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Letter to Editor

Influence of Expansiveness of Select Plant Species on Floristic Diversity of Meadow Communities

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Abstract

The aim of our investigations conducted on grasslands situated in the region of Wielkopolska was to analyze changes in the occurrence of selected plant species in the sward of meadow communities, to determine causes of their expansion and the impact on natural and useful values of these plant complexes.

The occurrence of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* from meadow communities was subject to comparative analysis. The behaviour of the above species, described as aggressive, was analyzed on the basis of changes in the frequency of their occurrence (i.e. constancy degree) in communities and the achieved ground covering coefficient. In addition, causes and consequences of the expansive behaviour of the analyzed plant species were assessed.

The expansive behaviour of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* is associated, on the one hand, with the occupation of new sites and, on the other, with a significant increase in the proportion of these species in the sward as evidenced by the obtained values of the ground-covering coefficient. The spreading the analyzed plant species results from the direct or indirect anthropo-pressure on sites and vegetation type of meadow communities. The discussed expansive species – course hairgrass, velvet grass and Canadian thistle – occurring in grass communities, especially during longer time intervals, exert unfavourable influence on their natural and use values.

Keywords: *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense*, expansiveness, meadow communities and sites, natural and use values

Introduction

In conditions of continuous and intensive anthropopressure, expansive behaviours are evoked in some rare species exhibiting appropriate adaptation capabilities [1, 2]. These are synanthropic species spreading either within its natural range or brought in from outside [3].

Causes of this type of behaviour of plant species in meadow communities should be sought in their biological traits that allow them to adapt to changing habitat conditions and utilization methods [4-6]. Consequences of such encroachment of foreign species include, changes in the floristic composition of existing biocenosis [7, 8]. Their rapidly increasing proportion in the sward in the first place hampers the development of indigenous plants and may lead to gradual simplification of the floristic composition of meadow communities or even to their domination by a few species of alien origin.

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In recent years, on grassland it has been possible to observe a rapid increase of the range of some meadow plants, primarily by taking over new sites, including course hairgrass, velvet grass and such dicotyledons as Canadian thistle and common nettle. Their fast spread can probably be attributed to unstable moisture conditions and, frequently, to mistakes made in the course of utilization and cultivation of grasslands [9].

Polymorphism, ecological plasticity competitiveness, seed productivity and a rapidly growing and well-developing root system all favour the expansion of tufted hairgrass and velvet grass, especially in conditions when moisture content is not regulated, fertilization is insufficient and utilization irregular [10-12].

The aim of the investigations conducted on grasslands situated in the region of Wielkopolska was to analyze changes in the occurrence of selected plant species in the sward of meadow communities to determine causes of their expansion and the impact on natural and useful values of these plant complexes.

Experimental Procedures

The performed comparative analysis comprised the occurrence in meadow communities of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense*. Approximately 5,000 phytosociological relevés from 1966 to 2007 derived from five river valleys situated in the region of Wielkopolska (Warta – 1230, Obra – 1900, Barycz – 820, Wełna – 470, and Noteć – 650 phytosociological relevés) were analyzed (Fig. 1). Bearing in mind the observed changes in utilization as well as in site conditions of meadows and pastures in Poland during a period of political and social transformations, the collected material of phytosociological relevés was analysed in two time intervals: before 1989 and after 1989. Phytocenologic research was carried out by the method of Swiss-French school Braun-Blanquet [13], i.e. phytosociological relevés were performed during the period from the middle of May to the middle of July from an area of 75-100 m^2. After assigning relevés to the phytosociological system, the species were assessed in accordance with the Braun-Blanquet method with regard to:

- the number of occurrences in relation to the total number of phytosociological relevés of a given association, i.e. the constancy degree was determined,
- mean area cover by the species in the community, i.e. the covering coefficient was calculated according to the following formula:

$$Species\ covering\ coefficient = \frac{\sum of\ mean\ percentage\ cover\ of\ the\ species\ in\ all\ relevés\ of\ the\ association\ in\ which\ it\ occurs}{total\ number\ of\ relevés\ of\ the\ association} \times 100$$

The behaviour of the examined species described as 'expansive' was analyzed on the basis of changes in the frequency of their occurrence (constancy degree) in communities and the achieved ground cover coefficient. Causes of the occurrence of these species were evaluated on the basis of the assessment of site conditions carried out with the assistance of the phyto-indication method, i.e. with the help of indicator numbers developed by Ellenberg et al. [14]: moisture content (F), soil reaction (R) and nitrogen content in soil (N). For all phytosociological surveys the authors calculated weighted averages of index values in relation to the quantity and next arithmetic averages of indices for entire communities in the two above-mentioned time intervals. Consequences of the species expansive behaviour were determined on the basis of:

- changes taking place in the floristic structure of communities,
- the impact on natural values by analyzing their floristic wealth and diversity, botanical structure, geographic-historical spectrum, dynamic tendencies of sward species,
- "fodder value score" – FVS defined by Filipek [15], in which "10" equated high-quality fodder.

Floristic diversity was evaluated using the Shannon-Wiener index H' [16]:

$$H = -\sum (p_i \times \ln p_i)$$

...where p_i is the cover proportion of the i-species.

The geographical-historic spectrum was described as the proportion (%) of synanthropic and alien species in the community floristic composition. Dynamic tendencies of sward species (E) were described after Zarzycki [17] according to the scale from "-2" – species marked by a

Fig. 1. A map of the study area.

Table 1. Comparison of constancy degrees of *Deschampsia caespitosa*, *Holcus lanatus* and *Cirsium arvense* in selected communities and valleys of Wielkopolska, 1966-2007.

Phytosciological unit	River valley									
	Warta		Obra		Barycz		Wełna		Noteć	
	Year									
	1966	2005	1977	2006	1968	2003	1973	2007	1966	1995
Deschampsia caespitosa										
Glycerietum maximae	II	IV	-	-	-	-	-	-	-	II
Phalaridetum arundinaceae	II	II	V	IV	III	III	-	III	-	III
Alopecuretum pratensis	IV	II	V	III	V	III	V	III	V	IV
Arrhenatheretum elatioris	IV	IV	-	IV	-	II	IV	V	-	IV
Lolio-Cynosuretum	II	IV	-	V	-	III	V	III	-	III
Communities with *Molinietalia*	-	II-V	-	IV	V	III-V	V	IV	0-V	III-V
Communities of *Trifolio fragiferae-Agrostietalia stoloniferae*	-	I-III	-	II-V	III	III	-	-	0-IV	0-III
Communities with *Arrhenatheretalia*	-	II-III	III	V	V	III	0-III	-	0-IV	III-IV
Community with *Carex nigra*	-	IV	V	III	-	IV	-	-	-	-
Holcus lanatus										
Communities with *Phragmitetea*	-	I-V	-	I-III	III-IV	II-V	-	I-V	0-II	II-III
Scirpetum silvatici	V	II	-	-	-	IV	-	-	-	IV
Alopecuretum pratensis	-	II	-	IV	V	III	IV	II	IV	II
Other communities with *Molinietalia*	-	I-V	III	II-V	V	II-V	V	V	0-III	III-V
Arrhenatheretum elatioris	IV	II	-	V	-	V	IV	IV	-	IV
Lolio-Cynosuretum	III	II	-	III	-	V	III	II	-	III
Other communities with *Arrhenatheretalia*	-	I-II	III	V	V	II-III	-	III	0-IV	III-IV
Community with *Carex nigra*	-	II	-	V	-	-	-	-	-	-
Cirsium arvense										
Caricetum gracilis	-	I	-	III	-	I	-	I	V	V
Phalaridetum arundinaceae	-	III	-	III	-	I	-	I	-	IV
Alopecuretum pratensis	I	IV	I	II	-	II	-	II	-	II
Lolio-Cynosuretum	-	III	I	I	-	I	-	I	-	I
Arrhenatheretum elatioris	II	III	I	II	-	I	-	-	III	IV
Community *Poa pratensis-Festuca rubra*	III	IV	II	I	-	I	-	-	-	III
Diantho-Armerietum elongatae	-	I	-	I	-	-	-	-	-	II

decrease in a number of locations to "+2" – species marked by a considerable number increase and occupation of new locations. Research results were obtained as an arithmetic mean from the calculated indices for the phytosociological relevés of a given community and the time interval.

Plant communities were analyzed and identified by the communities code [18].

Results and Discussion

The process of transformations of plant communities is written into their biology and evolution, although the intensity of these changes is stimulated strongly by human activity [19, 20]. Increasing anthropo-pressure frequently favours the spreading of certain species – primarily apophytes – within their natural range of occurrence either

Table 2. Number of communities with *Deschampsia caespitosa*, *Holcus lanatus* and *Cirsium arvense* in valleys of the Wielkopolska region.

River valley	Plant communities	Years:	
		Up to 1989	after 1989
Deschampsia caespitosa			
Warta	Class *Phragmitetea*	2	10
	Class *Molinio-Arrhenatheretea*	11	11
	Order *Molinietalia*	8	5
	Trifolio fragiferae-Agrostietalia stolonifera	1	2
	Arrhenatheretalia	2	4
	Class *Scheuchzerio-Caricetea nigrae*	1	1
	Class *Nardo-Callunetea*	1	-
Obra	Class *Phragmitetea*	3	6
	Class *Molinio-Arrhenatheretea*	10	8
	Order *Molinietalia*	5	3
	Trifolio fragiferae-Agrostietalia stolonifera	2	2
	Arrhenatheretalia	3	3
	Class *Scheuchzerio-Caricetea nigrae*	1	1
	Class *Koelerio glauca-Corynephoretea canescentis*	-	2
Barycz	Class *Phragmitetea*	2	6
	Class *Molinio-Arrhenatheretea*	6	10
	Order *Molinietalia*	4	5
	Trifolio fragiferae-Agrostietalia stolonifera	1	1
	Arrhenatheretalia	1	4
	Class *Scheuchzerio-Caricetea nigrae*	-	1
	Class *Koelerio glauca-Corynephoretea canescentis*	1	-
	Class *Nardo-Callunetea*	-	1
Wełna	Class *Phragmitetea*	-	4
	Class *Molinio-Arrhenatheretea*	5	7
	Order *Molinietalia*	3	3
	Arrhenatheretalia	2	4
Noteć	Class *Phragmitetea*	1	7
	Class *Molinio-Arrhenatheretea*	5	12
	Order *Molinietalia*	3	7
	Trifolio fragiferae-Agrostietalia stolonifera	1	2
	Arrhenatheretalia	1	3
Holcus lanatus			
Warta	Class *Phragmitetea*	-	7
	Class *Molinio-Arrhenatheretea*	4	12
	Order *Molinietalia*	2	7
	Trifolio fragiferae-Agrostietalia stolonifera	-	1
	Arrhenatheretalia	2	4
	Class *Scheuchzerio-Caricetea nigrae*	-	1

Table 2. Continued.

River valley	Plant communities	Years:	
		Up to 1989	after 1989
Obra	Class *Phragmitetea*	3	5
	Class *Molinio-Arrhenatheretea*	10	9
	Order *Molinietalia*	5	3
	Trifolio fragiferae-Agrostietalia stolonifera	2	2
	Arrhenatheretalia	3	4
	Class *Scheuchzerio-Caricetea nigrae*	1	1
	Class *Koelerio glauca-Corynephoretea canescentis*	-	2
Barycz	Class *Phragmitetea*	2	2
	Class *Molinio-Arrhenatheretea*	6	12
	Order *Molinietalia*	4	4
	Trifolio fragiferae-Agrostietalia stolonifera	1	2
	Arrhenatheretalia	1	6
	Class *Koelerio glauca-Corynephoretea canescentis*	1	-
	Class *Nardo-Callunetea*	1	-
Wełna	Class *Phragmitetea*	-	4
	Class *Molinio-Arrhenatheretea*	5	7
	Order *Molinietalia*	3	3
	Arrhenatheretalia	2	4
Noteć	Class *Phragmitetea*	1	7
	Class *Molinio-Arrhenatheretea*	5	12
	Order *Molinietalia*	3	7
	Trifolio fragiferae-Agrostietalia stolonifera	1	2
	Arrhenatheretalia	1	3
Cirsium arvensis			
Warta	Class *Phragmitetea*	1	6
	Class *Molinio-Arrhenatheretea*	5	10
	Order *Molinietalia*	3	6
	Trifolio fragiferae-Agrostietalia stolonifera	2	1
	Arrhenatheretalia	-	3
	Class *Koelerio glauca-Corynephoretea canescentis*	-	1
Obra	Class *Phragmitetea*	1	3
	Class *Molinio-Arrhenatheretea*	5	8
	Order *Molinietalia*	2	3
	Trifolio fragiferae-Agrostietalia stolonifera	1	2
	Arrhenatheretalia	2	3
	Class *Scheuchzerio-Caricetea nigrae*	2	1
	Class *Koelerio glauca-Corynephoretea canescentis*	-	2
Barycz	Class *Phragmitetea*	-	3
	Class *Molinio-Arrhenatheretea*	2	6
	Order *Molinietalia*	1	3
	Trifolio fragiferae-Agrostietalia stolonifera	1	1
	Arrhenatheretalia	-	2
Noteć	Class *Phragmitetea*	1	1
	Class *Molinio-Arrhenatheretea*	1	3
	Order *Molinietalia*	1	1
	Trifolio fragiferae-Agrostietalia stolonifera	-	-
	Arrhenatheretalia	1	2

Table 3. Habitat-utilization causes of changes in the proportions of *Deschampsia caespitosa*, *Holcus lanatus* and *Cirsium arvense* in communities and their natural-economic consequences.

Treatment	*Ph.a.*		*M.c.*		*Al.p.*		*L-C*		Community *Po.p.-F.r.*	
	D*	A*	D*	A*	D	A*	D*	A*	D*	A*
Cover index of *Deschampsia caespitosa*	85.1	221	191.2	351.5	241.2	230.8	433	282.6	402.8	271.9
Cover index of *Holcus lanatus*	15.4	226	156	102	107.2	248.6	134.1	308.9	178.9	105.2
Cover index of *Cirsium arvense*	3.4	15.0	-	7.1	43.6	180	-	30.5	43.1	31.0
Causes of changes in the proportions of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* in sward										
Ellenberg's index – moisture (F)	6.8	6.7	5.8	6.6	5.9	5.7	5	5.3	5.5	5.1
Ellenberg's index – soil reaction (R)	4.6	5.2	3.2	3.7	4.5	5.1	4.4	5	4.4	4.3
Ellenberg's index – content of nitrogen in soil (N)	3.4	4.6	2.7	2.4	2.7	4.1	2.4	3.8	2.9	3.7
Utilisation										
- cuts	3x	2x	1x	2x	1x	3x	-	-	-	-
- grazing (LU ha^{-1})**	-	-	-	-	-	-	1	3	1	2
Fertilisation (kg NPK ha^{-1})	150	100	-	60	100	150	80	120	30	60
Natural-economic consequences in the proportions of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* in sward										
Total numbers of plant species in community	53	72	45	56	61	75	65	71	42	60
Shannon -Wiener index – plant diversity H'	1.57	2.03	1.71	1.59	1.67	2.11	1.71	1.82	0.99	2.13
% of synanthropic species	71	72.3	65.6	68.2	77.7	78.7	84.9	85.6	73.9	83.2
% of alien species	7.4	5.0	0.8	-	4.2	6	2.3	5.9	3.2	6.5
% of species of highest dynamic tendencies	59.8	67.4	60.0	51.4	73.2	72.3	72.4	76.8	70.4	75.8
Fodder value score - FVS	6.0	5.0	4.7	3.0	6.8	5.7	6.7	6.1	6.6	5.6

Period: D* – up to 1989; A* – after 1989.
Ph.a. – association of *Phalaridetum arundinaceae*; *M.c.*- association of *Molinietum caeruleae*; *Al.p.* – association of *Alopecuretum pretense*; *L-C,* association of *Lolio-Cynosuretum*; Community *Po.p.-F.r.* – community *Poa pratensis-Festuca rubra.*
**(LU ha^{-1}) – Livestock unit.

by direct or indirect impact on habitat [21]. The occurrence of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* is an example of this type of phenomenon which has all the hallmarks of ecological expansion. The performed comparative analysis of the floristic composition of communities identified in many river valleys in Wielkopolska indicates that the examined plant species in communities in which they were found so far frequently increased their proportion but, at the same time, they expanded the range of their occurrence by appearing in new plant communities (Table 1).

Habitat changes, supported (most frequently caused) by unsystematic and inappropriate utilization of meadows and pastures, clearly favour the appearance in new communities, especially such plant species as *Deschampsia caespitosa* and *Holcus lanatus*. The obtained results indicate that a steady increase in the ecological scale of the examined plant species occurs by their taking over of both marshy and temporarily dry habitats. The observed process takes place in all examined river valleys and is associated with the appearance of course hairgrass, velvet grass and Canadian thistle in new communities. This refers in particular to the *Phragmitetea* and *Molinio-Arrhenatheretea* classes of the *Arrhenatheretalia* order and, to a lesser extent, even to the *Koelerio glauca-Corynephoretea canescentis* class (Table 2).

The consequences of continued high proportions of grasses, especially *Deschampsia caespitosa* and *Holcus lanatus*, in the old communities and their appearance in new communities include changes in quantitative relationships of the species occurring in the sward (Table 3).

Coefficients of ground cover exert some impact on the species number in a community (Figs. 2, 3). The scientific investigations carried out so far indicate that the appearance of expansive species, i.e. course hairgrass and velvet grass which are characterized by high competitiveness, leads to reduced species diversity of plant communities. However, in the majority of the analysed communities a reverse correlation was observed, i.e. an increase of species number. This may indicate an initial stage of succession during

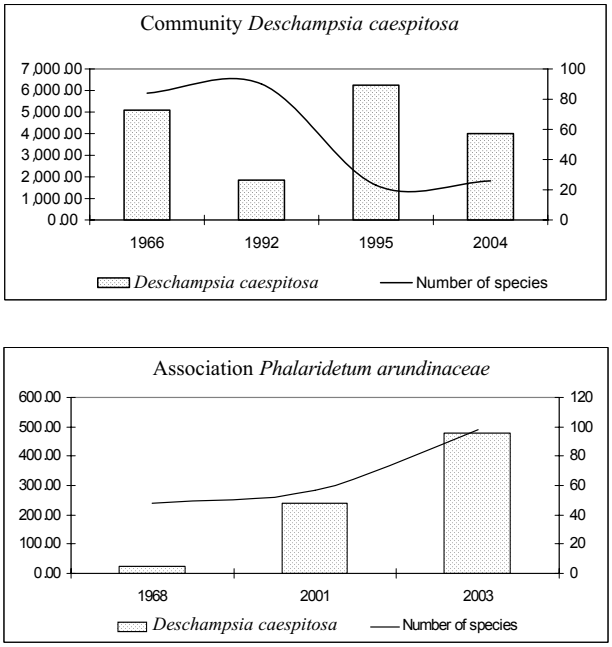

Fig. 2. Impact of the proportion of *Deschampsia caespitosa* (expressed by the coverage coefficient) on changes in species numbers in select associations.

which the number of species usually increases in comparison with the typical forms of associations. There are, most frequently, ordinary synanthropic species or even of foreign origin of wide ecological spectrum indicating a trend toward overtaking new sites. Also, Shafi and Yarranton [22] (as well as Dzwonko and Loster [23]) reported increased diversity during the transitory stage of the secondary succession induced by changes in the utilization intensity.

The strongest impact on the occurrence of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* is exerted by site conditions as well as utilization of plant communities (Table 3).

The appearance of the analyzed plant species in new communities is strongly associated with changes in their site conditions. Reduced moisture content of marshy sites is connected with the lowering of ground water levels and, frequently, with the shortening of the flooding periods, which favours increased proportions of all the analyzed species in communities. Canary grass meadows provide a good illustration as their sites in the region of Wielkopolska underwent considerable drying. This process contributed to a more frequent and at higher proportions occurrence of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* in patches of this association. On the other hand, their occurrence in the communities of the *Molinio-Arrhenatheretea* class seems to be more connected with the utilization. The proportions of course hairgrass and velvet grass are small in the sward of intensively utilized meadows and pastures as confirmed by lower values of the ground covering coefficient (Fig. 3). The occurrence of the Canadian thistle in these site conditions seems to be more connected with fertilization, primarily organic (i.e. application of slurry).

Negative consequences of the expansive behaviour of some plant species should be emphasized. Changes in quantitative relationships in the sward meadow communities caused by the intrusion of invasive plants result in an increase in the proportions of synanthropic species in the sward as well as plants of greater dynamic tendencies. Both the research results presented in this study and literature [11, 24, 25] data confirm that the observed expansive behaviour of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* reduce natural and fodder value score of the examined communities.

However, many researchers emphasise that invasions of plants of alien origin pose a much greater threat to biodiversity on a global scale because they lead to both fragmentation and degradation of natural communities [26-28].

Conclusions

1. The expansive behaviour of apophytes *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* is associated with taking over by these plants of new habitats and frequently results from their increased proportion in current communities as indicated by the calculated values of the ground-covering coefficient.
2. Spreading of the above-mentioned species is the result of direct or indirect anthropo-pressure exerted on sites and vegetation of meadow communities.

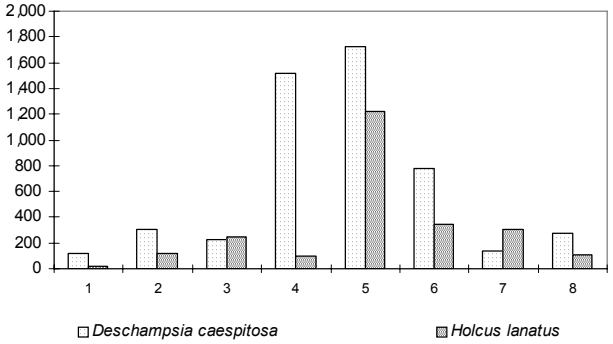

Fig. 3. Effect of meadow and pasture utilization on proportions of *Deschampsia caespitosa* and *Holcus lanatus* in communities (expressed by the coverage coefficients)
1 – no utilization; wet site (*Phragmitetum australis*, *Caricetum ripariae*),
2 – meadows cut 2 to 3 times; wet site (*Phragmitetum australis, Caricetum ripariae*),
3 – meadows cut twice; sites characterized by changing moisture conditions (*Alopecurus pratensis*),
4 – cut meadows; sites characterized by changing moisture conditions (*Molinietum coeruleae*),
5 – meadows cut irregularly (communities: *Deschampsia caespitosa, Holcetum lanati*),
6 – meadows cut twice; drying sites (*Arrhenatheretum elatioris*),
7 - pastures 2-3 LU ha^{-1}; moderately wet (*Lolio-Cynosuretum*),
8 - pastures 1 LU ha^{-1}; drying sites (community: *Poa pratensis-Festuca rubra*).

3. The growing proportion of *Deschampsia caespitosa, Holcus lanatus* and *Cirsium arvense* in plant communities, during the initial period encourages the development of floristic diversity, but over longer periods of time reduces natural and fodder value score of meadows and pastures.

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References

1. COLAUTTI R. I., MACIZAAC H. J. A neutral terminology to define "invasive" species. Diversity and Distributions, **10**, 135, **2004**.
2. JACKOWIAK B. The expansion models of synanthropic and transgenic plants, 11 (N.S.). Phythocoenosis, **6**, 1, **1999** [In Polish].
3. FALIŃSKI J. B. Synanthropisation of the plant cover – an attempt to define the nature of the process and of the main Fields of investigations. Phytoceneosis, **1,** (3), 157, **1972** [In Polish].
4. BUSCH E. J., BARRETT S.C.H. Genetics of mine invasions by Deschampsia caespitosa (Poaceae). Can. J. Bot. **71**, 1336, **1993**.
5. KORNAŚ J. Plant invasions in Central Europe: historical and ecological aspects. (F. du Castriii, A.J. Hansen, M. Debussche, Eds.) Biological Invasions in Europe and the Mediteranean Basin. Kluwer Academic Publishers, Dordrecht, pp. 19-34, **1990**.
6. REJMANEK M. Invasive plants: approaches and predictions. Austral. Ecology, **25**, 497, **2000**.
7. OLACZEK R. Synathropization of phytocoenoses. Memorabilia Zool. **37**, 93, **1982**.
8. KRYSZAK A. Synanthropisation of selected meadow communities. Water-Environment-Rual Areas, **4,** (1), 201, **2004** [In Polish].
9. KRYSZAK J., KRYSZAK A., KLARZYŃSKA A. Canary grass meadows (Phalaridetum arundinaceae) in the Barycz River valley. Water-Environment-Rual Areas, **7**, 2a (20), 109, **2007** [In Polish].
10. HORN A. Die Rasenschmiele. Diss. Berlin, pp. 64. **1936**.
11. GRYNIA M. Geobotanic characteristics of turf hairgrass meadows exemplified by some valleys stituated in West Poland. Pr. Kom. Nauk Roln. i Kom. Nauk Leśn. Pozn. Tow. Przyj. Nauk, **31**, 223, **1971** [In Polish].
12. WILLIAMS E.D. Long-term effects of fertilizer on the botanical composition and soil seed population of a permanent grass sward. Grass and Forage Sci. **40**, 479, **1985**.
13. BRAUN-BLANQUET J. Pflanzensoziologie, Springer Verlag: Vien, pp. 865, **1964**.
14. ELLENBERG H., WEBER H. E., DÜLL R., WIRTH V., WERNER W., PAULISSEN D. Zeigerwerte von Pflanzen in Mitteleuropa. Scripta Geobot., 18. Verlag E. Goltze KG Göttingen, pp. 258, **1992**.
15. FILIPEK J. The proposal for the classification of meadow and pasture plants on the basis of fodder value scores. Post. Nauk Roln. **4**, 59, **1973** [In Polish].
16. MAGURRAN A.E. Measuring biological diversity. Blackwell Publishing, Malden: USA, pp. 256, **2004**.
17. ZARZYCKI K., TRZCIŃSKA-TACIK H., RÓŻAŃSKI W., SZELĄG Z., WOŁEK J., KORZENIAK U. Ecological indicator values of vascular plants of Poland. W. Szafer Institute of Botany, Polish Academy of Science: Kraków, pp. 183, **2002** [In Polish].
18. MATUSZKIEWICZ W. A quide to identification of plant communities of Poland. Vademecum geobotanicum, Wydawnictwo Naukowe PWN: Warsaw, **3**, pp. 537, **2005** [In Polish].
19. D'ANTONIO C. M., VITOUSEK P. M. Biological invasions by exotic grasses, the grass-fire cycle, and global change. Annual Review of Ecology and Systematics, **23**, 63, **1992**.
20. FALIŃSKI J.B. Invasions in the plant world: mechanisms, danger, research project. Phytocoenosis 16 (N.S.), Seminarium Geobotanicum: Warszawa-Białowieża, **10**, pp. 31, **2004** [In Polish].
21. DAVIES M.A., THOMPSON K, GRIME J. P. Charles S.Elton and the dissociation of invasion ecology from the rest ecology. Diversity and Distributions, **7**, 97, **2001** [In Polish].
22. SHAFI M.J., YARRANTON G.A. Diversity, floristic richness, and species evenness during a secondary (posifire) succession. Ecology, **54**, 897, **1973**.
23. DZWONKO Z., LOSTER S. Vegetation differentiation and secondary succession on limestone hill in southern Poland. Journal Vegetation Science, **1**, 615, **1990**.
24. DENISIUK Z., KORZENIAK J. Non-forest plant communities of the lower forest zone in the Bieszczady National Park. Monografie Bieszczadzkie, **5**, 162, **1999** [In Polish].
25. KRYSZAK A., KRYSZAK J., GRYNIA M., CZEMKO M. Deschampsia caespitosa (Poaceae) in the sward of meadow-pasture communities in the Wielkopolska. Fragm. Flor. Geobot. Polonica, Suppl., **9**, 73, **2007** [In Polish].
26. ABBOT R. J. Plant invasions, interspecific hybridization and the evolution of new plant taxa. Trends in Ecology and Evolution, **7**, 401, **1992**.
27. GENOVESI P., SHINE C. European strategy on invasive alien species. Nature and Environment, **137**, 67, **2004**.
28. KOLAR C.S., LODGE D.M. Progress in invasion biology: predicting invaders. Trends Ecol. Evolut., **16**, 199, **2001**.