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Geoecological characteristics of plant endemism in the Balkan part of Serbia

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ABSTRACT: Due to complex and heterogeneous geographical characteristics, Serbia is represented by a diverse flora with many endemic taxa of vascular plants. Investigation of plant endemics stored in the national herbaria and perusal of extensive literature sources indicate that 46 taxa occur exclusively within the political borders of the Republic of Serbia, while 104 taxa can also be found in adjacent countries of the Balkan Peninsula. These national and subendemics are presented in the form of a list together with their ecological and geographical characteristics. Centres of endemism are located in the southern and eastern regions of Serbia and on the territory of Kosovo and Metohija. The majority of taxa are associated with mountainous regions of Kosovo, Metohija, and Central Serbia, at medium elevations between 500 and 1500 m. Most of the national endemics occur on limestones and dolomites and on soils such as cambisols, lithosols, and rankers. They are mainly under the influence of a modified mountain and moderately continental climate.

Keywords: vascular plants, Serbia, endemism, physical geography, Balkan Peninsula

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INTRODUCTION

An endemic taxon is one native to and restricted to a particular area. A taxon can be endemic for both environmental and biological reasons. Factors thought to influence endemism include fragmented habitats and variation in climatic and edaphic conditions, although few generalisations can be made about endemism (Kruckeberg & Rabinowitz 1985; Major 1988). In the classical biogeographical usage, the term endemism does not necessarily imply rarity or even a small range (Kruckeberg & Rabinowitz 1985). Different types of endemism exist. An endemic taxon may represent a taxon newly evolved in a particular region (neoendemism), a once widespread taxon now reduced to a small area (palaeoendemism), or a taxon which retained a narrow distribution throughout its evolution (holoendemism) (Hobohm *et al.* 2014b). The degree of endemism of an area is often cited as a measure of the uniqueness of the flora and is consequently important for prioritising sites for conservation (Myers *et al.* 2000; Brooks *et al.* 2002). Based on the distributional range of obligate serpentine endemics, Stevanović *et al.* (2003) presented the following general classification: (1) trans-Balkan or trans-regional

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Balkan endemics (taxa distributed in the greater part of serpentine areas in the Balkans); (2) regional endemics (taxa restricted to a single floristic subregion or province); and (3) local or steno-endemics (taxa distributed in a single floristic district or narrow geographical area such as a single mountain or island).

Balkan endemic plants include taxa that are confined solely to territory of the Balkan Peninsula (Turrill 1929; Strid & Tan 1997). Detailed studies of the flora of the Balkan Peninsula date back to the beginning of the 20th century (Hayek 1924–1933; Turrill 1929). Turrill (1929) numbered 1754 Balkan endemic species, representing 26.8% of the total vascular flora of the Peninsula. Recent studies of the Balkan endemic flora conducted by Stevanović (2005) and Stevanović *et al.* (2007) estimated that the vascular flora of the Balkans comprises almost 8000 plants, of which between 2600 and 2700 taxa (species and subspecies) are Balkan endemics.

The territory of Serbia has diverse physico-geographical characteristics. It consists of two large macro-regional units divided by the rivers Sava and Danube: the southeastern part of the Pannonian plain and the middle part of the Balkan Peninsula (Šabić *et al.* 2010). Due to climatic, orographic, geological, and pedological heterogeneity, Serbia is considered as one of the centres of biodiversity in Europe with an extensive range of ecosystem types. During the glacial periods this territory served as a refuge for a number of species. Thus, the country harbours numerous endemic-relict floral elements from previous geological ages. Serbia hosts 39% of Europe's vascular plant species (Stevanović *et al.* 1995). Apart from thorough floristic surveys of the Balkan Peninsula, there have been only a few analyses of plant endemics in Serbia, e.g., Gajić (1984) and Diklić (1987) recorded 197 endemic plants in Serbia. Later, Stevanović *et al.* (1995) numbered 287 Balkan endemics in Central Serbia and the Kosovo region, which represent 8.06% of the total vascular flora of this area. In detailed and long-term field studies of Central Serbia and the Kosovo region, Tomović *et al.* (2014) confirmed the presence of 492 Balkan endemic species and subspecies.

The aim of this study is to present certain geoecological patterns of plant endemism in Serbia. Results are given in the form of a list of Balkan endemic species and subspecies that are restricted solely to the territory of Serbia. Moreover, we here record endemic plants that, in addition to Serbia, also occur in one or two nearby countries, such as Albania, Bulgaria, the Republic of Macedonia, Montenegro, Bosnia and Herzegovina, Croatia, and Greece.

MATERIAL AND METHODS

Study Area. The territory of Central (or proper) Serbia and the Autonomous Province of Kosovo and Metohija occupies the central part of the Balkan Peninsula. It covers an area of 66855 km^2 or 75.7% of total land of the Republic of Serbia. Natural borders define this territory – the rivers Sava and Danube in the north, the Balkan mountain range (Stara Planina) in the east, the Šar Planina mountain range in the south, and the river Drina and the Dinarides with the Prokletije mountain range in the west. Since the Autonomous Province of Vojvodina (north of the rivers Sava and Danube) does not belong to territory of the Balkan Peninsula, this region was omitted from the analysis.

The geology of Serbia is very complex and heterogeneous. Sedimentary rocks are the most common type of rocks and are represented mostly by limestones and red sandstones (widespread in the Carpatho-Balkanides and Dinarides). Among the metamorphic rocks present, crystalline schists and serpentinites are common (on the Serbian-Macedonian massif and in the Dinarides). Due to volcanic activity in the past, igneous rocks are present in certain places (the Radan-Toplica, Kosovo-Kopaonik-Rudnik, and Crni Timok regions) (Jovanović & Srećković-Batoćanin 2006).

The recent relief of Central Serbia and Kosovo and Metohija is a result of the tectonic conjunction of three large mountain systems separated by deep faults: the Dinarides in the west, the Serbian-Macedonian (Rhodope) massif in the central part, and the Carpatho-Balkanides in the east. In the northern part of the territory, the Dinarides and Serbian-Macedonian belt are separated from the Pannonian depression by a fault. Elevation of the terrain increases from north to south, with the highest mountains (the Balkan, Šar, and Prokletije mountain ranges) being peripherally located. Kosovo and Metohija represent the gently rolling basin bottom of a former lake. Elevations between 300 m and 1500 m comprise 90% of this region (Rodić & Pavlović 1994).

The climate of Central Serbia and Kosovo and Metohija is mostly influenced by its relief features. The hilly northern parts of Central Serbia and mountainous regions up to 800 m are under the influence of Pannonian climate. This continental climate is characterised by pronounced seasonal differences, with warm summers, cold winters, and autumns generally warmer than springs. Regions above 800 m experience moderately continental climate (with moderately warm and dry summers and cold winters), while those at elevations above 1400 m have mountain climate. Valleys that are partially protected from strong winds have a transitional climate type which is a combination of the two aforementioned climate types. This climate, often referred to as moderate climate, is marked by somewhat higher air temperatures throughout the year. The Metohija region and Šar and Prokletije foothills are under the influence of Mediterranean climate, with mild and wet winters and warm and dry summers (Ducić & Radovanović 2005).

Geology, topography, climate, hydrology, and other factors influenced the formation and diversification of soils. Among the common soil types, chernozems are usually formed on a basis of loess (Mačva, Stig, Braničevo);

cambisols are formed on loess or lake sediments (Šumadija; regions around the Western Morava, and Morava, and Drina rivers; Kosovo); vertisols occur on a clay basis (East Serbia, Šumadija, Kosovo); rendzinas can be found on carbonates and flysch (Southwest Serbia, Stari Vlah, Raška, Metohija); rankers occur on silicate and peridotite rocks (Mts. Kopaonik, Zlatibor, Golija); terra rossa or red Mediterranean soil is formed on carbonates (East and West Serbia, Metohija); podzols are developed in mountainous regions; and stagnosols occur near large rivers. Alluvium is formed around river systems, while eluvial and deluvial soils occur in mountainous regions (Janković & Atanacković 1999).

Data and Analysis. National endemics are species/subspecies that exclusively occur within the political borders of the Republic of Serbia. As subendemics, we include taxa that are marginally shared with only one or two neighbouring countries.

The present study is based on 1053 inspected and revised herbarium sheets deposited in collections of the Natural History Museum (BEO) and Institute of Botany and Botanical Garden "Jevremovac" of Belgrade University's Faculty of Biology (BEOU) [herbarium acronyms are according to Thiers (2016)], as well as on 447 literature records (dating from 1856 to 2012).

Systematics and nomenclature follow the latest checklists, papers (Greuter *et al.* 1984–1989; Greuter & Raab-Straube 2008), and databases [Euro+Med (2006–) (http://ww2.bgbm.org/ EuroPlusMed/) and The Plant List (http://www.theplantlist.org/)] and some older but basic floras (Pančić 1874, 1884; Hayek 1924–1933).

Information on species localities and habitats (including plant associations) was taken from the electronic database that contains transcripts of the collectors' original labels stored within the herbarium, and from literature sources. A survey of toponyms was conducted using topographic maps on scales of 1:25000 and 1:50000 (Military Geographical Institute 1966–1996).

Classification of endemics was done according to Stevanović *et al.* (2003). In his research on the serpentine flora of the Balkans, he categorised endemics into three groups based on their distributional range: trans-regional Balkan endemics, provincial or regional endemics, and district or local steno-endemics. Each endemic taxon was relegated to a chorological group corresponding to the floristic regions of Europe of Walter & Straka (1970). There are five such chorological groups: Mediterranean-Submediterranean, Central European, Pontic, Central European mountainous, and South European mountainous. Life forms were designated following Raunkiaer (1934) and Stevanović (1992). Taxa were classified as phanerophytes, nanophanerophytes, chamaephytes, hemicryptophytes, geophytes, and therophytes.

The geological basis of specific localities analysed in this study is given according to genesis of the bedrock and its mineral composition. Data were gathered from geological maps (scale 1:100000) (Group of authors 1970–1992). Classification of soil types was done according to Škorić *et al.* (1985). Pedological maps on a scale of 1:50000 (Group of authors 1958–1976) were used for identification of soil types.

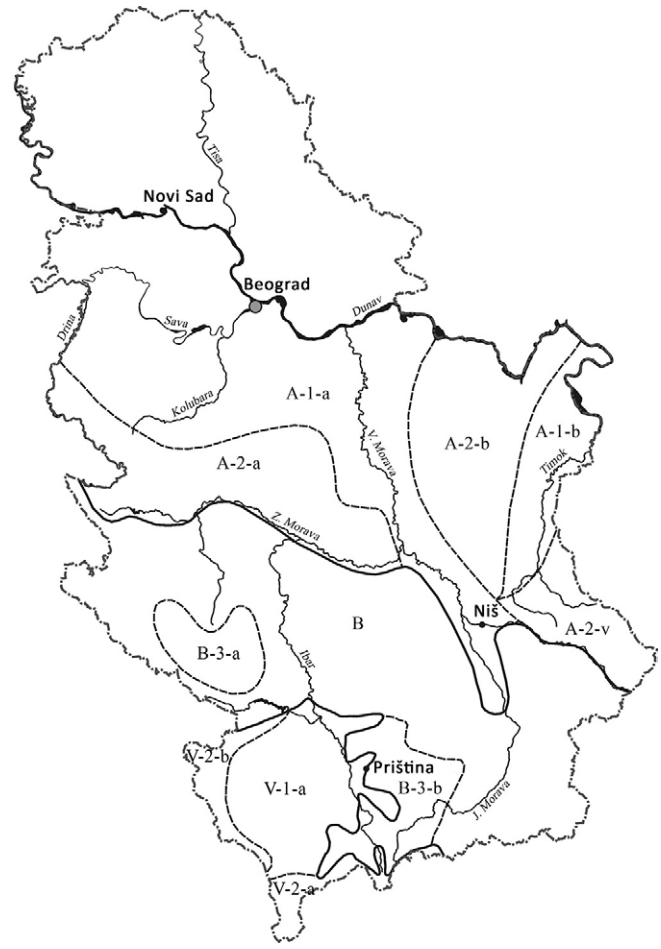

Fig. 1. Climatic regions of the Republic of Serbia. A – continental climate; B – moderately continental climate; V – modified Mediterranean climate. Full line – border between climatic regions; dashed line – border between climatic subregions; dot-dashed line – national border (Ducić & Radovanović 2005).

Climate classification was done according to Ducić & Radovanović (2005). This categorisation scheme represents a modification of earlier classification systems. On the territory of the Republic of Serbia, climate is divided into three main groups or climatic regions (A, B, V), while each region is further subdivided into units of lower rank (Fig. 1). Regionalisation is founded on complex interactions of relief and processes of atmospheric circulation. Region A is mostly marked by continental climate, region B is with moderately continental climate, while region V is characterised by the combination of Mediterranean and mountainous climate types. Climate regions do not have sharp boundaries, but are separated by transitional zones whose width depends on microclimatic

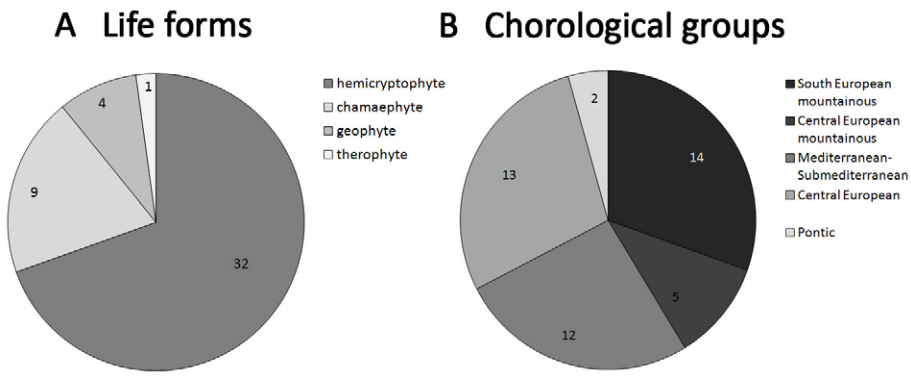

Fig. 2. Allocation of national endemics to different life forms (A) and chorological groups (B). Numbers inside pie charts indicate the number of taxa.

conditions. Characterisation of climatic variations is difficult due to the relatively small number of climate-monitoring stations.

In the following text, the compositional state of endemic plants is given as a percentage of the total number of national and subendemic taxa found in Serbia. This means that the percentage in question describes only the ratio within a single category (region, substrate type, climate type, life form, etc.), while endemics for different categories can overlap (e.g., 24% of the total number of national endemic taxa registered in Serbia was found to live in the Kosovo region, although out of those 24% some also inhabited other regions and are not exclusively restricted to the Kosovo region).

RESULTS AND DISCUSSION

On the territory of Serbia, 46 taxa are described as national endemics, while 104 taxa are characterised as subendemics. National endemic taxa are analysed in detail and their geoecological attributes are presented in Table 1. Subendemics are only listed with their distribution in Table 2.

National endemics belong to 14 families and 22 genera, while subendemics include plants from 23 families and 55 genera. Balkan endemics in Central Serbia and the Kosovo region comprise 492 taxa (Tomović *et al.* 2014), of which 9.4% of national endemics or 21.1% of subendemics are distributed in Serbia. The family Asteraceae contains the largest number of endemic taxa – 22 national endemics and 43 subendemics. The genus *Hieracium* L. alone has 20 taxa of national endemics and 30 taxa of subendemics in Serbia. This geographically highly variable and species-rich genus includes 82 Balkan endemic taxa present in Central Serbia and the Kosovo region (Tomović *et al.* 2014), which would suggest that 24% of those are uniquely distributed in Serbia. Among the nationally endemic taxa, four species (*Scabiosa achaeta* Vis. & Pančić, *Althaea kragujevacensis* Pančić, *A. vranjensis* Diklić & Nikolić, and *Trapa annosa* Janković) are no longer present in the flora of Serbia and are probably globally extinct.

The largest group of national endemics are the hemicryptophytes (32 taxa; 70%), while fewer taxa belong to the categories of chamaephytes (9 taxa; 19%), geophytes (4 taxa; 9%), and therophytes (1 taxon; 2%) (Fig. 2A). There is a correlation between life form and altitudinal and rainfall gradients. Hemicryptophytes are abundant in areas with high rainfall rates and lower temperatures, and vice versa. Chamaephytes attain their highest density rates within the altitudinal range of 1400–2000 m a.s.l., but these records tend to decrease as rainfall rates increase (Giménez *et al.* 2004).

Chorological analysis (Fig. 2B) of national endemics indicates that the majority of taxa (29 taxa; 63%) are associated with mountainous regions of Kosovo, Metohija, and Central Serbia, although a few also occur on mountains of East Serbia. Endemic orophytes from the South European mountainous chorological group (14 taxa; 31%) live in rocky habitats of mountains that are under Mediterranean climatic influence. Endemic taxa of the Central European mountainous chorotype (5 taxa; 11%) are closely related to species distributed in the mountains of Central Europe (Tomović *et al.* 2014). There are 12 taxa (26%) which belong to the Mediterranean-Submediterranean chorotype, indicating that the influence of Mediterranean climate on the Serbian flora is significant. Taxa of the Mediterranean-Submediterranean, Central European (13 taxa; 28%), and Pontic (2 taxa; 4%) chorotypes are distributed in various regions of Serbia.

Centres of endemism are located in the southern and eastern regions of Serbia and on the territory of Kosovo and Metohija (Fig. 3). In the region of Metohija, 41% (19 taxa) of national endemics and 55% (57 taxa) of subendemic taxa occur, while 24% (11 taxa) of national endemics and 28% (29 taxa) of subendemics are distributed on the territory of Kosovo. Within the nationally endemic taxa, most have narrow geographical distribution or are located in a specific area (for example on a single mountain). We recorded 28 district endemics, 14 provincial endemics, and four trans-regional endemics. On the territory of Kosovo and Metohija, the greatest number of endemic taxa is recorded in the Prokletije and Šar Planina Mountains. Other

Table 1. National endemics distributed in Serbia. Regions: Š (Šumadija); NE (Northeast Serbia); W (West Serbia); C (Central Serbia); E (East Serbia); SW (Southwest Serbia); M (Metohija); K (Kosovo); S (South Serbia); SE (Southeast Serbia). Endemism types: DE (district endemite), PE (provincial endemite), TRE (trans-regional endemite). Chorological groups: SEM (South European mountainous), CEM (Central European mountainous), CEUR (Central European), PONT (Pontic), MED-SUBMED (Mediterranean-Submediterranean). Life forms: Ch (chamaephytes), H (hemicryptophytes), G (geophytes), T (therophytes). The cross symbol (†) indicates an extinct taxon.

Taxon	Locality	Region	UTM	Elevation (m a.s.l.)	Habitat	Endemism type	Chorological group	Life form	Geological substrate	Soil type	Climatic region/ subregion
Asteraceae											
Achillea alexandri-regis Bornm. & Rudsky	Šar Planina (Ošljak)	K	DM87, DM97	1800-2212	rocky grounds, pastures;	DE	SEM	H	limestones	lithosol – rendzina	V-2-a
Centaurea albertii Rexhepi	Đakovica (Deva); Koznik mtn.; Priština (Goleš)	K, M	DN60, DN91, DM48	800-1000	rocky grounds, grassy terrains	DE	MED-SUBMED	H	diabases, harzburgites, serpentinites	cambisol dystric, lithosol, ranker, rendzina	B, B-3-b, V-2-b
Hieracium albopellitum (Zahn) Niketić	Prokletije mts. (Gubavac, Paklen, Peć)	M	DN32, DN42	750-2350		PE	SEM	H	alluvium, dolomites, limestones	cambisol eutric, fluvisol, lithosol	V-2-b.
Hieracium bertisceum Niketić	Prokletije mts. (Marijaš)	M	DN21	2350	open stony ridge between *Pinus peuce* and *Pinus mugho* communities	DE	SEM	H	calcschists, limestones, marbles	ranker	V-2-b
Hieracium bifidum subsp. *stolanum* Zahn	Bor (Stol mtn.)	NE	EP99	1150	rocky grounds	PE	CE	H	dolomites, limestones	rendzina	A-2-b
Hieracium bjeluschae subsp. *tommasiniiforme* Schaeffer & Zahn	Prokletije mts. (Paklen)	M	DN32	750-950	rocky grounds, rock crevices	PE	SEM	H	dolomites, limestones	cambisol eutric, lithosol	V-2-b
Hieracium bupleuroides subsp. *malacosericeum* Rech. fil. & Zahn	Mokra gora mtn. (Beli Rzav river valley); Tara mtn. (Zaovine); Prokletije mts. (Paklen)	W, M	CP74, CP75, DN32	900	rocky grounds and outcrops	DE	CE	H	dolomites, limestones, marls	cambisol eutric, lithosol, ranker, regosol, rendzina	B, V-2-b
Hieracium erythrocarpum subsp. *aculeatissimum* Zahn	Stara planina mts.	E	FP30	1200-1800		DE	CEM	H	arkoses, clays, dolomites, limestones, sandstones, siltstones	cambisol eutric, ranker, rendzina	A-2-v
Hieracium erythrocarpum subsp. *kurvalae* Rech. fil. & Zahn	Prokletije mts. (Dečanska Bistrica, Kurvala, Marijaš, Nedžinat, Paklen, Prilepska mtn., Rugova canyon)	M	DN21, DN22, DN31, DN32	1600-2300		DE	CEM	H	calcschists, dolomites, greenschists, granitoid rocks, limestones, marbles, sericite schists	kalkomelanosol, cambisol eutric, lithosol, ranker	V-2-b

Taxon	Locality	Region	UTM	Elevation (m a.s.l.)	Habitat	Endemism type	Chorological group	Life form	Geological substrate	Soil type	Climatic region/ subregion
Hieracium grossianum subsp. *schefferianum* Zahn	Prokletije mts. (Dečanska Bistrica, Kurvala)	M	DN31	1600	rocky grounds and outcrops	PE	SEM	H	granitoid rocks, greenschists, sericite schists	lithosol, ranker	V-2-b
Hieracium heldreichii subsp. *pseudopilosissimum* Zahn	Stara planina mts.	E	FP30	1200-1800		PE	SEM	H		cambisol eutric, ranker, rendzina	A-2-v
Hieracium jurassicum subsp. *papyraceum* (Zahn) Greuter	Golija mtn.	SW	DN49	700-100		DE	CE	H	micaschists, phyllites	ranker	B
Hieracium markovanum Arv.-Touv.	Pljačkavica mtn., Suva mtn.	S, E	EN71, EN98	700-1240	rocky outcrops	PE	CE	H	clastic flysch deposits, clays, dolomites, gravels, limestones, marls, sands, sandstones	kalkomelanosol, cambisol eutric, lithosol	B
Hieracium murorum subsp. *bistricense* Zahn	Prokletije mts. (Dečanska Bistrica)	M	DN31	800		DE	CE	H	granitoid rocks, greenschists, sericite schists	lithosol	V-2-b
Hieracium murorum subsp. *valdecordatum* Zahn	Prokletije mts. (Paklen)	M	DN32	750-1200		DE	CE	H	dolomites, limestones	cambisol eutric, lithosol	V-2-b
Hieracium pichleri subsp. *chromoneurum* Zahn	Prokletije mts. (Koprivnik	M	DN31, DN32	2200		PE	SEM	H	dolomites, limestones	kalkomelanosol, cambisol eutric, lithosol	V-2-b
Hieracium praecox subsp. *basilacistum* Rech. fil. & Zahn	Prokletije mts. (Loćanska Bistrica river valley)	M	DN21, DN31	1200		PE	CE	H	cherts, conglomerates, greenschists, limestones, phyllites, sandstones, sericite schists	lithosol	V-2-b
Hieracium racemosum subsp. *chaetotrichum* Zahn	Juhor mtn.	C	EP25	700		DE	CE	H	gneisses, micaschists, migmatites, leptinolites	regosol	A-2-a
Hieracium racemosum subsp. *semigrisescens* Zahn	Stara planina mts. (Tri kladenca); Suva mtn.	E	FN49, EN98	630-1800		PE	CE	H	clastic flysch deposits, clays, conglomerates, dolomites, gravels, limestones, quartz sands, sands	kalkomelanosol, cambisol eutric, lithosol, ranker	A-2-v, B

Hieracium schefferi Rech. fil. & Zahn	Prokletije mts. (Dečanska Bistrica)	M	DN31	600-800	pine forests	DE	CE	H	cherts, conglomerates, greenschists, limestones, limnoglacial sediments, phyllites, sandstones	cambisol eutric	V-2-b
Hieracium sericophyllum subsp. *acropolioscapum* Zahn	Prokletije mts. (Koprivnik)	M	DN31, DN32	2200		PE	SEM	H	dolomites, limestones	cambisol eutric, lithosol, ranker	V-2-b
Hieracium sparsum subsp. *ipekanum* Rech. fil. & Zahn	Prokletije mts. (Paklen)	M	DN32	750-950		DE	CEM	H	dolomites, limestones	cambisol eutric, lithosol	V-2-b
Boraginaceae											
Solenanthus krasniqii (T. Wraber) Niketić	Paštrik mtn. (Gorožup)	M	DM67	1500-1600	pastures and meadows	DE	SEM	H	limestones	kalkomelanosol	V-2-b
Brassicaceae											
Alyssum montanum subsp. *serbicum* Novák	Goč mtn.; Gornji Milanovac; Ibar river valley; Kopaonik mtn.; Kosovska Mitrovica; Kragujevac; Kraljevo; Maljen mtn.; Ozren mtn.; Pešter; Rogozna mtn.; Stolovi mtn.; Studena mtn.; Šar Planina	Š, NW SW, C, K	DP18, DP57, DP61, DP62, DP71, DP72, DP73, DP98, DN08, DN37, DN67, DN69, DN76, DN84, DN85, DN86, DN89, EN06, DM88, DM97, EM07	250-1443	rocky ground, rocky outcrops, near roads, pastures	TRE	MED-SUBMED	Ch	cherts, clastites, clays, diluvium, glaciofluvial deposits, greenschists, harzburgites, limestones, metabasites, metadiabases, peridotites, river and lake sediments, sandstones, sericite schists, serpentinites	kalkomelanosol, cambisol dystric, cambisol eutric, coluvial soils, podzol, pseudogley, ranker, rendzina, vertisol	A-1-a, A-2-a, A-2-b, B, V-1-a, V-2-a
Bornmuellera dieckii Degen	Šar Planina (Brezovica, Kodža Balkan mtn.)	K	DM87, DM88, DM97	1170-2090	rocky grounds, rocky outcrops, pastures	DE	SEM	Ch	cherts, diabases, glaciofluvial deposits, limestones, metadiabases	kalkomelanosol, coluvial soils	V-2-a
Cardamine pancicii Hayek	Kopaonik mtn. (Bačište hotel, Bećirovac, Crni Jelak, Kriva river-Metalica, Kukavica, Pajino preslo, Pančić peak, Pojila-Sedlo, Putnik hotel, Suvo rudište)	C	DP90, DN89	1500-2000	vegetation near streams, rocky grounds, pastures	DE	SEM	H	calcschists, dolomites, granodiorites, greenschists, limestones, marbles, quartz-diorites, sericite schists	ranker	B

Taxon	Locality	Region	UTM	Elevation (m a.s.l.)	Habitat	Endemism type	Chorological group	Life form	Geological substrate	Soil type	Climatic region/ subregion
Campanulaceae											
Edraianthus canescens D.Lakušić, Niketić & Stevan.	Ovčar-Kablar gorge (Kablar mtn., Ovčar Banja)	W	DP36	300-310	rocky grounds and outcrops, rock crevices, screes	DE	SEM	Ch	limestones	cambisol eutric	A-2-a
Edraianthus stankovicii (Lakušić) D. Lakušić & Surina	Bor (Krivelj, Stol mtn., Veliki krš)	NE	EP88, EP89, EP99	800-1155	rocky grounds and outcrops, rock fissures, rocky grasslands, pastures	DE	SEM	Ch	limestones		A-2-b
Caryophyllaceae											
Cerastium neoscardicum Niketić	Šar Planina (Kodža Balkan mtn.)	K	DM97	1400-2090	mountain pastures, rocky grounds, edge of *Pinus heldreichii* forests	DE	CEM	Ch	harzburgites, serpentinites	kalkomelanosol	V-2-a
Dipsacaceae											
Scabiosa achaeta Vis. & Pančić †	Ibar river valley (Raška-Trnava)	C	DN69	300-1100		DE	MED-SUBMED	H	gabbros, harzburgites, rhodingites	ranker	B
Lamiaceae											
Nepeta rtanjensis Diklić & Milojević	Rtanj mtn. (Golema Vrnovica, Javor, Kostadinovica, Mužinac, ridge, Šarbanovac, Tumba)	NE	EP64, EP74	650-850	rocky grounds, screes, zone of oak forests (*Quercetum farnetto-cerris*)	DE	MED-SUBMED	Ch	clays, conglomerates, dolomites, limestones, marls, sands, sandstones	kalkomelanosol, cambisol eutric, lithosol, rendzina	A-2-b
Salvia officinalis subsp. *multiflora* Gajić	Merošina; Sićevo gorge; Prizrenska Bistrica river gorge; Svrljig; Svrljig mtn.	E, C, M	EP60, EP62, EP71, EP81, EP90, EN69, EN88, EN89, EN99, FN09, DM8	300-950	meadows, marshes, salt marshes, rocky grounds, coves, cracks and screes	DE	MED-SUBMED	Ch	clays, conglomerates, dolomites, limestones, sands, sandstones, siltstones	kalkomelanosol, cambisol eutric, fluvisol, lithosol, rendzina, vertisol	A-1-a, A-1-b, A-2-b, A-2-v, V-2-b
Salvia pratensis subsp. *pozegensis* (Watzl-Zemann) Diklić	Ibar river valley; Priština (Kosovo polje); Požega	W, K	DP25, DN85, DN86, EN02	320-1100	meadows, near roads	DE	PONT	H	alluvium, harzburgites, serpentinites	fluvisol	A-2-a, B, B-3-b

Thymus adamovicii Velen.	Goč mtn.; Gornji Milanovac; Ibar river valley; Kopaonik mtn.; Stolovi mtn.; Tara mtn.; Zlatibor mtn.	Š, W, C	CP76, CP84, CP93, CP94, DP03, DP57, DP62, DP71, DP82, DN89	300-530	rocky grounds, *Pinus nigra*, *P. sylvestris* forests	DE	MED-SUBMED	Ch	harzburgites, limestones, marls, peridotites, schists, serpentinites	kalkomelanosol, cambisol, cambisol eutric, ranker	A-2-a, B
Malvaceae										
Althaea kragujevacensis Pančić †	Kragujevac (Metino brdo, Petrovac, Vraćevšnica-Ljuljaci)	Š	DP67, DP77, DP97	250	ass. *Trifolio-Chrysopogonetum grylli*	DE	CE	H	arenites, conglomerates, quartz latite, sandstones, siltstones	luvisol, vertisol	A-1-a
Althaea vranjensis Diklić & Nikolić †	Vranje (Šamin do, Zlatokop)	SE	EN70	500-750	ruderal sites, edge of arable land	DE	MED-SUBMED	H	alluvium, conglomerates, clays, sandstones		B
Ranunculaceae										
Aquilegia pancicii Degen	Suva mtn. (Devojački grob-Trem, Golaš, Golemo Stražište-Trem, Golubanovac, Jelov pažar, Kosmovac, Lasni rid, Ledenica, Preslap, Rženac, Smrdan, Sokolov kamen, Točila, Trem, Vratska padina)	E	EN97, EN98, FN07, FN08	630-1750	wet and overgrown screes of mountain and subalpine belt, beech and spurce forests	DE	CEM	H	conglomerates, dolomites, limestones, sandstones, siltstones	kalkomelanosol, cambisol eutric, lithosol	B
Helleborus multifidus subsp. *serbicus* (Adamović) Merxm. & Podl.	Čemerno mtn.; Giljeva mtn.; Goč mtn.; Golija mtn.; Gornji Milanovac; Ibar river valley; Kopaonik mtn.; Kosovska Mitrovica; Kraljevo; Mokra gora mtn.; Novi Pazar; Ozren mtn.; Ravna mtn.; Banjska; Stolovi mtn.; Studena mtn.; Studenica river valley; Troglav mtn.	Š, W SW, C, K	CP75, CP85, DP50, DP51, DP52, DP53, DP57, DP60, DP61, DP62, DP68, DP71, DP72, DP74, DP73, DP75, DP78, DP81, DP82, DN08, DN49, DN57, DN59, DN67, DN68, DN69, DN78, DN79, DN85, DN88, DN89, DN96, DN97, DN99, EN06	320-1600	meadows, pastures, rocky grounds and outcrops, oak, hop-hornbeam and pine forests	PE	MED-SUBMED	G	andesites, breccias, cherts, clays, conglomerates, dacites, diabases, gabbro-amphibolites, gabbro-diabases, granodiorites, greenschists, harzburgites, latites, limestones, marls, metabasites, peridotites, quartz latites, sandstones, sericite schists, serpentinites, siltstones	cambisol dystric, cambisol eutric, coluvial soils, litosol, luvisol, podzol, ranker, rendzina	A-2-a, A-2-b, B, B-3-a, V-1-a

Taxon	Locality	Region	UTM	Elevation (m a.s.l.)	Habitat	Endemism type	Chorological group	Life form	Geological substrate	Soil type	Climatic region/ subregion
Rosaceae											
Drymocallis malacophylla (Borbás) Kurtto	Ozren mtn.; Tara mtn.; Zlatibor mtn.	W, SW	CP84, CP85, CP92, CP93, CP94, CP95, DN08, DN09, DN18, DN19	700-1000	rocky grounds and outcrops	PE	MED-SUBMED	Ch	conglomerates, dolomites, harzburgites, limestones, marls, sands, serpentinites	cambisol eutric, ranker, rendzina, vertisol	A-2-b, B
Trapaceae											
Trapa annosa Janković †	Morava river (Bagrdan gorge, Brzan, Ćuprija, Jagodina, Lapovo, Paraćin, Smederevska Palanka, Stalać, Velika Plana)	Š	EQ00, EQ03, EP18, EP19, EP25, EP26, EP33, EP42	90-130	old river meanders, oxbow lakes, bogs	DE	CE	T	alluvium, clays, gravels, sands	fluvisol	B
Violaceae											
Viola kopaonikensis Pančić ex Tomović & Niketić	Kopaonik mtn.; Željin mtn.; Pešter karst plateau; Rogozna mtn.	C, SW, K	DP81, DN27, DN37, DN76, DN77, DN79, DN88, DN97, EN06	1100-1960	rocky grounds and outcrops, screes, pastures	PE	SEM	H	granodiorites, harzburgites, sericite-chlorite schists, serpentinites	ranker	B, B-3-a, V-1-a.
Liliaceae											
Tulipa kosovarica Kit Tan, Shuka & Krasniqi	Drenica mtn. (Lapušnik); Koznik mtn. (Mrasor, Mrasor-Labučevo); Mališevo (Gorić)	K, M	DN60, DN81, DM79	400-730	open vegetation, open thermophilous forests (*Quercus pubescens*, *Juniperus oxycedrus*	DE	MED-SUBMED	G	chlorite-sericite schists harzburgites, serpentinites	ranker	V-1-a
Tulipa luanica Millaku	Paštrik mtn. (Kušnin)	M	DM67	1000-1800	forest and open vegetation	DE	MED-SUBMED	G	limestones	kalkomelanosol, lithosol	V-2-b
Tulipa serbica Tatić & Krivošej	Ibar river valley (Kamenica, Lozište, Srbovac); Rogozna mtn. (Donja Kamenica, Gornja Kamenica)	K	DN85, DN86	900	dry meadows, pastures, rocky grounds	DE	MED-SUBMED	G	harzburgites, serpentinites	cambisol dystric, ranker	B

Poaceae											
Stipa novakii Martinovský	Čačak; Gornji Milanovac; Ibar river valley; Kopaonik mtn.; Kraljevo; Maljen mtn.; Mokra gora mtn.; Priboj; Priština; Rogozna mtn.; Zlatibor mtn.	Š, NW, W, SW, C, K	CP85, CP91, CP94, DP18, DP21, DP26, DP28, DP36, DP52, DP57, DP62, DN67, DN79, DN85, DN86, DN88, DN91, EN05, EN06	310-1650	rocky grounds and outcrops, meadows	TRE	PONT	H	alluvium, clays, diabases, granodiorites, greenschists, harzburgites, limestones, marls, peridotites, sandstones, sericite schists, serpentinites	cambisol dystric, fluvisol, luvisol, pseudogley, ranker, rendzina	A-2-a, B, B-3-b
Trisetum flavescens subsp. *serbicum* (Velen.) Hayek	Knjaževac; Ostrozub mtn. (Bukova glava); Stara planina mts.; Surdulica; Vlasina; Vranje (Markovo kale)	E, SE, S	FP02, FP30, EN71, EN92, EN95, FN02, FN03, FN12, FN13, FN14	1200-1500	meadows, wet meadows, edge of beech forests, near streams	PE	CEM	H	albite-chlorite-muscovite schists, clays, conglomerates, dacites, gneisses, granodiorites, leptinolites, limestones, muscovite-chlorite schists, sands, sandstones	kalkomelanosol, cambisol eutric, ranker, rendzina	A-1-b, A-2-v, B

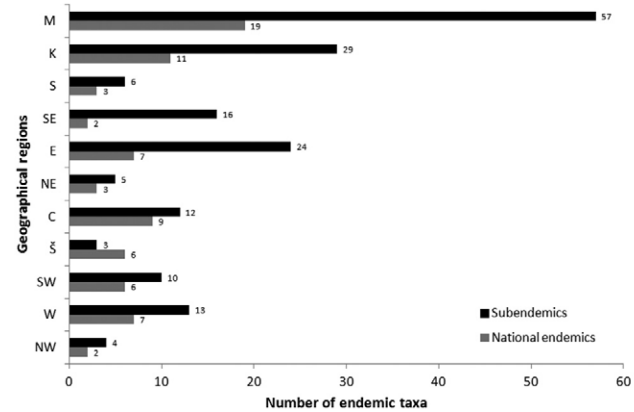

Fig. 3. Distribution of endemic taxa in different regions of the Republic of Serbia. M – Metohija, K – Kosovo, S – South Serbia, SE – Southeast Serbia, E – East Serbia, NE – Northeast Serbia, C – Central Serbia, Š – Šumadija, SW – Southwest Serbia, W – West Serbia, NW – Northwest Serbia.

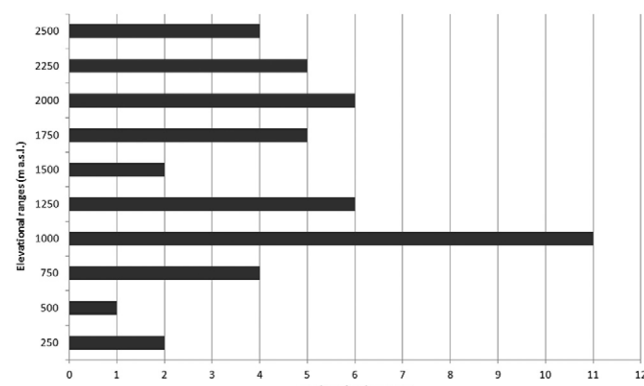

Fig. 4. Elevational ranges of national endemic taxa.

important centres of endemism include the Kopaonik mountain range in central and southern parts of Serbia, the western part of the Balkan Mountains (Stara Planina), and parts of the Ibar and the Morava river valleys (see the list of Balkan endemic plant taxa distributed exclusively in Serbia). Most of the subendemic taxa occur in regions of the borders with Albania, the Republic of Macedonia, and Bulgaria (Table 2).

The elevational gradient is just one among many other factors that can influence endemism in plants (Giménez *et al.* 2004; Werff & Consiglio 2004). The greatest number of national endemics is found at medium elevations between 500 and 1500 m a.s.l. (24 taxa; 52%). However, a considerable number are also distributed in high mountain areas with an elevational range above 1500 and up to 2500 m a.s.l. (22 taxa; 48%) (Fig. 4). In many temperate regions, endemism peaks at medium altitudes (Hobohm *et al.* 2014a). Mountainous regions with diverse microclimates

Table 2. Subendemic plant taxa distributed in Serbia and nearby Balkan countries. Nearby countries: Al – Albania; BH - Bosnia and Herzegovina; Bu - Bulgaria; Cg – Montenegro; Ct – Croatia; Gr – Greece; Mk – Republic of Macedonia).

Taxa	Regions in Serbia	Nearby countries	UTM coordinates in Serbia
PINOPSIDA			
Pinaceae			
Picea omorika (Pančić) Purkynê	W, SW	BH	CP57, CP66, CP67, CP75, CP76, CP86, CP90
MAGNOLIOPSIDA			
Apiaceae			
Peucedanum serpentini Andrasovszky & Jáv.	M	Al	DM39
Aristolochiaceae			
Aristolochia merxmuelleri Greuter & E. Mayer	M	Al	DN60
Asteraceae			
Achillea baldaccii Degen	M	Al	DN33; DM59, DM67
Achillea pindicola subsp. *corabensis* (Heimerl) Greuter	K, M	Al, Mk	DM73, DM74, DM75, DM87, DM97; EM06
Anthemis cretica subsp. *cinerea* (Pančić) Oberpr. & Greuter	SW, K, M	Bu, Cg	DN31, DN32, DN76; DM87, DM96, DM97; EM06, EM07, EM17
Centaurea epapposa Velen.	E, W	Bu	CP75; FN28
Centaurea ipecensis Rech. fil.	M	Cg	DN22, DN31, DN32, DN33, DN43
Centaurea melanocephala Pančić	C, M	Al	DP62; DM39
Centaurea ognjanoffii Urum.	SE	Bu	FN10, FN20; FM08, FM18
Centaurea phrygia subsp. *moesiaca* (Urum. & J. Wagner) Hayek	E, SE	Bu	EN98; FN03
Crepis baldaccii subsp. *albanica* Jáv.	M	Al, Mk	DN22, DN31, DN32
Crepis bertiscea Jáv.	M	Al, Cg	DN20, DN32
Crepis macedonica Kitanov	M	Al, Mk	DM74
Galatella albanica Degen	K, M	Al	DN85, DN86; DM38, DM39, DM49, DM79
Hieracium amphithales K. Malý & Zahn	W, SW	Ct	CP74, CP75, CP91
Hieracium andrasovszkyi subsp. *cremnophilum* O. Behr, E. Behr & Zahn	M	Al, Mk	DM67
Hieracium andrasovszkyi subsp. *doerfleri* Hayek & Zahn	M	Al	DM67
Hieracium andrasovszkyi subsp. *kobilicanum* O. Behr, E. Behr & Zahn	M	Mk	DM86, DM96
Hieracium balkanum Pančić	E	Bu	FP21; FN49

Hieracium bifidum subsp. *pallescentisimile* O. Behr, E. Behr & Zahn	M	Al	DM67
Hieracium bulgaricum Freyn	SE	Bu	EN81; FN11; EM78, EM 99; FM18
Hieracium coloriscapum subsp. *stenopyllophorum* O. Behr, E. Behr & Zahn	K	Mk	EM07, EM17
Hieracium djimilense subsp. *brachytrichoiphyes* O. Behr, E. Behr & Zahn	K, M	Mk	DM86, DM96, DM97; EM06
Hieracium djimilense subsp. *cordatifrons* Zahn	E	Bu	FP30
Hieracium durmitoricum (Rohlena & Zahn) Niketić	M	Cg	DN22
Hieracium gaudryi subsp. *cernyanum* Hayek & Zahn	M	Al	DM65, DM66
Hieracium gaudryi subsp. *hayekianum* Dörfler & Zahn	M	Al	DM67
Hieracium guglerianum subsp. *telekianum* Kümmerle & Zahn	M	Al	DN22, DN32
Hieracium macrodontoides subsp. *gigantophyllum* Zahn	M	Cg	DN32
Hieracium marmoreum subsp. *marmoreum* Pančić & Vis.	NE, E, SE	Bu	EQ40, EQ71; EP46, EP67, EP71, EP72, EP73, EP74, EP77, EP80, EP83, EP87, EP89, EP90, EP91, EP92, EP99; EN88, EN89, EN98, EN99; FN08, FN20, FN24, FN26, FN35, FN38; EM89
Hieracium naegelianum subsp. *ljubotenicum* O. Behr, E. Behr & Zahn	K	Mk	EM07, EM17
Hieracium pannosum subsp. *eumecobracchion* Hayek	K	Mk	EM07, EM17
Hieracium pannosum subsp. *trojanum* Zahn	NE, E	Bu	FP06; FN38
Hieracium praecurrens subsp. *megaladenophyes* K. Malý & Zahn	M	BH	DN21, DN22, DN31, DN32
Hieracium pseuderiopus subsp. *nikolae* Zahn	E	Bu	FP21
Hieracium pseudobifidum subsp. *caesiopictum* (Zahn) Zahn	M	Ct	DN21, DN31, DN32
Hieracium pseudobifidum subsp. *zljebense* (Zahn) Zahn	M	Cg	DN33
Hieracium pseudosparsum Zahn	E	Bu	FP30; FN49
Hieracium sparsum subsp. *livadicanum* O. Behr, E. Behr & Zahn	K	Mk	EM07
Hieracium sparsum subsp. *pilosifrons* Zahn	E	Bu	FP30
Hieracium sparsum subsp. *staraeplaninae* Zahn	E	Bu	FP40
Hieracium transiens (Freyn) Freyn	E	Bu	FP40
Hieracium velenovskyi Freyn	E, SE	Bu	FN03, FN39, FN49, FN58
Hieracium wiesbaurianum subsp. *livadicae* O. Behr, E. Behr & Zahn	K	Mk	EM07
Pilosella serbica (F.W.Schultz & Sch.Bip.) Szeląg	C	Cg	DP81; DN89

Taxa	Regions in Serbia	Nearby countries	UTM coordinates in Serbia
Boraginaceae			
Paramoltkia doerfleri (Wettst.) Greuter & Burdet	K, M	Al	DN40, DN60, DN61, DN80; EN00, EN31; DM39, DM67, DM89; EM26, EM27
Brassicaceae			
Cardamine serbica Pančić	W	Cg	CP76
Lunaria telekiana Jáv.	M	Al, Cg	DN31, DN32
Campanulaceae			
Campanula secundiflora Vis. & Pančić	W, SW	Cg	CP90; DP23; CN98, CN99
Edraianthus montenegrinus Horak	SW, M	Al, Cg	DN20, DN21, DN22, DN23, DN31, DN32, DN33, DN43, DN44, DN54, DN64
Edraianthus serbicus Petrović	NE, E, SE	Bu	EQ40; EP67, EP74, EP77, EP89, EP90, EP99; FP06; EN88, EN89, EN97, EN98, EN99; FN07, FN08, FN09, FN20, FN26, FN28, FN35, FN38
Caryophyllaceae			
Minuartia bulgarica (Velen.) Graebner	E, SE, C	Bu	FP30; EN36, EN90; FN00, FN01, FN10, FN14, FN20; FM08, FM18, FM19
Cerastium malyi (Georgiev) Niketić	W, SW, C, K	Al, BH, Cg	CP84, CP92, CP93, CP94; DP02, DP03
Dianthus behriorum Bornm.	M	Al	DM67
Dianthus nitidus subsp. *lakusicii* T. Wraber	M	Cg	DN23, DN33
Dianthus scardicus Wettst.	K, M	Mk	DM65, DM66, DM73, DM74, DM75, DM86, DM96; EM06, EM07, EM17
Heliosperma macranthum Pančić	M	Al, Cg	DN21, DN22, DN31, DN32
Heliosperma nikolicii (Seliger & T. Wraber) Niketić & Stevanović	K, M	Al	DM86, DM87, DM97
Heliosperma oliverae Niketić & Stevanović	M	Cg	DN20, DN21, DN30
Heliosperma pusillum subsp. *moehringiifolium* (Uechtr. ex Pančić) Niketić & Stevanović	NE, E	Bu	FQ03; EP48, EP58, EP64, EP67, EP68, EP74, EP77, EP89, EP93, EP94, EP99; EN97, EN98, EN99; FN07, FN08, FN47
Silene schmuckeri Wettst.	M	Mk	DM74, DM86, DM96
Dipsacaceae			
Knautia pancicii Szabó	W	BH	CP84, CP93, CP94
Fabaceae			
Astragalus wilmottianus Stoj.	E, SE	Bu, Mk	FN07, FN17, FN20
Lathyrus pancicii (Jurišić) Adamović	E	Bu	EN98
Medicago prostrata subsp. *pseudorupestris* (Hayek) Micevski	M	Mk	DM67, DM87
Trifolium wettsteinii Dörfler & Hayek	K, M	Al	DN33; DM65, DM66, DM67, DM87, DM97; EM07, EM17
Genista nissana Petrović	E, K	Mk	EP70; EN79; EM26

Gentianaceae			
Gentiana pneumonanthe subsp. *nopcsae* (Jáv.) T. Wraber	M	Al	DM39
Lamiaceae			
Micromeria albanica (K. Malý) Šilić	K, M	Al	DM69, DM87, DM97
Stachys officinalis subsp. *skipetarum* Jáv.	M	Al	DM39
Thymus bulgaricus (Domin & Podp.) Ronniger	NE, E	Bu	FQ13; EP81, EP87; EN77
Oleaceae			
Forsythia europaea Degen & Bald.	K, M	Al	DN31, DN32, DN42, DN60, DN91; DM38, DM39, DM48, DM49, DM59, DM65, DM66, DM67, DM69, DM79
Orobanchaceae			
Orobanche esulae Pančić	E, SE, S	Bu, Mk	EP70, EP81, EP90; FP02; EN71, EN82, EN88, EN89, EN99; FN07, FN08, FN17, FN18, FN27, FN28
Polygalaceae			
Polygala doerfleri Hayek	K, M	Al	DN33, DN60, DN91, DN94; DM39, DM48, DM49, DM67; EM16
Ranunculaceae			
Aquilegia blecicii Podobnik	C, M	Cg	DN22, DN23, DN31, DN32, DN43, DN44, DN79, DN89
Consolida uechtritziana (Huth) Soó	SE, S	Cg	EN71, EN84
Rosaceae			
Potentilla doerfleri Wettst.	K, M	Mk	DM73, DM74, DM86, DM96; EM06, EM07, EM17
Sanguisorba albanica Andrasovszky & Jáv.	M	Al	DN60; DM39
Rutaceae			
Haplophyllum boissieranum Vis. & Pančić	W, C, K, M	Al	CP74, CP76, CP85; DP62, DP72, DP82; DN33, DN60, DN69, DN79, DN85, DN86, DN89
Scrophulariaceae			
Linaria rubioides subsp. *nissana* (Petrović) Niketić & Tomović	E	Bu	EP81, EP90; FP11; EN89, EN99; FN07, FN08, FN09, FN17, FN18, FN19, FN26, FN27, FN28, FN29, FN35, FN37, FN38, FN39, FN46, FN47, FN48, FN49
Linaria rubioides subsp. *rubioides* Vis. & Pančić	Š, NW, W, SW, C	BH	CP66, CP72, CP74, CP75, CP76, CP82, CP84, CP85, CP86, CP91, CP92, CP93, CP94; DP02, DP10, DP26, DP28, DP36, DP37, DP38, DP61
Melampyrum trichocalycinum Vandas	K, M	BH	DN32, DN43, DN67, DN76; EN15; DM87, DM97
Pedicularis ernesti-mayeri Stevanović, Niketić & D. Lakušić	M	Al, Cg	DN31, DN32

Taxa	Regions in Serbia	Nearby countries	UTM coordinates in Serbia
Pedicularis heterodonta Pančić	E, SE, S, NW, W, SW, C, K, M	BH	CP74, CP75, CP76, CP82, CP85, CP86, CP93, CP94; DP00, DP05, DP18, DP22, DP27, DP28, DP52, DP62, DP71, DP72, DP80; EP62, EP90; FP21, FP30, FP40; DN08, DN19, DN31, DN32, DN69, DN88, DN89, DN97, DN98; EN05, EN06, EN46, EN80, EN94, EN98; FN00, FN01, FN03, FN04, F08, FN13, FN14, FN15, FN24, FN35, FN38, FN47, FN48, FN49; DM87, DM97; EM89; FM19
Scrophularia tristis (K. Malý) Šilić	Š, W, SW, C, K, M	BH	CP74, CP75, CP76, CP84, CP85, CP86, CP91, CP94; DP05, DP10, DP26, DP36, DP52, DP57, DP61, DP62, DP72, DP80; DN19, DN57, DN60, DN67, DN69, DN76, DN79, DN84, DN85, DN86, DN87, DN89; DM97
Verbascum anisophyllum Murb.	E, SE	Bu	FN20, FN26, FN35
Verbascum viridissimum Stoj. & Stefanov	SE	Bu	FN10
Veronica barrelieri subsp. *andrasovszkyi* (Ják.) M. Fisher	M	Al	DN60; DM39
Valerianaceae			
Valeriana pancicii Halácsy & Bald.	M	Al, Cg	DN20, DN21, DN22, DN23, DN31, DN32, DN33; DM65, DM66
LILIOPSIDA			
Liliaceae			
Allium rubriflorum (Adamović) Anačkov , N.Friesen & Seregin	E	Bu	EP70, EN99, FN07, FN08, FN17, FN18, FN28
Colchicum macedonicum Košanin	M	Al, Mk	DM73, DM74
Fritillaria macedonica Bornm.	K, M	Al, Mk	DM96; EM06
Tulipa scardica Bornm.	K, M	Mk	DN60; EM16
Iridaceae			
Crocus alexandri Ničić ex Velen.	E, SE, S, C, K	Bu	EN12, EN22, EN27, EN48, EN55, EN60, EN68, EN71, EN78, EN81, EN90; EM68
Crocus kosaninii Pulević	S, K	Mk	EN55, EN60, EN73, EN74, EN75, EM69
Crocus rujanensis Ranđelović & D. A. Hill	S	Mk	EM58, EM67, EM68
Crocus scardicus Košanin	K, M	Al, Mk	DM74, DM75, DM96; EM06, EM07, EM17
Poaceae			
Bromopsis moesiaca (Velen.) Holub	SE, C	Bu	DN89; EM78, EM89
Festuca stojanovii (Acht.) Kožuharov ex Foggi & Petrova	SE	Bu	FN20
Poa glauca subsp. *frearitis* (Halácsy) H. Scholz	M	Gr	DN20
Stipa mayeri Martinovský	M	Al	DN60; EM16
Sesleria serbica (Adamović) Ujhelyi	Š, NW, W, SW, C, K	BH	CP03, CP75, CP76, CP82, CP84, CP85, CP93, CP94; DP18, DP26, DP27, DP28, DP36, DP52, DP56, DP57, DP61, DP62, DP70, DP71, DP72, DP82; DN08, DN67, DN69, DN79, DN88, DN89, DN97
Sesleria ujhelyii V. Strgar	NW, W	BH	CQ52; CP88, CP93, CP99; DP05, DP08, DP18, DP19, DP23, DP26, DP29, DP36

provide numerous refuge areas. These refugia are relatively stable environments, a situation that promotes high endemic diversity. On a large biogeographical scale, species richness and endemic richness coincide with each other. However, on a smaller scale (e.g., looking at a particular region of the Balkan Peninsula, i.e., territory of the Republic of Serbia), species richness generally decreases with elevation (Stevens 1992). As a general rule, the number of endemic species is expected to increase at high elevations, in part due to isolation mechanisms (Vetaas & Grytnes 2002). Serbia has several mountains with a height of more than 2000 m, while peaks with an elevation of over 2500 m are characteristic only of the mountains of Kosovo and Metohija.

Based on formation processes, minerals present, chemical composition, and physical characteristics, we divided geological bedrock into groups and subgroups. Out of 46 national endemic taxa, 34 taxa occur on sedimentary rocks, 22 taxa on metamorphic rocks, 20 taxa on igneous rocks, and eight taxa on various sediments (Fig. 5). There are 31 taxa that are associated with chemical and/or biological sedimentary rocks – limestones, dolomites and cherts. Limestone terrains in the Republic of Serbia cover an area of 8414 km^2 or 9.5% of its territory. In the Vojvodina region, limestones cover only about 5 km^2 and are associated with the Fruška Gora mountain. Limestones and dolomites are characteristic features of the Dinaric and Carpathian-Balkan mountain systems (Gavrilović 1976). Thirteen taxa are serpentine endemics that grow on ultramafic rocks. Ultramafic (ultrabasic) rocks, such as peridotite, harzburgite, and serpentinite, contain small amounts of silica and generate soils that are poor in essential plant nutrients (N, P, K, Ca) and high in potential toxins (Mg, Ni, Cr, Co). Vegetation growing on serpentinised rocks is often reduced in height, biomass, and ground cover. Some plant species are limited to or excluded from such environments, while a few others have adapted and are prone to accumulation of heavy metals in their tissues (Adamson *et al.* 1993; Harrison *et al.* 2004). The majority of serpentine endemics are distributed in Central, West, and Southwest Serbia. Stevanović *et al.* (2003) found 335 taxa of Balkan endemics growing on serpentine, among which 123 are obligate serpentine endemics. There are 10 taxa that occur on granitoid rocks and 16 on metamorphic rocks containing schists. Both granite and schist components produce a poor nutritional status of soils. Depending on mineral composition, schists have the ability to easily release nutrient elements due to their weatherable character. However, schists are known for their deficiency of Mg, K, P, and N – elements that can limit the growth of many plant species (Gleason *et al.* 2010).

The genesis of soils is correlated with properties of the parental bedrock. The majority of national endemic taxa were found on cambisols, lithosols, and rankers. An overview of associations of taxa with specific soil types is given in Table 3. A large number of endemics were found to grow on cambisols (25 taxa) – 22 taxa on productive eutric cambisols and six taxa on less fertile dystric cambisols. Although cambisols can form under a wide range of vegetation types, their formation is often linked with forested areas (especially in the case of dystric cambisols). Eutric cambisols are usually formed on calcareous or other similar neutral and basic substrates (various sediments). This soil is generated at lower elevations, on flat and slightly undulating relief forms. Dystric cambisols are lithogenic soils formed on acidic substrates and silicate rocks. High levels of rainfall can lead to accumulation of humus, leaching, and further acidification of this soil type (Bašić 2013). In Serbia (the whole country), eutric cambisols cover an area of approximately 560 000 ha, while dystric cambisols cover an area of around 2 280 000 ha (Dedijer *et al.* 2007). Twenty taxa occur on lithosols, which are characteristic of mountainous areas or terrains with increased processes of erosion (e.g., the

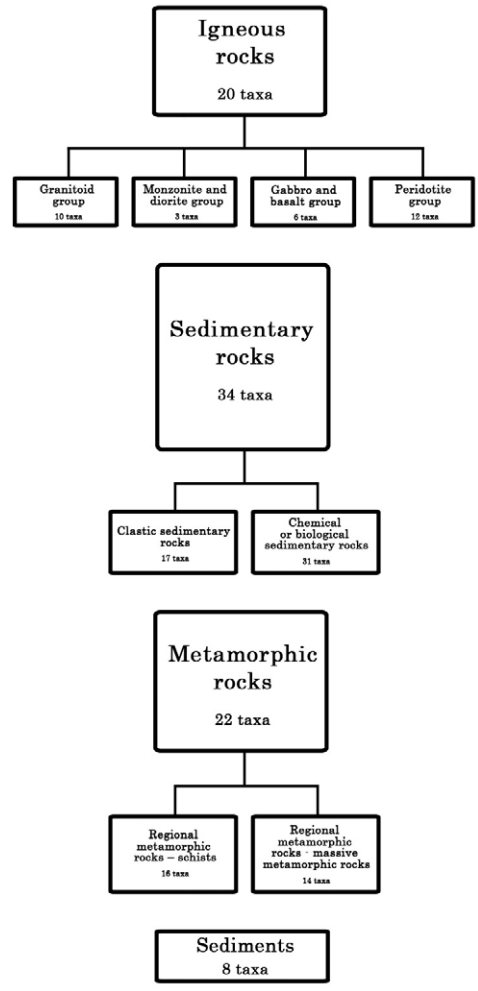

Fig. 5. Bedrock geology of national endemic taxa (the number of endemic taxa corresponds to size of the box for the main geological types).

Table 3. Distribution of national endemic plants on different soil types.

Soil Type	Number of taxa
Terrestrial soils	
Initial automorphic soils	
Lithosols	20
Regosols	2
Colluvial soils	3
Humus-accumulative soils	
Kalkomelanosols	14
Rankers	21
Rendzinas	13
Vertisols	4
Cambic soils	
Cambisols eutric	22
Cambisols dystric	6
Eluvial illuvial soils	
Luvisols	3
Podzols	2
Hydromorphic soils	
Initial multilayer soils	
Fluvisol	5
Amphygleyic soils	
Pseudogleys	2

Table 4. Distribution of national endemic plants in different climatic regions and subregions.

Climatic region / subregion	Number of taxa
Climatic region A	17
Subregion A-1-a	3
Subregion A-1-b	2
Subregion A-2-a	7
Subregion A-2-b	7
Subregion A-2-v	5
Climatic region B	19
Subregion B-3-a	1
Subregion B-3-b	4
Climatic region V	24
Subregion V-1-a	4
Subregion V-2-a	4
Subregion V-2-b	17

erodible slopes of mountain belts and active flood plains of river systems). Shallow and dry soils with little humic material, lithosols are commonly formed on limestone and dolomite substrates (Chesworth 2008). In Serbia lithosols cover an area of 107 000 ha (Dedijer *et al.* 2007). Twenty-one taxa were found on rankers – a thin type of soil that is usually formed over siliceous acidic rocks in hilly and mountainous regions. Rankers are light, sandy, and skeletal soils that are well aerated and permeable to rainwater, typical of forests, and rich in organic matter (Chesworth 2008; Bašić 2013). In Serbia rankers cover an area of 572 000 ha (Dedijer *et al.* 2007).

Climatic variability (spatial and temporal), together with topographic complexity, is a major driver of diversity and endemism in plants (Irl *et al.* 2015). The distribution of local endemics can be explained by variations in climatic conditions, especially microclimate parameters (Hobohm & Tucker 2014). The greatest number of national endemic taxa belongs to climatic region V – 24 taxa, while region B includes 19 and region A 17 taxa. Each of these regions is divided into subregions (Table 4). A considerable number of endemic taxa of different climatic regions (especially climatic zone V) inhabit mountainous habitats. The climates of high mountain areas tend to be more stable than those of lower regions, and this favours endemism. Such climates may also have been relatively stable in evolutionary time (Bruchmann & Hobohm 2014). Microclimatic conditions have a strong influence on plant distributions and can promote high diversity and endemism in plants. Small-scale topography and microclimates support populations of narrow endemics and disjunct taxa. This is the reason why many national endemics in Serbia inhabit diverse microhabitats of river gorges, canyons, and mountains. Differences of microclimatic conditions can be considerable within small distances (a few metres). Microclimates can also lower the impact of climate change on a regional level (Hobohm *et al.* 2014b; Vanderplank *et al.* 2014).

CONCLUSION

Due to diverse physical and geographical characteristics, the Republic of Serbia has a considerable number of endemic plant taxa; 46 taxa of national endemics and 104 of subendemics distributed in Serbia represent 9.4 and 21.1%, respectively, of the total Balkan endemic flora in our country. Centres of endemism are located in the southern and eastern regions of Serbia and on the territory of Kosovo and Metohija.

Among the national endemics, the greatest number are hemicryptophytes. The majority of taxa are associated with mountainous regions of Kosovo, Metohija, and Central Serbia and belong to the South European mountainous (31%) and Central European mountainous (11%) chorological groups. The greatest number of plant taxa are located at medium elevations between 500 and 1500 m a.s.l. (52%), but a considerable number are also distributed in high mountain areas with a range of elevations above 1500 and up to 2500 m a.s.l. (48%). Due to the significant presence of limestone terrains in Serbia, the greatest number of taxa occur on sedimentary rocks (mostly limestones and dolomites). Most endemic taxa were found on cambisols, lithosols, and rankers, soils that extend over large areas on the territory of Serbia. Numerous national endemic taxa live in diverse habitats of mountains or river valleys and are under the influence of a modified mountain and moderately continental climate.

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Botanica SERBICA

REZIME

Geoekološke odlike endemizma biljaka u balkanskom delu Srbije

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Usled kompleksnih i heterogenih geografskih karakteristika Srbija ima raznovrsnu floru sa mnoštvom endemičnih taksona vaskularnih biljaka. Pregledom materijala balkanskih endemičnih biljaka deponovanih u okviru kolekcija nacionalnih herbarijuma, kao i relevantnih literaturnih izvora, utvrđeno je da se 47 taksona javlja isključivo unutar političkih granica Republike Srbije, dok se 103 taksona, osim u Srbiji, može naći i u okolnim državama. Ovi nacionalni i gotovo-nacionalni endemiti su prikazani u obliku liste, pored koje su prikazane i njihove ekološke i geografske karakteristike. Centri endemizma se nalaze u južnim i istočnim regionima Srbije i na teritorijama Kosova i Metohije. Većina taksona je vezana za planinske oblasti Kosova, Metohije i Centralne Srbije i nadmorske visine između 500 i 1500 m. Najveći broj nacionalnih endemita se javlja na krečnjacima i dolomitima i na zemljištima kao što su kambisoli, litosoli i rankeri. Endemiti se najvećim delom nalaze pod uticajem modifikovane planinske i umerenokontinentalne klime.

Ključne reči: vaskularne biljke, Srbija, endemizam, fizička geografija, distribucija