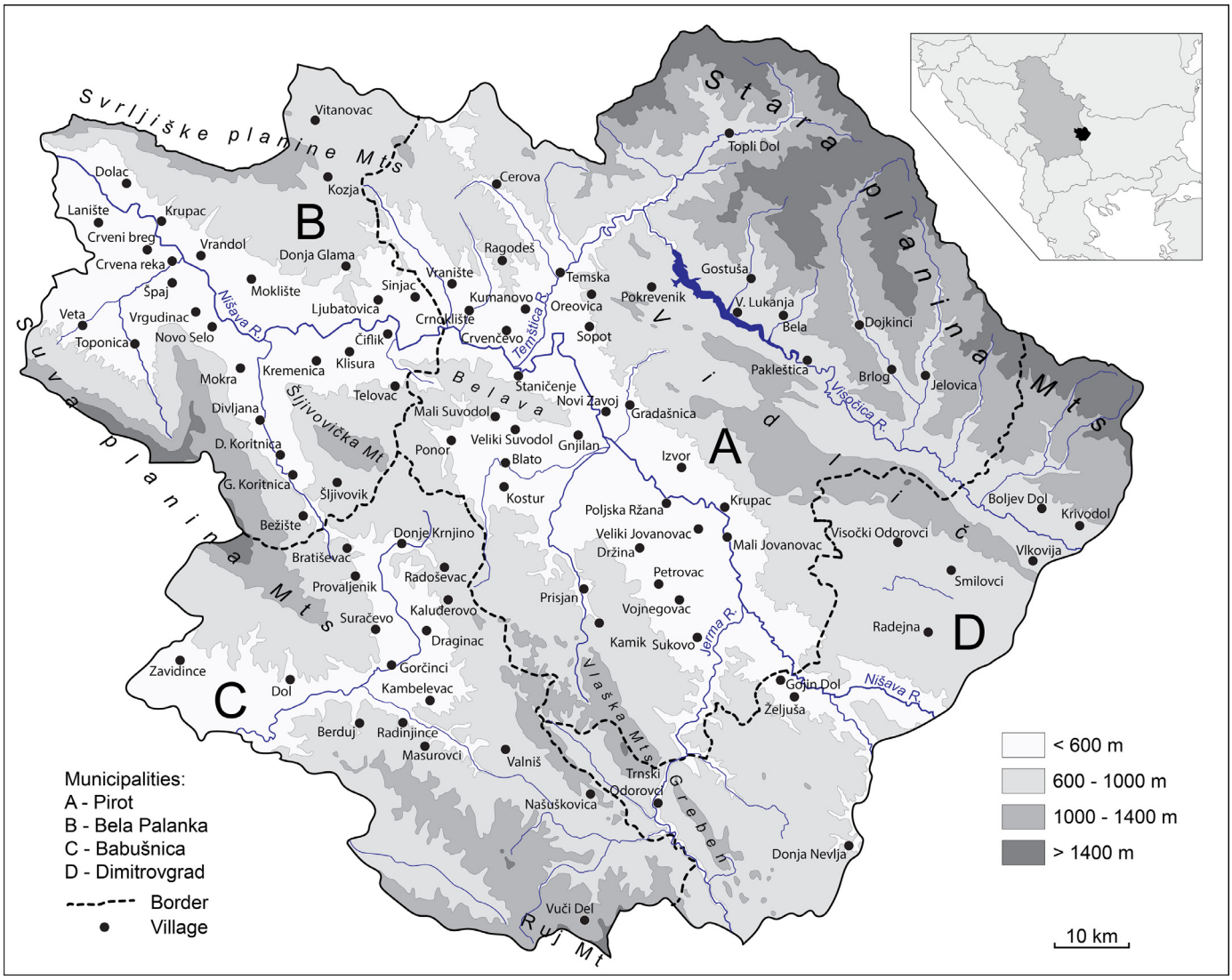

Fig. 1. Map of the study area with mountains and water bodies was highlighted, with villages visited in the scope of ethnobotanical interviews in which local inhabitants were mentioned using medicinal plants in veterinary ethnopharmacology.

were recorded in areas C and D (villages of Babušnica and Dimitrovgrad municipalities), while the lowest in the villages of areas B (villages of Bela Palanka municipality).

Plant vouchers were collected, mostly when accompanied by the informants and authenticated according to "Flora of SR Serbia" (Josifović, ed, 1970–1986) and "Flora of the People's Republic Bulgaria" (Jordanov, 1963–1979). The nomenclature is adjusted following the "Flora Europaea" (Tutin et al., 1964–1980). The nomenclature of the taxa listed, given at species level, was also compiled from databases: The EURO+MED PlantBase – the information resource for Euro-Mediterranean plant diversity (https://ww2.bgbm.org/EuroPlusMed/query.asp) and GPC – Global Plant Checklist managed by IOPI – International Organization for Plant Information (http://www1.biologie.uni-hamburg.de/b-online/ibc99/iopi/query.htm). All species collected during fieldwork were labeled after identification and deposited in the herbarium collection at the Department of Biology and Ecology, Faculty of Sciences and Mathematics, University of Niš "Herbarium Moesiacum Niš" (HMN). The voucher numbers were given continuously from 14,008 to 14,053. Quotation frequency (QF), that was calculated for every reported species, refers to a portion of selected species in the total number of use reports (Zlatković et al., 2013). Original questionnaire data in Serbian, obtained during the field survey, are also deposited in the HMN herbarium.

2.3. Data analysis

The survey results on the knowledge and use of medicinal plants were systematized in a tabular manner, where plants are arranged in alphabetical order of their scientific names (Table 2). We noted for each species scientific name of the plant, family, voucher specimen, the local name, quotation frequency, part used, form, use, therapeutic category, and administration codes.

Informant consensus factor (FIC), with factor ranges from 0 to 1, is used to express ethnobotanical homogeneity (Zlatković et al., 2013). It is the quotient between the number of use-reports minus the number of used taxa and the number of use-reports minus one (Trotter and Logan, 1986). The maximum value of this factor indicates the best rate of agreement between the informants, which means that informants show immense knowledge and coherence about medicinal plant uses (Akeretta et al., 2010).

A comparison with results of previous studies was performed by analyzing the percentages of quoted species and their medicinal uses and by considering the Jaccard index (calculated using formula JI = c x 100/a + b - c, where a is the number of species of area A, b is the number of species of area B, and c is the number of species common to A and B) (Šavikin et al., 2013).

Table 2
Ethnoveterinary uses of medicinal plants in Pirot County reported from informants.

Latin name (Family) (Voucher specimen)	Local name(s) - most common	QF [%]	Part used	Form	Use / Administration[a]	Reports	Use in neighboring areas[b]
Achillea millefolium L. (Asteraceae) (14,008)	hajdučka trava, ravnež	0.98	herba	water extract	Diarrhea (Dg) / I	1	3♣ 6♣
			recent herba	oil	Wounds (Dm) / E	1	4♣ 7◆ 9♣
Aesculus hippocastanum L. (Hippocastanaceae) (14,009)	divlji kesten, kesten	1.46	semen	boiled seed	Diarrhea (Dg) / I	3	8◆
Agrimonia eupatoria Ledeb. (Rosaceae) (14,010)	petrovac, petrovčić	0.49	herba	oil	Udder edema of cows (Rp) / E	1	9◆
Allium sativum L. (Liliaceae) (14,011)	beli luk	0.49	bulbus	oil	Udder edema of cows (Rp) / E	1	2◆ 3◆ 6◆ 7◆
Anthyllis vulneraria L. (Fabaceae) (14,012)	zvezdan žuti, belodun	0.49	flos	water extract	Diarrhea (Dg) / I	1	■
Arctium lappa L. (Asteraceae) (14,013)	čičak, čobanka, repušina	1.46	herba	water extract	Colds (Rs) / I	3	7◆*
Artemisia absinthium L. (Asteraceae) (14,014)	beli pelin, pelin	0.49	herba	water extract	Cold of horses (Rs) / I	1	1◆ 4◆
Arum maculatum L. (Araceae) (14,015)	zmijsći kukuruz	0.49	rhizoma	oil	Udder edema of cows (Rp) / E	1	■
Berteroa incana (L.) DC. (Brassicaceae) (14,016)	tvrdac	1.46	herba	water extract	Diarrhea (Dg) / I	3	■
Brassica napus L. (Brassicaceae) (14,017)	uljana repica	1.46	semen	oil	Scabies in rabbit ears (Dm) / E	1	■
			semen	oil	Spots on the skin of pigs (Dm) / E	2	
Calendula officinalis L. (Asteraceae) (14,018)	neven	0.98	flos	water extract	Colds (Rs) / I	1	4◆ 6♣* 9◆
			flos	oil	Swine and sheep erysipelas (on the hoof) / E	1	
Carum carvi L. (Apiaceae) (14,019)	kim	0.49	semen	dry seeds	Carminative (Dg) / I	1	■
Celosia argentea L. (Amaranthaceae) (14,020)	strator	1.95	semen	water extract	Swine erysipelas (If) / E	3	■
			semen	water extract	Stomach viruses (If) / I	1	
Centaurium erythraea Rafin. (Gentianaceae) (14,021)	crven kantarion, gorčika, kičica	0.98	herba	oil	Wounds and burns (Dm) / E	1	■
			herba	water extract	Diarrhea (Dg) / I	1	
Chelidonium majus L. (Papaveraceae) (14,022)	lišaivac, lišavica, rosomača, rusa	1.46	herba	fresh plant	Wounds (Dm) / E	2	7◆ 9♣
			herba	oil	Udder edema of the cow (Rp) / E	1	
Cichorium intybus L. (Asteraceae) (14,023)	cikorija, gologuza, plavocvet	14.15	herba	water extract	Diarrhea (Dg) / I	29	■
Cydonia oblonga Miller (Rosaceae) (14,024)	dunja	0.49	folium	water extract	Diarrhea (Dg) / I	1	7♣
Datura stramonium L. (Solanaceae) (14,025)	tatula	0.49	folium	water extract	Diarrhea (Dg) / I	1	■
Dryopteris filix-mas (L.) Schott (Dryopteridaceae) (14,026)	muška paprat, navala	0.98	rhizoma	dry rhizome	Intestinal parasites (fluke…) (Dg) / I	2	1♣ 4♣
Elymus repens (L.) Gould (Poaceae) (14,027)	pir, pirevina, pirovina	0.49	rhizoma	fresh rhizome	Diarrhea (Dg) / I	1	■
Equisetum arvense L. (Equisetaceae) (14,028)	rastavić, rastaviče, rastavičje	0.49	herba	oil	Swine and sheep erysipelas (on the hoof) / E	1	4◆ 9◆
Ficus carica L. (Moraceae) (14,029)	smokva	0.49	folium	water extract	Diarrhea (Dg) / I	1	■
Fraxinus excelsior L. (Oleaceae) (14,030)	jasen, beli jasen	1.46	cortex	water extract	Plaque in poultry (If) / I	2	7◆
			cortex	water extract	Disinfection (If) / E	1	
Helleborus odorus Waldst. & Kit. (Ranunculaceae) (14,031)	kukurek, divlji kukurek	11.22	rhizoma	fresh plant	Temperature in livestock (in the ear) (If) / E	8	1♣ 8♣
			rhizoma	fresh plant	Killing diseased livestock (If) / I	11	
			rhizoma	fresh plant	Poisoning (Dg) / I	2	
			rhizoma	fresh plant	Snake bites (Vr) / E	1	
			rhizoma	/	Animal diseases (Vr) / E	1	3♣ 4◆ 7◆ 9◆
Hypericum perforatum L. (Hypericaceae) (14,032)	kantarion, drenčak	13.66	herba	oil	Wounds (Dm) / E	21	1◆ 4♣ 9♣
			herba	water extract	Diarrhea (Dg) / I	4	2♣* 4♣ 9♣
			herba	oil	Wounds and burns (Dm) / E	1	
			herba	oil	Wounds (lubrication pots of cows) (Dm) / E	1	
			herba	oil	Corns and calluses (Dm) / E	1	

(*continued*)

Table 2 (*Continued*)

Latin name (Family) (Voucher specimen)	Local name(s) - most common	QF [%]	Part used	Form	Use / Administration[a]	Reports	Use in neighboring areas[b]
Iris germanica L. (Iridaceae) (14,033)	perunika, divlja ruža	0.49	rhizoma	water extract	Cold of horses (Rs) / I	1	■
Juglans regia L. (Juglandaceae) (14,034)	orah	0.49	pericarp	water extract	Diarrhea (Dg) / I	1	■
Juniperus communis L. (Cupressaceae) (14,035)	kleka, zimzelen	0.49	fructus	fresh fruit	Snake bites (Vr) / E	1	■
Lysimachia nummularia L. (Primulaceae) (14,036)	metilj trava	0.98	herba	water extract	Intestinal parasites (Dg) / I	2	■
Lythrum salicaria L. (Lythraceae) (14,037)	potočnjak, vrbičica	3.9	herba	water extract	Diarrhea (Dg) / I	8	9♣
Matricaria chamomilla L. (Asteraceae) (14,038)	bela rada, kamilica, podrumče	1.95	flos	water extract	Stomach diseases (Dg) / I	2	
			flos	water extract	Colds (R) / I	2	4♣ 9♣
Melissa officinalis L. (Lamiaceae) (14,039)	matičnjak, matočina	0.49	folium	water extract	Diarrhea (Dg) / I	1	4◆ 7◆ 9◆
Mentha x piperita L. (Lamiaceae) (14,040)	djoz, džodžan, mentolka, nana	1.95	herba	water extract	Stomach diseases (Dg) / I	2	■
			herba	water extract	Diarrhea (Dg) / I	2	
Paliurus spina-christi Miller (Rhamnaceae) (14,041)	draka, drača	2.44	fructus	water extract	Diarrhea (Dg) / I	5	■
Plantago major L. (Plantaginaceae) (14,042)	bokvica, žilivlak, parabica	1.46	folium	fresh folium	Diarrhea (Dg) / I	1	4♣
			folium	water extract	Cough (Rs) / I	1	
			folium	fresh plant	Wounds (Dm) / E	1	8♣ 9♣
Potentilla reptans L. (Rosaceae) (14,043)	petoprsnica, petoprsta	0.98	herba	oil	Udder edema of cows (Rp) / E	1	■
			herba	water extract	Diarrhea (Dg) / I	1	
Quercus cerris L. (Fagaceae) (14,044)	cer, granica, hrast	1.46	cortex	water extract	Diarrhea (Dg / I	2	7◆ 8◆ 9♣
			folium	water extract	Diarrhea (Dg) / I	1	
Rumex patientia L. (Polygonaceae) (14,045)	divlje zelje, ljigavac, štavljak	12.68	semen	water extract	Diarrhea (Dg) / I	26	1♣* 4♣*
Salvia officinalis L. (Lamiaceae) (14,046)	kalaver, kaloper, žalfija	0.49	folium	water extract	Cough (Rs) / I	1	9♣
Sanguisorba minor Scop. (Rosaceae) (14,047)	lubeničarka, dinjica	0.98	herba	fresh plant	Snake bites (Vr) / E	2	■
Sonchus arvensis L. (Asteraceae) (14,048)	mleč	0.49	folium	fresh f plant	Temperature in livestock (If) / E	1	■
Taraxacum officinale aggr. (Asteraceae) (14,049)	maslačak, mleč, mlečak	0.49	herba	fresh plant	Snake bites (in sheep) (Vr) /) / E	1	7◆ 8◆
Teucrium chamaedrys L. (Lamiaceae) (14,050)	podubica	0.49	herba	water extract	Diarrhea (Dg) / I	1	9◆
Tilia platyphyllos Scop. (Tiliaceae) (14,051)	lipa	0.49	folium	water extract	Diarrhea (Dg) / I	1	■
Veratrum album L. (Liliaceae) (14,052)	čeremika, čemerika	7.32	rhizoma	fresh plant	Skin diseases (scabies and pediculosis) (Dm) / E	12	4♣ 5♣ 9♣
			rhizoma	dry rhizome	Sinus diseases (Rs) / I	2	
			rhizoma	water extract	Paw (If) / I	1	
Verbena officinalis L. (Verbenaceae) (14,053)	vrbena	0.98	herba	water extract	Diarrhea (Dg) / I	2	■

[a] Quotation frequency: QF; Therapeutic category (in brackets): Dg - Digestive, Dm - Dermatology, If - Infectious, Rp - Reproductive, Rs – Respiratory, Vr - Various; Administration codes: I - Internal, E - External.

[b] Numbers refer to the following references: 1. Jarić et al. (2007), 2. Pieroni et al. (2005), 3. Pieroni et al. (2011), 4. Davidović et al. (2011, 2012), 5. Pieroni et al. (2013), 6. Pieroni et al. (2014a), Pieroni et al. (2014b), Pieroni et al. (2015), Šubarević et al. (2015). Symbols indicate comparison outcomes as follows: (♣) use is identical or similar, (◆) use is different from what reported, (■) use not mentioned by authors (1–9), (*) sister taxa: *Arctium minus* instead of *Arctium lappa, Calendula arvensis* instead of *Calendula officinalis, Hypericum maculatum* instead of *Hypericum perforatum, Rumex* sp. instead of *Rumex patientia*.

3. Results and discussion

3.1. Quantitative analyses

We recorded 4917 use reports of the 192 medicinal plants cited. Most uses concerned human medicine (3754 reports), whereas 206 reports were linked to veterinary ethnopharmacology, and 31 reports were linked to human and veterinary ethnopharmacology at the same tame.

Of the total number of the interviewed population, 148 persons mentioned the use of 46 medicinal plants in veterinary ethnopharmacology (Table 2), of which 125 were Serbs with 177 reports, 18 were Bulgarians with 22 reports, and 5 were Roma with six reports. The total number of reports exceeded the number of taxa, as each taxon often had more than one use, and different respondents also mentioned the same species.

We found a high degree of coincidence between the plants in Serbia and Pirot County used in human and veterinary medicine (Sarić, 1989; Marković et al., 2010, 2020). People in the rural area of County use specific plants to take care of both themselves and their livestock, making these species in that regard very important in their daily lives. Most of the species (44) are used to treat both veterinary and human diseases.

Pharmaceutical aspects of ethnobotanical studies are, however, may be used to discover new or infrequently registered medicinal plants' uses, which may provide the basis for new drugs (Šavikin et al., 2013). Our informants reported 22 plant taxa not mentioned in neighboring regions (marked with a symbol □ in Table 2).

To the best of authors' knowledge, they are the plants which uses are not previously noted in ethnobotanical research in the Balkan Peninsula.

The use of 9 plant taxa is different compared to neighboring regions (*Aesculus hippocastanum* L., *Agrimonia eupatoria* Ledeb., *Allium sativum* L., *Artemisia absinthium* L., *Equisetum arvense* L., *Fraxinus excelsior* L., *Melissa officinalis* L., *Taraxacum officinale* aggr., *Teucrium chamaedrys* L.), although they are mentioned in neighboring areas. Fifteen plant taxa, mentioned in neighboring regions, have the same or similar uses in veterinary ethnopharmacology (Table 2).

The use of "sister" taxa in neighboring regions has been reported, for example, *Arctium minus* (Hill) Bernh. in Gollobordo in Eastern Albania (Pieroni et al., 2014b) instead of *Arctium lappa* L., *Calendula arvensis* (Vaill.) L. in Peshkopia in Eastern Albania (Pieroni et al., 2014a) instead of *Calendula officinalis* L., *Hypericum maculatum* Crantz in Northern Albanian Alps (Pieroni et al., 2005) instead of *H. perforatum*. A similar composition could explain previously quoted facts in phytochemicals responsible for the curative effect, which leads to the conclusion that people develop the use of the available species (Šavikin et al., 2013).

3.2. Botanical families

Among 46 species used to treat livestock health issues, taxa belonged to 30 families, where Asteraceae (8 species), Lamiaceae (4), Rosaceae (4), Brassicaceae (2), Liliaceae (2) and Oleaceae (2) were the most abundant. The same families are also the most relevant in human medicine in other areas studied in surrounding regions (Jarić et al., 2007, 2014, 2015; Menković et al., 2011; Šavikin et al., 2013; Zlatković et al., 2014; Janaćković et al., 2019). Furthermore, most of the families mentioned are very large and very rich in medicinal plants. The most abundant families in our study, concerning reports of veterinary uses, were Asteraceae (43 reports), Hypericaceae (28 reports), Polygonaceae (26 reports), and Ranunculaceae (23 reports). It is worth mentioning that, although the number of species used in veterinary ethnopharmacology is 23.95% of the total number of mentioned medicinal plants, the number of families reaches 69.7%.

3.3. Parts of the plant used in the composition of veterinary remedies

The majority of the most commonly used plant parts have been reported for use. Nevertheless, aerial plant parts were exploited more frequently than underground organs. The most frequently used parts of plants were the aerial part (41.3%), leaves (20%), rhizome (13.04%), seed (10.87%), and floral structures (6.52%). In lower proportion bark and fruit (4.35% each one), pericarp and bulbs (2.17% each) have been used. These proportions are similar with the percentages of parts of plants used in Serbia for human medicine (Sarić, 1989; Jarić et al., 2007, 2014, 2015; Šavikin et al., 2013; Zlatković et al., 2014; Janaćković et al., 2019).

Besides being the easiest to collect and being present at all stages of leaf vegetation, leaves are more exposed to environmental damages, and therefore they synthesize as mechanisms of defense active compounds of therapeutic interest (Akerreta et al., 2010). McCune and Johns (2007) reported that for this reason, a leaf is the most employed organ in traditional medicine. Other parts of the plant (flowers, fruits, cone) also contain compounds of pharmacological activity, but since their availability is limited by phenophase, they are less widely used (Akerreta et al., 2010).

3.4. Methods of preparation and administration

Reported herbal preparations are intended mainly for cows, calves, sheep, and horses, but cover almost all domestic animal species. Plants used in traditional remedies are prepared and administered in different forms, and the administration of these medicines includes internal oral absorption or external application in the form of oil or fresh succus of the plant. The percentage of internal uses (141 reports or 68.78%) is significantly higher than that in external uses (64 reports or 31.22%).

Water extraction was by far the most common preparation used, infusions, and decoctions (62.93%). In a minor proportion, dry powdered rhizome (1.95%), boiled seed (1.43%), fresh folium (0.98%), dry seeds, and fresh rhizome (0.49% each one) were mentioned for internal use.

Two forms of preparation for external uses are preparations in oil or maceration (17.56%) and direct administration of fresh succus of plants (12.2%). Preparations in oil were used for treatments of wounds (10.24%), the udder edema of the cow (2.44%), wounds and burns (1.95%), soot disease in pigs and erysipelas in pigs and sheep, on the hoof (0.98% each one), corns and calluses, burns and in rabbit ears (0.49% each one). Direct administration of fresh succus of plants was used against skin diseases, i.e., scabies and pediculosis (5.85%), the temperature in livestock with applications in the ears (3.9%), snake bites (1.95%) and for treatments of wounds (1.43%).

3.5. The treated illnesses

The different health issues were grouped in six therapeutical groups, that includes digestive (Dg), dermatological (Dm), infectious (If), reproductive (Rp), respiratory (Rs), and various (Vr) diseases (Table 3). Five remedies to treat digestive problems (Dg) were found, that includes 1) diarrhea, 2) intestinal parasites, 3) stomach diseases, 4) poisoning, and 5) carminative. Five remedies to cure dermatological problems (Dm) were treated 1) wounds, 2) skin diseases (scabies and pediculosis), 3) burns, 4) skin spots, 5) corns, and calluses. Seven infective disorders (If) were mentioned by respondents 1) killing diseased livestock, 2) the temperature in livestock, 3) erysipelas in pigs and sheep, 4) plaque in poultry, 5) disinfection, 6) stomach viruses, and 7) pow. Udder edema (mastitis) were treated in Pirot County, as the problem of the reproductive system (Rp). Three remedies for respiratory tract infections (Rs) were treated by local inhabitants, that includes 1) cold, 2) cough, and 3) sinus diseases. At the end of Table 3, a group, namely "Various" (Vr) were indicated, which includes five reports against snake bites and one use-report is used if the animals are sick, without specifying the type of disease or condition.

Most of the plants are used to treat only one ailment (30 out of 46 species recorded, 62.22%). *Cichorium intybus* L. is one of them since it is only used in the treatment of diarrhea. At the same time, *C. intybus* is the most used plant in the County (29 reports, quotation frequency 14.15%), and it is one of the plants that are not previously noted in ethnobotanical research in Balkan Peninsula, in parts of published research results, which refer to veterinary ethnopharmacology (Table 2).

The plants that had the highest quotation frequency in our study were *H. perforatum* (28 reports, 13.66%) and *Rumex patientia* L. (26 reports, 12.68%). On the other hand, *H. odorus* and *Veratrum album* L. had lower quotation frequency. However, they have more diverse applications for different groups of diseases (Table 2). *H. odorus* was reported for treatment of digestive alternations, infective and various, while *V. album* was quoted for dermatology affections, infective and respiratory alternations.

Digestive disorders have been most frequently reported, where 53.17% of the uses tackled by popular phytomedicine in animals. The most frequently quoted disease was diarrhea (98 reports, 47.8%) According to our results, diarrhea is mostly treated with aboveground parts of *C. intybus* and *Lythrum salicaria,* L. as well as with seeds of *R. patientia.* Similarly to these findings, Šubarević et al. (2015) reported the utilization of L. *salicaria* decoction in broiler calves for bloody diarrhea. Moreover, according to Davidović et al. (2011, 2012), the seed of dock (*Rumex* sp.) boiled in water was used to treat diarrhea in

Table 3
Taxa most employed in each therapeutic category and region for veterinary indications.

Indications	Municipality	Reports	Reports ratio [%]	No. of uses	No. of taxa	FIC[a]	Taxa most used	Taxa ratio [%]
Digestive	Pirot	61	29.8	3	19	0.7	*Cichorium intybus, Rumex patientia, Lythrum salicaria*	60.7
	Bela Palanka	19	9.3	4	9	0.6	*Rumex patientia, Paliurus spina-christi*	47.4
	Babusnica	17	8.3	1	7	0.6	*Rumex patientia, Cichorium intybus*	58.8
	Dimitrovgrad	12	5.9	2	7	0.5	*Cichorium intybus, Hypericum perforatum*	58.3
	Pirot (County)	109	53.2	5	28	0.8	*Cichorium intybus, Rumex patientia, Lythrum salicaria*	30.7
Dermatology	Pirot	23	11.2	5	6	0.8	*Hypericum perforatum, Veratrum album*	78.3
	Bela Palanka	8	3.9	3	3	0.7	*Hypericum perforatum, Veratrum album, Brassica napus*	100.0
	Babusnica	11	5.4	3	3	0.8	*Hypericum perforatum, Veratrum album*	90.9
	Dimitrovgrad	2	1.0	1	1	0.0	*Hypericum perforatum*	100.0
	Pirot (County)	44	21.4	5	7	0.9	*Hypericum perforatum, Veratrum album*	81.8
Infectious	Pirot	10	4.9	3	3	0.8	*Helleborus odorus*	80.0
	Bela Palanka	17	8.3	7	5	0.6	*Helleborus odorus, Celosia argentea, Fraxinus excelsior*	88.2
	Babusnica	2	1.0	2	2	0.0	*Helleborus odorus, Veratrum album*	100.0
	Dimitrovgrad	1	0.5	1	1	0.0	*Helleborus odorus*	100.0
	Pirot (County)	30	14.6	7	7	0.8	*Helleborus odorus, Celosia argentea, Fraxinus excelsior*	86.7
Reproductive	Pirot	1	0.5	1	1	0.0	*Allium sativum*	100.0
	Bela Palanka	-	-	-	-	0.0	-	-
	Babusnica	2	1.0	1	2	0.0	*Agrimonia eupatoria, Potentilla reptans*	100.0
	Dimitrovgrad	2	1.0	1	2	0.0	*Arum maculatum, Chelidonium majus*	100.0
	Pirot (County)	5	2.4	1	5	0.0	*Agrimonia eupatoria, Allium sativum, Arum maculatum, Chelidonium majus, Potentilla reptans*	100.0
Respiratory	Pirot	9	4.4	3	7	0.3	*Arctium lappa*	33.3
	Bela Palanka	1	0.5	1	1	0.0	*Matricaria chamomilla*	100.0
	Babusnica	-	-	-	-	0.0	-	-
	Dimitrovgrad	1	0.5	1	1	0.0	*Matricaria chamomilla*	100.0
	Pirot (County)	11	5.4	3	8	0.3	*Arctium lappa, Matricaria chamomilla*	45.5
Various	Pirot	3	1.5	1	3	0.0	*Helleborus odorus, Juniperus communis, Sanguisorba officinalis*	100.0
	Bela Palanka	1	0.5	1	1	0.0	*Helleborus odorus*	100.0
	Babusnica	-	-	-	-	0.0	-	-
	Dimitrovgrad	2	1.0	1	2	0.0	*Sanguisorba minor, Taraxacum officinale*	100.0
	Pirot (County)	6	9.9	2	4	0.4	*Helleborus odorus, Sanguisorba minor*	66.7

[a] FIC - Informant consensus factor.

pigs. The same authors reported that summer grazing and quality hay in the winter could prevent alimentary diseases in the "bush", which is an indigenous cattle breed for many Balkan countries. Lesser quoted plants for diarrhea treatment were *Paliurus spina-christi* Miller (5), *H. perforatum* (4), *A. hippocastanum* (3), *Berteroa incana* (L.) DC. (3), *Quercus cerris* L. (3) and *Verbena officinalis* L. (2). One of the respondents quoted a list of plants for the treatment of diarrhea, where *Achillea millefolium* L., *Anthyllis vulneraria* L., *Centaurium erythraea* Rafin., *Cydonia oblonga* Miller, *Datura stramonium* L., *Elymus repens* (L.) Gould, *Ficus carica* L., *Juglans regia* L., *M. officinalis, Plantago major* L., *Potentilla reptans* L., *T. chamaedrys* and *Tilia platyphyllos* Scop. have been mentioned. For one self-sawn wild species, *B. incana* does not exist bibliographic references in Serbia's scientific literature for the use in medicine (Sarić, 1989). According to Davidović et al. (2011, 2012), in Serbia's ethnomedicine, the treatment of diarrhea in ruminants included *P. major, C. officinalis, Urtica dioica* L., *Althaea officinalis* L., *Anethum graveolens* L., and *Salix alba* L. *A. millefolium* is also used for the treatment of diarrhea in South-Western Serbia (Pieroni et al., 2011) and Eastern Albania (Pieroni et al., 2014a; Pieroni et al., 2014b).

Intestinal parasites are widespread in the gastrointestinal tract of cattle, and plants reported for this issue in the Pirot County were *Lysimachia nummularia* L. and *Dryopteris filix-mas* (L.) Schott. Similarly, Davidović et al. (2011, 2012) reported that the decoction of the rhizome of *D. filix-mas* is one of the most potent natural drugs against tapeworms (*Taenia saginata, Taenia solium*) and flukes (*Fasciola hepatica*). Filicin and filmarone act toxically on worms, while oleorescin paralyzes their musculature and prevents parasites adhesion on bowels mucous membrane (Jarić et al., 2007). The same authors also mentioned that *A. absinthium* and *Artemisia vulgaris* were used for centuries as anthelmintics in Serbia, especially against oval and cylindrical worms, treatment of animals infected by blood parasites (*Trypanosoma* and *Plasmodium* spp.).

Local inhabitants of the Pirot County use the leaves of *Matricaria chamomilla* L. and *Mentha x piperita* L. for stomach diseases of their domestic animals, and seed of *Carum carvi* L. as carminative. *H. odorus* is used against poisoning. According to Zlatković (2006) and Šubarević et al. (2015), horse poisoning is treated with the milk of the mare. The same authors also wrote that fresh *V. album* is poisonous in sheep grazing, while not in the hay. Poisoning can even occur during the administration of herbal tea to a sheep. Besides, Šubarević et al. (2015) reported that inhabitants of Stara Planina Mts believe that sheep eat “preštip” (*Genista sagittalis* L.) not to get a fluke, and when stomach pains occur, they eat St. John's Wort or thyme for relief.

Cattle wounds are the most frequently reported health issue (61.36% uses reports) in dermatology. The oil extract of *H. perforatum* and its application on the skin affected with wounds was the most frequent mode of administration (50% uses reports). Powder of *A. millefolium* and *C. erythraea* combined with oil and wound dressing with *Chelidonium majus* L. and *P. major* were also noted for the treatment of skin wounds in our research. Zlatković (2006) wrote that the combination of *A. millefolium* and *Cynoglossum officinale* L. could be used to treat wounds in animals. In ethnoveterinary medicine of Serbia yarrow (*A. millefolium*), marigold (*C. officinalis*) and aloe (*Aloe* sp.) are quoted as plants with anti-inflammatory and antiseptic action used in the healing of the wounds, where they help to form granular tissue and accelerate the wound epithelization. According to Pieroni et al. (2015), the fresh *P. major* was noted for the treatment of wounds in animals. The oil extract of *H. perforatum* is used externally in various skin and mucous membrane injuries and wounds as well as in burns (Davidović et al., 2011, 2012). Except for mentioned procedures and species, Pieroni et al. (2013) and Šubarević et al. (2015) were mentioned the use of pure lard for wounds and burns, combined with *C. officinalis*. In Eastern Albania, *A. sativum* is mixed with salt and rubbed on animal skin (Pieroni et al., 2014a). In Western

Macedonia, the *V. album* is used to treat sheep infected with scabies and pediculosis (Pieroni et al., 2013). Our respondents mention the same application of *the V. album* in cattles (29.55% uses reports). They claimed that animals develop dietary habits for preventing various diseases. Two respondents in our research have mentioned the use of *Brassica napus* L. for spots of the skin of pigs and one respondent the use of *H. perforatum* for the treatment of corns and calluses.

Infective diseases are sometimes the cause of the necessity of the sacrifice of cattle. The inhabitants of the Pirot County have been used *H. odorus* for this purpose (11 reports), but the same plant was used against temperature in livestock (8 reports). Moreover, *Sonchus arvensis* L. is employed for the same purpose. According to the results of Šubarević et al. (2015), *H. odorus* can be used to treat swine erysipelas and swine fever. In brief, a portion of the rhizome or seed of *H. odorus* was attached to the pig's or cow's ear and held until the ear falls off. This treatment method was a unique form of traditional treatment of cattle on Stara Planina Mts and Pirot County. In Kopaonik Mt and Eastern Albania (Raicë and Mokra area), *H. odorus* was used in the same way, but in sheep, without specifying in which disease and whether as therapy or prevention (Jarić et al., 2007; Pieroni et al., 2015). *H. odorus* was used in horses against influenza and pneumonitis by puncturing the skin on the chest and planting the seed or part of the rhizome (Zlatković, 2006; Pironi et al., 2015).

Erysipelas in pigs and sheep (on the hoof) in the Pirot County can be treated with *Celosia argentea* L. (3 reports), *C. officinalis,* and *E. arvense* (1 report, each). Cockscomb (*C. argentea*) is a cultivated ornamental plant in Serbia that belongs to the Amaranthaceae family. Four informants have mentioned the use of the seeds of *C. argentea,* commonly called "strator", of which three respondents mention the use against swine erysipelas, and one respondent the use against stomach viruses. Furthermore, cockscomb is frequently used in traditional Chinese human medicine for treating different diseases such as ulcers, to serve as anthelminthic, to treat trauma to blood, and hygroparalysis (Tang et al., 2016). Pharmacological studies proved that *C. argentea* possesses bioactivities, such as antioxidant, anti-diarrhea, anti-diabetes, anti-tumor, and hepatoprotective effect (Sharma et al., 2010; Wu et al., 2013; Tang et al., 2016). None of these authors reported the application of this plant in veterinary medicine, which our respondents mentioned. Plaque and disinfection in poultry in the Pirot County are treated with *F. excelsior* and pow with *V. album*.

Udder edema is a disorder evinced by excessive accumulation of fluids in the intercellular tissue spaces of the mammary gland (Ghodasara et al., 2012). Udder edema causes difficulty with milking and may also reduce milk production. In our study, there are five plants, *A. eupatoria, A. sativum, Arum maculatum* L., *Ch. majus,* and *P. reptans* reported for the treatment of udder edema. Agrimony (*A. eupatoria*) was used for mastitis in human medicine together with betony, and vervain (Breverton, 2011). In our study, a formulation to massage into the blocked or inflamed udders of a cow with crush garlic (*A. sativum*) contains cooking oil, that is not needed to biol, only well mixed. Formulation with garlic should apply in a circular motion over the entire udder. Similar formulations are made with *A. maculatum, Ch. majus,* and *P. reptans*. Treatments of udder edema are very different in our study than in Western Herzegovina, where combinations of the juice of *Sambucus ebulus* L., whole egg, oil, and soot were used for mastitis, also oak bark, blood release above the udder (Višekruna, 2004). Šubarević et al. (2015) reported the use of warm poultice on udders. South-Western Serbia formulation with *H. odorus* was used for the treatment of mastitis of cows (Pieroni et al., 2011).

Respiratory indications reported in this study were mainly cold, cough, and sinus diseases. Plants for the treatment of cold were *A. lappa, M. chamomilla,* and *C. officinalis.* Furthermore, inhabitants were mentioned *A. absinthium* and *Iris germanica* against the cold in horses, *P. major* and *Salvia officinalis* L. for the treatment of cough, and powdered rhizome of *V. album* against sinus diseases. Šubarević et al. (2015) previously reported that colds in animals at Stara Planina Mts were treated with chamomile, sage, nettle, and thyme tea, while in Herzegovina the cold was treated with coffee, wine and a homemade brandy named "rakija" (Višekruna, 2004). In Eastern Albania, the seeds of *A. hippocastanum* were given to animals to eat against respiratory diseases (Pieroni et al., 2015). In South-Western Serbia, *A. sativum* was used to treat respiratory troubles (Pieroni et al., 2011).

In the treatment of snake bites, *H. odorus, Juniperus communis* L., *Sanguisorba minor* Scop., and *T. officinale* have been applied. Previously published data on traditional ways of treating snakebite in animals are in discrepancy with our findings (Višekruna, 2004; Zlatković, 2006; Davidović et al., 2011, 2012; Pierroni et al., 2013; Šubarević et al., 2015). Davidović et al. (2011, 2012) reported that in Serbia, the juice obtained by crushing the dwarf elder leaves (*S. ebulus*) is applied directly at the place of the snake bite or a bee sting. Furthermore, the same authors suggest that thanks to its anti-inflammatory action, the root, and leaf of this plant could be used in the treatment of burns, inflammations, edema, eczema, and urticaria. In western Herzegovina, the snake bite is also treated by applying the juice of *S. ebulus, Ocimum basilicum* L., salt, and brandy balm (Višekruna, 2004). Zlatković (2006) reported that the wound of snakebite in an animal should be stabbed with a knife, hawthorn or needle, and later treated with tobacco smoke and cigarette burn, and nettle. The use of tobacco smoke and cigarette burn at the wound of a snake bite has also been reported in Herzegovina, Serbia, and Macedonia (Višekruna, 2004; Zlatković, 2006; Pierroni et al., 2013). In some regions of Serbia, the place of snakebite is being thrashed by a dog rose branch (*Rosa canina* L.) in order to draw the poison out, while infection of wounds after the bite of a wolf in cows and sheep is prevented by the compress made of cooked white hellebore rhizome (*V. album*) (Davidović (2011., 2012). Also, according to Šubarević et al. (2015), a compress of crushed *E. arvense* is used for the treatment of snakebite in animals on Stara Planina Mts.

Local inhabitants of Stara Planina Mts point out that local Roma people use a homemade alcoholic drink "rakija" to calm down the temperamental horses before selling. The use of alcohol for sedation and anesthesia of cattle, sheep, and goats is well known. Alcohol was administered orally to bovine animals at a dose of one to four liters, depending on the size and general condition of the animal, as a 30% solution, as described in the older veterinary literature (Šubarević et al., 2015).

3.6. Comparison with other studies in neighboring regions

Recent studies emphasize the floristic similarity between the lists of medicinal plants recorded in different ethnic groups or regions of the Balkan Peninsula (Šavikin et al., 2013; Zlatković et al., 2014). One of the most exploited methods to determine the relationship between species list of actual toward other selected areas was by calculating the similarity coefficient, according to Jaccard (1932). Our results are unique in Southeastern Europe, and data for comparison are rarely found in other sources since the majority of ethnopharmacological surveys in the Balkans human medicine oriented (Pieroni et al., 2013).

Difference between Pirot County and neighboring regions increases when the number of ethnoveterinary uses for quoted plants was used in the comparison (JI ranged from 1.96 to 23.44). The highest degree of similarity was found with areas Stara Planina Mts in four villages of municipality Dimitrovgrad (Šubarević et al., 2015) and Serbia in general (Davidović et al., 2011, 2012) (Table 4). Veterinary uses are shared mainly with Stara Planina Mts and Serbia in general, perhaps due to proximity and more accessible communication compared to other regions on the Balkan Peninsula.

For some well-known medicinal plant species new applications in veterinary domain have been recorded, what can present a solid starting point for further phytopharmacological research. The use of plant taxa *A. hippocastanum, A. eupatoria, A. sativum, A. absinthium, E.*

Table 4
Comparison between ethnoveterinary plant uses in Pirot County and those recorded in previously conducted ethnobotanic field studies in surrounding regions.

Area	Year(s) of the interview	Number of participants	Number of recorded plant species used in veterinary ethnopharmacology	% of plant species also quoted in Pirot County	Number of reports of ethnoveterinary uses of medicinal plants	Number of recorded ethnoveterinary uses of medicinal plants	% of medicinal uses also quoted in Pirot County	Jaccard index for ethnoveterinary uses level	Reference(s)
1.Kopaonik Mt	2002–2005	60	11	45.45	11	11	36.36	9.62	Jarić et al. (2007)
2. Lëpushë, Northern Albanian Alps	2004	25	9	22.22	11	10	20.00	3.77	Pieroni et al. (2005)
3. Pešter Plateau, Sandžak (South-Western Serbia	2010	42	8	37.5	8	6	83.33	5.88	Pieroni et al. (2011)
4. Serbia	2011–2012	–	34	35.29	36	9	66.67	17.65	Davidović et al. (2011, 2012)
5. Reka valley, Mount Korab (Western Macedonia	2012	17	6	16.66	9	7	57.14	1.96	Pieroni et al. (2013)
6. Peshkopia (Eastern Albania)	2012	32	10	30.00	11	8	50.00	5.66	Pieroni et al. (2014a)
7. Gollobordo, Eastern Albania	2013	58	57	17.54	76	22	9.09	10.75	Pieroni et al. (2014b)
8. Rraicë and Mokra (Eastern Albania)	2014	36	20	20.00	36	11	36.36	8.19	Pieroni et al. (2015)
9. Stara Planina Mts	2015	50	33	45.45	43	26	38.46	23.44	Šubarević et al. (2015)
10. Pirot County	2017	148	46	–	205	30	–	–	presented data

arvense, F. excelsior, M. officinalis, T. officinale, and *T. chamaedrys* in veterinary ethnopharmacology of the Pirot County is different in comparison with neighboring regions, although they are also mentioned in neighboring areas.

Species that were not previously reported in other ethnoveterinary surveys in Balkan Peninsula are *A. vulneraria, A. maculatum, B. incana, B. napus, C. carvi, C. argentea, C. erythraea, C. intybus, D. stramonium, E. repens, F. carica, Iris germanica, J. regia, J. communis,* L. *nummularia, Mentha x piperita, P. spina-christi, P. reptans, S. minor, S. arvensis, T. platyphyllos,* and *V. officinalis.* To the best of authors' knowledge, species that were not previously reported in thematically similar surveys in veterinary ethnopharmacology around the world are *B. incana* and *C. argentea* (treatment of diarrhea and swine erysipelas, respectively). These species could be particularly interesting for future pharmacological studies for the indications proposed by our survey respondents. Due to this new information, an increased interest in the chemical profile and biological activities of these species can be expected. Their importance lies in the possibilities of finding new uses for medicinal plants and discovering new herbal remedies in veterinary medicine.

Conclusions

Rural lifestyles in mountain villages and traditional knowledge of its inhabitants are becoming a rarity. Since the current trend of village obsolescence leads to the disappearance of this knowledge from the population, ethnobotanical studies are a practical way to conserve them. These studies could preserve cultural patrimony and make available data that could lead to the development of new medicines.

The current study showed that a part of medicinal plants, that constitute the pharmaceutical Ethno flora of Pirot County, is used in veterinary medicine (46 species). The main ailments treated are digestive troubles and dermatological problems. We have presented information about the use of medicinal plants in veterinary medicine, which is related to the Balkan region in general. An apparent similarity can be seen in earlier studies on the Balkan Peninsula, and slightly more significant differences were observed in the description. Some scarcely reported plant uses had been detected in our studies, such as the use of *B. incana* against diarrhea and *C. argentea* against erysipelas in pigs and sheep. These species could be promising new drugs for phytotherapeutic applications.

Presented results are specific and prosperous because the part of them comes from the nomadic people who live in the past depended only on animal husbandry on Stara Planina Mts. Since their knowledge about plants used in veterinary medicine was transmitted from one generation to another, our results represent their legacy.

Declaration of Competing Interest

The authors have declared that no competing interest exist.

Acknowledgment

This research is part of the project: Ethno-pharmacological study of the region of southeastern Serbia, O-02-17, funded by the Serbian Academy of Sciences and Arts.

Author contributions

Marija S. Marković – Conceptualization, data collection, drafting the article
Dejan S. Pljevljakušić – Writing, reviewing, editing
Biljana M. Nikolić – Data curation, data interpretation
Dragoljub L. Miladinović – Methodology, data collection

Mrdjan M. Djokić - Data interpretation assistance, graphical design

Ljubinko B. Rakonjac – Analysis, supervision

Vesna P. Stankov Jovanović – Experimental design, writing assistance

References

Akerreta, S., Calvo, I.M., Cavero, Y.M., 2010. Ethnoveterinary knowledge in Navarra (Iberian Peninsula). J. Ethnopharmacol. 130, 369–378. https://doi.org/10.1016/j.jep.2010.05.023.

Breverton, T., 2011. Breverton's Complete Herbal: A Book of Remarkable Plants and Their Uses. Publisher: Quercus, London, United Kingdom, p. 385.

Davidović, V., Joksimović-Todorović, M., Maksimović, Z., Hristov, S., Stanković, B., Relić, R., 2011. A review of plants used in ethnoveterinary medicine. Maced. J. Anim. Sci. 1 (2), 377–382. https://www.researchgate.net/profile/Zoran_Maksimovic/publication/308100859_Review_of_plants_used_in_ethnoveterinary_medicine/links/57e0fd5008aec6ce9f2a3150/Review-of-plants-used-in-ethnoveterinary-medicine.pdf.

Davidović, V., Joksimović-Todorović, M., Stojanović, B., Relić, R., 2012. Plant usage in protecting the farm animal health. Biotechnol. Anim. Husb. 28 (1), 87–98. https://doi.org/10.2298/BAH1201087D.

Ghodasara, N.S., Savsani, H.H., Vataliya, H.P., 2012. Therapeutic management of periparturient udder edema in Jaffrabadi buffaloes and Gir cows. Buffalo Bull. 31 (3), 111–113. http://ibic.lib.ku.ac.th/e-bulletin/IBBU201203004.pdf.

González, J.A., Verde, A., Pardo-de-Santayana, M., 2020. The use of plants for animal health care in the Spanish inventory of traditional knowledge. In: McGaw, L., Abdalla, M. (Eds.), Ethnoveterinary Medicine. Springer, Cham. https://doi.org/10.1007/978-3-030-32270-0_17.

Gradé, J.T., Tabuti John, R.S., Van Damme, P., 2009. Ethnoveterinary knowledge in pastoral Karamoja, Uganda. J. Ethnopharmacol. 122, 273–293. https://doi.org/10.1016/j.jep.2009.01.005.

Jaccard, P., 1932. Die statistische-floristische methoden als grundlage der pflanzensoziologie. Handb. Biol. Arb. 11, 165–202.

Janaćković, P., Gavrilović, M., Savić, J., Marin, P., Dajić Stevanović, Z., 2019. Traditional knowledge of plant use from Negotin Krajina (Eastern Serbia): an ethnobotanical study. Indian J. Tradit. Knowl. 18 (1), 25–33 http://nopr.niscair.res.in/bitstream/123456789/45686/3/IJTK%2018%281%29%2025-33.pdf.

Jarić, S., Mačukanović-Jocić, M., Đurđević, L., Mitrović, M., Kostić, O., Karadžić, B., Pavlović, P., 2015. An ethnobotanical survey of traditionally used plants on Suva planina mountain (south-eastern Serbia). J. Ethnopharmacol. 4 (175), 93–108. https://doi.org/10.1016/j.jep.2015.09.002.

Jarić, S., Mitrović, M., Karadžić, B., 2014. Plant resources used in Serbian medieval medicine: ethnobotany and Ehnomedicine. Genet. Resour. Crop. Ev. 61 (7), 1359–1379. https://doi.org/10.1007/s10722-014-0118-1.

Jarić, S., Popović, Z., Mačukanović-Jocić, M., Đurđević, L., Mijatović, L., Karadžić, B., Mitrović, M., Pavlović, P., 2007. An ethnobotanical study of the usage of wild medicinal herbs from Kopaonik Mountain (Central Serbia). J. Ethnopharmacol. 111, 160–175. https://doi.org/10.1016/j.jep.2006.11.007.

Jordanov, D., 1963. Flora Reipublicae Popularis Bulgaricae, 1-7. Serdicae. In Aedibus Academiae Scientiarum Bulgaricae(in Bulgarian).

Josifović, M., 1970. Flore de la Republique Socialiste de Serbie, 1–9. Acaddemie Serbe des Sciences et des Arts, Belgrade. (In Serbian).

Krstić, D., 2019. Ideas of the Pirot region population that concern the term the Torlaks. Pirotski zbornik 44, 1–63. https://doi.org/10.5937/pirotzbor1944001K.

Kubkomawa, H.I., Nafarnda, D.W., Adamu, S.M., Tizhe, M.A., Daniel, T.K., Shua, N.J., Ugwu, C.C., Opara, M.N., Neils, J.S., Okoli, I.C., 2013. Ethno-veterinary health management practices amongst livestock producers in Africa - a review. World J. Agri. Sci 1, 252–257.

Kunwar, R., Bussmann, R.W., 2008. Ethnobotany in the Nepal Himalaya. J. Ethnobiol. Ethnomed. 4, 24. https://doi.org/10.1186/1746-4269-4-24.

Lans, C., Khan, T., Curran, M.M., McCorkle, C.M., 2007b. Ethnoveterinary medicine: potential solutions for large-scale problems? In: Wynn, S., Fougère, B. (Eds.), Veterinary Herbal Medicine. Missouri Mosby Inc, pp. 17–32.

Lans, C., Turner, N., Khan, T., Brauer, G., Boepple, W., 2007a. Ethnoveternary medicines used for ruminants in British Columbia, Canada. J. Ethnobiol. Ethnomed 3, 11. https://doi.org/10.1186/1746-4269-3-11.

Marković, M., 2019a. Application of yarrow (*Achillea millefolium* L.) in ethnomedicine of the Pirot county (southeastern Serbia). Arh. Farm. (Belgr) 69, 367–384 https://doi.org/0004-19631905367M.pdf (In Serbian).

Marković, M., Matović, M., Pavlović, D., Zlatković, B., Marković, A., Jotić, B., Stankov-Jovanović, V., 2010. Resources of medicinal plants and herbs collector's calendar of Pirot County (Serbia). Biol. Nyssana 1 (1–2), 9–21. http://journal.pmf.ni.ac.rs/bionys/index.php/bionys/article/view/50.

Marković, M., Nikolić, B., Rakonjac, Lj., Pešić, D., 2015b. Vegetation patterns of dry grasslands on Vidlič Mountain (Southeastern Serbia). Bull. Faculty For. 112, 59–82. https://doi.org/10.2298/GSF1512059M.

Marković, M., Rakonjac, Lj., Pešić, D., Nikolić, B., Lučić, A., 2015a. Floristic characteristics of oriental hornbeam scrubwood on the mountain of Vidlič. Šumarstvo 3, 43–56. http://www.srpskosumarskoudruzenje.org.rs/pdf/sumarstvo/2015_3/sumarstvo2015_3_rad05.pdf.

Marković, M., Stankov Jovanović, V., Smiljić, M., 2019b. Medicinal flora of the Vidlič Mountain in Serbia. Univ. Thought, Publ. Nat. Sci. 9 (1), 17–26. https://doi.org/10.5937/univtho9-17725.

Marković, S.M., Nikolić, M.B., Zlatković, K.B., Nikolić, S.D., Rakonjac, B.Lj., Stankov-Jovanović, P.V., Djokić, M.M., Ratknić, B.M., Lučić, Ž.A., 2018. Short-term patterns in the post-fire diversity of limestone grasslands and rocky ground vegetation. Appl. Ecol. Env. Res 16 (3), 3271–3288. https://doi.org/10.15666/aeer/1603_32713288.

Marković, S.M., Rakonjac, B.Lj., Nikolić, M.B., 2020. Medicinal Plants of the Pirot County. Institute of Forestry, Belgrade. (In Serbian).

Matejić, S.J., Stefanović, N., Ivković, M., Živanović, N., Marin, D.P., Džamić, M.A., 2020. Traditional uses of autochthonous medicinal and ritual plants and other remedies for health in Eastern and South-Eastern Serbia. J. Ethnopharmacol. 261 (113186), 1–28. https://doi.org/10.1016/j.jep.2020.113186 28 October 2020.

McCorkle, C.M., 1986. An introduction to ethnoveterinary research and development. J. Ethnobiol. 6, 129–149. https://ethnobiology.org/sites/default/files/pdfs/JoE/6-1/McCorkle1986.pdf.

McCune, L., Johns, T., 2007. Antioxidant activity relates to plant part, life form and growing condition in some diabetes remedies. J. Ethnopharmacol. 112, 461–469. https://doi.org/10.1016/j.jep.2007.04.006.

Menković, N., Šavikin, K., Tasić, S., Zdunić, G., Stešević, D., Milosavljević, S., Vincek, D., 2011. Ethnobotanical study on traditional uses of wild medicinal plants in Prokletije mountains (Montenegro). J. Ethnopharmacol. 133 (1), 97–107. https://doi.org/10.1016/j.jep.2010.09.008.

Mihajlov, M., Milojević, B., 1985. Pharmacognosy map of the surroundings of Pirot. In: Proceedings of the Symposium "Centennial of the Flora of the surroundings of Nis. Nis. University of Nis, Faculty of Technology in Leskovac, Branch of the Serbian Biological Society, pp. 145–155. (In Serbian).

Mijović, D., Lakušić, D., Ranđelović, V., 2007. Basic characteristics of Stara planina Mt in Serbia 31 In: biodiversity of Stara planina in Serbia. Project results: "Cross-border cooperation through the management of shared natural resources. Promotion of Networking and Cooperation Between the Countries of Southeast Europe ". Regional Center for the Environment in Central and Eastern Europe. Belgrade. Office in Serbia. (In Serbian).

Milojević, B., Mihajlov, M., 1985. Folk terminology of medicinal herbs in the vicinity of Pirot. In: Proceedings of the Symposium "Centennial of Flora around Nis". University of Nis, Faculty of Technology in Leskovac. Nis. Branch of the Serbian Biological Society, pp. 167–180. (In Serbian).

Muhammad, G., Khan, M.Z., Hussain, M.H., Iqbal, Z., Iqbal, M., Athar, M., 2005. Ethnoveterinary practices of owners of pneumatic-cart pulling camels in Faisalabad City (Pakistan). J. Ethnopharmacol. 97, 241–246. https://doi.org/10.1016/j.jep.2004.11.008.

Marković, M., Pavlović-Muratspahić, D., Matović, M., Marković, A., Stankov-Jovanović, V., 2009. Aromatic flora of the Vidlič Mountain. Biotechnol. Biotech. Eq. 23 (2), 1225–1229. https://doi.org/10.1080/13102818.2009.10817643.

Petrović, J., 1998. Nature of Bela Palanka and Middle Ponišavlje. Faculty of Science. Institute of Geography, Novi Sad, p. 56. (In Serbian).

Pieroni, A., Cianfaglione, K., Nedelcheva, A., Hajdari, A., Mustafa, B., Quave, C.L., 2014b. Resilience at the border: traditional botanical knowledge among Macedonians and Albanians living in Gollobordo, Eastern Albania. J. Ethnobiol. Ethnomed 31, 10. https://doi.org/10.1186/1746-4269-10-31.

Pieroni, A., Dibra, B., Grishaj, G., Grishaj, I., Maçai, S.G., 2005. Traditional phytotherapy of the Albanians of Lepushe, Northern Albanian Alps. Fitoterapia 76 (3–4), 379–399. https://doi.org/10.1016/j.fitote.2005.03.015.

Pieroni, A., Giusti, M.E., Quave, C.L., 2011. Cross-Cultural ethnobiology in the Western Balkans: medical ethnobotany and ethnozoology among Albanians and Serbs in the Pešter Plateau, Sandžak, South-Western Serbia. Hum. Ecol. 39 (3), 333–349. https://doi.org/10.1007/s10745-011-9401-3.

Pieroni, A., Ibraliu, A., Mehmood Abbasi, A., Papajami-Toska, V., 2015. An ethnobotanical study among Albanians and Aromanians living in the Raicë and Mokra areas of Eastern Albania. Genet. Resour. Crop. Evol. 62, 477–500. https://doi.org/10.1007/s10722-014-0174-6.

Pieroni, A., Nedelcheva, A., Hajdari, A., Mustafa, B., Scaltriti, B., Cianfaglione, K., Quave, C., 2014a. Local knowledge on plants and domestic remedies in the mountain villages of Peshkopia (Eastern Albania). J. Mt. Sci. 11 (1), 180–194. https://doi.org/10.1007/s11629-013-2651-3.

Pieroni, A., Rexhepi, B., Nedelcheva, A., Hajdari, A., Mustafa, B., Kolosova, V., 2013. One century later: the folk botanical knowledge of the last remaining Albanians of the upper Reka Valley, Mount Korab, Western Macedonia. J. Ethnobiol. Ethnomed. 9, 22. https://doi.org/10.1186/1746-4269-9-22.

Pirot County GIS, 2019. https://www.stat.gov.rs/oblasti/registar-prostornih-jedinica-i-gis/administrativno-teritorijalna-podela-i-nstj-nivoi-1-2-3/upravni-okruzi/ (accessed 13 May 2020)

Ranđelović, N., Sotirov, S., Stamenković, V., Redžepi, F., Ranđelović, V., Zlatković, B., 1991. Medicinal herbs of the Pirot subregion. In: Proceedings 7/8: Faculty of Technology, Leskovacpp. 29–33. (In Serbian).

Said, O., Khalil, K., Fulder, S., Azaizeh, H., 2002. Ethnopharmacological survey of medicinal herbs in Israel, the Golan Heights and the West Bank region. J. Ethnopharmacol. 83, 251–265. https://doi.org/10.1016/S0378-8741(02)00253-2.

Sarić, M., 1989. Medicinal Plants of SR Serbia. Department of Natural and Mathematical Sciences of SANU, Special Editions DXCVIII, Belgrade, p. 65. (In Serbian).

Šavikin, K., Zdunić, G., Menković, N., Živković, J., Ćujić, N., Tereščenko, M., Bigovic, D., 2013. Ethnobotanical study on traditional use of medicinal plants in SouthWestern Serbia, Zlatibor district. J. Ethnopharmacol 146, 803–810. https://doi.org/10.1016/j.jep.2013.02.006.

Sharma, P., Vidyasagar, G., Singh, S., Ghule, S., Kumar, B., 2010. Antidiarrhoeal activity of leaf extract of *Celosia argentea* in experimentally induced diarrhoea in rats. J. Adv. Pharm. Technol. Res. 1 (1), 41–48. https://doaj.org/article/440dca0c284d40078a5157cbfbc0ce88.

Stankov Jovanović, V., Šmelcerović, A., Smiljić, M., Ilić, M., Marković, M., 2018. Ethnopharmacological application of St. John's Wort in Pirot county. Pirotski Cbornik 43, 141–146. https://doi.org/10.5937/pirotzbor1843141S.

Statistical Office of the Republic of Serbia, 2011. The Census of Population. Households and Dwellings in the Republic of Serbia.. 2011 URL: http://popis2011.stat.rs/?lang=en (accessed 13 May 2020).

Stojković, D., 2010. Settlements and population of the municipality of Pirot (Review of certain historical, ethnic and demographic characteristics). J. Ethnogra. Museum 71, 1–108 (In Serbian).

Šubarević, N., Stevanović, O., Petrujkić, B., 2015. Use of phytotherapy as a form of ethnoveterinary medicine in the area of Stara planina mountain in Serbia. Acta Med. Hist. Adriat. 13 (1), 75–94. https://www.researchgate.net/publication/281820098_Use_of_phytotherapy_as_a_form_of_ethnoveterinary_medicine_in_the_area_of_Stara_planina_mountain_in_Serbia.

Svetieva, A., 2005. Shopi. ETHNOLOG - Rev. Etnol. Assoc. Macedonia 11, 9–21.

Tang, Y., Xin, H., Giuo, M., 2016. Review on research of the phytochemistry and pharmacological activities of *Celosia argentea*. Rev. Bras. Farmacogn. 26 (6), 787–796. https://doi.org/10.1016/j.bjp.2016.06.001.

Trotter, R.T., Logan, M.H., 1986. Informant consensus: a new approach for identifying potentially effective medicinal plants. In: Etkin, N.L. (Ed.), Plants in Indigenous Medicine and Diet, Behavioural Approaches. Redgrave Publishing Company, Bredfort Hills, New York, pp. 91–112.

Tsioutsiou, E.E., Giordani, P., Hanlidou, E., Biagi, M., De Feo, V., Cornara, L., 2019. Ethnobotanical study of medicinal plants used in Central Macedonia, Greece. Evid. Based Complement. Alternat. Med. 22. https://doi.org/10.1155/2019/4513792 ProQuesthttps://doi.org/.

Tutin, T.G., Heywood, V.H., Burges, N.A., Moore, D.M., Valentine, D.H., Walters, S.M., Webb, D.A., 1964. Flora Europaea, I-V. Cambrige University Press, London.

Vidanović, G., 1955. Visok, Economic Geographyc Exploration. In: Jovanović, P. (Ed.), Special Edition of the Geographical Institute 6 (28). Serbian Academy of Science, Belgrade. (In Serbian).

Vidanović, G., 1960. Vidlič-Zabrđe, contribute of recognition economic type of develop and disposition of production and trade of farms stagnant boundary limestone area. In: Vujević, P. (Ed.), Special Edition of the Geographical Institute No 15, 5. Serbian Academy of Science, Belgrade. (In Serbian).

Višekruna, D., 2004. National Veterinary in Brotnje, western Herzegovina. Vol. Mat. Srpska 41, 51–70 (In Serbian).

Wanzala, W., Zessin, K.H., Kyule, N.M., Baunmann, M.P.O., Mathias, E., Hassanali, A., 2005. Ethnoveterinary medicine: a critical review of its evolution, perception, understanding and the way forward. Livestock Res. Rural Dev. 17 (11), 119. http://www.lrrd.org/lrrd17/11/wanz17119.htm.

Wu, B.Q., Wang, Y., Liang, L., Jiang, Q., Guo, L.M., Zhang, J.J., 2013. Novel triterpenoid saponins from the seeds of *Celosia argentea*. L. Nat. Prod. Res. 27 (15), 1353–1360. https://doi.org/10.1080/14786419.2012.740034.

Živković, J., Ilić, M., Šavikin, K., Zdunić, G., Ilić, A., Stojković, D., 2020. Traditional use of medicinal plants in South-Eastern Serbia (Pčinja District): ethnopharmacological investigation on the current status and comparison with half a century old data. Front. Pharmacol.. https://doi.org/10.3389/fphar.2020.01020 08 July 2020https://doi.org/.

Zlatković, B., Bogosavljević, S., 2014. Taxonomic and pharmacological valorization of the medicinal flora in Svrljiški Timok gorge (Eastern Serbia). Facta Univ. Ser.: Med. Biol. 16 (2), 76. http://casopisi.junis.ni.ac.rs/index.php/FUMedBiol/article/view/545.

Zlatković, B., Bogosavljević, S., Radivojević, A., Pavlović, M., 2014. Traditional use of the native medicinal plant resource of Mt. Rtanj (Eastern Serbia): ethnobotanical evaluation and comparison. J. Ethnopharmacol. 151 (1), 704–713. https://doi.org/10.1016/j.jep.2013.11.037.

Zlatković, D., 2006. Traditional Cattle Breeding of the Stara Planina Mt and its Perspective. Pi press, Pirot. (In Serbian).