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Early spring flora of the Sub-Pannonic steppic grassland (NATURA 2000 site) in Bilje, northeast Croatia

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Abstract – The diversity of early spring vascular flora was studied in the Sub-Pannonic steppic grassland in the village of Bilje, north eastern Croatia. In all, 109 plant taxa within 35 families were found. The highest number of taxa belongs to the families Poaceae, Fabaceae, Asteraceae, Caryophyllaceae, Lamiaceae and Rosaceae. Specific habitat conditions, characterized by moderately wet and moderately acidic soil with intermediate fertility and the effects of the continental climate favour the development of different plant life forms. Out of the total recorded plant taxa, hemicryptophytes make up 59.6%, followed by therophytes (22.0%) and geophytes (13.8%). Chorological analysis shows that the most numerous are plants of Eurasian (33.9%), Pontic-Central-Asian (21.1%) and Central European (21.1%) floral elements. According to their status in the Red List, three critically endangered (CR), one vulnerable (VU) and three nearly threatened (NT) plant species were found. Altogether, the steppe-like grassland in Bilje is a unique habitat rich in valuable plants of the Croatian flora, including the critically endangered *Doronicum hungaricum*, therefore it is of great importance to preserve it. Important management tools include mowing and controlling the spreading of cultivated and invasive plant species.

Key words: chorological types, flora, life-forms, NATURA 2000, Pannonian Region, steppe-like grassland

Introduction

Grasslands, herbaceous communities mostly dominated by grasses (Poaceae) or other graminoids, like Cyperaceae and Juncaceae (Janišová et al. 2011), are among the largest ecosystems in the world. In Europe there are various grassland types, ranging from humid grasslands in the north and north-west parts of the continent, through steppic and mesic grasslands to the near-desert types that occur in south-east Spain (Owen 2008). Dry grasslands cover much smaller European areas than mesic and wet grasslands and most of them are semi-natural habitats, resulting from centuries of traditional land use, such as grazing, mowing, temporary abandonment of arable fields, and/or other disturbance events (Dengler et al. 2014). Dry grasslands involve a variety of grassland biotopes (Rodwell et al. 2002) that are usually present on relatively dry and nutrient-poor soils. Some of the most important dry grassland habitats are Sub-Pannonic steppic grasslands of the alliance *Festucion valesiacae* (Klika 1931) developed on rocky substrate and clay-sandy sedimentation layers enriched with gravels. Through the centuries, many of Sub-Pannonic steppic grasslands have been destroyed by afforestation and ploughing, or by land abandonment which led to their degradation (Ruprecht et al. 2009). Steppe-like grasslands are dominated by *Festuca valesiaca* Schleich. ex Gaudin, *Carex humilis* Leyss., *Chrysopogon gryllus* (L.) Trin., *Stipa* species, but they are also important habitats for many rare and endangered plant species (Cremene et al. 2005, Buček et al. 2006, Jones et al. 2010). Therefore, these grasslands are considered biodiversity hotspots and included as an EU priority habitat type in the NATURA 2000 network, designated under code 6240*.

The Republic of Croatia differs from most European countries with respect to its huge variety of habitats and great diversity of flora. Grasslands cover approximately 17.6% of the Croatian terrestrial area (Anonymous 2006). Sub-Pannonic steppic grasslands are very rare and only few occur in the continental part of Croatia. This study focused on the grassland in the village of Bilje situated in northeast

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Croatia. The most significant contribution to the floristic knowledge of the area was given by Zahirović (2000), while there have been no recent scientific publications on surveying the steppe-like grassland flora of Bilje. The aim of the current investigation was to investigate the diversity of spring steppe-like grassland flora with special reference to rare and endangered plant species.

Materials and methods

The study was carried out at the grassland surface at the local cemetery in the village of Bilje (45°36'N, 18°45'E), situated 5 km northeast of Osijek (Croatia, Baranja region, Fig. 1). The area is influenced by a continental climate. According to data from Osijek meteorological station (1981–2010), mean air temperature is 11.3 °C with an annual precipitation of 684 mm. Geomorphologically, the study area mostly belongs to the lowland area built of Quaternary sediments formed during the Pleistocene and Holocene (Banak et al. 2012). The Holocene sediments are mostly fluvial sands and sandy clay (Regional plan of the Municipality of Bilje 2005). Steppe-like grassland covers 0.63 ha and it is among the last remnants of dry steppe grasslands of the alliance *Festucion valesiacae* in Croatia. Thus, it is included in the national ecological network of Croatia (designated with code HR2000728) which is a part of the EU NATURA 2000 network. In 2001, the area was protected as a natural monument.

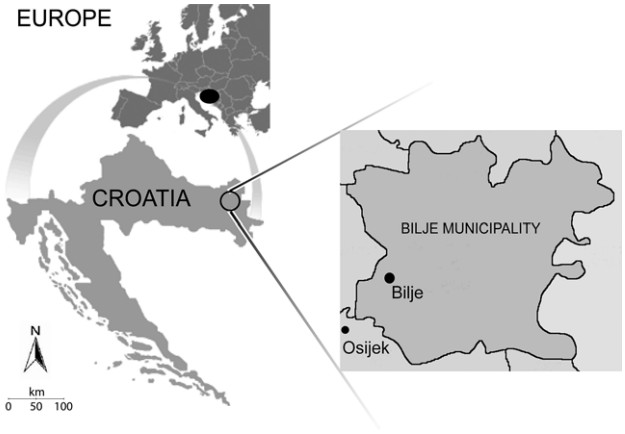

Fig. 1. Study area: Sub-Pannonic grassland in Bilje (northeast Croatia).

The research on the grassland flora was conducted weekly during eight field surveys, carried out from the beginning of April to the end of May 2015. Plant taxa were identified according to Javorka and Csapody (1975), Knežević and Volenik (1981) and Domac (1989) and arranged alphabetically and systematically. The nomenclature and interpretation of plant life forms (Therophyta – T, Chamaephyta – Ch, Hemicryptophyta – H, Phanerophyta – P, Nano-phanerophyta – N, Geophyta – G) were adjusted according to the Croatian Flora Checklist (Nikolić 2016). Phytogeographical analysis was interpreted according to Josifović (1970–1977), Zahirović (2000), and Ranđelović et al. (2007). Geoelements were described with the following numbers: 1 – Pontic – Central – Asian, 2 – Central European, 3 – sub-Atlantic, 4 – sub-Mediterranean, 5 – Eurasian, 6 – sub-Boreal, 7 – Adventive plants and 8 – Cosmopolites. The species were categorized by threat levels according to Nikolić and Topić (2005) and Nikolić (2016), and invasive plant species according to Nikolić et al. (2014). The diversity of environmental grassland parameters was determined according to Ellenberg et al. (1994) and adjusted according to the Croatian Flora Checklist (Nikolić 2015). Ellenberg indicator values (EIV) included the following indicators described by numerical scales ranging from 1–9: light (L), temperature (T), salinity (S), moisture (M), soil reaction (SR), and nitrogen (N). Descriptive statistical analysis of environmental parameters was carried out using STATISTICA software package (StatSoft. Inc., ver. 12).

Results

A total of 109 vascular plant taxa (92 species and 17 subspecies) from 35 families were identified during the study period (Tab. 1). Poaceae was the largest taxonomic group (represented by 12 taxa), followed by Fabaceae (10 taxa), Asteraceae (8 taxa) and Caryophyllaceae (8 taxa). Lamiaceae and Rosaceae were present with six taxa, each.

Tab. 1. List of vascular plant taxa occurring in steppe-like grassland in Bilje in spring of 2015. Life form: H – Hemicryptophyta, T – Therophyta, Ch – Chamaephyta, P – Phanerophyta, N – Nano-phanerophyta, G – Geophyta; Chorological type: 1 – Pontic – Central – Asian, 2 – Central European, 3 – sub-Atlantic, 4 – sub-Mediterranean, 5 – Eurasian, 6 – sub-Boreal, 7 – Adventive plants and 8 – Cosmopolites; Threat levels: CR – critically endangered, VU – vulnerable, NT – nearly threatened; Asterisk (*) denotes invasive species.

List of taxa	Life form	Chorological types	Threat levels
SPERMATOPHYTA			
MAGNOLIOPHYTINA			
MAGNOLIATAE			
Apiaceae			
Anthriscus sylvestris (L.) Hoffm.	H	5	
Peucedanum oreoselinum (L.) Moench	H	1	
Aristolochiaceae			
Aristolochia clematitis L.	H	4	
Asteraceae			
Achillea millefolium L.	H	5	
Ambrosia artemisiifolia L. *	T	7	
Artemisia vulgaris L.	H	8	
Doronicum hungaricum Rchb. f.	G	1	CR
Erigeron annuus (L.) Pers.*	H	7	
Inula hirta L.	H	1	
Taraxacum officinale Weber	H	5	
Bellis perenis L.	H	2	

Tab 1. – continued

List of taxa	Life form	Chorological types	Threat levels
Boraginaceae			
Anchusa officinalis L.	H	2	
Myosotis discolor Pers. subsp. *discolor*	T	2	
Myosotis ramosissima Rochel	T	8	
Brassicaceae			
Arabis glabra (L.) Bernhardt	H	8	
Arabidopsis thaliana (L.) Heynh.	T	5	
Capsella bursa-pastoris (L.) Medik.	H	8	
Erophila verna (L.) Chevall. subsp. *verna*	T	8	
Calepina irregularis (Asso) Thell.	T	4	
Campanulaceae			
Campanula patula L.	H	2	
Campanula rapunculus L.	H	5	
Caryophyllaceae			
Cerastium semidecandrum L.	H	2	
Dianthus carthusianorum L.	H	4	
Holosteum umbellatum L.	T	5	
Lychnis viscaria L. subsp. *viscaria*	H	1	
Moenchia mantica (L.) Bartl. subsp. *mantica*	T	1	
Saponaria officinalis L.	H	5	
Silene latifolia Poir. subsp. *alba* (Mill.) Greuter & Bourdet	H	5	
Stellaria media (L.) Vill.	T	8	
Cistaceae			
Helianthemum nummularium (L.) Mill. subsp. *nummularium*	Ch	2	
Cichoriaceae			
Hieracium pilosella L. subsp. *pilosella*	H	2	
Hypochoeris maculata L.	H	5	
Tragopogon pratensis L. subsp. *orientalis* (L.) Čelak.	H	5	
Clusiaceae			
Hypericum perforatum L.	H	5	
Crassulaceae			
Sedum telephium L. subsp. *maximum* (L.) Krock.	H	5	
Euphorbiaceae			
Euphorbia cyparissias L.	H	5	
Fabaceae			
Lotus corniculatus L.	H	2	
Medicago minima (L.) Bartal.	T	1	
Medicago sativa L. subsp. *sativa*	H	7	
Trifolium alpestre L.	H	1	
Trifolium repens L.	H	5	
Trifolium montanum L.	H	1	
Vicia cracca L.	H	5	
Vicia grandiflora Scop.	T	1	
Vicia lathyroides L.	T	2	
Vicia villosa Roth subsp. *villosa*	T	1	
Fagaceae			
Quercus robur L.	P	2	
Geraniaceae			
Erodium cicutarium (L.) L' Hér.	H	5	
Geranium sanguineum L.	H	1	
Geranium dissectum L.	T	8	
Lamiaceae			
Ajuga genevensis L.	H	5	
Lamium purpureum L.	T	2	
Mentha aquatica L.	H	5	
Salvia pratensis L.	H	2	
Thymus pulegioides L.	Ch	2	
Glechoma hederacea L.	H	5	
Oleaceae			
Syringa vulgaris L.	N	7	
Papaveraceae			
Papaver dubium L.	T	8	
Papaver rhoeas L.	T	5	
Plantaginaceae			
Plantago lanceolata L.	H	5	
Plantago media L.	H	5	
Polygalaceae			
Polygala comosa Schkuhr	H	5	
Polygonaceae			
Rumex acetosa L. subsp. *acetosa*	H	5	
Rumex acetosella L.	G	8	
Ranunculaceae			
Pulsatilla pratensis (L.) Miller subsp. *nigricans* (Störck) Zamels	H	1	CR
Ranunculus polyanthemos L.	H	1	
Rosaceae			
Filipendula vulgaris Moench	H	6	
Potentilla argentea L.	H	1	
Potentilla cinerea Chaix ex Vill.	H	1	
Potentilla heptaphylla L.	H	2	
Prunus tenella Batsch	N	1	CR
Geum urbanum L.	H	5	
Saxifragaceae			
Saxifraga bulbifera L.	H	4	
Scrophulariaceae			
Verbascum phoeniceum L.	H	1	
Veronica austriaca L. subsp. *austriaca*	H	1	
Veronica chamaedrys L.	H	2	
Veronica hederifolia L.	T	2	
Veronica persica Poir.*	T	8	
Valerianaceae			
Valerianella locusta (L.) Laterrade	T	4	
Violaceae			
Viola arvensis Murray	T	5	

Tab 1. – continued

List of taxa	Life form	Chorological types	Threat levels
Viola tricolor L.	T	5	
Viola odorata L.	H	2	
LILIATAE			
Amaryllidaceae			
Allium sphaerocephalon L. subsp. *sphaerocephalon*	G	1	
Allium vineale L.	G	2	
Narcissus poeticus L.	G	7	
Narcissus pseudonarcissus L. subsp. *pseudonarcissus*	G	3	
Asparagaceae			
Muscari botryoides (L.) Mill.	G	1	
Muscari comosum (L.) Mill.	G	4	
Ornithogalum umbellatum L.	G	2	
Polygonatum latifolium (Jacq.) Desf.	G	1	VU
Cyperaceae			
Carex caryophyllea Latourr.	H	5	
Carex praecox Schreb.	H	5	NT
Iridaceae			
Iris variegata L.	G	1	NT
Iris sp.	G	5	
Juncaceae			
Luzula campestris (L.) DC.	H	8	
Liliaceae			
Gagea pratensis (Pers.) Dumort.	G	5	
Orchidaceae			
Orchis morio L.	G	2	NT
Poaceae			
Anthoxanthum odoratum L.	H	5	
Apera spica-venti (L.) P. Beauv.	T	5	
Arrhenatherum elatius (L.) P. Beauv. ex J. Presl & C. Presl	H	2	
Briza media L.	H	5	
Bromus inermis Leyss.	H	5	
Chrysopogon gryllus (L.) Trin.	H	1	
Dactylis glomerata L.	H	5	
Festuca rupicola Heuff. subsp. *rupicola*	H	2	
Hordeum murinum L.	T	8	
Koeleria pyramidata (Lam.) P. Beauv.	H	2	
Poa bulbosa L.	H	5	
Poa pratensis L.	G	8	

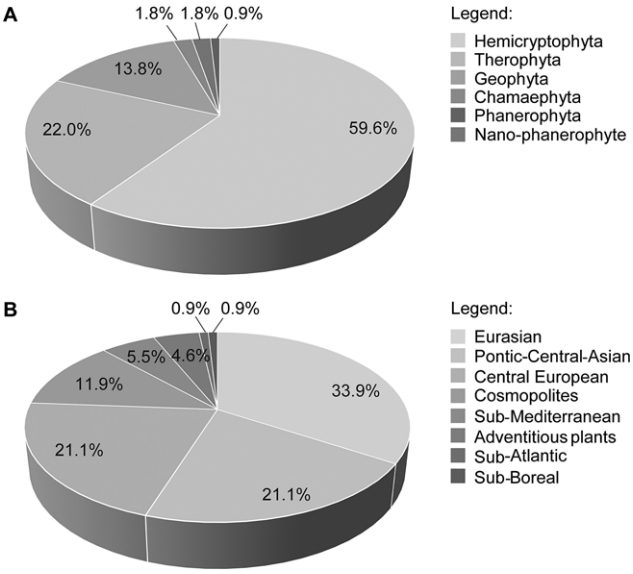

Fig. 2. Life form (A) and chorological spectrum (B) of steppe-like grassland flora occurring in Bilje in spring 2015.

Ecological indicatory values (Fig. 3) were defined for more than 90% of the plant taxa. The greatest number of plant taxa preferred half-light conditions (38 taxa, EIV L = 7) and relatively warm habitats (32 taxa, EIV T = 6) characterized by moderately wet (33 taxa, EIV M = 5) and moderately acid soils (41 taxa, EIV SR = 6) with intermediate fertility (24 taxa, EIV N = 5). Almost none of the identified taxa (93%) tolerate salty soils (EIV S = 0).

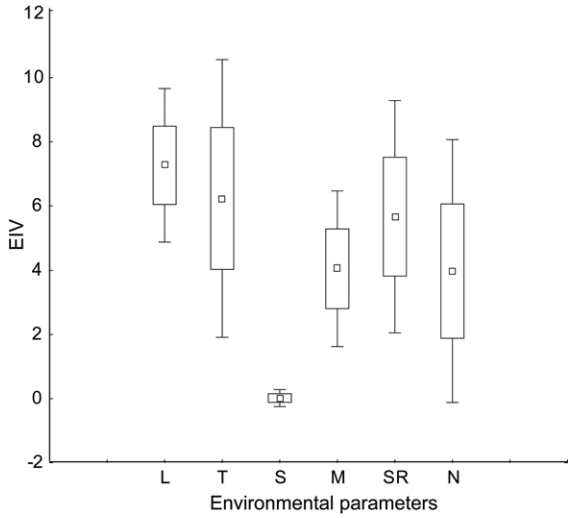

Fig. 3. Box and whiskers plot for environmental variables. Ellenberg indicator values (EIV): L – light, T – temperature, S – salinity, M – moisture, SR – soil reaction, N – nitrogen.

Regarding the distribution of plant life forms (Fig. 2A), hemicryptophytes were dominant (59.6%), followed by therophytes (22.0%) and geophytes (13.8%). According to phytogeographical analysis (Fig. 2B) Eurasian (33.9%), Pontic-Central-Asian (21.1%), and Central-European (21.1%) floral elements predominated. Cosmopolites were represented with 13 (11.9%) taxa.

According to threat status given in the Red Book of Vascular Flora of Croatia, *Doronicum hungaricum* Rchb.f., *Pulsatilla pratensis* (L.) Miller subsp. *nigricans* (Störck) Zamels and *Prunus tenella* Batsch are critically endangered (CR), *Polygonatum latifolium* (Jacq.) Desf., is vulnerable (VU) and *Carex praecox* Schreber, *Iris variegata* L. and *Orchis morio* L. are nearly threatened (NT). In the early

spring flora, three invasive species (*Ambrosia artemisifolia* L., *Erigeron annuus* (L.) Pers. and *Veronica persica* Poir) were found.

Discussion

Northeast Croatia belongs to the Pannonian region. In the period following the last ice age, forest steppes i.e. mosaic of grasslands and woodlands were parts of the original Pannonian landscape and covered these areas for a long time (Illyés et al. 2007). For centuries, the Pannonian region was heavily influenced by humans and consequently, much of the area was converted to productive agricultural land. Today, in the Pannonian Region, dry grasslands occur only as small fragments, mainly on sites not suitable for intensive cultivation and agricultural production (Sundseth 2009). The steppe-like grassland in Bilje remained preserved due to the specific location in the grounds of the local cemetery.

The plant community indicates prevailing environmental conditions in certain habitats (Schaffers and Sýkora 2000). According to Ellenberg indicator values the steppe-like grassland in Bilje is a well-illuminated, relatively warm habitat characterized by fresh soil of average moisture, moderately acid and moderately rich in nitrogen. The alliance *Festucion valesiacae* was also found in warmer, drier, and less nutrient rich habitats in Romania (Dengler et al. 2012), Serbia (Aćić et al. 2015) as well as in the Carpathians and the Pannonian Basin (Dúbravková et al. 2010).

Dry grasslands are usually characterized by high species richness (Dengler and Boch 2008, Purger and Csiky 2008, Zima and Štefanić 2009, Vassilev et al. 2011, Vitasović Kosić and Britvec 2014, Pirini et al. 2014). In comparison of the number of taxa with that of the steppe-like grassland flora of the NATURA 2000 site near Bapska, Eastern Croatia (79 taxa, Šegota et al. 2015), we can conclude that plant species richness of the investigated grassland in Bilje is relatively high, probably due to the anthropogenic influence. Human impact may change habitats, leading to the increase in the number of plant taxa (Alegro et al. 2006). The appearance of some species such as *Viola odorata*, *Syringa vulgaris* and *Iris* sp., which were also cultivated on the surrounding graves, suggests that anthropogenic activities mediated their spreading along the grassland area. However, the early spring flora which accounts for more than 80% of the total grassland plant taxa found by the previous floristic investigation in Bilje (Zahirović 2000) indicates a well-conserved habitat. A specific characteristic of its flora is the prevalence of Eurasian, Pontic-Central-Asian, and Central-European floral elements with a mosaic complex of different steppic species which also were found in steppe-like grasslands in Bulgaria (Vasillev and Apostolova 2013) and Serbia (Ranđelović et al. 2007). The family Poaceae is represented with genera like *Festuca*, *Chrysopogon*, *Poa* and *Koeleria*, together with species from the Fabaceae, Asteraceae and Caryophyllaceae families, which add certain specificity to the grassland flora in Bilje. These plant families usually characterize steppe flora around the world (Türe and Böcük 2007, Matevski et al. 2008).

Hemicryptophytes made up the large majority of the recorded species. This life form is well represented in the European flora (Ellenberg 1988) and usually characterizes grassland communities (Šugar et al. 2005). Furthermore, the high number of therophytes indicates the dryness of this region, the modification of the climate (Rauš and Šegulja 1983, Tomašević 2006) and considerable anthropogenic influence (Mitić et al. 2007).

Some of the recorded plant species are listed in the Red Book of Vascular Plants of Croatia (Nikolić and Topić 2005). The critically endangered *Pulsatilla pratensis* subsp. *nigricans* grows at several locations in Croatia (Vrbek 2001, Vitasović Kosić et al. 2009, Nikolić 2016), while the steppe-like grassland in Bilje is one of the two reported habitats for *Doronicum hungaricum* in the country (Nikolić 2016). In northeast Croatia, *Prunus tenella* is reported as a very rare species (Krčmar and Ozimec 2004, Purger and Csiky 2008). It grows at the edge of the steppe-like grassland in Bilje. Besides in Croatia, the endangered species *Doronicum hungaricum* and *Prunus tenella*, as well as the nearly threatened *Iris variegata* and *Orchis morio*, are also included in the national Red Lists of Vascular Flora of some other European countries (Jackowiak et al. 2007, Grulich 2012, Turis et al. 2014). The steppe-like grassland was also marked by the presence of some woody (e.g. *Quercus*, *Syringa*) and invasive (*Ambrosia artemisiifolia*, *Erigeron annuus*, *Veronica persica*) species. Their occurrence could be an important threat for grassland flora. Generally, trees and shrubs encroach on the sites and develop layers of high cover leading to a rapid decrease in species richness (Dúbravková and Hajnalová 2012). Invasive species, due to the biological characteristics (Lonsdale 1999), may outcompete native species for resources (Brewer and Cralle 2003), suppress their growth (Jordan et al. 2008), and have a negative influence on species diversity (Dogra et al. 2010).

Together with habitat loss, the abandonment of the traditional ways of land management and uncontrolled digging of plants have been generally recognized as the most important threats to plant diversity (Young et al. 2005, Nikolić 2016). In the investigated steppe-like grassland, plant diversity depends on the specific types of management. Mowing is an especially important management tool to control the spread of woody plant species. Considering the uncommon position of this steppe-like grassland within the local cemetery where the opening of new burial places is already limited, controlling the spread of cultivated and invasive plant species should be important steps toward long-term persistence of diverse steppe flora. Since the plant diversity, characterized by rare and endangered plant species, represents an important and irreplaceable natural resource in these steppe-like grassland, conservation of this habitat is therefore of great importance.

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