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Beata Węgrzynek, Teresa Nowak

Department of Plant Systematics, University of Silesia, Jagiellońska 28,
40-032 Katowice, beata.wegrzynek@us.edu.pl; teresa.nowak@us.edu.pl

RARE AND ENDANGERED SEGETAL WEED SPECIES IN THE SILESIAN UPLAND (S POLAND) RECORDED IN THE LAST TWENTY YEARS

ABSTRACT

The paper presents a list of the rarest endangered segetal weeds recorded in the Silesian Upland during the previous two decades (1989-2009) with threat categories as well as their distribution concentration map. In the area researched, fifty red-listed taxa (i.e. species, subspecies, and forma) considered to be endangered on a regional and/or national scale were recorded. Thirty-five of them constitute the group of the rarest species (up to 20 localities in the studied area). *Lythrum hyssopifolia* (included in the Polish Red Data Book of Plants), *Adonis aestivalis, Anagallis foemina, A. arvensis fo. azurea, Filago arvensis, Fumaria parviflora, F. rostellata, F. schleicheri, Kickxia elatine, Misopates orontium, Saxifraga tridacylites* are among the most interesting segetal weed species noted in the study area. Archaeophytes are the most dominant; however, there is also a remarkable group of apophytes. One species, i.e. *Portulaca oleracea* is a kenophyte, while *Fumaria parviflora* has the status of an ephemerophyte in Polish flora. In the northern part of the Silesian Upland (mesoregions the Tarnowskie Góry Ridge and the Chełm) and in the north-eastern part (the Jaworzno Hills) the concentration of the analyzed species localities corresponds to the presence of calcium-rich rendzina soils as well as to the traditional agricultural methods still commonly applied in that area. a decrease in the number of stands of a vast majority of calcicolous weeds including the character species of the *Caucalidion lappulae* alliance was observed. Moreover, the analysis of relationship between some environmental factors and the endangered species by using CCA was tested.

Key words: apophytes, archaeophytes, endangered weeds, red-listed taxa, southern Poland, the Silesian Upland

INTRODUCTION

The problem of changes in the segetal flora composition under modern agricultural methods has attracted the interest of many authors (e.g. Kornaś 1987a, b; Wnuk 1989; Warcholińska 1998). Weeds connected with extreme habitats are especially threatened with extinction – those growing in calcium compounds (rendzina soil) as well as those occurring on the most infertile acidous sandy soils. A decreasing number of localities of weeds is interrelated with traditional agriculture methods (e.g. species vulnerable to herbicides, obligatory speirochor-

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ic species) has also been observed (e.g. Kornaś 1987a, b; Siciński 1998; Warcholińska 1998). It has been widely discussed that the extinction of some segetal flora elements impoverishes local biodiversity at different organizational levels. As numerous weeds are source of food for many animals species, the declines in populations of insects and birds were assessed in relation to changing in arable field flora composition (e.g. Siciński 1998; Robinson *et al.* 2001; Robinson, Sutherland 2002).

The main aim of the paper is to present an overview of the number of localities and a concentration map of the distribution of the rarest, most interesting and threatened segetal weed species recorded during the last twenty years in the Silesian Upland. Moreover, the second subject was an assessment of the relationships between chosen environmental factors and listed weed species.

MATERIAL AND METHODS

The Silesian Upland is a macro-region located in southern Poland. It occupies an area of approximately 4000 square kilometers. According to the division of Poland into physical-geographical regions the Silesian Upland consists of the following subregions (mesoregions): the Chełm, the Tarnowskie Góry Ridge, the Katowice Upland, the Jaworzno Hills and the Rybnik Plateau (Kondracki 1994). The Carboniferous formations, which form the basic geological structure of the region, are covered with Triassic and Jurassic deposits in the northern and eastern part of the region (Gilewska 1972; Kondracki 1994).

The study area was divided into 1172 basic squares of 2 × 2 km according to the ATPOL grid square system (Zając 1978). At least one record of a particular taxon in the square was considered a locality.

This study focused on the occurrence of the rarest (up to twenty localities in the area investigated) and endangered weed species recorded in the years 1989-2009. During this period detailed floristic and phytosociological researches, including those concerning segetal weeds, were carried out. The floristic investigations by the cartogramme method in the Silesian Upland have been conducted since the late 1980th. The material for analysis (floristic data and seventy three phytosociological relevés by the method of Braun-Blanquet) has been taken from earlier published (Nowak, Węgrzynek 1998; Nowak 1999; Węgrzynek 2003a, b, c, 2005, 2006; Węgrzynek *et al.* 2007) and non-published work by the authors of the present article. Unpublished data obtained during the authors' own field investigations on segetal flora and vegetation carried out between 1989 and 2009 were also considered. Moreover, the available published and unpublished records of other authors were analysed (e.g. Sendek 1981, 1989, *and literature therein*, 1992; Urbisz An. 1996, *and literature therein*; Szotkowski 1998; Tokarska-Guzik 1999, *and literature therein*: Urbisz Al. 2001, *and literature therein*).

The selection of weed species was based on their presence on the list of threatened and endangered elements of segetal flora in Poland (Warcholińska 1998) and/or in the *Polish Red Data Book of Plants* (Kaźmierczakowa, Zarzycki 2001), the *Red List of Plants and Fungi in Poland* (Mirek *et al.* 2006), the regional list of protected, threatened and rare plants of Silesia Province (Parusel *et al.* 1996; Bernacki *et al.* 2000). A very rare ephemerophyte, i.e. *F. parviflora*, was also included in the list of distinguished species.

Plant names follow Mirek *et al.* (2002) and assignment to geographical-historical groups was in accordance with Zając (1979), Zając *et al.* (1992) and Mirek *et al.* (2002). Syntaxonomic classification of the selected species was given by Kornaś (1950) and Matuszkiewicz (2001).

The selected species are listed in Table 1. Categories of threat according to different authors and the number of localities recorded in the period of 1989-2009 are presented. As the floristic investigations by the cartogramme method in the Silesian Upland have been conducted only since the late 1980th, some data concerning the time before 1989 are not precise, only total stand numbers are given. Amongst the localities obtained from data collected in the years 1989-2009 those stations where species from arable fields were listed were taken into account. Moreover, a map of the concentration of the analysed species was prepared.

Canonical correspondence analysis (CCA; CANOCO 4.5 package; ter Braak, Šmilauer 2002) with soil type, pH, moisture degree, slope, exposition and cover of cultivated plants, total weed cover as constrained variables was used to assess habitat requirements of endangered species. For the purpose of this analysis data matrix of 73 phytosociological relevés with percentage cover was subjected. Since Braun-Blanquet scale is not appropriate for statistical treatment, cover values were transformed into medians of their percentage intervals i.e.: 0.1; 0.5; 17.5; 37,5; 62.5; 87.5. Monte Carlo test with 999 permutations was used to determine significance of relationship between cover of species and environmental variables.

RESULTS AND DISCUSSION

In the study area 51 taxa (species, subspecies, and form) of red-listed arable field weeds were recorded during the last twenty years (1989-2009). Thirty five of them constitute the group of the rarest weeds (Table 1).

Among the selected weeds archaeophytes prevail (twenty taxa), and thirteen species belong to apophytes. One species, i.e. *Portulaca oleracea* is a representative of kenophytes, while *Fumaria parviflora* has the status of an ephemerophyte in Polish flora.

Table 1

Category of threat and localities number of the rarest weeds recorded in the Silesian Upland within the last twenty years

L.p.	Specie name	Synanthropic status	Category of threat					Localities number
			1	2	3	4	5	
1	*Adonis aestivalis* L.	Arch	V	V		E	EN	2
2	*Anagallis arvensis* L. fo. *azurea* Hyl.	Arch	V					2
3	*A. foemina* Mill	Arch	V	V				1
4	*Arnoseris minima* (L.) Schweigg. & Körte	Ap				E	LR	12
5	*Cerinthe minor* L.	Ap	R				VU	4
6	*Chenopodium polyspermum* L.	Arch	I					19
7	*Equisetum telmateia* Ehrh.	Ap				V	LR	3
8	*Euphorbia exigua* L.	Arch	V					5
9	*Filago arvensis* L.	Ap	I					2
10	*Fumaria parviflora* Lam.	Ephem						1
11	*F. rostellata* Knaf.	Arch					EN	2
12	*F. schleicheri* Soy.-Will.	Arch	E					3
13	*F. vaillantii* Loisel.	Arch	V					11
14	*Holosteum umbellatum* L.	Ap	I					10
15	*Hypericum humifusum* L.	Ap	V					8
16	*Kickxia elatine* (L.) Dumort	Arch	V	E		V	EN	1
17	*Lythrum hyssopifolia* L.	Ap	V		LR	I	DD	1
18	*Melampyrum arvense* L.	Ap	V			R		10
19	*Melandrium noctiflorum* Fries	Arch	I					14
20	*Misopates orontium* (L.) Raf.	Arch	E			V	VU	1
21	*Myosotis discolor* Pers.	Ap				I	VU	2
22	*Nonea pulla* DC.	Ap	R			V	LR	4
23	*Odontites verna* (Bellardi) Dumort.	Arch	I					3
24	*Portulaca oleracea* L.	Ken	R					1
25	*Radiola linoides* Roth.	Ap	V				CE	6
26	*Saxifraga tridactylites* L.	Ap	R			R	VU	1
27	*Sherardia arvensis* L.	Arch	V					7
28	*Silene gallica* L.	Arch	V	V				1
29	*Stachys annua* L.	Arch	V					11
30	*Teesdalea nudicaulis* (L.) R. Br.	Ap				V		15
31	*Valerianella rimosa* Bastard	Arch	V					15
32	*V. dentata* (L.) Pollich	Arch	I					4
33	*V. locusta* (L.) Betcke	Arch	R	V				3
34	*Veronica opaca* Fries	Arch	V					4
35	*V. polita* Fries	Arch	I			V		1

Category of threat according to: 1 – list of threatened segetal vascular plants in Poland (Warcholińska 1998), E – critically endangered, V – vulnerable, R – rare, I – indeterminate category; 2 - Red list of plants and fungi in Poland (Mirek et al. eds. 2006), E – declining – critically endangered, V- vulnerable; 3 - Polish Red Data Book of Plants (Kaźmierczakowa & Zarzycki eds. 2001), LR – the lower risk category; 4 – Red list of Upper Silesian vascular plants (Parusel et al. eds 1996), E – critically endangered, V – vulnerable, R – rare, I – indeterminate category; 5 – Protected, threatened and rare plants in the flora of Silesia Province (Voivodship) (Bernacki et al. 2000), CE – critically endangered, EN – endangered, VU – vulnerable, LR – lower risk species, DD – data deficient

Archaeophytes occurring on arable fields comprise the most numerous group of perishing and endangered elements of Polish segetal flora (Wnuk 1989; Warcholińska 1998). However, some of them have been reported as very expansive and troublesome weeds. They are almost exclusively members of the *Poaceae* family, e.g. *Apera spica-venti, Avena fatua, A.* x*vilis, Echinochloa crus-galli, Setaria pumila, S. viridis* (Węgrzynek 2009, *and literature therein*). Grasses are widely known for their ability to spread and their persistence features, like their enormous ecological plasticity, including in the ease of creation of herbicide-resistant ecotypes (e.g. Borowiec *et al.* 1975; Gawroński 2002; Jędruszczak, Antoszek 2002; Rola, Rola 2002; Adamczewski, Matysiak 2007). All species selected as the rarest in the Silesian Upland are annual dicotyledones considered to be much more vulnerable to herbicides (Wnuk 1989, Siciński 1998).

The vast majority of distinguished weeds is characterised by a very narrow ecological tolerance scale (Zarzycki *et al.* 2002). Numerous calcicolous species were distinguished. Among this group there are both archaeophytes considered to be "traditional" weeds characteristic for the *Caucalido-Scandicetum* and the *Lathyro-Melandrietum* associations (Kornaś 1950; Anioł-Kwiatkowska 1988), like *Adonis aestivalis, Anagallis arvensis* fo. a*zurea, A. femina, Euphorbia exigua, Melandrium noctiflorum*, as well as xerothermic meadows native species like *Cerinthe minor, Nonea, Pula* or *Saxifraga tridactylites.* Some species representing this group, e.g. *Sherardia arvensis* and *Euphorbia exigua* were reported as common species in the northern part of the area researched until the 1970s (Kobierski 1974). Moreover, some very interesting *Caucalido-Scandicetum* species like: *Caucalis platycarpos, Conryngia orientalis, Vaccaria pyramidata,* which are currently extinct in the Silesian Upland, were reported in the area researched before 1945 (Sendek 1989). Calcicolous species, including segetal weeds, are considered to be one of the most endangered elements of Polish flora (e.g. Wnuk 1989; Siciński 1998; Warcholińska 1998; Kaźmierczakowa, Zarzycki 2001).

Arnoseris minima, Filago arvensis, Holosteum umbellatum, Myosotis discolor, Teesdalea nudicaulis represent another stentopic species group. They are apophytes connected with psammophilous grasslands, however *Arnoseris minima* is also regarded as a character species of the *Arnoserido-Scleranthetum* association (Kornaś 1950; Matuszkiewicz 2001). In turn, *Lythrum hyssopifolia, Hypericum humifusum, Radiola linoides* are species occurring in wet habitats, including wet fields and stubble fields (Matuszkiewicz 2001; Zarzycki *et al.* 2002). In accordance with the modern agriculture standards in the area studied, wet soils are often drainaged and arable fields are ploughed very quickly after the harvest.

The relatively high number of apophytes considered to be rare species in the area studied (Parusel *et al.* 1996; Bernacki *et al.* 2000) and listed as segetal

weeds in the Silesian Upland shows that arable fields can play the role of a refugium for some native species. In addition to the species mentioned above, *Equisetum telmateia*, which is protected by law belongs to this group. In the area the species has been reported from numerous (about 30%) anthropogenic stations (Stebel, Drobnik 2003).

The biggest decrease in number of localities was recorded for *Anagallis foemina* (14 localities before 1989 and only one confirmed in the last twenty years), *Sherardia arvensis* (112 before 1989, 12 after 1989, only seven on arable fields reported), *Euphorbia exigua* (55, 11 and 10 respectively). The number of localities of some species has increased. They are often noted in ruderal communities *Chenopodium polyspermum, Fumaria* and *Vailantii* in gardens, neglected cemeteries, parks, and in post-industrial and agricultural wastelands (*Equisetum telmateia* especially in railway areas and *Melampyrum arvense* on the mowed roadsides). There are also species that were not reported for the Silesian Upland before 1989, i.e. *Fumaria parviflora, F. rostellata and Veronica opaca*. Additionally, during the studies, the presence of three species (*Misopates orontium, Valerianella locusta, V. rimosa*) given by Sendek (1981) in the GOP was confirmed.

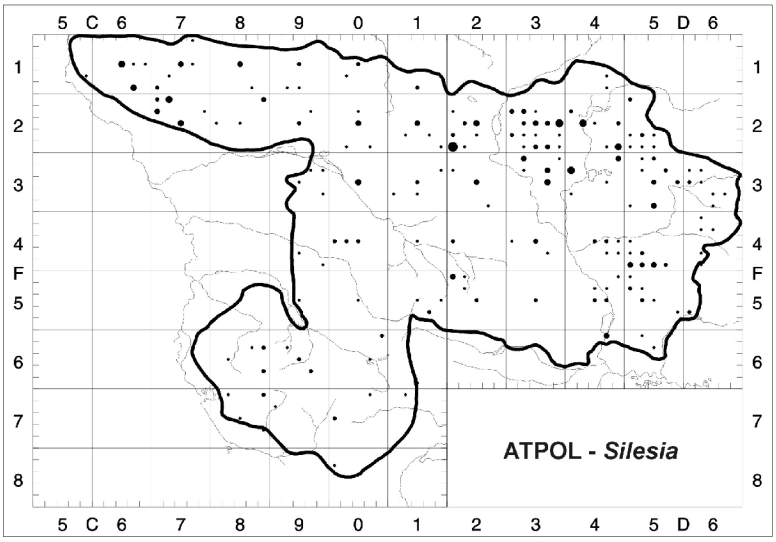

Fig. 1. Map of concentration of the rarest endangered weed species recorded in the period of 1989-2009 in the studied area

Localities of the rarest segetal weeds are concentrated in the northern part (the Chełm and the Tarnowskie Góry Ridge) as well as in the north-eastern part (the Jaworzno Hills) of the Silesian Upland (Fig. 1). This is correlated with their geomorphological structure (Gilewska 1972). Their characteristic feature is the presence of calcium-rich rendzina soils formed on Triassic deposits. Locally, infertile acid sandy soils have also been observed (Gilewska 1972). Moreover, the

northern part of the area studied is traditionally an agricultural region and more than 60% of the area is under agricultural management. Until 1945 the most interesting weed species were concentrated in its western part (the Chełm) (Sendek 1989). Nowadays, intensive modern agriculture methods are usually applied in the area, while in the Tarnowskie Góry Ridge and the Jaworzno Hills small farms with traditional and even ecological management prevail (Rocznik… Katowice 2007; Rocznik… Opole 2007).

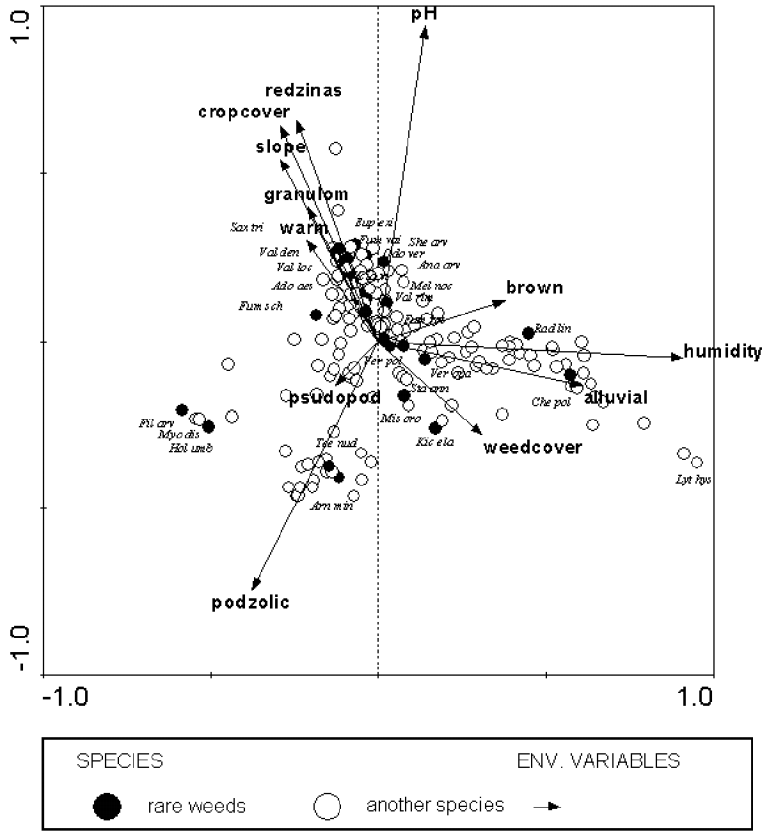

Fig. 2. Cannonical correspondence analysis (CCA) diagram of the endangered species in the studied area and environmental data. It presents the two first CCA axes which illustrate respectively 23.8 and 42.2% of cumulative variance of species-environment variation

The applied in ordination variables explain ca. 24% total vegetation variation. Among environmental variables only moisture, pH as well as cultivated plants and weeds cover were significant ($p<0.05$). Moisture degree explains 5.01%, pH – 4.2%, cultivated plant cover – 2.8% while weed cover – 1.9% of a general species variability. Fig. 2 shows the species ordination according to the two first axes of CCA. The first axis arranges the species in order of the moisture gradient, e.g. *Radiola linoides, Chenopdium polyspermum, Veronica opaca*. Along gradient of total weed cover *Kickxia elatine, Misopates orontium* are placed.

Species from genus *Valerianella, Sherardia arvensis, Melandrium noctiflorum, Anagallis arvensis* fo. *azurea* group parallelly to the second axis according to pH high value. These species also prefer slopes with S and SW exposition and they are connected with high cover of cultivated plants.

Changes in the composition of segetal flora appear to be very dynamic and multithreaded and their monitoring should be continued in the area researched. The decline of numerous weed species as well as the massive occurrance of other species have importance for functional biodiversity. The establishment of field flora reserves ("agro-reserves") in the areas where the most valuable segetal weed occur can be probably the last chance for preservation of these species *in situ*.

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