ECOLOGICAL ANALYSIS OF THE GRASSLAND FLORA IN THE RIPARIAN ZONE OF OKANJ OXBOW LAKE (VOJVODINA, SERBIA)

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Abstract

The flora of the grassland surrounding Okanj oxbow lake, located in the vicinity of the village of Elemir (the Vojvodina Province, Serbia), was found to comprise 182 plant taxa. Of these 182 taxa (166 species, 7 subspecies and 2 varieties, 6 forms and 1 lusus naturae), 174 were used for ecological analysis, i.e., 166 species, 7 subspecies and, because of its plant geographic and ecological importance, one variety (the Pontic-Pannonian element *Aster tripolium* var. *pannonicus*). Based on mean values of the ecological indices developed according to Landolt's criteria, it was concluded that the grassland flora in the riparian zone around Okanj oxbow lake was composed of taxa adapted to a habitat having the following average values: medium humid to moderately dry (F-2.65), moderately basic (R-3.28), moderately poor in the biogenic mineral N (N-3.20) and organo-mineral substances (H-2.99), with a moderately adequate aeration (D-3.97), and considerably saline (S$_+$ - 26.44 %). The flora is predominated by heliophilous (L-3.80) and thermophilous (T-4.01) plants adapted to the moderately continental climatic conditions of the studied habitat (K-3.18).

Introduction

Okanj oxbow lake is formed from a meander of the Tisza River. It is located north of the village of Elemir in central Banat (the Vojvodina Province, Serbia), Fig. 1. The lake is replenished from groundwater and precipitation. The banks of Okanj are made of the solonchakic solonetz soil, which surrounds spots of non-cultivated calcareous chernozem (micellar) on loess terrace (Nejgebauer *et al*., 1971). These sizable non-cultivated surfaces are covered by natural vegetation that is used by local residents for mowing and grazing sheep and cattle. The studied area can be characterized as having a moderately continental climate, with a dry period from July to October which is unfavorable for the vegetation cover (Knežević *et al*., 2009).

The objective of this study was to provide a description of the ecological characteristics of the natural grassland occupying the riparian zone of Okanj lake on the basis of bioindicator values determined for the analyzed plant taxa.

Fig. 1. Map with the studied locality.

Material and Methods

The basis for the ecological analysis of grassland flora in the riparian zone of Okanj lake water, located north of the village of Elemir in central Banat (the Vojvodina Province, Serbia), was the publication of Knežević *et al*., (2009) titled "Plant cover of the saline grassland in the riparian zone of the Okanj oxbow lake (the Vojvodina Province, Serbia)". In that publication, the plants of the studied area were identified and conformed with the help of the publications "Flora of SR Serbia (Josifović, 1970-1976), "Flora Europaea" (Tutin *et al*., 1960-1980), "A magyar flóra és vegetació rendszertani-növényföldrajzi kézikönyve" (Soó, 1964-1985) and "Iconography of the Flora from the South-Eastern part of Central Europe" (Jávorka & Csapody, 1975).

Ecological indices for the analysis of the main environmental factors (humidity - F, chemical reaction - R, contents of nitrogen and nitrogen-containing compounds - N, content of humus, i.e., organo-mineral compounds - H, dispersion, i.e., aeration of the substrate - D, plant reaction to salinity - S, plant reaction to light - L, plant reaction to temperature - T, plant reaction to continentality - K) were selected according to the publication "Ökologische Zeigerwerte zur Sweizer Flora" by Landolt (1977) and for the species not described by Landolt, according to the publication "Monograph of the Flora of Vascular Plants on Saline Soils in Banat (Yugoslavia)" by Knežević (1994). As the taxon *Cynoglosum montanum* Höjer has not been characterized by ecological indices in these publications, we characterized it on basis of our previous studies and according to the criteria of Landolt, which is as follows: $F_3 R_3 N_2 H_3 D_3 S_- L_4 T_4 K_3$.

Out of the 182 taxa found to comprise the grassland flora in the riparian zone of Okanj lake (166 species, 7 subspecies and 2 varieties, 6 forms and 1 lusus naturae), 174 were used for ecological analysis, i.e., 166 species, 7 subspecies and, because of its plant geographic and ecological importance, one variety (the Pontic-Pannonian element *Aster tripolium* var. *pannonicus*).

Table 1 lists the following ecological indices for the 174 analyzed taxa: humidity of the habitat - F, chemical reaction of the habitat - R, contents of nitrogen and nitrogen-containing compounds - N, content of humus, i.e., organo-mineral compounds - H, dispersion, i.e., aeration of the substrate - D, plant reaction to light - L, plants reaction to temperature – T, and plant reaction to continentality – K. For each index were given its numerical values, the number of species characterized by a specific numerical value, the percentage of species having the specific numerical value, and the mean frequency values of the ecological index in question. For the reaction of plants to salinity (**S**), we provided the number and percentage of species characterized by the ecological indices S_- or $S_{+.}$

Results and Discussion

The flora of the grassland on the banks of Okanj lake was found to comprise of 182 taxa (Knežević *et al*., 2009). Of the 182 taxa in the grassland flora, 174 were used for ecological analysis, i.e., 166 species, 7 subspecies and, because of its plant geographic and ecological importance, one variety (the Pontic-Pannonian

element *Aster tripolium* var. *pannonicus*), Tab. 1. The taxon *Cynoglosum montanum* Höjer, which had not been characterized by ecological indices according to Landolt, was estimated to have the following values: $F_3 R_3 N_2 H_3 D_3 S_- L_4 T_4 K_3$.

Plant reaction to humidity of the habitat (F): The analysis of the ecological index for humidity (F) indicated the presence of a large number of plants characterized by humidity indices F_2 (66 species, 37.93%), which are adapted to arid habitats, and F_3 (57 species, 32.76%), which are adapted to moderately dry habitats. The dry conditions have also enabled the development of plants characterized by the humidity index F_1 (20 species, 11.49%), i.e., xerophytes which are indicators of extremely arid habitats. Therefore, 82.18% of the analyzed grassland flora belongs to the taxa characterized by ecological indices F_2, F_3 and F_1, the indicators of dry conditions. The numbers of indicators of humid habitats, characterized by the humidity index F_4 (17 taxa; 9.77%), and indicators of very humid habitats, which are characterized by the humidity index F_5 (14 taxa; 8.05%), provided evidence that the studied grassland also included habitats in which water was available to plants over an extended period of time.

The mean value of the ecological humidity index for the analyzed taxa was F - 2.65, which proved that the investigated grassland was an average a moderately dry habitat.

Plant reaction to chemical reaction of the habitat (R): Dominance of neutrophilous plants with the ecological index R_3 (113 taxa; 64.94%) was evident in the analyzed flora. There were a significant number of indicators of neutral to basic chemical reactions with the ecological index R_4 (55 species, 31.61%). There were few indicators of acid habitats characterized by the ecological index R_2 (6 taxa; 3.45%). Indicators of extremely acid habitats, characterized by the ecological index R_1, and indicators of extremely basic habitats, characterized by the ecological index R_5, are not found in the studied flora.

The mean value of the ecological index for chemical reaction of the habitat, for the studied taxa, was R - 3.28, which shows that the studied grassland is a moderately basic habitat.

Plant reaction to the contents of nitrogen and nitrogen-containing compounds (N): In the analysis of the ecological index for the contents of nitrogen and nitrogen-containing compounds, it was characteristic that the most taxa in the grassland had the ecological index N_4 (72 species, 41.38%), indicating a habitat relatively rich with biogenic minerals. Taxa with the ecological index N_3 took a somewhat smaller share (53 species, 30.46%). Those were indicators of a moderate content of biogenic minerals. Still lower, but nevertheless significant, was the share of taxa with the index N_2 (32 species, 18.39%), which grow in habitats poor with biogenic minerals. Indicators of habitats extremely poor with nutrients, characterized by the index N_1 (10 taxa; 5.75%), and indicators of habitats very rich with nutrients, indicated by the index N_5 (7 taxa; 4.02%), were represented by a small number of taxa.

Table 1. Ecological analysis flora of gassland in the riparian zone of the Okanj oxbow lake (the Vojvodina province, Serbia).

Ecological index	Numerical values of ecological index	Number of taxa	%	Mean value
F – humidity	1	20	11,49	
	2	66	37,93	
	3	57	32,76	F – 2,65
	4	17	9,77	
	5	14	8,05	
R – chemical reaction of the site	1	0	0	
	2	6	3,45	
	3	113	64,94	R - 3,28
	4	55	31,61	
	5	0	0	
N –nitrogen and nitrogen compounds	1	10	5,75	
	2	32	18,39	
	3	53	30,46	N - 3,20
	4	72	41,38	
	5	7	4,02	
H – humus	1	2	1,15	
	2	24	13,79	
	3	123	70,69	H - 2,99
	4	24	13,79	
	5	1	0,58	
D – dispersion (aeration)	1	0	0	
	2	3	1,72	
	3	44	25,29	D - 3,97
	4	83	47,70	
	5	44	25,29	
S – salinity	-	128	73,56	
	+	46	26,44	
L – light	1	0	0	
	2	0	0	
	3	39	22,42	L - 3,80
	4	130	74,71	
	5	5	2,87	
T – temperature	1	0	0	
	2	0	0	
	3	32	18,39	T – 4,01
	4	109	62,64	
	5	33	18,97	
K – continentality	1	1	0,58	
	2	26	14,94	
	3	91	52,30	K - 3,18
	4	52	29,88	
	5	4	2,30	

The mean value of N - 3.20 indicated that the studied grassland was, on average, moderately abundant with biogenic compounds.

Plant reaction to humus content (**H**): The analysis of the ecological index for humus content showed that taxa having the ecological index H_3 (123 taxa; 70.69%) were highly prevalent in the studied grassland. This characterized the grassland as a habitat moderately rich with organo-mineral compounds. Indicators of low humus content, with the ecological index H_2 (24 species, 13.79%), and indicators of a relatively high humus content, with the ecological index H_4 (24 species, 13.79%) were represented in much lower numbers. There was an extremely small number of indicators of

humusless habitats with the ecological index H_1 (2 species, 1.15%). Finally, there was only one indicator having the ecological index H_5 (1 taxon; 0.58%).

The mean value of the ecological index for humus content, H-2.99, characterized the studied grassland as a habitat that was moderately rich in humus.

Plant reaction to dispersion (aeration) of the substrate (**D**): Almost a half of the analyzed taxa from the studied grassland belonged to plants with the ecological index D_4 (83 taxa; 47.70%), which indicated a moderately favorable dispersion, i.e., a moderately favorable aeration. The taxa indicating an aerated habitat, characterized by the ecological index D_3 (44 species, 25.29%), and the taxa indicating a low aeration of the habitat, characterized by

the ecological index D_5 (44 species, 25.29%) were equally represented. This proves that the studied grassland contains a number of plants adapted to sandy permeable, i.e., well-aerated soil (D_3) as well as plants adapted to an impervious and clayey, i.e., poorly aerated soil (D5). Indicators of soil containing large particles, i.e., plants characterized by the ecological index D_2 (3 taxa; 1.72%) were scant, while indicators of undeveloped soil, i.e., plants characterized by the ecological index D_1, were not found in the studied grassland.

The mean value of D-3.97 indicated that the soil of the studied grassland had a moderately favorable dispersion, i.e., that it was fairly favorably aerated.

Plant reaction to salinity (**S**): The taxa characterized by the ecological index S_+ (46 species, 26.44%) comprised more than a quarter of the analyzed flora. In spite of the dominance of plants characterized by the ecological index S_- (128 species, 73.56%), this points out the halophytic character of the flora in the studied grassland. The above statement was based on the fact that among the taxa characterized by the ecological index S_- there is a number of plants that are tolerant to saline habitats as well as plants that avoid high salinity of habitat by developing in the spring period, when the salt concentration in the substrate drops due to heavy rainfall.

Plant reaction to light (**L**): The analyzed flora was predominated by plants characterized by the ecological index L_4 (130 taxa; 74.71%). This is understandable, since the plant cover of grassland ecosystems is typically adapted to full light and tolerates a certain degree of shading. Further evidence to this effect is the considerably lower but still significant presence of the taxa characterized by the ecological index L_3 (39 taxa; 22.42%), which are indicators of semi-shade. The plants characterized by the ecological index L_5 (5 taxa; 2.87%), i.e., plants that are not tolerant to shading, were few. Plants characterized by the ecological index L_2, which are indicators of the shade, and plants characterized by the ecological index L_1, which are indicators of deep shade, are not found in the studied grassland.

The mean value of L - 3.80 confirmed that heliophilous plants were dominant in the studied grassland.

Plant reaction to temperature (**T**): The analysis of ecological indices for temperature indicated that the flora of the studied grassland was predominated by thermophilous plants characterized by the ecological index T_4 (109 taxa; 62.64%). This group was followed by the extremely thermophilous plants characterized by the ecological index T_5 (33 species, 18.97%). Compared with the latter, the share of species of moderately warm habitats, characterized by the ecological index T_3 (32 species, 18.39%), was only slightly lower. The analyzed flora contained neither the taxa of cold habitats, characterized by the ecological index T_2, nor the taxa of very cold habitats, characterized by the ecological index T_1.

The mean value of T - 4.01 bore evidence of the prevalence of thermophilous plants in the flora of the studied grassland.

Plant reaction to continentality (**K**): The analysis of adaptation of the flora of the studied grassland to climatic conditions indicated that plants belonging mostly outside the typical continental regions were present in largest numbers. These plants were characterized by the ecological index K_3 (91 taxa; 52.30%). Frequent influences of the typical continental climate resulted in a large number of taxa characterized by the ecological index K_4 (52 species, 29.88%). Therefore, when taken together, the taxa spreading beyond the typical continental regions and the taxa inhabiting the regions with the typical continental climate are collectively represented by 143 species or 82.18% of the analyzed flora. This situation is understandable for the studied habitat located on the solonchakic solonetz soil because plants characterized by the ecological indices K_3 and K_4 tend to grow in areas with limited rainfall and low air humidity, with considerable fluctuations in daily and annual temperatures (high summer temperatures and low winter temperatures). The studied grassland comprised also a significant number of plants characterized by the ecological index K_2 (26 species, 14.94%). These plants grow mainly in areas with a sub-oceanic climate. They manage to grow in the studied continental area on account of the influence of the Mediterranean climate coming from the south. According to the classification of Soo (1964-1980), this last group includes Mediterranean (*Helminthia echioides*), sub-Mediterranean (*Ornithogalum umbellatum*), sub-Mediterranean - Central European (*Lotus tenuis*, *Scilla autumnalis*), sub-Mediterranean - south Eurasian (*Sambucus ebulus*), Pontic - Mediterranean (*Cerastium dubium*), sub-Pontic - sub-Mediterranean (*Valerianella rimosa*), Central European - sub-Mediterranean (*Valerianella locusta*), Central European - Mediterranean (*Allium vineale*), European – Mediterranean (*Carduus acanthoides*, *Cerastium pumilum*, *Sambucus nigra*), Atlantic - Mediterranean (*Trifolium strictum*), Eurasian - Mediterranean (*Bromus sterilis*, *Veronica anagalloides*, *Epilobium adnatum*), Eurasian - Mediterranean (*Calystegia sepium*, *Consolida regalis*, *Mentha pulegium*) and circumpolar - Mediterranean (*Galium mollugo*) plants. Plants characterized by the ecological index K_5 (4 species, 2.30%), although poorly represented, still show that the studied area is influenced even by the typical continental climate. According to Soo (1964-1980), those are, within the analyzed flora, the continental (*Artemisia maritima* subsp. *salina*), Eurasian - continental (*Festuca valesiaca* subsp. *pseudovina*), Eurasian (*Crepis tectorum*) and Eurasian - Mediterranean (*Achillea setacea*) plants. The studied flora included only one indicator of regions with the oceanic climate (high relative air humidity and mild winters), characterized by the ecological index K_1 (1 taxon; 0.58%). It was the species *Bupleurum tenuissimum*, which had been defined by Soo (1966) as a European plant with the Atlantic - Mediterranean character. Borhidi (1993), using the continentality scale 1-9, characterized that species with the ecological index CB 4, i.e., as a sub-oceanic species distributed mainly in Central Europe, but extending far to the east.

The mean value of K - 3.18 confirmed that the plant cover of the analyzed grassland was adapted to the moderate continental climate of the studied area, which was prevalently influenced by the climate of the eastern continental regions.

Conclusion

The flora of the grassland surrounding Okanj oxbow lake, located in the vicinity of the village of Elemir (the Vojvodina Province, Serbia), was found to comprise 182 plant taxa (166 species, 7 subspecies and 2 varieties, 6 forms and 1 lusus naturae). Of the identified taxa, 174 were used for ecological analysis - 166 species, 7 subspecies and, because of its plant geographic and ecological importance, one variety (the Pontic-Pannonian element *Aster tripolium* var. *pannonicus*). Based on the mean values of the ecological indices developed according to Landolt's criteria, it was concluded that the grassland flora in the riparian zone around Okanj oxbow lake is composed of taxa adapted to a habitat having the following average values: medium humid to moderately dry (F – 2.65), moderately basic (R – 3.28), moderately poor in the biogenic mineral (N – 3.20) and organo-mineral substances (H – 2.99), with a moderately adequate aeration (D – 3.97), and considerably saline (S$_+$ - 26.44 %). The flora is predominated by heliophilous (L – 3.80) and thermophilous (T – 4.01) plants adapted to the moderately continental climatic conditions of the studied habitat that is most influenced by the continental climate of the regions further east of it (K – 3.18).

Acknowledgements

References

Borhidi, A. 1993. *A magyar flóra szociális magatartás tipusai, természetességi és relativ ökológiai értékszám*ai. A környezetvédelmi és területfejlesztési minisztérium természetvédelmi hivatala és A janus pannonius tudományegyetem kiadványa, Pécs.

Jávorka, S., V. Csapody. 1975. *Iconographie der Flora des Südostlichen Mitteleuropea*. Akademiai Kiado, Budapest.

Josifović, M. 1970-1976. *Flora SR Srbije I-IX*. SANU, Beograd.

Knežević, A. 1994. *Monografija flore vaskularnih biljaka na slatinama u regionu Banata (Jugoslavija)*. Matica srpska, Novi Sad.

Knežević, A., P. Boža, M. Stankov, L.J. Nikolić, S. Stojanović, D. Džigurski, B. Ljevnaić and D. Polić. 2009. Plant cover of the saline grassland in the riparian zone of the Okanj oxbow lake (the Vojvodina province, Serbia). Annals of faculty of engineering Hunedoara. *Journal of Engineering*, Tome VII, Fascicule 4: 189-194.

Landolt, E. 1977. *Ökologische Zeigerwerte zur Schweizer Flora*. Veröffentlichungen des Geobotanischen Institutes der ETH, Stiftung Rübel, 64. Heft, Zürich.

Nejgebauer, V., B. Živković, D. Tanasijević and N. Miljković. 1971. *Pedološka karta Vojvodine*. Institut za poljoprivredna istraživanja, Novi Sad.

Soó, R. 1964-1985. *A magyar flóra és vegetació rendszertani-növényföldrajzi kézikönyve* I-VII. Akadémiai Kiadó, Budapest.

Tutin, G., V.H. Heywood, N.A. Burges, D.H. Valentine, S.M. Walters and D.A. Webb. 1964-1980. *Flora Europea 1-5*. University press, Cambridge.