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Ecological and sociological spectrum of *Ostericum palustre* at new localities in central Poland

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Abstract: The paper presents new data on the distribution of *Ostericum palustre* (a strictly protected vulnerable species) in central Poland. In the period of 2008-2009, new population of this species were found in the north-eastern part of Łódź Province. *Ostericum palustre* was present in the described localities in meadow, herb, peat bog and reed bed communities. The species was most numerous in well preserved purple moor-grass meadows. New localities of *Ostericum palustre* described in the article are instrumental in the protection of this species in central Poland.

Keywords: protected species, threatened plants, non-forest communities, Habitats Directive

1. Introduction

Ostericum palustre Besser (*Angelica palustris* (Besser) Hofm.) is an endangered species not only in Poland but also in Europe and therefore it has been taken under strict protection (Regulation 2004). Most importantly however, it is the species of considerable importance in Europe and as such it is listed in Annex II and IV of the Habitats Directive (1992). It is also one of the key taxa taken into account for determining Natura 2000 areas (Załuski 2004). It is also protected under the Bern Convention (Convention 1979). In Poland the species is considered vulnerable (V) (Zarzycki & Szeląg 2006). *Ostericum palustre* has also been included in the numerous local lists of endangered species (Kucharczyk & Wójciak 1995; Rutkowski 1997; Głowacki *et al*. 2003; Kucharczyk & Szukałowicz 2003; Markowski & Buliński 2004; Jackowiak *et al*. 2007), and it has been listed as extinct (Ex) in the area of the former Kraków province (Zając & Zając 1998). In central Poland, *Ostericum palustre* has been classified as critically endangered – CR (Jakubowska-Gabara & Kucharski 1999).

Ostericum palustre is an Euroasian species (Meusel *et al*. 1978) with its western range limit in Poland. It is categorized as a subcontinental species with the oceanic amplitude of 3, which means that it occurs in areas with an oceanic climate, up to an extremely continental climate (Klotz *et al*. 2002). In Poland, most of *Ostericum palustre* localities are found in the centre – from Wielkopolska to the Lublin Highland – (Zając & Zając 2001; Czarna & Załuski 2001; Załuski 2004) (Fig. 1). The richest localities are those in Kujawy and Wielkopolska (Załuski 1995; Czarna 1999; Krasicka-Korczyńska 2008), and along the Bug River (Ćwikliński & Głowacki 2000). A few new localities have recently been found in the south-west of the Polish range (Bróż *et al*. 2002; Bróż & Podgórska 2006; Nobis *et al*. 2008; Nobis & Piwowarczyk 2008).

In central Poland, *Ostericum palustre* was listed in four localities in the Łódź Province and five localities in the west part of Mazovian Province (Zając & Zając 2001). The most numerous population of this species in the Łódź Province (approx. 350 individuals) was found in Bujały (Sadkowice commune) in the Rokitna Valley (Jakubowska-Gabara & Pisarek 1997). Other localities were found in the north-east part of the province – one locality in Łowicz (DD39) (Fagasiewicz 1984), and the other ones in the Bolimów Forest (ED40, ED41). Pisarek (1984, 1989) listed the species in three glades in Bolimów Forest – Siwica in Nieborów range, Strożyska in Mokra Prawa range and Ruda range. Additionally, *Ostericum palustre* was found in three other localities in the area of the "Polana Siwica" nature reserve and in the north-west part of the Bolimów Landscape

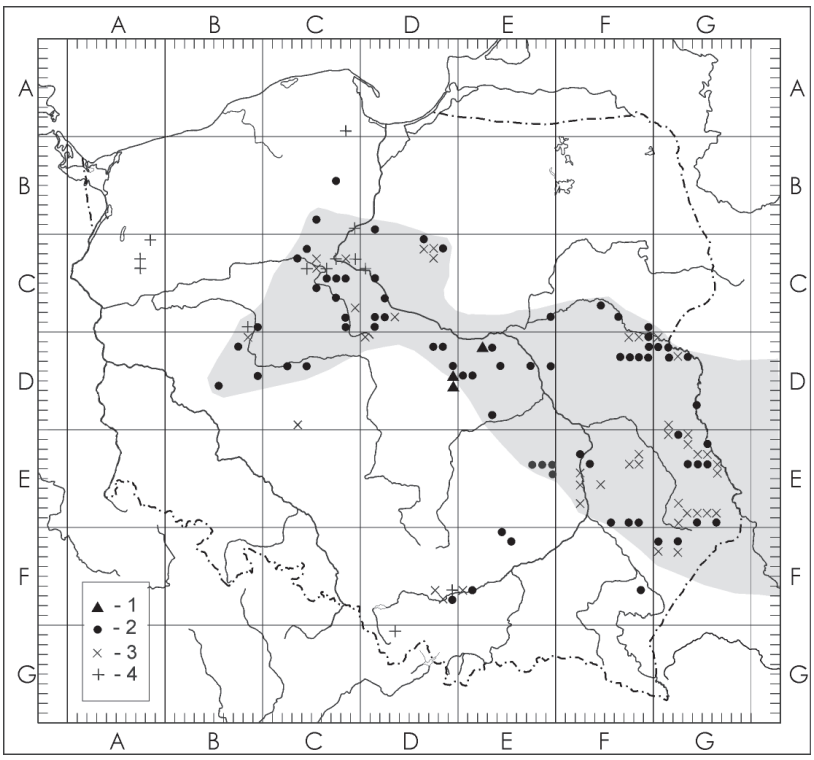

Fig. 1. Distribution of *Ostericum palustre* in Poland (after Nobis & Piwowarczyk 2008, supplemented)
Explanations: 1 – new localities found by the authors, 2 – presently existing localities noted after 1990, 3 – localities not confirmed, noted in the period 1951-1990, 4 – localities probably extinct, noted untill 1950

Park in the vicinity of Zygmuntów village (Jakubowska-Gabara *et al*. 2003). The localities outside of Łódź Province, on the south-west bank of the Vistula River, are those now located in Warsaw (Służew, Wilanów, Wolica – ED37 – Sudnik-Wójcikowska 1987), and those listed by Głowacki as yet unpublished (Zając A. oral information): Brwinów (ED34), Helenów (DD17) and Łuszczyn in Pacyna commune (DD18), north-east from Żychlin in the Przysowa River valley and Korfowe (ED13) in the Kampinos Forest, listed in 1990. Special attention should be given to the locality in the Kampinos Forest because the information was not published by Głowacki in any of his later works concerning precious plant species of this region (Figat *et al*. 1995; Głowacki & Ferchmin 2003). The first published information on the occurrence of *Ostericum palustre* in the Kampinos Forest was that by Kącki and Michalska-Hejduk (2008).

The aim of this research was to obtain a more comprehensive knowledge about the distribution and habitat preferences of *Ostericum palustre* in central Poland.

2. Materials and methods

A total of 17 phytosociological relevés were recorded, using the Braun-Blanquet method, in *Ostericum palustre* localities.

Phytosociological relevés data were used to calculate the Shannon diversity index (*H'*) (Odum 1982) according to the following formula:

$$H' = -\sum_{i=1}^{s}(p_i \ln p_i)$$

p_i – relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community
S = the number of species (species richness)

In addition, a vegetation cover index (*Wp*) was calculated according to the formula by Pawłowski (1977):

$$Wp = \frac{\sum \overline{pp}}{n}$$

where: *pp* – average percentage cover for a given species (the following values were adopted for individual cover indices: 5 – 87.5; 4 – 62.5; 3 – 37.5; 2 – 17.5; 1 – 5; + – 0.5*); *n* – the total number of relevés in a table.
* – for a cover value +, a value of 0.5 was adopted (instead of a value of 0.1 adopted by most of the authors) to give greater importance to accidental species that often play an important role in the communities examined.

For each of the communities, a weighted average of ecological indicators was calculated (Zarzycki *et al*. 2002): moisture – W (1 – very dry soils and 6 – aquatic environment), light – L (1 – deep shade and 5 – full light), soil acidity – R (1 – strongly acidic soils of pH<4 and 5 – alkaline soils of pH>7) and organic matter concentration – H (1 – humus-poor soils and 3 – humus-rich soils). Calculations were made allowing for individual cover indices of all species in individual phytosociological relevés. If there was more than a single

value of a given indicator, a weighted average was adopted (Roo-Zielińska 2004).

Mowing tolerance was determined with the help of the BIOLFLOR database (Klotz *et al*. 2002). The mean values obtained were used to compare samples in terms of land management practice and disturbance. Level of mowing tolerance was recorded using the following scale: 1 to 3 – intolerant or sensitive; 4 to 5 – sensitive to moderately tolerant; 6 to 7 – moderately tolerant to fully tolerant; 8 to 9 – fully tolerant to exceptionally tolerant.

Moreover, available phytosociological relevé data from additional regions of Poland were used to compare *Ostericum palustre* habitat preferences. They included the data from Iłża Foreland (11 records) (Bróż & Podgórska 2006; Nobis & Piwowarczyk 2008) and from the southern part of Poland: in the vicinity of Kraków (4 records) and of Przeworsk (4 records) (Nobis *et al*. 2008). The obtained results were then analysed by the Kruskal-Wallis test and modified Tukey's test for a non-parametric analysis were used as post-hoc tests to compare the values of individual floristic indices between four different geographical regions.

The names of the species were given after Mirek *et al*. (2002) and their phytosociological affiliations after Matuszkiewicz (2001).

3. Results

New localities of *Ostericum palustre* in central Poland were observed on the Łowicz-Błonie Plain to the north-west of Skierniewice – in the Ruczaj watercourse valley, in the meadows of the Baranice village and in the Kampinos Forest – in the meadows by Olszowiecki Channel (Fig. 2, Table 1). Populations of *Ostericum*

Table 1. Locality of phytosociological records

No of record	Locality	North latitude	East longitude	No of ATPOL square 1km x 1km
1	Granica	52.2825	20.4465	ED1278
2	Granica	52.2823	20.4462	ED1278
3	Granica	52.2809	20.4493	ED1278
4	Granica	52.2795	20.4580	ED1278
5	Granica	52.2809	20.4493	ED1278
6	Granica	52.2791	20.4554	ED1278
7	Parma	52.0417	19.9975	DD4923
8	Granica	52.2807	20.4499	ED1381
9	Granica	52.2821	20.4482	ED1381
10	Granica	52.2825	20.4465	ED1381
11	Lasocin	52.2898	20.3704	ED1264
12	Parma	52.0411	19.9853	DD4923
13	Parma	52.0411	19.9853	DD4923
14	Pszczonów	51.9633	19.9307	DD5912
15	Pszczonów	51.9635	19.8493	DD5912
16	Lasocin	52.2938	20.3820	ED1264
17	Parma	52.0413	19.9936	DD4923

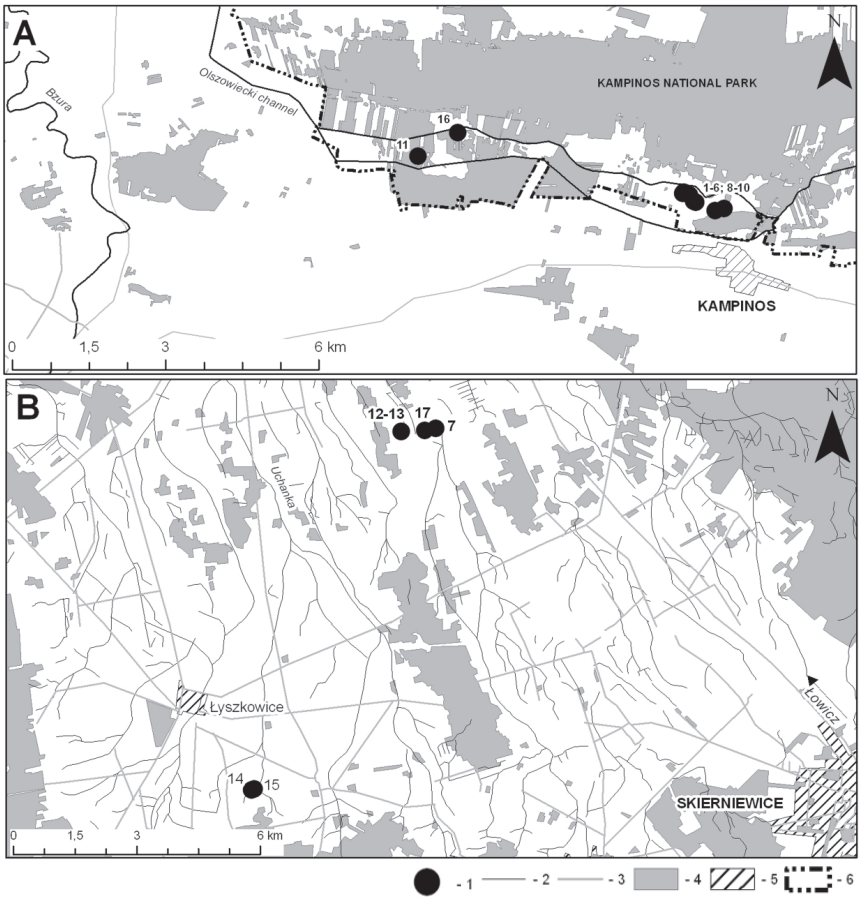

Fig. 2. Distribution of *Ostericum palustre* in new localities in central Poland
Explanations: 1 – new localities, 2 – rivers, streams, ditches, 3 – roads, 4 – forests, 5 – towns, 6 – borders of the Kampinos National Park

Table 2. Communities with *Ostericum palustre* at new localities in Central Poland

No of relévés	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Syntaxonomical unit*	1	1	1	1	1	1	1	2	2	2	2	3	4	5	5	5	6
Date day	19	17	16	16	16	16	24	16	19	19	10	24	6	24	24	10	24
month	7	7	7	7	7	7	7	7	7	7	7	7	9	7	7	7	7
year	09	09	09	09	09	09	09	09	09	09	09	08	08	08	08	08	08
Cover of shrub layer [%] b	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Cover of herb layer [c] in all relévés =100%																	
Cover of mosses layer [%] d **	10	-	30	-	-	40	20	-	10	-	-	-	-	-	-	-	-
Number species in relévé	27	35	34	35	26	23	37	34	32	24	36	32	18	20	16	23	30
Ch., D. All. *Molinion*																	
Ophioglossum vulgatum	1	1	1	1	1	.	.	1	+	.	+	1	.	.	.	.	.
Molinia caerulea	2	2	1	.	3	.	.	1	1	+	1	.	.	.	.	.	.
Succisa pratensis	.	1	1	2	.	3	.	+	+	.	.	.	.	.	.	.	.
Briza media	1	1	2	1	.	.	1	1	.	.	.	.	.	.	.	.	.
Salix rosmarinifolia c	.	1	.	.	1	.	.	4	5	5	3	.	.	.	.	.	.
Potentilla erecta	1	1	.	3	.	.	1	+	.	.	.	.	.	.	.	.	.
Selinum carvifolium	4	.	.	.	.	.	3	.	.	.	1	.	.	.	.	2	.
Dianthus superbus	2	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex glauca	.	.	.	+	.	.	.	.	.	.	1	.	.	.	.	.	.
Carex panicea	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.
Linum catharticum	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ch. All. *Filipendulion*																	
Lythrum salicaria	1	.	1	1	1	.	1	1	1	1	.	1	.	1	1	1	1
Valeriana officinalis	1	.	.	1	.	1	+	1	1	1	1	2	.	1	.	.	1
Lysimachia vulgaris	.	+	.	1	1	.	2	1	1	.	.	.	.	3	+	.	2
Filipendula ulmaria	1	1	.	.	.	.	.	2	1	1	1	.	2	.	.	2	+
Hypericum tetrapterum	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Ch. O. *Molinietalia*																	
Ostericum palustre	2	2	3	1	1	1	1	1	+	1	1	1	1	1	1	1	2
Galium uliginosum	1	2	1	+	1	1	1	1	1	.	.	1	.	1	1	1	1
Deschampsia caesptitosa	1	1	.	1	2	1	1	1	1	+	1	1	2	.	.	.	1
Cirsium palustre	1	1	1	2	1	1	1	1	+	1	.	.	.	.	.	1	2
Geum rivale	.	1	.	1	.	2	1	3	1	1	.	.	.	.	.	3	.
Lychnis flos-cuculi	1	1	1	1	.	1	1	1	+	1	1	.	.	.	.	1	+
Equiseum palustre	.	.	.	.	.	1	2	.	.	.	.	.	.	1	.	.	1
Caltha palustris	.	.	.	+	.	+	.	.	.	.	.	.	.	1	1	.	.
Lotus uliginosus	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Myosotis palustris	.	.	.	+	.	.	.	.	1	1	.	.	.	.	.	.	.
Angelica sylvestris	.	.	.	.	.	.	.	.	.	.	.	1	.	1	+	.	.
Juncus effussus	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
Sanguisorba officinalis	.	.	.	.	.	.	+	.	.	.	.	.	1	.	.	.	+
Cirsium oleraceum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.
Lotus corniculatus	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Ch. Cl. *Molinio-Arrhenatheretea*																	
Festuca rubra	2	2	2	.	.	2	2	2	1	2	2	2	3	.	.	.	1
Festuca pratensis	1	2	3	2	2	2	.	1	1	.	1	.	1	.	.	1	1
Poa pratensis	1	1	1	1	2	.	1	1	1	1	1	.	.	.	.	1	1
Holcus lanatus	.	1	1	1	.	2	2	1	.	.	1	2	1	.	.	.	1
Ranunculus acris	1	1	2	.	1	1	1	1	+	1	1	.	1	.	.	.	1
Achillea millefolium	+	0	2	1	.	1	1	1	1	.	.	1	1	.	.	1	1
Rumex acetosa	1	1	1	.	.	.	1	.	.	1	.	1	1	.	.	.	1
Potentilla anserina	.	1	.	1	.	.	1	.	.	.	1	1	.	.	.	2	.
Ranunculus repens	.	.	.	.	1	.	1	.	+	.	.	1	1	1	.	.	1
Plantago lanceolata	.	.	.	.	.	2	.	+	.	+	1	.	2	.	.	.	.
Agrostis stolonifera	.	.	.	.	1	.	1	1	.	.	.	.	.	.	.	.	1
Prunella vulgaris	1	1	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.
Cerastium holosteoides	.	1	+	1	.	.	.	.	.	.	+	.	+	.	.	.	.
Arrhenatherum elatior	.	.	.	1	.	.	.	+	.	.	1	1	.	.	.	.	.
Centaurea jacea	+	.	1	1	.	.	.	.	.	.	.	1	.	.	.	.	.
Trifolium pratense	.	1	+	1	.	.	.	+	.	.	.	.	.	.	.	.	.
Vicia cracca	.	.	.	.	.	.	.	.	.	.	1	.	1	1	.	.	.
Phleum pratense	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.
Carex hirta	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.
Agrostis gigantea	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.
Ch. Cl. *Phragmitetea*																	
Carex acutiformis	2	1	.	.	2	.	.	2	2	2	.	.	.	3	4	3	.
Equiseum fluviatile	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	1
Phragmites australis	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.

Peucedanum palustre	.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.
Galium palustre	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	.
Ch. Cl. *Scheuchzerio-Caricetea nigrae*																	
Carex nigra	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
Viola palustris	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1
Carex flava	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Epipactis palustris	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Comarum palustre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
Ch. Cl. *Alnetea glutinosae*																	
Lycopus europaeus	.	+	1	.	1	.	.	1	1	1	.	.	.	1	1	.	
Salix cinerea c	.	1	1	.	2	.	.	1	+	+	.	.	.	.	.	.	
b	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	
Others																	
Galium verum	1	2	1	2	2	3	.	2	1	1	1	1	.	.	.	2	1
Mentha arvensis	+	1	1	.	1	.	1	1	1	1	.	1	.	.	.	.	.
Eupatorium cannabinum	.	.	.	1	.	.	.	.	1	.	2	.	.	2	2	.	.
Veronica chamaedrys	.	.	1	1	.	.	1	.	.	.	1	1	1	.	.	.	.
Medicago lupulina	.	1	1	1	.	2	.	.	.	.	.	.	.	.	.	.	.
Glechoma hederacea	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	3	.
Cirsium arvense	.	.	1	.	.	.	.	.	+	.	.	1	.	1	1	.	.
Anthoxanthum odoratum	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	1
Epilobium palustre	.	.	.	.	.	.	1	.	.	.	.	+	.	.	.	.	1
Equisetum pratense	.	.	.	.	1	.	.	1	+	.	.	.	.	.	.	.	.
Plantago media	.	+	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Equisetum arvense	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.
Euphorbia amygdaloides	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.
Agrostis capilaris	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.
Frangula alnus c	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	+	.
Luzula multiflora	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.
Carex leporina	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.
Epilobium parviflorum	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Sporadic: Ch.O. *Molinietalia* – *Juncus conglomeratus* 7(1), *Lathyrus pratensis* 16(+), *Rhinantus angustifolia* 6 (2), *Stachys palustris* 16(1), *Trifolium hybridum* 3(1); **Ch.Cl. *Molinio-Arrhenatheretea*** – *Avenula pubescens* 4(1), *Bromus hordeaceus* 7(+), *Galium mollugo* 11(1), *Inula britanica* 2(+), *Leucanthemum vulare* 3(1), *Mentha longifolia* 14(2), *Potentilla reptans* 11(+), *Rumex crispus* 12(1); **Ch.Cl. *Phragmitetea*** – *Carex appropinquata* 15(1), *Carex rostrata* 17(1), *Poa palustris* 16(+), *Scutellaria galericulata* 5(1); **Ch.Cl. *Scheuchzerio-Caricetea*** – *Juncus articulatus* 5(+), *Stellaria palustris* 10(+); **Ch.Cl. *Alnetea glutinosae*** – *Alnus glutinosa* c 10(1), *Calamagrostis canescens* 5(1), *Salix pentandra* 3(+); **Others** – *Dactylorhiza incarnata* 4(+), *Epilobium adenocaulon* 7(+), *Epilobium hirsutum* 14(1), *Epipactis helleborine* 11(+), *Euonymus europaea* c 11(1), *Fraxinus excelsior* c 10(+), *Galeopsis* sp. 12(+), *Galium aparine* 7(+), *Myosotis caespitosa* 12(1), *Plantago pauciflora* 8(+), *Polygala vulgaris* 11(+), *Polygonum amphibium* 15(+), *Rhamnus catharticus* c 16(+), *Senecio paludosus* 4(+), *Symphytum officinale* 9(1)

Explanations: * – Syntaxonomical units, 1 (reléves 1-7) – *Molinieum caeruleae*, 2 (reléves 8-11) – *Molinion*/*Filipendulion* with *Salix rosmarinifolia,* 3 (reléve 12) – *Filipendulion,* 4 (reléve 13) – community of *Molinio-Arrhenetheretea,* 5 (reléves 14-16) *Caricetum acutiformis*, 6 (reléve 17) – community with *Comarum palustre* of *Scheuchzerio-Caricetea*; ** – species of bryophytes were not included in the phytosociological table, whereas the coverage of „d" layer was given

palustre Besser were mostly found in *Molinietum caeruleae* purple moor-grass meadows (Table 2, Relevés 1-7), also in those clearly turning into willow thickets (Table 2, relevés 8-11) and those in which herb community of the *Filipendulion* alliance was formed (Table 2, relevé 12). In one case – relevé 13 – it was a meadow plot representing depleted community of the *Molinio-Arrhenetheretea* class. *Ostericum palustre* was also found in *Carex* reed beds – in *Caricetum acutiformis* ass. (Table 2, relevés 14-16) and in the *Comarum*

Table 3. Biodiversity and ecological indicators

No of record	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Number of species	27	35	34	35	26	23	37	34	32	24	36	32	18	20	16	23	30
Shannon index (H')	2.7	3.3	3.1	3.2	2.9	2.7	3.2	2.9	2.5	2.3	3.2	3.2	2.6	2.6	2.0	2.6	2.9
Moisture inicator (W)	4.0	4.1	4.1	4.1	4.0	4.1	4.0	3.9	3.9	3.9	3.8	4.1	3.9	3.9	3.8	3.8	4.0
Light indicator (L)	3.7	3.7	3.5	3.5	4.0	3.4	3.8	3.8	4.0	4.0	3.5	3.5	3.4	4.3	4.5	3.8	4.0
Trophy indicator (T)	3.5	3.5	3.6	3.5	3.6	3.5	3.4	3.5	3.6	3.6	3.6	3.6	3.6	3.8	3.8	3.6	3.3
Soil reaction indicator (R)	4.0	4.0	3.9	4.0	3.9	4.0	3.9	4.0	3.9	4.0	4.1	4.0	3.9	4.2	4.1	4.1	3.7
Tolerance to mowing	4.7	5.4	5.1	4.7	5.0	5.3	5.2	5.1	4.7	5.2	5.7	5.8	6.1	4.3	4.3	5.0	4.8

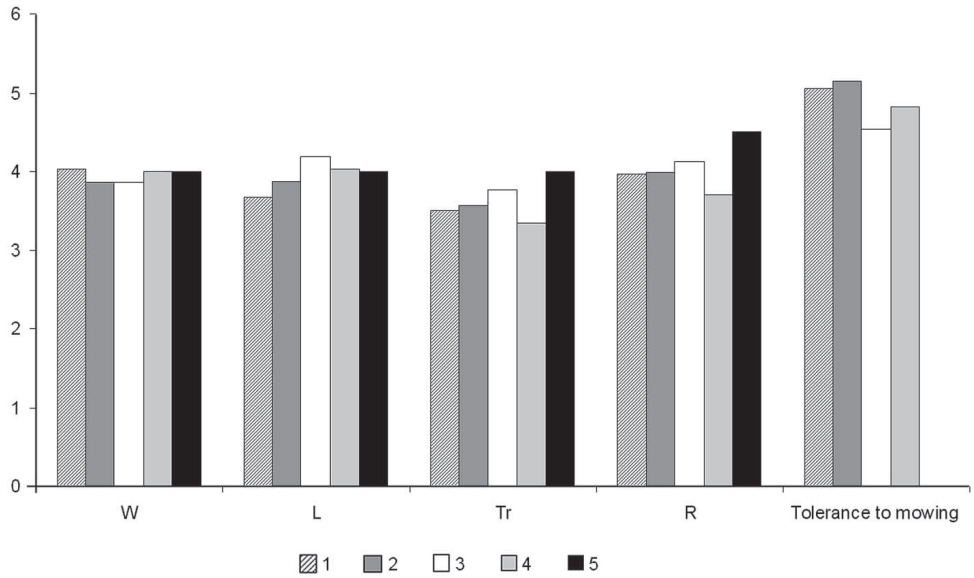

Fig. 3. Ecological indicator values of *Ostericum palustre* at the background of main communities with this species
Explanations: 1 – *Molinietum caeruleae*, 2 – *Molinion/Filipendulion* communities, 3 – *Magnocaricion* communities, 4 – *Scheuchzerio-Caricetea nigrae* communities, 5 – value of *Ostericum palustre*

palustre community of *Scheuchzerio-Caricetea nigrae* class (Table 2, relevé 17).

Phytocoenoses with *Ostericum palustre* were diverse in terms of floristic richness – the number of species in meadow and herb plots was high and ranged from 23 to 37, and was significantly lower in *Carex* reed beds, where 16 to 23 taxa were recorded. *Molinietum caeruleae* had the highest biological diversity expressed by the Shannon index, with the index being higher than 3 (Table 3).

Phytocoenoses with *Ostericum palustre* were characterized by similar moisture values (W ranged from 3.8 to 4.1), with other indices being slightly different (Table 3, Fig. 3). Considerable differences were noted in the case of phytocoenoses with *Ostericum palustre* in terms of mowing tolerance (4.2 to 6.1): from sensitive to moderately tolerant (Table 3). *Carex* reed beds phytocoenoses were characterised by a very low index.

4. Discussion

In the new localities that have been described in this article, *Ostericum palustre* was observed mainly in *Molinietum caeruleae* phytocoenoses and herb communities belonging to *Filipendulion*. The species is characteristic for *Molinietalia* damp meadows according to Matuszkiewicz (2001). According to many authors (Grynia 1962; Kępczyński & Załuski 1991; Nobis & Piwowarczyk 2008) it is most frequently found in extensively used meadows belonging to *Molinion*, *Selino-Molinietum caeruleae* (*Molinietum caeruleae*) (Grynia 1962; Kępczyński & Załuski 1991) as well as *Angelico-Cirsietum oleracei* (Grynia 1962) or *Cirsietum*

Table 4. Mean values of ecological indicators in new localities of Central Poland and in other regions

Ecological indicator	Geographical locality				Test K-W (H)	p – value
	1	2	3	4		
W	3.96^{a}	$4.10^{a,b}$	3.92^{b}	4.01	8.345	0.04
L	3.80	3.94	3.82	3.92	2.468	ns
T	$3.56^{c,d}$	3.73^{c}	$3.82^{d,e}$	3.65^{e}	16.211	0.001
R	$3.98^{f,g,h}$	4.09^{f}	4.14^{g}	4.09^{h}	12.387	0.006
mowing tolerence	5.08	5.30	5.78	5.06	5.423	ns

Explanations: Values followed by the same letter are statistically significant according to the Kruskal-Wallis Test, ns – not statistically significant , 1 – present research, 2 – Iłża Foreland (Bróż & Podgórska 2006; Nobis & Piwowarczyk 2008), 3 – vicinity of Kraków, 4 – vicinity of Przeworsk (Nobis *et al*. 2008)

rivularis (Bróż & Podgórska 2006) phytocoenoses belonging to *Cathion* alliance. Only some of the authors report its occurrence in herb communities, such as: *Filipendulo-Menthetum longifoliae* (Bróż & Podgórska 2006) and *Filipendulo-Geranietum* (Załuski 2004 after Głoćko 1981) and Kucharczyk (unpub. data). The spectrum of the occurrence of this species is however much larger, because it is occasionally found in fresh meadows and pastures – in *Lolio-Cynosuretum*, *Potentillo-Festucetum arundinaceae* (Sudnik-Wójcikowska 1981) and *Poa pratensis-Festuca rubra* ass. (Krasicka-Korczyńska 2007, 2008) or even in *Ribeso nigri-Alnetum* (Fijałkowski 1994). Many authors, similarly like the authors of this article, found *Ostericum palustre* in phytocoenoses of the *Phragmitetea* and *Scheuchzerio-Caricetea nigrae* classes (Nobis & Piwowarczyk 2008). Most often, they were *Carex* reed beds – (*Caricetum acutiformis*, *C. gracilis*, *C. distichae*) and communities with *Carex nigra* (Krasicka-Korczyńska 2007, 2008), *C. acutiformis*, *C. ripariae*, *C. appropinquatea* (Fijałkowski & Chojnacka-Fijałkowska 1982; Bróż *et al.* 2002), *C. buxbaumi*, *C. distichae*, *C. davallianae* and *Schoenetum ferruginei* (Nobis & Nobis 2009).

When the localities described in this article and in literature on the subject are compared, the localities described in this article may be considered floristically fairly rich. The average number of species per relevé is 28, while in the Iłża Foreland, the average is 25 (Bróż & Podgórska 2006; Nobis & Piwowarczyk 2008), in the vicinity of Kraków – 37, and in the vicinity of Przeworsk even 45 (Nobis *et al.* 2008).

Phytocoenoses under examination had similar values of light and mowing tolerance index, comparing to other regions of Poland (Bróż & Podgórska 2006; Nobis & Piwowarczyk 2008; Nobis *et al.* 2008). On the other hand, statistically significant variations occur in relation to soil moisture, trophic conditions and soil acidity. The differences in acidity are particularly distinct. According to this indicator, the examined phytocoenoses, are statistically significantly more acidic compared to others (Table 4). This fact is worth mentioning because *Ostericum palustre* prefers neutral to slightly alkaline soils (R for this species is 4-5, Zarzycki *et al.* 2002). In the region described in the present article, *Ostericum palustre* was found also in *Caricion nigrae* phytocoenosis with *Comarum palustre*, characterized by the lowest index of acidity – 3.6 (Fig. 3).

The results obtained confirm that the Kampinos National Park is a particularly valuable refuge for this species. Along the Olszowiecki Channel, in the plots of well-preserved purple moor-grass meadows, *Ostericum palustre* is highly stable and dense. The growth of its local population is dynamic. It can be confirmed by the fact that during the previous studies carried out in purple moor-grass meadows, in the southern marsh strip of the Kampinos Forest, the species was not found (Michalska-Hejduk 2001a). No other similar species from the Apiaceae family were reported at that time either, which excludes the possibility that the author of the previous examination could have made a mistake.

It is also worth mentioning that in all of the described localities, *Ostericum palustre* is numerous and its local populations are not endangered. Detailed studies must be carried out into the distribution of the species in the vicinity of the Kampinos and Bolimów Forests. In our opinion, the species probably occurs in numerous, still not described, localities in this part of the Łódź and Mazovia Provinces. It is also important to define ecological requirements for this endangered species in the near future, in order to ensure it is effectively protected. It is of utmost importance because, as the results of this study showed, *Ostericum palustre* is found in the plots where weighted average for mowing tolerance index is 5, which means that these phytocoenoses are tolerant of moderate mowing. Yet, the meadows included in agro-environmental programmes, also those belonging to *Ostericum palustre*, are often mowed twice. This is the case for example with the Bydgoski Channel, where, as the studies show (Krasicka-Korczyńska 2007, 2008), *Ostericum palustre* occurs less frequently than in the meadows mowed in accordance with standard management. In the opinion of Krasicka-Korczyńska (2008), postponing – from May until mid June – of the first mowing in the meadows covered by the programs, results in mowing of individuals at the peak of their generative growth stage, which prevents the seeds from maturing. Mowing carried out in May precedes vegetative growth and allows a plant to flower and produce mature fruits before the second mowing. This problem has not been observed in purple moor-grass meadows that are mowed only once, late in the summer. This is the case in the Kampinos National Park, where *Ostericum palustre* occurs in the actively protected purple moor-grass meadows (Michalska-Hejduk 2001b). However, it is in those plots that the abundance of the species is the highest (Table 2, relevés 1-3).

5. Conclusions

- *Ostericum palustre* was present in the described localities in meadow, herb, peat bog and reed bed communities.
- The species was most numerous in well preserved purple moor-grass meadows.
- The localities are floristically rich compared with other localities found in different parts of Poland.
- In all of the described localities, *Ostericum palustre* occurs numerously and is healthy.

- According to the authors, new localities of *Ostericum palustre* described in the article are crucial for the protection of this species in central Poland.
- Further studies are needed both on the distribution of the species in the area adjacent to the Kampinos and Bolimów Forests and on its ecological requirements, with special attention paid to the effect of mowing on its condition.

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