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FLORA OF NATURAL PASTURES IN THE BOCAR AREA (BANAT, SERBIA) AS A BIOINDICATOR OF HABITAT ECOLOGICAL CONDITIONS

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Abstract

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Natural pastures, as unique flora and vegetation habitats, are very sensitive to environmental conditions and anthropogenic impacts; thus, understanding the relationship between plants and environmental factors is essential. Development of plants, i.e., their specific life forms, in a habitat, is affected by the climatic conditions, as well as the plant requirements with respect to other environmental factors, which are thus reliable bioindicators of environmental conditions. Studies on flora and vegetation of natural pastures, as endangered ecosystems, are thus a starting point for the assessment, monitoring and conservation of their biodiversity, aimed at ensuring their sustainable use, i.e., maintenance of their agricultural productivity. Therefore, the aim of this paper is to present the current state of the flora of the studied ecosystem, assess the prevalent environmental conditions based on the identified flora, and-via analysis of variance and correspondence analysis-determine the relationship between ecological factors and the occurrence of certain plant life forms. These findings, in addition to careful selection and planning of mowing and grazing, which should be adapted to local conditions, are expected to facilitate the natural ecosystem recovery.

The studied ecosystem flora comprises 135 taxa (119 species, 5 subspecies, 4 varieties, 6 forms and 1 lusus). Based on the ecological analysis of the identified taxa, the studied ecosystem-in temperate climate conditions ($K_{\bar{x}}$ = 3.23), on a soil characterized by considerable degree of salinity in places (S_{+} = 34.92%)-is moderately moisture ($F_{\bar{x}}$ = 3.01), neutral to mildly acidic ($R_{\bar{x}}$ = 3.25), mesotrophic ($N_{\bar{x}}$ = 3.15), moderately rich in organic compounds ($H_{\bar{x}}$ = 2.97), moderately aerated ($D_{\bar{x}}$ = 4.15), and subject to a favorable light ($L_{\bar{x}}$ = 3.76) and thermal regimen ($T_{\bar{x}}$ = 3.91).

The biological spectrum of the identified taxa (therophytes - 38.52%, hemicryptophytes - 37.04%, geophytes - 20.00%, chamaephytes - 3.70% and phanerophytes - 0.74%) indicates that the environmental conditions of the studied pastures are favorable for therophyte and hemicryptophyte development.

Analysis of variance showed that, in the studied pastures, the development of the identified life forms is dependent on all ecological factors. The correspondence analysis between the ecological index values and the identified life forms revealed that extreme environmental conditions - very wet (F_5), extremely oligotrophic (N_1) and highly eutrophic (N_5), humus-free (H_1) or humus-rich (H_5) soil, adequately aerated habitat (D_2), prevalent semi-shade conditions (L_2), or strong direct light (L_5) - are not conductive of the development of the identified ecomorphs i.e. identified taxa.

Key words: natural pastures, flora, ecology, life forms, statistical analysis, Banat

Introduction

Grasslands are among the most widespread ecosystems on Earth, covering about 3500 million hectares (Carlier et al., 2009) and more than 30% of agricultural land in Central Europe (Zimkova et al., 2007). In Serbia, it covers about 1.4 million hectares (Aćić et al., 2013), and are found at all altitudes, ranging from lowlands to mountains, in different climatic, edaphic and orographic conditions (Kojić et al., 2005). They are important agricultural resources, as they are used for livestock grazing (Pykälä, 2005; Metera et al., 2010), in addition to being habitats of medicinal plants and wild varieties of cultivated plants, as an important genetic pool for resistance to various stresses (Escaray et al., 2012; Petrović, 2012).Their economic significance depends on the quality of the vegetative cover and yield (Kojić et al., 2005). However, due to different environmental conditions, such as

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reduced amount of water and nutrients, as well as variations in rainfall and natural vegetation complexity, they are often characterized by low productivity (Naz, et al., 2010; Ozturk et al., 2012; Knežević et al., 2012b; Knežević et al., 2012c). Many natural grasslands of the studied area (Vojvodina, Serbia) have been developed on halomorphic (saline) soil and occupy 8.06% of the Province of Vojvodina territory (Belić et al., 2004). However, rapid urbanization, reclamation practices and the use of various agricultural measures have led to a significant reduction in their area, whereby pastures are presently among the most fragile and threatened habitats in Serbia and abroad (Ranđelović et al., 2007; Kahmen and Poschlod, 2008; Aćić et al., 2013). Therefore, according to the European Union Habitats Directive (92/43/CEE), protection of these habitat types is a priority (http://ec.europa.eu/environment/nature/legislation/habitatsdirective/).

As habitats of unique flora and vegetation (De Haan et al., 1997; WallisDeVries et al., 2002; Bernhardt and Koch, 2003; Pagiola et al. 2004; Wright, 2005; Pornaro et al., 2013), natural pastures are very sensitive to environmental conditions and anthropogenic impacts, making understanding of the relationship between plants and environmental factors essential. Development of plants and their specific life forms, in addition to climatic conditions, depends on their requirements with respect to other environmental factors; thus, they can serve as reliable environmental conditions bioindicators (Nikolić et al., 2011; Roukos et al., 2011; Petrova et al., 2013). Studies on flora and vegetation of natural pastures, as endangered ecosystems, are thus a starting point for the assessment, monitoring and conservation of their biodiversity, aimed at ensuring their sustainable use, i.e., maintenance of their agricultural productivity as a means of natural ecosystem recovery (Kar, 2013). In addition, preservation and protection of pastures requires careful selection and planning of mowing and grazing, which should be adapted to local conditions (Pykälä et al., 2005; Metera et al., 2010). Consequently, comprehensive research studies in the field of ecology, botany, agriculture, animal production and rural economy should be accompanied by work on extensive grazing (Metera et al., 2010).

Therefore, the aim of this paper is to present recent state of the flora of the studied ecosystem, assess the prevalent environmental conditions based on the identified flora, and-via analysis of variance (ANOVA) and correspondence analysis-determine the relationship between environmental factors and the occurrence of certain plant life forms. These findings, in addition to careful selection and planning of mowing and grazing, which should be adapted to local conditions, are expected to facilitate the natural ecosystem recovery.

Materials and Methods

Study area

Natural pasture flora studies were carried out in the vicinity of the Bočar village, located in the Serbian part of Banat region at 45°46’5.13”N latitude and 20°16’53.20”E longitude (Figure 1). The area is dominated by temperate climate. Due to its geographical position, Banat is subject to relatively easy penetration of air currents from the east across Carpathian Mountains and the lowlands of Wallachia from the northwest, in addition to the Central European climate impacts across the Alps, and the influence of Mediterranean climate from the southwest, across the Dinarides, which mitigates the continentality of the study area (Ljevnaić-Mašić, 2010). This area is characterized by hot and dry summers, long, cold and harsh winters, and moderately warm and short spring and autumn, and is thus subject to significant temperature fluctuations. The air temperature steadily increases from the January minimum towards the maximum in July and August, after which it gradually declines toward the autumn and winter period (Ljevnaić-Mašić, 2010). In summer, temperatures can reach up to 44°C, while sometimes declining to -33°C during winter (Lazić and Pavić, 2003). Mean annual air temperature increases from west to east and from north to south (Obradović, 2009; Ljevnaić-Mašić, 2010). The average annual air temperature is 11.0°C and, from mid-July to late September, the study area enters an adverse semi-arid period. Mean annual precipitation increases from north to south (Ljevnaić-Mašić (2010). During the last six decades, the vegetative season in Serbia has been extended by 2 to 23 days, with Banat characterized by the longest vegetative period (Radičević et al., 2008).

Fig. 1. Study area

In the Bočar area, according to the national classification, the most common soil types are clayic humogley and solonetz (Škorić et al., 1985), corresponding to Vertisol and Solonetz, based on the International Classification (WRB, 2006). Pedogenesis, and therefore the local flora, is affected by the presence of high groundwater levels. Groundwater is located at a depth of about 2 m and, owing to the clayey soil texture, water retention on the soil surface is possible after abundant rainfall. These soils are characterized by coarser texture, lower overall porosity, i.e., poor water-air regime, higher compaction, and medium to lower water-permeability (Živković et al., 1972). The surface layer of these soils is non-calcareous with neutral chemical reaction. Humus content in Vertisol and Solonetz is predominately medium to high (Ćirić et al., 2013). The total content of water-soluble salts is low in the surface layer, increasing significantly with depth. According to the criteria proposed by Manojlović et al. (1995), the readily available potassium content is at good or optimal levels, while readily available phosphorus content is low. Although these soil properties do not provide optimal conditions for plant growth and development, sparse vegetation has nevertheless developed and is used by locals as natural pastures (Knežević et al., 2012c). These habitats are, according to the Institute for Nature Conservation of Vojvodina Province, designated for protection (http://www.pzzp.rs/page.php?id=78).

Data pertaining to the flora and vegetation of natural pastures in the vicinity of the Bočar village are sourced from a previous work in this area (Knežević et al., 2012c). The identified plant species were determined using standard determination keys (Josifović, M. ed. I-X, 1970-1977; Săvulescu, T. ed. I-XIII, 1952-1976; Tutin et al. 1964; Tutin et al. 1968-1980). The taxonomy follows classification by Takhtajan (2009) and ecological indices are determined according to Landolt (1977). Taxa for which Landolt does not provide ecological indices are, according to the author's criteria, given by Knežević (1994) and Knežević et al. (2012c). Life forms are determined according to Landolt (1977), and those not covered by this classification are based on Raunkier (1910) and Čanak et al. (1978). To determine the significance of differences and the relationship between specific ecological indices and the identified life forms, analysis of variance (ANOVA) and correspondence analysis were conducted using the STATISTICA 7.0 software.

Results and Discussion

The studied ecosystem flora comprises 135 taxa (119 species, 5 subspecies, 4 varieties, 6 forms and 1 lusus), as shown in Table 1. They form stands of 11 associations belonging to classes *Phragmitetea* Tx. et Prsg 1942 and *Festuco-Puccinellietea* Soó 1968 (Knežević et al., 2012c). Taxonomic analysis revealed that the representatives of the families Poaceae (24 taxa), Asteraceae (17 taxa) and Fabaceae (15 taxa) are most abundant (Table 1).

From the identified taxa, 126 were selected for ecological flora analysis, i.e., 119 species and 5 subspecies, as well as ecologically specific varieties *Aster tripolium* L. var. *pannonicus* (Jacq.) Beck and *Glyceria fluitans* (L.) R. BR. var. *poaeformis,* whose higher taxonomic categories were not noted in the studied flora (Table 1).

Plant response to habitat humidity - F (Figure 2). Ecological analysis of the examined flora with respect to habitat humidity indicates presence of plants adapted to different levels of habitat humidity. The highest participation is noted for subxerophytes (F_2), i.e., plants adapted to moderately arid habitats (F_2 – 33.33%, 42 taxa), while xerophytes (as indicators of extremely dry habitats, F_1) are least abundant, with 4.76% (6 taxa) participation. The presence of subxerophytes and xerophytes (38.09% in total), found in the most elevated parts of the pasture, is a result of a physiological drought and adverse semi-arid period lasting from mid-July to late September (Knežević et al., 2012c; Ljevnaić-Mašić, 2010). Significant mesophyte presence, as an indicator of moderately humid habitats, is also noted (F_3 – 32.54%, 41 taxa). This is followed by less pronounced, but still significant, hygrophyte presence, as a bioindicator of wet habitats (F_4 – 15.08%; 19 taxa). Finally, a number of hydrophytes, i.e., aquatic plants (F_5 – 14.29%, 18 taxa) are present, which develop on occasionally wet habitats, the lowest parts of the pastures and natural depressions, due to the presence of storm water and high levels of groundwater, which is characteristic of Banat (Knežević et al., 2012a). Development of plants adapted to different habitat humidity levels is a result of climatic, edaphic and microrelief factors (Knežević et al., 2012a). The mean value of the ecological index for habitat humidity characterizes the studied ecosystem as moderately humid ($F_{\bar{x}}$ = 3.01).

Plant response to habitat chemical reaction – R (Figure 2). In the ascertained flora, neutrophilic plants predominate (R_3 – 60.32%, 76 taxa). Significant presence of bioindicators of neutral to mildly alkaline medium (R_4 – 32.54%, 41 taxa) is noted, which is characteristic of saline habitats (Kabić, 1988). Finally, with 7.14% (9 taxa), indicators of acidic habitats (R_2) are least represented. Acidophilic (R_1) and basophilic (R_5) plants are not present in the analyzed flora. The mean value of the ecological index for habitat chemical reaction ($R_{\bar{x}}$ = 3.25) indicates that the soil of the studied ecosystem is neutral to slightly acidic.

Plant response to soil mineral content – N (Figure 2). Adaptability analysis of the identified taxa with respect to the

Table 1
The studied ecosystem flora

Plant species	Familia	Life form	Ecological indices								
			F	R	N	H	D	S	L	T	K
Achillea millefolium L.	Asteraceae	h	2	3	3	3	4	-	4	3	3
Achillea setacea W. et K.	Asteraceae	h	1	3	2	2	3	-	4	5	5
Agrimonia eupatoria L.	Rosaceae	h	2	4	3	3	4	-	4	4	3
Agropyrum repens (L.) Beauv.	Poaceae	g	3	3	4	2	3	+	4	3	3
Agrostis alba L.	Poaceae	h	4	3	3	3	4	-	4	5	2
Agrostis alba L. f. *coarctata* Rchb.	Poaceae	h	4	3	3	3	4	-	4	5	2
Alisma lanceolatum With.	Alismataceae	g	5	3	3	3	5	-	4	4	3
Alisma plantago-aquatica L.	Alismataceae	g	5	3	3	3	5	-	4	4	3
Alopecurus geniculatus L.	Poaceae	h	4	3	4	3	5	+	3	4	3
Alopecurus pratensis L.	Poaceae	h	4	3	4	3	5	-	4	3	3
Anagallis foemina Mill.	Primulaceae	t	2	3	3	3	4	-	3	3	4
Artemisia maritima L. subsp. *monogyna* (W. et K.) Gams.	Asteraceae	c	2	4	2	2	4	+	4	4	5
Aster tripolium L. var. *pannonicus* (Jacq.) Beck	Asteraceae	h	3	4	2	2	4	+	4	4	4
Atriplex tatarica L.	Chenopodiaceae	t	3	3	4	2	4	+	3	3	4
Beckmannia eruciformis (L.) Host	Poaceae	h	5	4	4	3	5	+	4	3	4
Bolboschoenus maritimus (L.) Palla	Cyperaceae	g	5	4	3	3	5	+	4	4	3
Bromus commutatus Schrad.	Poaceae	t	2	3	3	3	5	-	3	4	3
Bromus mollis L.	Poaceae	t	3	3	4	3	4	-	4	4	3
Bupleurum tenuissimum L.	Apiaceae	t	3	3	3	3	5	+	4	5	1
Butomus umbellatus L.	Butomaceae	g	5	3	4	4	5	-	3	4	3
Calamagrostis epigeios (L.) Roth.	Poaceae	h	3	3	3	2	3	-	3	3	3
Camphorosma annua Pall.	Chenopodiaceae	t	2	4	1	1	4	+	5	4	4
Camphorosma annua Pall. f. *nana* Moq.	Chenopodiaceae	t	2	4	1	1	4	+	5	4	4
Carduus nutans L.	Asteraceae	u	2	4	4	2	3	-	4	4	3
Carex distans L.	Cyperaceae	h	4	3	3	3	5	+	4	4	2
Carex vesicaria L.	Cyperaceae	g	5	3	3	3	5	-	4	4	3
Carex vulpina L.	Cyperaceae	h	5	4	2	4	4	-	3	4	3
Centaurium umbellatum Gilib.	Gentianaceae	u	3	3	3	3	4	-	4	4	3
Cerastium caespitosum Gilib.	Caryophyllaceae	c	3	3	3	3	4	-	3	3	3
Cerastium dubium L. (Bast.) Schwarz.	Caryophyllaceae	t	4	3	3	3	4	-	3	5	2
Chenopodium rubrum L. subsp. *botryoides* Sm.	Chenopodiaceae	t	3	3	5	3	4	+	4	3	4
Chenopodium rubrum L. subsp. *botryoides* Sm. var. *crassifolium* (Horn.) Kov.	Chenopodiaceae	t	3	3	5	3	4	+	4	3	4
Chenopodium vulvaria L.	Chenopodiaceae	t	2	3	5	3	3	-	4	4	4
Cichorium intybus L.	Asteraceae	g	2	4	3	3	5	-	5	4	3
Cirsium arvense (L.) Scop.	Asteraceae	g	3	3	4	3	4	+	3	4	3
Cirsium lanceolatum (L.) Scop.	Asteraceae	t	3	3	4	4	4	-	3	3	3
Convolvulus arvensis L.	Convolvulaceae	g	2	4	3	3	4	-	4	4	3
Cynodon dactylon (L.) Pers.	Poaceae	g	2	3	3	3	3	-	4	5	2
Dactylis glomerata L.	Poaceae	h	3	3	4	3	4	-	3	4	3
Daucus carota L.	Apiaceae	u	2	3	2	3	3	-	4	4	3
Dipsacus laciniatus L.	Dipsacaceae	u	3	4	4	3	5	-	4	5	3
Eryngium campestre L.	Apiaceae	h	2	4	3	3	3	-	4	5	3
Euphorbia cyparisias L.	Euphorbiaceae	h	2	3	2	3	4	-	4	3	3
Festuca vallesiaca Sch. subsp. *pseudovina* (Hack.) A. et G.	Poaceae	h	1	3	2	2	3	+	4	4	5

Table 1 (*continued*)

Fragaria viridis Duchense	Rosaceae	h	2	3	3	3	4	-	3	5	4
Galium aparine L.	Rubiaceae	t	3	3	5	3	4	-	3	4	3
Galium verum L.	Rubiaceae	g	2	4	2	3	5	-	4	4	4
Galium verum L. f. *spiculifolium* Schur	Rubiaceae	g	2	4	2	3	5	-	4	4	4
Glyceria fluitans (L.) R. Br. var. *poaeformis* Fries.	Poaceae	g	5	4	3	4	5	+	4	3	3
Gypsophila muralis L.	Caryophyllaceae	t	3	2	1	2	3	-	4	4	4
Heleocharis palustris (L.)R.Br.	Cyperaceae	g	5	4	2	4	5	-	4	3	3
Hordeum asperum (Simk.) Deg.	Poaceae	t	2	3	3	3	4	-	4	4	4
Hordeum maritimum Stokes subsp. *gussoneanum* (Parl.) A. et G.	Poaceae	t	2	4	3	3	5	+	5	4	3
Hypericum perforatum L.	Hypericaceae	h	2	3	3	3	5	-	3	4	3
Inula britannica L.	Asteraceae	h	4	4	3	3	4	+	3	5	3
Juncus compressus Jacq.	Juncaceae	g	4	3	3	3	5	+	4	3	3
Juncus compresus Jacq. var. *compressus* f. *porphyrocarpus* J. Murr.	Juncaceae	g	4	3	3	3	5	+	4	3	3
Juncus conglomeratus L.	Juncaceae	h	4	2	3	4	5	-	4	3	2
Juncus gerardii Lois.	Juncaceae	g	4	3	3	3	4	+	5	3	4
Lactuca saligna L.	Asteraceae	u	1	3	4	3	4	+	4	5	4
Lathyrus aphaca L.	Fabaceae	t	2	3	3	3	4	-	3	4	4
Lathyrus hirsutus L.	Fabaceae	u	2	4	3	3	3	-	3	4	4
Lathyrus tuberosus L.	Fabaceae	g	2	4	3	3	5	-	4	4	4
Lepidium draba L.	Brassicaceae	h	2	3	4	3	4	-	3	4	4
Lepidium ruderale L.	Brassicaceae	u	2	3	4	2	3	-	4	4	4
Lolium perenne L.	Poaceae	h	3	3	4	3	5	-	4	3	3
Lotus corniculatus L.	Fabaceae	h	2	4	3	3	4	-	4	3	3
Lotus tenuis Kit.	Fabaceae	h	3	4	2	3	5	+	4	4	2
Lycopus europaeus L.	Lamiaceae	g	5	3	3	5	5	-	3	4	3
Lycopus exaltatus L.	Lamiaceae	g	5	4	4	4	5	-	3	5	4
Lysimachia nummularia L.	Primulaceae	c	4	3	4	3	5	-	2	4	2
Lythrum salicaria L.	Lythraceae	h	4	3	3	4	5	-	3	4	3
Lythrum virgatum L.	Lythraceae	h	4	3	4	4	5	-	3	4	4
Marrubium peregrinum L.	Lamiaceae	h	2	4	2	2	5	-	4	4	4
Marrubium vulgare L.	Lamiaceae	h	2	4	5	3	4	-	4	5	4
Matricaria chamomilla L.	Asteraceae	t	3	3	3	3	4	+	4	4	3
Matricaria chamomilla L. f. *salina* (Schur) Jáv.	Asteraceae	t	3	3	3	3	4	+	4	4	3
Matricaria inodora L.	Asteraceae	t	3	3	4	4	4	+	4	3	3
Medicago falcata L.	Fabaceae	h	2	4	2	3	3	-	4	4	4
Medicago lupulina L.	Fabaceae	u	2	4	3	3	4	-	3	4	3
Melilotus officinalis (L.) Pallas	Fabaceae	u	2	4	3	3	3	-	4	4	3
Mentha pulegium L.	Lamiaceae	g	4	3	4	4	5	+	3	5	2
Myosurus minimus L.	Ranunculaceae	t	4	2	2	3	5	-	4	4	2
Oenanthe silaifolia M.B.	Apiaceae	h	5	4	3	3	5	+	4	4	3
Ononis spinosa L.	Fabaceae	c	2	3	2	3	5	-	4	4	3
Ornithogalum gussonei Ten.	Hyacinthaceae	g	2	4	3	4	4	-	4	5	4
Panicum crus-galli L.	Poaceae	t	3	3	5	3	4	-	3	4	3
Pastinaca sativa L.	Apiaceae	u	2	4	3	3	4	-	4	4	3
Pholiurus pannonicus (Host) Trin.	Poaceae	t	3	4	2	3	5	+	4	4	4
Phragmites communis Trin.	Poaceae	g	5	3	3	3	4	+	3	3	3
Plantago lanceolata L.	Plantaginaceae	h	2	3	3	3	4	-	3	3	3

Table 1 (*continued*)

Plantago lanceolata L. var. *sphaerostachya* M. et K.	Plantaginaceae	h	2	3	3	3	4	-	3	3	3
Plantago schwarzenbergiana Schur	Plantaginaceae	h	3	3	3	2	5	+	4	4	4
Plantago tenuiflora W. et K.	Plantaginaceae	t	3	4	1	3	5	+	4	3	4
Plantago tenuiflora W. et K. f. *depauperata* Domin	Plantaginaceae	t	3	4	1	3	5	+	4	3	4
Poa pratensis L.	Poaceae	h	3	3	3	4	4	-	4	3	3
Podospermum canum C. A. Mey.	Asteraceae	h	2	4	2	2	4	+	4	4	3
Polygonum aviculare L.	Polygonaceae	t	3	3	4	3	5	-	4	3	3
Portulaca oleracea L.	Portulacaceae	t	3	3	4	3	4	-	4	4	3
Potentilla argentea L.	Rosaceae	h	1	2	2	2	3	-	4	3	4
Potentilla reptans L.	Rosaceae	h	3	3	4	3	5	-	4	3	3
Prunella vulgaris L.	Lamiaceae	h	3	3	3	3	4	-	4	3	3
Prunus spinosa L.	Rosaceae	n	2	4	3	3	3	-	4	4	3
Puccinellia limosa (Schur) Holmb.	Poaceae	h	3	4	2	2	4	+	4	4	4
Pulicaria vulgaris Gärtn.	Asteraceae	t	4	2	5	3	5	+	4	5	3
Ranunculus lateriflorus DC	Ranunculaceae	t	4	3	1	3	5	+	4	4	4
Ranunculus sardous Cr.	Ranunculaceae	t	4	3	3	3	5	+	4	4	2
Roripa austriaca (Cr.) Bess.	Brassicaceae	h	4	3	4	3	3	-	3	4	4
Roripa kerneri Menyh.	Brassicaceae	h	4	4	4	3	5	+	4	4	3
Rumex crispus L.	Polygonaceae	h	3	3	4	2	4	+	4	3	3
Rumex patientia L.	Polygonaceae	h	3	3	4	3	4	-	4	5	4
Salvia nemorosa L.	Lamiaceae	h	2	3	4	3	4	-	4	5	4
Schoenoplectus lacuster (L.) Palla	Cyperaceae	g	5	3	3	4	4	-	5	4	3
Setaria viridis (L.) P.B.	Poaceae	t	2	3	4	2	4	-	4	4	3
Sinapis arvensis L.	Brassicaceae	t	3	4	4	3	4	-	4	4	3
Spergularia media (L.) Presl.	Caryophyllaceae	c	3	3	3	3	3	+	4	4	3
Statice gmelini Willd. subsp. *hungaricum* (Klokov) Soó	Plumbaginaceae	h	2	3	1	2	4	+	4	4	4
stenactis annua (L.) Ness.	Asteraceae	u	3	3	3	3	3	-	4	3	3
Suaeda maritima (L.) Dum.	Chenopodiaceae	t	3	4	4	3	3	+	4	3	4
Symphytum officinale L.	Boraginaceae	h	3	3	4	4	4	-	3	4	3
Symphytum officinale L. l. *albiflorum* Kirschl.	Boraginaceae	h	3	3	4	4	4	-	3	4	3
Trifolium angulatum W.et K.	Fabaceae	t	3	4	2	3	4	+	4	4	3
Trifolium arvense L.	Fabaceae	u	1	2	1	2	3	-	4	4	4
Trifolium campestre Schreb.	Fabaceae	u	2	3	2	3	4	-	4	4	3
Trifolium pratense L.	Fabaceae	h	3	3	3	3	4	-	3	3	3
Trifolium repens L.	Fabaceae	h	3	3	4	3	5	+	4	3	3
Trifolium striatum L.	Fabaceae	u	2	2	2	2	3	+	4	5	2
Typha angustifolia L.	Typhaceae	g	5	4	3	3	5	+	4	4	3
Typhoides arundinacea (L.) Mnch.	Poaceae	g	5	3	4	3	4	-	3	4	3
Verbascum blattaria L.	Scrophulariaceae	u	2	4	4	3	3	+	4	5	3
Verbena officinalis L.	Verbenaceae	u	3	3	4	3	5	-	4	4	3
Veronica anagallis-aquatica L.	Scrophulariaceae	h	5	3	4	4	5	-	4	4	3
Veronica scutellata L.	Scrophulariaceae	g	5	2	3	4	3	-	3	4	3
Vulpia myuros (L.) Gmel.	Poaceae	t	1	2	3	2	3	-	4	5	3
Xanthium italicum Moretti	Asteraceae	t	3	3	5	3	2	+	4	5	3
135	31										

Legend:

h – Hemicryptophytes; t – Therophytes; u - Therophytes-Hemicryptophytes; g – Geophytes; c – Chamephytes; n - Phanerophytes soil mineral content revealed presence of plants adapted to different mineral compositions. Mesotrophic plants, i.e., indicators of habitats with moderate mineral content, are most abundant (N_3 – 42.86%, 54 taxa), followed by eutrophic plants, as indicators of habitats relatively rich in nitrogen compounds (N_4 – 30.16%, 38 taxa). These are followed by bioindicators of habitats characterized by low content of biogenic substances, i.e., oligotrophic habitats (N_2 – 16.67%, 21 taxa). Less significant presence of bioindicators of extremely eutrophic (N_5 – 5.55%, 7 taxa) and extremely oligotrophic (N_1 – 4.76%, 6 taxa) soil is noted. These findings, combined with the mean value of the ecological index for plant adaptability to the soil mineral content of $N_{\bar{x}} = 3.15$, indicate that the studied ecosystem is mesotrophic, i.e., characterized by medium nitrogen and nitrogen compound content and average productivity.

Plant response to soil humus content – H (Figure 2). The studied flora is dominated by the plants adapted to moderate organic matter content in the soil (H_3 – 68.25%, 86 taxa). Plants whose development requires small amount of humus are significantly less abundant (H_2 – 16.67%, 21 taxa), as are plants favoring soil relatively rich in organic matter (H_4 – 13.49%; 17 taxa). Plants adapted to humus-free (H_1) and humus-rich (H_5) soils are represented by one taxon each, corresponding to 0.79% (Table 1). The mean bioindicator value representing the habitat soil humus content ($H_{\bar{x}} = 2.97$) indicates that the investigated site is moderately rich in organic compounds.

Plant response to soil aeration (dispersion) – D (Figure 2). Flora of the investigated natural grasslands is characterized by the dominance of plants favoring moderately aerated soil (D_4 – 42.86%, 54 taxa). These are followed by bioindicators of poorly aerated habitats with 36.51% (D_5 – 46 taxa). Bioindicators of well aerated habitats (D_3 – 19.84%, 25 taxa) are slightly less abundant, while the plants that require very well aerated soils for their development are represented by only one taxon (D_2 – 0.79%) (Table 1). Taxa characterized by the ecological index D_1, i.e., those developing in well-aerated habitats, were not observed in the analyzed pasture flora. Based on the mean value of the ecological index for habitat aeration ($D_{\bar{x}} = 4.15$), it was determined that the studied natural pastures developed on coarser-textured soil, which is moderately aerated, i.e., characterized by slightly lower oxygen concentration (Kabić, 1988).

Plant response to habitat salinity – S (Figure 2). Of 126 taxa subjected to ecological analysis, 44 (S_+ – 34.92%), or one third, favor soil with increased Na^+ ion concentration. This indicates halophytic character of the analyzed flora, whereby rhizospheric layers of the investigated pasture soil are in places significantly saline. Percentage participation of plants characterized by the ecological index for salinity S_- is high (S_- – 65.08%). The much smaller percentage participation of halophytes in the analyzed flora indicates that most of the investigated ecosystem is in the process of desalination, whereby only the deeper layers of soil contain significant amounts of salt (Kabić, 1988), as confirmed by phytocenological studies of this ecosystem. Specifically, in the investigated ecosystem, stands of 11 associations belonging

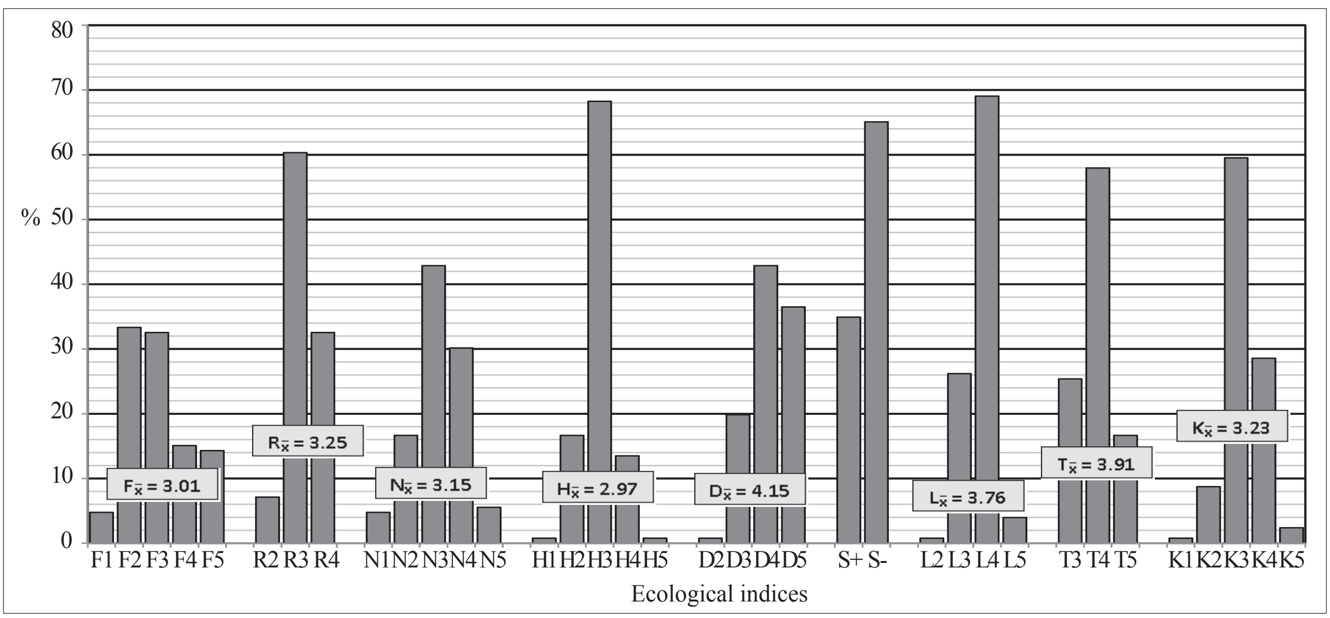

Fig. 2. Ecological analysis of the studied flora

to classes *Phragmitetea* Tx. et Prsg. 1942 (1 association) and *Festuco-Puccinellietea* Soó 1968 (10 associations) were identified (Knežević et al., 2012c).

Plant response to habitat insolation – L (Figure 2). Ecological analysis of the relationship between plant development and habitat insolation reveals dominant presence of the light indicators, characterized by the ecological index L_4 (69.05%, 87 taxa). They are followed by semi-shade indicators (L_3) with 26.19% (33 taxa), suggestive of a denser set of individual vegetative cover stands. Smaller number of plants favoring extensively insolated habitats (L_5 – 3.97%, 5 taxa) and those preferring shadows (L_2 – 0.79%; 1 taxon) are identified. The presence of plants requiring highly insolated habitats are indicative of degradation processes in the studied ecosystem (Knežević et al., 2012a). Indicators of deep shadows (L_1) were not observed. Based on the mean value of this ecological index ($L_{\bar{x}}$ = 3.76), the investigated pastures were characterized as insolated habitats with favorable light regimen. In fact, their meadow vegetation stands are of mostly moderate density, dominated by plants adapted to the conditions characterized by direct sunlight and moderate shade. However, plants that tolerate semi-shade have found suitable conditions for development at the ground level.

Plant response to the habitat temperature – T (Figure 2). Analysis of the ecological index for habitat temperature indicates that the studied flora is dominated by thermophilic plants characterized by the ecological index T_4 (57.94%, 73 taxa). These are followed by mesothermal (T_3 – 25.40%, 32 taxa) and extremely thermophilic (T_5 – 16.67%, 21 taxa) plants. Bioindicators of cold habitats (T_2) and plants adapted to very low temperatures (T_1) were not found in the studied flora. The average value of this ecological index ($T_{\bar{x}}$ = 3.91) further confirms that the examined natural pastures are warm habitats.

Plant response to the habitat continentality – K (Figure 2). Since the studied flora consists of more than a half of the taxa characterized by the ecological index K_3 (K_3 – 59.52%, 75 taxa), it can be concluded that, at the investigated site, the most significant climatic effects are temperate. In addition, the considerable presence of taxa characterized by the ecological index K_4 (K_4 – 28.57%, 36 taxa) compared to taxa characterized by ecological index K_2 (K_2 – 8.73%, 11 taxa), indicates more pronounced impact of the continental climate of the eastern and northern regions compared to that of sub-oceanic climate of the western and southern regions. Negligible presence of taxa characterized by the ecological index K_5 (K_5 – 2.38%; 3 taxa) is indicative of the penetration and influence of markedly continental climate in the investigated ecosystem. Negligible impact of oceanic climate on the study area is confirmed by the presence of only one taxon characterized by the ecological index K_1 (K_1 – 0.79%; 1 taxon). The mean value of the ecological index for continentality ($K_{\bar{x}}$ = 3.23) confirms that the vegetation of natural pastures surrounding the Bočar village is well adapted to the temperate climate of the study area.

Presence of certain plant life forms in a habitat is caused by the prevalent environmental conditions and is a reliable bioindicator of the state of the environment (Nikolić et al., 2011). Therefore, in addition to the ecological analysis, analysis of plant life forms, as specific adaptations to the existing environmental conditions, also reveals indicators of the types of adaptation to the conditions prevailing in a given ecosystem. This analysis indicates that the analyzed flora is of therophytic-hemicryptohpytic character. Hemicryptophytes contributed by 37.04%, and are followed by therophytes with 26.67% (Table 2). Therophytic-hemicryptohpytic character of the studied flora is further confirmed by the presence of 11.85% taxa that, according to Landolt (1977), belong to the therophytic-hemicryptohpytic group. The presence of geophytes (20.00%) should also be noted. The studied pastures are habitats that practically eliminate the presence of chamaephytes and phanerophytes (Table 2).

In order to establish presence of statistically significant differences among the identified life forms with respect to particular ecological indices, analysis of variance (ANOVA) was performed, revealing statistically significant differences for all ecological indices. This ascertains that the development of the identified life forms i.e. identified taxa, in the studied pastures is affected by all environmental factors (Table 3). Tzialla et al. (2006), Bátori et al. (2009, 2011) and Nikolić et al. (2011) reported similar results.

To assess the relationship between the identified plant life forms and the individual ecological index values, correspondence analysis was performed (Figures 3 and 4). Development of hemicryptophytes and therophytes, as the dominant life forms in the investigated ecosystem, is a result of a moderately moist and moderately to poorly aerated soil (Figure 3).

However, very wet and poorly aerated soils typical of the spring season are favorable for the development of a signifi-

Table 2
Frequencies of plant species sampled according to life form

Life form	Taxon	%
Hemicryptophytes (h)	50	37.04
Therophytes (t)	36	26.67
Therophytes-Hemicryptophytes (u)	16	11.85
Geophytes (g)	27	20
Chamephytes (c)	5	3.7
Phanerophytes (n)	1	0.74
Total	135	100

Table 3
The significance of the relationship between plants life forms and ecological indices

Ecological index	SS	df	MS	F-value	p
F	132.022	20	6.601	31.268	0.000**
R	121.444	10	12.144	59.618	0.000**
N	99.644	20	4.982	37.367	0.000**
H	187.756	20	9.388	56.327	0.000**
D	157.375	15	10.49	50.36	0.000**
L	185.597	15	12.373	80.988	0.000**
T	38.111	10	3.811	17.15	0.000**
K	142.2	20	7.11	49.223	0.000**
S	54.472	5	10.894	49.025	0.000**

Legend:
SS - Sum of Squeres; df - Degrees of Freedom ; MS - Mean Squere; ** p < 0.01

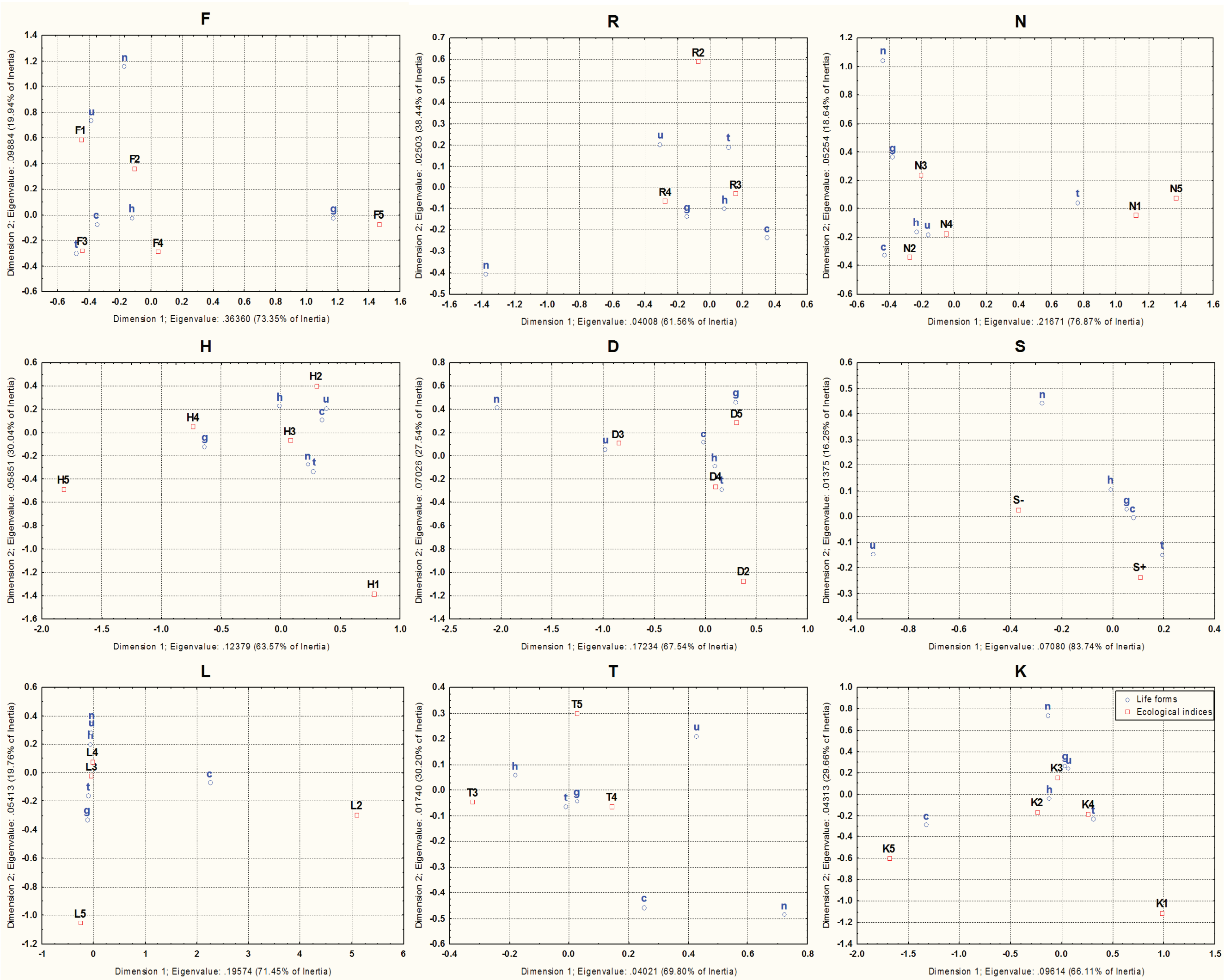

Fig. 3. I Correspondence analysis -between plant life forms and individual ecological indices

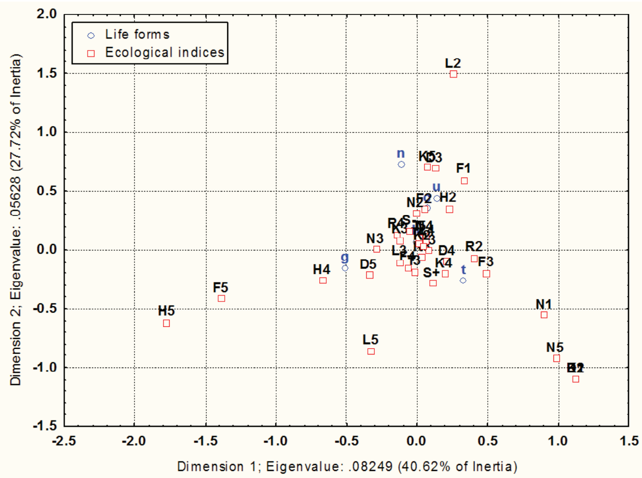

Fig. 4. II Correspondence analysis - between plant life forms and all ecological indices

cant number of geophytes (Figure 3). Most of the identified plant life forms thrive in mesotrophic to eutrophic habitats, characterized by neutral to slightly alkaline chemical reactions. In addition, in the studied pastures, therophytes developed in areas containing both negligible and significant quantities of nitrogen compounds. The identified plant life forms, in the temperate climatic conditions, have adapted to the well-insolated, warm, and mostly unsalinated soil. A significant proportion of therophytes, geophytes and hemicryptophytes are an indicator of salinated habitats, as they develop in parts of the pasture where Na^+ ion concentrations are high (Figure 3).

Based on correspondence analysis of the relationship between all the identified life forms and the values of all ecological indices, which explained approx. 68% of these relationships, it can be concluded that the development of the identified ecomorphs i.e. identified taxa, on the studied pastures does not favor extreme environmental conditions, i.e., very wet (F_5), extremely oligotrophic (N_1) and highly eutrophic (N_5), humus-free (H_1) or humus-rich (H_5) soil (Figure 4). Similarly, adequately aerated habitat (D_2), characterized by prevalent semi-shade conditions (L_2), or strong direct light (L_5), (Figure 4) is not conductive of the development of these ecomorphs.

Conclusion

Flora of natural pastures in the vicinity of the Bočar village (Vojvodina, Serbia) comprises a total of 135 taxa (119 species, 5 subspecies, 4 varieties, 6 forms one 1 lusus). The ecological analysis, biological spectrum of the ascertained natural pasture flora, analysis of variance and correspondence analysis were used to determine the prevalent environmental conditions in the study area, which favor the development of specific plant life forms.

Based on the ecological analysis of the identified taxa, the soil of the investigated ecosystem is characterized as moderately moist, neutral to slightly acidic, moderately rich in nitrogen and organic compounds, moderately aerated, with favorable light and thermal regimen, dominated by temperate climatic conditions. The soil salinity is, in places, considerable. These environmental conditions of the studied pastures are conductive of vigorous therophyte, hemicryptophyte and geophyte development, while practically eliminating the presence of chamaephytes and phanerophytes, as confirmed by the biological spectrum.

Analysis of variance revealed that the development of the identified plant life forms at the studied pastures is influenced by all environmental factors, characterized as ecological indices. The correspondence analysis showed that the development of the identified ecomorphs i.e. identified taxa, does not favor extreme environmental conditions, i.e., very wet (F_5), extremely oligotrophic (N_1) and highly eutrophic (N_5), humus-free (H_1) or humus-rich (H_5) soil, adequately aerated habitat (D_2), prevalent semi-shade conditions (L_2), or strong direct light (L_5), which is in accordance with the findings of the ecological analysis.

Studies on flora and vegetation of natural pastures, as endangered ecosystems, are thus a starting point for the assessment, monitoring and conservation of their biodiversity, aimed at ensuring their sustainable use, i.e., maintenance of their agricultural productivity that would, in addition to careful selection and planning of mowing and grazing, which should be adapted to local conditions, facilitate the recovery of these natural ecosystems.

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