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TAXONOMIC AND PHARMACOLOGICAL VALORIZATION OF THE MEDICINAL FLORA IN SVRLJIŠKI TIMOK GORGE (EASTERN SERBIA)

***Bojan Zlatković*[1*], *Stefan Bogosavljević*[2]**

[1]*University of Niš, Faculty of Sciences and Mathematics, Department of Biology and Ecology, Niš, Serbia*
[2]*Pharmacy "Filly Farm", Health Institution of Niš, Niš, Serbia*

Abstract. *This paper presents the results of taxonomic and pharmacological valorization of autochthonous medicinal flora in the Svrljiški Timok gorge in Eastern Serbia. The taxonomic structure of group of medicinal plants in the study area was compared with spectrums of medicinal flora of Serbia and similar geographic objects in the region. Herbal substances are listed and the main effect and safety of use is provided for each substance. After the discussion on threat status for each species, necessity of protection of this gorge, characterized by pronounced species diversity and richness in resources of medicinal plants, was specified.*

Key words: *Pharmacological valorization, medicinal plants, herbal substances*

Introduction

The term "medicinal plants" designates plants containing pharmacologically active substances, where dried and fresh parts are either directly used in therapy or further processed in order to derive medicinal substances or phyto-preparations [1]. Many medicinal plant species are important as source material for industrial production of medicines and various dietetic, cosmetic, hygienic and other plant products, widely used at the global scale. Due to the high concentration of biologically active substances, they have an important role both in traditional and in modern medicine (phytotherapy). Use of plants for medicinal purposes is an integral part of medicine and these medicaments and therapeutic methods are highly important, while in certain conditions, particularly regarding the chronic and the less severe ailments, they may completely substitute for other, more expensive medicaments [2]. Use of medicinal herb preparations is increasing throughout the world and it is assumed that the amount of products in the market will keep increasing as well.

Of the 3662 taxa presently known to comprise the vascular flora of Serbia [3] the group of medicinal plants includes 420 species [2]. Sporadic data on use of medicinal plants in Serbia have been recorded since the 14th century [2], while in the 19th and 20th century there was an expansion in research, primarily marked by appearance of several monographic works listing species with known medicinal properties. Dr. Josif Pančić [4, 5] was the first to provide data on medicinal flora of Serbia and use of medicinal plants. Contribution by other authors [6, 7] is also highly important, as they greatly popularized the use of medicinal plants in Serbia, offering both data on use of medicinal plants and on their distribution and habitats. Research activity was intensified in the second half of 20th century [8], introducing a modern approach to describing the current conditions and distribution of medicinal plants in Serbia, based both on experience of folk medicine and the laboratory research.

However, the modern studies of medicinal flora in specific geographic units in Serbia are still ongoing and therefore insufficient for rationalization of use of this natural resource [9]. While most of the studied floras pertain to mountain areas or certain administrative regions [9–15], the importance of gorges and canyons in Serbia, acknowledged as particularly important areas in terms of richness and conservation of flora, is still not sufficiently recognized.

The role of refugium gorges and canyons of Balkan Peninsula stems from the high level of richness, originality and ancient character of their flora [16]. The goal of this paper is to present the list of recorded plant species and results of analysis of the taxonomic structure of medicinal flora in the wider area of Svrljiški Timok gorge. It combines the list of recorded medicinal plants with the diversity of their most important medical uses and forms. In this era of mass exploitation of natural resources, it was also necessary to include an overview on the aspect of threat status and conservation of these species, as their collecting is a potential threat factor to populations and habitats of autochthonous medicinal flora in the study area.

Correspondence to: Bojan Zlatković
Department of Biology and Ecology, University of Niš, Faculty of Sciences and Mathematics, 33 Višegradska St, 18000 Niš, Serbia
Phone: +381 18 533015, ext. 155 Fax: +381 18 533014
E-mail: bojanzlat@yahoo.com

The gorge of Svrljiški Timok is situated in Eastern Serbia, occupying a 15 km long part of river valley of Timok between Svrljiška and Knjaževačka Kotlina valleys. The gorge is in a hill region, mostly composed of massive limestone rocks. According to altitude, exposition and type of atmospheric circulations, the gorge may be assigned to Moravica-Svrljig climatological region, with partial Mediterranean influences in the pluviometric regime [17]. In contrast to most other gorges and canyons of Eastern Serbia, which are either completely or partially in W-E direction and have one less insulated cliff, the plant life of this gorge has a more thermophilous character [16] as the main direction of this gorge is N-S. In spite of high vertical cliffs above the river, this gorge is mostly open, enabling relatively good insulation during most of the day, strongly influencing the habitat character, vegetation type and composition of flora.

The wider area of the gorge is within the zone of forest vegetation dominated by the climatogeneous forest of Italian and Turkey Oak with hornbeam *(Quercetum farnetto-cerris* subass. *carpinetosum orientalis*). Steep rocky slopes are inhabited by low hornbeam forests and scrub *(Carpinetum orientalis),* alternating with lilac-hornbeam scrub (*Syringo-Carpinetum orientalis*). According to Mišić [16], fragments of polydominant forests (*Carpino orientalis-Quercetum mixtum* and *Syringo-Aceri monspessulani-Coryletum colurnae*) develop at the more sheltered places, as a specific feature of refugium habitats in gorges and canyons of Balkan Peninsula. The eroded slopes of the gorge are overgrown with xerophilous types of herbaceous vegetation (pastures, meadows and stony ground) and diverse vegetation of fissures in limestone rocks.

Material and Methods

The size of study area is app. 66 km^2, including the NW slopes of Mt. Tresibaba and the extreme SE slopes of Mt. Devica, within the squares EP81, EP91 and EP92 (UTM system, zone 34T). The field studies were performed from 2005 to 2008, including various aspects of the vegetation season. The collected plant material has been stored in the herbarium of the Faculty of Science and Mathematics, at the Department of Biology and Ecology of University in Niš (HMN).

The nomenclature and classification of taxa was matched with the Euro+MedChecklist [18] and regional floras [19, 20] used for identification of material. Accepting the modern definition and standpoint of expert organizations [21] on elimination of term „herbal drug" from official use, in the further text it is replaced with the term „herbal substance".

The comprehensive list of medicinal plants, based on field and literature records, was adjusted according to compendium of medicinal plants given for the country by Sarić [2] and other literature relevant for territory of Serbia [1, 22]. Table 1 includes a list of all taxa with main data - name of plant species, family, vernacular name, list of herbal substances derived from that species, main effects and uses, presence of taxa in certain pharmacopeias [23–31]. The main uses and effects, as well as chemical names of herbal substances derived from medicinal plants in this area, are presented according to the relevant literature sources [1, 31].

The conservation status of taxa was matched with the list of CITES convention and the Ordinance on strictly protected and protected wild species of plants, animals and fungi, based on Law on nature protection in Republic of Serbia (Official Gazette of the Republic Serbia, No. 36/09).

Results

The taxonomic analysis has shown that the flora of medicinal plants at Svrljiški Timok includes 190 taxa (182 species and 8 subspecies) from 53 families and 139 genera (Table 1), pertaining to more than 45 percent of the total number of assumed medicinal taxa in the flora of Serbia. From the taxonomic standpoint, the group of medicinal plants is absolutely dominated by dicotyledonous angiosperms (174 taxa, 91.6%), while monocots represent a much smaller percentage (10 taxa, 5.3%) of medicinal flora of this gorge. The ferns are represented with just 5 species (including 1 species of horsetails) and contributed to total list of medicinal flora with just 2.6%, while the group of gymnosperms is represented with a single species and a very modest share of 0.5% in the total medicinal flora of the gorge. Within the flora of Svrljiški Timok, following families were represented by the greatest number of medicinal taxa: *Labiatae* (32 taxa, 16.8%), *Compositae* (20 taxa, 10.5%), *Rosaceae* (14 taxa, 7.4%), *Leguminosae* (9 taxa, 4.7%), *Cruciferae* (8 taxa, 4.2%), *Scrophulariaceae* (8 taxa, 4.2%). The genera of medicinal plants with the highest number of species are *Acer*, *Artemisia*, *Quercus*, *Rumex*, *Salix*, *Stachys* and *Thymus*.

There are relevant data on medical use for a relatively high percentage (65.3%) of plants in the study area that are considered to be medicinal plants. Cumulatively they may be used as a biological source in preparation of 146 different herbal substances listed in the table 1, potentially being implemented in treatment of more than 90 ailments and medical disorders. The flora of this gorge is primarily a significant resource for raw herbal material produced from aerial plant organs (67%). The most important herbal substance is the upper part of flowering plant (*herba*) with 42%, followed by leaf (*folium*) with 16%, flowers and inflorescences (*flos*) with 9% of the total number of herbal substances. The herbal substances derived from processed roots and rhizomes (*radix et rhizoma*) and other underground parts of plants are represented with 18%. The suggested use of most herbal substances listed in the table is in treating ailments and disorders of digestive system (25%), followed by cardiovascular (15%), respiratory (14%), immune (12%) and skin system (9%).

In the area of Svrljiški Timok gorge there are 49 species protected by Ordinance on protected and strictly protected wild species of plants animals and fungi at national level, and 3 species protected by international CITES convention.

Table 1. List of medicinal plant taxa (species and subspecies) from Svrljiški Timok gorge

Botanical taxa and family	Vernacular name	Herbal substance	Effects and use	Presence in pharmacopoeias and other relevant literature	Conserva--tion aspect
Acer campestre L. (*Aceraceae*)	Klen	*Aceris sirupus*	Same as *A. platanoides.*		
Acer monspessulanum L. (*Aceraceae*)	Maklen	*Aceris sirupus*	Same as *A. platanoides.*		
Acer platanoides L. (*Aceraceae*)	Mleč	*Aceris sirupus*	Laxative.		
Acer tataricum L. (*Aceraceae*)	Žešlja	*Aceris cortex, A. folium.*	Astrigent.		
Achillea crithmifolia Waldst. & Kit. (*Compositae*)	Hajdučka trava	*Millefolii herba*	Same as *A. millefolium.*		
Achillea millefolium L. (*Compositae*)	Hajdučka trava	*Millefolii herba*	Cholagogue, hemostatic, dyspepsia, diarrhea.	Ph Eur, BP, PDR, E+, WHO	3
Adonis flammea Jacq. (*Ranunculaceae*)	Bulka	*Adonidis herba*	Cardiotonic, diuretic.		
Adonis vernalis L. *(Ranunculaceae)*	Gorocvet	*Adonidis herba*	Cardiotonic, diuretic.	PDR, E+	1, 2
Aegopodium podagraria L. (*Umbelliferae*)	Sedmolist	*Podagrariae herba*	Rheumatism, gout, sciatica, cold. Externally, for inflammation of the skin and hemorrhoids.	PDR	
Agrimonia eupatoria Ledeb. subsp. *grandis* (Andrz. ex Ascherson & Graebner) Bornm. (*Rosaceae*)	Petrovac	*Agrimoniae herba*	Cholagogue, diuretic, diarrhea.	Ph Eur, BP, PDR, E+	2
Ajuga reptans L. (*Labiatae*)	Puzava ivica	*Ajugae herba*	Cholelithiasis, stomach disorders.	PDR	
Alliaria petiolata (Bieb.) Cavara & Grande (*Cruciferae*)	Lukovac	*Alliariae folium recens, A. herba*	Diaphoretic, diuretic.		
Althaea officinalis L. (*Malvaceae*)	Beli slez	*Althaeae radix, A. folium*	Antitussive, mucilaginous, catarrh of the respiratory tract, bronchitis, enteritis, cystitis, urethritis, varicosities.	Ph Eur, PDR, BP, E+, WHO	3
Anacamptis morio (L.) R. M. Bateman, Pridgeon & M. W. Chase (*Orchidaceae*)	Kaćun	*Salep tuber*	Same as *O. simia.*	PDR	1, 3
Anacamptis pyramidalis (L.) L. C. M. Richard (*Orchidaceae*)	Plaštak	*Salep tuber*	Same as *O. simia.*		1, 3
Anchusa officinalis L. (*Boraginaceae*)	Volovski jezik	*Anchusae herba, A. flos*	Mild diuretic, expectorant.		
Anthemis arvensis L. (*Compositae*)	Prstenak	*Anthemidis (arvensis) flos*	Carminative, dyspepsia.		
Anthyllis vulneraria L. subsp. *polyphylla* (DC.) Nyman (*Leguminosae*)	Belodun	*Anthyllidis vulnerariae flores*	Dermatic, diuretic, depurative.	PDR	3
Arctium lappa L. subsp. *lappa* (*Compositae*)	Čičak	*Bardanae radix*	Anorexia, gout, rheumatoid cystitis. Externally, for eczema and psoriasis.	PDR, E-	3
Arctium tomentosum Miller (*Compositae*)	Čičak veliki maljavi	*Bardanae radix*	Same as *A. lappa.*	E-	
Artemisia absinthium L. (*Compositae*)	Pelen	*Absinthii herba*	Roborantium, cholagogue, carminative.	Ph Eur, BP, PDR, E+	
Artemisia alba Turra (*Compositae*)	Rudinski pelin	*Artemisiae (albae) herba*	Similar as *A. absinthium.*		
Artemisia pontica L. (*Compositae*)	Sitan pelin	*Absinthii pontici herba*	Similar as *A. absinthium.*		3
Artemisia vulgaris L. (*Compositae*)	Crna komonika	*Artemisiae (vulgaris) herba*	Antimicrobial, dyspepsia.	PDR, E-	
Asparagus officinalis L. (*Asparagaceae*)	Špargla	*Asparagi herba, A. rhizoma*	Slight diuretic (herba), infections of urinary tract, kidney stones (rhizoma).	PDR, E+ (rhiz), E- (herb)	

Asplenium ceterach L. (*Polypodiaceae*)	Zlatna paprat	*Ceterach folium*	Diuretic, astrigent, diarrhea.		
Asplenium scolopendrium L. (*Polypodiaceae*)	Jelenji jezik	*Scolopendrii folium*	Diuretic, mild laxative, kidney stones.	PDR	
Ballota nigra L. (*Labiatae*)	Modri tetrljan	*Ballotae herba*	Anthelmintic, mild sedative.	BP, PDR	
Bellis perennis L. (*Compositae*)	Bela rada	*Bellidis perennis herba*	Astrigent, antiphlogistine, expectorant.	PDR	
Berberis vulgaris L. (*Berberidaceae*)	Žutika	*Berberidis cortex radicis*	Stomachic, tonic, cholagogue.	PDR, E-	
Bidens tripartitus L. (*Compositae*)	Kozji rogovi	*Bidentis herba*	Astrigent, diuretic.	PDR, WHO	
Brassica nigra (L.) Koch (*Cruciferae*)	Crna slačica	*Sinapis nigrae semen*	Rubefacient. In folk medicine as antirheumatic, against neuritis, pleurisy and acute bronchitis.	PDR	
Campanula rapunculus L. (*Campanulaceae*)	Zijevčica	*Campanulae radix, C. herba*	Wounds healing.		
Campanula trachelium L. (*Campanulaceae*)	Zvončić brazdasti	*Campanulae radix, C. herba*	Similar as *C. rapunculus.*		
Capsella bursa-pastoris (L.) Medicus (*Cruciferae*)	Tarčužak	*Bursae pastoris herba*	Hemostatic, diarrhea.	PDR, E+	
Cardamine impatiens L. (*Cruciferae*)	Režuha	*Cardamine folium*	Against chronic catarrh of the respiratory tract.		
Centaurea jacea L. (*Compositae*)	Vasiljak	*Centaureae jaceae flos sine calycibus*	Diuretic, cholagogue.		
Centaurium erythraea Rafin. (*Gentianaceae*)	Kičica	*Centaurii herba*	For appetite, anorexia, chronic dyspepsia.	Ph Eur, BP, PDR, E+	3
Chelidonium majus L. (*Papaveraceae*)	Rusa	*Chelidonii herba*	Externally, for warts, eczema and psoriasis.	Ph Eur, BP, PDR, E+, WHO	
Cichorium intybus L. (*Compositae*)	Ženetrga	*Cichorii herba et radix*	Cholagogue, diuretic, for appetite, dyspepsia.	PDR, E+	
Clinopodium menthifolium Merino (*Labiatae*)	Divlja metvica	*Calaminthae officinalis herba*	Mild sedative, tonic.		
Colchicum autumnale L. (*Colchicaceae*)	Mrazovac	*Colchici semen*	Antiphlogistine, gout, skin cancer.	PDR, E+	3
Cornus mas L. (*Cornaceae*)	Dren	*Corni fructus*	Astrigent, tonic, diarrhea.		3
Corylus avellana L. (*Corylaceae*)	Leska	*Coryli avellanae folium, C. a. cortex, C. a. semen*	Diarrhea.		3
Corylus colurna L. (*Corylaceae*)	Medveđa leska	*Coryli colurnae folium, C. c. cortex, C. c. semen*	Similar as *C. avellana.*		3
Cotinus coggygria Scop. (*Anacardiaceae*)	Ruj	*Cotini folium*	Astringent, hemostatic.		
Crataegus monogyna Jacq. (*Rosaceae*)	Beli glog	*Crataegi folium cum flore*	Cardiotonic, hypotensive, antiarrhythmic, sedative.	Ph Eur, BP, E+, WHO	3
Cynoglossum officinale L. (*Boraginaceae*)	Mišinac	*Cynoglossi folium, C herba, C. radix*	Burns, ulcers, edema.	PDR, E-	
Datura stramonium L. (*Solanaceae*)	Tatula	*Stramonii folium*	Antispasmodic.	Ph Eur, BP, PDR, E-	
Daucus carota L. (*Umbelliferae*)	Šargarepa	*Dauci radix recens, D. fructus*	Digestive, antidiabetic, antispasmodic (fructus).	PDR	
Descurainia sophia (L.) Webb ex Prantl (*Cruciferae*)	Strižica	*Descurainiae folium recens, D. herba*	Wounds healing, expectorant.		
Dictamnus albus L. (*Rutaceae*)	Jasenak	*Dictamni radix*	Anthelmintic.	PDR	
Digitalis ferruginea L. (*Scrophulariaceae*)	Besniče	*Digitalis lanatae folium*	Cardiotonic, indirect diuretic.	PDR	
Digitalis grandiflora Miller (*Scrophulariaceae*)	Krupnocvetni naprstak	*Digitalis grandiflorae folium*	Similar as *D. lanata*		
Digitalis lanata Ehrh. (*Scrophulariaceae*)	Besniče	*Digitalis lanatae folium*	Cardiotonic, indirect diuretic.	PDR	
Dryopteris filix-mas (L.) Schott (*Polypodiaceae*)	Navala	*Filicis maris rhizoma*	Anthelmintic, migraines.	PDR, E-	
Epilobium angustifolium L. (*Onagraceae*)	Noćurak	*Epilobii herba (folium)*	BHP.	PDR	

Equisetum arvense L. (*Equisetaceae*)	Poljski rastavić	*Equiseti herba*	Diuretic.	Ph Eur, BP, PDR, E+, WHO	3
Erodium cicutarium (L) L'Her. (*Geraniaceae*)	Živa trava	*Erodii cicutarii herba*	Hemostatic.		
Eryngium campestre L. (*Umbelliferae*)	Vetrovalj	*Eryngii radix*	Diuretic.	PDR	
Eupatorium cannabinum L. (*Compositae*)	Konopljuša	*Eupatorii cannabini herba*	Bitter tonic, immunostimulant, cytotoxic.	PDR	
Fagus sylvatica L. subsp. *moesiaca* (K. Mal'y) Szafer (*Fagaceae*)	Bukva	*Fagi pyroleum*	Antiseptic, anti-Dandruff, antiscabetic.		
Filipendula vulgaris Moench (*Rosaceae*)	Suručica	*Filipendulae radix et herba*	Diarrhea, epilepsy, kidney stones.		
Fragaria vesca L. (*Rosaceae*)	Jagoda	*Fragariae folium*	Diuretic, laxative, diarrhea, haemorrhoids.	PDR, E-	3
Frangula alnus Miller (*Rhamnaceae*)	Krušina	*Frangulae cortex*	Purgative, constipation.	Ph Eur, BP, PDR, E+, WHO	3
Fraxinus excelsior L. (*Oleaceae*)	Beli jasen	*Fraxini folium, F. cortex, F. semen*	Astrigent, diuretic, diaphoretic, antirheumatic.	Ph Eur, BP, PDR, E-	
Fraxinus ornus L. (*Oleaceae*)	Crni jasen	*Manna*	Laxative, diuretic.	Ph Eur, PDR, E+	
Galega officinalis L. (*Leguminosae*)	Ždraljevina	*Galegae officinalis herba*	Diuretic, antidiabetic.	PDR, E-	
Galeopsis speciosa Miller (*Labiatae*)	Zijevčica	*Galeopsidis herba*	Mild expectorant, astrigent.		
Galium odoratum (L.) Scop. (*Rubiaceae*)	Lazarkinja	*Asperulae herba*	Antiphlogistine, mild sedative, expectorant.	PDR, E-	3
Galium verum L. (*Rubiaceae*)	Ivanjsko cveće	*Galii veri herba*	Diuretic, diaphoretic, antispasmodic, sedative. Externally, for skin ailments, wounds, ulcers and acne.	PDR	3
Genista tinctoria L. (*Leguminosae*)	Žutičica	*Genistae tinctoriae herba, G. t. flos*	Diuretic, laxative, diaphoretic.	PDR	
Gentiana cruciata L. (*Gentianaceae*)	Prostrel	*Gentianae cruciatae radix et herba*	Stomachic, cholagogue, tonic, for appetite.		3
Geranium macrorrhizum L. (*Geraniaceae*)	Zdravac	*Geranii macrorrhizi herba*	Astrigent.		3
Geranium robertianum L. (*Geraniaceae*)	Živa trava	*Geranii robertiani herba*	Astrigent, diarrhea, gastritis, dysentery.	PDR	3
Geum urbanum L. (*Rosaceae*)	Zečja stopa	*Gei urbani rhizoma, G. u. herba*	Astrigent, hemostatic, roborantium, diarrhea.	PDR	
Glechoma hederacea L. (*Labiatae*)	Dobričica	*Glechomae herba*	Stomachic, mild expectorant, astrigent, cholagogue, diuretic.	PDR	3
Glechoma hirsuta Waldst. & Kit. (*Labiatae*)	Dobričica dlakava	*Glechomae hirsutae herba*	Same as *G. hederacea.*		
Gymnadenia conopsea (L.) R. Br. (*Orchidaceae*)	Vranjak	*Salep tuber*	Same as *O. simia.*		1, 3
Hedera helix L. (*Araliaceae*)	Bršljan	*Hederae folium*	Expectorant, antispasmodic, antimicrobial, anti-cellulite.	Ph Eur, BP, PDR, E+	3
Helianthus tuberosus L. (*Compositae*)	Čičoka	*Helianthii tuberosi radix*	Antidiabetic.		
Humulus lupulus L. (*Cannabaceae*)	Hmelj	*Lupuli strobuli*	Sedative, hypnotic.	Ph Eur, BP, PDR, WHO	
Hyoscyamus niger L. (*Solanaceae*)	Bunika	*Hyoscyami folium*	Spasms of the gastrintestinal tract.	PDR, E+	
Hypericum perforatum L. (*Clusiaceae*)	Kantarion	*Hyperici herba*	Antidepressant, astrigent, antiseptic, antiphlogistine, antiviral, gastritis, burns, wounds, cuts.	Ph Eur, BP, PDR, E+, WHO	3
Hyssopus officinalis L. (*Labiatae*)	Miloduh	*Hyssopi herba*	Antimicrobial, antiviral, carminative, mild antispasmodic, chronic bronchitis, asthma.	PDR, E-	3

Isatis tinctoria L. (*Cruciferae*)	Sač	*Isatis tinctoriae folium*	Vitamin C deficiency.		
Juglans regia L. (*Juglandaceae*)	Orah	*Juglanidis folium*	Astrigent, diarrhea.	PDR, E+	
Lamium purpureum L. (*Labiatae*)	Mrtva kopriva	*Lamii purpuree herba, L. p. flos*	Mild astrigent, antihemorrhagic, mucilaginous.		
Ligustrum vulgare L. (*Oleaceae*)	Kalina	*Ligustri folium, L. fructus*	Diarrhea.		
Lilium martagon L. (*Liliaceae*)	Ljiljan	*Lilii martagoni bulbus, L. m. flos*	Anti-inflammatory, antiseptic, cuts, wounds, burns, ulcers, frostbites.	PDR	
Linaria vulgaris Miller (*Scrophulariaceae*)	Lanilist	*Linariae herba*	Anti-inflammatory, diuretic, diaphoretic, hemorrhoids, ulcers.	PDR	
Lycopus europaeus L. (*Labiatae*)	Vučja noga	*Lycopi herba*	Antigonadotropic, antithyroid.	PDR, E+	
Lysimachia nummularia L. (*Primulaceae*)	Protivak	*Lysimachiae herba*	Same as *L. punctata.*	PDR	
Lysimachia punctata L. (*Primulaceae*)	Protivak jednocvetan	*Lysimachiae herba*	Styptic, diarrhea.		
Lysimachia vulgaris L. (*Primulaceae*)	Trava od metilja	*Lysimachiae herba*	Same as *L. punctata.*	PDR	
Lythrum salicaria L. (*Lythraceae*)	Potočnjak	*Salicariae herba*	Astrigent, hemostatic, diarrhea.	Ph Eur, BP, PDR	
Malva sylvestris L. (*Malvaceae*)	Crni slez	*Malvae flos, M. folium*	Mucilaginous, expectorant, antitussive, bronchitis, asthma.	Ph Eur, BP, PDR, E+	
Marrubium peregrinum L. (*Labiatae*)	Očajnica	*Marrubii peregrini herba*	Digestive, catarrh of the respiratory tract.		
Matricaria chamomilla L. (*Compositae*)	Kamilica	*Chamomillae flos*	Antiseptic, carminative, mild sedative, antiphlogistine, gastrointestinal spasms, cough, bronchitis, fever and colds, inflammation of the skin, mouth and pharynx, wounds and burns.	Ph Eur, BP, PDR, E+, WHO	
Medicago falcata (L.) Hudson (*Leguminosae*)	Žuta lucerka	*Medicago herba*	Sedative.		
Medicago lupulina (L.) Hudson (*Leguminosae*)	Dunjica	*Medicago lupulinae herba*	Hemostatic.		
Medicago sativa L. (*Leguminosae*)	Lucerka	*Medicago sativae herba*	Vitamin C deficiency.	PDR	
Melilotus albus Medicus (*Leguminosae*)	Kokotac beli	*Meliloti albi herba*	Similar as *M. officinalis.*		
Melilotus officinalis (L.) Pallas (*Leguminosae*)	Ždraljevina	*Meliloti herba*	Edema, thrombophlebitis.	Ph Eur, BP, PDR, E+	3
Melissa officinalis L. (*Labiatae*)	Matičnjak	*Melissae folium*	Sedative, antispasmodic, carminative, antibacterial, virostatic, migraine.	Ph Eur, BP, PDR, E+, WHO	3
Melittis melissophyllum L. (*Labiatae*)	Matočika	*Melittis herba*	Insomnia.		
Mentha arvensis L. (*Labiatae*)	Vodena metvica	*Menthae arvensis aetheroleum*	Carminative, cholagogue, antibacterial, secretolytic, cooling.	Ph Eur, BP, PDR, E+	
Mentha longifolia (L.) Hudson (*Labiatae*)	Konjski bosiljak	*Menthae longifoliae folium*	Carminative, antispasmodic.	PDR	
Mentha pulegium L. (*Labiatae*)	Barska nana	*Pulegii herba*	Carminative, antispasmodic, diaphoretic, antiseptic, sedative. Only in folk medicine.	PDR	
Nepeta nuda L. (*Labiatae*)	Macina trava glatka	*Nepetae nudae herba*	Carminative, colics, nervous disorders, migraine.		
Nigella arvensis L. (*Ranunculaceae*)	Mačkovi brkovi	*Nigellae (arvensis) semen*	Diuretic, carminative, anthelmintic, choleretic.		
Ononis spinosa L. subsp. *hircina* (Jacq.) Gams (*Leguminosae*)	Zečiji trn	*Ononidis radix*	Diuretic, kidney and bladder stone, rheumatism, gout.	Ph Eur, BP, PDR, E+	3
Orchis simia Lam. (*Orchidaceae*)	Majmunoliki kaćun	*Salep tuber*	Antitussive, mucilaginous, diarrhea, hoarseness, cough.	PDR	1, 3

Origanum vulgare L. (*Labiatae*)	Vranilova trava	*Origani herba*	Antimicrobial, cough, bronchitis, diarrhea, infections of urinary tract.	Ph Eur, PDR, E-, WHO	3
Papaver dubium L. (*Papaveraceae*)	Turčinak beli	*Papaveris dubii flos*	Mild antitussive, sedative.		
Pastinaca sativa L. subsp. u*rens* (Req. ex Godron) Čelak. (*Umbelliferae*)	Pastrnjak	*Pastinacae fructus*	Hypotensive, vitiligo.	PDR	
Persicaria hydropiper (L.) Delarbre (*Polygonaceae*)	Lisac	*Polygoni hydropiperis herba*	Antirheumatic, diuretic.	PDR	
Physalis alkekengi L. (*Solanaceae*)	Ljoskavac	*Alkekengi fructus*	Diuretic, kidney stones, rheumatism, gout.	PDR	
Pilosella officinarum Vaill. (*Compositae*)	Zečja loboda	*Hieracii herba*	Diarrhea, kidney ailments, pulmonary ailments.	PDR	
Pimpinella saxifraga L. (*Umbelliferae*)	Bedrinac	*Pimpinellae herba, P. radix*	Lung ailments. Externally for varicose veins (herba). Catarrhs of the upper respiratory tract (radix).	E-	
Pinus nigra Arnold (*Pinaceae*)	Crni bor	*Pini aetheroleum*	Catarrhal diseases of the upper and lower respiratory tract.	PDR, E+	
Plantago lanceolata L. (*Plantaginaceae*)	Muška bokvica	*Plantaginis lanceolatae folium (herba)*	Astrigent, antibacterial, catarrh of the respiratory tract, stomatitis, skin injuries.	Ph Eur, BP, PDR, E+	
Plantago major L. (*Plantaginaceae*)	Ženska bokvica	*Plantaginis majoris folium*	Diuretic, cystitis with hematuria, haemorrhoids, chronic bronchitis.	WHO	
Plantago media L. (*Plantaginaceae*)	Srednja bokvica	*Plantaginis mediae folium*	Respiratory disorders, digestive disorders, hemorrhoids, inflammation of the skin.		
Platanthera chlorantha (Custer) Reichenb. (*Orchidaceae*)	Vimenjak	*Salep tuber*	Same as *O. simia.*		1, 2
Polygala vulgaris L. (*Polygalaceae*)	Kija	*Polygalae herba*	Expectorant, chronic bronchitis, gastritis, enteritis, dyspepsia.		
Polygonum aviculare L. (*Polygonaceae*)	Troskot	*Polygoni avicularis herba*	Expectorant, astrigent.	Ph Eur, BP, PDR, E+, WHO	
Polypodium vulgare L. (*Polypodiaceae*)	Slatka paprat	*Polypodii rhizoma*	Expectorant, antiasthmatic, laxative.		
Populus nigra L. (*Salicaceae*)	Crna topola	*Populi gemma*	Superficial skin injuries, external haemorrhoids, frostbite and sunburn.	PDR, E+	
Potentilla reptans L. (*Rosaceae*)	Petoprsnica	*Potentillae reptans herba*	Astrigent, diarrhea, mouth and throat rinsing.	PDR	
Primula veris L. (*Primulaceae*)	Jagorčevina	*Primulae radix, P. flores cum (sine) calycibus*	Expectorant, nervous agitation, hysteria.	Ph Eur, BP, PDR, E+	3
Prunella vulgaris L. (*Labiatae*)	Crnj	*Prunellae herba*	Throat inflammations.	PDR	
Prunus mahaleb L. (*Rosaceae*)	Rašeljka	*Pruni mahalebi flos, P. m. fructus*	Similar as *P. spinosa.*		
Prunus spinosa L. (*Rosaceae*)	Trnjina	*Pruni spinosi flos*	Expectorant, diuretic, cold, constipation, mouth and throat rinsing.	PDR, E-	3
Pulmonaria officinalis L. (*Boraginaceae*)	Plućnjak	*Pulmonariae herba, P. folium*	Expectorant, mild diuretic, mucilaginous, astrigent.	PDR, E-	3
Quercus cerris (K. Maly) Czecz. (*Fagaceae*)	Cer	*Quercus cortex*	Astrigent, mild virostatic, diarrhea, inflammation of the skin and mucous membranes.	Ph Eur, BP, E+	
Quercus frainetto Ten. (*Fagaceae*)	Sladun	*Quercus cortex*	Same as *Q. cerris.*	E+	
Quercus petraea (Mattuschka) Liebl. (*Fagaceae*)	Kitnjak	*Quercus cortex*	Same as *Q. cerris.*	Ph Eur, BP, PDR, E+	
Quercus pubescens Willd. (*Fagaceae*)	Medunac	*Quercus cortex*	Same as *Q. cerris.*	Ph Eur, BP, E+	
Rorippa sylvestris (L.) Besser (*Cruciferae*)	Žutenica	*Rorippae folium et herba recens*	Diaphoretic, antidiabetic, anemia.		
Rosa canina L. (*Rosaceae*)	Šipak	*Rosae fructus*	Astrigent, tonic, mild diuretic, colds, vitamin C deficiency.	Ph Eur, BP, PDR, E-	3

Rosa gallica L. (*Rosaceae*)	Ruža mesečarka	*Rosae fructus*	Same as *R. canina.*	BP, PDR	
Rubus caesius L. (*Rosaceae*)	Kupina	*Rubi folium*	Astrigent, mild hypoglycemic, diarrhea.	PDR, E+	
Rumex acetosa L. *(Polygonaceae)*	Kiseljak veliki	*Rumicis acetosae herba*	Diuretic, astrigent, for anemia.	PDR	
Rumex conglomeratus Murray (*Polygonaceae*)	Kiseljak	*Rumici conglomerati herba*	Same as *R. acetosa.*		
Rumex patientia L. (*Polygonaceae*)	Zelje	*Lapathi hortensis radix*	Same as *R. acetosa.*		
Rumex sanguineus L. (*Polygonaceae*)	Kiseljak veliki	*Rumicis acetosae herba*	Diuretic, astrigent, for anemia.	PDR	
Ruscus aculeatus L. (*Asparagaceae*)	Veprina	*Rusci aculeati rhizoma*	Chronic venous insufficiency, hemorrhoids.	Ph Eur, BP, PDR, E+	3
Salix alba L. (*Salicaceae*)	Bela vrba	*Salicis cortex*	Antipyretic, antiphlogistic, analgetic, fever, rheumatism, headaches.	Ph Eur, BP, PDR, E+, WHO	
Salix caprea L. (*Salicaceae*)	Iva	*Salicis cortex*	Same as *S. alba.*	E+	
Salix fragilis L. (*Salicaceae*)	Krta vrba	*Salicis cortex*	Same as *S. alba.*	Ph Eur, BP, PDR, E+, WHO	
Salix purpurea L. (*Salicaceae*)	Rakita	*Salicis cortex*	Same as *S. alba.*	Ph Eur, BP, PDR, E+, WHO	
Salvia nemorosa L. (*Labiatae*)	Plavetnik	*Salviae nemorosae herba cum floribus*	Similar as *S. sclarea.*		
Salvia pratensis L. (*Labiatae*)	Divlja žalfija	*Salviae pratensis herba cum floribus*	Similar as *S. sclarea.*		
Salvia sclarea L. (*Labiatae*)	Mečje uvo	*Salviae sclareae herba cum floribus*	Polyarthritis, osteomyelitis.	Ph Eur	
Sambucus ebulus L. (*Caprifoliaceae*)	Apta	*Ebuli radix, E. fructus*	Diuretic, diaphoretic, purgative, neuralgia, rheumatism, gout.	PDR	
Sambucus nigra L. (*Caprifoliaceae*)	Zova	*Sambuci flos sine stipitas*	Diaphoretic, diuretic, laxative, anti-inflammatory, colds, influenza.	Ph Eur, BP, PDR, E+, WHO	3
Sanguisorba minor Scop. (*Rosaceae*)	Dinjica	*Sanguisorbae minoris herba*	Astrigent, styptic, diarrhea, hemorrhoids.		
Saponaria officinalis L. (*Caryophyllaceae*)	Sapunjača	*Saponariae radix*	Expectorant, eczema, analgesic.	PDR, E+	
Satureja kitaibelii Wierzb. (*Labiatae*)	Rtanjski čaj	*Saturejae kitaibelii herba*	Antiseptic, digestive, diuretic.		3
Sedum maximum (L.) Hoffm. (*Crassulaceae*)	Bobovnik	*Sedi maximi folium recens*	Burns, ulcers, edema.		
Sisymbrium officinale (L.) Scop. (*Cruciferae*)	Osak	*Sisymbrii folium recens, S. herba recens*	Expectorant, hoarseness.	PDR	
Solidago virgaurea L. (*Compositae*)	Zlatnica	*Virgaureae herba*	Diuretic, antiphlogistine, antispasmodic.	Ph Eur, BP, PDR, E+	3
Sorbus domestica L. (*Rosaceae*)	Oskoruša	*Sorbi domesticae fructus*	Tonic, diarrhea.	PDR	
Sorbus torminalis (L.) Crantz (*Rosaceae*)	Brekinja	*Sorbi (torminalis) fructus*	Similar as *S.domestica.*	PDR	
Stachys officinalis (L.) Trevisan (*Labiatae*)	Ranilist	*Betonicae herba*	Astrigent, sedative, diarrhea.	PDR	
Stachys palustris L. (*Labiatae*)	Čistac barski crveni	*Stachydis palustris herba*	Similar as *S. sylvatica.*	PDR	
Stachys recta L. (*Labiatae*)	Čistac	*Stachydis rectae herba*	Similar as *S. sylvatica.*		
Stachys sylvatica L. (*Labiatae*)	Čistac crveni šumski	*Stachydis sylvaticae herba*	Astrigent, diarrhea.	PDR	
Symphytum officinale L. (*Boraginaceae*)	Gavez	*Symphyti radix*	Fractures, purulent wounds, astrigent, cell proliferative.	PDR, E+	3
Taraxacum officinale Weber (*Compositae*)	Maslačak	*Taraxaci folium, T. radix*	Choleretic, diuretic, laxative, cholagogue.	PDR, E+, WHO	
Teucrium chamaedrys L. (*Labiatae*)	Podubica	*Chamaedrys herba*	Spasm, diarrhea, liver, gall and kidney ailments, hemorrhoids.	PDR	3

Teucrium montanum L. (*Labiatae*)	Trava iva	*Teucrii montani herba*	Stomachic, cholagogue, tonic.		3
Thymus odoratissimus Mill. (*Labiatae*)	Majkina dušica	*Serpylli herba*	Expectorant, antiseptic, stomachic, carminative, bronchospasm, catarrh of the respiratory tract.	Ph Eur, BP, PDR, E+	
Thymus praecox Opiz subsp. *jankae* (Čelak) Jalas (*Labiatae*)	Majkina dušica	*Serpylli herba*	Expectorant, antiseptic, stomachic, carminative, bronchospasm, catarrh of the respiratory tract.	Ph Eur, BP, PDR, E+	
Thymus pulegioides L. subsp. pannonicus (All.) Kerguélen (*Labiatae*)	Majkina dušica	*Serpylli herba*	Expectorant, antiseptic, stomachic, carminative, bronchospasm, catarrh of the respiratory tract.	Ph Eur, BP, PDR, E+	
Thymus pulegioides L. subsp. p*ulegioides* (*Labiatae*)	Majkina dušica	*Serpylli herba*	Expectorant, antiseptic, stomachic, carminative, bronchospasm, catarrh of the respiratory tract.	Ph Eur, BP, PDR, E+	
Tussilago farfara L. (*Compositae*)	Podbel	*Farfarae folium, F. flos*	Expectorant, antitussive, asthma, bronchitis, laryngitis.	PDR, E+ (folium), E- (flos)	3
Ulmus glabra Hudson (*Ulmaceae*)	Brest	*Ulmi cortex (mundatus)*	Astrigent, burns, chilblains, ulcers.		
Urtica dioica L. (*Urticaceae*)	Kopriva	*Urticae folium, U. radix, U. semen*	Antihemorrhagic, hypoglycemic, diuretic, roborantium, anemia, BPH.	Ph Eur, BP, PDR, E+, WHO (radix)	
Valeriana officinalis L. (*Valerianaceae*)	Odoljen	*Valerianae radix (rhizoma)*	Sedative, hypnotic, antispasmodic, carminative, mild hypotensive, migraines.	Ph Eur, BP, PDR, E+, WHO	
Veratrum nigrum L. (*Melanthiaceae*)	Crna čemerika	*Veratri nigri rhizoma*	Antihypertensive, diarrhea, neuralgia, rheumatism, gout.		3
Verbascum phlomoides L. (*Scrophulariaceae*)	Divizma krupnocvetna	*Verbasci flos*	Expectorant, diuretic, bronchitis, cold, wound healing.	Ph Eur, BP, PDR, E+	
Verbena officinalis L. (*Verbenaceae*)	Vrbena	*Verbenae herba*	Diuretic, astrigent, cholagogue, expectorant.	BP, PDR, E-	
Veronica beccabunga L. (*Scrophulariaceae*)	Razgon	*Beccabungae herba*	Edema.	PDR	
Veronica chamaedrys L. (*Scrophulariaceae*)	Zmijina trava	*Veronicae chamaedrys herba*	Bronchitis, asthma, gastrointestinal aliments, rheumatism, arthritis.		
Veronica incana L. (*Scrophulariaceae*)	Divlja lafendija	*Veronicae incanae herba*	Similar as *V. chamaedrys.*		
Viburnum lantana L. (*Caprifoliaceae*)	Udika	*Viburni lantanae folium, V. l. fructus*	Diarrhea.		
Vinca herbacea Waldst. & Kit. (*Apocynaceae*)	Zimzelen plavičasti	*Vincae herbaceae folium*	Sedative, antihypertensive, cerebral circulatory disorders.		2
Viola odorata L. (*Violaceae*)	Ljubičica	*Violae odoratae radix (rhizoma), V. o. flos*	Expectorant, emetic, bronchitis.	PDR	3

Presence in pharmacopoeias and other relevant literature: Ph Eur - European Pharmacopoeia 5 (2005), PDR - PDR for Herbal Medicines, second edition (2000), BP - British Pharmacopoeia 2009 (2008), E+ - Commision E Positive (Approved) Monographs, E- - Commission E Negative (Unapproved) Monographs, WHO - WHO monographs on selected medicinal plants (Vols. 1, 2, 3, 4) & commonly used in the Newly Independent States (NIS).
Conservation aspect: 1 - CITES, 2 - The Ordinance on strictly protected wild species of plants, animals and fungi, 3 - The Ordinance on protected wild species of plants, animals and fungi.

Discussion

The gorges and canyons of Balkan Peninsula are characterized by pronounced floristic diversity and diverse habitat types, enabling survival of plants with different ecological demands. Numerous botanical studies since mid-20th century have significantly contributed to knowledge on flora and vegetation of many gorges in Bosnia-Herzegovina, Montenegro [32] and Macedonia, as well as within the territory of Serbia [33], including the gorge of Svrljiški Timok.

According to studies by Bogosavljević et al. [34], the vascular flora of Svrljiški Timok gorge includes more than 689 taxa at species and subspecies level. The group of medicinal and aromatic plants is also important with 27.6% of total flora, indicating the significance of this

region. In comparison with the medicinal flora of Serbia there is a significant overlap in percentage ratio of main plant classes, with the most prominent taxa of dicots (88.8%), monocots (6.6%), gymnosperms (3%) and ferns (1.6%). The greatest significance is definitively that of *Labiatae* and *Compositae*, with 20 or more species each, higher than the average number of taxa per family (14) in this plant group. The combined participation of these families is 51%, showing the greatest contribution to the total number of medicinal species in flora of the study area. These two groups were also richest in species within the overall flora of Svrljiški Timok gorge [34]. The greatest diversity is shown by family *Labiatae*, with 32 species and 20 genera, which is therefore even richer than family *Compositae* which is richer in the overall flora of the gorge.

From the aspect of taxonomic richness, the medicinal flora of Svrljiški Timok gorge is also closely matching the structure of medicinal flora in Serbia as a whole (*Labiatae* 16.2%, *Compositae* 12%, *Rosaceae* 9%, *Umbelliferae* 6.4%, *Scrophulariaceae* and *Polygonaceae* 4% each, *Leguminosae* 3.6%, *Cruciferae* 3.2%). However, regarding the richest genera in overall flora of Serbia (*Achillea*, *Rumex*, *Artemisia*, *Teucrium*, *Thymus*, *Mentha*, *Veronica*) there are some pronounced discrepancies both in qualitative and quantitative sense. Discrepancies in the taxonomic spectrum are explained by increased presence of thermophilous habitat types, including rocks and stony ground, and by representation of xerophilous vegetation types in the gorge when compared to Serbia as a whole. Such conditions are primarily suitable for an increased presence of Pontian and Mediterranean-submediterranean plants in the total flora of the study area, influencing its medicinal flora.

Almost half of the total number of medicinal plant species in the medicinal flora of Serbia was recorded in the gorge of Svrljiški Timok, indicating the importance of study area from the aspect of biodiversity and a special place among the other areas of Eastern Serbia. The slopes of Sićevačka Klisura gorge hosted 4% [35], Rtanj Mt. 25% [36, 37], and Južni Kučaj and Juhor 39% [11] of the total number of medicinal plants growing in Serbia. It must also be stressed that comparison was based on literature data and that additional research in these regions is necessary and would probably change the above analysis.

Comparison of medicinal species listed in Table 1 with the lists in modern pharmacopeias [23, 24] and other literature data on this topic [25–31] indicates overlap in 124 cases. Out of the total number of species included in Table 1, 44 species (35%) are used in preparing herbal substances recorded in the 5th European pharmacopeia. The same number is prescribed by the British pharmacopeia with overlap in 93% of cited species (each includes a set of 41 species). Commission E, an expert group formed with the goal of estimating efficiency and effectiveness of plant materials and their phyto-preparations, traditionally publishes its results in form of monographs with positive or negative scores. The positive grade (E+), indicating that a certain herbal substance was studied and shown to have consistent effect, was assigned to substances derived from 54 species of the study area. The negative grade (E-), indicating risk in using such substance and insufficient knowledge of its effects, was assigned to 20 of the studied species. It is interesting to note that the second group includes many popular medicinal plants widely used in folk medicine in Serbia, such as *Hyssopus officinalis*, *Origanum vulgare*, *Pulmonaria officinalis*, *Tussilago farfara* etc. The World Health Organization (WHO) has published several monographs on medicinal plants, with the goal of harmonizing the use of herbal-based traditional medicines and preparations throughout the world, as well as monographs for specific parts of the world and even for separate countries. The first few editions include 21 taxa from the study area. In all, there, there are 16 taxa included in all of the cited literature sources, including some of the most popular medicinal plants such as *Achillea millefolium*, *Althaea officinalis*, *Hypericum perforatum*, *Matricaria chamomilla*, *Melissa officinalis* and *Urtica dioica*. It must be stressed that some plant species from this area (*Gentiana cruciata*, *Satureja kitaibelii* and *Teucrium montanum*) are very popular in folk medicine but not included in any of the cited sources in lists of medicinal plants.

Medicinal plants are among the most important natural resources and therefore their conservation has general ecological and manifold economic importance. Implementation of numerous regulations and laws in form of international and national conventions is introducing order into conservation of plant species, with the goal of preserving the natural resources. The Ordinance on protected and strictly protected wild species of plants, animals and fungi (Official Gazette of the Republic Serbia No. 36/09) lists several medicinal plants growing in the area of Svrljiški Timok gorge. *Adonis vernalis*, *Agrimonia eupatoria* subsp. *grandis*, *Platanthera chlorantha*, *Vinca herbacea*, as relatively rare in the wild, were placed under protection of first degree, and collecting, direct destruction or any other activities that may pose a threat to these species are forbidden, or their collecting and harvesting is allowed only in certain amounts. Some of he most important species are additionally protected by international CITES convention [38]: *Anacamptis morio*, *A. pyramidalis*, *Gymnadenia conopsea* and *Orchis simia*, referring the endangered medicinal orchid species recorded from the field.

Conclusion

Within the medicinal flora of Serbia, the flora of medicinal plants in the gorge of Svrljiški Timok stands out as rich and taxonomically diverse and distinctive. It is composed of 190 species and subspecies of vascular plants, while the families with the greatest number of medicinal representatives are *Labiatae* and *Compositae*. Out of the total number of recorded medicinal plants in this area, use of 16 plant species and their herbal substance

was recommended by most relevant pharmacopeias. On the other hand, only a relatively low percentage (25.8%) of medicinal flora in gorge of Svrljiški Timok is under legal protection. According to a number of parameters, including floral richness in medicinal plants, the gorge of Svrljiški Timok is an area important from the aspect of biodiversity conservation. Therefore it is necessary to implement the principles of nature conservation and rational use of natural resources.

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