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Ecological and syntaxonomical spectra of grass species of the grassland communities occurring in the lower section of the Bug River Valley

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Abstract. The research was conducted in the lower section of the Bug River Valley, where were described 15 plant communities from 4 phytosociological classes. On the basis on this data set, the analysis of both ecological and syntaxonomical spectra of grass species was done. Grasses occurred in every community denoted in the research area. There were found 33 species of *Poaceae* family. The largest number of them was stated in the floristic composition of the following associations: *Arrhenatheretum elatioris*, *Alopecuretum pratensis*, *Deschampsietum caespitosae* and *Lolio-Cynosuretum*. The widest ecological spectrum showed *Phleum pratense*, while the broadest syntaxonomical range presented *Deschampsia caespitosa*.

Keywords: ecological scale, stenobionts, eurybionts, plant distribution, ecological gradients.

1. Introduction

Nowadays, semi-natural grasslands are subjected to dynamic changes resulting from the strong and multidirectional human pressure. Species responses to habitat changes are greatly varied. They present different strategies and possibilities expressed at the genotypic and phenotypic level (Gratani, 2014; da Silveira Pontes et al., 2015). However, their possibilities in this respect are not the same. Some of them disappear, while others expand their territories and, in some cases, they may even become an invasive in new environments. Available information on the remarkable adaptability of species to changeable habitat conditions induces the extension of knowledge about the ecological spectra of plants.

It was estimated that there are about 10 000 species of *Poaceae* family in the world (Frey, 2010), of which over 300 species occur in Poland (Trąba, 2014). *Poaceae* family as a whole presents a very broad ecological spectrum (Frey, 2010), however individual species may belong both to stenobionts or to eurybionts. Grass species growing in Poland represent both native

and alien flora. Based on the elaboration of Matuszkiewicz (2008) it may be concluded that over 1/3 of Polish plant communities represent grassland plant communities. Furthermore, grasses are in the characteristic composition for almost every syntaxons, with exception of water phytocoenoses (Balcerkiewicz, 2007). According to Trąba (2014) the most often they occurred in phytoceonoses of the following syntaxonomical classes: *Molinio-Arrhenatheretea*, *Stellarietea mediae*, *Festuco-Brometea* and also *Koelerio glaucae-Corynephoretea canescentis*.

The systems of ecological indicators (Ellenebrg, 1992; Zarzycki, 2002) present information of plant preferences for chosen ecological factors, while do not include the ecological ranges of plant species. The present study is a detailed elaboration on ecological and syntaxonomical spectra of grass species occurred in the semi-natural grassland communities described in the Bug River Valley from Długie Kamieńskie to Kossaki.

2. Study area

The study area is placed in the northeast Poland along the left bank of the Bug river valley from Długie Kamieńskie (52° 40' 24" N, 22° 15' 43 " E) to Kossaki (52° 38' 43" N, 22° 21' 28" E) in the Ceranów gmina (Sienkiewicz-Paderewska et al., 2017, Fig. 1.). According to the Warsaw Statistical Office (2012) 80.0–89.9% of the total area of Ceranów gmina is under legal protection due to nature conservation. The study area belongs to the 'Nadburzański Landscape Park' and to the Natura 2000 Special Area of Conservation and Special Protection Area 'Dolina Dolnego Bugu'. The research area covers ca. 410 ha and includes permanent grassland located from the left part of the river bed to the anti-flooding embankment of the river bed. The area is flat with local drains and shelterbelts. The moisture conditions are changeable and varies from dry to wet places, with stagnant water sometimes. The major part of that area is covered with permanent grasslands that was either extensively mowed (usually 2 cuts per year) or pastured. The mowing management due to higher soil moisture prevails from the bridge in Nur towards Kossaki, while pasturing dominates from the bridge towards Długie Kamieńskie. Through all the study area the spring flooding of the Bug River is observed.

According to the physico-geographical regionalization of Poland this area belongs to the mezoregion Dolina Dolnego Bugu (Kondracki, 2002) and is located in the mazowiecko-podlaski climatic region (Okołowicz, 1965) with a predominant influence of the continental climate. The average annual precipitation in this area is 550 mm, snow cover duration varies from 90 to 110 days, and vegeta-

tion period lasts on average 210 days. Average annual air temperature is 7.4ºC (Ceranów, 2011).

3. Methods

The research was carried out in the 2011 from the 4 of June to the end of July. Along to the river bed were designated three transects. The 99 phytosociological relevés were recorded on the permanent grasslands in each transect every 100 m (excluding groups of trees, shrubs or local dips) with the use of the Braun-Blanquet (1964) method. Names of plants followed Mirek et al. (2002). The abundance of each species was recorded using the Braun-Blanquet scale (r, +, 1, 2, 3, 4, 5). The mean cover (D) from the cover-abundance scale was transformed as follows: r = 0.1%, + = 0.5%, 1 = 5%, 2 = 17.5%, 3 = 37.5%, 4 = 62.5%, 5 = 87.5%. The locations of relevés were described using GPSMAP 76CSx receiver. The classification process of the recorded phytocoenoses and the name of syntaxa followed Matuszkiewicz (2008) and Nowiński (1967). The detailed description of these phytocoensoes is included in the elaboration of (Sienkiewicz-Paderewska et al., 2017)

Ecological spectra of the examined grass species in the given area were determined using phytoindication method (Ellenberg et al., 1992). The value of Ellenberg indices were calculated for each relevé (separately) as weighted mean of indicator values for species when the abundance of species were the weights. The averaged abundance of species from the *Poaceae* family were calculated for the relevés that were described by different intervals of Ellenberg indices. That is, the L index was calculated for each relevé, the relevés were grouped according similar L values (by 0.5 unit), and the average abundance for each species was calculated for each group of relevés. The same procedure was applied to the other indicators. The species with the lowest constancy were omitted because occasionally occurrence not allows for the reliable conclusions.

4. Results and discussion

In the research area were denoted 15 plant communities representing 4 phytosociological classes. Their syntaxonomical positions are as follows:

Class: ***Phragmitetea*** R.Tx. et PRSG 1942,
Order: ***Phragmitetalia*** (Koch 1926)
Alliance: ***Phragmition*** (Koch 1926)
Associations: *Acoretum calami* Kobendza 1948
Eleocharitetum palustris Sennikow 1919

Glycerietum maximae Hueck 1931
Alliance: ***Magnocaricion*** Koch 1926
Associations: *Caricetum gracilis* (Graeben. et Hueck 1931) R.Tx. 1937
Caricetum vulpinae (Nowiński 1928),
Phalaridetum arundinaceae (Koch 1926 n.n.) Libb 1931
Alliance: ***Sparganio-Glycerion fluitantis*** Br.-Bl. et Siss. inn Boer 1942,
Assocation: *Sparganio-Glycerietum fluitantis* Br.-Bl. 1925
Class: ***Molinio-Arrhenatheretea*** R.Tx. 1937,
Order: ***Trifolio fragiferae-Agrostietalia stoloniferae*** R. Tx. 1970,
Alliance: ***Agropyro-Rumicion crispi*** Nordh. 1940 em. R.Tx. 1950
Association: *Ranunculo-Alopecuretum geniculati* R.Tx. 1937
Community: *Agrostis stolonifera-Potentilla anserina* Oberd.1979/1980 in Oberd.1983
Order: ***Molinietalia caeruleae*** W. Koch 1926
Alliance: ***Calthion palustris*** R.Tx. 1936 em. Oberd. 1957
Community: *Deschampsietum caespitosae* Horvatić
Alliance: ***Alopecurion pratensis*** Pass. 1964
Association: *Alopecuretum pratensis* (Regel. 1925) Steffen 1931
Order: ***Arrhenatheretalia*** (Pawł. 1928)
Alliance: ***Arrhenatherion elatioris*** (Br.-Bl. 1925) Koch 1926
Association: *Arrhenatheretum elatioris* Br.-Bl. ex Scgerr. 1925
Alliance: ***Cynosurion*** R.Tx. 1947
Association: *Lolio-Cynosuretum* R.Tx. 1937
Class: ***Epilobietea angustifolii*** R. Tx. et Prsg 1950
Order: ***Atropetalia*** Vlieg. 1937
Alliance: ***Epilobion angustifolii*** (Růbel 1933) Soó 1933
Association: *Calamagrostietum epigeji* Juraszek 1928
Class: *Koelerio glaucae-Corynephoretea canescentis* (Klika in Klika et Novak 1941)

In the described communities were recorded 33 species of *Poaceae* family. Grasses were found in every community. The largest number of them appeared in the following communities: *Arrhenatheretum elatioris* (22), *Alopecuretum pratensis* (19), *Lolio-Cynosuretum* (16), and *Deschampsietum caespitosae* (14). In other analyzed phytocoenoses their number ranged from 1 to 9. The lowest number of grass species was in *Acoretum calami*. The greatest frequency (>30%) in the relevés collected in the whole examined area had respectively: *Alopecurus pratensis*, *Poa pratensis*, *Deschampsia caespitosa*, *Anthoxanthum odoratum*, *Festuca pratensis*, *Holcus lanatus*, and *Arrhenatherum elatius* (Table 1). On the other hand, the largest mean cover (D) showed: *Arrhenatherum*

elatius, *Alopecurus pratensis*, *Holcus lanatus*, *Deschampsia caespitosa*, *Anthoxanthum odoratum*, *Glyceria maxima* and *Phleum pratense* (Table 1).

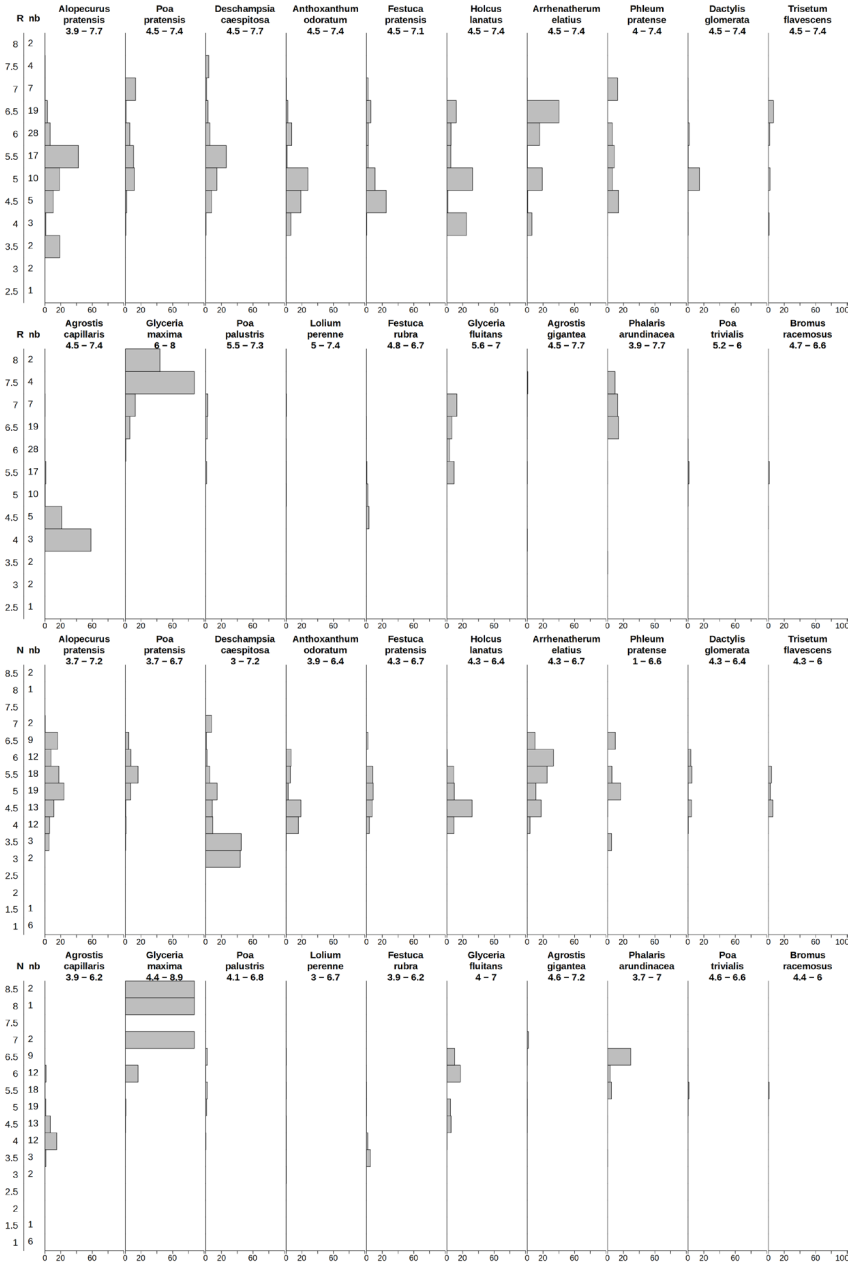
Table 1. The averaged mean cover of species occurred in the study area, their constancy and the frequency

Species name	Mean cover (D)	Constancy (frequency in %)	Species name	Mean cover	Constancy (frequency in %)
Alopecurus pratensis	1237	III (44)	*Phalaris arundinacea*	390	I (9)
Poa pratensis	560	III (43)	*Poa trivialis*	21	I (9)
Deschampsia caespitosa	840	III (41)	*Bromus racemosus*	20	I (7)
Anthoxanthum odoratum	648	II (37)	*Agrostis stolonifera*	178	I (6)
Festuca pratensis	452	II (33)	*Elymus repens*	3	I (6)
Holcus lanatus	861	II (31)	*Corynephorus canescens*	84	I (6)
Arrhenatherum elatius	1412	II (31)	*Festuca arundinacea*	6	I (5)
Phleum pratense	519	II (28)	*Briza media*	2	I (4)
Dactylis glomerata	192	I (18)	*Festuca ovina*	158	I (4)
Trisetum flavescens	184	I (16)	*Alopecurus geniculatus*	230	I (4)
Agrostis capillaris	300	I (13)	*Cynosurus cristatus*	3	I (3)
Glyceria maxima	648	I (12)	*Avenula pubescens*	2	I (3)
Poa palustris	75.	I (11)	*Calamagrostis epigejos*	70	I (2)
Lolium perenne	14	I (11)	*Poa annua*	1	I (2)
Festuca rubra	40	I (10)	*Phragmites australis*	1	I (1)
Glyceria fluitans	451	I (10)	*Poa angustifolia*	1	I (1)
Agrostis gigantea	6	I (9)			

D – averaged mean cover multiplied by 100.

Ecological spectra of grasses recorded

Soil moisture (F). Soil moisture strongly affected the occurrence of plants and thus, the occurrence of plant communities. The broadest spectrum in terms of moisture showed: *Phleum pratense*, *Festuca pratensis*, *Alopecurus pratensis*, *Deschampsia caespitosa*, *Lolium perenne* and *Agrostis capillaris* (Fig. 1). Such a large observed intervals indicate that most of the above mentioned species


R nb
Alopecurus pratensis 3.9 – 7.7
Poa pratensis 4.5 – 7.4
Deschampsia caespitosa 4.5 – 7.7
Anthoxanthum odoratum 4.5 – 7.4
Festuca pratensis 4.5 – 7.1
Holcus lanatus 4.5 – 7.4
Arrhenatherum elatius 4.5 – 7.4
Phleum pratense 4 – 7.4
Dactylis glomerata 4.5 – 7.4
Trisetum flavescens 4.5 – 7.4
Agrostis capillaris 4.5 – 7.4
Glyceria maxima 6 – 8
Poa palustris 5.5 – 7.3
Lolium perenne 5 – 7.4
Festuca rubra 4.8 – 6.7
Glyceria fluitans 5.6 – 7
Agrostis gigantea 4.5 – 7.7
Phalaris arundinacea 3.9 – 7.7
Poa trivialis 5.2 – 6
Bromus racemosus 4.7 – 6.6
N nb
Alopecurus pratensis 3.7 – 7.2
Poa pratensis 3.7 – 6.7
Deschampsia caespitosa 3 – 7.2
Anthoxanthum odoratum 3.9 – 6.4
Festuca pratensis 4.3 – 6.7
Holcus lanatus 4.3 – 6.4
Arrhenatherum elatius 4.3 – 6.7
Phleum pratense 1 – 6.6
Dactylis glomerata 4.3 – 6.4
Trisetum flavescens 4.3 – 6
Agrostis capillaris 3.9 – 6.2
Glyceria maxima 4.4 – 8.9
Poa palustris 4.1 – 6.8
Lolium perenne 3 – 6.7
Festuca rubra 3.9 – 6.2
Glyceria fluitans 4 – 7
Agrostis gigantea 4.6 – 7.2
Phalaris arundinacea 3.7 – 7
Poa trivialis 4.6 – 6.6
Bromus racemosus 4.4 – 6

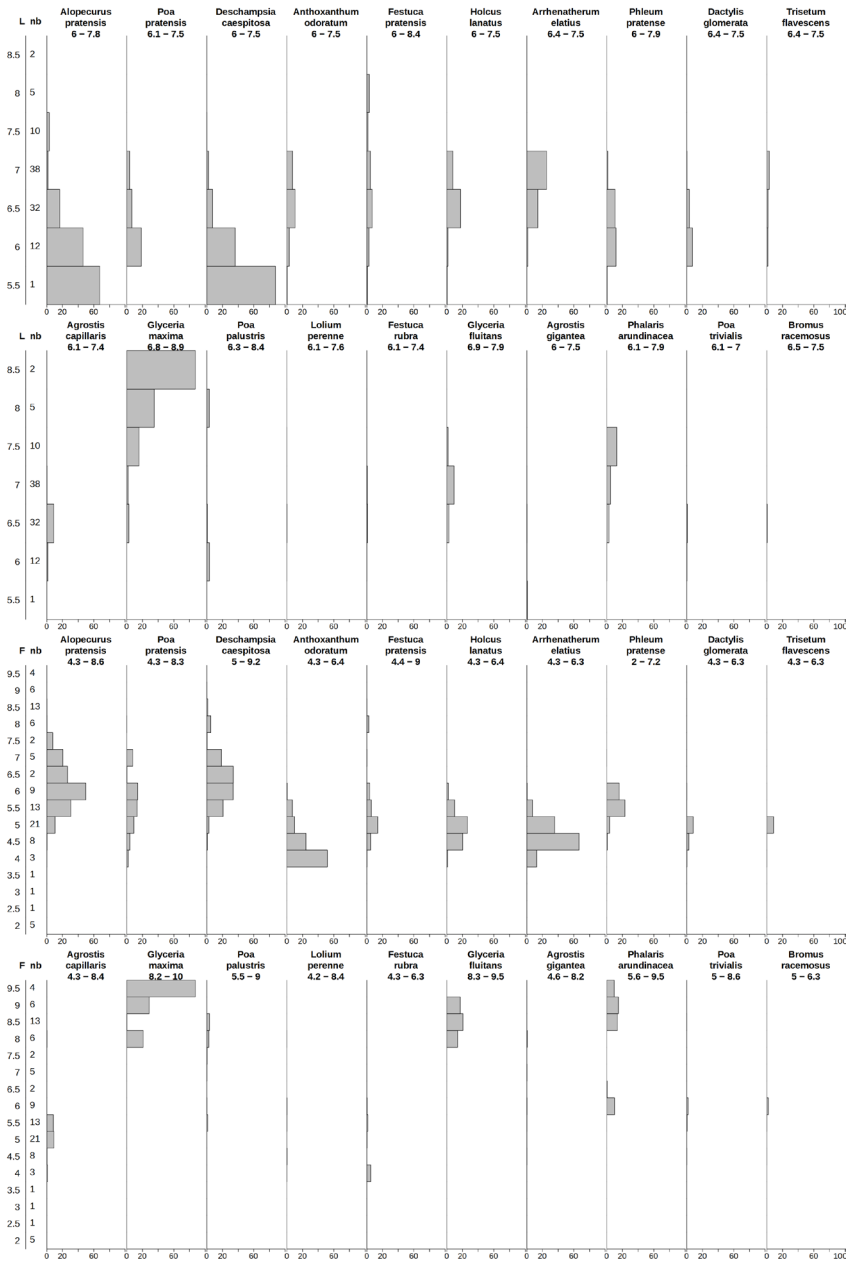


Figure 1. The averaged abundance of species from the *Poaceae* family for the relevés aggregated by Ellenberg L, F, R and N indices; nb – the number of relevés with respective range of studied index. The range of index for the relevés with presence of the species is under the species name

may exist as well in dry or fresh as in constantly damp or even wet sites. In the examined grassland association were also noted some specialist. For instance, the definitely dry habitats occupied *Festuca ovina*, *Corynephorus canescens*, *Calamagrostis epigejos*. At the other extreme in terms of preferences for habitat moisture were *Glyceria maxima* and *Glyceria fluitans*, that both evidently preferred wet habitats. Likewise, in the middle part of the moisture spectrum were placed some species of relatively narrow ecological range in terms of soil moisture. Among them were found: *Bromus racemosus*, *Trisetum flavescens*, *Dactylis glomerata*, *Arrhenatherum elatius*, *Holcus lanatus*, *Festuca rubra*, *Anthoxanthum odoratum*. It should be noted that the reliability of the Fig. 1 is greater for the part based on the larger number of relevés.

Nitrogen content (N). The majority of analyzed grass species grew in habitats of medium nitrogen content (Fig.1). Only *Glyceria maxima* showed strongly nitrophilous character, however, it may appear also in sites of intermediate fertility. *Festuca ovina* and *Corynephorus canescens* were found in extremely infertile sites only. What is interesting, the *Phalaris arundinacea* and *Dactylis glomerata* known as nitrophilous species, occurred only in places of intermediate soil fertility. Based on the analyzed data, it was stated that the widest spectrum in terms of nitrogen content had *Phleum pratense*, and next: *Glyceria maxima* and *Deschampsia caespitosa*.

Soil reaction (R). The widest range, from acid to weakly basic soils, showed *Phalaris arundinacea* and *Alopecurus pratensis*. On the most acidic soils grew *Calamagrostis epigejos*, while the highest pH (neutral to basic) preferred *Glyceria maxima*.

Light availability (L). The Ellenberg values of light spectra of the examined grass species ranged between 6.0 and 8.9 (Fig.1a). Based on that there can be stated that some species preferred semi-shade sites while others grew in well-lit ones.

It should be mentioned that the maximum and minimum are the least robust statistics (they are maximally sensitive to outliers in the sample). Therefore, the range of the best suitable habitat conditions, in which the bars on the Fig.1. were relatively long, should be taken into account instead the whole range of Ellenberg indices for which the species occured. For example, in the given area the range of N content for the *Deschampsia caespitosa* varied between 3.0 and 7.2, while the preferable conditions in terms of N content was between 3.0 and 4.0. That means that *Deschampsia caepsitosa* described in the research area preferred infertile sites, though it may occur also in fertile ones.

The range of the values of the L index for considered species was relatively narrow. It amounted less or more 1 unit, while, for other analyzed indexes (F, R, N) the range contained 2–3 units (Fig.1). It suggests that light the most strongly

limited the occurrence of grass species in the given area. It can explain why the cessation of grassland management is such often mentions as the most serious problem for conservation of semi-natural grassland communities (Stypiński and Piotrowska, 1997; Hájkova et al., 2009; Habel et al., 2013). Appearance of shrubs and tree seedling quickly results in changes in light conditions (Sienkiewicz-Paderewska et al., 2012). However, the issues related to the reaction of species to various habitat parameters need a wide discussion based on the analysis of much larger data sets. For instance, Zelnik and Čarni (2013) had stated that the most significant environmental parameter influencing the floristic composition of the *Molinion* communities is soil pH. Among other important factors affected *Molinion* vegetation there were also mentioned: soil moisture, nutrient status and the content of Ca^{+2} ions. Instead, Kryszak et al. (2012) when analyzed variability of the *Arrhenatheretum elatioris* growing under differentiated soil conditions have concluded that internal differentiation of this syntaxon depends on soil moisture and availability of nutrients.

A wide ecological amplitudes of some species, i.e. *Phleum pratense*, *Alopecurus pratensis*, *Deschampsia caespitosa* explain, in some sense, a wide ecological spectrum of syntaxons for which the above mentioned species are characteristic. In other words, their broad ecological spectra explain the appearance of lots of subassociations or variants of associations often described by other authors for (Trąba et al., 2008; Brągiel et al., 2016).

Syntaxonomical spectra of species recorded

In order to facilitate the analysis of the syntaxonomical spectra of the grass species, the diagram of their occurrence in the described plant communities was performed (Fig. 2). The widest syntaxonomical spectrum among examined species in the area of the lower section of the Bug River unquestionably had *Deschampsia caespitosa* which occurred in the 10 to 15 analyzed plant communities. Moreover, *D. caespitosa* was present in the communities from both *Phragmitetea* and *Molinio-Arrhenatheretea* classes. It confirms the expansive character and a broad ecological spectrum of this species underlined by some authors (Kucharski, 1999; Kryszak et al., 2009). A similar pattern was stated in the case of *Alopecurus pratensis*, it was a component of 7 to 15 analyzed communities. *Deschampsia caespitosa* and *Alopecurus pratensis* generally show similar ecological spectra and also their associations – *Deschampsietum caespitosae* and *Alopecuretum pratensis*. Some authors claims that *Deschampsietum* is the degraded form of the associations from *Calthion* and *Molinion* aliances (Barabasz, 1997), *Alopecurion* (Baryła and Urban, 2002) or *Arrhenatherion* (Denisiuk and

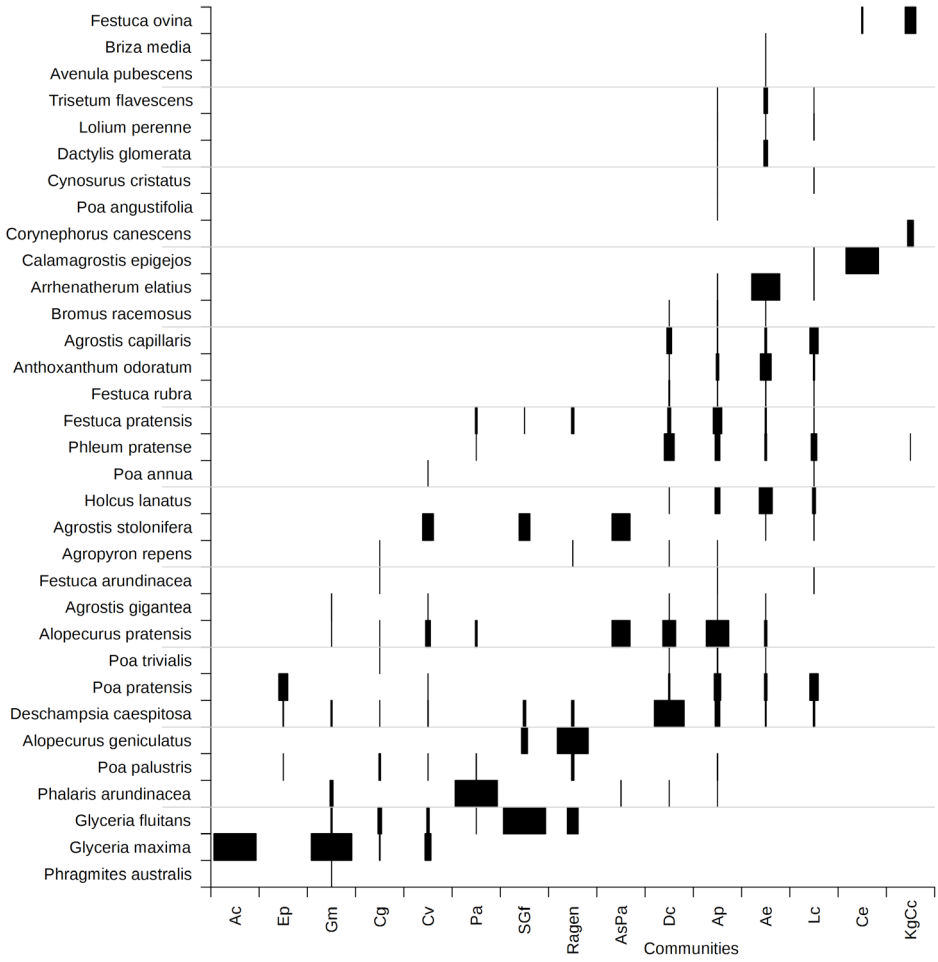


Figure 2. The occurrence of species in the analyzed communities. The width of each rectangle corresponds to the averaged mean cover of this species in the community

Ac – Acoretum calami; *Ep – Eleocharitetum palustris*; *Gm – Glycerietum maximae*; *Cg – Caricetum gracilis*; *Cv – Caricetum vulpine*; *Pa – Phalaridetum arundinaceae*; *SGf – Sparganio-Glycerietum fluitantis*; *Ragen – Ranunculo-Alopecuretum geniculati*; *AsPa* – community with *Agrostis stolonifera-Potentilla anserina*; *Dc – Deschampsietum caespitosae*; *Ap – Alopecuretum pratensis*; *Ae – Arrhenatheretum elatioris*; *Lc – Lolio-Cynosuretum*; *Ce – Calamagrostietum epigeji*; *KgCc – Koelerio glaucae-Corynephoretea canescentis*.

Korzeniak, 1999). However, as was indicated by Sienkiewicz-Paderewska and Paderewski (2015) *Alopecuretum pratensis* and *Deschampsietum caespitosae* are rather separate syntaxons. Their requirements in terms of site humidity and light availability are similar, but they spectra of both nitrogen content and soil reaction do not overlap. *Alopecuretum* needs nutrient – rich, neutral to alkaline soils, while *Deschampsietum* may also appear in the nutrient – poor, acidic soils and such conditions are preferable to this species. Thus, the ecological amplitude of *Deschampsietum caespitosae* in terms of site fertility and soil reaction is much wider. In those previous studies, the patches of *Arrhenatheretum elatioris* occurred on neutral to alkaline, nutrient – rich soil, well – lit, dry or moderately damp and the spectrum of this association evidently differ from the spectrum of both *Alopecuretum pratensis* and *Deschampsietum caespitosae*. Nevertheless, in the botanical composition of the *Deschampsietum caespitosae*, *Alopecuretum pratensis* and *Arrhenatheretum elatioris* described in the lower section of Bug River Valley, there was stated a large number of common species (Sienkiewicz-Paderewska et al., 2017).

The relatively wide phytosociological spectrum also showed other species: *Glyceria fluitans*, *Poa palustris*, *Poa pratensis*, *Phleum pratense* which appeared in the 6 to 15 communities. But *Glyceria fluitans* was an element of the associations belonging to the *Phragmitetea* class mainly (the most often in the *Magnocaricion* phytocoenoses) and, in addition, in the composition of the *Ranunculo-Alopecuretum geniculati* (Fig. 2).

The syntaxonomical spectrum and the spectrum of habitat conditions expressed by the range of Ellenberg indicator values does not have to coincide with each other. For example, if the species occurs only in one association, but it is common for this and the association has wide range of habitat conditions, then this species will have the narrow syntaxonomical spectrum and, in the same time, wide range of acceptable habitat conditions. The opposite situation is when the species is not characteristic for associations and occurs in many of them, but it prefers specific habitat conditions. Of course it can be rather expected that the syntaxonomical and ecological spectra will be relatively compatible with each other.

4. Conclusions

- Grasses have been found in every grassland community described in the research area.
- In the described 15 communities 33 species of *Poaceae* family were recorded.

- The largest number of grass species was stated in the following communities: *Arrhenatheretum elatioris*, *Alopecuretum pratensis*, *Lolio-Cynosuretum* and *Deschampsietum caespitosae*.
- The widest ecological spectrum in terms of the analyzed habitat parameters, i.e. soil moisture, soil pH, nitrogen content and light availability showed *Phleum pratense*, while the broadest syntaxonomical range had *Deschampsia caespitosa*.

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Ekologiczne i syntaksonomiczne spektra traw występujących w zbiorowiskach trawiastych w Dolinie Dolnego Bugu

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Streszczenie

Prezentowane badania wykonano w Dolinie Dolnego Bugu na odcinku Długie Kamieńskie-Kossaki, gdzie stwierdzono występowanie 15 roślinnych zbiorowisk nieleśnych (głównie w randze zespołów) należących do 4 klas fitosocjologicznych: *Phragmitetea*, *Molinio-Arrhenatheretea*, *Koelerio glaucae-Corynephoretea canescentis* i *Epilobietea angustifolii*. W opisanych zbiorowiskach występowały 33 gatunki z rodziny traw. Najwięcej gatunków traw odnotowano w zespołach: *Arrhenatheretum elatioris*, *Alopecuretum pratensis*, *Deschampsietum caespitosae* i *Lolio-Cynosuretum*.

Najszersze spektrum ekologiczne pod względem rozpatrywanych czynników siedliskowych: wilgotności gleby, odczynu roztworu glebowego, zawartości azotu w glebie i dostępności światła, stwierdzono w przypadku *Phleum pratense*. Najszersze spektrum syntaksonomiczne stwierdzono w przypadku *Deschampsia caespitosa*. Gatunek ten wystąpił w 10 na 15 opisanych zbiorowisk roślinnych z klas *Phragmitetea* i *Molinio-Arrhenatheretea*.

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