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Biopotential of microbial biofilms in the protection of subterranean habitats in Dinaric karst

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This brief overview of cave biota associated with microbial biofilms, including speleophyton, bacteria, protozoa and cave-dwelling fauna in Dinaric karst caves, is focused on taxa with potential application in biotechnology, bioremediation/ biostimulation and biomonitoring.

The review discusses the dynamics and structure of biofilms and the interspecies interactions of biofilms in a number of Dinaric karst caves, as well as a new approach to biofilm investigation.

A deep understanding of subterranean ecosystems and the unique organisms that inhabit them, connected by complex interactions, could elucidate many new aspects in the evolution of signal pathways important for producing novel biologically active molecules. Consideration of the potential applications will improve the preparation of cave management plans, especially of touristic open caves, but also help consultants to propose the most appropriate (bio)monitoring with a strong focus on habitat protection and biodiversity conservation.

Keywords: microbial biofilm, subterranean habitats, biotechnology, bioremediation, Dinaric karst

INTRODUCTION

A subterranean (hypogean) environment, including both terrestrial and aquatic habitats, *is trophically dependent* on surface ecosystems. The high constancy of abiotic factors makes hypogean habitats and their associated inhabitants among the most vulnerable on Earth (Gibert and Deharveng, 2002). Biodiversity in the hypogean realm is generally low compared to surface habitats of the same region, presumably due to the very specific and often harsh environmental conditions such as the lack of light and low nutrient availability (Juberthie, 2000). The lack of sunlight and consequent absence of photosynthetic activity, stable (low to moderate) temperature, high relative humidity and low rates of evaporation largely determine the distribution and population density of cave fauna (Holsinger, 1988). In such nutrient-poor conditions, the biome becomes increasingly dominated by microorganisms (Barr, 1967; Culver and Sket, 2000), metabolically miscellaneous and unexpectedly diverse (Barton and Jurado, 2007).

In some rare cave ecosystems energy originates from *in situ* bacterial chemoautotrophy (e.g. Movile cave in Romania (Sarbu et al., 1996), but most caves depend on nutrient input originating from the cave exterior. Nutrient transport in the dark zone relies either on allochthonous organic material (Gibert et al., 1994) sourced from penetrating plant roots, streams and percolating groundwater that enter caves, or on the decomposition of material such as bat guano, dung of birds and rodents, carcasses and migrating animals (Gunde-Cimerman et al., 1998; Culver and Pipan, 2009). In addition, chemolithoautotrophic primary production provides for the usage of sulphur-, ammonium- or nitrite-based chemolithotrophy and autochthonous organic carbon (Chen et al., 2009; Porter et al., 2009). Under environmental conditions, most bacteria persist in biofilm mode encased in an extracellular polymeric substance (EPS) matrix, responsible for architecture, morphology, coherence and activity (Flemming et al., 2000a) but also provide a beneficial structure to biofilm forming microbes in bioremediation (Flemming and Wingender, 2001; Flemming and Wingender, 2010; More et al., 2014). In fact, the variety of microniches provided by the biofilm also promotes a great diversity of microbial life and metabolic potential.

Dinaric karst is known worldwide as the richest subterranean fauna region, a hotspot of subterranean biodiversity (Vandel, 1965; Sket et al., 2004), on account of its numerous habitat types as an adaptive zone and the abundance of adaptive types inhabiting them (Gunn, 2004; White and Culver, 2012; Sket, 2017) as well as processes involved in the adaptation, speciation and evolution of subterranean animals. Notwithstanding the well documented biodiversity of cave-dweller animals (Sket, 2003; Sket, 2012), microbial communities were often neglected in past studies despite their high ecological importance (Engel, 2012a; Engel, 2012b) resulting from their biodiversity and incredible biochemical and physiological evolution in response to environmental conditions (Engel, 2010). In the Dinarides, "unusual aquatic organic formations" were first observed in Vjetrenica cave (Bosnia and Herzegovina) by the Czech speleobiologist Karel Absolon (1912), while several years later these formations were described as bacterial colonies by Olga Smolikova (1919). Over the past few decades, several studies of the bacterial diversity of microbial mats/biofilms have been reported (Pašić et al., 2010; Pleše et al., 2011; Porca et al., 2012; Kostanjšek et al., 2013; Pleše et al., 2016) revealing the diversity and uniqueness of the microbial world of caves.

Microbes, including bacteria, archaea, phytoplankton, protozoans and fungi, still catalyse the major transformations of elements, break down organic matter, and produce and consume oxygen and carbon dioxide (Smil, 2003). Thus bacteria and microbial eukaryotes, especially fungi and protists, are used for pollution removal (Bouwer and Zehnder, 1993; Cerniglia, 1997; Mitra and Mukhopadhyay, 2016) bioremediation (Balaji et al., 2014) biomonitoring (Pronk et al., 2009) and different branches of biotechonology (medical, agricultural, industrial biotechnology etc) (De Lurdes and Dapkevicius, 2013). The combination of *omics*-driven technologies and improved cultivation techniques is extending the knowledge of their biological diversity, paving the way for new biotechnological exploitations (Handelsman, 2004; Shestakov, 2012; Luna, 2015). In consequence, it has been emphasised that microbial ecologists can indeed contribute to socio-ecology and efforts toward achieving global sustainability by understanding the characteristics and processes of microbial communities that enable microbial services (Ducklow, 2008).

Our review, which focused on recent publications of the composition of microbial communities in Dinaric karst caves, suggests implementing the obtained results *in situ*, with a view to the protection of particular, critically endangered, subterranean habitats and the cave-dwelling fauna. Consideration of potential applications will improve the preparation of cave management plans, especially of touristic open caves, but also help consultants to propose the most appropriate (bio)monitoring with a strong focus on habitat conservation.

BIOLOGICAL PROPERTIES OF MICROBIAL BIOFILMS

The enormous global biodiversity of bacteria (Woese, 1987; Pace, 1997; Olsen et al., 1986; Dykhuizen et al., 1998; Schloter et al., 2000; Curtis et al., 2002; Torsvik et al., 2002; Rappé

and Giovannoni, 2003) and diverse biochemical and physiological evolution in response to environmental conditions, gave rise to an incredible diversity of adaptive solutions. The dynamics of biofilm formation are influenced by biotic and abiotic factors (Lawrence et al., 1991; Costerton et al., 1994; Wolfaardt et al, 1994; Costerton et al., 1995) whereas the nature of the carbon source has been shown to be essential in the control of the biofilm development pathways, architectural heterogeneity (Tolker-Nielsen and Molin, 2000) and species diversity (Caldwell et al., 1992; James et al., 1995a; Moller et al., 1997).

Although each biofilm is unique (Tolker-Nielsen and Molin, 2000), they share some common features and structural attributes which can generally be considered as universal, pertaining to the relatively high diversity, Proteobacteria domination and phylogenetically novel sequence types. Biofilms are very heterogeneous in both space and time, containing microcolonies of bacterial cells encased in an EPS matrix and separated from other microcolonies by interstitial voids (Lewandowski, 2000). The matrix architecture and biofilm mechanical stability are determined by a number of intrinsic factors, such as cell motility (Tolker-Nielsen et al., 2000), as well as extrinsic factors, combining to produce a dynamic, heterogeneous microenvironment for the attached and enveloped cells (Allison, 2003). Microorganisms use this polymer matrix for the concentration of nutrients used for their survival and growth while other cave-dwellers utilize these microbial formations as a food source. The three-dimensional structure of the biofilm also provides protection against predation, toxic substances and physical perturbation.

Most types of EPS are both hydrophilic and hydrophobic (Sutherland, 2001) and also highly hydrated, because EPS can incorporate large amounts of water into its structure by hydrogen bonding. EPS, primarily composed of polysaccharides, may account for 50% to 90% of the total organic carbon of biofilms (Flemming et al., 2000b). The chemical nature of the substratum may also affect the success of cell attachment and the morphology of attached cells, as well as subsequent biofilm structure (Dalton et al., 1994). The mechanisms that contribute to genetic and physiological heterogeneity (distinct metabolic pathways, stress responses, etc.) include microscale chemical gradients, adaptation to local environmental conditions and the genotypic variation that occurs through mutation and selection (Stewart and Franklin, 2008).

As a protected mode of growth, biofilm formation is an ancient and integral component of the prokaryotic life cycle, a key factor for survival in diverse environments and crucial for the colonisation of new niches (Hall-Stoodley et al., 2004). Biofilms represent primary units of evolutionary selection (Caldwell and Costerton, 1996). They provide an ideal niche for the genetic exchange of plasmid DNA by horizontal gene transfer (HGT). It has been well documented that conjugation occurs at a greater rate between cells in biofilms than between planktonic cells (Hausner and Wuertz, 1999; Roberts et al., 1999), but also promote plasmid stability (Madsen et al., 2012). Additionally, Ghigo (2001) has suggested that medically relevant strains of bacteria that contain conjugative plasmids more readily develop biofilms, while without plasmids these same organisms produce only microcolonies devoid of any further development. Since plasmids may contain genes for resistance to multiple antimicrobial agents or heavy metals, and also many other genes crucial for survival in a particular environment, biofilm also provides a mechanism for selecting and promoting the spread of these plasmids among the members of the community.

INTRA- AND INTER-SPECIES INTERACTIONS IN MICROBIAL BIOFILM

Host-symbiont interactions are common in nature and comprise long-term associations that range from mutualism to parasitism (Brownlie and Johnson, 2009). Although competition also occurs within biofilms, which was observed on *Hyphomicrobium* sp. biofilms invaded by *Pseudomonas putida* resulting in its dominance (James et al., 2005b) and on laboratory-grown biofilms containing *Klebsiella pneumoniae and Pseudomonas aeruginosa* (Stewart et al., 2007), the generally accepted view is that subterranean, near-starvation, oligotrophy leads to replacement of selfish competition by cooperative and mutual interactions, such as observed in biofilms (Barton and Jurado, 2007).

Development of *omics* technologies have enhanced our understanding of microbial communities, and also contributed to a new holistic approach to the biofilm function. Individual microbes react individually to the host environment in the context of other microbes and their mutual interactions, producing as a result an integrated collective behaviour (Comolli, 2014). Based on the diverse metabolic processes carried out by different bacteria, the relative abundance of specific biofilm members would clearly be expected to play a role in regulating the overall metabolic potential of the biofilm system (Moller et al., 1997). Bacteria use *quorum sensing* to coordinate gene expression according to the density of their local population (Xie et al., 2000; Mangwani et al., 2016). As well as the use of chemical signals to synchronise behaviour across entire populations, the type and extent of microbe-microbe and microbe-host nutritional interactions will determine the metabolism of the entire community in a given environment (Comolli, 2014). In fact,

microbial communities are evolving entities whose driving mechanisms are the interactions among them (Kassen and Rainey, 2004). Complex intra- and inter-species interactions should be considered among the cave-dwelling animal taxa but also between them and microbial (bacterial, archaeal, fungal and protists) communities in the mats/biofilm (Pleše et al., 2016). The role of microbial biofilms in the food web of subterranean habitats was confirmed by isotopic analyses of the microbial biomass, invertebrate consumers of microbes and invertebrate predators. It was also postulated that invertebrates subsisted on microbes or other invertebrates that feed on them (Sarbu et al., 1996).

A unique example of symbiosis in the early stages of evolution is that between chemoautotrophic bacteria (belongs to *Thiothrix* phylotypes) and a freshwater cave amphipod *Niphargus ictus* G. Karaman, 1985, endemic to the sulphide-rich Frasassi Cave system in central Italy, which originated less than 1 million years ago (Dattagupta et al., 2009). An interesting feeding strategy of the cave isopod *Mesoniscus graniger* (Frivaldszky, 1865) (Crustacea: Isopoda) was observed (Šustr et al., 2005) in respect to troglobite food sources and food web in subterranean ecosystems, in addition to the utilization of guano, filter-feeding and microphagous feeding strategies. It includes organic deposits with associated microorganisms, as sources of essential polyunsaturated fatty acids (PUFA). Indeed, algae, fungi and bat guano were found to be the most important potential resources of PUFA, essential to isopod nutrition. A food web based on the rich microbial biomass of hygropetric moonmilk and troglobitic beetle *Cansiliella servadeii* Paoletti 1972 (Coleoptera: Leptodirini) (Paoletti et al., 2011) has been recorded. In spite of the limited food sources for cave-dwelling animal species, some nutritional specialisations in terms of food web and food preferences were described for selected terrestrial arthropods from Slovakian karst (Smrž et al., 2015).

Faecal deposition by bats also affects community structure in guano-based ecosystems. Bat guano forms the basis of a food web consisting of bacteria, fungi, protozoans, nematodes, and arthropods (Harris, 1970). The diversity of organisms associated with guano has been shown to vary depending on the diet of the bat producing it. Thus the structure of a guano community is more dependent on the microenvironment provided by the guano than on the cave environment as a whole (Ferreira et al., 2007). Insects on dung in caves are exposed to a high diversity and quantity of fungi, and some species are known to produce anti-microbial substances (Ribeiro et al., 2012). Moreover, it was reported that mites, as the most diverse invertebrate taxa in bat guano, especially those that eat microfungi (e.g. *Histoplasma capsulatum*), may provide natural biological control for this pathogen, as well as regulating cave-dwelling microfungi in general (Estrada-Barcenas et al., 2010). It was also reported that cave salamanders consume the guano of grey bats (*Myotis grisescens* A. H. Howell, 1909) (Fenolio et al., 2006). Though a predator, the olm *Proteus anguinus* Laurenti, 1768 has been observed to thrive on a diet of mud and associated microflora (Vandel and Bouillon, 1959; Vandel, 1964).

A comprehensive and multidisciplinary approach to the complexities and different aspects of interspecies interaction, such as host-symbiont vs. host-parasite, predator-prey interactions to some trait-mediated indirect interactions such as the ecology of fear, and the evolution of behavioural plasticity, enhance our understanding of the significant impact on species interactions, community structure, and ecosystem function (Miner et al., 2005; Agrawal, 2001).

BIOPOTENTIAL OF CAVE BIOTA IN DINARIC KARST

SPELEOPHYTON

Cave ecosystems have a simple structure and small energy flow based upon primary bioproduction of cyanobacteria and algae (Golubić, 1967; Mulec, 2008). The ecological demands of primary producers in caves, especially in the darkness zone, are extremely low. However, owing to their broad tolerance range, as a result of genome evolution and their long life history, some species of algae live at a light intensity that is even lower than their compensation point (Hill and Forti, 1997). This possibility has been observed in Dinophyta, which are able to switch to heterotrophic nutrition as an alternative mode of energy supply (Adhikari, 2002). Due to their low energy flux, cave ecosystems are extremely sensitive to changes in primary production rate, whereas in electrically lit surroundings biofilms composed of algae and cyanobacteria develop (Borderie et al., 2014). The higher input of energy driven by lamps renders allochthonous taxa more competitive in relation to native ones (Mulec and Kosi, 2009). Since lampenflora has been recognized as a main cause of rock biodeterioration (Albertano, 2012), it has to be carefully treated. The drastic example of cleaning with sodium hypochlorite in the Mammoth Cave had negative consequences for native microbes and algal diversity (Smith and Olson, 2007). A new approach using well-controlled UV-C irradiation in algal proliferation control in caves was confirmed as highly effective (Borderie et al., 2014).

DIVERSITY OF SPELEOPHYTON: AN OVERVIEW FOR SOUTH-EAST (SE) AND EAST EUROPE

Cave vegetation is divided into three zones according to light conditions, reflecting the evolutionary path of

photoautotrophs from algae in complete darkness, through mosses and ferns in the twilight area, to phanerogams which grow around the cave entrance (Latella and Stoch, 2002). The cave-dwelling flora mainly consists of cyanobacteria, green algae and diatoms (Mulec et al., 2008, Czerwik-Marcinkowska et al., 2015) while Cyanophyta were found exclusively in the darkness zone (Martínez and Asencio, 2010). In general, speleophyton diversity is low due to the factors limiting photosynthesis (Smith and Olson, 2007).

Among Cyanophyta, the order *Chroococcales* seems to be predominant, followed by *Oscillatoriales* and *Nostocales* (Martínez and Asencio, 2010). Algae in caves occur in two living forms, aerophytic and as freshwater taxa (Kuehn et al., 1992; Sanchez et al., 2002).

Since algal flora in Dinaric caves has been neglected, records were relatively scarce. Findings from Slovenia (Mulec, 2005; Mulec et al., 2007; 2008) and recently, from Serbia (Popović et al., 2017), provide recent data on algal composition in cave biofilms, as do sources from Bulgaria (Blagoy et al., 2007), Poland (Czerwik-Marcinkowska and Mrozinska, 2009; 2011; Czerwik-Marcinkowska et al., 2015), Greece (Lamprinou et al., 2014) and Hungary (Komáromy, 1977).

In Slovenia, no fewer than 42 algal taxa were detected in Račiške ponikve (Mulec and Kosi, 2008) as well 35 from Škocjanske jame, with the most abundant being Cyanophyta (71%), Chlorophyta (19%) and Chrysophyta (10%) (Mulec et al., 2007). A previous study of Slovenian caves showed that *Aphanocapsa muscicola, Chlorella* sp., *Lyngbya* sp., *Synechocystis* sp. and *Trentepohlia aurea* are common taxa in subterranean habitats. The same study also reported the discovery of typical cave species on poorly illuminated cave walls, *Geitleria calcarea* (Mulec, 2005).

The algal flora analysis from three caves in Serbia reveals the prevalence of cyanobacteria, mostly chrococcalean taxa, with *Gloeocapsa* as the most diverse genus. In addition to cyanobacteria, Chlorophyta and Bacillariophyta were found in the sampling sites with representatives of aerophytic and freshwater forms (Popović et al., 2017).

The aerophytic speleophyton of Bulgaria displays a prevalence of cyanobacteria (59 taxa) of the total of 64 identified species (Blagoy et al., 2007). In Greece the distribution pattern of Cyanophyta has recently been analysed in two caves of the "Diros" complex in the Peloponnese (Lamprinou et al., 2014). Of the 43 detected taxa of Cyanophyta, no fewer than 23 belong to to the order *Chroococcales*, 17 to *Oscillatoriales* and three to the order *Nostocales*. The most common species were *Scytonema julianum, Iphinoe spelaeobios* and *Leptolyngbya gracillima*. In Poland, Chlorophyta, Chrysophyta, Bacillariophyta, Xanthophyta and Cyanophyta were detected as well as representatives of Dinophyta (*Gloeodinium cracoviense*, *Phytodinium aureum)*, mentioned previously regarding their ability to alter their energy supply mode (Czerwik-Marcinkowska and Mrozinska, 2009; 2011). From Hungary, five taxa of Chlorophyta, three of Xanthophyta, nine of Bacillariophyceae and four taxa of Cyanophyta were reported, while *Chlorella minutissima, Ch. zofingensis, Hantzschia amphyoxis* and *Navicula contenta* should be considered as typical representatives of algal cave flora (Komáromy, 1977).

POTENTIAL USE OF SPELEOPHYTON IN BIOENGINEERING

The bioengineering of individual microbial organisms or microbial communities has great potential in agriculture, bioremediation and industry. Algae have long been recognised as a food source in the human diet and the nutrology of domestic animals (Newton, 1951; Tseng, 1981; Aaronson, 1986; Turner, 2003; Gantar and Svircev, 2008; Dillehay et al., 2008; Craigie, 2010), which is extremely important in a global food crisis (Switzer, 1980; Jassby, 1988; Gantar and Svircev, 2008). Algae can be used in biomonitoring as *a* valuable *indicator* of even a small alteration in aquatic ecosystems (Pantle and Buck, 1955; Sladaček, 1973; Fournier et al., 2005), *and* as a source of novel bioactive compounds as well in biofuel production (Xiong et al., 2008; Griffiths and Harrison, 2009; Rodolfi et al., 2009; Rodolfi et al., 2016; Kumar et al., 2017; Arbenz et al., 2018). The biopotential of speleophyton is shown in Table 1.

Cyanobacteria have significant bioengineering potential, while the potential of other groups of cave-dwelling flora such as Chlorophyta, Xanthophyta, Chrysophyta, Bacillariophyta and Dinophyta is considered to be negligible. The mucilaginous sheath secreted by cyanobacteria provides a limited diffusion site whereas pH increases due to carbon uptake (Riding, 2011). The sheath provides support, stability and protection against physical damage, dehydration and grazers (Dudman, 1977). In the Dinaric region, cyanobacteria *Scytonema julianum* seems to be an interesting candidate for bioengineering on account of its ability to promote the formation of biofilms in a karst environment (Lamprinou et al., 2014). Further, the genus *Leptolyngbya*, already known as a producer of sheath-forming extracellular polymeric substances, has an important role in accelerating microbial biofilm formation (Albertano, 2012). In addition, *Gloeocapsa sp*. as a common species in the karst subterranean habitats may be an appropriate candidate for bioremediation/ biostimulation processes, by enriching microhabitats with autochthonous species, but without affecting a sensitive food web (Czerwik-Marcinkowska et al., 2015). It has been demonstrated that *Gloeothece sp.* may remove heavy metals (Cu2+, Pb2+) from aqueous solutions by sequestration in the extracellular matrix (Pereira et al., 2011).

Table 1. The potential usage of speleophyton in bioengineering.

Group of algae / Taxon	Potential usage in bioengineering	Reference
Cyanobacteria and algae	The important role in biofilm formation; Pioneer colonizers of bare rocks in general	Falasco et al., 2014
Scytonema julianum	Formation of biofilms on karst	Lamprinou et al., 2014
Iphinoe spelaeobios	Ability to mobilize calcium ions from calcareous substrate	Albertano, 2012 Smith and Olson, 2007
Leptolyngbya sp.	Ability to secrete sheath-forming EPS rich in polysaccharides which allows adhesion of biofilm	Albertano, 2012
Cyanobacteria	Biofilms can induce changes of chemical parameters in microhabitat	Albertano, 2012
Coccoid cyanobacteria	Promote attaching and colonization other members of biofilm	Popović et al., 2017
Cyanobacteria	Chelating agents	Falasco et al., 2014 Whitton, 2012
Aerophytic algae	The 3D biofilm structure acts as a *trap* for planktonic and phytobenthic algal species; Increase the primary bioproduction	Mulec and Kosi, 2008
Gloeocapsa sp.	Formation of biofilms on cave walls	Czerwik-Marcinkowska et al., 2015
Gloeothece sp.	Removal of heavy metals (Cu^{2}+, Pb^{2}+) from aqueous solutions by sequestration in the extracellular matrix;	Pereira et al., 2011
	The important role in biofilm formation; Pioneer colonizers of bare rocks in general	

BACTERIA

Along with previous studies of the diversity and composition of microbial biofilms from all over the world (Chelius and Moore, 2004; Gonzalezet al., 2006; Macalady et al., 2007; Shabarova and Pernthaler, 2010; Borsodi et al., 2012) and those from the Dinaric karst (Pašić et al., 2010; Porca et al., 2012; Kostanjšek et al., 2013; Pleše et al., 2016), a few studies, mostly based on microscopy and DNA metabarcoding, have analysed the taxonomical and functional characteristics of the microbiome from the surface of speleothems (Spear et al., 2007; Yücel and Yamaç, 2010; Ortiz et al., 2013; Sallstedt et al., 2014).

Comparative analysis of the results obtained from two studies of the composition of microbial communities (Kostanjšek et al., 2013; Pleše et al., 2016) from Vjetrenica cave in Bosnia and Herzegovina (from two different sampling sites) has yielded different results (Pleše et al., 2016). Kostanjšek et al. (2013) demonstrated that bacterial aggregates named "Candidatus *Troglogloea absoloni*" from Vjetrenica cave (Bosnia and Herzegovina) (sampling site: Donji Absolonov kanal) primarily consist of filamentous Betaproteobacteria, whereas other microbial populations present in the crust include members of the Bacteriodetes, Gammaproteobacteria, Actinombacteria, Alphaproteobacteria, and Planctomycetes. However, in Vjetrenica clone libraries obtained by Pleše et al. (2016) (sampling site: Donja Vjetrenica) *Nitrospirae* prevailed with 60% while neither *Alpha-* nor *Gamma-* proteobacterial sequences were retrieved, which is explained by different conductivity and consequent variations in the amount of dissolved solids, mostly nitrates (Pleše et al., 2016). Indeed, small alterations in the environment may affect the microbial biofilm composition and, consequently, influence particular interspecies interactions.

BIOPOTENTIAL OF BACTERIAL BIOFILMS: EXAMPLES FROM SOME DINARIC KARST CAVES

With the focus on the possible bioremediation and biotechnological potential of microbial biofilms sampled in three Dinaric caves (Veternica, Izvor Bistrac and Vjetrenica), the list of candidate taxa were shown in Table 2A (phylotypes obtained using bacterial 16S) and Table 2B (phylotypes obtained using five protein coding genes: leucyl-tRNA synthetase (*leuS*), elongation factor G (*fusA*), CTP synthetase (*pyrG*), 50S ribosomal protein L2 (*rplB*) and ATP-dependent DNA helicase (*recG*)). In Veternica and Vjetrenica clone libraries *Nitrospirae* prevailed with 36% and 60% respectively, while in Izvor Bistrac the most abundant were *Alphaproteobacteria* (41%) followed by *Firmicutes* (32%) (Pleše et al., 2013). The *Nitrospirae* phylotypes obtained from all sampling sites showed similarity with Candidatus *Nitrospira defluvii*, which differs greatly from other known nitrite oxidizers in the key enzyme nitrite oxidoreductase (NXR) as a physiological adaptation to a substrate-limited conditions, that allow for a mixotrophic lifestyle (Lücker et al., 2010).

Table 2A. Phylogenetic affinities of phylotypes[a16S] identified from the selected caves in Dinaric karst.

Clone[a]/ Sample site[b]	NCBI Acc. No.	16S ID[c]	Closest identified sequence with ACCN	Origin of the closest identified sequence	Reference
BIOREMEDIATION					
VET_03	JQ886446	99%	*Thiobacillus thioparus* (Hm173634)	Thiocyante assimilation	Boden et al., 2012
VET_04 VJET_03	JQ886447 JQ886429	92%	Planctomycete A-2 (AM056027)	The novel anammox bacteria; Wastewater treatment plant	Jia and Xu, 2005
VET_11	JQ886454	100%	*Novosphingobium* sp. K16 (Aj000920)	Chlorophenol-degrading bacteria /polluted water	Mannisto et al., 1999
IZB_02	JQ886434	100%	*Methylobacterium radiotolerans* strain P3 (Hm192796)	Phenol degradation; Methanol-utilizing bacterium	Tuan et al., 2011
IZB_03	JQ886435	99%	*Bradyrhizobium* sp. PC34 (Jf317681)	Nitrogen-fixing bacteria	Nievas et al., 2011
IZB_08 IZB_09	JQ886439 JQ886440	100%	*Bacillus* sp. PKSWIII (Jf768714)	Sub-surface soil of uranium-rich deposits	Kumar et al., 2013
IZB_10 IZB_12	JQ886441 JQ886443	100%	*Sphingomonas* sp. SeL7 (Hm352418)	Degaradation of polycyclic hydrocarbons	Yang et al., 2010
PATHOGENS					
IZB_06	JQ886437	100%	*Anaerococcus* sp. 8405254 (HM587319)	Anaerobe human pathogen	La Scola et al., 2011
VET_01 IZB_01	JQ886444 JQ886433	100%	*Shigella boydii* (Jq315923)	Human pathogen (dysentery)	Prasanna Kumar, 2011
IZB_11	JQ886442	99%	*Acinetobacter* sp. K-1 (Hq634943)	Nosocomial pathogen	Zhang and Feng, 2010
IZB_05	JQ886436	100%	*Microbacterium* sp. PrLB9 (Hm352399)	Nosocomial pathogen	Yang et al., 2010

[a]16S ribosomal RNA gene sequences (Pleše et al., 2016)
[b]Sample sites/ habitate type: (VET) Veternica (hygropetric); (IZB) Izvor Bistrac (Endogean underground streams); (VJET) Vjetrenica (Endogean underground river; Underground lakes)
[c]According to Fig. 6 (Pleše et al., 2016)

Table 2B. Phylogenetic affinities of phylotypes[ap] identified from the selected caves in Dinaric karst.

Clonea/ Sample siteb	Acc. No	prot. IDc	Closest identified sequence with ACCNd	Origin of the closest identified sequence	Reference
VJET_fusA VET_fusA IZB_fusA	JQ973807 JQ973808 JQ973809	98-99%	*Candidatus Nitrospira defluvii* YP_003796984	Nitrite oxidizer; *N. defluvii* differs dramatically from other known nitrite oxidizers in the key enzyme nitrite oxidoreductase (NXR)	Lücker et al., 2010
VJET_pyrG IZB_pyrG_01	JQ973794	91% 88%	*Methylibium petroleiphilum* strain PM1 YP_001023228	Degradation of the fuel additive MTBE (methyl tertiary butyl ether); Aerobic degradation of aromatic hydrocarbons including benzene, toluene, xylenes and phenol.	Kane et al., 2007 Burns et al., 2001 Deeb et al., 2001
VJET_pyrG	JQ973792	86%	*Leptothrix_cholodnii*_SP-6 YP_001793015	Metal-rich aquatic environments; Oxidizes both iron and manganese; Deposits Mn- and Fe-oxides on its sheath; Sequestration of heavy metals	Takeda et al., 2005 Copeland et al., 2008
IZB_pyrg_03	JQ973796	96%	*Magnetospirillum_gryphiswaldense*_ MSR-1_CAM75505	Phosphate accumulating; Abilities for phosphate recycling from wastewater	Richter et al., 2007 Zhou et al., 2017
IZB_pyrG_04	JQ973788	94%	*Novosphingobium aromaticivorans* DSM 12444 (YP_497290)	Degradation of a wide variety of aromatic hydrocarbons and polycyclic aromatic compounds	Copeland et al., 2014
IZB_recG VET_recG VJET_recG	JQ973799 JQ973798 JQ973797	89%	*Geobacter uraniireducens* YP_001231561	Use uranium as an electron acceptor for their respiration and reduce it to insoluble form; *Geobacter* sp. can oxidize organic pollutants in the subsurface using Fe(III) as an electron acceptor	Lovely et al., 1989 Lovley, 1991 Zhang et al., 2010 Kumar et al., 2013
VET_pyrG	JQ973793	91% 86%	*Acidovorax ebreus* TPSY YP_002551754 *Variovorax paradoxus* EPS YP_004154487	Anaerobic nitrate-dependent Fe(II) oxidizer; Anaerobically oxidize iron and uranium; Degradation of a wide array of recalcitrant organic pollutants including 2,4-dinitrotoluene, aliphatic polycarbonates and polychlorinated biphenyls	Byrne-Bailey et al., 2010 Lucas et al., 2008 Satola et al., 2012

[a] Protein coding genes leucyl-tRNA synthetase (*leuS*), elongation factor G (*fusA*), CTP synthetase (*pyrG*), 50S ribosomal protein L2 (*rplB*) and ATP-dependent DNA helicase (*recG*) (Pleše et al., 2016)
[b] Sample sites/ habitate type: (VET) Veternica (hygropetric); (IZB) Izvor Bistrac (Endogean underground streams); (VJET) Vjetrenica (Endogean underground river; Underground lakes)
[c] According to Fig. 7 (Pleše et al., 2016)

Besides a few pathogenic or nosocomial bacteria important for public health and indicators of faecal contamination, such as *Shigella boydii* (Gammaproteobacteria, Enterobacteriales) (shigellosis; dysentery), one of the most important phylotypes shows marked similarity with *Methylibium petroleiphilum* strain PM1 (Betaproteobacteria; Burkholderiales) (Vjetrenica and Izvor Bistrac), which can grow on and completely degrade the fuel additive MTBE (methyl tertiary butyl ether) (Bruns et al., 2001). Furthermore, PM1 strain has a broad range of metabolic capabilities such as the ability to aerobically degrade aromatic hydrocarbons including benzene, toluene, xylenes and phenol (Deeb et al., 2001).

Geobacter uranireducens Rf4 (Deltaproteobacteria; Desulfomonadales) in the subsurface environment is the primary bacterium able to use uranium as an electron acceptor for respiration and to reduce it to insoluble form (Lovley, 1991; Palmisano and Hazen, 2003). Additionally, species of the genus *Geobacter* can oxidize organic pollutants in the subsurface using Fe(III) as an electron acceptor (Lovely et al., 1989; Zhang et al., 2010). It is important to note that Izvor Bistrac is contaminated by metal waste as well as explosive remnants of war (ERW).

Acidovorax ebreus (strain TPSY) (Betaproteobacteria; Burkholderiales) is able to anaerobically oxidise iron and uranium when coupled with nitrate reduction. These bacteria may be important for the remediation of uranium in contaminated environments.

Variovorax paradoxus (Betaproteobacteria; Burkholderiales) is abundant in numerous environments that are contaminated with either recalcitrant organic compounds or heavy metals. The diverse metabolic capabilities of *V. paradoxus* enable it to degrade a wide array of recalcitrant organic pollutants including 2,4-dinitrotoluene, aliphatic polycarbonates and polychlorinated biphenyls. Both its catabolic and anabolic capabilities have been suggested for biotechnological use, such as to neutralise or degrade pollutants at contaminated sites (Satola et al., 2012).

Pseudomonas aeruginosa (Gammaproteobacteria; Pseudomonadales) is a ubiquitous environmental bacterium as well as an important opportunistic human pathogen. Certain isolates infect a broad range of host organisms, from plants to humans (He et al., 2004). As an important soil bacterium, it possesses a complex metabolism capable of degrading polycyclic aromatic hydrocarbons and producing biologically active secondary metabolites including quinolones, rhamnolipids, lectins, hydrogen cyanide, and phenazines. Its metabolism complexity is reflected in a relatively large genome size of about 6.5 Mb. PA14 is also an excellent model for the study of pathogenesis and biofilm formation, adaptable for a free-living and pathogenic life style. Comparative genomic analysis of the virulent strain PA14 and the less pathogenic strain PAO1 reveals that the virulence of *P. aeruginosa* is the result of a pool of pathogenicity-related genes that interact in various combinations in different genetic backgrounds (Lee et al., 2006). Significant similarity (app. 90%) of phylotypes isolated from subterranean habitats in Croatia (Veternica and Izvor Bistrac) was shown with both strains of *P. aeruginosa*, UCBPP-PA14 and PAO1 (Pleše et al., 2016).

An interesting finding was the similarity (app. 90%) with two species of the genus *Desulfovibrio*: *D. vulgaris* (YP_967305) and *D. magneticus* (ZP_11310108). Rajeev et al. (2014) reported on two diguanylate cyclases (DGCs) in the bacterium *Desulfovibrio vulgaris* Hildenborough that function as part of a two-component signalling pathway, each one specific for one choice of growth fate. Once the fate has been committed, the type of interactions, topological relationships and constraints, and the physical means to establish them determine metabolic strategies.

Bacteria are also a significant source of biotechnologically important substances. A recent study from 19 karstic caves in Turkey yielded 180 isolates (62%; out of 290) which exhibited antimicrobial activity against bacteria and fungi, even against multiresistant strains of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin resistant *Enterobacter faecium* (VRE), and *Acinetobacter baumanii* (Ortiz et al., 2013). Novel phylotypes isolated from Izvor Bistrac (Pleše et al., 2016), showing similarity to *Stigmatella aurantiaca* and *Myxococcus xantus* (Deltaproteobacteria; Myxococcales), known for producing antimicrobial compounds, may play a role in maintaining the balance of the microbial population in its habitat (Dworkin, 2007).

Sulphur cave bacteria are of particular interest. These were observed for the first time from sulphurous karstic cave springs in Split, where several new bacterial species have been described: *Thiothrix longiarticulata*, *T. voukii, Beggiatoa gigantea* and *Thiosiphon adriaticum* (Gammaproteobacteria, Thiotrichales) (Klas, 1936a; 1936b; 1937; 1938). *Thiophysa gigantea* was found in the Sumporače sulphur caves in Mokošica near Dubrovnik in 1948 and described by biologist Zora Klas (Klas 1949; 1950; 1951). Later, *Thiogloea*, a new genus from the same cave, with two species, *T. ruttneri* and *T. ragusina*, was described by academician Zvonimir Dévidé (Dévidé, 1952). The list of recorded bacterial taxa in Sumporača mala and Sumporača velika caves, with the capacity to oxidise sulphur compounds, comprises at least 14 species of the genera *Beggiatoa, Thiothrix, Thiophysa, Thiovulum, Thiospira* and *Thiogloea* (Cukrov et al., 2012; Cukrov and Ozimec, 2012).

PROTOZOA

Protozoans, as an important indicator of biotic and abiotic changes in the environment, are an integral part of all ecosystems, as regards their dynamics and community structure. Although cave-dwelling protozoa have been investigated since 19th century, data still remain scarce (Mulec, 2008). In caves, protozoa are usually isolated from the water column, guano or sediments. Another important but barely studied group consists of protozoan epibionts and parasites on cave animals (Golemansky and Bonnet, 1994; McAllister and Bursey, 2004). A comprehensive study on protozoa composition from four caves including nine different habitats in Slovenian karst first reported on the diversity of small free-living amoebae (FLA) in carbonate precipitating habitats in karst caves. The potentially pathogenic *Acanthamoeba castellanii* genotype T4 and *Hartmannella vermiformis* were identified from a cave pool with calcite rafts in Pečina v Borštu cave. Both amoebae can serve as vectors for intracellular pathogenic bacteria. A new vahlkampfiid amoeba, *Allovahlkampfia spelaea* gen. nov., sp. nov. was also described from weathered limestone in the same cave (Mulec and Walochnik, 2007; Walochnik and Mulec, 2009).

Murga et al. (2001) demonstrated the colonisation and subsequent predation of heterotrophic biofilms by *Hartmannella vermiformis*, a free-living protozoon. Predation has also been demonstrated with *Acanthamoeba* spp. in contact lens storage case biofilms (McLaughlin-Borlace et al., 1998).

The temporal and spatial distribution and biodiversity analysis of protozoa in Veternica Cave (Croatia) yielded 47 protozoan taxa on three types of microhabitats (microcaverns, mud puddles and hygropetric), while the lowest biodiversity was recorded on hygropetric habitats (Kajtezović, 2012).

POTENTIAL USE OF PROTOZOA IN BIOTECHNOLOGY AND BIOMONITORING

Small free-living amoebae (FLA) are ubiquitous protozoans that feed on bacteria, algae, fungi and detritus (Laybourn-Parry, 1992; Foissner and Berger, 1996). They are widely distributed in terrestrial and aquatic habitats and may play a significant role at the base of food webs, but also help to maintain soil fertility by making nutrients available. Moreover, protozoan excretory products include dissolved phosphorus and nitrogen compounds and other organic molecules (Laybourn-Parry, 1992).

Protozoa, especially ciliates, are recognised as excellent bioindicators for water quality in different habitats, and their characteristics give them a distinct advantage over higher organisms (Laybourn-Parry, 1992; Foissner and Berger, 1996). Similarly, cave protozoa can be used as indicator organisms for monitoring water quality, due to their relative ease of culturing, their short life cycle, their cosmopolitan distribution, and their sensitivity and quick response to environmental changes (Guidolin and Coppellotti Krupa, 1999). Moreover, symbiotic associations of protozoa and endosymbiotic methanogens have been reported in groundwater communities whereas, under certain conditions, the protozoa hosting endosymbionts become important members of the microbial community. As they feed on moribund biomass and produce methane, their system-wide conclusions are relevant for engineered bioremediation approaches in general (Holmes et al., 2014).

FUNGI: MYCOTECHNOLOGY

Generally, entomopathogenic fungi are a rich source of natural bioactive compounds. A comprehensive study on 47 typical entomopathogenic fungi tested for their ability to produce antibacterial compounds indicated that the majority of them possessed the ability to produce anti-*Bacillus* and anti-*Staphylococcus* compounds (81% and 64 %, respectively), but only in the presence of insect-derived materials (Lee et al., 2005). Entomopathogenic fungi have been used as a traditional Chinese herbal remedy for more than 1500 years in both China and Japan (Shah and Pell, 2003). Antitumour, antimetastatic, immunomodulatory, antioxidant, anti-inflammatory, insecticidal, antimicrobial, hypolipidaemic, hypoglycaemic, antiaging, neuroprotective, and renoprotective effects are some of the main effects shown by *Cordyceps* fungi (Ng and Wang 2005). The most common example is entomopathogen ascomycetes *Ophiocordyceps sinensis* (Berk.) G.H.Sung, J.M.Sung, Hywel-Jones & Spatafora (2007) (Sung et al., 2007), also known as Himalayan Gold (Gould, 2007). The physiologically active compounds in extracts from Tochukaso [Tochu-Kaso (*jpn.*) *summer grass winter worm* fungus; Dong Chong Xia Cao (*chi*)], product of an *Ophiocordyceps sinensis*-infected insect body from which a fruiting body emerges, promote overall vitality and human longevity by enhancing the immune system (Samuels and Paterson, 1995; Liu et al., 2002). The other potential species is *Cordyceps militaris* (L.) Fr. (1818), which has been successfully grown on artificial media for commercial purpose (Shrestha et al., 2012). Important active compounds have been isolated from *C. militaris*, such as adenosine, cordycepin, polysaccharides, mannitol, superoxide dismutase (SOD), and carotenoids (Guo et al., 2016). *C. militaris* has been recorded in 14 localities in Slovenia (Ogris, 2013) but is not traditionally used as a medicinal mushroom (Gregori, 2013).

Although cave fungi in Dinaric karst are poorly known, several important parasitic troglobionts and troglophilic species on cave coleopterans and troglophilic moths in

Croatian caves have been recorded. The Preliminary Checklist of troglobiotic fungi and fungi occurring both in and outside the cave underground in Croatia (Matočec, 2002), shows two potential genera from the family Laboulbeniaceae with a few species, as possible candidates for producing bioactive compounds: (1) genus *Laboulbenia* Mont. et C. P. Robin including tree species, ectotrophic commensals on carabids: troglophile (TP) *L. flagellata* Peyritsch commensal on TP *Laemostenus cavicola* (Schaum, 1858), troglobitic (TB) *L. shanorii* Bánhegyi commensal on TB *Neotrechus dalmatinus* (L. Miller, 1861) and *N. suturalis* (Schaufuss, 1864) and TB *L. subterranea* Thaxt. commensal on TB *Neotrechus dalmatinus* (L. Miller, 1861); (2) genus *Rhachomyces* Thaxt. with two TB species: *R. hypogaeus* (Thaxt.) Thaxt, commensal on TB *Typhlotrechus bilimekii* (Sturm, 1847) and *R. stipitatus* Thaxt. on TB *Typhlotrechus velebiticus* (Ganglbauer, 1904) and cave carabid *Duvalius reitteri* Miller, 1881. Moreover, TB *Hirsutella* sp., parasite on TB *Leptodirus hochenwartii* Schmidt, 1832 and *Parapropus sericeus* (Schmidt, 1852), was recorded (Gottstein Matočec S. et al., 2002). Impressive bioactivity by hirsutellones A and B, isolated from entomopathogenic *Hirsutella nivea* BCC 2594, was shown against *Mycobacterium tuberculosis* (Isaka et al., 2005; 2006).

Two species of the genus *Cordyceps* have been recorded in the caves of Croatia: (1) TB *Cordyceps riverae* Pacioni, found only in European cave habitats [while geometrid moths *Triphosa dubitata* (Linnaeus, 1758) and *T. sabaudiata* (Duponchel, 1831) are the only certainly known hosts]; and (2) *Cordyceps sphingum* (Tul.) Sacc., widespread in Europe and North America outside of cave habitats. Interestingly, the only record of *C. sphingum* in Croatia is one from Tučepska Vilenjača cave, Mt. Biokovo, Dalmatia (Matočec and Ozimec, 2001).

Analysis of the mycoflora of the nocturnal troglophilic cave cricket *Troglophilus neglectus* Krauss, 1879 cadavers, collected in Kozlov rog tunnel (Slovenia), revealed no fewer than 80 strains of fungi (30 species of 12 genera), belonging to entomopathogenic, opportunistic pathogenic and saprophytic fungi (Gunde-Cimerman N et al., 1998). Among opportunistic pathogenic fungi, a few species of genus *Mucor* could be considered due to its pathogenic and biotoxic activity on humans, cattle, pigs, poultry and insects such as Lepidoptera, Coleoptera and Diptera species (Prevoo et al., 1991; Reiss, 1993).

SUBTERRANEAN FAUNA

Ecological categories are defined as stygoxene and trogloxene species, which spend their complete life cycle in surface environments and are only accidentally found in subterranean habitats; stygobite and troglobite species, which spend their complete life cycle in subterranean environments; and stygophiles and troglophiles, which may have several kinds of life cycles—some populations live in surficial habitats and others in subterranean habitats, or have individual life cycles necessitating the use of both surface and subterranean environments (Gibert and Deharveng, 2002). Europe is a hotspot both of subterranean biodiversity and of research into subterranean biology, both historically and at present (Deharveng et al., 2009). The Dinaric karst in the western Balkan Peninsula is a global hotspot of subterranean biodiversity, with more than 900 aquatic and terrestrial obligate subterranean (troglobiotic) species recorded (Sket, 2005). Troglobiotic beetles are considered the most important contributors to terrestrial subterranean biodiversity in most temperate karst regions, including the Dinaric karst, where they represent about 42% of the terrestrial troglobionts (Sket et al., 2004). Subterranean biodiversity in Europe is actually higher than on other continents as indicated by (Culver and Sket, 2000) while some of the real biodiversity hotspots are western Balkans (northeast Italy, Slovenia, Croatia, Bosnia and Herzegovina, and Serbia) and the Pyrenees (France and Spain) (Sket, 1999).

Associated fauna was evaluated in five Dinaric caves where bacterial communities were analysed in a previous study (Pleše et al., 2016) in order to provide insights into ecological concepts and their connection to microbial ecosystems as a nutrition resource (Table 3).

Fauna is selected according to underground water habitats: hygropetric, endogean streams, endogean underground rivers, exogean underground rivers and underground lakes, defined according to NATURA 2000, Pal. Class. and Croatian National Habitat Classification (CNHC), as reported previously (Pleše et al., 2016). With the notable exception of Veternica, high biodiversity was observed in the Checklist of the most prominent species (taxa) inhabiting the adaptive zone of bacterial communities/biofilm, with a significant number of relict and endemic taxa. Most of the representatives associated with bacterial communities belong to aquatic and/or hygropetric fauna.

Veternica, a complex cave with several independent underground streams but scarce stygobitic fauna, is located in the southwest part of NP Mt Medvednica. With a total length of 7128 m, it is the sixth longest cave in Croatia, and an important bat habitat in NW Croatia, with 14 species of bats recorded (Žvorc et al., 2005). *Mesoniscus graniger* (Frivaldszky, 1865) was found in the hygropetric habitat of Veternica, unique to

Table 3. Checklist of fauna associated with microbial communities from selected Dinaric caves in Croatia and Bosnia and Herzegovina (or caves in the adjacent region*).

Sites	The Fauna Check List	Ecology	Endemity	References
Veternica (Croatia)	*Niphargus stygius likanus* S. Karaman, 1952[+] *Mesoniscus graniger* (Frivaldsky,1865)[++]	SB SB	NE 0	Karaman, 1952 ([+]) Ozimec, 2003 ([+,++]) Bedek, 2007 ([+,++]) Bedek et al., 2011 ([+,++])
Izvor Bistrac (Croatia)	*Eunapius subterraneus* Sket and Velikonja, 1984 *Marifugia cavatica* Absolon and Hrabe, 1930 *Velkovrhia enigmatica* Matjašič and Sket, 1971* *Niphargus croaticus* (Jurinac, 1887) *Niphargus jalzici* G. Karaman, 1989* *Niphargus stygius* Schiødte, 1847 *Niphargus steueri subtypicus* Sket, 1960* *Typhlogammarus mrazeki* (Schäferna, 1906)* *Troglocaris intermedia Babić*, 1922 *Proteus anguinus* Laurenti, 1768*	SB SB SB SB SB SB SB SB/HY SB SB	NE e e NE NE NE NE e NE e	Kovač Konrad et al., 2014 Fišer et al., 2007
Miljacka 4 (Croatia)	*Marifugia cavatica* Absolon and Hrabe, 1930* *Hadziella sketi* Bole, 1961 *Sphaeromides virei mediodalmatina Sket*, 1964 *Monolistra (Microlistra) pretneri spinulosa Sket*, 1965 *Proasellus anophthalmus rhausinus* (Remy, 1941) *Alpioniscus balthasari* (Frankenberger, 1937) *Cyphopleon kratochvili* (Frankenberger, 1939) *Niphargus* sp. *Typhlogammarus mrazeki* (Schäferna, 1906) *Proteus anguinus* Laurenti, 1768*	SB SB SB SB SB TB TB SB SB/HY SB	e ME ME ME e ME e ? e e	Ozimec et al., 2012
Rokina Bezdana (Croatia)	*Eunapius subterraneus* Sket and Velikonja, 1984 *Typhlogammarus mrazeki* (Schäferna, 1906) *Niphargus* sp. *Titanethes dahli* Verhoeff, 1926 *Troglocaris intermedia* Babić, 1922 *Proteus anguinus* Laurenti, 1768	SB SB/HY SB SB SB SB	NE e ? NE NE e	Ozimec, 2009
Vjetrenica (Bosnia and Herzegovina)	*Marifugia cavatica* Absolon and Hrabe, 1930 *Velkovrhia enigmatica* Matjašič and Sket, 1971 *Prostoma hercegovinense* Tarman, 1961 *Lanzaia vjetrenicae* Kuščer, 1933 *Zavalia vjetrenicae* Radoman, 1973 *Typhlogammarus mrazeki* (Schäferna, 1906) *Acanthocyclops troglophilus* (Kiefer, 1932) *Diacyclops karamani* (Kiefer, 1932) *Eucyclops inarmatus* Kiefer, 1932 *Pseudocypridopsis hartmanni* Petkovski et al, 2009 *Troglocaris hercegovinensis* (Babić, 1922) *Troglomysis vjetrenicensis* Stammer, 1936 *Monolistra (Pseudomonolistra hercegoviniensis* Absolon, 1916 *Proasellus hercegovinensis* (S. Karaman , 1933) *Niphargus balcanicus* (Absolon, 1927) *Niphargus boskovici* S. Karaman, 1952 *Niphargus cvijici* S. Karaman, 1950 *Niphargus factor* G. Karaman and Sket, 1991 *Niphargus steueri kolombatovici* S. Karaman, 1950 *Niphargus trullipes* Sket, 1958 *Niphargus vjeternicensis* S. Karaman, 1932 *Niphargus zavalanus* S. Karaman, 1950 *Hadzia fragilis* S. Karaman, 1932 *Cyphonethes herzegowinensis* (Verhoeff, 1900) *Hadesia vasiceki* (J. Müller, 1911) *Nauticiella stygivaga* Moravec and Mlejnek, 2002 *Proteus anguinus* Laurenti, 1768	SB SB SB SB SB SB/HY SB SB SB SB SB SB SB SB SB SB SB SB SB SB SB SB SB SB SB SB SB SB TB SB SB	e e SE SE SE e SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE SE e	Ozimec and Lučić, 2010

Legend: (TB) Troglobiont; (SB) Stygobiont; (Hy) Hygropetric (habitat type); (NE) North Dinaric endem; (ME) Midle Dinaric endem; (SE) South Dinaric endem; (0) Not Dinaric endem.

running water films or small springs over exposed bedrock. This troglophilic isopod inhabits the area from the Northern Carpathians over the Bihor and the Banat Mountains to the North Dinarids and the Julian Alps (Bedek et al., 2011).

The Izvor Bistrac is part of the Đulin ponor – Medvedica cave system in Ogulin (Croatia), characterised by its unique fauna with a number of endemic species, including the blind cave beetle *Leptodirus hochenwartii* Schmidt, 1832; the cave dwelling tube worm *Marifugia cavatica* Absolon and Hrabe, 1930, the only freshwater serpulid in the world; and the only stygobitic sponge *Eunapius subterraneus* Sket and Velikonja, 1984 as well as olm *Proteus anguinus.*

Miljacka 4 is part of the very peculiar cave system of the Miljacka river sinkhole, which conducted water from Zrmanja River to Krka River in north Dalmatia (Croatia). The cave is located on the river Krka. At least five caves, recognised as Miljacka caves 1-5, belong to the area where the Miljacka rises, with strong indications of connections between them. Fauna includes several snails, crustaceans *Sphaeromides*, *Monolistra* and *Alpioniscus Typhlogammarus mrazeki* but also *M. cavatica* and *P. anguinus* in adjacent region (Jalžić et al., 2007).

Rokina Bezdana is part of a huge underground sinkhole river in the Lika region (Croatia), of which up to 1016 m has so far been explored. This large underground cave with pronounced hydrogeological activity has been only partly investigated, but is recognised as an important cave habitat for stygobiotic taxa as: *Eunapius subterraneus, Typhlogammarus mrazeki, Niphargus* sp., *Titanethes dahli* and *P. anguinus.*

The endogean river of Rokina Bezdana and Izvor Bistrac belong to the Ogulin-Plaški plateau, recognised as refugia where many rare and relict species have survived (Ozimec et al., 2009). These caves are inhabited by sessile organisms such as the only freshwater stigobitic sponge *Eunapius subterraneus* Sket and Velikonja, 1984, a filter feeder endemic for the region, as well as *M. cavatica, Velkovrhia enigmatica,* and mobile as *T. mrazeki* and *P. anguinus* (with the exception of the sponge, all were also found in Vjetrenica).

Vjetrenica, a complex cave with a total length of 7,013.90, is located in the southern part of the Dinaric Karst, on Popovo polje (Eastern Herzegovina). Vjetrenica is one of the world's most prominent hotspots of biodiversity with cave-dwelling fauna, and is the type locality for 38 endemic taxa. The most recent list of the Vjetrenica Cave fauna, dating from December 2009, includes 219 taxa: 37 protists and 182 animals with 101 cave-dwelling taxa (49 troglobitic and 52 sygobitic) (Ozimec and Lučić, 2010). The fauna associated with the bacterial communities in Vjetrenica, characteristic of an endogean river, is composed of sessile invertebrates (*Marifugia cavatica* Absolon and Hrabe, 1930*, Velkovrhia enigmatica* Matjašič and Sket, 1971) and the motile, as a nemertean worm *Prostoma hercegovinense* Tarman, 1961, several aquatic snails, isopod crustaceans of the genera *Cyphonethes, Alpioniscus*, *Proasellus* and *Monolistra,* several species of the amphipod genus *Niphargus,* the *decapod genera Troglocaris,* and *Speleocaris*, the unique myside *Troglomysis vjetrenicensis* Stammer, 1936 as well as *Proteus anguinus*. In addition, the typical hygropetric representatives *Hadesia vasiceki* (J. Müller, 1911), *Typhlogammarus mrazeki* (Schäferna, 1906) and recently *Nauticiella stygivaga* Moravec and Mlejnek, 2002, were found. Despite their diverse phylogenetic origins, hygropetric species share a number of common features that give them a characteristic resemblance (Ribera et al., 2003) allowing them to feed on solvent particles in water film.

Dinaric karst is the habitat of one of the best-known representatives of stygofauna, the cave-dwelling amphibian, olm *Proteus anguinus* found only in the Dinaric karst region of the Balkan Peninsula (Italy, Slovenia, Croatia and Bosnia and Herzegovina), which is a globally vulnerable species (VU). *P. anguinus* was recorded in four of the five investigated caves, which dramatically increases the urgency of its habitat protection.

BIOPOTENTIAL OF CAVE-DWELLING FAUNA

Cave-dwelling invertebrates also represent promising sources of bioactive compounds. The saliva of all blood-sucking arthropods contains different bioactive lipids and proteins with anti-clotting, anti-platelet, vasodilatory, anti-inflammatory and immunomodulatory features. Sialotranscriptome (transcriptome of salivary glands) of several ixodid and argasid ticks show a broad spectrum of antimicrobial proteins (Francischetti et al., 2009). Recent progress in transcriptome research has revealed that hard ticks have hundreds of different proteins expressed in their salivary glands, the majority of which have no known function, and include many novel protein families (e.g., their primary structure is unique to ticks).

Nine genera with 22 species have been recorded in the subterranean acarine fauna of Croatia. *Eschatocephalus vespertilionis* (Koch, 1844) is a parasite on bats *Rhinolophus* spp.*,* and a guanophilic species *Macrocheles penicilliger* (Berlese, 1904) was found in the Kordun area (Ozimec, 2002).

ECOSYSTEM SERVICES PROVIDED BY HYPOGEAN MICROBIAL BIOFILMS

Ecosystem services are the benefits that humans obtain from ecosystems that enhance their well-being (Kunz et al., 2011). The ecological benefits of microbial biofilms and their impact on hypogean ecosystems have been widely applied for bioremediation, biotechnology, bioconservation and

biomonitoring. The vulnerability of hypogean ecosystems is the outcome of their inhabitants' adaptation to constant conditions in the natural environment, and consequent complex interspecies interactions among the members of the three domains of life. According to the Millennium Ecosystem Assessment project (2005), biodiversity is a necessary underlying component of ecological goods and services. Biodiversity supports ecological goods and services such as biological control and genetic resources (Constanza et al., 1997). For instance, bats provide many ecosystem services; humans derive direct benefits from bats as food, guano for fertilizer, and through contributions to medicine and culture (Kunz et al., 2011).

CONSERVATION OF SUBTERRANEAN FAUNA

Subterranean ecosystems are generally oligotrophic habitats, receiving poor supplies of degradable organic matter from the surface, but anthropogenic impacts on underground ecosystems (intensive tourism and recreational caving) cause major alterations to the whole subterranean environment. Caves open to tourist traffic offer an opportunity to study the impacts of organic matter amendments in the form of human and rodent hair and dander, clothing lint, material from rodent activity (nesting materials and faeces), and algal growth in and around artificial lighting (Chelius et al., 2009). In spite of their high levels of biodiversity, caves and other subterranean habitats are still rarely considered in conservation and management plans (Medellin et al., 2017).

Water resources in the karst are extremely sensitive to all kinds of pollution, especially during dry seasons. Surface streams may often disappear completely, and underground waters may dwindle, with a consequent higher concentration of pollutants. The impact of climate change to these fragile ecosystems through the reduction of water in aquifers and lack of seasonal flooding means that cave temperature is generally strictly connected with the external climate (Baldino, 2004).

Fauna is extremely sensitive throughout, since subterranean species are ecologically specialised and are mainly endemics tending to extinction. In some areas, cave fauna may be an important indicator of the health of the habitat (Sket, 2017). Increased contamination of the environment with toxic pollutants has paved the way for efficient strategies which can be implemented for environmental restoration. Bioremediation is a growing technology with advanced potential for cleaning pollutants, while biofilm formed by various microorganisms potentially provides a suitable microenvironment for efficient bioremediation processes (Mangwani et al., 2016).

A NEW APPROACH IN MICROBIAL BIOFILM INVESTIGATION

The application of molecular techniques to the study of microbial diversity (Olsen et al., 1986; Pace et al., 1986) has revealed the existence of an incredible variety of genotypes and species in all known habitats. However, molecular ecology has moved beyond the use of a relatively small number of markers, towards a sophisticated estimation of gene expression at the whole genome level. Thus the use of microarrays and RNAseq (i.e. transcriptomics) makes it possible to capture the molecular response to environmental challenges. Transcriptome analysis helps in the elucidation of possible adaptations to ecosystems with a strong anthropogenic impact, given that variation in gene expression affected by environmental stimuli (Banskar et al., 2016) suggests that transcription may be affected by even small changes in environment (De Mandal et al., 2017).

Next generation sequencing platforms are rapidly changing the approach to characterising microbial communities from various sources and different habitats. Metagenomic studies, using these sequencing technologies, have contributed enormously to our understanding of the structure and functioning of microbial biofilms, as well as of subterranean ecosystems as a complex entity. In this regard, using Ion Torrent sequencing, it was observed that two guano samples had more than 98% sequences representing Proteobacteria (Alvarez et al., 2015), which is the most abundant phyla in the composition of microbial biofilms. Analysis of the taxonomic composition and presumed functional diversity of cave sediment metagenomes, using paired end Illumina sequencing, yielded a representation of gene sets involved in amino acid metabolism (20.9%) and carbohydrate metabolism (20.4%) in the KEGG pathways. The identification of genes responsible for carbon degradation, carbon fixation, methane metabolism, nitrification, nitrate reduction and ammonia assimilation (Richards et al., 2009) will undoubtedly enhance our understanding of the structure, regulation and evolution of subterranean ecosystem and their inhabiting biota.

Community-level physiological profiling (CLPP) using BIOLOG® EcoPlates™ has recently become a popular method for characterizing and comparing the functional diversity, functional potential, and metabolic activity of heterotrophic microbial communities. The method was described in 1991 by Garland and Mills (Button et al., 2016) and created specifically for community analysis and microbial ecological studies. Its application has expanded to many fields such as ecotoxicology, agronomy, and the monitoring and profiling of microbial communities in various wastewater treatment

systems, including constructed wetlands for water pollution control (Garland et al., 1991).

CONCLUSION

A deep understanding of vulnerable subterranean ecosystems and the unique organisms that inhabit them could shed light on many new aspects in the phylogeny and evolution of microorganisms as well as animal taxa, adjacent to their energy suppliers in microbial communities and biofilms. Bacteria present in subterranean ecosystem often survive by modifying their metabolic pathway, which doubtless affects the other cave-dwelling organisms and the entire ecosystem inside the cave. Understanding their excellent survival strategies will help to discover some new (bio)active molecules and develop an environmentally-friendly technique for the removal of toxic substances. Only an interdisciplinary approach in microbial ecology will make it possible to enhance the protection of subterranean habitats and biodiversity conservation.

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ABBREVIATIONS:

CLPP	Community-level physiological profiling
EPS	Extracellular Polymeric Substances
ERW	Explosive remnants of war
MRSA	Methicillin-resistant *Staphylococcus aureus*
MTBE	Methyl tertiary butyl ether
PUFA	Polyunsaturated fatty acids
SOD	Superoxide dismutase
VRE	Vancomycin resistant *Enterobacter faecium*
TB	Troglobiont
SB	Stygobiont
Hy	Hygropetric (habitate type)
NE:	North Dinaric endem
ME:	Midle Dinaric endem
SE:	South Dinaric endem
E:	Dinaric endem
0:	Not Dinaric endem

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SAŽETAK

Kratki pregled živog svijeta koji naseljava podzemna staništa Dinarida, uključujući cijanobakterije i alge te bakterije, protozoa i špiljsku faunu, usmjeren je na moguću primjenu spomenutih vrsta u biotehnologiji, bioremedijaciji / biostimulaciji i biomonitoringu. U članku se razmatra dinamika i struktura biofilmova na primjeru nekoliko dinarskih špilja u kršu, inter- i intraspecijske interakcije unutar biofilmova te novi pristupi i metode u istraživanju mikrobnog biofilma.

Sustavno istraživanje podzemnih ekosustava i njihovog jedinstvenog živog svijeta, povezanog složenim interakcijama, doprinosi razumijevanju njihove evolucije, biokemije i fiziologije te otvara mnoge nove aspekte korištenja određenih taksa važnih za proizvodnju novih bioaktivnih molekula. Također, multidiscplinarnost u istraživanju s fokusom na moguće primjene mikrobnih biofilmova doprinijet će učinkovitijem provođenju planova upravljanja špiljama, osobito turističkih otvorenih špilja uz obavezni, stručno vođeni monitoring, s ciljem zaštite staništa i očuvanje biološke raznolikosti.

Ključne riječi: mikrobni biofilm, podzemni habitati, biotehnologija, bioremedijacija, Dinarski krš

A review of the doublet collection of Otto Blau's herbarium (SARA)

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Review aerticle
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This paper presents the preliminary results of the review of materials from the doublet collection of Otto Blau's herbarium, which is part of the Herbarium of the National Museum of Bosnia and Herzegovina (SARA). Analysis of the total number of specimens (2503) provided data on the sites (in Bosnia and Herzegovina and Montenegro) where the specimens of various plant groups were collected (***Phycophyta***– 1, ***Mycophyta***– 5, ***Lichenophyta***– 6, ***Bryophyta***– 14, ***Pteridophyta*** – 27 and ***Spermatophyta***– 2450). The collection contains 127 families, 579 genera and 1501 species of ***Pterydophyta*** and ***Spermatophyta.*** The supreme value of the collection lies in its 6 registered type specimens.

Key words: Blau's herbarium, SARA, National Museum, Sarajevo, Bosnia and Herzegovina, type species, sites, list.

INTRODUCTION

The oldest specimens deposited in the SARA herbarium belong to the collection of Dr. Otto Blau (Fig. 1), who was based in Bosnia and Herzegovina from 1861 to 1872, first as Prussian and later as German consul. A diplomat and esteemed orientalist, he collected a quantity of geographical and botanical material during numerous trips in Bosnia and Herzegovina, for the purpose of studying its people and nature. The results of his research were published in 24 papers, where he wrote about the people, political relations, trade, cultural relations, archaeology, phytogeography, numismatics, geography, mining, economy and other distinctive features of Bosnia and Herzegovina. The travelogueconsisting of a summary of Blau's observations, published in Berlin in 1877 under the title "Reisen in Bosnia and Herzegowina: Topographische und pflanzengeographische Aufzeichnungen" ("Travels in Bosnia and Herzegovina: topographic and plant geographical notes"), is the most important contribution to the further knowledge of the geographic and biogeographic characteristics of Bosnia and Herzegovina, and is considered to be one of the earliest published works onthe phytogeography of Bosnia and Herzegovina, preceded only by the works of Ami Boué (1840) and Otto Sendtner (1847).

Otto Blau collected multiple specimens of each plant species, and formed two identical sets. The plant material was determined by Paul Friedrich Ascherson, a long-time curator of the Berlin-Dahlem Botanical Museum. The first set, which was sent to the Botanical Museum, was accompanied by complete information for each species (sites, collection dates, scientific names). The second set remained in the consulate in Sarajevo and had numbered specimens with scientific names, but without any habitat information. Before leaving Sarajevo, Dr. Blau decided to write a "herbarium catalogue", where he entered all the data from the original labels along with a species number. The catalogue and the second set weresent to the University of Strasbourg and then to the Royal Botanic Museum in Berlin, where the first set was already located.

During that period, Karlo Malý was volunteering as a botanist in the National Museum of Bosnia and Herzegovina. He recognised the value of Otto Blau's herbarium collection, andproposed an exchange of materials with the Botanic Museum in Berlin which was accepted, and in 1906 one set of Blau's collection with the original catalogue and field reports became the property of the National Museum in Sarajevo, which was duly announced to the public (K.Malý, 1909). The second set was destroyed during World War II, after Berlin was bombed by the Allies.

From the museological point of view, Blau's doublet collection is ofspecial scientific and historical significance. Given the fact that some specimens from Blau's collection were later described as new taxa, including some endemics, this paper should contribute to new knowledge of the highly valuable floristic material and contents of the 152-year-old collection.

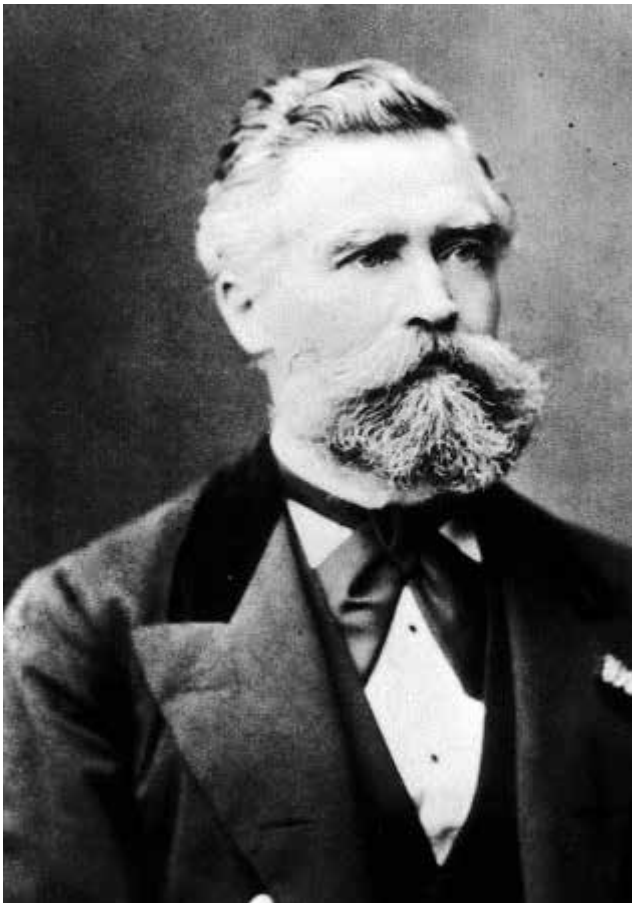

Figure1. Dr. Otto Blau (1828-1879).

MATERIALS AND METHODS

Otto Blau's doublet collection with 2503 specimens is deposited in the Department of Natural Sciences of the National Museum of Bosnia and Herzegovina in Sarajevo, in a separate cabinet in the Herbarium. The plant material was collected during the period 1868-1872, at numerous sites in Bosnia and Herzegovina, and some specimens were collected in Montenegro.

The herbarium is systematized by families and genera, written on 22×26 cm paper folders which contain all collected species of a certain genus enclosed in a separate envelope. Each single sheetcontainsa non-mounted specimen with information on the territory where it was collected (eg. *Bosnien*) and the catalogue (inventory) number in the upper part, and data on the scientific name of the species and the author in the lower part.

The catalogue contains a detailed topographic description of Sarajevo and its surroundings, as well as other sites visited with a list of characteristic plant species, followed by a table with complete data on each specimen: inventory/

catalogue number; scientific name and author; common name(s) for some species; the name of the collection site with some data on altitude and geological substrate; date, month and year of collection and remarks. The catalogue ends with an alphabetical list of species with inventory numbers and a systematic overview of the taxa.

The nomenclature is given according to the catalogue data. The analysis of the degree of exploration of Blau's doublet collection was based on the floristic works of various authors (Ascherson & Kanitz, 1877; Beck, 1903-1927; Beck & Malý, 1950; Beck, Malý & Ž. Bjelčić, 1967, 1974, 1983). The categorization of type specimens was taken from the study of the Department of Natural Sciences of the National Museum of Bosnia and Herzegovina (1984).

RESULTS AND DISCUSSION

LIST OF SITES FROM BOSNIA AND HERZEGOVINA AND MONTENEGRO

Bosnia: Sarajevo, Stari grad, Bendbaša, Kozja ćuprija, Mošćanica valley, Miljacka gorge, Han Hreša, Jarčedol, Trebević, Borije, Hum, Brus, Hrid, Dobra voda, Ablakovina, Međuše, Miljevići, Mrkovići, Kovačići, Grlice near Vojkovići, Lukavica, Lapišnica valley, Bistrica, Jahorina, Ljubogošće, Mt. Romanija, Romanija plateau, Mokro, Sumbulovac, Glasinac, Gorica, Košava valley, Kobilja Glava, Vogošća, Ozren, Bukovik, Vučija luka, Glog, Drljevac, Han jezero, Han Toplice, Dobrinjka valley, Igman, Hrasnica, Blažuj, Reljevo, Vrelo Bosne, Ilidža, Zujevina, Hadžići, Pazarić, Dubovci, Bjelašnica, Hranisava, Željeznica valley, Ilovica, Krupa valley, Gradac, Treskavica, Foča, Kotorsko near Foča, Zagorje, Vučja, Sušice, Mosorovići, Bergovina near Kalinovik, Bosna valley, Rakovica, Kiseljak, Dusina, Fojnica, Vitez, Han, Vetranica near Vitez, Lepenica, Kreševo, Mt. Inač, Lopata, Vranci, Breza, Visoko, Mt. Lipeta near Vareš, Zenica, Busovača, Travnik, Karaula, Vlašić, Vranica, Mt. Zec, Vrbas valley, Skender Vakuf, Vakuf, Mt. Tisovac, Vrbanja, Banjaluka, Sana valley, Prijedor, Vranduk, Žepče, Usora, Lašva valley, Maglaj, Doboj, Derventa, Ukrina valley, Brod, Jajce, Jezero, Ostro hill near Jajce; **Herzegovina**: Mt. Ivan, Bradina, Paprasko, Konjic, Lisičići, Trešanica valley, Borci, Boračko lake, Bijela, Jablanica, Neretva valley, Grabovica, Crno vrelo, Drežnica, Prenj, Porim, Podporim, Raška Gora, Mostar, Podvelež, Lištica, Mostarsko Blato, Lipnica, Blagaj, Buna, Bunica valley, Nevesinje, Gacko, Višnjevo, Lipnik near Gacko, Ravno, Trebinje; **Montenegro**: Piva gorge, Durmitor, Dubljevići, Borkovići, Nikolin do, Komarske grede and Smriječno near Plužine.

The results of the analysis of the distribution of plant species reveal that the material was collected almost throughout Bosnia and Herzegovina (2405 sheets), while 97 sheets were collected at a few sites in Montenegro.

LIST OF ALGAE, FUNGI, LICHENS AND MOSSES (BOSNIA AND HERZEGOVINA)

Algae

Chara foetida var. *subhispida* A.Braun

Fungi

Geaster limbatus Fr.
Tulostoma conicum
Uromyces scutellata Winter
Agaricus lateritius Schaeff.
Agaricus oreades Bolton

Lichens

*Bryopogon jubatum*Link.
Cladonia rangiferina (L.) Weber
Peltigera aphthosa(L.) Willd.
Ramalina calycina
Stricta pulmonaria (L.) Biroli
Usnea barbata Fr.

Mosses

Aneura pinguis (L.) Dumort.
Bartramia pomiformis Hedw.
Brachythecium plumosum (Hedw.) Schimp.
Cinclidotus aquaticus (Hedw.) Bruch & Schimp.
Eurhynchium striatum (Hedw.) Schimp.
Fontinalis antipyretica Hedw.
Funaria hygrometrica Hedw.
Hylocomium splendens (Hedw.) Schimp.
Hypnum cupressiforme Hedw.
Hypnum schreberi Willd.
Jungermannia barbata Schreb.
Marchantia polymorpha L.
Mnium cuspidatum Hedw.
Polytrichum formosum Hedw.

REGISTER OF SPERMATOPHYTES AND PTERIDOPHYTES FROM BOSNIA AND HERZEGOVINA

THE LIST OF FAMILIES, GENERA AND NUMBER OF PLANT SPECIES (IN BRACKETS) IS GIVEN BELOW:

Fam. *Papilionaceae*: *Trifolium* L. *(18), Melilotus* Mill. *(4), Trigonella* L. *(1), Dorycnium* Vill. *(1), Lotus* L. *(3), Galega* L. *(1), Colutea* L. *(1), Robinia* L. *(1), Astragalus* L. *(2), Oxytropis* DC. *(1), Hippocrepis* L. *(1), Coronilla* L. *(4), Onobrychis* Mill. *(1), Pisum* L. *(2), Lathyrus* L. *(11), Vicia* L. *(15), Phaseolus* L. *(1), Genista* L. *(6), Cytisus* L. *(6), Ononis* L. *(3), Anthyllis* L. *(1), Medicago* L. *(4);*

Fam. *Rosaceae*: *Amygdalus* L. *(1), Prunus* L. *(8),Crataegus* L. *(2), Amelanchier* Med. *(1),Cotoneaster* Med *(1), Pirus* L. *(6), Cydonia* Mill. *(1), Spiraea* L. *(2),Ulmaria* Mill. *(2), Aruncus (1), Geum* L. *(3), Potentilla* L. *(12), Fragaria* L. *(3), Rubus* L. *(5), Rosa* L. *(6), Agrimonia* L. *(1), Aremonia Neck. (1), Alchemilla* L. *(2), Sanguisorba* L. *(1), Dryas* L. *(1);*

Fam. *Myrtaceae*: *Punica* L. *(1);*
Fam. *Lythraceae*: *Lythrum* L. *(2);*
Fam. *Onagrarieae*: *Epilobium* L. *(7), Circaea* L. *(1);*
Fam. *Haloragеae*: *Ceratophyllum* L. *(1), Calitriche L. (2), Myriophyllum* L. *(1), Hippuris* L. *(1);*
Fam. *Lineae*: *Linum* L. *(9);*
Fam. *Geraniaceae*: *Erodium* L'Her. *(1), Geranium* L. *(13);*
Fam. *Balsamineae*: *Impatiens* L. *(1);*
Fam. *Oxalideae*: *Oxalis* L. *(1);*
Fam. *Rutaceae*: *Ruta* L. *(2), Haplophyllum* Juss. F. *(1), Dictamnus* L. *(1);*
Fam. *Zygophylleae*: *Tribulus* L. *(1);*
Fam. *Terebinthaceae*: *Rhus* L. *(1);*
Fam. *Euphorbiaceae*: *Euphorbia* L. *(13), Mercurialis* L. *(2);*
Fam. *Rhamneae*: *Paliurus* Mill. *(1), Rhamnus* L. *(2), Frangula* Mill. *(2);*
Fam. *Ilicineae*: *Ilex* L. *(1);*
Fam. *Celastineae*: *Evonymus* L. *(2);*
Fam. *Staphylaceae*: *Staphylea* L. *(1);*
Fam. *Ampelideae*: *Vitis* L. *(3);*
Fam. *Hippocastaneae*: *Aesculus* L. *(1);*
Fam. *Acerineae*: *Acer* L. *(7);*
Fam. *Tiliaceae*: *Tilia* L. *(3);*
Fam. *Malvaceae*: *Lavatera* L. *(1), Althaea* L. *(3), Malva* L. *(3), Hibiscus* L. *(1), Abutilon* Gaertn. *(1);*
Fam. *Cucurbitaceae*: *Cucurbita* L. *(2), Citrullus* Forsk. *(1), Cucumis* L. *(2), Bryonia* L. *(2), Sicyos* L. *(1);*
Fam. *Caryophylleae*: *Cucubalus* L. *(1), Agrostemma* L. *(1), Coronaria* Guett. *(2), Melandrium* Roehl. *(3), Viscaria* Bernh. *(1), Silene* L. *(10), Vaccaria* Med. *(1), Saponaria* L. *(1), Heliosperma* Rchb. *(3),Gypsophila* L. *(1),Tunica* Scop. *(3),Dianthus* L. *(12), Drypis* L. *(1), Sagina* L. *(1), Alsine* Wahlenb. *(4),Arenaria* L. *(1),Moehringia* L. *(2), Holosteum* L. *(1),Stellaria* L. *(4),Moenchia* Ehrh. *(1),Cerastium* L. *(9), Malachium* Fr. *(1), Spergula* Presl. *(1), Herniaria* L. *(2), Scleranthus* L. *(3);*
Fam. *Portulacaceae*: *Portulaca* L. *(1);*
Fam. *Hypericineae*: *Hypericum* L. *(8), Parnassia* L. *(1);*
Fam. *Cistaceae*: *Helianthemum* Mill. *(3);*
Fam. *Violaceae*: *Viola* L. *(12);*
Fam. *Polygalaceae*: *Polygala* L. *(8);*
Fam. *Resedaceae*: *Reseda* L. *(3);*
Fam. *Cruciferae*: *Hesperis* L. *(1), Malcolmia* R. Br. *(2), Arabis* L. *(6), Turritis* L. *(1), Dentaria* L. *(3), Cardamine* L. *(7), Sisymbrium* L. *(2), Alliaria* Scop. *(1), Nasturtium* R. Br. *(5), Barbaraea* R. Br. *(1), Erysimum* L. *(4), Syrenia* Andrz. *(1), Brassica* L. *(4), Sinapis* L. *(1), Diplotaxis* DC. *(1), Cochlearia* L. *(1), Draba* L. *(2), Erophilla* Mill. *(1), Lunaria* L. *(1), Berteroa* DC. *(1), Alyssum* L. *(6), Vogelia* Med. *(1), Thlaspi* L. *(5), Aethionema* R.Br. *(1), Capsella* Med. *(1), Biscutella* L. *(1), Lepidium* L. *(2), Hutchinsia* R.Br. *(1), Raphanus* L. *(1);*
Fam. *Papaveraceae*: *Corydalis* Vent. *(3), Fumaria* L. *(1), Papaver* L. *(1), Chelidonium* L. *(1);*
Fam. *Nymphaeaceae*: *Nuphar* Sm. *(1);*
Fam. *Berberideae*: *Berberis* L. *(1), Epimedium* L. *(1);*
Fam. *Ranunculaceae*: *Clematis* L. *(4),Anemone* L. *(4),Pulsatilla*Mill. *(2), Hepatica* Mill. *(1), Thalictrum* L. *(4),Trollius* L. *(1),Ranunculus* L. *(14), Eranthis* Salisb. *(1), Caltha* L. *(1), Helleborus* L. *(1), Isopyrum* L. *(1), Nigella* L. *(2), Aquilegia* L. *(1), Delphinium* L. *(1), Aconitum* L. *(1), Actaea* L. *(1);*
Fam. *Crassulaceae*: *Sedum* L. *(8), Sempervivum* L. *(1), Saxifraga* L. *(6);*
Fam. *Ribesiaceae*: *Ribes* L. *(1), Chrysosplenium* L. *(1);*
Fam. *Umbelliferae*: *Sanicula* L. *(1), Astrantia* L. *(1), Eryngium* L. *(3), Aegopodium* L. *(1), Carum* L. *(1),Pimpinella* L. *(1), Berula* L. *(1), Bifora* Hoffm. *(1), Bupleurum* L. *(7), Coriandrum* L. *(1), Smyrnium* L. *(1), Oenanthe* L. *(3), Meum* Mill. *(1), Seseli* L. *(4), Trinia* Hoffm. *(1), Athamantha* L. *(2), Silaus* Mill. *(1), Cnidium* Cuss. *(1), Libanotis* Hill. *(1), Pleurospermum* Guss. *(1), Chaerophyllum* L. *(3), Myrrhis* Mill. *(6), Scandix* L. *(1), Aethusa* L. *(1), Conium* L. *(1), Angelica* L. *(1), Lophosciadium* DC. *(1), Peucedanum* L. *(7), Pastinaca* L. *(1), Heracleum* L. *(2), Tordylium* L. *(1), Laserpitium* L. *(5), Orlaya* Hoffm. *(1), Daucus* L. *(1), Torilis* Adans. *(3), Pančićia* Vis. *(1);*
Fam. *Araliaceae*: *Hedera* L. *(1);*
Fam. *Corneae*: *Cornus* L. *(2);*
Fam. *Ericaceae*: *Erica* L. *(1),Calluna* Salisb. *(1), Arctostaphylos Adans. (1), Vaccinium* L. *(1), Pyrola* L. *(2);*
Fam. *Primulaceae*: *Primula* L. *(6), Androsace* L. *(1), Cyclamen* L. *(2), Soldanella* L. *(1), Lysimachia* L. *(3), Anagallis* L. *(2);*
Fam. *Acanthaceae*: *Acanthus* L. *(1);*
Fam. *Scrophulariaceae*: *Melampyrum* L. *(5), Alectorolophus* Hall. *(2), Euphrasia* L. *(4), Odontites* Hall. *(1), Pedicularis* L. *(4), Antirrhinum* L. *(2), Linaria* Mill. *(4), Veronica* L. *(15), Gratiola* L. *(1), Digitalis* L. *(3), Scrophularia* L. *(4), Verbascum* L. *(8);*
Fam. *Solanaceae*: *Datura* L. *(1), Hyosciamus* L. *(1), Nicotiana* L. *(2), Atropa* L. *(1),Solanum* L. *(5), Physalis* L. *(1);*
Fam. *Orobanchaceae*: *Orobanche* L. *(6), Phelypaea* L. *(1), Lathraea* L.*(1);*
Fam. *Gentianeae*: *Erythraea* Borkh. *(2), Gentiana* L. *(11), Chlora* Adans.*(1);*
Fam. *Apocyneae*: *Vinca* L. *(1);*
Fam. *Asclepiadeae*: *Vincetoxicum* Moehr. *(2);*
Fam. *Jasmineae*: *Syringa* L. *(1), Fraxinus* L. *(3), Ligustrum* L. *(1);*
Fam. *Polemoniaceae*: *Polemonium* L. *(1);*
Fam. *Convolvulaceae*: *Convolvulus* L. *(3), Cuscuta* L. *(3);*
Fam. *Boraginaceae*: *Heliotropium* L. *(2),Cerinthe* L. *(1),Asperugo* L. *(1), Onosma* L. *(2), Echium (2), Pulmonaria* L. *(2), Lythospermum* L. *(3), Anchusa (1), Myosotis* L. *(5), Symphytum* L. *(2), Cynoglossum* L. *(2), Lappula* Gilib. *(1), Moltkia* Lehm. *(1);*
Fam. *Labiatae*: *Mentha* L. *(4), Lycopus* L. *(2), Salvia* L. *(7), Origanum* L. *(2), Thymus* L. *(3), Satureia* L. *(6), Micromeria* Benth. *(1), Calamintha* Adans. *(6), Melissa* L. *(1), Hyssopus* L. *(1), Prunella* L. *(3), Scutellaria* L. *(4), Nepeta* L. *(2), Glechoma* L. *(2), Melittis* L. *(1), Lamium* L. *(4), Chaeturus* Lk. *(1), Leonurus* L. *(1), Galeopsis* L. *(5), Betonica* L. *(1), Stachys* L. *(9), Sideritis* L. *(1), Marrubium* L. *(2), Ballota* L. *(1), Teucrium* L. *(4), Ajuga* L. *(4);*
Fam. *Verbenaceae*: *Verbena* L. *(1);*
Fam. *Caprifoliaceae*: *Lonicera* L. *(4), Viburnum* L. *(2), Sambucus* L. *(3), Adoxa* L. *(1);*
Fam. *Rubiaceae*: *Galium* L. *(16), Asperula* L. *(6), Sherardia* L. *(1);*
Fam. *Valerianeae*: *Valerianella* Mill. *(4), Valeriana* L. *(3);*
Fam. *Dipsacaceae*: *Dipsacus* L. *(2), Cephalaria* Schrad. *(3), Knautia* L. *(3), Succisa* Hall. *(2),Scabiosa* L. *(6);*
Fam. *Synantherеae*: *Eupatorium* L. *(1), Adenostyles* Cass. *(1),Petasites* Gartn. *(2), Homogyne* Cass. *(1), Tussilago* L. *(1), Aster* L. *(3), Erigeron* L. *(3), Stenactis* Cass. *(1), Bellidiastrum* Cass. *(1), Bellis* L. *(1), Solidago* L. *(1), Bidens* L. *(1),Inula* L. *(8), Pulicaria* Gartn. *(2), Bupthalmum* L. *(1), Telekia* Baumg. *(1), Micropus* L. *(1), Filago* L. *(2),Gnaphalium* L. *(5),Helichrysum* Pers. *(1), Cupularia* Lam. *(1), Artemisia* L. *(4),Carpesium* L. *(1), Chrysanthemum* L. *(11), Anthemis* L. *(5), Achillea* L. *(8), Doronicum* L. *(2), Arnica* L. *(1), Senecio* L. *(11), Xanthium* L. *(2), Calendula* L.

(1), Echinops L. *(3), Xeranthemum* L. *(2), Carlina* L. *(4), Crupina* Cass. *(1), Centaurea* L. *(15), Kentrophyllum* Neck. *(1), Chamaepeuce* DC. *(1), Onopordon* L. *(1), Cirsium* Adans. *(8), Jurinea* Cass. *(1), Lappa* Scop. *(3), Serratula* L. *(1), Aposeris* Neck. *(1), Lampsana* Mill. *(1), Cichorium* L. *(1), Scolymus* L. *(1), Hypochoeris* L. *(1), Pterotheca* Cass. *(1), Sonchus* L. *(4),Leontodon* L. *(5), Picris* L. *(1), Scorzonera* L. *(2), Tragopogon* L. *(3), Prenanthes* L. *(1), Lactuca* L. *(3), Mulgedium* Cass. *(3), Chondrilla* L. *(2), Taraxacum* Web. *(1), Hieracium* L. *(26), Crepis* L. *(8), Achyrophorus* Vaill. *(1);*

Fam. *Campanulaceae*: *Specularia* DC. *(1), Campanula* L. *(13), Symphyandra* DC. *(1), Phyteuma* L. *(3), Hedraeanthus* Griseb. *(4), Jasione* L. *(1);*

Fam. *Globulariaceae*: *Globularia* L. *(1);*

Fam. *Plumbagineae*: *Plumbago* L. *(1), Armeria* Willd. *(1);*

Fam. *Plantagineae*: *Plantago* L. *(1);*

Fam. *Amaranthaceae*: *Polycnemum* L. *(1), Amaranthus* L. *(3);*

Fam. *Chenopodeae*: *Spinacia* L. *(1), Chenopodium* L. *(5), Beta* L. *(1);*

Fam. *Polygonaceae*: *Polygonum* L. *(10), Fagopyrum* Mill. *(1), Rumex* L. *(11);*

Fam. *Thymeleae*: *Daphne* L. *(2);*

Fam. *Santalaceae*: *Thesium* L. *(3);*

Fam. *Loranthaceae*: *Viscum* L. *(1);*

Fam. *Aristolochieae*: *Asarum* L. *(1), Aristolochia* L. *(2);*

Fam. *Urticaceae*: *Urtica* L. *(2),Parietaria* L. *(3), Humulus* L. *(1), Cannabis* L. *(1), Celtis* L. *(1), Ulmus* L. *(1), Morus* L. *(2);*

Fam. *Amentaceae*: *Quercus* L. *(5), Castanea* Mill. *(1), Juglans* L. *(1), Fagus* L. *(1), Corylus* L. *(2), Carpinus* L. *(2), Ostrya* Scop. *(1), Betula* L. *(2), Alnus* Mill. *(3);*

Fam. *Salicineae*: *Salix* L. *(7), Populus* L. *(4);*

Fam. *Conifereae*: *Pinus* L. *(3), Abies* Mill. *(1), Picea* A. Dietr. *(1), Juniperus* L. *(1);*

Fam. *Alismaceae*: *Alisma* L. *(1);*

Fam. *Orchidaceae*: *Orchis* L. *(13), Gymnadenia (1), Aceras* R.Br. *(2), Platanthera* Rich. *(3), Ophrys* L. *(3), Neottia* Ludw. *(2), Epipactis* Zinn *(3), Cephalanthera* Rich. *(2), Nigritella* Rich. *(1);*

Fam. *Iridaceae*: *Iris* L. *(3), Gladiolus* L. *(1), Crocus* L. *(3);*

Fam. *Amaryllideae*: *Galanthus* L. *(1), Narcissus* L. *(2);*

Fam. *Liliaceae*: *Colchicum* L. *(2), Veratrum* L. *(2), Tofieldia Huds. (1), Erythronium* L. *(1), Gagea* Salisb. *(2), Lilium* L. *(2), Muscari* Mill. *(3), Hyacinthus* L. *(1), Scilla* L. *(3), Ornithogalum* L. *(5), Allium* L. *(8), Tulipa* L. *(1), Anthericum* L. *(1);*

Fam. *Smilaceae*: *Asparagus* L. *(2), Convallaria* L. *(1), Polygonatum* Adans. *(2), Maianthemum* Web. *(1), Ruscus* L. *(2), Paris* L. *(1);*

Fam. *Dioscoreae*: *Tamus* L. *(1);*

Fam. *Juncaceae*: *Luzula* DC. *(5), Juncus* L. *(7);*

Fam. *Cyperaceae*: *Carex* L. *(26), Scripus* L. *(3), Eriophorum* L. *(1), Cyperus* L. *(2);*

Fam. *Gramineae*: *Lolium* L. *(1),Hordeum* L. *(4), Triticum* L. *(3), Brachypodium* P.B. *(1), Secale* L. *(1), Festuca* L. *(4), Molinia* Schrk. *(1), Arundo* L. *(1), Glyceria* R.Br. *(1), Catabrosa* P.B. *(1), Poa* L. *(9), Eragrostis Host (1), Briza* L. *(1), Sesleria* Scop. *(5), Cynosurus* L. *(1), Dactylis* L. *(1), Koeleria* Pers. *(2), Melica* L. *(3), Bromus* L. *(9), Sieglingia* Bernh. *(1), Avena* L. *(3), Holcus* L. *(1), Anthoxanthum* L. *(1), Agrostis* L. *(1), Milium* L. *(1), Stipa* L. *(1), Lasiagrostis* Lk. *(1), Andropogon* L. *(1), Sorghum* Moench. *(2), Zea* L. *(1), Oryza* L. *(1), Phleum* L. *(3), Alopecurus* L. *(2), Tragus* Haller *(1), Panicum* L. *(7);*

Fam. *Aroideae*: *Arum* L. *(1), Lemna* L. *(2), Typha* L. *(2), Sparganium* L. *(1);*

Fam. *Najadeae*: *Potamogeton* L. *(6);*

Fam. *Juncagineae*: *Triglochin* L. *(1);*

Fam. *Lycopodiaceae*: *Lycopodium* L. *(2);*

Fam. *Ophioglossaceae*: *Botrychium* Sw. *(1);*

Fam. *Polypodiaceae*: *Notholaena* R. Br. *(1), Pteris* L. *(1), Blechnum* L. *(1), Scolopendrium* Adans. *(1), Asplenium* L. *(6), Cystopteris* Bernh. *(1), Aspidium* Sw. *(5), Polypodium* L. *(1), Phegopteris* Fee *(1), Grammitis* Sw. *(1);*

Fam. *Equisetaceae*: *Equisetum* L. *(4).*

REGISTER OF SPERMATOPHYTES AND PTERIDOPHYTES FROM MONTENEGRO

Fam. *Papilionaceae*: *Trifolium* L. *(1), Onobrychis* Mill. *(1);*

Fam. *Rosaceae*: *Dryas* L. *(1), Prunus* L. *(1);*

Fam. *Lineae*: *Linum* L. *(1);*

Fam. *Geraniaceae*: *Geranium* L. *(1);*

Fam. *Terebinthaceae*: *Rhus* L. *(1);*

Fam. *Rhamneae*: *Rhamnus* L. *(2);*

Fam. *Acerineae*: *Acer* L. *(2);*

Fam. *Cucurbitaceae*: *Bryonia* L. *(1);*

Fam. *Caryophylleae*: *Alsine* Wahlenb. *(1), Cerastium* L. *(3),Dianthus* L. *(5), Melandrium* Roehl. *(2);*

Fam. *Hypericineae*: *Parnassia* L. *(1);*

Fam. *Cruciferae*: *Barbaraea* R.Br. *(1), Draba* L. *(1);*

Fam. *Ranunculaceae*: *Clematis* L. *(1), Thalictrum* L. *(1), Delphinium* L. *(1);*

Fam. *Crassulaceae*: *Sempervivum* L. *(1);*

Fam. *Umbelliferae*: *Bupleurum* L. *(1), Eryngium* L. *(1), Laserpitium* L. *(1), Peucedanum* L. *(2), Seseli* L. *(3),), Tordylium* L. *(1);*

Fam. *Araliaceae*: *Cornus* L. *(1);*

Fam. *Ericaceae*: *Arctostaphylos* Adans. *(1);*

Fam. *Primulaceae*: *Androsace* L. *(1);*

Fam. *Scrophulariaceae*: *Melampyrum* L. *(1), Euphrasia* L. *(1), Odontites* Hall. *(1), Pedicularis* L. *(1), Linaria* Mill. *(1), Verbascum* L. *(3);*

Fam. *Gentianeae*: *Gentiana* L. *(2);*

Fam. *Jasmineae*: *Fraxinus* L. *(1);*

Fam. *Labiatae*: *Mentha* L. *(1), Salvia* L. *(1), Satureia* L. *(2), Hyssopus* L. *(1), Stachys* L. *(2);*

Fam. *Rubiaceae*: *Asperula* L. *(1);*

Fam. *Dipsacaceae*: *Scabiosa* L. *(3);*

Fam. *Synanthereae*: *Pulicaria* Gartn. *(1), Inula* L. *(1), Artemisia* L. *(1), Chrysanthemum* L. *(2),Centaurea* L. *(2), Senecio* L. *(3), Tragopogon* L. *(2), Scorzonera* L. *(1);*

Fam. *Campanulaceae*: *Campanula* L. *(2), Edraianthus* DC. *(1);*

Fam. *Plumbagineae*: *Armeria* Willd. *(1);*

Fam. *Amentaceae*: *Quercus* L. *(1);*

Fam. *Salicineae*: *Salix* L. *(2), Populus* L. *(1);*

Fam. *Conifereae*: *Pinus* L. *(1), Juniperus* L. *(1);*

Fam. *Liliaceae*:*Colchicum* L. *(1), Allium* L. *(2);*

Fam. *Cyperaceae*: *Carex* L. *(1);*

Fam. *Gramineae*: *Poa* L. *(1), Sesleria* Scop. *(1), Bromus* L. *(1), Phleum* L. *(1);*

Fam. *Aroideae*: *Arum* L. *(1);*

Fam. *Polypodiaceae*: *Cystopteris* Bernh. *(1).*

The review of the herbarium structure reveals the numbers of different plant groups for both countries:

- Bosnia and Herzegovina: *Phycophyta* - 1, *Mycophyta* - 5, *Lichenophyta* - 6, *Bryophyta* - 14, *Pteridophyta* - 26, *Spermatophyta* - 2353;
- Montenegro: *Pterydophyta* - 1, *Spermatophyta* - 96.

Table 1 summarizes the data on the number of families, genera and species for the Bosnian-Herzegovinian part of Blau's collection, and revealsthe following:

Pteridophyta are represented by 4 families, 13 genera and 26 species,

Spermatophyta are represented by 89 families, 496 genera and 1378 plant species.

Table 1. Numerical representation of systematic categories from *Herbarium Blavianum* collection for Bosnia and Herzegovina

	Family	Genus	Species
Pteridophyta	4	13	26
Spermatophyta	89	496	1378
Total:	93	509	1404

Table 2 gives an overview of systematic categories for the Montenegrin part of Blau's collection. *Pteridophyta* includes 1 family, 1 genus and 1 species, while *Spermatophyta* are categorized in 33 families, 69 genera and 96 species.

Table 2. Numerical representation of systematic categories from *Herbarium Blavianum* collection for Montenegro

	Family	Genus	Species
Pteridophyta	1	1	1
Spermatophyta	33	69	96
Total:	34	70	97

The plant material has never been taxonomically reviewed since the collection was established, so that the original collection data has been used. There is no doubt that the review according to the newer classification planned for the upcoming period will alter the proportion of existing systematic categories.

In addition, some specimens were incompletely determined to the level of genus (43 specimens from Bosnia and Herzegovina and 2 specimens from Montenegro). The dynamics of material collection by year is different (Bosnia and Herzegovina: 1868 –1150 specimens, 1869 – 865 specimens, 1870 – 4 specimens, 1871 – 481 specimens and 1872 – 3 specimens; Montenegro: 1869 – 97 specimens).

The collection also includes the specimens that were used to describe new taxa – types which were categorized in 1984 according to ICBN rules adopted at the XIX International Botanical Congress in Montreal (1959):

- *Alyssum cinereum* Blau (Syn. *A. moellendorffianum* Asher.) **HOLOTYPUS!** (Fig. 2.)
- *Potentilla reptans* L. var. *blavii* Ascher. et Graebn. **HOLOTYPUS!** (Fig. 3.)
- *Crepis blavii* (Ascherson) Stadlmann (Syn. *Mulgedium blavii* Ascherson) **HOLOTYPUS!** (Fig. 4.)
- *Avenastrum blavii* Beck /Syn. *Avenula blavii* (Asch. et Jka.) W. Sauer et Cmel. /**HOLOTYPUS!** (Fig. 5.)
- *Saxifraga blavii* Beck (Syn. *S. adscendens* var. *blavii* Engler) **SYNTYPUS!** (Fig. 6.)
- *Bromus erectus* Huds. (Syn. *B. moellendorffianum* A.G.) **TYPUS!** (Fig. 7.), with the remark indicating that the species of the typus will be defined after the scientific review.

Figure 2. *Alyssum cinereum* Blau (Syn. *A. moellendorffianum* Asherson). Locus classicus: in kalkigem Berglezum in Treschanitza-Tal.

Figure 3. *Potentilla reptans* L. var. *blavii* Ascher. et Graebn. Locus classicus: as a weed in Otto Blau's garden in Sarajevo.

Figure 4. *Crepis blavii* (Ascherson) Stadlmann (Syn. *Mulgedium blavii* Ascherson). Locus classicus: "in fruticetis inter Paljev do et Bakračuša, rar."

Figure 5. *Avenastrum blavii* Beck /Syn. *Avenula blavii* (Asch. et Jka.) W. Sauer et Cmel./. Locus classicus: in saxis calc. montis Trebević pr. Sarajevo. 800 m.

Figure 6. *Saxifraga blavii* Beck. (Syn. *S. adscendens* var. *blavii* Engler). Locus classicus: aufren hoheren Kuppen der Romanija 4000".

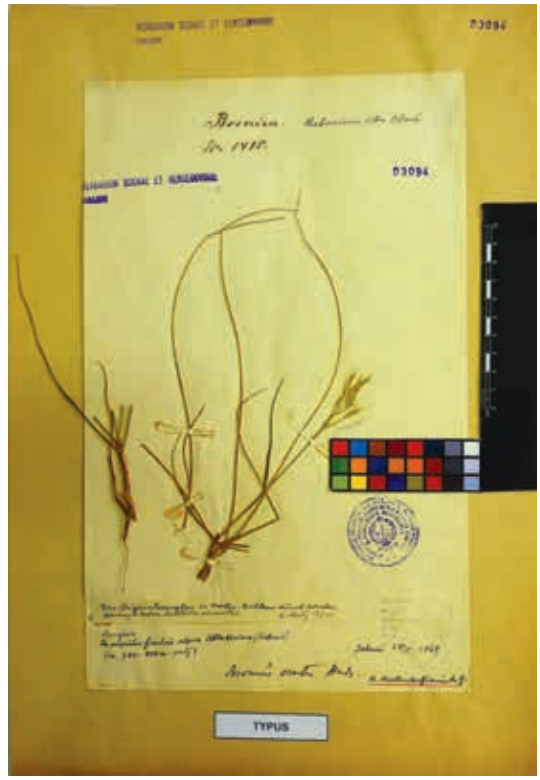

Figure 7. *Bromus erectus* Huds. (Syn. *B. moellendorffianum* A.G.) TYPUS! Locus classicus: in rupinum supra Ablakovina (Trebević), ca 780 – 800 m. Malý.

CONCLUSIONS:

Analysis of the total number of sheets from Otto Blau's doublet collection resulted in new data on its content and revealed that:

- most specimens were collected in the territory of Bosnia and Herzegovina (96.1%), while a minor part of the collection originates from Montenegro (3.9%);
- the collection consists of algae – 0.04%, fungi – 0.20%, lichens– 0.24%, mosses – 0.56%, ferns – 1.08% and spermatophytes– 97.88%;
- the Bosnian-Herzegovinian part of the collection is systematically divided into 93 families, 509 genera and 1404 species, while specimens from Montenegro include 34 families, 70 genera and 97 taxa (those data refer to *Pteridophyta* and *Spermatophyta*);
- a total of 43 specimens from Bosnia and Herzegovina and 2 from Montenegro do not have valid scientific names and were omitted from the analysis;
- most specimens (46%) were collected during the first year when the collection was established;
- six nomenclature types (4 holotypuses, 1 syntypus and 1 typus) were identified and labelled based on the rules of the International Codex of Botanical Nomenclature (ICBN).

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SAŽETAK

U radu su prikazani preliminarni rezultati istraživanja materijala iz kolekcije dubleta Otto Blaua koja čini dio herbarija Zemaljskog muzeja Bosne i Hercegovine (SARA). Analizom ukupnog broja primjeraka (2503) su dati podaci o lokalitetima (BiH, Crna Gora) na kojima su prikupljeni uzorci različitih biljnih grupa (***Phycophyta*** – 1, ***Mycophyta*** – 5, ***Lichenophyta*** – 6, ***Bryophyta*** – 14, ***Pteridophyta*** – 27 i ***Spermatophyta*** – 2450). Registrirano je 127 porodica,579 rodova i 1501 vrsta ***Pterydophyta*** i ***Spermatophyta***. Najveću vrijednost predstavljaju registrirani tipski primjerci (6) koji su uloženi u istoimenu zbirku.

Ključne riječi: Blauov herbar, SARA, Zemaljski muzej, Sarajevo, Bosna i Hercegovina, tipske vrste, nalazišta, popis.

Giant Fennel *Ferula communis* L. (Apiaceae) – a New Species in the Flora of Bosnia and Herzegovina

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Scientific article
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Ferula communis L., a Mediterranean plant species, has been recorded for the first time in Bosnia and Herzegovina in two anthropogenic habitats south of the city of Mostar. This study reports the newly discovered localities and presents a short morphological description of the species.

Key words: distribution, *Ferula*, Herzegovina,new records, vascular flora.

INTRODUCTION

The genus *Ferula* L. (Apiaceae) includes about 170 species extending from central Asia westward throughout the Mediterranean region to northern Africa (Pimenov and Leonov, 1993). According to Hand (2011), ca 20 species from the genus *Ferula* occur in Europe, of which only five are growing in the Balkans (Hayek,1927; Hand, 2011). There are only three species of *Ferula* in the flora of former Yugoslavia: *Ferula communis* L., *Ferula glauca* L. and *Ferula heuffelii* Heuff.(Hand, 2011). Previously, no species of the genus had been recorded in the territory of Bosnia and Herzegovina. Many species of the genus have been known since antiquity as sources of aromatic resins used in traditional medicine.

F. communis is native to southern and central Europe, the lands around the Mediterranean Sea, the Middle East, the Canary Islands, the Balkan Peninsula, the Apennine Peninsula, the Iberian Peninsula and North Africa. In the European region the plant is common, occurring from Portugal to Greece, Spain, France, Italy, Croatia, Montenegro, Albania and Cyprus. The plant is introduced in Great Britain. (Rankou et al, 2015).

In the territory of former Yugoslavia, *F. communis* was known only in Croatia (Hayek,1927; Hand, 2011; Nikolić, 2016) and Montenegro (Hayek,1927; Rohlena, 1942; Hand, 2011). In the literature available to me, this plant was not known in the flora of Bosnia and Herzegovina, and may now be considered a new member of it. Even Beck (Beck, 1927) did not mention it in the flora of Bosnia and Herzegovina.

MATERIAL AND METHODS

Ferula communis was found at two sites during floristic investigations in the spring of 2015 and the spring of 2016 in the southern part of the Neretva valley (Bosnia and Herzegovina). Digital photographs and GPS coordinates were taken in the field.

Identification of the specimens was performed according to Cannon (1968) and Pesmen (1972). The taxonomy and nomenclature of species have been adjusted according to Hand (2011). Herbarium samples (No. inv. 51839) are stored in the Herbarium of the National Museum of Bosnia and Herzegovina (SARA).

The paper presents a short morphological description of the species based mainly on the collected specimens, as well as the distribution of the taxon.

RESULTS AND DISCUSSION

Ferula communis L.,Sp. Pl.: 246. 1753. (Heterotypic synonym**:** *Ferula meoides* L., Sp. Pl.: 247. 1753), also known as Giant Fennel, and the alien Giant Hogweed*Heracleum mantegazzianum* Sommier & Levier,are the largest herbaceous plants in the European flora.

To identify this new species, I propose an adjusted keyto the species that grow in the neighbouring countries, according to Cannon (1968) and Pesmen (1972).

1. Sheaths of uppermost leaves very large, situated close beneath and enveloping the developing umbels; rays of terminal umbel (15-) 20-40.2
1. Sheaths of uppermost leaves not very large and conspicuous; rays of terminal umbel not more than 15.F. heuffelii
2. Leaf lobes 0.3-0.8 mm wide, green on both facesF. communis
2. Leaf lobes 1-3 mm wide, green above and glaucous beneath F. glauca

F. communis (Fig. 1.) is a glabrous perennial herb up to 3 m, occasionally more, very robust, rather pungent, with stout, hollow stems. Leaves 3-6 pinnate, triangular-ovate in outline, 25-45 × 20-30 cm. Ultimate segments always linear10-50 × 0.3-3 mm, green on both faces. Sheaths strongly inflated, coriaceous, amplexicaul. Upper leaves becoming progressively reduced to a large sheath with or without a small blade, conspicuous especially just before flowering. Umbels large and rounded, bright yellow-green, the terminal umbel stalkless, surrounded by smaller, stalked, umbels, with 20-40 rays; bract absent, secondary bracts, few, linear-lanceolate. Fruits strongly compressed dorsally, elliptical, 10-16 × 5-10 mm with filiform dorsal ribs, lateral wings 1-1.5 mm wide. 2n=22 (Cannon,1968; Pesmen (1972).

According to Sánchez Cuxart (2003) and Hand (2011) *Ferula communis* L, is divided into three subspecies, namely*F. communis* L. subsp. *communis*, *F. communis* subsp. *cardonae* Sánchez-Cux. & M. Bernal, and*F. communis* subsp. *catalaunica* (C. Vicioso) Sánchez-Cux. & M. Bernal. Only *F. communis* L. subsp. *communis* occurs in the Eastern Mediterranean area and the Balkans.

The first finding of this species for Bosnia and Herzegovina is from South Herzegovina in the village of Žitomislići, between Buna and Čapljina, on the left bank of the Neretva river, ca 400 m south of the junction to the village of Pijesci (43° 20′ 14.98″ N; 17° 78′ 63.13″ E), (Fig. 2.). A single specimen only was recorded on April 11th 2015, on the roadside between the main M 17 road and the Neretva river. In March 30th 2016 three specimens were found at the second site, in the vicinity of the villageof Buna, along the edge of the ditch on the left side of the main M 17road, betweenthe junction to Hodbina and the bridge over the river Buna(43° 24′ 43.17″ N; 17° 83′ 53.49″ E), (Fig. 2.).

CONCLUSION

F. communis flowers from March to July and reproduces easily by seeds which can be distributed over large distances. The origin and distribution of this species in Bosnia and Herzegovina is not clear. It is difficult to determine whether

Figure 1. *Ferula communis* in the vicinity of the village of Žitomislići, betweenBuna and Čapljina a. habitat b. whole plant c. umbels d. flowers (Photos by Semir Maslo).

Figure 2. The distribution of ***Ferula communis*** in Bosnia and Herzegovina

F. communis is native to Bosnia and Herzegovina or is introduced. This estimate is particularly difficult, because the flora of the South Herzegovina has not been systematically explored for a long time. The species is relatively common in the neighbouring Dalmatia, especially in the vicinity of Dubrovnik, and there is a possibility it has been introduced in Bosnia and Herzegovina from that area. Future detailed floristic research in the Mediterranean area of Herzegovina should provide an answer.

ACKNOWLEDGEMENTS

I would like to thank Aldin Boškailo for mapping the distribution of the species as well as Jessica Andersson for improving the English of this paper.

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Ferula communis L. (Apiaceae) – nova vrsta u flori Bosne i Hercegovine

SAŽETAK

U ovom radu navodi se po prvi put nalaz vrste ***Ferula communis*** L. u flori Bosne i Hercegovine. Vrsta je sakupljena u naselju Žitomislići početkom aprila 2015. kao i u naselju Buna krajem marta 2016. U oba slučaja vrsta je nađena uz rubove magistralnog puta M 17.

U radu se donosi kratak opis morfoloških karakteristika vrste, kao i karta distribucije.

Ključne riječi: Ferula, nova vrsta, flora, rasprostranjenje, Hercegovina.

Index Florae Bosnae et Hercegovinae[1] (Part 4)

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Review article
UDK: 581.92 (497.6 Sarajevo)

Three parts of the ***Index Florae Bosnae et Hercegovinae***, published in the Bulletin of the National Museum of Bosnia and Herzegovina, included three large families of flowering plants (Angiospermae). In the first part, the Fabaceae family (GZM 34/2014) was covered by Prof. Dr. Ljubomir Mišić, who listed 51 genera, 260 species and 74 subspecies. The second part of the Index, compiled by Dr. Željka Bjelčić, covered the Brassicaceae family (GZM 35/2015), with 53 genera, 171 species and 44 subspecies. The third part of the Index presented the Lamiaceae family (GZM 37/2017), which was elaborated by Dr. Čedomil Šilić who listed 30 genera, 124 species, 58 subspecies and 8 hybrids.

1 Citation: SARAJLIĆ, N. (2018) Poaceae. Index Florae Bosnae et Hercegovinae, Part 4. In Šoljan, D. (ed.): Index Florae Bosnae et Hercegovinae

The fourth part of the *Index Florae Bosnae et Hercegovinae* covers the grass family (Poaceae). It was compiled by Nermina Sarajlić MSc, who lists 97 genera, 312 species and 48 subspecies.

The text of the fourth part of the Index is essentially the same as the previous three, and was prepared according to the following formula:

- the scientific name of the genus, authority, common name(s) in the local language and English,
- the scientific name of the species, authority, the reference to the first publication,
- synonyms, where applicable,
- the genera, species and subspecies are listed in alphabetical order
- the nomenclature is compliant with Euro+Med PlantBase (http://ww2.bgbm.org/EuroPlusMed/query.asp)
- the Red list of flora of the Federation of Bosnia and Herzegovina (2013), whose categorization is consistent with IUCN categories, version 3.1 (2001), was used to obtain data on the vulnerability of individual taxa. The Red List of protected species of flora and fauna of Republika Srpska - List of vascular flora (2012) was also consulted.
- endemic taxa are indicated,
- the internationally accepted symbols (SARA, W, NL...) were used to indicate the herbaria in which samples of certain grasses originating from Bosnia and Herzegovina are stored.

The author surveyed a very large number of literature sources and added her own field observations. The list of references contains more than 200 bibliographic units. The data from herbarium collections, primarily the Herbarium of the National Museum of Bosnia and Herzegovina (SARA), along with a large number of foreign herbaria in which specimens originating from Bosnia and Herzegovina are stored, available via http://www.gbif.org/ were also used. Nevertheless, some data, such as those for the taxa for which only one record was found (herbarium specimen or bibliographic source), or those whose presence on the territory of Bosnia and Herzegovina is dubious, should be subsequently checked, and this list accordingly remains open for additions and revisions.

POACEAE BARNHART 1895

(= GRAMINEAE JUSS. 1789)

ACHNATHERUM P. Beauv. – hrapavica (needlegrass)

***bromoides* (L.) P. Beauv.** Ess. Agrostogr.: 146. 1812 (= *Agrostis bromoides* L., *Aristella bromoides* (L.) Bertol., *Stipa aristella* L., *S. bromoides* (L.) Dörfl, *S. bromoides* (L.) Brand ex Koch): Struschka (1880) – LD

***calamagrostis* (L.) P. Beauv.** Ess. Agrostogr.: 19. 1812 (= *Agrostis calamagrostis* L., *Calamagrostis argentea* Lam. & DC, *Lasiagrostis calamagrostis* (L.) Link, *Stipa calamagrostis* (L.) Wahlenb., *S. calamagrostis* (L.) Wahlenb. var. *colorata* (Pančić) Maly): Conrath (1888) – SARA, E, W

AEGILOPS L. – ostika (goatgrass)

***biuncialis* Vis.** Fl. Dalmat. 1: t. 1, f. 2. 1842 – USNPGS

***cylindrica* Host** Icon. Descr. Gram. Austriac. 2: 6. 1802 (= *Aegilops caudata* Ten non L., *Triticum cylindricum* (Host) Cesati, Passer. & Gibelli): Kutleša & Lakušić (1964)

***geniculata* Roth** in Bot. Abh.: 45. 1787 (= *Aegilops ovata* L. pp, *Triticum ovatum* (L.) Gren. & Godr.): Adamović (1889)

***neglecta* Bertol.** Fl. Ital. 1: 787. 1833 (= *A. neglecta* Req. ex Bertol, *A. ovata* L., nom. ambig., *A. triaristata* Willd., *Triticum ovatum* var. *triaristatum* Asch. & Graebn., *T. triaristatum* Godr. & Gren.): Struschka (1880) – SARA, USNPGS

***triuncialis* L.** Sp. Pl.: 1051. 1753 (= *Triticum triunciale* (L) Gren. & Godr., *T. triunciale* (L.) Raspail): Murbeck (1891) – SARA, W

***uniaristata* Vis.** Fl. Dalmat. 3: 345. 1851: Maslo (2014b)

AGROSTIS L. – rosulja (bentgrass)

***alpina* Scop.** Fl. Carniol., ed. 2, 1: 60. 1772: Protić (1902)

***canina* L.** Sp. Pl.: 62. 1753 (= *A. canina* var. *mutica* Gaud., *A. canina* var. *pudica* Döll, *A. canina* subsp. *stolonifera* Blytt): Formanek (1890) – SARA

***capillaris* L.** Sp. Pl.: 62. 1753 (= *A. tenuis* Sibth., *A. vulgaris* With., *A. vulgaris* var. *montana* Schur): Freyn & Brandis (1888) – SARA, W

***castellana* Boiss. & Reut.** Diagn. Pl. Nov. Hisp.: 26. 1842 (= *A. castellana* subsp. *byzantina* (Boiss.) Hack., *A. castellana* var. *mutica* Hack., *A. olivetorum* Godr. & Gren.): Murbeck (1891) – SARA

***gigantea* Roth** Tent. Fl. Germ. 1: 31. 1788 (= *A. alba* L., *A. alba* L. var. *gigantea* Reichb., *A. alba* L. var. *gigantea* Gaud.): Brandis (1891) – SARA, W

***rupestris* All.** Fl. Pedem. 2: 237. 1785: Beck (1903) – SARA

***schraderiana* Bech.** in Ber. Schweiz. Bot. Ges. 48: 282. 1938 (= *A. tenella* (Schrad.) Schleich, *Calamagrostis tenella* (Schrad.) Link, *C. tenella* var. *aristata* Mutel): Maly (1928b) – SARA

***stolonifera* L.** Sp. Pl.: 62. 1753 (= *A. alba* auct., *A. alba* L. var. *flavida* (Schur) A. & G., *A. alba* var. *patula* Gaud., *A. alba* var. *prorepens* Aschers, *A. stolonifera* var. *prorepens* W. D. J. Koch, *A. stolonifera* L. subsp. *stolonifera*): Struschka (1880) – SARA

(DD) ***vranicensis* Pawl. ?**: (Lakušić et al., 1979)

***AIRA* L. – metlača (hair-grass)**

***caryophyllea* L.** Sp. Pl.: 66. 1753 (= *Aera caryophyllea* L., *Avena caryophyllea* (L.) Wigg.): Boller (1892) – SARA

***elegantissima* Schur** in Verh. Mitth. Siebenbürg. Vereins Naturwiss. 4: 85. 1853 (= *Aera capillaris* Host. f. *ambigua* (De Not.) Aschers, *Aira capillaris* Host, *A. elegans* Gaudin, *A. elegans* Willd ex Gaudin, *A. elegans* var. *biaristata* Godr., *Avena capillaris* (Host) Mert. & W. D. J. Koch): Formanek (1890) – SARA, BRNU

***ALOPECURUS* L. – lisičiji repak (foxtail grass)**

***aequalis* Sobol.** Fl. Petrop.: 16. 1799 (= *A. fulvus* Sm.): Maly (1893) – SARA

***geniculatus* L.** Sp. Pl.: 60. 1753: Protić (1902) – SARA

***gerardi* Vill.** Hist. Pl. Dauphiné 2: 66. 1787 (= *A. gerardii* Vill. f. *pantocsekii*, *Colobachne gerardi* Link, *Phleum gerardi* All.): Beck (1903) – SARA

***myosuroides* Huds.** Fl. Angl.: 23. 1762 (= *A. agrestis* L.): Struschka (1880) – SARA

***pratensis* L.** Sp. Pl.: 60. 1753 (= *A. pratensis* subsp. *eu-pratensis* Asch. & Graebn., *A. pratensis* L. f. *obscurus* Gris.): Freyn & Brandis (1888) – SARA

subsp. ***alpestris* (Wahlenb.) Selander** in Acta Phytogeogr. Suec. 28: 33. 1950 (= *A. pratensis* var. *alpestris* Wahlenb.): Bjelčić (1964) – SARA

***rendlei* Eig** in J. Bot. (London) 75: 187. 1937 (= *A. utriculatus* Pers., *A. utriculatus* (Savi) Pers., *A. utriculatus* (L.) Pers. f. *violascens* L. F. Čelak., *Tozzettia pratensis* Savi, *T. utriculata* Savi): Hofmann (1882) – SARA, PRC

***ANDROPOGON* L. – vlaska (beard grass)**

***distachyos* L.** Sp. Pl.: 1046. 1753: Kutleša & Lakušić (1964)

***ANISANTHA* K. Koch – ovsik (brome)**

***diandra* (Roth) Tutin** in A. R. Clapham, Tutin & E. F. Warb., Fl. Brit. Isles, ed. 2: 1149. 1962 (= *Bromus diandrus* Roth): Svoboda (2012)

***madritensis* (L.) Nevski** in Trudy Sredne-Aziatsk. Gosud. Univ., ser. 8b, Bot. 17: 21. 1934 (= *Bromus madritensis* L., *B. polystachyus* DC): Beck (1903) – SARA

***rigida* (Roth) Hyl.** in Uppsala Univ. Arsskr. 7: 32. 1945 (= *Bromus rigidus* Roth): Maslo (2014b)

***sterilis* (L.) Nevski** in Trudy Sredne-Aziatsk. Gosud. Univ., ser. 8b, Bot. 17: 20. 1934 (= *Bromus sterilis* L., *B. sterilis* var. *intermedius* Rchb., *B. sterilis* var. *lanuginosus* (Rohlena) Asch. & Graebn.): Struschka (1880) – SARA

***tectorum* (L.) Nevski** in Trudy Sredne-Aziatsk. Gosud. Univ., ser. 8b, Bot. 17: 22. 1934 (= *Bromus australis* (Gris.) R. Br., *B. tectorum* L., *B. tectorum* var. *nudus* Klett & Richter, *B. tectorum* subsp. *longipilus* (Kumm. & Sendtn.) K. Richt.): Protić (1902) – SARA

***ANTHOXANTHUM* L. – mirisavka (vernal grass)**

***alpinum* Á. Löve & D. Löve** in Rit Landbúnaoard. Atvinnud. Háskólans B 3: 105. 1948: Lakušić et al. (1979)

***odoratum* L.** Sp. Pl.: 28. 1753 (= *A. odoratum* L. subsp. *odoratum*, *A. odoratum* var. *glabrescens* Čelak, *A. odoratum* var. *longiaristatum* Čelak., *A. odoratum* f. *montanum* (Asch. & Graebn.) A. Nyár, *A. odoratum* var. *vulgatum* Asch. & Graebn): Struschka (1880) – SARA

***APERA* Adans. – stržac (silkybent)**

***spica-venti* (L.) P. Beauv.** Ess. Agrostogr. 31: 151. 1812 (= *Agrostis spica-venti* L.): Freyn & Brandis (1888) – SARA

***ARRHENATHERUM* P. Beauv. – ovsenica (oatgrass)**

***elatius* (L.) J. Presl & C. Presl** Fl. Cech.: 17. 1819 (= *A. avenaceum* P. Beauv., *A. elatius* f. *biaristatum* Peterm., *A. elatius* var. *bulbosum* (Gaud.) Koch, *A. elatius* (L.) J. Presl & C. Presl subsp. *elatius*, *Avena elatior* L.): Brandis (1888) – SARA

***ARUNDO* L. – italijanska trska, trstika (giant cane)**

***donax* L.** Sp. Pl.: 81. 1753 (= *Donax arundinacea* Beauv., *D. donax* (L.) Asch. & Graebn., *Scolochloa arundinacea* Mert. & Koch.): Struschka (1880)

***AVENA* L. – zob, ovas (oat)**

***barbata* Link** in J. Bot. (Schrader) 1799(2): 315. 1800 (= *A. atherantha* Presl., *A. hirsuta* Roth, *A. strigosa* subsp. *barbata* (Pott.) Thell.): Beck (1903) – SARA

***fatua* L.** Sp. Pl.: 80. 1753 (= *A. fatua* var. *glabrata* Peterm.): Vandas (1889) – SARA

***nuda* L.** Demonstr. Pl.: 3. 1753 – SARA

(cult) ***sativa* L.** Sp. Pl.: 79. 1753 (= *A. fatua* L. var. *sativa* Haussk, *A. sativa* subsp. *sativa* Thell): Boué (1840) – SARA, USNPGS

subsp. ***orientalis* (Schreb.) Jess.** Deutschl. Gräser: 212. 1863 (= *A. orientalis* Schreb., *A. sativa* L. subsp. *orientalis* Schreb.): Beck (1903) – SARA

***sterilis* L.** Sp. Pl., ed. 2, 1: 118. 1762: Beck (1903) – SARA

***AVENELLA* Drejer – busika (hair grass)**

***flexuosa* (L.) Drejer** Fl. Excurs. Hafn.: 32. 1838 (= *Aera flexuosa* L., *Aira flexuosa* L., *Avena flexuosa* Leers, *Deschampsia flexuosa* (L.) Trin.): Freyn & Brandis (1888)

subsp. ***corsica* (Tausch) Holub** in Folia Geobot. Phytotax. 23: 413. 1988 (= *Aira montana* L., *Deschampsia flexuosa* var. *montana* Beck): Beck (1903) – SARA

***AVENULA* (Dumort.) Dumort. – zobika, ovsika (oatgrass)**

***pubescens* (Huds.) Dumort.** in Bull. Soc. Bot. Belg. 7: 68. 1868 (= *Avena pubescens* Huds., *A. pubescens* var. *alpina* Gaudin, *Avenastrum pubescens* (Huds.) Opiz, *A. pubescens* Jessen, *Helictotrichum pubescens* (Huds.) Pilg): Formanek (1890) – SARA

***BELLARDIOCHLOA* Chiov. – ljubičasta vlasnjača**

***variegata* (Lam.) Kerguélen** in Lejeunia, ser. 2, 110: 26, 56. 1983 (= *Bellardiochloa violacea* (Bellardi) Chiov, *Festuca pilosa* Hall., *F. poaeformis* Host., *F. rhaetica* Suter, *Poa violacea* Bellardi): Freyn & Brandis (1888)

BOTHRIOCHLOA Kuntze – vlaska (beardgrass)

***ischaemum* (L.) Keng** in Contr. Biol. Lab. Sci. Soc. China, Bot. Ser. 10: 201. 1936 (= *Andropogon ischaemum* L., *A. ischaemum* var. *genuinus* Hack., *Dichanthium ischaemum* (L.) Roberty): Struschka (1880) – SARA

BRACHYPODIUM P. Beauv. – kostrika (false brome)

***glaucovirens* (Murb.) Sagorski** in Mitth. Thüring. Bot. Vereins 16: 34. 1901 (= *Brachyodium sylvaticum* (Huds.) P. Beauv. subsp. *glaucovirens* Murb.): Murbeck (1891) – SARA, LD, NL, W

(?) ***phoenicoides* (L.) Roem. & Schult.** Syst. Veg. 2: 740. 1817: Svoboda (2012)

***pinnatum* (L.) P. Beauv.** Ess. Agrostogr.: 101, 155. 1812 (= *B. pinnatum* (L.) Beauv. subsp. *pinnatum, B. pinnatum* var. *vulgare* Koch): Freyn & Brandis (1888)

***retusum* (Pers.) P. Beauv.** Ess. Agrostogr.: 101. 1812 (= *B. ramosum* Roem. & Schult., *Bromus ramosum* L., *Triticum ramosum* Vis.): Beck (1903) – NL

***rupestre* (Host) Roem. & Schult.** Syst. Veg. 2: 736. 1817 (= *B. caespitosum* (Host.) Roem. & Schult., *B. pinnatum* subsp. *rupestre* (Host) Schübl. & G. Martens, *Bromus caespitosus* Host, *B. rupestris* Host.): Brandis (1891) – SARA

***sylvaticum* (Huds.) P. Beauv.** Ess. Agrostogr.: 101. 1812 (= *B. gracile* (Weigel) P. Beauv., *B. sylvaticum* (Huds.) P. Beauv. subsp. *sylvaticum*, *Bromus sylvaticus* (Huds.) Pollich, *Festuca sylvatica* Huds.): Conrath (1888) – SARA, LD, NL, W

BRIZA L. – treslica (quaking grass)

***maxima* L.** Sp. Pl.: 70. 1753: Vandas (1889) – SARA

***media* L.** Sp. Pl.: 70. 1753: Freyn & Brandis (1888) – SARA

subsp. ***elatior* (Sm.) Rohlena** in Sitzungsber. Königl. Böhm. Ges. Wiss. Prag., Math.-Naturwiss. Cl. 1912: 130. 1912: Milanović et al. (2015) – SARA

***minor* L.** Sp. Pl.: 70. 1753 (= *B. virens* L.): Struschka (1880) – SARA

BROMOPSIS Fourr. – ovsik, stoklasa (brome)

***benekenii* (Lange) Holub** in Folia Geobot. Phytotax. 8: 167. 1973 (= *Bromus benekenii* (Lange) Trimen, *B. benekeni* Syme, *B. ramosus* var. *benekenii* (Lange) Asch. & Graebn., *Schedonorus benekeni* Lange): Murbeck (1891)

***condensata* (Hack.) Holub** in Folia Geobot. Phytotax. 8: 167. 1973 (= *Bromus condensatus* Hackel, *B. erectus* Huds. var. *australis* Griseb, *B. erectus* subsp. *condensatus* (Hack.) Asch. & Graebn): Fiala (1896) – SARA

subsp. ***microtricha* (Borbás) Jogan & Bačič** in Hladnikia 11: 26. 2001 (= *Bromus condensatus* var. *microtrichus* (Borbás) Hayek): Hayek (1933)

***erecta* (Huds.) Fourr.** in Ann. Soc. Linn. Lyon, nov. ser., 17: 187. 1869 (= *Bromus borbasii* Hack, *B. condensatus* var. *australis* Griseb., *B. erectus* Huds., *B. erectus* var. *borbasii* Hack. ex Borbás, *B. erectus* var. *dissolutus* Beck, *B. erectus* Huds. subsp. *erectus*, *B. erectus* subsp. *euerectus* Asch. & Graebn., *B. erectus* var. *fallax* Beck, *B. erectus* var. *glabratus* Maire, *B. erectus* Huds. var. *glabriflorus* Borb., *B. erectus* var. *pubiflorus* Borbás, *B. erectus* var. *trichanthus* C. A. Mey., *B. erectus* var. *typicus* Fiori, *B. erectus* var. *villosus* Döll, *B. pubiflorus* Borbás, *B. racemiferus* Borb.): Struschka (1880) – SARA, TLMF

subsp. ***stenophylla* (Link) H. Scholz & Valdés** in Willdenowia 36: 660. 2006 (= *Bromus erectus* subsp. *stenophyllus* (Link) Asch. & Graebn.): Svoboda (2012) – NL

subsp. ***transsilvanica* (Steud.) H. Scholz & Valdés** in Willdenowia 36: 660. 2006 (= *Bromus erectus* subsp. *transsilvanicus* (Steud.) Asch. & Graebn., *B. erectus* var. *transsilvanicus* (Steud.) Beck, *B. transsilvanicus* Steud): Murbeck (1891) – SARA

***inermis* (Leyss.) Holub** in Folia Geobot. Phytotax. 8: 167. 1973 (= *Bromus inermis* Leyss.): Protić (1900b) – SARA

(CR) (o) ***moellendorfiana* (Asch. & Graebn.) Holub** in Folia Geobot. Phytotax. 8: 168. 1973 (= *Bromus erectus* subsp. *moellendorfianus* Asch. & Graebn., *B. moellendorfianus* (Asch. & Graebn.) Hayek, *B. moellendorfianus* (Asch. & Graebn.) Hayek f. *trichocalycinum* Maly): Maly (1928b) – SARA, MPU, BM, W, GB

***pannonica* (Kumm. & Sendtn.) Holub** in Folia Geobot. Phytotax. 8: 168. 973. 1973 (= *Bromus erectus* var. *hercegovinus* Beck, *B. erectus* f. *hirtiflorus* K. Maly, *B. erectus* subsp. *pannonicus* (Kumm. & Sendtn.) Asch. & Graebn., *B. erectus* var. *reptans* Borbás, *B. erectus* var. *vernalis* Pančić, *B. pannonicus* Kumm. & Sendtn., *B. pannonicus* Kumm. & Sendtn subsp. *pannonicus*, *B. pannonicus* var. *reptans* Borbás, *B. repens* Borbás, *B. reptans* Borbás, *B. vernalis* Hack., *B. vernalis* (Pančić) Hack.): Freyn & Brandis (1888) – SARA, SEV, TLMF

***ramosa* (Huds.) Holub** in Folia Geobot. Phytotax. 8: 168. 1973 (= *Bromus asper* Murray, *B. ramosus* Huds.): Vandas (1889) – SARA

***riparia* (Rehmann) Holub** in Folia Geobot. Phytotax. 8: 169. 1973 (= *Bromus erectus* var. *puberulus* Beck, *B. riparius* Rehmann, *B. transsilvanicus* var. *angustifolius* Sagorski, *B. transsilvanicus* var. *puberulus* (Beck) Asch. & Graebn.): Beck (1903)

subsp. ***fibrosa* (Hack.) Tzvelev** in Fedorov, Fl. Evropeiskoi Casti SSSR 1: 176. 1974 (= *Bromus fibrosus* Hack.): Freyn & Brandis (1888) – SARA

BROMUS L. – ovsik, stoklasa (brome)

***arvensis* L.** Sp. Pl.: 77. 1753 (= *B. arvensis* L. subsp. *arvensis*, *B. arvensis* var. *hyalinus* Schur, *B. arvensis* f. *violaceus* Asch. & Graebn.): Hofmann (1882) – SARA, JL, NL, O

***commutatus* Schrad.** Fl. Germ. 1: 353. 1806 (= *B. commutatus* var. *apricorum* Simonkai, *B. commutatus* Schrad subsp. *commutatus*, *B. erectus* Huds. subsp. *hackelii* Borb., *B. pratensis* Ehrh., *B. pratensis* var. *apricorum* (Simonk.) Schinz & Thell.): Brandis (1891) – SARA

***hordeaceus* L.** Sp. Pl.: 77. 1753 (= *B. hordeaceus* L. subsp. *hordeaceus*, *B. hordeaceus* var. *typicus* Beck, *B. molliformis* Lloyd, *B. mollis* L., *Serrafalcus mollis* Parl.): Struschka (1880) – SARA, W

***intermedius* Guss.** Fl. Sicul. Prodr. 1: 114. 1827 (= *B. intermedius* var. *polystachya* Vis., *B. modensis* Steud., *Serrafalcus intermedius* (Guss.) Parl.): Murbeck (1891)

***japonicus* Thunb.** Fl. Jap.: 52. 1784 (= *B. patulus* Mert. & W. D. J. Koch): Protić (1900b) – SARA

subsp. ***subsquarrosus* (Borbás) Pénzes** in Bot. Közlem. 33: 119. 1936: Prodan (1910) – SARA

***racemosus* L.** Sp. Pl., ed. 2, 1: 114. 1762 (= *B. mollis* var. *leptostachys* Pers.): Struschka (1880) – SARA

***secalinus* L.** Sp. Pl.: 76. 1753 (= *B. secalinus* var. *elongatus* (Gaudin) Asch. & Graebn., *Serrafalcus secalinus* Bab): Hofmann (1882) – SARA

***squarrosus* L.** Sp. Pl.: 76. 1753 (= *B. squarrosus* var. *gomboczii* Pénzes, *B. squarrosus* var. *puberulus* Beck, *B. squarrosus* var. *uberrimus* Murb., *B. squarrosus* var. *villosus* Koch, *B. squarrosus* var. *volgenis* (Jacq.) Pénzes): Struschka (1880) – SARA, GZU, LD, NL

subsp. ***danubialis* Pénzes** in Bot. Közlem. 33: 131. 1936 (= *B. wolgensis* Fisch. ex Jacq.) – SARA

CALAMAGROSTIS Adans. – šašuljica (reed grass)

***arundinacea* (L.) Roth** Tent. Fl. Germ. 2(1): 89. 1789 (= *C. montana* Host, *C. sylvatica* (Schrad.) DC): Freyn & Brandis (1888)

***epigejos* (L.) Roth** Tent. Fl. Germ. 1: 34. 1788 (= *C. epigejos* (L.) Roth subsp. *epigejos*): Murbeck (1891) – SARA

***pseudophragmites* (Haller f.) Koeler** Descr. Gram.: 106. 1802 (= *Arundo littorea* Schrad, *A. pseudophragmites* Hall. F. in Roem, *Calamagrostis laxa* Host., *C. littorea* P. Beauv.): Beck (1903) – SARA

***varia* (Schrad.) Host** Icon. Descr. Gram. Austriac. 4: 27. 1809 (= *C. montana* DC, *C. sylvatica* Host, *C. varia* (Schrad.) Host subsp. *varia*, *Deyeuxia varia* (Schrad.) Kunth): Vandas (1889) – SARA, NL

***villosa* (Chaix) J. F. Gmel.** Syst. Nat., ed. 13, 1: 172. 1791 (= *Agrostis villosa* Chaix in Vill., *Calamagrostis alpina* Host, *C. halleriana* Gaud., *C. pseudophragmites* Link., *C. villosa* var. *extrema* (Beck) Asch. & Graebn., *C. villosa* var. *mutica* Torges, *C. villosa* var. *nutans* (Saut. ex Rchb.) Asch. & Graebn.): Beck (1903) – SARA

CATABROSA P. Beauv. – slatka trava, metlušica (water whorlgrass)

***aquatica* (L.) P. Beauv.** Ess. Agrostogr.: 97. 1812 (= *C. aquatica* var. *uniflora* Gray): Beck (1903) – SARA

CATAPODIUM Link – ljuljolika, tvrdulja (fern-grass)

***marinum* (L.) C. E. Hubb.** in Kew Bull. 9: 375. 1954 (= *Catapodium loliaceum* (Huds.) Link, *Desmazeria loliacea* (Huds.) Nym, *D. loliacea* Nym, *D. marina* (L.) Druce, *Poa loliacea* Huds., *Scleropoa loliacea* Gren. & Godr., *Triticum rotboellia* DC, *T. unilaterale* All.): Beck (1903)

***rigidum* (L.) C. E. Hubb.** in Dony, Fl. Bedfordshire: 437. 1953 (= *Desmazeria rigida* (L.) Tutin, *Sclerochloa rigida* (L.) Link, *Scleropoa rigida* (L.) Griseb.): Vandas (1889) – SARA

CERATOCHLOA P. Beauv. (rescuegrass)

***cathartica* (Vahl) Herter** in Revista Sudamer. Bot. 6: 144. 1940 (= *Bromus catharticus* Vahl): Maslo (2012)

CHRYSOPOGON Trin. – kršin (goldbeard grass)

***gryllus* (L.) Trin.** Fund. Agrost.: 188. 1820 (= *Andropogon gryllus* L., *Polinia gryllus* Spreng.): Struschka (1880) – SARA

CLEISTOGENES Keng – krutovlatka

***serotina* (L.) Keng** in Sinensia 5: 149. 1934 (= *Diplachne serotina* (L.) Link, *Festuca serotina* L., *Molinia serotina* (L.) Mert. & W. D. J. Koch): Murbeck (1891) – SARA

CRYPSIS Aiton – trnika (pricklegrass)

***alopecuroides* (Piller & Mitterp.) Schrad.** Fl. Germ.: 167. 1806 (= *C. phalaroides* M. B., *Heleochloa alopecuroides* (Piller & Mitterp.) Host, *H. explicata* (Link) Hack., *Phalaris explicata* Link in Schrad, *P. geniculata* S. S., *Phleum alopecuroides* Pill. & Mitterp.): Struschka (1880) – SARA

CUTANDIA Willk.

(?) ***divaricata* (Desf.) Barbey** Fl. Sard. Comp., Suppl.: 193. 1884 (= *Scleropoa divaricata* (Desf.) Parl.): Svoboda (2012)

CYNODON Rich. – zubača (Bermuda grass)

***dactylon* (L.) Pers.** Syn. Pl. 1: 85. 1805 (= *Digitaria dactylon* (L.) Scop., *D. stolonifera* Schrad., *Fibichia dactylon* (L.) Beck, *F. umbellata* Koeler, *Panicum dactylon* L.): Struschka (1880) – SARA

CYNOSURUS L. – krestac (dogstail grass)

***cristatus* L.** Sp. Pl.: 72. 1753: Freyn & Brandis (1888) – SARA

***echinatus* L.** Sp. Pl.: 72. 1753: Freyn & Brandis (1888) – SARA

DACTYLIS L. – ježevica, pasja trava (orchard grass)

***glomerata* L.** Sp. Pl.: 71. 1753 (= *Bromus glomeratus* (L.) Scop., *Dactylis glomerata* var. *ciliata* Peterm., *D. glomerata* L. subsp. *euglomerata* Hayek, *D. glomerata* L. subsp. *glomerata*): Struschka (1880) – SARA

subsp. ***hispanica* (Roth) Nyman** Consp. Fl. Eur.: 819. 1882 (= *D. glomerata* var. *australis* Willk., *D. glomerata* var. *hispanica* (Roth) W. D. J. Koch, *D. glomerata* f. *maritima* Hack, *D. hispanica* Roth): Murbeck (1891) – SARA

(DD) subsp. ***lobata* (Drejer) H. Lindb.** in Oefvers. Förh. Finska Vetensk.-Soc. 38 (13): 9. 1906 (= *Dactylis aschersoniana* Graebn., *D. glomerata* var. *gracilis* Schur, *D. glomerata* var. *pendula* Dumort., *D. glomerata* var. *scabra* (W. Mann ex Opiz) Beck, *D. polygama* Horvat): Formanek (1890) – SARA, NL

DANTHONIA DC. – trozubica, šiljka (heathgrass)

***alpina* Vest** in Flora 4: 145. 1821 (= *Avena calycina* Vill., *A. stricta* Host., *Danthonia calycina* (Vill.) Rchb., *D. provincialis* DC.): Adamović (1889) – SARA, K

***decumbens* (L.) DC.** in Lamarck & Candolle, Fl. Franç., ed. 3, 3: 33. 1805 (= *Sieglingia decumbens* (L.) Bernh., *Triodia decumbens* (L.) P. Beauv.): Beck (1903) – SARA, K

DANTHONIASTRUM (Holub) Holub

***compactum* (Boiss. & Heldr.) Holub** in Folia Geobot. Phytotax. 5: 436. 1970 (= *Avena compacta* Boiss. & Heldr., *Avenastrum compactum* (Boiss. & Heldr.) Halácsy): Hayek (1933) – SARA

(EN) ***neumayerianum* (Vis.) Tzvelev** in Bot. Zhurn (Moscow & Leningrad) 94(4): 571. 2009 (= *Avena neumayeriana* Vis., *Avenastrum neumayerianum* Beck): Beck (1903) – SARA

***DASYPYRUM* (Coss. & Durieu) T. Durand – hajnaldija (mosquito grass)**

***villosum* (L.) P. Candargy** in Arch. Biol. Vég. (Athènes) 1: 35, 62. 1901 (= *Agropyrum villosum* (L.) Link, *Haynaldia villosa* (L.) Schur, *Secale villosum* L., *Triticum villosum* (L.) M. Bieb., *T. villosum* var. *glabratum* (Borbás) Asch. & Graebn.): Vandas (1889) – SARA

***DESCHAMPSIA* P. Beauv. – busika (hair grass)**

***cespitosa* (L.) P. Beauv.** Ess. Agrostogr.: 91. 1812 (= *Aira caespitosa* L., *Deschampsia cespitosa* var. *montana* (Schur) Vasey ex Beal, *D. cespitosa* var. *parviflora* Beck, *D. cespitosa* var. *setifolia* (W. D. J. Koch) Griseb., *D. caespitosa* var. *typica* Beck): Murbeck (1891) – SARA

***media* (Gouan) Roem. & Schult.** Syst. Veg. 2: 687. 1817 (= *Aira juncea* Vill., *A. media* Gouan, *Deschampsia juncea* (Vill.) P. Beauv.): Freyn & Brandis (1888) – SARA

***DIGITARIA* Haller – svračica (crabgrass)**

***aegyptiaca* (Retz.) Willd.** Enum. Pl.: 93. 1809 – SARA

***ciliaris* (Retz.) Koeler** Descr. Gram.: 27. 1802 (= *Digitaria sanguinalis* var. *ciliaris* Asch., *Panicum ciliare* Retz., *P. sanguinale* var. *ciliare* Retz): Freyn & Brandis (1888) – SARA

***ischaemum* (Schreb.) Muhl.** Descr. Gram.: 131. 1817 (= *D. filiformis* auct. non (L.) Koeler, *D. humifusa* Rich. in Pers., *Panicum filiforme* Garcke, *P. glabrum* (Schrad.) Gaudin, *P. humifusum* Kunth, *P. lineare* Krock., *Syntherisma glabrum* Schrad.): Murbeck (1891) – SARA

***sanguinalis* (L.) Scop.** Fl. Carniol., ed. 2, 1: 52. 1772 (= *D. sanguinalis* (L.) Scop subsp. *sanguinalis*, *Panicum sanguinale* L.): Brandis (1891) – SARA

subsp. ***pectiniformis* Henrard** in Blumea 1: 93. 1934 – SARA

***DRYMOCHLOA* Holub – vlasulja, vijuk (fescue)**

***drymeja* (Mert. & W. D. J. Koch) Holub** in Folia Geobot. Phytotax. 19: 99. 1984 (= *Festuca drymeja* Mert. & W. D. J. Koch, *F. montana* M. Bieb.): Conrath (1888) – SARA, S

***sylvatica* (Pollich) Holub** in Folia Geobot. Phytotax. 19: 99. 1984 (= *Festuca altissima* All., *F. silvatica* (Pollich) Vill., *Poa sylvatica* Pollich): Hayek (1933) – SARA

***ECHINOCHLOA* P. Beauv. – koštan (barnyard grass)**

***crus-galli* (L.) P. Beauv.** Ess. Agrostogr.: 53. 1812 (= *Panicum crus-galli* L.): Struschka (1880) – SARA

***oryzoides* (Ard.) Fritsch** in Verh. Zool.-Bot. Ges. Wien 41: 742. 1891 (= *E. crus-galli* f. *oryzoides* Fritsch): Slavnić & Bjelčić (1963)

***ELEUSINE* Gaertn. – eleuzina (goosegrass)**

***indica* (L.) Gaertn.** Fruct. Sem. Pl. 1: 8. 1788: Mišić (1998) – SARA

***ELYMUS* L. – pirika (couch grass)**

***caninus* (L.) L.** Fl. Suec., ed. 2: 39. 1755 (= *Agropyron caninum* (L.) P. Beauv., *A. caninum* f. *breviaristatum* Beck, *Triticum caninum* L.): Murbeck (1891) – SARA

***ELYTRIGIA* Desv. – pirika (couch grass)**

***atherica* (Link) Kerguélen** in Lejeunia, ser. 2, 120: 86. 1987 (= *Agropyron litorale* Dumort., *A. pungens* auct. non (Pers.) Roem. & Schult., *A. pycnanthum* Godr. & Gren.): Beck (1903) – SARA

***caespitosa* (K. Koch) Nevski** in Trudy Sredne-Aziatsk. Gosud. Univ., ser. 8b, Bot. 17: 61. 1934 (= *Agropyron caespitosum* K. Koch): Beck (1903)

subsp. ***nodosa* (Nevski) Tzvelev** in Novosti Sist. Vyš. Rast. 10: 30. 1973 (= *Elymus nodosus* (Nevski) Melderis) – W

***intermedia* (Host) Nevski** in Trudy Bot. Inst. Akad. Nauk SSSR, Ser. 1, Fl. Sist. Vyš. Rast. 1: 14. 1933 (= *Agropyron glaucum* Roem. & Schult., *A. intermedium* (Host) P. Beauv., *A. intermedium* subsp. *glaucum* (Roem. & Schult.) Asch. & Graebn., *Elymus hispidus* (Opiz) Melderis, *Triticum glaucum* Desf. ex DC, *T. intermedium* Host.): Freyn & Brandis (1888) – SARA, W

subsp. ***trichophora* (Link) Á. Löve & D. Löve** in Bot. Not. 114: 50. 1961 (= *Agropyron intermedium* subsp. *trichophorum* (Link) Asch. & Graebn., *Agropyrum savignonii* De Not, *Triticum glaucum* var. *villosum* Sadl., *T. intermedium* subsp. *trichophorum* Asch. & Graebn., *T. intermedium* var. *villosum* Hack., *T. trichophorum* Link): Murbeck (1891)

***pungens* (Pers.) Tutin** in Watsonia 2: 186. 1952 (= *Agropyrum acutum* Roem. & Schult., *Triticum acutum* DC, *T. pungens* Pers.): Murbeck (1891)

***repens* (L.) Nevski** in Trudy Bot. Inst. Akad. Nauk SSSR, ser. 1, Fl. Sist. Vyš. Rast 1: 14. 1933 (= *Agropyron repens* (L.) P. Beauv., *A. repens* var. *bromiforme* Schur, *A. repens* subsp. *caesium* (J. Presl & C. Presl) Rothm., *A. repens* var. *glaucum* (Döll) Maire, *A. repens* var. *littoreum* (Schumach.) Hegi, *Elymus repens* (L.) Gould, *E. repens* (L.) Gould subsp. *repens*, *Triticum repens* L., *T. repens* var. *maritimum* W. D. J. Koch & Ziz): Struschka (1880) – SARA, NL

***ERAGROSTIS* Wolf – kosmatka (lovegrass)**

***cilianensis* (All.) Janch.** in Mitt. Naturwiss. Vereins Wien 5(9): 110. 1907 (= *E. leersioides* Guss., *E. major* Host., *E. megastachya* (Koeler) Link, *E. megastachya* var. *cilianensis* (All.) Asch. & Graebn., *Poa megastachya* Koel.): Murbeck (1891) – SARA

***minor* Host** Icon. Descr. Gram. Austriac. 4: 15. 1809 (= *E. poaeoides* P. Beauv., *Poa eragrostis* L.): Vandas (1889) – SARA

***pilosa* (L.) P. Beauv.** Ess. Agrostogr.: 162. 1812 (= *Poa pilosa* L.): Hofmann (1882) – SARA

***FESTUCA* L. – vlasulja, vijuk (fescue)**

***alfrediana* Foggi et Signorini** subsp. ***durmitorea* D. Lakušić et Foggi** Bot. J. Linn. Soc. 170: 635 (2012): Milanović et al. (2015)

(o) ***alpina* Suter** Helvet. Fl. 1: 55. 1802 (= *Festuca malyi* Widder, *F. ovina* subsp. *alpina* (Suter) Hack., *F. ovina* (L.) var. *alpina* Koch): Beck (1903) – SARA

***amethystina* L.** Sp. Pl.: 74. 1753 (= *F. amethystina* L. subsp. *amethystina*, *F. austriaca* Hack, *F. inarmata* Schur): Boller (1892) – SARA

(o) subsp. ***kummeri* (Beck) Markgr.-Dann.** in Bot. J. Linn. Soc. 76: 326. 1978 (= *F. amethystina* L. subsp. *kummeri* Beck, *F. amethystina* var. *mutica* (Kumm. & Sendtn.) K. Maly, *F. violacea* var. *mutica* Kumm. & Sendt.): Beck (1903) – SARA

***arvernensis* Auquier et al.** in Lejeunia, ser. 2, 89: 15. 1977 (= *F. glauca* Lam. non Vill., *F. ovina* var. *glauca* Koch): Beck (1903)

(EN) ***bosniaca* Kumm. & Sendtn.** in Flora 32: 756. 1849 (= *F. bosniaca* Kumm. & Sendtn. subsp. *bosniaca*, *F. julica* Paulin, *F. pungens* Kit. non Lam., *F. pungens* Schult, *F. varia* var. *croatica* Hack., *F. varia* subsp. *pungens* (Kit.) Hegi, *F. varia* var. *pungens* Hack): Freyn & Brandis (1888) – SARA, GOET, W

(o) subsp. ***chlorantha* (Beck) Markgr.-Dann.** in Bot. J. Linn. Soc. 76: 326. 1978 (= *F. pungens* var. *chlorantha* Beck, *F. pungens* var. *flavescens* Kumm. & Sendtn. non Bell.): Beck (1903)

(?) ***circummediterranea* Patzke** in Oesterr. Bot. Z. 122: 261. 1974 (= *F. laevis* (Hack.) K. Richt): Svoboda (2012)

(VU) ***dalmatica* (Hack.) K. Richt.** Pl. Eur. 1: 95. 1890 (= *F. ovina* var. *dalmatica* Hack.): Formanek (1890) – SARA, W

***filiformis* Pourr.** in Mém. Acad. Sci. Toulouse 3: 319. 1788 (= *F. capillata* Lam., *F. ovina* var. *capillata* (Lam.) Hack., *F. tenuifolia* Sibth.): Beck (1903)

***flavescens* Bellardi** App. Fl. Pedem.: 11. 1792 (= *F. varia* Haenke var. *flavescens* (Bellardi) Hack.): Maly (1952)

***halleri* All.** Fl. Pedem. 2: 253. 1785 (= *F. sulcata* Hack. var. *hirsuta* (Host.) Beck.): Protić (1902) – SARA

(o) ***hercegovinica* Markgr.-Dann.** in Bot. J. Linn. Soc. 76: 323. 1978: Alegro (2006) – SARA, Z+ZT

***heteromalla* Pourr.** in Hist. & Mém. Acad. Roy. Sci. Toulouse 3: 319. 1788: Beck (1890)

***heterophylla* Lam.** Fl. Franç. 3: 600. 1779 (= *F. rubra* subsp. *heterophylla* Hack): Freyn & Brandis (1888) – SARA

(DD) (o) ***illyrica* Markgr.-Dann.** in Bot. Jahrb. Syst. 92: 151. 1972: Markgraf-Dannenberg (1973) – SARA

(?) ***jeanpertii* (St.-Yves) Markgr.** in Repert. Spec. Nov. Regni Veg. Beih. 30(3): 276. 1933: Svoboda (2012)

(VU) (o) ***korabensis* (Markgr.-Dann.) Markgr.-Dann.** in Bot. J. Linn. Soc. 76: 326. 1978 (= *F. violacea* var. *korabensis* Markgr.-Dann.): Markgraf-Dannenberg (1973) – SARA

***koritnicensis* Hayek & J. Vetter** in Denkschr. Kaiserl. Akad. Wiss., Wien. Math.-Naturwiss. Kl. (Wien) 99: 220. 1924: Svoboda (2012)

***laevigata* subsp. *crassifolia* (Gaudin) Kerguélen & Plonka** in Lejeunia, ser. 2, 142: 15. 1993 (= *F. duriuscula* subsp. *crassifolia* (Gaudin) K. Richt.): Beck (1903)

***longifolia* Thuill.** Fl. Env. Paris, ed. 2: 50. 1800: Maly (1952)

***nigrescens* Lam.** Encycl. 2: 460. 1788 (= *F. fallax* (Hack) Richt, *F. rubra* subsp. *commutata* (Gaudin) Markgr.-Dann., *F. rubra* L. var. *fallax* (Thuill.) Hack, *F. rubra* var. *nigrescens* (Lam.) Lam.): Freyn & Brandis (1888) – SARA

***nitida* Schult.** Oestr. Fl., ed. 2, 1: 239. 1814 (= *F. violacea* var. *minor* (Hack.) Dalla Torre & Sarnth., *F. violacea* var. *nítida* (Schult.) Hegi): Beck (1903)

(o) subsp. ***macrathera* (Hack.) Foggi & Signorini** in Willdenowia 35: 242. 2005 (= *F. macranthera* (Beck) Markgr.-Dann., *F. violacea* subsp. *macrathera* (Hack.) Markgr.-Dann., *F. violacea* var. *macrathera* Hack ex G. Beck, *F. violacea* Ser. ex Gaudin var. *macrathera* Hack.): Beck (1903) – SARA

***ovina* L.** Sp. Pl.: 73. 1753 (= *F. ovina* var. *vulgaris* W. D. J. Koch): Fiala (1896) – SARA

***pallens* Host** Icon. Descr. Gram. Austriac. 2: 63. 1802 (= *F. glauca* subsp. *pallens* (Host) K. Richt): Beck (1903)

(NT) ***panciciana* (Hack.) K. Richt.** Pl. Eur. 1: 96. 1890 (= *F. dalmatica* subsp. *panciciana* Hack., *F. ovina* var. *panciciana* Hack., *F. sulcata* var. *panciciana* Hack.): Formanek (1890) – SARA, WU

***picturata* Pils** in Pl. Syst. Evol. 136: 92. 1980 (= *F. picta* Schult.): Lakušić et al. (1969)

***quadriflora* Honck.** Verz. Gew. Teutschl.: 271. 1782 (= *F. pumila* Chaix, *F. pumila* Vill., *F. varia* subsp. *pumila* (Vill.) Hack): Protić (1902)

(EN) ***riloensis* (Hayek) Markgr.-Dann.** in Bot. J. Linn. Soc. 76: 327. 1978 (= *F. halleri* All. var. *riloensis* Hack., *F. halleri* subsp. *riloensis* Hayek): Hayek (1933) – SARA, WU

***rubra* L.** Sp. Pl.: 74. 1753 (= *F. duriuscula* L., *F. ovina* var. *duriuscula* Koch., *F. rubra* L. f. *barbata* (Schrk.) Hackel, *F. rubra* subsp. *duriuscula* Syme, *F. rubra* var. *genuina* Hack., *F. rubra* var. *planifolia* Hack., *F. rubra* L. subsp. *rubra*, *F. rubra* L. subsp. *vulgaris* (Gaudin) Hayek): Freyn & Brandis (1888) – SARA

subsp. ***juncea* (Hack.) K. Richt** Pl. Eur. 1: 99. 1890 (= *F. rubra* L. subsp. *juncea* (Hackel) Soo): Milanović et al. (2015)

***rupicaprina* (Hack.) A. Kern.** Sched. Fl. Exs. Austro-Hung. 3: 145. 1884 (= *F. rupicaprina* (Hack.) Nym): Maly (1928b)

***stenantha* (Hack.) K. Richt.** Pl. Eur. 1: 96. 1890 (= *F. ovina* subsp. *laevis* var. *stenantha* Hack): Beck (1903)

***stricta* Host** Icon. Descr. Gram. Austriac 2: 62. 1802 (= *F. valesiaca* subsp. *stricta* (Host) Hegi): Svoboda (2012) – SARA

subsp. ***sulcata* (Hack.) Pils** in Phyton 24(1): 49. 1984 (= *F. ovina* var. *hirsuta* Link, *F. ovina* subsp. *sulcata* Hack., *F. rupicola* Heuffel, *F. rupicola* Heuffel subsp. *rupicola*, *F. sulcata* (Hack.) Nyman, *F. sulcata* Hack. var. *barbulata* Hack, *F. sulcata* var. *genuina* Hackel): Freyn & Brandis (1888) – SARA

subsp. ***trachyphylla* (Hack.) Pils** in Phyton 24(1): 58. 1984 (= *F. duriuscula* L. var. *trachyphylla* Lam.): Maly (1920)

***trichophylla* (Gaudin) K. Richt.** Pl. Eur. 1: 100. 1890 (= *F. rubra* var. *trichophylla* Gaudin): Maly (1928b) – SARA

subsp. ***asperifolia* (St.-Yves) Al-Bermani** in Anales Jard. Bot. Madrid 50(2): 219. 1992 (= *F. rubra* subsp. *asperifolia* (St.-Yves) Markgr.-Dann.) – SARA

***vaginata* Willd.** Enum. Pl.: 116. 1809 (= *F. ovina* subsp. *vaginata* (Willd.) Čelak.): Beck (1903) – SARA

***valesiaca* Schleich. ex Gaudin** Agrost. Helv. 1: 242. 1811 (= *F. ovina* L. subsp. *valesiaca* (Schleich) Arcang, *F. ovina* var. *valesiaca* (Gaudin) Link, *F. ovina* L. var. *valesiaca* Koch.): Formanek (1890)

subsp. ***parviflora* (Hack.) Tracey** in Pl. Syst. Evol. 128: 291. 1977 (= *F. ovina* L. var. *pauciflora* Kumm. & Sendtn., *F. ovina* var. *pseudovina* Hack., *F. pseudovina* Hack. ex Wiesb.): Beck (1903) – SARA, W

***varia* Haenke** in Jacquin, Collecteana 2: 94. 1789 (= *F. varia* subsp. *eu-varia* Hack., *F. varia* subsp. *eu-varia* var. *genuina* Hack, *F. varia* var. *genuina* Gren. & Godr., *F. sudetica* Tausch ex Steud.): Boller (1892) – SARA

***violacea* Gaudin** in Alpina 3: 57. 1808 (= *F. ovina* var. *violacea* Koch, *F. rubra* subsp. *violacea* Hack, *F. violacea* var. *genuina* Hack.): Fiala (1896)

× *FESTULOLIUM* Asch. & Graebn.

***loliaceum* (Huds.) P. Fourn.** in Les Quatre Flores de la France 81. 1935. (= *Brachypodium pinnatum* (L.) P. B. var. *loliaceum* A. & G., *Festuca adscendens* Retz., *F. elatior* × *Lolium perenne*, *F. loliacea* Curt.): Hayek (1933)

***GASTRIDIUM* P. Beauv. – gnjidača (nit grass)**

***ventricosum* (Gouan) Schinz & Thell.** in Vierteljahrsschr. Naturf. Ges. Zürich 58: 39. 1913 (= *Agrostis ventricosa* Gouan., *Gastridium australe* P. Beauv., *G. lendigerum* (L.) Desv., *G. lendigerum* Gaud., *Milium lendigerum* L.): Fiala (1896) – SARA

***GLYCERIA* R. Br. – pirevina (mannagrass)**

***fluitans* (L.) R. Br.** Prodr.: 179. 1810 (= *Festuca fluitans* L., *Hydrochloa fluitans* Host.): Murbeck (1891) – SARA

***maxima* (Hartm.) Holmb**. in Bot. Not. 1919: 97. 1919 (= *G. aquatica* (L.) Wahlenb., *G. spectabilis* Mert & W. D. J. Koch, *Molinia maxima* Hartm., *Poa aquatica* L.): Protić (1902) – SARA

***notata* Chevall.** Fl. Gén. Env. Paris 2(1): 174. 1827 (= *G. plicata* (Fr.) Fr.): Formanek (1890) – SARA

(?) ***pedicellata* F. Towns.** in Ann. Mag. Nat. Hist., ser. 2, 5: 105. 1850: Svoboda (2012)

(?) ***spicata* Guss.** Fl. Sicul. Syn. 2: 784. 1845: Svoboda (2012)

***striata* (Lam.) Hitchc.** in Proc. Biol. Soc. Wash. 41: 157. 1928: Milanović et al. (2015)

***HELICTOCHLOA* Romero Zarco**

(NT) (o) ***blaui* (Asch. & Janka) Romero Zarco** in Candollea 66: 102. 2011 (= *Avena blaui* Asch. & Janka, *A. blavii* Aschers & Janka, *Avenastrum blavii* (Aschers & Janka) G. Beck, *Avenula blavii* (Asch. & Janka) W. Sauer & Cmel.): Murbeck (1891) – SARA, O, BPBM, CHAH, NL, TLMF

***planiculmis* (Schrad.) Romero Zarco** in Candollea 66: 102. 2011 (= *Avena planiculmis* Schrad., *Avenastrum planiculme* (Schrad.) Opiz, *Helictotrichon planiculme* (Schrad.) Pilger): Formanek (1890) – SARA

***pratensis* (L.) Romero Zarco** in Candollea 66: 103. 2011 (= *Avena alpina* Sm, *A. pratensis* L., *A. pratensis* subsp. *subdecurrens* Borb., *Avenastrum alpinum* Fritsch, *A. pratense* (L.) Opiz, *Helictotrichon pratense* (L.) Besser, *H. pratense* (L.) Pilger): Vandas (1889)

(NT) ***versicolor* (Vill.) Romero Zarco** in Candollea 66: 103. 2011 (= *Avena versicolor* Vill., *A. scheuchzeri* All., *Avenastrum versicolor* (Vill.) Fritsch): Beck (1903) – SARA

***HELICTOTRICHON* Besser (alpine oatgrass)**

***convolutum* (C. Presl) Henrard** in Blumea 3: 430. 1940: Maslo (2016a)

***filifolium* (Lag.) Henrard** in Blumea 3: 430. 1940 (= *Avenastrum filifolium* (Lag.) Fritsch): Beck (1903)

***HIEROCHLOË* R. Br. – darica (sweetgrass)**

***australis* (Schrad.) Roem. & Schult.** Syst. Veg. 2: 514. 1817 (= *Holcus australis* Schrad): Freyn & Brandis (1888) – SARA

***HOLCUS* L. – medunika (velvetgrass)**

***lanatus* L.** Sp. Pl.: 1048. 1753 (= *H. lanatus* L. var. *coloratus* Rchb., *H. lanatus* L. subsp. *lanatus*): Freyn & Brandis (1888) – SARA

***mollis* L.** Syst. Nat., ed. 10, 2: 1305. 1759: Freyn & Brandis (1888) – SARA

***HORDELYMUS* (Jess.) Harz – šumski ječam (wood-barley)**

***europaeus* (L.) Harz** Landw. Samenk. 2: 1147. 1885 (= *Cuviera europaea* (L.) Koeler, *Elymus europaeus* L., *Hordeum europaeum* (L.) All., *H. sylvaticum* Huds.): Brandis (1891) – SARA

***HORDEUM* L. – ječam (barley)**

***bulbosum* L.** Cent. Pl. 2: 8. 1756 (= *H. nodosum* Heria, *H. strictum* Desf.): Beck (1903)

***geniculatum* All.** Fl. Pedem. 2: 259, t. 91. 1785 (= *H. gussoneanum* Parl., *H. maritimum* subsp. *gussoneanum* (Parl.) Asch. & Graebn.): Maly (1908) – SARA

***marinum* Huds.** Fl. Angl., ed. 2, 1: 57. 1778 (= *H. maritumum* With.): Maly (1928b) – SARA

***murinum* L.** Sp. Pl.: 85. 1753 (= *H. murinum* f. *major* Gren. & Godr., *H. pseudomurinum* Tapp. in Koch): Struschka (1880)

(?) subsp. ***glaucum* (Steud.) Tzvelev** in Novosti Sist. Vyš. Rast. 8: 67. 1971: Svoboda (2012)

subsp. ***leporinum* (Link) Arcang.** Comp. Fl. Ital.: 805. 1882 (= *H. leporinum* Link): Maly (1927) – SARA

***secalinum* Schreb.** Spic. Fl. Lips.: 148. 1771 (= *H. pratense* Huds.): Protić (1902) – SARA

(cult) ***vulgare* L.** Sp. Pl.: 84. 1753 (= *H. hexastichum* L., *H. polystichon* Haller f., *H. sativum* Jessen, *H. sativum* subsp. *hexastichon* (L.) K. Richt, *H. sativum* Jessen subsp. *polystichum* var. *tetrastichum*, *H. sativum* var. *vulgare* (L.) K. Richt, *H. vulgare* subsp. *hexastichon* (L.) Čelak, *H. vulgare* var. *medicum* Korn.): Struschka (1880) – SARA, SINGER, VIR, USNPGS

(cult) subsp. ***distichon* (L.) Körn.** in Zeit. Ges. Brauw. 5: 125. 1882 (= *H. aestivum* Haller, *H. distichon* L., *H. vulgare* var. *distichon* (L.) Hack, *H. vulgare* var. *nutans* (Schubl & Martens) Alef.): Brandis (1891) – SARA, SINGER, VIR

***HYPARRHENIA* E. Fourn. – oštra vlaska (thatching grass)**

***hirta* (L.) Stapf** in Prain, Fl. Trop. Afr. 9: 315. 1919 (= *Cymbopogon hirtus* (L.) Thomson) – SARA

***KOELERIA* Pers. – smilica (Junegrass)**

***australis* A. Kern.** in Oesterr. Bot. Z. 17: 8. 1867 (= *K. australis* A. Kern f. *glabra* G. Beck, *K. splendens* Presl var. *canescens* (Vis.) G. Beck): Formanek (1890) – SARA

***eriostachya* Pančić** in Verh. Zool.-Bot. Ges. Wien 6: 591. 1856 (= *K. eriostachya* var. *carniolica* (A. Kern.) Domin, *K. eriostachya* var. *carniolica* (Kern) f. *glabriflora* Dom, *K. grandiflora* Pančić non Bertol): Maly (1928a) – SARA

***lobata* (M. Bieb.) Roem. & Schult.** Syst. Veg. 2: 620. 1817 (= *K. subaristata* (Pančić) Domin): Lakušić et al. (1987b)

***macrantha* (Ledeb.) Schult.** Mant. 2: 345. 1824 (= *Aira cristata* L., *Koeleria cristata* Pers., *K. gracilis* Pers., *K. gracilis* var. *borbasii* Domin, *K. cristata* var. *glabra* Regel, *K. gracilis* var. *aspera* Domin., *K. gracilis* f. *glabrescens* Domin, *K. cristata* var. *grandiflora* Pers.): Murbeck (1891) **–** SARA, W

***pyramidata* (Lam.) P. Beauv.** Ess. Agrostogr.: 84. 1812 (= *K. ciliata* Kern in Baen, *K. cristata* (L.) Pers, *K. pyramidata* subsp. *pyramidata* Domin): Protić (1900b)

subsp. ***montana* (Hausm.) Domin** in Biblioth. Bot 14 (65): 153. 1907 (= *K. cristata* var. *montana* Hausm., *K. montana* (Hausm.) Dalla Torre): Maly (1904) **–** SARA

***splendens* C. Presl** Gramin. Sicul.: 18. 1818 (= *K. bivestita* Schur, *K. crasipes* Freyn non Lange, *K. gracilis* Haussk non Pers., *K. grandiflora* Bert., *K. splendens* var. *pseudorigidula* Domin): Freyn & Brandis (1888) **–** SARA

subsp. ***grandiflora* (Bertol. ex Schult.) Domin** in Magyar Bot. Lapok 3: 277. 1904 (= *K. cristata* var. *argentea* Beck, *K. grandiflora* Bertol. ex Schult., *K. splendens* var. *bosniaca* Domin, *K. splendens* var. *grandiflora* Bert.): Freyn & Brandis (1888) **–** SARA

***subcaudata* (Asch. & Graebn.) Ujhelyi** in Ann. Hist.-Nat. Mus. Natl. Hung. 56: 197. 1964 (= *K. australis* Kern var. *glabra* Beck, *K. splendens* subsp. *subcaudata* (Asch. & Graebn.) Domin): Janchen & Waltz (1908) **–** SARA

LAGURUS L. – zečji rep (hare's-tail)

***ovatus* L.** Sp. Pl.: 81. 1753: Protić (1902) **–** SARA

LEERSIA Sw. – tajnica, divlja riža (cutgrass)

***oryzoides* (L.) Sw.** Prodr.: 21. 1788 (= *Homalocenchrus oryzoides* (L.) Pollich, *Oryza clandestina* A. Br., *Phalaris oryzoides* L.): Conrath (1888) **–** SARA, S

LEUCOPOA Griseb. – vlasulja, vijuk (fescue)

***pulchella* (Schrad.) H. Scholz & Foggi** in Willdenowia 35: 243. 2006 (= *Festuca pulchella* Scrad, *F. scheuzeri* Gaudin) **–** SARA

***spectabilis* (Bertol.) H. Scholz & Foggi** in Willdenowia 35: 243. 2006 (= *Festuca coarctata* (Hack.) Beck, *F. nemorosa* Fritsch, *F. sieberi* Tausch., *F. spadicea* var. *nemorosa* Poll., *F. spectabilis* Bertol., *F. spectabilis* Jan., *F. spectabilis* var. *coarctata* Hack): Beck (1903) **–** SARA

subsp. ***affinis* (Hack.) H. Scholz & Foggi** in Willdenowia 35: 243. 2005 (= *Festuca affinis* Hack., *F. affinis* Boiss & Heldr. f. *croatica* A. Kern, *F. croatica* Pichl., *F. spectabilis* subsp. *affinis* (Boiss. & Heldr. ex Hack.) Hack): Beck (1903)– SARA

subsp. ***carniolica* (Hack.) H. Scholz & Foggi** in Willdenowia 35: 243. 2005 (= *Festuca spectabilis* var. *carniolica* Hack.): Murbeck (1891)

subsp. ***croatica* (A. Kern.) Foggi, Parolo, Gr. Rossi, Ardenghi & Quercioli** in Inform. Bot. Ital. 42: 351. 2010 (= *Festuca affinis* Boiss & Heldr. subsp. *croatica* (Hack) Richt, *F. affinis* Boiss & Heldr. var *croatica* Hack, *F. croatica* A. Kern., *F. spectabilis* Jan var. *croatica* Kern): Murbeck (1891) **–** SARA

LOLIUM L. – ljulj (ryegrass)

***multiflorum* Lam.** Fl. Franç. 3: 621. 1778 Fl. Franç. 3: 621. 1778 (= *L. aristatum* Lag., *L. multiflorum* subsp. *italicum* A. Braun, *L. multiflorum* f. *longiaristatum* Asch. & Graebn., *L. multiflorum* var. *muticum* DC., *L. multiflorum* var. *ramosum* Guss. ex Arcang., *L. perenne* var. *aristatum* Willd.): Freyn & Brandis (1888) **–** SARA

***perenne* L.** Sp. Pl.: 83. 1753 (= *L. perenne* L. subsp. *perenne*, *L. perenne* var. *ramosum* Sm, *L. perenne* var. *tenue* (L.) Huds., *L. vulgare* Host.): Struschka (1880) **–** SARA, W

***remotum* Schrank** Baier. Fl. 1: 382. 1789: Maly (1908) **–** SARA

***rigidum* Gaudin** Agrost. Helv. 1: 334. 1811 (= *L. strictum* C. Presl): Šilić & Abadžić (1987)

subsp. ***lepturoides* Sennen & Mauricio** Cat. Fl. Rif Orient.: 135. 1933 (= *L. lepturoides* Boiss, *L. loliaceum* (Bory & Chaub) Hand.-Mazz., *L. rigidum* var. *lepturoides* Haussk, *L. rigidum* var. *loliaceum* Hal., *L. rigidum* var. *rotboelloides* Heldr. in Boiss, *Rotboellia loliacea* Bory & Chaub): Hayek (1933)

(o) ***subulatum* Vis.** Fl. Dalmat. 1: 90. 1842: Maly (1912) **–** SARA

***temulentum* L.** Sp. Pl.: 83. 1753 (= *L. arvense* With., *L. robustum* Rchb., *L. temulentum* subsp. *arvense* (With.) Tzvelev, *L. temulentum* var. *arvense* (With) Ljilj., *L. temulentum* var. *leptochaeton* A. Braun, *L. temulentum* var. *macrochaeton* A. Braun, *L. temulentum* var. *typicum* Beck): Struschka (1880) **–** SARA, NL

MELICA L. – mekuš (melic grass)

***altissima* L.** Sp. Pl.: 66. 1753: Protić (1902)

***ciliata* L.** Sp. Pl.: 66. 1753 (= *M. ciliata* L. subsp. *ciliata*, *M. ciliata* L. var. *linnaei* Hack., *M. ciliata* var. *linnaei* Halacsy & Braun, *M. ciliata* subsp. *nebrodensis* (Parl.) Husn., *M. nebrodensis* Parl., *M. ciliata* L. subsp. *nevesinjensis* W. Hempel, *M. ciliata* var. *typica* Beck): Struschka (1880) **–** SARA, GZU, S, NL

(?) ***minuta* L.** Mant. Pl. 1: 32. 1767: Svoboda (2012)

***nutans* L.** Sp. Pl.: 66. 1753 (= *M. montana* Huds.): Freyn & Brandis (1888) **–** SARA

***transsilvanica* Schur** in Verh. Siebenb. Ver. Naturw. 4: 86. 1853 (= *M. ciliata* subsp. *transsilvanica* (Schur) Husn., *M. ciliata* var. *transsilvanica* Schur): Beck (1903) **–** W

***trebinjensis* Strobl** in Linnaea 62: 185. 1879 (= *M. ciliata* f. *trebinjensis* Strobl, *M. nebrodensis* f. *trebinjensis* Strobl.): Beck (1903)

***uniflora* Retz.** Observ. Bot. 1: 10. 1779: Freyn & Brandis (1888) **–** SARA

MILIUM L. – prosulja, divlje proso (wood millet)

***effusum* L.** Sp. Pl.: 61. 1753 (= *M. confertum* L., *M. effusum* f. *confertum* L., *M. effusum* var. *violaceum* Holler): Vandas (1889) **–** SARA

MISCANTHUS Andersson – kineski šaš (silvergrass)

(cult) ***sinensis* Andersson** in Öfvers. Förh. Kongl. Svenska Vetensk.-Akad. 12: 166. 1855: Maslo et al. (2019)

***MOLINIA* Schrank – beskoljenka (moor grass)**

***arundinacea* Schrank** Baier. Fl. 1: 336. 1789 (= *M. caerulea* L. subsp. *arundinacea* (Sch) H. K. G. Paul, *M. caerulea* var. *litoralis* (Host) Griseb., *M. litoralis* Host.): Freyn & Brandis (1888) – SARA

***caerulea* (L.) Moench** Methodus: 183. 1794 (= *Aira caerulea* L., *Molinia altissima* Link, *M. caerulea* var. *arundinacea* (Schrank) Asch., *M. varia* Schrank): Conrath (1888) – SARA

***MOOROCHLOA* Veldkamp**

***eruciformis* (Sm.) Veldkamp** in Reinwardtia 12: 139. 2004 (= *Echinochloa eruciformis* Rchb., *Panicum eruciforme* Sibth & Sm.): Vandas (1889) – SARA

***NARDUS* L. – tvrdača (matgrass)**

***stricta* L.** Sp. Pl.: 53. 1753: Formanek (1890) – SARA

***OCHLOPOA* (Asch. & Graebn.) H. Scholz – vlasnjača, livadarka (meadow grass)**

***annua* (L.) H. Scholz** in Ber. Inst. Landschafts-Pflanzenökologie Univ. Hohenheim, Beih. 16: 58. 2003 (= *Poa annua* L.): Struschka (1880) – SARA

***supina* (Schrad.) H. Scholz & Valdés** in Willdenowia 36: 662. 2006 (= *Poa annua* subsp. *supina* (Schrad.) Link, *P. annua* subsp. *varia* Gaudin, *P. supina* Schrad.): Maly (1928b) – SARA

***ORYZA* L. – riža (rice)**

(cult) ***sativa* L.** Sp. Pl.: 333. 1753: Fiala (1892b)

***PANICUM* L. – proso (millet)**

***capillare* L.** Sp. Pl.: 58. 1753: Slavnić (1956) – SARA

***dichotomiflorum* Michx.** Fl. Bor.-Amer. 1: 48. 1803: Maslo & Šarić (2016)

(cult) ***miliaceum* L.** Sp. Pl.: 58. 1753: Struschka (1880) – SARA

***repens* L.** Sp. Pl., ed. 2, 1: 87. 1762: Hayek (1933) – SARA

***riparium* H. Scholz** in Feddes Repert. 113: 275. 2002: Nobis et al. (2016)

***PARVOTRISETUM* Chrtek – zobika, ovsika (oatgrass)**

***myrianthum* (Bertol.) Chrtek** in Preslia 37: 201. 1965 (= *Trisetum myrianthum* (Bertol.) Parl.): Beck (1903) – SARA

***PASPALUM* L. – paspalum (knotgrass)**

***dilatatum* Poir.** in Lamarck, Encycl. 5: 35. 1804: Šilić & Abadžić (2000)

***distichum* L.** Syst. Nat., ed. 10, 2: 855. 1759 (= *P. distichum* subsp. *paspalodes* (Michx.) Thell., *P. paspaloides* (Michx.) Scribn.): Bajić (1954) – SARA

***PATZKEA* G. H. Loos – vlasulja, vijuk (fescue)**

***paniculata* (L.) G. H. Loos** in Jahrb. Bochum. Bot. Vereins 1: 126. 2010 (= *Anthoxanthum paniculatum* L., *Festuca aurea* Lam., *F. fibrosa* Griseb, *F. paniculata* (L.) Schinz & Thell, *F. spadicea* L., *F. spadicea* var. *aurea* Lam., *F. spadicea* var. *fibrosa* Griseb): Beck (1897) – SARA, G

***PHALARIS* L. – svjetlica (canary grass)**

***aquatica* L.** Cent. Pl. 1: 4. 1755: Maslo (2014b)

***canariensis* L.** Sp. Pl.: 54. 1753: Hofmann (1882) – SARA

***paradoxa* L.** Sp. Pl., ed. 2, 2: 1665. 1763 (= *Ph. sibthorpii* Griseb.): Boller (1892)

***PHALAROIDES* Wolf – blještac (reed canary grass)**

***arundinacea* (L.) Rauschert** in Feddes Repert. 79: 409. 1969 (= *Baldingera arundinacea* (L.) Dumort., *B. colorata* (Aiton) P. Gaertn, B. Mey & Scherb, *Digraphis arundinacea* (L.) Trin., *Phalaris arundinacea* L., *Typhoides arundinacea* (L.) Moench): Beck (1903) – SARA

***PHLEUM* L. – mačica, mačiji repak (timothy, cat's-tail)**

(VU) ***alpinum* L.** Sp. Pl.: 59. 1753 (= *Ph. alpinum* var. *commutatum* Gaud, *Ph. commutatum* Gaud., *Ph. pratense* L. subsp. *alpinum* (L.) Asch. & Graebn; *Ph. subalpinum* Brügger): Freyn & Brandis (1888) – SARA

***echinatum* Host** Icon. Descr. Gram. Austriac. 3: 8. 1805 (= *Ph. felinum* Sm.): Struschka (1880) – SARA

***exaratum* Griseb.** Spic. Fl. Rumel. 2: 463. 1844 (= *Ph. graecum* Boiss. & Heldr.): Hayek (1933)

***hirsutum* Honck.** Verz. Gew. Teutschl. 1: 183. 1782 (= *Ph. michelii* All., *Ph. michelii* var. *subincrassatum* Griseb.): Murbeck (1891) – SARA

***nodosum* L.** Syst. Nat., ed. 10, 2: 871. 1759 (= *Ph. bertolonii* DC., *Ph. bulbosum* Host, *Ph. pratense* subsp. *bertolonii* (DC.) Bornm., *Ph. pratense* L. var. *bertolonii* DC, *Ph. pratense* var. *nodosum* (L.) Schreb.): Murbeck (1891) – SARA

***paniculatum* Huds.** Fl. Angl.: 23. 1762 (= *Ph. asperum* Vill., *Ph. asperum* Jacq., *Phalaris aspera* Retz, *Chilochloa aspera* Beauv.): Protić (1902) – SARA

***phleoides* (L.) H. Karst.** Deut. Fl.: 374. 1881 (= *Ph. boehmeri* Wibel., *Ph. phalarioides* Koeler, *Phalaris phleoides* L., *Chilochloa boehmeri* P. Beauv.): Freyn & Brandis (1888) – SARA

***pratense* L.** Sp. Pl.: 59. 1753 (= *Ph. pratense* L. subsp. *pratense*, *Ph. pratense* subsp. *vulgare* Asch. & Graebn.): Freyn & Brandis (1888) – SARA

***rhaeticum* (Humphries) Rauschert** in Feddes Repert. 90: 399. 1979 – SARA

***subulatum* (Savi) Asch. & Graebn.** Syn. Mitteleur. Fl. 2(1): 154. 1899 (= *Phalaris bellardi* Willd., *Ph. sativa* Pers., *Ph. subulata* Savi, *Phleum bellardi* Willd, *Ph. tenue* (Host) Schrad.): Struschka (1880) – SARA

subsp. ***ciliatum* (Boiss.) Humphries** in Bot. J. Linn. Soc. 76: 339. 1978 (= *Ph. tenue* var. *ciliatum* Boiss.): Murbeck (1891)

***PHRAGMITES* Adans. – trska (reed)**

***australis* (Cav.) Steud.** Nomencl. Bot., ed. 2, 2: 324. 1841 (= *Arundo phragmites* L., *Czernya arundinacea* C. Presl, *Phragmites australis* (Cav.) Steud. subsp. *australis*, *Ph. communis* Trin., *Ph. vulgaris* Samp.): Struschka (1880) – SARA

***PIPTATHERUM* P. Beauv. – šćevar (ricegrass)**

***holciforme* (M. Bieb.) Roem. & Schult.** Syst. Veg. 2: 328. 1817 (= *Agrostis holciformis* M. Bieb., *Oryzopsis holciformis* (M. Bieb.) Hack.): Maly (1908) – NL

***miliaceum* (L.) Coss.** Notes Pl. Crit. 2: 129. 1851 (= *Agrostis miliacea* L., *A. oseroensis* Seenus, *Milium multiflorum* Cav., *Oryzopsis miliacea* (L.) Asch. & Schweinf, *Piptatherum miliaceum* (L.) Coss. subsp. *miliaceum*, *P. multiflorum* (Cav.) P. Beauv.): Struschka (1880)

subsp. ***thomasii* (Duby) Freitag** in Notes Roy. Bot. Gard. Edinburgh 33: 363. 1975 (= *P. miliaceum* (L.) Coss. subsp. *thomasii* (Duby) Sojak): Maslo (2014b) – SARA

***virescens* (Trin.) Boiss.** Fl. Orient. 5: 507. 1884 (= *Milium paradoxum* L., *M. paradoxum* Scop., *Oryzopsis virescens* (Trin.) Beck, *Piptatherum paradoxum* Koch, *P. paradoxum* (L.) P. Beauv., *Urachne virescens* Trin.): Conrath (1888) – SARA

***POA* L. – vlasnjača, livadarka (meadow-grass)**

***alpina* L.** Sp. Pl.: 67. 1753 (= *P. alpina* L. subsp. *alpina*, *P. alpina* var. *typica* Beck, *P. alpina* var. *vivipara* L., *P. subalpina* Schur): Freyn & Brandis (1888)

subsp. ***brevifolia* Gaudin** Fl. Helv. 1: 245. 1828 (= *P. alpina* var. *brevifolia* (DC) Gaudin): Beck (1903) – SARA, NL

***angustifolia* L.** Sp. Pl.: 67. 1753 (= *P. pratensis* var. *angustifolia* L., *P. pratensis* var. *strigosa* (Hoffm.) Gaudin): Freyn & Brandis (1888) – SARA

***badensis* Willd.** Sp. Pl. 1: 392. 1797 (= *P. alpina* subsp. *badensis* (Willd.) Beck): Formanek (1890)

***bulbosa* L.** Sp. Pl.: 70. 1753 (= *P. bulbosa* var. *colorata* Hack. ex Asch. & Graebn., *P. bulbosa* subsp. *vivipara* (Koeler) Arcang., *P. vivipara* (Koeler) Willd.): Struschka (1880) – SARA

***cenisia* All.** Auct. Fl. Pedem. 40. 1789 (= *P. distichophylla* Gaudin., *P. flexuosa* Host., *P. oreophila* Boiss & Heldr, *P. psychrophila* Boiss & Heldr): Beck (1897) – SARA

***chaixii* Vill.** Fl. Delph.: 7. 1786 (= *P. silvatica* Chaix, *P. sudetica* Haenke): Zawodny (1897) – SARA

***compressa* L.** Sp. Pl.: 69. 1753 (= *P. compressa* var. *langiana* (Rchb) Koch, *P. langiana* Rchb): Freyn & Brandis (1888) – SARA

***glauca* Vahl** in Oeder, Fl. Dan. 6 (17): 3. 1790 (= *P. caesia* Sm.): Beck (1903) – SARA

***hybrida* Gaudin** in Alpina 3: 46. 1808: Protić (1902) – SARA

(?) ***jubata* A. Kern.** in Oesterr. Bot. Z. 23: 6. 1873 (= *P. grimburgii* Hack.): Svoboda (2012)

***media* Schur** in Verh. Mitth. Siebenbürg. Vereins Naturwiss. Hermannstadt 4 (Sert. Fl. Transs.): 87. 1853 (= *P. ursina* Velen): Horvat & Pawlowski (1939)

(VU) ***minor* Gaudin** in Alpina 3: 44. 1808 (= *P. laxa* subsp. *minor* (Gaudin) Hook. f., *P. pyrenaica* Lange): Beck (1903) – SARA

***molinerii* Balb.** Elenco: 85. 1801: Maly (1952)

***nemoralis* L.** Sp. Pl.: 69. 1753 (= *P. montana* All, *P. nemoralis* var. *agrostoides* Asch. & Graebn., *P. nemoralis* var. *glauca* Gaudin, *P. nemoralis* f. *glauca* Koch., *P. nemoralis* L. subsp. *nemoralis*): Freyn & Brandis (1888)

***palustris* L.** Syst. Nat., ed. 10, 2: 874. 1759 (= *P. fertilis* Host, *P. serotina* Ehrh.): Struschka (1880)

***perconcinna* J. R. Edm.** in Bot. J. Linn. Soc. 76: 330. 1978 (= *P. bulbosa* var. *concinna* Posp., *P. bulbosa* L. var. *pseudoconcinna* (Schur) Asch. & Graebn., *P. carniolica* auct. non Hladn. & Graf., *P. concinna* Gaud.): Beck (1903) – SARA

***pratensis* L.** Sp. Pl.: 67. 1753 (= *P. attica* Boiss. & Heldr., *P. pratensis* var. *anceps* Gaudin, *P. pratensis* L. subsp. *angustifolia* (L.) Hay f. *setacea* (Hoffm.) Doll., *P. pratensis* L. subsp. *pratensis*, *P. pratensis* f. *setacea* Doll, *P. pratensis* var. *vivipara* (Malmgr.) Boivin, *P. pratensis* subsp. *vulgaris* Gaudin): Freyn & Brandis (1888) – SARA

subsp. ***irrigata* (Lindm.) H. Lindb** in Sched. Pl. Finl. Exs. 2: 20. 1916 (= *P. pratensis* var. *latifolia* Weihe ex Mertens & Koch) – SARA

(VU) ***pumila* Host** Fl. Austriac. 1: 146. 1827 (= *P. alpina* L. subsp. *parnassica* (Boiss.) K. Richt., *P. alpina* var. *pumila* (Host) Rchb, *P. thessala* Boiss. & Orph): Adamović (1889) – SARA

***stiriaca* Fritsch & Hayek** in Jahreskat. Wiener Bot. Tauschvereins 1904: 226. 1904: Maly (1938) – SARA

***trivialis* L.** Sp. Pl.: 67. 1753 (= *P. trivialis* var. *glabra* Döll, *P. trivialis* L. subsp. *trivialis*): Freyn & Brandis (1888) – SARA, MHNH

subsp. ***sylvicola* (Guss.) H. Lindb.** in Oefvers. Förh. Finska Vetensk.-Soc. 38(13): 9. 1906 (= *P. attica* Freyn, *P. sylvicola* Guss.): Maly (1912) – SARA

***POLYPOGON* Desf. – bradica (beard-grass)**

***monspeliensis* (L.) Desf.** Fl. Atlant. 1: 67. 1798 (= *Alopecurus monspeliensis* L., *Phleum crinitum* Schreb.): Beck (1903) – SARA

***viridis* (Gouan) Breistr.** in Bull. Soc. Bot. France 110 (Sess. Extr.): 56. 1966: Maslo & Šarić (2018b)

***PSILURUS* Trin. – šćetinac (bristle-tail grass)**

***incurvus* (Gouan) Schinz & Thell.** in Vierteljahrsschr. Naturf. Ges. Zürich 58: 40. 1933 (= *Nardus aristatus* L., *Psilurus aristatus* (L.) Duval-Jouve, *P. nardoides* Trin.): Maly (1909) – SARA

***PUCCINELLIA* Parl. – bezbridnjača (alkali grass)**

***distans* (Jacq.) Parl.** Fl. Ital. 1: 367. 1850 (= *Atropis distans* (L.) Griseb., *Festuca distans* Kunth., *Glyceria distans* (L.) Wahlenb., *Poa distans* L.): Protić (1900a)

***festuciformis* (Host) Parl.** Fl. Ital. 1: 368. 1850 (= *Atropis festuciformis* Host, *A. palustris* (Seenus) Briq., *Poa palustris* (Seenus) Hayek, *P. teyberi* Hayek, *Puccinellia festuciformis* (Host) Parl. subsp. *festuciformis*): Beck (1903)

***ROSTRARIA* Trin. – smilica (hairgrass)**

***cristata* (L.) Tzvelev** in Novosti Sist. Vyš. Rast. 7: 47. 1971 (= *Festuca cristata* L., *F. phleoides* Vill., *Koeleria dactyloides* Spr., *K. gracilis* Hausskn non Pers., *K. grandiflora* Bertol, *K. phleoides* (Vill.) Pers., *K. phleoides* f. *exilis* Domin, *K. phleoides* var. *glabriflora* Trautv., *Lophochloa cristata* (L.) Hyl., *L. phleoides* (Vill.) Rchb): Murbeck (1891) – SARA

***SCHEDONORUS* P. Beauv. – vlasulja, vijuk (fescue)**

***arundinaceus* (Schreb.) Dumort**. Observ. Gramin. Belg: 106. 1824 (= *Bromus arundinaceus* (Schreb.) Roth, *Festuca arundinacea* Schreb, *F. arundinacea* Schreb. subsp. *arundinacea*, *F. elatior* subsp. *arundinacea* (Schreb.) Hack., *F. elatior* L. var. *pseudololiacea* Fries, *F. pratensis* Huds. var. *subspicata* Meyer, *F. pseudololiacea* Fries var. *loliacea* Kumm. & Sendtn.): Freyn & Brandis (1888) – SARA

***giganteus* (L.) Holub** in Preslia 70: 113. 1998 (= *Bromus giganteus* L., *Festuca gigantea* (L.) Vill.): Conrath (1888) – SARA

***pauneroi* (Cebolla et al.) H. Scholz** in Willdenowia 35: 243. 2006 (= *Festuca arundinacea* var. *glaucescens* Boiss.) – SARA

***pratensis* (Huds.) P. Beauv.** Ess. Agrostogr.: 99. 1812 (= *Festuca elatior* L., *F. elatior* subsp. *pratensis* (Huds.) Hack., *F. pratensis* Huds., *F. pratensis* Huds. var. *genuina* Hack, *F. pratensis* var. *subspicata* (G. Mey.) Asch. & Graebn.): Freyn & Brandis (1888) – SARA

***SCLEROCHLOA* P. Beauv. – tvrdika (hardgrass)**

***dura* (L.) P. Beauv.** Ess. Agrostogr.: 98. 1812 (= *Cynosurus durus* L. *Poa dura* (L.) Scop.): Protić (1900) – SARA

***SECALE* L. – raž (rye)**

(cult) ***cereale* L.** Sp. Pl.: 84. 1753 (= *S. cereale* L. var. *aestivum*, *S. cereale* subsp. *cereale*): Struschka (1880) – SARA, USNPGS

***strictum* (C. Presl) C. Presl** Fl. Sicul.: XLVI. 1826 (= *S. cereale* f. *montanum* Guss., *S. dalmaticum* Vis., *S. montanum* Guss.): Beck (1903)

***SESLERIA* Scop. – šašika (moor-grass)**

***autumnalis* (Scop.) F. W. Schultz** Arch. Fl.: 296. 1861 (= *Phleum autumnale* Scop., *Sesleria argentea* (Savi) Savi, *S. auctumnalis* (Scop.) Kern., *S. cylindrica* DC, *S. elongata* Host): Conrath (1888) – SARA

***caerulea* (L.) Ard.** Animadv. Bot. Spec. Alt.: 18. 1764 (= *Cynosurus caeruleus* L., *Sesleria albicans* Schult, *S. caerulea* subsp. *calcarea* (Čelak.) Hegi, *S. caerulea* subsp. *uliginosa* (Opiz) Čelak, *S. caerulea* subsp. *varia* (Jacq) Hayek, *S. varia* Wettst.): Protić (1900b)

(o) subsp. ***angustifolia* (Hack. & Beck) Jogan** in Hladnikia 11: 21. 2001 (= *S. albicans* subsp. *angustifolia* (Hack. & Beck) Deyl, *S. angustifolia* (Hack. & Beck) Deyl., *S. caerulea* (L.) var. *angustifolia* Hack. & Beck): Beck (1903) – SARA

***coerulans* Friv.** in Flora 19: 438. 1836 (= *S. marginata* Gris.): Fiala (1891)

(?) ***insularis* Sommier** in Bull. Soc. Bot. Ital. 1905: 126. 1905 (= *S. corsica* (Hack.) Ujhelyi): Svoboda (2012)

(o) subsp. ***sillingeri* (Deyl) Deyl** in Bot. J. Linn. Soc. 76: 364. 1978 (= *S. sillingeri* Deyl): Svoboda (2012) – SARA

***juncifolia* Suffren** Principes Bot.: 113. 1802 (= *S. interrupta* Vis., *S. juncifolia* subsp. *interrupta*, *S. tenuifolia* Schrad., *S. tenuifolia* Schrad. subsp. *tenuifolia*, *S. tenuifolia* var. *juncifolia* (Suffren) Marchesetti): Freyn & Brandis (1888)

(o) subsp. ***kalnikensis* (Jav.) Jogan** in Hladnikia 11: 26. 2001 (= *S. tenuifolia* Schad. subsp. *kalnikensis* (Jav.) Deyl): Batinica (1981) – SARA

(o) ***latifolia* (Adamović) Degen** in Magyar Bot. Lapok 4: 133. 1905 (= *S. latifolia* (Adam.) Degen var. *serpentinica* Deyl): Riter-Studnička (1963) – SARA

***nitida* Ten.** Fl. Napol. 1: 322, Prodr. X. 1811: Freyn & Brandis (1888) – SARA

***rigida* Rchb.** Fl. Germ. Excurs. 140: 3. 1831 (= *S. filifolia* Hoppe, *S. haynaldiana* Schur, *S. rigida* Rchb. subsp. *rigida*): Riter-Studnička (1963)

(o) ***robusta* Schott, Nyman & Kotschy** in Schott, Analect. Bot.: 1. 1854 (= *S. nitida* auct. Balcan non Ten., *S. nitida* var. *fallax* Beck, *S. nitida* var. *hercegovina* Beck, *S. nitida* var. *inermedia* Beck, *S. nitida* var. *stenophylla* Beck, *S. robusta* Schott, Nyman & Kotschy subsp. *robusta*): Beck (1903) – SARA

(o) ***serbica* (Adamović) Ujhelyi** in Feddes Repert. Spec. Nov. Regni Veg. 62: 64. 1959: Riter-Studnička (1963) – SARA

(o) ***ujhelyii* Strgar** in Bot. Jahrb. Syst., 102: 1982: Strgar(1982)

***uliginosa* Opiz** in Berchtold & Seidl, Oekon.-Techn. Fl. Böhm. 1: 493. 1836: Fiala (1896) – SARA

(?) ***wettsteinii* Dörfl. & Hayek** in Akad. Wiss. Wien, Math.-Naturwiss. Kl., Denkschr 94: 206. 1917 (= *S. gigantea* Dorfl. & Hayek): Svoboda (2012)

***SETARIA* P. Beauv. – muhar (bristle-grass)**

***faberi* R. A. W. Herrm.** in Beitr. Biol. Pflanzen 10: 51. 1910: Maslo & Šarić (2018a)

***italica* (L.) P. Beauv.** Ess. Agrostogr.: 51. 1812 (= *Panicum germanicum* Mill., *P. italicum* L.): Hofmann (1882) – SARA

***pumila* (Poir.) Roem. & Schult.** Syst. Veg. 2: 891. 1817 (= *S. glauca* (L.) Beauv., *S. glauca* f. *pumila* Poir.): Struschka (1880) – SARA

***verticillata* (L.) P. Beauv.** Ess. Agrostogr.: 51. 1812 (= *Panicum verticillatum* L.): Struschka (1880) – SARA

***verticilliformis* Dumort.** Fl. Belg.: 150. 1827 (= *S. decipiens* Schimp., *S. gussonei* Kerguélen): Kutleša & Lakušić (1964)

***viridis* (L.) P. Beauv.** Ess. Agrostogr.: 51. 1812 (= *Panicum viride* L., *P. viride* subsp. *euviride* Aschers. & Graebn.): Freyn & Brandis (1888) – SARA

***SORGHUM* Moench – sirak (Johnsongrass)**

(cult) ***bicolor* (L.) Moench** Methodus: 207. 1794 (= *Andropogon arundinaceus* subsp. *sativus* f. *vulgaris*, *A. sorghum* (L.) Brot., *A. sorghum* subsp. *vulgare* (Pers.), *Holcus sorghum* L., *Sorghum vulgare* Pers.): Struschka (1880) – SARA

***cernuum* (Ard.) Host** Icon. Descr. Gram Austr. 4: 2, tab. 3. 1809 (= *Andropogon arundinaceus* subsp. *sativus* var. *cernuus* Koern. & Wern., *A. cernuus* Roxb., *Holcus cernuus* Ard., *Sorghum cernuum* Host.): Beck (1903)

***halepense* (L.) Pers.** Syn. Pl. 1: 101. 1805 (= *Andropogon arundinaceus* Scop., *A. halepensis* (L.) Brot., *A. sorghum* Hack, *Holcus halepensis* L.): Struschka (1880) – SARA

***saccharatum* (L.) Moench** Methodus: 207. 1794 (= *Andropogon arundinaceus* subsp. *sativus* f. *saccharatus*, *A. saccharatus* Kunth.,

A. sorghum subsp. *saccharatus* (L.), *Holcus saccharatus* L., *Sorghum saccharatum* Pers.): Struschka (1880)

***SPOROBOLUS* R. Br. (dropseed)**

***vaginiflorus* (A. Gray) A. W. Wood** Class-Book Bot., ed.: 775. 1861: Nobis et al. (2016)

***STIPA* L. – kovilje (feather grass)**

***capillata* L.** Sp. Pl., ed. 2, 1: 116. 1762: Murbeck (1891) – SARA, S, LD

***eriocaulis* Borbás** in Math. Termeszettud. Közlem. 15: 311. 1878 (= *S. gallica* Čelak, *S. pennata* L. subsp. *eriocaulis* (Borbás) Martinovský & Skalický): Prodan (1912)

subsp. ***austriaca* (Beck) Martinovský** in Webbia 20: 720. 1965 (= *S. pennata* L. var *austriaca* Beck): Fiala (1896) – SARA

***novakii* Martinovský** in Feddes Repert. 73: 147. 1966 – SARA

***pennata* L.** Sp. Pl.: 78. 1753 (= *S. joannis* Čelak, *S. mediterranea* subsp. *gallica* Čelak, *S. pennata* subsp. *eupennata* Asch. & Graebn., *S. pennata* subsp. *gallica* Čelak, *S. pennata* subsp. *joannis* (Čelak) K. Richt, *S. pennata* L. var. *joannis* Čelak, *S. pennata* var. *mediterranea* Trin & Rupr., *S. pennata* L. subsp. *pennata*): Struschka (1880) – SARA, LD

***pulcherrima* K. Koch** in Linnaea 21: 440. 1848 (= *S. grafiana* Stev., *S. mediterranea* (Trin. & Rupr.) Asch. & Graebn., *S. pennata* subsp. *pulcherrima* (K. Koch) Freitag, *S. pennata* L. var. *pulcherrima* Asch. & Koch): Zawodny (1897) – SARA, NL

subsp. ***epilosa* (Martinovský) Tzvelev** in Novosti Sist. Vyšš. Rast. 11: 18. 1974 (= *S. epilosa* Martinovský) – SARA

***TRACHYNIA* Link – dvoklasa pasjača (purple false brome)**

***distachya* (L.) Link** Hort. Berol. 1: 43. 1827 (= *Brachypodium distachyon* (L.) P. Beauv., *B. distachyon* f. *multiflorum* (Willk.) Pamp., *Bromus distachyos* L., *Triticum ciliatum* DC): Vandas (1889)

***TRAGUS* Haller – lopušnik (burr grass)**

***racemosus* (L.) All.** Fl. Pedem. 2: 241. 1785 (= *Cenchrus racemosus* L., *Lappago racemosa* Honck, *Tragus muricatus* Moench.): Vandas (1889) – SARA

***TRIPIDIUM* H. Scholz – sladorovac (plumegrass)**

***strictum* (Host) H. Scholz** in Willdenowia 36: 664. 2006 (= *Saccharum strictum* (Host) Spreng.): Maslo & Abadžić (2015)

***TRISETARIA* Forssk.**

***panicea* (Lam.) Paunero** in Anales Jard. Bot. Madrid 9: 524. 1950 (= *Trisetum paniceum* (Lam.) Pers.): Maslo (2016a)

***TRISETUM* Pers. – zobika, ovsika (oatgrass)**

***alpestre* (Host) P. Beauv.** Ess. Agrostogr.: 88. 1812 (= *Avena alpestris* Host, *Trisetum flavescens* subsp. *alpestre* Asch. & Graebn., *T. pratense* subsp. *alpestre* Beck): Freyn & Brandis (1888) – SARA

***flavescens* (L.) P. Beauv.** Ess. Agrostogr.: 88. 1812 (= *Avena flavescens* L., *Trisetum flavescens* (L.) P. Beauv. subsp. *flavescens*, *T. flavescens* var. *glabrata* Asch., *T. flavescens* subsp. *pratense* (Pers.) Asch. & Graebn., *T. pratense* Pers., *T. pratense* subsp. *pratense* Beck): Beck (1903) – SARA

***spicatum* (L.) K. Richt.** Pl. Eur. 1: 59. 1890 (= *Avena airoides* Koeler) – SARA

***TRITICUM* L. – pšenica (wheat)**

(cult) ***aestivum* L.** Sp. Pl.: 85. 1753 (= *T. aestivum* L. subsp. *aestivum*, *T. aestivum* var. *lutescens* (Alef.) Hayek, *T. sativum* Lam., *T. sativum* subsp. *tenax* Asch. & Graebn., *T. vulgare* Vill. var *aestivum* (L.) Will): Struschka (1880) – SARA, CRI, EURISCO, USNPGS

(cult) subsp. ***spelta* (L.) Thell.** in Naturwiss. Wochenschr., ser. 2, 17: 471. 1918 (= *T. sativum* subsp. *spelta* Asch. & Graebn., *T. spelta* L., *T. vulgare* var. *spelta* Alef): Beck (1903) – SARA

(cult) ***monococcum* L.** Sp. Pl.: 86. 1753: Beck (1903) – SARA

(cult) ***turgidum* L.** Sp. Pl.: 86. 1753 (= *T. sativum* var. *turgidum* (L.) Delile): Beck (1903)

(cult) subsp. ***dicoccon* (Schrank) Thell.** in Naturwiss. Wochenschr., ser. 2, 17: 470. 1918 (= *T. dicoccon* (Schrank) Schübl.): Kovačević (1950) – SARA, EURISCO, USNPGS

(cult) subsp. ***durum* (Desf.) Husn.** Graminées 4: 80. 1899 (= *T. durum* Desf.): Kovačević (1950) – SINGER, USNPGS

(cult) subsp. ***polonicum* (L.) Thell.** in Naturwiss. Wochenschr., ser. 2, 17: 470. 1918 (= *T. polonicum* L.): Boué (1840) – SARA

***VENTENATA* Koeler – bodljozub (wiregrass)**

***dubia* (Leers) Coss.** in Durieu, Expl. Sci. Algérie 2: 104. 1855 (= *Avena dubia* Leers, *A. fertilis* All., *A. tenuis* Moench, *Ventenata avenacea* Koel, *V. bromoides* Koel): Murbeck (1891) – SARA, VAL

***VULPIA* C. C. Gmel. – brčak (rat's-tail fescue)**

***bromoides* (L.) Gray** Nat. Arr. Brit. Pl. 2: 124. 1821 (= *Bromus dertonensis* All., *Festuca bromoides* L., *F. sciuroides* Roth., *Vulpia dertonensis* (All.) Gola, *V. myuros* var. *bromoides* (L.) Parl., *V. sciuroides* (Roth) C. C. Gmel.): Hofmann (1882) – SARA

***ciliata* Dumort.** Observ. Gramin. Belg.: 100. 1824 (= *Festuca danthonii* Asch. & Graebn., *Vulpia danthonii* (Asch. & Graebn.) Volkart): Maly (1908) – SARA

(?) ***fasciculata* (Forssk.) Fritsch** Excursionsfl. Oesterreich, ed. 2: 74, 692. 1909: Svoboda (2012)

(?) ***ligustica* (All.) Link** Hort. Berol. 1: 148. 1827: Svoboda (2012)

***myuros* (L.) C. C. Gmel.** Fl. Bad. 1: 8. 1805 (= *Festuca myuros* L., *Vulpia pseudomyuros* (Soy.-Will.) Rchb.): Struschka (1880) – SARA, O

***ZEA* L. – kukuruz (maize)**

(cult) ***mays* L.** Sp. Pl.: 971. 1753: Boué (1840) – SARA, EURISCO

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ABBREVIATIONS AND SYMBOLS

(BM)	Natural History Museum London Collection
(CRI)	Crop Research Institute
(BRNU)	Specimens Masaryk University Brno
(CHAH)	Australia's Virtual Herbarium
(E)	Royal Botanic Garden Edinburgh Herbarium
(EURISCO)	Bioversity International, The European Genetic Resources Search Catalogue
(G)	Geneva Herbarium – General Collection
(GB)	University of Gothenburg Herbarium
(GOET)	Universitat Gottingen
(GZU)	Karl Franzens University of Graz, Insitute for Botany Herbarium
(JE)	Friedrich-Schiller-Universitat Jena
(K)	Royal Botanic Gardens, Kew - Herbarium Specimens
(KFTA)	Saint Petersburg S. M. Kirov Forestry Academy
(LD)	Lund Botanical Museum
(MNHN)	The vascular plants collection at the Herbarium of the Muséum national d'Histoire Naturelle
(MPU)	Herbarium specimens of Université de Montpellier 2, Institut de Botanique
(NL)	Natural History Museum Maastricht Herbarium
(O)	Natural History Museum, University of Oslo: Vascular Plant Herbarium
(PRC)	Charles University in Prague Herbarium
(S)	Swedish Museum of Natural History Department of Botany
(SARA)	Herbarium of the National Museum of Bosnia and Herzegovina
(SEV)	Herbario de la Universidad de Sevilla
(SINGER)	The System-wide Information Network for Genetic Resources
(TLMF)	Tiroler Landesmuseum Ferdinandeum
(USNPGS)	United States National Plant Germplasm System Collection
(VAL)	Colección de plantas vasculares del herbario de la Universitat de València
(VIR)	N. I. Vavilov Institute of Plant Genetic Resources
(W)	Naturhistorisches Museum Wien Botanische Abteilung
(WU)	University of Vienna, Institute for Botany – Herbarium
(Z+ZT)	Herbaria of the University and ETH Zürich
CR	critically endangered
DD	data deficient
EN	endagered
NT	near threatened
VU	vulnerable
(cult.)	cultivated
(o)	endemic taxon
(?)	controversial occurrence in B&H

A Contribution to the Knowledge of the Plant Associations on the rocks of the Miljacka Gorge

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This paper presents new knowledge on the phytocoenological composition of the rocks in the Miljacka gorge. The gorge has been explored over many years of field trips. Part of the research conducted on the north side of the gorge is set out in the paper and three new phytocoenological associations have been analysed. In addition to the phytocoenological composition of the associations, other parameters are given which provide significant detail of the relations in the gorge and represent the basis for further research. The paper also presents specific data on the distribution of certain rare and endemic species in the area studied. This creates the possibility for the specific protection of these species, since it is a protected area. A list of species of the area studiedas given in the list of plant species for the "Red Book forBosnia and Herzegovina" is provided at the end of this paper.

Key words: phytocoenosis, protected area, gorge, Miljacka

INTRODUCTION:

TOPOGRAPHIC POSITION OF THE AREA STUDIED

The area studied is located east of Sarajevo, extending from the Bentbaša area to the bridge known as Kozija ćuprija. The first association is located in the area of Bentbaša, on the rocks of the precipitous slope below the Bijela tabija. The other two are below Borije and Hrastova Glavica, and in the area near the Kozija ćuprija bridge.

The area lies between the 18th and 19thlongitudes east (18° 27´30´´-18° 28´20´´) and between the 43rd and 44thlatitudes north (43° 51´ 10´´-43° 51´ 40´´). It is important to point out that the location of the associations studied lies within the boundaries of the "Bentbaša" protected area (Map 1).

CLIMATE CHARACTERISTICS OF THE AREA STUDIED

CLIMATE OF THE AREA STUDIED

According to Đug et al., the climate of the area studied belongs to the climatic type designated as Cfb, a moderately warm and wet climate with warm summers and with no dry season. According to Drešković (2003: 147, 148), the average temperature of the hottest month ranges from 15 °C to 22 °C, at least four months have an average monthly temperature ≥ 10 °C, the average temperature of the coldest month is always > -3.0 °C, and the annual temperature amplitude ranges from 12 °C do 22 °C. Annual precipitation rangesfrom 700 to 1200 mm of rainfall, evenly distributed throughout the year.

In addition, the effects of the real Supra-Mediterranean and distant steppe areas are felt in this area (Redžić, 1997: 35). The most significant meteorological data are set out in tables 12, 13 and 14.

WIND AS AN ECOLOGICAL FACTOR

Wind is one of the most important factors for the formation of vegetation, and usually has a direct impact on the appearance as well as the structure and certain patterns of vegetation dynamics (Redžić, 1991: 12). According to Horvat (1948: 148), wind has a very significant physiological effect,causinga reduction in temperature and increased plant evaporation.Čirić (1984: 182) states that the effect of wind can cause permanent displacement of soil material, which constantly disturbs the normal development of the land, maintaining it permanently in the primary development stages. Wind has a significant impact in the area studied, both by carrying away and by depositing soil particles, as well as on seed distribution– anemochory. Anemochory is one of the most important ways in which plants living in such ecosystems are able to spread, the other being mirmecochory. According to research by various authors, these two methods of plant displacement relate principally to the terrestrial layer of the community (Horvat, 1949: 305). The winds in the Miljacka gorgeblow ENE and WSW; during the day, and for most of the year, the prevailing direction in the Miljacka gorge is ENE (Drešković, 2003).

FROST AS AN ECOLOGICAL FACTOR

Frost as an ecological factor is very important for vegetation development. It is formed by evaporation of the wet soil layers (Horvat 1949: 133). According to Milosavljević (1970), the area studiedfalls within a wider areaaveraging 21-30 days with frost during the vegetation period (March-October), and with a maximum of 3-4 days with frost during the peak growth period (May). The same author (Milosavljević, 1940: 4) states thatthere is a high risk of frost in narrow and winding valleys. There is no doubt, therefore, that the plants in the Miljacka gorge suffer severe adverse effects of frost during part of the year.

GEOLOGICAL COMPOSITION OF THE AREA STUDIED

According to Čičić (1984), this area belongs to the Mesozoic period, specifically the lower Triassic. As regards tectonics, the same author (Čičić, 1984) states that the Miljacka gorge belongs to the transit zone and is very close to the border with the internal zone. In chemical composition, these rocks are of dolomitised limestone. Some rocks have undergone a process of mineralization and the production of calcite minerals. There are various relief forms on many of the rocks in the area studied. The most famous of these is the Triassic limestone spireknown as Babin zub, which is over 30 metres high (Lepirica, 2013: 84).

PEDOLOGICAL COMPOSITION OF THE AREA STUDIED

Lithosol is predominant on the whole area studied, with calcomelanosol occurring only to a minor extent. Calcomelanosol is most common on terraces or shelvesproviding an opportunity for the accumulation and development of this type of soil. According to Škorić et al. (1973), lithosol is regarded as an undeveloped soil of (A)-C profile. According to Škorić (1977: 24), a lithosol is a very shallow soil that is very close to the geological base. For this reason, the possibility of plants taking root in this usually very xerothermic substrate depends on the character of the rock. Such soils are very poor in nutrients, and biological activity is also very poor. This results in sparse plant populations. Ćirić (1984: 181) also states that lithosols are ecologically extremely dry habitats exposed to considerable warming and poor in accessible nutrients. The same author (Ćirić, 1984: 181) states that lithosol is an automorphic soilwatered only by atmospheric precipitation, where the absorbed water percolates freely, so that stagnant water is absent and the soil is deficient in humidification (wetting). It should also be noted that the lithosol on the rocks of the area studied is of different colours,for a variety of reasons. The most common is the

reddishcolour resulting from theiron-rich present on many rocks in the area studied.

GENERAL DATA ON FLORA AND PHYTOCOENOLOGY OF ROCKS

Gorges provide shelter for many plant species that have survived unfavourable glaciation periods. This makesgorges very interesting for botanical and phytocoenological research. Plants that inhabit rock crevices are called chasmophytes, a word deriving from the Greek *khazma* (chasm or fissure) and *phyton* (plant) (Lakušić, 1990: 180). Such plants are commonly known asrock plants (Horvat, 1949: 198). They usually inhabit exposed places subject to extreme environmental factors, such as intense solar radiation, wind and temperature, as well as very specific natural habitats with steep slopes and sparse, undeveloped soil (Janković, 1963: 172),resulting in a series of characteristic morpho-anatomical adaptations, primarily of the leaves.

Chasmophytes are most commonlycalciphile, basiphile, heliophile, and eurythermal species, and many are ombrophile species, i.e. species that are not exposed to direct rainfall and that live in sheltered places, overhangs and the like. It should also be emphasised that types of sciophyte and semi-sciophyte character are frequent. They mostly grow on limestone, but also on dolomite and dolomitised limestone. In the Alps, they also inhabit crevicesin silicate rocks (Horvat, 1949: 178).

Chasmophytes are well adapted to unfavourable external conditions and especially to physiological and physical drought. The most important morpho-anatomic adaptationsare hairiness, small growth, leaves covered with pubescent hairs, andindumentumcomposed of long glandular hairs (Šilić, 1990: 30).

An interesting phenomenon among certain species is that high altitude populations are heliophytes, while those at lower altitudes are sciophytes or semi-sciophytes. An example of this is*Edraianthus sutjeskae*(Lakušić, 1990: 125).

As for soil, chasmophytes most often inhabit primary undeveloped soils, mostly lithosol and rarely calcomelanosol. As these are soils that are directly generated by rock weathering, they are very poor in nutrients.

Plants that grow in rock crevices constitute a distinct class, *Asplenietea rupestris* (H. Meier) Br.-Bl. This consists of three orders in Bosnia and Herzegovina:

1. *Potentilletalia caulescentis* Br.-Bl. with relations: *Micromerion croaticae* H-at, restricted to the Dinarides, and the related*Moehringion muscosae* H-at et H-ić,restricted to the serpentine vegetation of central and eastern Bosnia and to crevicesin shady rocks in the forested area of the Dinarides.
2. *Amphoricarpetalia* Lkšić, with the related*Amphoricarpion autariati* Lkšić, restricted to warm gorges in BH, and penetrating in part into the continental region of Bosnia. Another relation is *Amphoricarpion neumayeri* Lkšić, which iswidespread in the subalpine belt of the Southeastern Dinarides. The third relation of this order is *Edraianthionjugoslavici* Lkšič, which is widespread in river gorges of the continental Dinarides. The area studied, the Miljacka gorge, belongs to this last.
3. *Molkeetalia petraeae* Lkšić with two relations: *Centaureo-Campanulion* H-ić, restricted mostly to the Adriatic area, but extending along the Neretva River as far as Mostar and beyond, and the related*Edraianthion* Lkšić, restricted to Orjen and southeast Herzegovina.

HISTORY OF EXPLORATION OF THE MILJACKA GORGE

Many botanists have studied the Miljacka gorge, drawn by its attraction, beauty and refugial character.

The first researcher to visit and pass through this area was the French geologist Ami Boué. Boué (1840) travelled from Pljevlje, via Čajniče and Goražde, and walking through the Miljacka gorge he came to Sarajevo.

Silence on the subject then descended until the occupation of Bosnia and Herzegovina by the Austro-Hungarian Monarchy. Hofmann (1882) provides data on the presence of some plants in the Miljacka gorge, among them*Corydalis ochroleuca*, *Genista triangularis*, and *Lonicera alpigena*.One of the greatest botanists of his time, Svante Murbeck, also visited and explored the Miljacka gorge. Murbeck (1891) mentions a number of plants found in this gorge, including*Scirpus setaceus*, *Cyperus fuscus*, *Alnus incana*, and *Euphorbia stricta* f. *latifolia*.

The curator of the National Museum of Bosnia and Herzegovina, Franjo Fiala, often spent time in thegorge during the course of his research (1889, 1891, and 1896). He also collected and herbalised a large number of plants from thegorge, depositingthem in the Herbarium of the National Museum of BH.Another great botanist, G. Beck, provided a mass of data in his *Flora Bosne i Hercegovine i Novopazarskog Sandžaka* (Beck, 1901, 1903 a & b, 1906 a, b & c, 1907, 1909, 1914, 1916 a & b, 1918, 1920, 1921, and 1923).

Another curator of the National Museum of BH who explored the Miljacka gorge, Đorđe Protić, gave details of some of the species found in the Miljacka gorge in his *Prilog k poznavanju flore Bosne i Hercegovine* (1908). The same author (Protić, 1897 and 1899) provided data on the diatoms of the Miljacka and (Protić, 1933) examined the biological self-cleaning of the Miljacka River.

One of the greatest Bosnian-Herzegovinian botanists, curator and founder of the Botanical Garden of the National Museum of BH, Karlo Malý,carried out much of his research in this gorge and the tributaries of the Miljacka: the

Lapišnica and Mošćanica. Malý provided a wealth of data on the vegetation of the gorge in his *Prilozi za floru Bosne and Herzegovine* (Malý,1899, 1904, 1910, 1912, 1917, 1919, 1920, 1923, 1928, 1940, and 1948) and in other works (Malý, 1931, 1932, 1933 a & b, 1935, Malý & Zahn, 1925, 1926, and 1929).

Botanical investigations in the gorge continued after World War II. Thus, Ritter-Studnička (1958) provided information on the discovery of certain adventive species in this gorge. Stefanović (1955: 51) reported that *Ailanthus glandulosa* Desf. occurs as a weed in the Bentbaša-Kozija ćuprija region.

Abadžić (1974) explored the ecology and variability of the population of the species *Scabiosa leucophylla* Borb. in the part of a gorgeknown as Orlovo krilo. Investigating the ecological and morphological differentiation among the populations of the species *Edraianthusjugoslavicus*, the same author (1984) conducted part of her research on this species in the Miljacka gorge. Abadžić (1987: 72) also noted the presence of *Echinocystis lobata* (Michx) Torrey et Gray in the valley of the Miljacka River, in several places.

Strgar (1974 and 1981) described a new species of *Sesleria ujchelyii*in the Miljacka gorge, specifically on the Dariva rocks.Professor Redžićinvestigated the gorge on several occasions. He covered the gorge in his doctoral dissertation (Redžić, 1991), and published two articles in the popular science magazine *Fondeko svijet* in which he gave a concise description of the flora and other characteristics of thegorge (Redžić, 1997 a and b).

Tanović (1995) conducted part of his research in the Miljacka gorge as part of his thesis. Others who have explored the gorge include Jukić (2001), Merdan (2004), Ravlić (2004), Šoljan et al. (2007), and Hasanbegović (2018).

MATERIAL AND METHODS OF RESEARCH

THE MATERIAL AND METHODS OF RESEARCHFALL INTO TWO PHASES: FIELD WORK AND LABORATORY WORK.

Field work:

The field work includes long-term field trips in every annual vegetation season. Each population was studied and monitored through several successive annual weather aspects, in order to identify ecological and especially phenological data.

During the vegetation season, phytocoenological populations were made according to the Braun-Blanket method (Braun-Blanket, 1932) in the area studied. Data on flora and phytocoenological composition were collected from these areas during the entire vegetation season, to be analysed in the next phase of work. The flowering of individual typical species was also observed throughout the season.

Laboratory work:

The collected data was statistically analysed, yielding data on the total number of species. The following parameters were also analysed: life form, phytocoenological affiliation, indicator value and floral element. Graphical representations for all the above parameters were produced. Finally, comparative relations of all parameters among the associations studied were given.

NOMENCLATURE

Many works and keys, both general and specialised for certain genera, were consulted in the determination of the plants.

General worksconsulted:

Aichele & Schwegler (1988), Beck (1916, 1920, 1922, 1927), Beck et al. (1950, 1967, 1974 and 1983), Čanak et al. (1978), Domac (1984), Horvatić (1954), Josifović et al. (1970-1977), Kojić (1981), Kvakan (1952), Šarić (1991), Šilić (1990, 2002, 2005) and Šoštarić-Pisačić & Kovačević (1968).

Specialised keys consulted for certain genera:

For genus *Edraianthus*-Lakušić (1973), for genera *Acinos* and *Micromeria*-Šilić (1979) and for genus *Allium*-Radić (1989).

Floral elements and life forms were taken from Lakušić & Redžić (1989 & 1991), Oberdorfer (1979), and Redžić (1988).

Phytocoenological affiliation was taken from Horvat et al. (1974), Lakušić (1989), Lakušić & Redžić (1989 & 1991), Oberdorfer (1979), and Redžić (1988).

Indicator values were taken from Lakušić & Redžić (1989 & 1991), Pavlović-Muratspahić (1995), and Redžić (1988).

Life forms were given according to Raunkiaer (1937).

The following works were consulted for the history of the research: Fiala (1892), Fukarek (1954), and Redžić (1997 b).

The following references were used for phytoceonology: Braun Blanket (1932), Horvat (1949), Mc Cune & Grace (2002), Kent & Coker (1992), and Stefanović (1986).

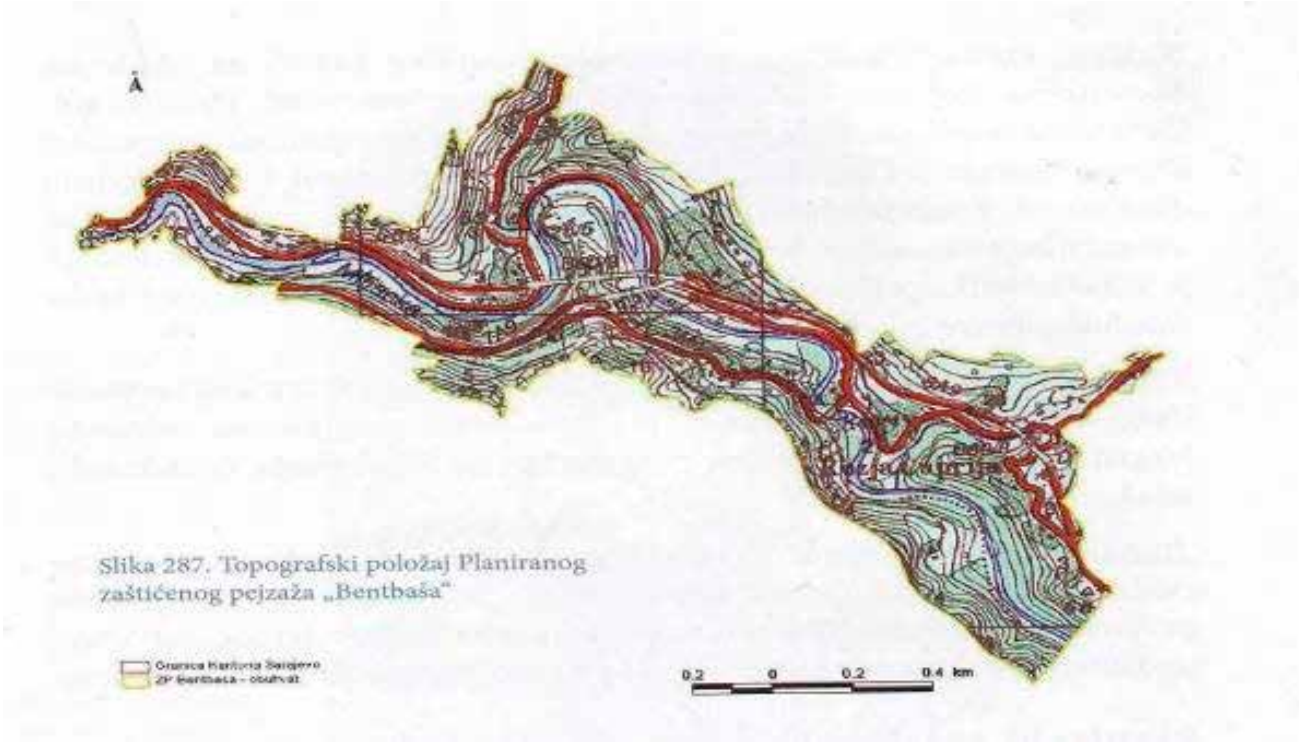
The phytocoenological division is given according to: Blečić & Lakušić (1976), Horvat (1937: 137), Lakušić 1968 and 1975 and Lakušić et al. 1969 and 1978, Zupančić et al. (1986).

Meteorological data, consisting ofmeasurements taken at two different hydrometeorological stations, were obtained with the assistance of the staff of the Federal Hydro-Meteorological Institute from Sarajevo.

Taxa in this paper are partly aligned with the *Flora Europaea* (Tutin et al., 1964-80).

Abbreviations:

Abbreviations for phytocoenologic units: *T.-S. u.- Thymo-Seslerietum ujchelyii*, *T.-E. l.- Thymo-Erysimetum linearifoliae*, *D.-G. j.- Diantho-Genistetum januensis*



Map 1. Position and boundaries of the "Bentbaša" protected area (Taken from Đug et al., 2008).

Abbreviations for indicator values: P-primary, PS-primary secondary, S-secondary, SP-secondary primary, T-tertiary.

Abbreviations for phytocoenologic orders (in alphabetical order): Amp.-*Amphoricarpetalia*, A. f.-*Arabidetalia flavescentis*, Arr.-*Arrhenatheretalia*, Art.-*Artemisietalia*, B. e.-*Brometalia erectii*, Che.-*Chenopodietalia*, E.-P.-*Erico-Pinetalia*, F.-*Fagetalia*, O.-*Onopordetalia*, P. m.-*Plantaginetalia* majoris, P. s.-*Prunetalia spinosae*, Q. p.-*Quercetalia pubescentis* and S.-C.-*Scorzonero-Chrysopogonetalia.*

Abbreviations for life forms: H-*hemicriptophyta*, Ch-*chamaephyta*, P-*phanerophyta*, G-*geophyta* and T-*therophyta.*

Abbreviation for IUCN status: R-rare species.

RESULTS AND DISCUSSION

THYMO-SESLERIETUM UJCHELYII COMB. NOVA ASSOCIATION

In the area studied, this association occupies the rocks located in the tunnel area of Bentbaša and Babin zub. Table 15 shows that the most important species are *Sesleria ujchelyii* and *Thymus jankae*. Here, *Sesleria ujchelyii* is the most common in the entire area studied, but it should be noted that this *Sesleria* does not appear at all on the opposite, south-eastern side of the gorge, where it is replaced by*Sesleria angustifolia*. It is not very common on the rest of the north side, apart from the Dariva rocks.On the other hand, *Thymus jankae* is one of the most important plants of this gorge. It appears on both sides of the gorge and participates in the formation of many associations In. addition to these species, high values have been identified for the following species:*Galium purpureum*, *Silene vulgaris*, *Erysimumlinearifolium*, *Sedum album*, *Leontodon crispus*, *Sanguisorba muricata*, *Stipa calamagrostis,* and *Tunica saxifraga*. It is interesting to note that this is the only site and association in the entire area studied where *Onosma stellulatum* was detected, in only one population. Similarly, *Sempervivumtectorum* was detected in this area only,in two separate populations with a small number of specimens.Other rare species include*Rhamnus rupestris, Minuartia bosniaca,* and *Genista januensis*. As regards ecological conditions, the association develops on limestone rocks. Most of the soil appears to be lithosol,while calcomelanosol occurs to a much smaller extent. The association is strongly influenced by

direct solar radiation. The largest number of species found in this association belong to the order of *Amphoricarpetalia*, with a somewhat smaller number of *Brometali erecti*. The following ordershave also high values: *Scorzonero-Chrysopogonetalia, Arrhenatheretalia,* and *Chenopodietalia* (Chart 1).

The highest indicator values are those of secondary and primary species (Chart 2).

The most common life form consists ofhemicryptophytes,with a much smaller number of chamaephytes, phanerophytes and other forms (Table 1). The largest number of species belong to sub-Mediterranean floral elements, with slightly lower values recorded in the Balkan and EurasSuboceanicfloral elements. The Euroasian and Nordic Euroasian floral elements also have high values (Table 2).

THYMO-ERYSIMETUM LINEARIFOLIAE **COMB. NOVA ASSOCIATION**

This association develops under the significant influence of the surrounding forest vegetation of the order *Quercetalia pubescentis*. It develops on dolomitised limestone rocks on which the soil is a lithosol and in places where a thin layer of calcomelanosol can be found.

In addition to the edificator types, the following species also have high values in this association: *Galium corrudaefolium*, *Sedum album,* and *S. ochroleucum*, *Stipa calamagrostis*, *Hypericum perforatum*, *Silene vulgaris*, *Chondrilla juncea*, *Tunica saxifrage,* and *Clematis vitalba* (table 16). The following species were identified from the *Quercetalia pubescentis* order: *Fraxinus ornus*, *Inula conyza*, *Arabis turitta*, *Hedera helix*, *Dactylis aschersoniana,* and *Ostrya carpinifolia*.

It is interesting to note that some species which makea significant contribution to the formation of many associations in the area studied occur in very small numbers in this association. Such is the case with *Micromeriathymifolia*, an important member of many associations on both sides of the Miljacka gorge, great burnet and canary clover, which can be found innumerous associations on both sides, *Sesleriaujchelyii*, an important member of some associations on the north side of the area studied, and Kitaibel's Pink, which is almostubiquitous on the eastern side

Table 1. Life forms of the association *Thymo-Seslerietum ujchelyii* comb. nova.

Life form	Total number	Total	%	Σ %
H	34		53.96	
H(Ch)	2		3.17	
H(T)	2		3.17	
H(G)	2		3.17	
		40		63.49
Ch	7		11.11	
Ch(H)	2		3.17	
		9		14.28
P	7		11.11	
P(Ch)	1		1.58	
		8		12.69
T	4		6.34	
T(Ch)	1		1.58	
		5		7.93
G	1		1.58	
		1		1.58
Total:	63	63	100 %	100 %

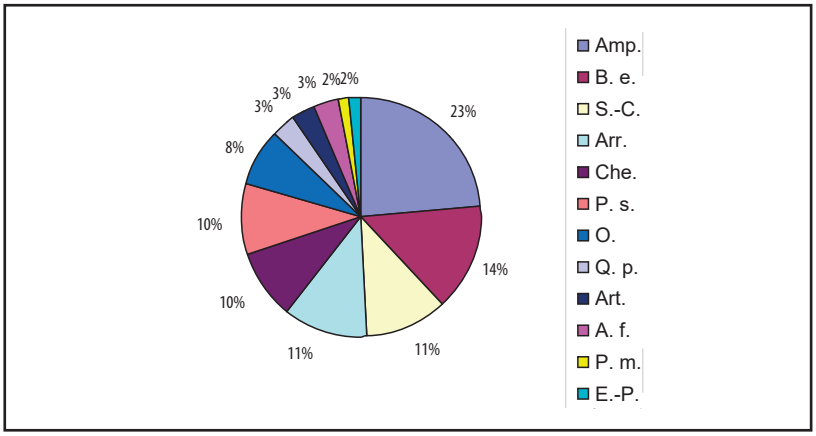


Chart 1. Phytocoenological affiliation to particular orders of the association *Thymo-Seslerietum ujchelyii comb.* nova (expressed in %).

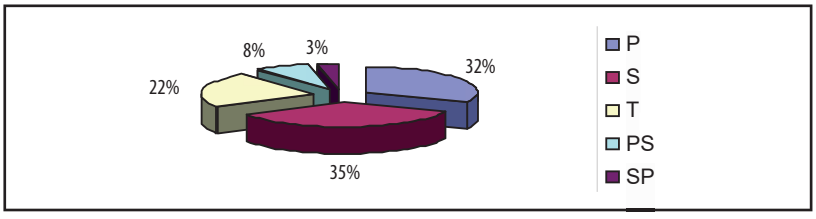


Chart 2. Percentage ratio of indicator values in the association *Thymo-Seslerietum ujchelyii* comb. nova.

Table 2. Spectrum of floral elements of the T*hymo-Seslerietum ujchelyii comb.* nova association.

Floral element	Number of species	Total	Participation (%)
din din-so-alp	3 1	4	6.77
balc s. o. balc balc-apen	5 1 2	8	13.55
pralp pralp-smed	1 1	2	1.69
smed (pralp)smed-subatl osmed osmed-gemässkont smed-subatl(circ) smed-euras smed(-euras) (o)smed submed(-subatl)	6 1 1 1 1 1 1 1 1	14	22.22
omed med(-kont) med med-smed-kont	2 1 1 1	5	7.93
subatl(-smed) subatl-smed (no-)subatl(smed)	1 1 1	3	5.08
euras(kont) euras(kont)smed euras(kont)-smed euras(kont)(-smed) euras-smed euras-smed,circ	1 1 1 1 1 1	6	10.16
no-euras-med no-euras-smed no-euras no-euras(subozean)	1 1 2 1	5	8.47
eurassubozean eurassubozean-smed eurassubozean(-smed) (no-)eurassubozean(smed)	5 4 1 1	11	12.25
euraskont(-smed)	1	1	1.69
(euras)kont-smed s. o. kont	1 1	2	3.38
gemässkont-osmed	1	1	1.69
n-persia	1	1	1.69
Total number of group floral elements: 13			
Total number of individual floral elements: 40			
Total:	63	63	100

Figure 1. *Sesleria ujchelyii*, an important member of the *Thymo-Seslerietum ujchelyii* comb. nova association.

of the gorge, and appears in this part at the very end of the gorge, but in this association it is very poorly represented.

Most species of this association belong to the *Amphoricarpetalia* order,while a significantly smaller number of species are listed in the following orders: *Quercetalia pubescentis, Chenopodietalia, Scorzonero-Chrysopogonetalia, Brometalia erecti* and *Prunetalia spinosae* (Chart 3). Primary indicator values are prevalent, with secondary values also present (Chart 4). The prevalent life forms arehemicryptophytes. chamaephytes and phanerophytes (Table 3). The largest number of species of this association belong to the sub-Mediterranean floral element. A significantly smaller number belong to the EurasSuboceanic, Mediterranean and Nordic Eurasian (Table 5).

DIANTHO-GENISTETUM JANUENSIS COMB. NOVA ASSOCIATION

This association has developed at the end of the area studied from the north side and near the Kozija ćuprija bridge. Kitaibel's Pink is one of the most important plants in the area studied. It is common on the southeastern side and is a member of numerous associations. On the northern side, it appears only at the end of the area studied, where it forms this association together with *Genistajanuensis*, which also more frequently appears only in this area. The association develops under the influence of the surrounding forest ecosystem and is therefore partly in shade, with reduced insolation.

These specific conditions have led to the creation of this association. Among important species of this association are*Thymus jankae*, *Galium corrudaefolium*, *Stipa calamagrostis* and *Melica ciliata* (Table 17). *Silene vulgaris*, *Sanguisorba muricata*, *Tunica saxifraga*, *Galium purpureum* and

Micromeria thymifolia also have high values. Members of the forest eco-system include-*Fraxinus ornus*, *Potentilla micrantha*, *Crataegus monogyna*, *Campanula trachelium*, *Clematis vitalba* and *Ligustrum vulgare*. As with the previous association (*Thymo-Erysimetum linearifoliae*), in this association too some of the very widespread species from the *Amphoricarpetalia* order of this side of gorge are missing or detected in a small number of populations or with a small number of specimens. These are*Asplenium trichomanes*, *Allium carinatum*, *Sesleria ujchelyii*, *Chondrilla juncea* and *Erysimum linearifolium*. Representatives of other orders which are quite common in the area studied which have very low values are *Coronilla emerus* ssp. *emeroides*, *Scabiosa leucophylla* and*Dorycnium herbaceum*, as well as *Inula conyza* and *Syringa vulgaris.*

Table 3. Life forms of the *Thymo-Erysimetum linearifoliae comb.* nova association.

Life form	Total number	Total	%	Σ %
H	19		42.22	
H(Ch)	1		2.22	
H(T)	1		2.22	
H(G)	1		2.22	
		22		48.88
Ch	8		17.77	
Ch(P)	1		2.22	
		9		20
P	8		17.77	
		8		17.77
T	2		4.44	
T(Ch)	2		4.44	
		4		8.88
G	1		2.22	
G(H)	1		2.22	
		2		4.44
Total:	45	45	100 %	100 %

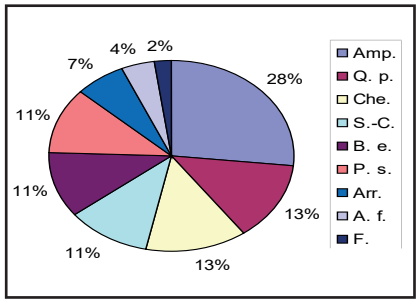


Chart 3. Phytocoenological affiliation to the individual orders of the *Thymo-Erysimetumlinearifoliae comb.* nova association (expressed in %).

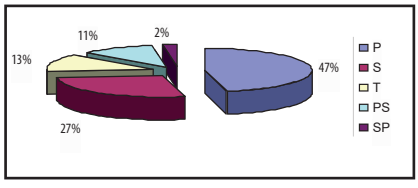


Chart 4. Percentage share of individual indicator values in the *Thymo-Erysimetum linearifoliae comb.* nova association.

Table 4. Floral elements of the *Thymo-Erysimetum linearifoliae comb.* nova association.

Floral element	Number of species	Total	Participation (%)
din	2	2	4.44
balc s. o. balc	2 1	3	6.66
pralp-smed	1	1	2.22
smed (pralp)smed-subatl osmed smed(-subatl) smed-subatl(circ) smed-gemässkont smed(-euras) smed-euras (o)smed submed(-subatl)	6 1 2 1 1 1 1 1 1 1	16	35.55
omed-smed med(-cont) med med-smed-cont	1 1 2 1	5	11.11
subatl-smed	2	2	4.44
euras(cont)(-smed) euras-smed euras-smed,circ	1 1 1	3	6.66
no-euras(-med) no-euras-smed no-euras(subocean)	1 2 1	4	8.88
eurassubocean eurassubocean-smed	1 4	5	11.11
s. o. cont europcont	1 1	2	4.44
gemässkont	1	1	2.22
china	1	1	2.22
Total number of group floral elements: 12			
Total number of individual floral elements: 31			
Total:	45	45	100 %

The highest number of the plants identified belong to the orders of *Amphoricarpetalia*,*Quercetaliapubescentis* and *Brometaliaerecti*. Orders *Prunetalia spinosae* and *Scorzonero-Chrysopogonetalia* also have high values (Chart 5). The highest indicator values are those of primary vegetation, with a rather smaller number for secondary vegetation (Chart 6). Hemicryptophytes predominate in life forms,with phanerophytes and chamaephytes in significantly smaller numbers(Table 5). The most common floral element is sub-Mediterranean, while representatives of EurasSuboceanic, Euro-Asian, and Balkan elements are represented in small numbers (Table 6).

COMPARATIVE TABLES ON THE RELATIONSHIP BETWEEN PHYTOCOENOLOGICAL ASSOCIATIONS, INDICATOR VALUES, LIFE FORMS, AND FLORAL ELEMENTS OF THE ASSOCIATIONS STUDIED

Table 7 shows that representatives of the order *Amphoricarpetalia*occur in the highest percentage in all associations. There is also a high percentage of representatives of the orders *Brometalia erectii* and *Scorzonero-Chrysopogonetalia*, representatives of meadow ecosystems, and of the orders *Quercetalia pubescentis* and *Prunetalia spinosae*, representatives of forest ecosystems. The main reason for such a high percentage of representatives

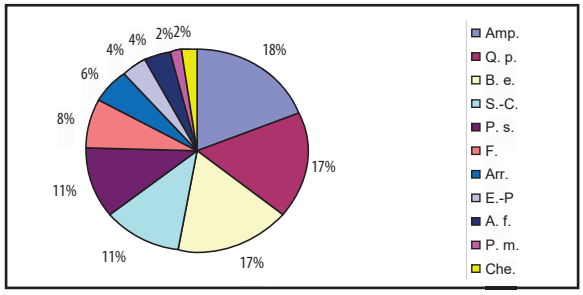


Chart 5. Phytocoenological affiliation to certain orders of the *Diantho-Genistetumjanuensis comb.* nova association (expressed in %).

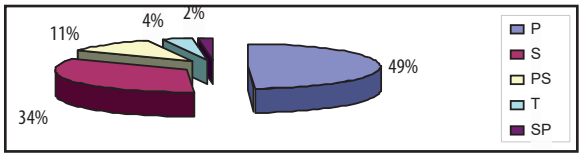


Chart 6. Percentage share of individual indicator values in the *Diantho-Genistetum januensis comb.* nova association (expressed in%)

Table 6. Life forms of the *Diantho-Genistetum januensis* comb. nova association.

Life form	Total number	Total	%	Σ %
H	27		50.94	
H(G)	2		3.77	
H(T)	2		3.77	
H(Ch)	1		1.88	
		32		60.37
P	11		20.75	
P(Ch)	1		1.88	
		12		22.64
Ch	7		13.20	
		7		13.20
G	1		1.88	
		1		1.88
T(Ch)	1		1.88	
		1		1.88
Total:	53	53	100 %	100 %

Table 7. Floral elements of the Diantho-Genistetum januensis comb. nova association.

Floral element	Number of species	Total	Participation (%)
din	2	3	5.66
din-so-alp	1		
balc	4	5	9.43
s. o. balc	1		
s. o. eur	1	1	1.88
pralp-smed	1	1	1.88
smed	5	18	33.96
(pralp)smed-subatl	1		
osmed	3		
smed(-subatl)	1		
smed-subatl(circ)	1		
smed(-gemässkont)	1		
smed-med	1		
smed(-euras)	2		
o(smed)	1		
(o)smed	1		
submed(-subatl)	1		
omed-smed	1	4	7.54
med(-cont)	1		
med	2		
subatl-smed	1	1	1.88
euras(cont)	1	6	11.32
euras(cont)-smed	1		
euras(kont)(-smed)	1		
euras(-smed)	1		
euras-smed	1		
euras-smed,circ	1		
no-euras-smed	1	4	7.54
no-euras	1		
no-euras(subocean)	1		
no-eurassubocean	1		
eurassubocean	5	6	11.32
eurassubocean-smed	1		
(gemäss)cont-smed	1	3	5.66
s. o. cont	1		
europcont	1		
gemässcont-osmed	1	1	1.88
Total number of group floral elements: 12			
Total number of individual floral elements: 37			
Total:	53	53	100

of these orders is in the proximity of these ecosystems with the associations studied. The table shows that the location of the association of *Thymo-Seslerietum ujchelyii* is under the influence of meadow ecosystems,while on the other hand, the associations of *Thymo-Erysimetum linearifoliae* and *Diantho-Genistetum januensis*are also subject to the strong influence of forest ecosystems because both associations are beneath the forest ecosystem.

Table 8 shows that the representatives of primary vegetation are dominant in two associations, whilerepresentatives of secondary vegetation in one. The main cause is the proximity of the secondary ecosystem and the association study. Tertiary vegetation representatives, which mostly inhabit terraces, also have high values. Secondary vegetation

Table 7. Relation of affiliation to certain phytocoenological orders in the phytocenoses studied (expressed in percentages).

F. p.→ Association	Amp.	B. e.	S.-C.	Arr.	Che.	P. s.	O.	Q. p.	Art.	A. f.	P.m.	E.-P.	F.
T.-S. u.	23	14	11	11	10	10	8	3	3	3	2	2	-
T.-E. l.	28	11	11	7	13	11	-	13	-	4	-	-	2
D.-G. j.	18	17	11	6	2	11	-	17	-	4	2	4	8

Table 8. Indicator value ratio in the associations studied (expressed in percentages).

Indicator value Association	P	S	T	PS	SP
Thymo-Seslerietum ujchelyii	32	35	22	8	3
Thymo-Erysimetum linearifoliae	47	27	13	11	2
Diantho-Genistetum januensis	22	13	4	11	2

Table 9. Life form relationships in the associations studied (expressed in percentage).

Life form Association	H, H(Ch), H(T), H(G)	Ch, Ch (H)	P, P(Ch)	T, T(Ch)	G
Thymo-Seslerietum ujchelyii	63.49	14,28	12.69	7.93	1.58
Thymo-Erysimetum linearifoliae	48.88	20	17.77	8.88	4.44
Diantho-Genistetum januensis	60.37	22.64	13.20	1.88	1.88

Table 10. Ratio of floral elements in the associations studied (expressed in percentages).

Association Floral element	Thymo-Sesleritum ujchelyii	Thymo-Erysimetum linearifoliae	Diantho-Genistetum januensis
din.	6.77	4.44	5.66
balk	13.55	6.66	9.43
s. o. eur	-	-	1.88
pralp	1.69	2.22	1.88
smed	22.22	35.55	33.96
med	7.93	11.11	7.54
subatl-smed	5.08	4.44	1.88
euras	10.16	6.66	11.32
no-euras	8.47	8.88	7.54
eurasiansubocean	12.25	11.11	11.32
euraskont	1.69	-	-
kont	3.38	4.44	5.66
gemasskont	1.69	2.22	1.88
n. pers.	1.69	-	-
china	-	2.22	-

representatives mainly display low values, which are mainly related to the aforementioned associations that are in direct contact with the forest ecosystem.

Table 9 shows that members of the hemicryptophyte life form are the most widespread in the associations studied. Evidently, the hemicryptophyte life form developed as a means of survival by plants in harsh living conditions. Other forms appear in a much smaller percentage. Geophytes occur in the smallest percentage, because they need deeper soil for their development and survival, which is rare on the rocks.

Table 10 shows that the largest number of species belong to the sub-Mediterranean floral element. This is not surprising, sincethe penetration of the supra-Mediterranean climate (Redžić, 1997b: 35), to which members of this floral element correspond, can be felt in this gorge. The values of the Eurasian suboceanic, Balkan, Eurasian and Mediterranean floral elements are significant.

PHENOLOGICAL CALENDAR OF FLOWERING OF INDIVIDUAL PLANTS ON THE ROCKS OF THE MILJACKA GORGE

The first plants to come into bloom in the area studied are *Sesleria ujchelyii* and *Erysimum linearifolium*, usually in the middle of April although some plants, depending on their position on the rocks, bloom in late March or early April. The following plants also bloom during the month of April: *Arabis hirsuta*, *A. glabra*, *A. turrita*, and *Coronilla emerus* ssp. *emeroides*. After them, in late April, *Thymus jankae* blooms profusely during May. *Onosmastelullatum* also begins to bloom in early May. In mid May, *Galium corrudaefolium*, *Minuartia bosniaca,* and *Helianthemum nummularium* begin to bloom.During the month of June, *Micromeria thymifolia* and *Leontodon crispus* flourish, while the last species to come into flower in the gorge is *Allium sphaerocephallum*, which begins to bloom in late August and most frequently during September and October.

A LIST OF PLANT SPECIES OF THE AREA STUDIED FOUND FOR THE "RED BOOK OF BOSNIA AND HERZEGOVINA" (ŠILIĆ 1996) WITH IUCN STATUS:

1. *Minuartia bosniaca* (G. Beck) K. Malý-(R),
2. *Onosma stellulata* W. et K.-(R),
3. *Micromeria thymifolia* (Scop.) Fritsch-(R),
4. *Scabiosa leucophylla* Borb.-(R).

CONCLUSIONS:

1. Three new phytocoenoses for the Miljacke Gorge have been described.
2. The most significant species are *Thymus jankae*, *Erysimum linearifolium*, *Minuartia bosniaca*, *Dianthus kitaibelii*, *Micromeria thymifolia*, *Sesleria ujchelyii*, *Galium corrudaefolium*, *Stipa calamagrostis*, and *Melica ciliata*.
3. The following species are also frequent: *Silene vulgaris, Sanguisorba muricata, Tunica saxifraga, Fraxinus ornus, Potentilla micrantha,* and *Clematis vitalba*.
4. The rarest species of the phytocoenoses studied are*Onosma stellulata, Sempervivum tectorum,* and *Rhamnus rupestris.*
5. There are also four species found on the "Red List of Bosnia and Herzegovina" of rare species (R) status.
6. Thelargest number of species in the associations studied belong to the phytocoenological order *Amphoricarpetalia*.
7. Primary species are dominant in the associations studied.
8. Hemicryptophytes represent the most numerous group of life forms in the associations studied.
9. Geophytes occur in the smallest percentage of life forms, revealing that the rocks constitute an extremely disadvantageous ecosystem for the development of this form.
10. The most significant floral element is sub-Mediterranean.
11. Representatives of the Eurasian Suboceanic, Balkan, Eurasian and Mediterranean floral elements have also significant values.

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SAŽETAK

Ovaj rad predstavlja nova saznanja o fitocenološkom sastavu stijena kanjona Miljacke. Kanjon je istraživan kroz višegodišnje terenske izlaske. U radu je prikazan dio istraživanja sa sjeverne strane kanjona i obrađene su tri nove fitocenološke zajednice. Također, osim fitocenološkog sastava zajednica date su i ostali parametri koji značajno govore o odnosima u kanjonu te predstavljaju bazu za dalja istraživanja. Isto tako rad donosi i konkretne podatke o rasprostranjenosti pojedinih rijetkih i endemičnih vrsta na istraživanom području što stvara mogućnosti konkretne zaštite tih vrsta pošto je riječ o zaštićenom području.

Ključne riječi: fitocenoza, zaštićeno područje, kanjon, Miljacka.

Figure 2. View of the habitat of *Thymo-Erysimetum linearifoliae* comb. nova association.

Figure 3. The habitat of *Sesleria ujchelyii* and *Thymus jankae* on the rocks on the northern side in the area studied.

Figure 4. Janke's thyme (*Thymus jankae*) is one of the most prominent plants in the area studied.

APPENDIX 1

Figure 5. *Erysimum linearifolium* is one of the most widespread plants in the area studied.

Figure 6. The Bosnian sandwort (*Minuartia bosniaca*) and in the background Janke's thyme (*Thymus jankae*) are among the most significant plants in the area studied.

Figure 7. *Onosma stellulatum* is one of the rarest plants in the area studied.

APPENDIX 2

Table 11. Meteorological data for the Sarajevo area, Sarajevo-Bjelave meteorological station, period 2007-2016.

Parameter	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Medium	Max.	Min.	Sum
Medium temperatures (C°)	1.2	2.8	6.0	11.1	14.8	18.9	21.2	21.1	16.0	10.6	6.9	1.1	11.0			
Absolute maximum temperatures (C°)	18.2	21.4	24.7	29.4	33.2	35.6	38.0	38.8	38.0	28.4	23.7	17.8		38.8		
Absolute minimum temperatures (C°)	-16.5	-19.0	-10.9	-3.7	-0.3	5.7	7.8	6.9	1.8	-3.1	-8.4	-16.0			-19.6	
Average number of days with min. temp. <0°C	18.5	14.5	9.1	1.1	0.0	0.0	0.0	0.0	0.0	1.5	8.0	20.3				73
On average the first day with the appearance of frost (min. temp. <0 °C)													October 21			
On average the last day with the appearance of frost (min. temp. <0 °C)													April 1			
Average number of days with max. temp. <0 °C	6.2	3.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	6.5				17
Average number of days with max. temp. ≥ 25 °C	0.0	0. 0	0.0	2.4	9.3	17.0	24.2	25.8	11.8	2.3	0.0	0.0				93
Average number of days with max. temp. ≥ 30 °C	0.0	0.0	0.0	0.0	1.1	6.7	13.4	15.1	4.2	0.0	0.0	0.0				41
Average number of days with min. temp. ≥ 20 °C	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.7	0.1	0.0	0.0	0.0				2
Average precipitation sums (mm)	84	69	79	67	103	94	67	48	85	96	85	72				949
Maximum daily precipitation sums (mm)	45.0	65.7	29.4	32.6	73.7	58.7	45.0	29.0	56.7	60.4	51.2	36.7		73.3		
Average number of days with daily precipitation ≥ 0.1 mm	16.1	15.8	15.3	14.8	15.5	13.1	10.4	8.8	10.9	13.7	13.1	15.3				163
Average number of days with daily precipitation ≥ 1.0	10.4	10.5	10.8	9.9	11.5	9.8	7.5	5.8	8.1	9.5	9.0	9.3				112
Average number of days with daily precipitation ≥ 10 mm	2.4	1.9	2.9	2.2	3.8	3.0	2.5	1.8	2.9	3.7	2.7	2.5				32
Average number of days with daily precipitation ≥ 20 mm	0.8	0.2	0.8	0.1	1.2	1.1	1.0	0.4	1.3	1.2	1.0	0.9				10
Maximum height of the snow cover (cm)	31	107	42	9	9	0	0	0	0	23	40	37		107		
Average number of days with snow cover ≥ 10 cm	6.6	6.6	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.0	5.2				24
Average number of days with snow cover ≥ 30 cm	0.2	2.6	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.2				4
Average number of days with snow cover ≥ 50 cm	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1				2
Medium cloudiness (tenth)	7.0	7.1	6.1	6.1	6.1	5.4	4.3	3.6	5.3	5.9	6.0	7.5	5.9			
Medium relative humidity (%)	78	73	68	64	67	67	64	63	69	76	75	80	70			
Insolation (hours)	76.7	89.7	139.9	168.2	192.8	221.7	268.1	255.5	181.8	147.9	114.3	68.0				1924.5

Table 12. Meteorological data for the Sarajevo area, Faletići-Mošćanica vrelo meteorological station, period 1961-1990.

Parameter	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Medium**	**Max.**	**Min.**	**Sum**
Average precipitation sums (mm)	82	76	78	80	95	101	88	81	78	85	104	95				1042
Maximum daily precipitation sums (mm)	103.6	53.9	49.2	81.0	59.6	50.8	47.8	45.5	90.1	54.0	62.1	60.2		103.6		
Average number of days with daily precipitation ≥ 0.1 mm	11.3	11.1	11.1	11.0	11.6	11.7	9.4	8.0	8.0	8.4	10.0	11.0				116.1
Average number of days with daily precipitation ≥ 1.0	10.0	9.8	10.2	10.5	11.0	11.2	8.8	7.9	7.6	8.1	10.0	11.0				116.1
Average number of days with daily precipitation ≥ 10 mm	2.5	2.5	2.2	2.6	3.2	3.6	3.4	3.0	2.8	2.9	3.8	3.2				35.7
Average number of days with daily precipitation ≥ 20 mm	0.9	0.7	0.7	07	1.2	1.1	1.2	0.9	1.0	1.1	1.4	1.0				12.0

Table 13. Data on the direction of wind movement (the wind rose) in the area of Sarajevo, Sarajevo-Bjelave Meteorological Station, period 2007-2016.
Data for tables 11 and 12 were prepared by Ms. Slavica Jovanović and for table 13 by Mr. Bakir Krajinović.

Parameter	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	WN	NNV	C
Frequences of directions (%)	2.1	0.8	0.8	2.2	7.0	26.5	6.1	4.6	3.0	2.7	2.5	5.9	9.7	11.3	6.7	6.2	1.8
Medium wind speed (m/s)	1.4	1.3	1.4	1.7	2.2	2.4	1.6	1.5	2.1	1.8	1.5	1.2	1.1	1.3	1.3	1.4	0.0

Table 14. Phytocoenological presentation of the *Thymo-Seslerietum ujchelyii* comb. nova association.

Phytocoenological position	Indicator value	Association	Thymo-Seslerietum ujchelyii comb. nova									
		Locality	The Miljacka canyon-Bentbaša									
		Altitude (m)	540	540	545	545	545	550	555			
		Exposition	E	N	E-NE	N-NE	E	E	E			
		Slope (°)	80-90	90	90	90-100	90	80-90	80-100			
		Geological base	Limestone (dolomitized limestone)									
		Type of soil	Lithosol and calcomelanosol									
		Image size (m^2)	Per 100 m^2									
		General cover (%)	35	30-40	30	20-30	30	25	20			
		Date	May 11, 2016.									
		Ordinal image number	1.	2.	3.	4.	5.	6.	7.	Frequency	Floral element	Life form
		Floristic composition										
Amp.	P	Thymus jankae Čelak.	1.2	1.2	1.2	+2	+2	+2	1.1	7/100 %	balk	Ch
Amp.	P	Sesleria ujchelyii Strgar	1.2	1.2	2.2	1.1	+2	+2	2.2	7/100%	din	H
S.-C.	S	Galium purpureum L.	1.2	2.2	1.1	1.1	-	1.1	+2	6/85 %	balk	H
B. e.	S	Silene vulgaris (Mch) Garcke	1.2	1.2	1.1	1.1	1.1	1.1	1.1	7/100 %	no-euras-smed	H(Ch)
B. e.	S	Sanguisorba muricata (Spach) Focke	1.2	+1	+2	+2	-	1.1	1.2	6/85 %	med(-cont)	H
Amp.	P	Leontodon crispus Vill.	1.2	1.1	+2	+1	-	-	-	4/55 %	balk	H
S.-C.	S	Tunica saxifraga (L.) Scop.	1.1	1.2	+2	1.1	2.2	1.1	-	6/85 %	(o)smed	H
Amp.	P	Erysimum linearifolium Tausch	1.1	+2	1.1	1.2	-	-	+2	5/70 %	s. o. balc	H
Che.	T	Veronica hederifolia L.	1.1	+2	+2	+2	-	-	-	4/55 %	eurassubocean-smed	T
S.-C.	S	Acinos arvensis (Lam.) Dandy	1.1	1.2	-	-	-	+2	-	3/40 %	smed-euras	T(Ch)
Arr.	S	Hypochoeris radicata L.	1.1	-	-	-	-	-	-	1/15 %	subatl(-smed)	H
Q. p.	P	Carex humilis Leyss.	1.1	-	-	-	-	-	-	1/15 %	(euras)cont-smed	H
S.-C.	S	Sedum album L.	+2	-	1.2	+2	1.1	1.1	1.2	6/85 %	(pralp)smed-subatl	Ch
S.-C.	S	Centaurea rhenana Borb.	+2	-	1.1	-	-	+1	+2	4/55 %	s. o. kont	H
Art.	T	Artemisia absinthium L.	+2	-	+2	-	-	-	+2	3/40 %	eurascont(-smed)	Ch(H)
P. s.	PS	Campanula trachelium L.	+2	-	-	-	-	-	-	1/15 %	eurassubocean-smed	H
O.	T	Tanacetum parthenifolium Willd.	+2	-	-	-	-	-	-	1/15 %	omed	H
Amp.	P	Stipa calamagrostis (L.) Wahlenb.	+1	1.2	+2	-	1.1	+2	-	5/70 %	pralp-smed	H
Arr.	S	Taraxacum officinale Web.	+1	-	+2	+1	-	-	-	3/40 %	no-euras(subocean)	H
Amp.	P	Asplenium trichomanes L.	+1	-	+2	-	-	-	-	2/30 %	eurassubocean	H
Amp.	P	Chondrilla juncea L.	+1	-	+2	-	-	-	-	2/30 %	med-smed-cont	H
O.	T	Carduus crispus L.	+1	-	+1	-	-	-	-	2/30 %	eurassubocean	H
B. e.	SP	Hypericum perforatum L.	+1	+1	-	-	-	-	-	2/30 %	eurassubocean-smed	H
Che.	T	Prunus domestica L.	+1	-	-	-	-	-	-	1/15 %	n-persia	P
P. s.	PS	Crataegus monogyna Jacq.	+1	-	-	-	-	-	-	1/15 %	submed(-subatl)	P
B. e.	S	Medicago lupulina L.	-	1.1	-	+2	+2	-	-	3/40 %	euras-smed	H(T)
Arr.	S	Poa pratensis L.	-	+2	+2	-	-	+2	-	3/40 %	euras(cont)(-smed)	H(G)

S.-C.	S	Sedum acre L.	-	+2	-	-	-	+2	+2	3/40 %	(no-)eurassuboce-an(-smed)	Ch
Amp.	P	Sempervivum tectorum L.	-	+2	-	-	-	-	-	1/15 %	pralp	Ch
Art.	T	Artemisia vulgaris L.	-	+1	-	+2	-	-	-	2/30 %	eurassubocean	Ch(H)
Amp.	P	Micromeria thymifolia (Scop.) Fritsch.	-	-	2.2	+2	-	+2	1.2	4/55 %	balk	Ch
Amp.	P	Galium corrudaefolium Tausch	-	-	1.1	-	+2	1.1	1.1	3/40 %	med	H
B. e.	S	Euphorbia cyparissias L.	-	-	+2	-	-	+1	-	2/30 %	smed(-euras)	H
Che.	T	Cirsium oleraceum (L.) Scop.	-	-	+2	-	-	-	-	1/15 %	euras(cont)	H
B. e.	S	Bromus erectus Huds.	-	-	+2	-	-	-	-	1/15 %	smed	H
Amp.	P	Minuartia bosniaca (G. Beck) K. Malý	-	-	+2	-	-	-	-	1/15 %	din	Ch
A. f.	P	Arabis hirsuta (L.) Scop.	-	-	+1	+1	-	+2	-	3/40 %	euras-smed,circ	H(T)
B. e.	S	Picris hieracioides L.	-	-	+1	-	-	-	-	1/15 %	euras(cont)-smed	H
B. e.	S	Sanguisorba minor Scop.	-	-	-	+2	-	-	-	1/15 %	smed	H
Amp.	P	Allium sphaerocephalum L.	-	-	-	+1	+1	+2	+2	4/55 %	balc	G
Arr.	S	Arrhenatherum elatius (L.) J. & K. Presl	-	-	-	+1	-	-	-	1/15 %	subatl-smed	H
O.	T	Anthemis tinctoria L.	-	-	-	+1	-	-	-	1/15 %	euras(cont)smed	H
Amp.	P	Melica ciliata L.	-	-	-	-	+2	-	-	1/15 %	smed	H
P. s.	PS	Rubus discolor Weihe & Nees	-	-	-	-	+2	-	-	1/15 %	(no-)subatl(-smed)	P
Che.	T	Stellaria media L.	-	-	-	-	+2	-	-	1/15 %	no-euras-med	T
Che.	T	Bromus sterilis L.	-	-	-	-	+2	-	-	1/15 %	smed	T
P. s.	PS	Clematis vitalba L.	-	-	-	-	+1	+2	+2	3/40 %	smed-subatl(circ)	P
Q. p.	P	Fraxinus ornus L.	-	-	-	-	+1	+2	-	2/30 %	osmed	P
Arr.	S	Vicia sepium L.	-	-	-	-	+1	+2	-	2/30 %	eurassubocean	H
Amp.	P	Rhamnus rupestris Scop.	-	-	-	-	+1	-	+2	2/30 %	balc-apen	P
Che.	T	Ballota nigra L.	-	-	-	-	+1	-	-	1/15 %	osmed-gemässkont	H(Ch)
O.	T	Bifora radians M. Bieb.	-	-	-	-	+1	-	-	1/15 %	omed	T
Arr.	S	Plantago lanceolata L.	-	-	-	-	+1	-	-	1/15 %	eurassubocean	H
P. s.	SP	Coronilla varia L.	-	-	-	-	-	+2	-	1/15 %	gemässkont-osmed	H
A. f.	P	Scrophularia canina L.	-	-	-	-	-	+2	-	1/15 %	smed	H
P. m.	T	Agropyron repens (L.) Beauv.	-	-	-	-	-	+2	-	1/15 %	no-euras	H(G)
P. s.	PS	Rosa canina L.	-	-	-	-	-	+2	+1	2/30 %	eurassubocean-smed	P
Arr.	S	Vicia cracca L.	-	-	-	-	-	+1	+1	2/30 %	no-euras	H
E.-P.	P	Genista januensis Viv.	-	-	-	-	-	-	1.1	1/15 %	din-so-alp	P(Ch)
Amp.	P	Onosma stellulatum W. K.	-	-	-	-	-	-	+2	1/15 %	din	H
B. e.	S	Helianthemum nummularium (L.) Run.	-	-	-	-	-	-	+2	1/15 %	smed	Ch
S.-C.	S	Eryngium amethystinum L.	-	-	-	-	-	-	+2	1/15 %	balc-apen	H
O.	T	Melilotus officinalis L.	-	-	-	-	-	-	+1	1/15 %	eurassubocean(-smed)	H

Table 15. Phytocoenological table on *Thymo-Erysimetum linearifoliae* comb. nova.

Phytocoenological position	Indicator value	Association	Thymo-Erysimetum linearifoliae comb. nova										
		Locality	The Miljacka canyon, rocks behind the Dariva										
		Altitude (m)	565	565	570	570	570	575	576	578			
		Exposition	E-SE	E-SE	SE	S-SE	S-SE	E-SE	E-SE	E-SE			
		Slope (°)	90	80-90	90	80-90	90-100	90	80	80-100			
		Geological base	Limestone (dolomitized limestone)										
		Type of soil	Lithosol and calcomelanosol										
		Image size (m²)	100	100	100	100	100	100	100	100			
		General cover (%)	20	20-30	30	20-25	30	20	5	5-10			
		Date	May 12, 2016.										
		Ordinal image number	1.	2.	3.	4.	5.	6.	7.	8.	Fre-quency	Floral element	Life form
		Floristic composition											
Amp.	P	Thymus jankae Čelak.	1.1	2.2	1.1	1.1	1.1	2.2	+2	2.2	8/100%	balk	Ch
Amp.	P	Galium corrudaefolium Tausch	1.1	-	+2	+2	1.1	1.1	+2	+2	7/87.5 %	med	H
Amp.	P	Stipa calamagrostis (L.) Wahlenb.	1.1	1.1	-	-	+1	+2	-	+2	5/62.5 %	pralp-smed	H
S.-C.	S	Sedum album L.	+2	1.1	+2	-	1.1	1.1	+2	2.2	7/87.5 %	(pralp)smed-subatl	Ch
Amp.	P	Erysimum linearifolium Tausch	+2	+1	+2	+1	+2	+2	+2	+2	8/100 %	s. o. balc	H
B. e.	SP	Hypericum perforatum L.	+2	+2	-	+1	+1	+1	-	+2	6/75 %	eurassubocean-smed	H
Amp.	P	Sedum ochroleucum Chaix	+2	1.1	-	-	-	+2	-	+2	4/50 %	med	Ch
Amp.	P	Melica ciliata L.	+2	-	-	1.1	-	-	-	-	2/25 %	smed	H
Amp.	P	Sesleria ujchelyii Strgar	+2	-	-	-	-	-	-	-	1/12.5 %	din	H
S.-C.	S	Acinos hungaricus Simonkai	+2	-	-	-	-	-	-	-	1/12.5 %	europcont	T(Ch)
P. s.	PS	Clematis vitalba L.	+1	-	+2	-	-	+2	+1	+2	5/62.5 %	smed-subatl(circ)	P
S.-C.	S	Centaurea rhenana Borb.	+1	-	-	-	-	+1	-	+2	3/37.5 %	s. o. cont	H
Q. p.	P	Inula conyza DC.	+1	-	-	-	-	-	+1	+2	3/37.5 %	smed(-euras)	H
Arr.	S	Taraxacum officinale Web.	+1	-	-	+1	-	-	-	-	2/25 %	no-euras(subocean)	H
P. s.	PS	Ligustrum vulgare L.	+1	-	-	-	-	-	-	-	1/12.5 %	smed	P
B. e.	S	Silene vulgaris (Mch) Garcke	-	1.1	+1	-	-	-	+1	+2	4/50 %	no-euras-smed	H(Ch)
S.-C.	S	Tunica saxifraga (L.) Scop.	-	1.1	-	-	+2	1.1	-	+2	4/50 %	(o)smed	Ch
Amp.	P	Micromeria thymifolia (Scop.) Fritsch	-	+2	-	+1	-	-	-	-	2/25 %	balk	Ch
B. e.	S	Helianthemum nummularium (L.) Run	-	+2	-	-	-	-	-	-	1/12.5 %	smed	Ch
Arr.	S	Poa pratensis L.	-	+1	+2	+2	-	-	-	-	3/37.5 %	euras(kont)(-smed)	H(G)
Che.	T	Ailanthus glandulosa Desf.	-	+1	-	-	-	-	-	-	1/12.5 %	china	P
Q. p.	P	Dactylis aschersoniana (Graebn.) Hay.	-	-	+2	-	+2	-	-	-	2/25 %	gemässkont	H
Amp.	P	Chondrilla juncea L.	-	-	-	+2	+1	+1	+1	+1	5/62.5 %	med-smed-cont	H

Q. p.	P	Fraxinus ornus L.	-	-	-	+2	-	-	-	-	1/12.5 %	osmed	P
Q. p.	P	Ostrya carpinifolia Scop.	-	-	-	+2	-	-	-	-	1/12.5 %	osmed	P
P. s.	PS	Rosa canina L.	-	-	-	+1	-	-	-	-	1/12.5 %	eurassubocean-smed	P
Che.	T	Rumex crispus L.	-	-	-	+1	-	-	-	-	1/12.5 %	eurassubocean-smed	H
Che.	T	Chenopodium album L.	-	-	-	+1	-	-	-	-	1/12.5 %	no-euras(-med)	T
Amp.	P	Dianthus kitaibeli Janka in Pančˇ.	-	-	-	+1	-	-	-	-	1/12.5 %	din	Ch
Che.	T	Tussilago farfara L.	-	-	-	+1	-	-	-	-	1/12.5 %	no-euras-smed	G(H)
S.-C.	S	Acinos arvensis (Lam.) Dandy	-	-	-	-	+2	-	-	-	1/12.5 %	smed-euras	T(Ch)
Q. p.	P	Arabis turitta L.	-	-	-	-	+2	-	-	-	1/12.5 %	smed	H
A. f.	P	A. hirsuta (L.) Scop.	-	-	-	-	+2	-	-	-	1/12.5 %	euras-smed.circ	H(T)
Che.	T	Euphorbia stricta L.	-	-	-	-	+2	-	-	-	1/12.5 %	smed-gemässkont	T
Amp.	P	Asplenium trichomanes L.	-	-	-	-	+1	-	-	-	1/12.5 %	eurassubocean	H
Q. p.	P	Hedera helix L.	-	-	-	-	+1	-	-	-	1/12.5 %	subatl-smed	Ch(P)
B. e.	S	Dorycnium herbaceum Vill.	-	-	-	-	+1	-	-	-	1/12.5 %	omed-smed	Ch
A. f.	P	Scrophularia canina L.	-	-	-	-	-	+2	-	+2	2/25 %	smed	H
Amp.	P	Allium carinatum L.	-	-	-	-	-	+2	-	-	1/12.5 %	smed(-subatl)	G
B. e.	S	Sanguisorba muricata (Spach.) Focke	-	-	-	-	-	+2	-	-	1/12.5 %	med(-cont)	H
Che.	T	Barbarea vulgaris R. Br.	-	-	-	-	-	+1	-	-	1/12.5 %	euras-smed	H
P. s.	PS	Prunus spinosa L.	-	-	-	-	-	+1	-	-	1/12.5 %	eurassubocean-smed	P
Arr.	S	Lolium perenne L.	-	-	-	-	-	-	+2	+2	2/25 %	subatl-smed	H
F.	P	Potentilla micrantha Ram.	-	-	-	-	-	-	+2	-	1/12.5 %	smed	H
P. s.	PS	Crataegus monogyna Jacq.	-	-	-	-	-	-	+1	-	1/12.5 %	submed(-subatl)	P

Table 16. Phytocoenological table of the *Diantho-Genistetum januensis* comb. nova association.

Phytocoenological position	Indicator value	Association	Diantho-Genistetum januensis comb. nova										
		Locality	The Miljacka canyon - in the vicinity of the Kozija ćuprija bridge										
		Altitude (m)	568	567	568	570	570	572	573	572			
		Exposition	E-SE	E-SE	E-SE	SE	E-SE	E-SE	E-SE	SE			
		Slope (°)	80	80-90	90	80-90	90	80-90	90	80-90			
		Geological base	Limestone (dolomitized limestone)										
		Type of soil	Lithosol and calcomelanosol										
		Image size (m²)	50	100	100	100	50	100	50	50			
		General cover (%)	30	30-35	25	30-40	30	30-40	30	30			
		Date	May 12, 2016.										
		Ordinal image number	1.	2.	3.	4.	5.	6.	7.	8.	Frequency	Floral element	Life form
		Floristic composition											
Amp.	P	Dianthus kitaibeli Janka in Panč.	2.2	1.1	2.2	1.1	1.1	1.1	1.1	1.1	8/100 %	din	Ch
Amp.	P	Thymus jankae Čelak.	1.1	1.1	1.1	1.1	1.1	-	1.1	1.1	7/87.5 %	balk	Ch
Amp.	P	Sedum ochroleucum Chaix.	1.1	1.1	+2	+2	+2	-	+2	1.1	7/87.5 %	med	Ch
S.-C.	S	S. album L.	1.1	-	-	-	-	+2	+2	1.1	4/50 %	(pralp)smed-subatl	Ch
E.-P.	P	Genista januensis Viv.	+2	+2	+2	+2	+2	+1	+2	+2	8/100 %	din-so-alp	P(Ch)
Amp.	P	Galium corrudaefolium Tausch	+2	1.1	+2	1.1	1.1	1.1	1.1	1.1	8/100 %	med	H
Amp.	P	Stipa calamagrostis (L.) Wahlenb.	+2	1.1	1.1	1.1	+2	1.1	1.1	1.1	8/100 %	pralp-smed	H
B. e.	S	Silene vulgaris (Mch) Garcke	+2	1.1	-	+2	1.1	-	+2	-	5/62.5 %	no-euras-smed	H(Ch)
B. e.	S	Sanguisorba muricata (Spach.) Focke	+2	+2	-	+2	+2	-	+2	+2	6/75 %	med(-cont)	H
Amp.	P	Melica ciliata L.	+2	1.1	-	-	1.1	+2	1.1	1.1	6/75 %	smed	H
S.-C.	S	Tunica saxifraga (L.) Scop.	+2	+2	-	+2	-	+2	-	+1	5/62.5 %	(o)smed	Ch
S.-C.	S	Galium purpureum L.	+2	-	+2	+2	-	-	+2	-	4/50 %	balc	H
B. e.	S	Teucrium chamaedrys L.	+2	+2	+2	-	-	-	-	-	3/37. 5 %	smed-med	Ch
A. f.	P	Arabis hirsuta (L.) Scop.	+2	-	-	+2	-	+1		-	3/37. 5 %	euras-smed, circ	H(T)
B. e.	S	Dorycnium herbaceum Vill.	+2	-	-	-	-	-	-	-	1/12.5 %	omed-smed	Ch
Q. p.	P	Fraxinux ornus L.	+1	+1	+1	+1	+1	-	+2	-	6/75 %	osmed	P
F.	P	Potentilla micrantha Ram.	+1	-	+1	+1	-	-	-	-	3/37.5 %	smed	H
P. s.	PS	Crataegus monogyna Jacq.	+1	+1	-	-	-	+1	-	-	3/37.5 %	submed(-subatl)	P
B. e.	S	Euphorbia cyparissias L.	+1	-	-	+1	-	-	-	+2	3/37.5 %	smed(-euras)	H
Arr.	S	Dactylis glomerata L.	+1	-	-	-	+1	-	-	-	2/25 %	euras(-smed)	H
P. s.	PS	Rosa canina L.	+1	-	-	-	+1	-	-	-	2/25 %	eurassubocean-smed	P
S.-C.	S	Centaurea rhenana Borb.	+1	-	-	-	-	-	1.1	-	2/25 %	s. o. cont	H
P. s.	PS	Campanula trachelium	-	+1	+1	+1	+2	-	+1	-	5/62.5 %	eurassubozean-smed	H
P. s.	PS	Clematis vitalba L.	-	+1	-	+1	-	+1	+2	+2	5/62.5 %	smed-subatl(circ)	P
F.	P	Geum urbanum L.	-	+1	-	-	-	-	-	-	1/12.5 %	eurassubozean-smed	H
P. m.	T	Agropyron repens (L.) Beauv.	-	+1	-	-	-	-	+2	-	2/25 %	no-euras	H(G)
Arr.	S	Poa pratensis L.	-	-	+2	+2	+2	-	-	-	3/37.5 %	euras(cont)(-smed)	H(G)
Amp.	P	Micromeria thymifolia (Scop.) Fritsch	-	-	+2	+2	-	-	1.1	1.1	4/50 %	balk	H
Q. p.	P	Coronilla emerus L. ssp. emeroides (Boiss. et Spr.) Hayek	-	-	+2	-	-	-	-	-	1/12.5 %	o(smed)	P
P. s.	PS	Ligustrum vulgare L.	-	-	+1	-	+1	+1	-	-	3/37.5 %	smed	P

Q. p.	P	Arabis turitta L.	-	-	-	+1	+2	-	-	-	2/25 %	smed	H
P. s.	PS	Cornus sanguinea L.	-	-	-	+1	-	-	-	-	1/12.5 %	osmed	P
S.-C.	S	Scabiosa leucophylla Borb.	-	-	-	+1	-	-	-	-	1/12.5 %	din	H
Arr.	S	Taraxacum officinale Web.	-	-	-	+1	-	-	-	-	1/12.5 %	no-euras(subocean)	H
Amp.	P	Asplenium trichomanes L.	-	-	-	+1	-	-	-	-	1/12.5 %	eurassubocean	H
B. e.	S	Plantago media L.	-	-	-	+1	-	-	-	-	1/12.5 %	euras(cont)-smed	H
B. e.	S	Stachys recta L.	-	-	-	-	+2	+2	-	+2	3/37.5 %	smed(-gemässkont)	H
Amp.	P	Erysimum linearifolium Tausch	-	-	-	-	+2	-	-	1.1	2/25 %	s. o. balk	H
Q. p.	P	Sesleria autumnalis (Scop.) F. W. Schul.	-	-	-	-	+2	-	-	-	1/12.5 %	balk	H
F.	P	Hieracium sylvaticum (L.) Grubf.	-	-	-	-	+1	+2	-	-	2/25 %	no-eurassubocean	H
B. e.	SP	Hypericum perforatum L.	-	-	-	-	+1	-	+2	+2	3/37.5 %	eurassubocean-smed	H
F.	P	Geranium robertianum L.	-	-	-	-	+1	-	-	-	1/12.5 %	eurassubocean-smed	H(T)
Amp.	P	Allium carinatum L.	-	-	-	-	-	+2	-	-	1/12.5%	smed(-subatl)	G
E.-P.	P	Cytisus nigricans L.	-	-	-	-	-	+1	-	-	1/12.5 %	gemässkont-osmed	P
Q. p.	P	Inula conyza DC.	-	-	-	-	-	+1	+1	-	2/25 %	smed(-euras)	H
S.-C.	S	Acinos hungaricus Simonkai	-	-	-	-	-	+1	-	-	1/12.5 %	europcont	T(Ch)
Q. p.	P	Silene otites (L.) Sm.	-	-	-	-	-	+1	-	-	1/12.5 %	(gemäss)kont(-smed)	H
B. e.	S	Galium verum L.	-	-	-	-	-	-	+2	+1	2/25 %	euras-smed	H
A. f.	S	Scrophularia canina L.	-	-	-	-	-	-	+2	-	1/12.5 %	smed	H
Q. p.	P	Syringa vulgaris L.	-	-	-	-	-	-	+2	-	1/12.5 %	s. o. eur	P
Q. p.	P	Ostrya carpinifolia Scop.	-	-	-	-	-	-	+1	-	1/12.5 %	osmed	P
Che.	T	Sonchus oleraceus (L). Scop.	-	-	-	-	-	-	+1	-	1/12.5 %	euras(cont)	H
Q. p.	P	Quercus petraea (Matt.) Lieb.	-	-	-	-	-	-	+1	-	1/12.5 %	subatl-smed	P

The life and work of professor dr. Ljubomir Mišić (1933 – 2018)

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Professor Dr. Ljubomir Mišić was born on 10 September 1933 in Nišor, Pirot Municipality, Serbia. He attended primary school in Tamnianica and high school in Pirot. He graduated in 1960 from the Faculty of the Humanities in Sarajevo, having studied in the Biology group of the Department of Natural Sciences and Mathematics. As an undergraduate eligible for higher degree he worked for a short while as a laboratory assistant at the Faculty of Agriculture in Sarajevo, where he was appointed to the post of assistant lecturer of Botany on 15 January 1962. He defended his doctoral dissertation, "Meadow and pasture vegetation on Mt. Treskavica," at the Faculty of Natural Sciences and Mathematics in Sarajevo on 22 February 1985, and was appointed to the post of senior lecturer of Botany at the Faculty of Agriculture, Sarajevo University, that same year. Dr. Mišić's productive scientific research work and numerous monographs, course notes, manuals and textbooks led to his promotion on 17 February 1987 to the post of Reader of Botany at the Faculty of Agriculture, Sarajevo University. He had a good knowledge of Russian, Bulgarian, German and French.

Professor Dr. Ljubomir Mišić

From his first appointment in 1962, Prof. Dr. Ljubomir Mišić spent his entire working life without a breakat the Faculty of Agriculture in Sarajevo. In addition to his regular duties at the faculty, he was also engaged at the University's Biology Institute, and taught in the Biology Department of the Faculty of Natural Sciences and Mathematics and the Forestry Faculty in Sarajevo. He remained in Sarajevo throughout the war against Bosnia and Herzegovina, teaching Botany and Fundamentals of Plant Production in three departments of the Faculty of Agriculture. Without the support of a junior lecturer or laboratory assistant, he was responsible for the entire teaching process – lectures, laboratory work, examinations and colloquia, not only at his parent faculty but also, from 1992, at the Forestry Faculty.

Despite carrying this considerable burden of teaching at these two faculties both before, during and after the war, Prof. Dr. Ljubomir Mišić also pursued his scientific work, achieving some very remarkable results. He had an intimate knowledge of meadow vegetation in Bosnia and Herzegovina, and his doctoral dissertation, "Meadow and pasture vegetation on Mt. Treskavica," remains unsurpassed on the subject. The crowning achievement of his wealth of experience and years of research into meadow and pasture vegetation was the publication in 1989 of *Livadske biljke* (Meadow plants) in the series Nature of Yugoslavia by Svjetlost, a prominent publishing house at that time together with the Institutes for Textbooks and Teaching Materials in Sarajevo and Belgrade.

The results of Prof. Ljubomir Mišić's thorough analysis of the flora and vegetation of the meadows and pastures of the Dinarics, with particular reference to Bosnia and Herzegovina, became an important source for phytogeographers, systematicists and botanists working in Yugoslavia and beyond. The breadth of his floristic discoveries was complemented by his detailed biosystematic approach to the analysis of each species. His serious attention to idioecological, phytocoenological, chorological and syngenetic research enabled him to consider a given species through the lens of population-genetic expression and its anatomical, morphological, ecological, chorological and other characteristics. Thus the dignity of a modern biosystematicist who found a place in the latest revision of the flora of Bosnia and Herzegovina is still upheld.

Prof. Dr. Ljubomir Mišić had a particular interest in medicinal and aromatic plants, and was very familiar with the value of the wild flora for the treatment of both human and animal ailments.

He had his own living collection of medicinal plants near Sarajevo, where he would spend his spare time among them in his garden, benefiting as a natural scientist and botanist from this direct contact with the plant world and thereby acquiring and extending his knowledge of medicinal plants in the most direct manner. He was always happy to give medicinal plants from his garden to his colleagues – I myself (Dubravka Šoljan).= still have a splendid sage bush (*Salvia officinalis*) grown from a cutting given to me by Prof. Mišić. Whenever I see that sage bush I remember my dear colleague – he lives there still!

Prof. Mišić conveyed the knowledge and experience, acquired above all from years of field work in Bosnia and Herzegovina as well as beyond, to his students in class, as well as in his course notes, textbooks and scholarly works. His knowledge of medicinal plants from a scientific perspective, and in particular the production potential of the wild flora of Bosnia and Herzegovina, enabled him to consider every opportunity for the cultivation and use of medicinal, aromatic, culinary and fodder plants in modern agricultural production. He incorporated this knowledge with great success into his Fundamentals of Plant Production course at the Faculty of Agriculture.

There can be no doubting the magnitude of Prof. Dr. Ljubomir Mišić's contribution as a researcher and scientist to floristic, systematic and phytogeographical studies of the endemic flora of Bosnia and Herzegovina. His knowledge of the genus *Gentiana* was unparalleled, particularly of the species native to the south-eastern Dinarics, such as *Gentiana kochiana*, *G. acaulis*, *G. dinarica,* and *G. symphyandra*. He conducted extensive comparative biosystematic studies on these species, which led to the publication of a number of major papers.

It is clear from all this that Prof. Dr. Ljubomir Mišić made an outstanding contribution to the development of the botanical sciences, with particular emphasis on systematics, ecology, and the anatomy, cytology and morphology of plants. The result of his research and tireless life's work was the publication of some 30 scientific works, four monographs, and about 40 studies, reports, scientific projects and evaluations. He wrote two textbooks, two manuals and one set of course notes used used in teaching prospective graduate agricultural engineers. All this earned him a place among the most productive scientists and experts who have left their imprint on the time and place where they worked.

Professor Ljubomir Mišić was also much appreciated by his students as an excellent lecturer and teacher, with a gift for artistic expression. His drawings on the blackboard complemented and brought to life the botany of which he was speaking. His course notes and textbooks too were filled with the splendid original drawings for which he was known and valued by his students and colleagues. He was kind and

Professor Ljbomir Mišić with his fellow botanists (L to R: Nikola Janjić, Željka Bjelčić, Petar Grgić, Lijerka Kutleša, Dubravka Šoljan and Sabaheta Abadžić).

patient with his students, always ready to help them master the course materials.

As already noted, Prof. Mišić participated in a great many scientific projects, in each of which he was extremely cooperative, conscientious and precise in executing his particular tasks. He was responsible for the Fabaceae family, with which he was very familiar, as part of the *Index florae* of Bosnia and Herzegovina, involving botanists from 1996 to 1997. He carried out this tasks with exemplary thoroughness, and prepared the text for publication in the planned series of papers in the Journal of the National Museum. Sadly, the paper was not published until 2014, as the first part of the series *Index florae Bosnae et Hercegovinae.*

The Sarajevo University Council awarded him a Plaque with diploma in 1989 for his very productive and successful teaching and scientific work, which along with his collaboration with leading institutions in the field of biology also earned him the Plaque of the Biology Institute of Sarajevo University.

We shall remember Professor Ljubomir Mišićas a kind, modest, retiring and remarkable man, whose face always bore a gentle, sweet smile. His clear brown eyes revealed his lively spirit and depth of intelligence. He was extremely caring and helpful towards his colleagues. He will live on in our memories for his benevolence, his diligence, and his courteous relations with his colleagues.

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NOTE

In addition to the works listed above, Prof. Dr. Ljubomir Mišić also published scholarly works, contributed numerous papers at congresses, symposia and consultations, and carried out various studies and evaluations, as well as producing many scientific and artistic illustrations for his own textbooks and those of other authors.