

## THE DISTRIBUTION AND HABITAT PREFERENCES OF THE DECLINING SPECIES *OROBANCHE ARENARIA* BORKH. AT THE NORTHERN LIMIT OF ITS GEOGRAPHICAL RANGE

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(Received: March 5, 2009. Accepted: January 11, 2010)

### ABSTRACT

Three new sites of *Orobanche arenaria* were discovered during floristic investigations in the Wyżyna Małopolska upland in central Poland. The new localities are concentrated in the Ponidzie area (Garb Pińczowski ridge and Niecka Połaniecka basin) and form the northern limit of the geographical range of *O. arenaria*. The paper presents information on the distribution of *Orobanche arenaria* in Poland, the abundance at the sites and habitats occupied by the species.

**KEY WORDS:** Orobanchaceae, *Orobanche arenaria*, distribution, habitat, Wyżyna Małopolska upland, Poland.

### INTRODUCTION

*Orobanche arenaria* Borkh., sand broomrape, belonging to the family Orobanchaceae, which contains holoparasitic plants lacking chlorophyll and growing on other vascular plants. The family Orobanchaceae comprises 15 genera with more than 220 species worldwide. *Orobanche* is the largest genus with about 170 species, most of which grow in the Mediterranean region (Uhlich et al. 1995). Sixteen species of the genus *Orobanche*, including two ephemero-phytes, are known in Poland (Mądalski 1967; Zajac and Zajac 2001; Rutkowski 2004; Halamski 2005). Nearly all central European *Orobanche* species are more or less seriously endangered (Kreutz 1995).

The broad range of the species comprises central, southern and eastern Europe, from Portugal, Spain, France, northern Italy, the Caucasus, Asia Minor, Iran to Central Asia. It is rarely observed in northern Europe, in NE France, NE Germany and in western and northern Poland. *Orobanche arenaria* has also been reported from northern Africa, Morocco, Algeria and Tunisia. The species probably originates from deserts of southern Russia (Beck 1930; Meusel et al. 1978; Kreutz 1995; Tzvelev 1981). It belongs to the Sub-Mediterranean-Euro-West-Asiatic element (Rothmaler et al. 2002). Polish localities of the species constitute the northern limit of its range.

As the occurrence of *O. arenaria* had not been confirmed at the majority of its localities in Poland and no new sites

had been reported. The species was classified as extinct (cat. Ex) in the red lists in Poland (Zarzycki and Szeląg 2006), likely to be extinct in the Sudetes (Fabiszewski and Kwiatkowski 2002), extinct (Ex) in Western Pomerania and Wielkopolska (Żukowski and Jackowiak 1995), vulnerable (V) in the Kujawsko-Pomorskie Voivodeship (Rutkowski 1997) and critically endangered (CR) in the Silesian Voivodeship (Kački et al. 2003). All species of the genus *Orobanche* are under protection in Poland.

### MORPHOLOGICAL CHARACTERISTICS AND TAXONOMIC NOTES

*Orobanche arenaria* Borkhausen, Neues Mag. Bot. (Roemer) 1:6, 1794.

Syn. *O. laevis* L., 1753; *O. comosa* Wallr., 1822; *O. borkhausenii* Andr. ex Besser, 1832; *O. abrotiva* Leyss. Sec. Reut.; *O. ionantha* A. Kerner, 1874; *O. robusta* Dietr., 1855; *Phelipaea arenaria* (Borkh.) Walp., 1844; *Ph. comosa* G. Don, 1838; *Ph. obtusiloba* Reut. ex Boiss.; *Phelipanche arenaria* (Borkh.) Pomel, 1874; *Ph. atlantica* Pomel, 1874; *Kopsia arenaria* Dum., 1822; *K. borkhausenii* Caruel in Parl.

*Orobanche arenaria*, *O. ramosa* L. and *O. purpurea* Jacq. represent the section *Trionychon* Wallr. in Poland. A different structure of the corolla and the calyx, especially the presence of two bracteoles by the calyx, the usually blue or

violet corolla, and carpological and karyological characteristics (Beck 1890, 1930; Gilli 1966a; Teryokhin et al. 1993; Holub 1977, 1990) distinguish the species within this section from those within section *Orobanche* L. (= *Osproleon* Wallr.), which comprises other native species. Some authors distinguish individual genera within the two sections (Soják 1972; Holub 1977, 1990; Teryokhin et al. 1993; Schneeweiss et al. 2004a, b). Lower taxa within *O. arenaria* species were described based on the density of the inflorescence and the length and colour of the corolla (Beck 1890, 1930; Gilli 1966b).

The species closest to *Orobanche arenaria* is *O. purpurea*, which differs from the former by the stem suffused with purple when fresh, smaller flowers, 18-25(-30) mm long, with anthers glabrous or very rarely hairy at top. The stem and elements of the inflorescence are more glandular-puberulent. Species of the genus *Achillea* are mostly host plants of *O. purpurea* (Beck 1930; Chater and Webb 1972; Kreutz 1995).

### BIOLOGY AND HABITAT CONDITIONS

*Orobanche arenaria* usually blooms from the end of May to July depending on the geographical location (Kreutz 1995). The blooming optimum occurs in the second half of June and at the beginning of July in Poland.

*Artemisia campestris* is the most frequent host plant of *Orobanche arenaria* in Europe (Beck 1890, 1930; Pusch and Barthel 1992; Uhlich et al. 1995; Kreutz 1995; Holub and Zázvorka 1999; Zázvorka 2000). In Poland the species was observed as a parasite on *Artemisia campestris* (Schube 1903; Muller 1911; Szcześniak 2003) or generally on species of the genus *Artemisia* (Mađalski 1967). Other hosts are also reported in the literature, e.g. *Artemisia arenaria*, *A. vulgaris*, *A. absinthium*, *A. crithmifolia*, *A. glutinosa*, *A. marschalliana* (Beck 1890, 1930; Novopokrovskij and Tzvelev 1958; Tzvelev 1981; Pujadas-Salva et al. 1994). The host status of the following plants is doubtful: *Anthemis cotula*, *Stachys recta*, *Eryngium maritimum*, *Phlomis nissolia*, *Andropogon gryllus*, *Salvia pratensis* (Beck 1930).

The altitudinal range of the species is up to 1850 m above sea level in France, up to 1410 m in Sweden, 500-2500 m in Turkey, 0-900 m in Italy, 5-1600 m in the Iberian Peninsula, 150-600 m in the Czech Republic (Meusel 1978; Pignatti 1982; Uhlich et al. 1995; Foley 2001; Zázvorka 2000).

*Orobanche arenaria* is a geophyte. It is usually reported from xerothermic grasslands, sands, steppes, grassy and rocky slopes, and coasts. The number of known localities of the species is very small and has been decreasing, e.g. 20-30 specimens were usually recorded in the Czech Republic and Slovakia (Holub and Zázvorka 1999). It prefers full light, the warmest and warm regions and microhabitats, less frequently temperate cold climatic conditions. It colonises dry, alkaline and sandy soils, poor in organic matter. It is reported from communities of the Festuco-Brometea class (Zarzycki et al. 2002). However, Oberdorfer (1994) described it as a species of the Sedo-Scleranthetea class and the Festuco-Brometea class. Rothmaler et al. (2002) recognized the species in a similar way, but also added scrub communities (Prunetalia). The species has also

been described from lower units of the Festuco-Brometea class (Astragalo-Stipion, Bromion, Festucion valesiacaе, Festucion vaginatae, Festucion rupicolaе, Cirsio-Brachypodion), from the Crataego-Prunetea class (Berberidion, Cotinon coggygriae) and Festuco-Sedetalia (Uhlich et al. 1995). Ellenberg (1979) places the species in the Sedo-Scleranthetea class. In the Czech Republic, the species was reported from Festucion valesiacaе, Helianthemo cani-Festucion pallentis, Potentillo arenariae-Festucion pallentis (of the Alysso-Festucion pallentis alliance) (Holub and Zázvorka 1999; Zázvorka 2000).

### THE OCCURENCE IN POLAND

*Orobanche arenaria* was reported from only 12 localities, mainly from Lower Silesia and Pomerania. The distribution of the localities is presented on a cartogram map in 10×10 km squares of the ATPOL grid (Zajac 1978) (Fig. 1). They are as follows:

1. Szczecin (Muller 1911), AB83; 2. Skłudzewo (Rutkowski 1995 npbl, ATPOL; Rutkowski 2004), CC28. 3. Włocławek (Mađalski 1967), DC73; 4. surroundings of an old distillery in Lubiąż, Wołów district (Schube 1903), BE25; 5. "Winna Mountain" hill near Lubiąż (Schube 1903), BE25; 6. Brodno, Środa Śląska district (Schube 1926), BE36; 7. Gliniany near Lubiąż (Szcześniak 2003), BE25; 8. Wrocław: Rędzin (Schube 1903), BE48; 9. a hill near Stary Dwór, Wołów district (Schube 1903), BE27; 10. Jańska Mountain (Patryja Mountain) near Piotrówek, Wrocław district (Schube 1903), BE77; 11. Bobrowniki, Nowa Sól district (Schube 1903), BD60; 12. St. Marcin mount south of Tarnów (Knapp 1872), EF77.

The majority of records go back to the beginning of the 20th century and have not been found since. A positive exception is the discovery of a new locality in a sand pit in Gliniany near Lubiąż which is the only site that has been confirmed. Three specimens were recorded in 2000, over ten in 2001 and no specimens were recorded in 2002 (Szcześniak 2003). Four specimens were recorded both in 2007 and 2008; however, only one specimen had a normally fully-developed inflorescence in 2008, whereas the others were variously damaged as a result of frost (Szcześniak verbal info).

### RESULTS

#### NEW LOCALITIES

The list of localities was provided vis-à-vis the network of ATPOL cartogram units of 2.5×2.5 km squares (Zajac 1978).

Three new localities of *Orobanche arenaria* were found in the Wyżyna Małopolska upland (Garb Pińczowski and Niecka Połaniecka mesoregions) during floristic investigations conducted in the period from 2006 to 2008 (Figs 1 and 2). A detailed list of species recorded at the localities is given in Table 1. Species characteristic of individual phytocoenoses at the localities and their percentage share are presented in Figure 3.

**Locality I.** Situated in the eastern part of the Garb Pińczowski ridge between the "Grodzisko" district in Pińczów

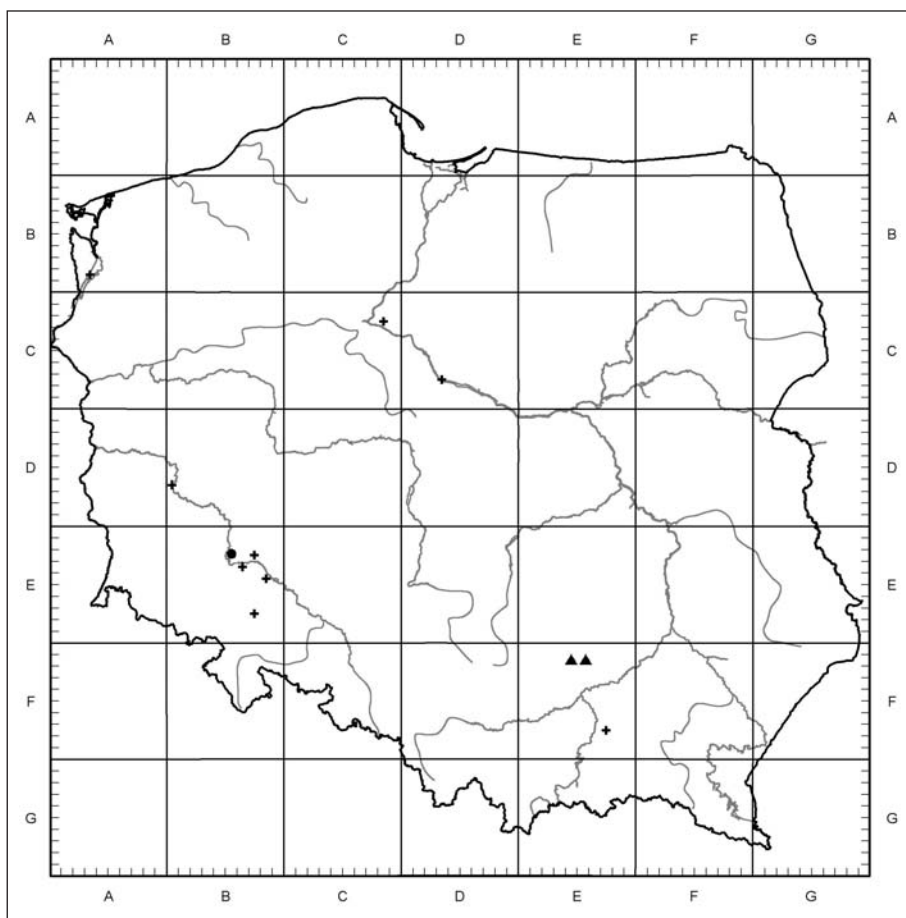


Fig. 1. Distribution of *Orobanchae arenaria* Borkh. in Poland (in the ATPOL grid, 10x10 km); [▲] – new localities, [●] – current localities, + – extinct localities.

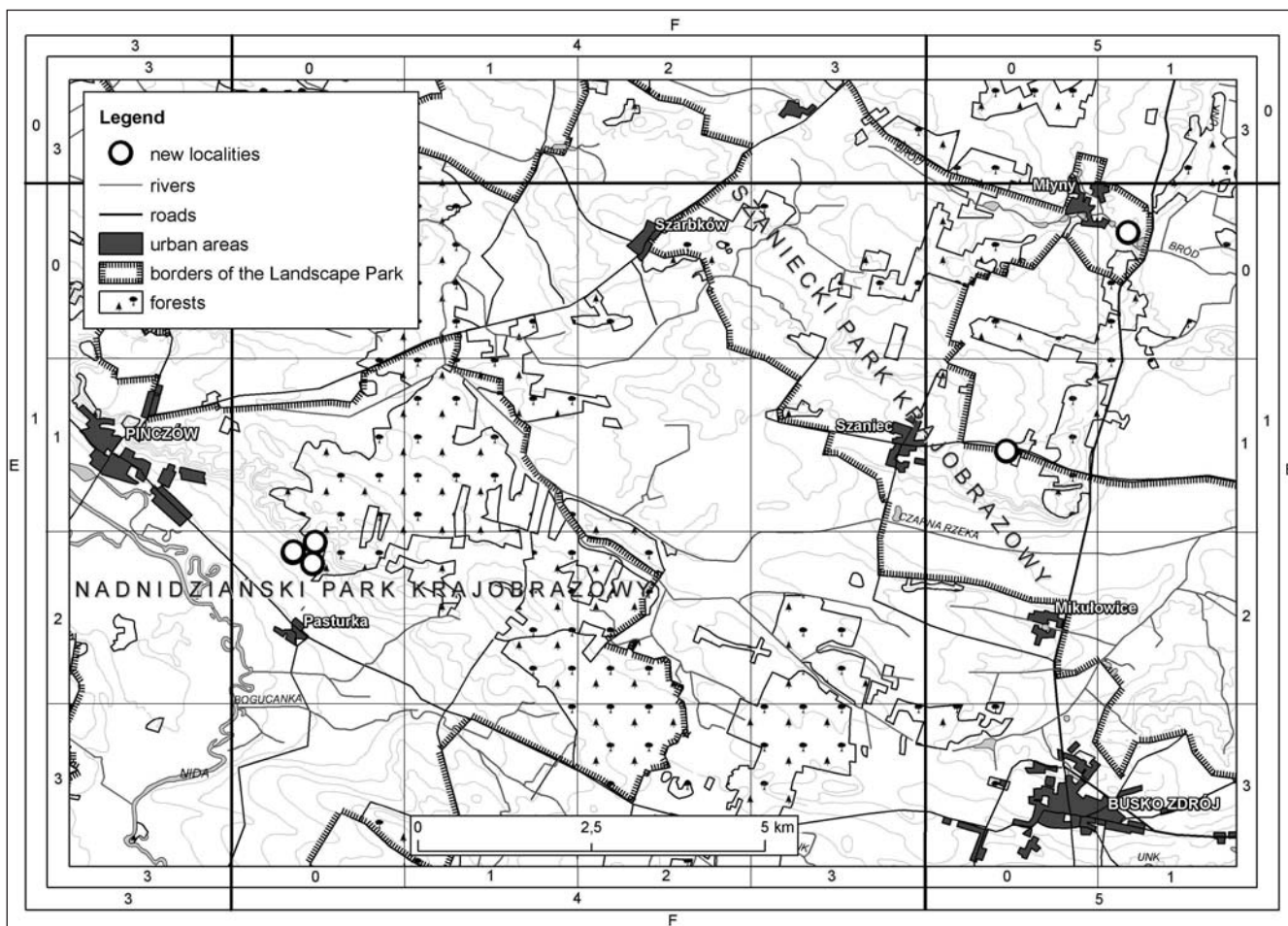


Fig. 2. New localities of *Orobanchae arenaria* Borkh. in the Ponidzie area.

TABLE 1. Plant communities with *Orobanchе arenaria* Borkh.

Number of relevé	1	2	3	4	5	6	7	
Location	Zwierzyniec	Mhyny	Pasturka 1a	Pasturka 1b	Pasturka 1c	Pasturka 1d	Pasturka 1e	
Date	05.07.06	05.07.06	25.06.07	25.06.07	25.06.07	15.07.08	15.07.08	
Area of relevé (m <sup>2</sup> )	100	90	100	100	100	100	100	C
Exposure	E	SSE	S	S	S	S	S	o
Inclination	<1	20	5	3	3	3	15	n
Latitude [N]	50°31'02,2"	50°32'46,3"	50°30'32,56"	50°30'31"	50°30'33"	50°30'27,31"	50°30'24,7"	s
Longitude [E]	20°42'35,3"	20°44'01,5"	20°33'41,69"	20°33'47"	20°33'44"	20°33'42,85"	20°34'07,5"	t
Altitude (m)	192	230	220	223	227	208	232	a
Density of tree layer A (%)	0	0	0	0	0	0	10	n
Density of shrub layer B (%)	20	0	0	0	0	0	20	c
Density of herb layer C (%)	60	70	80	80	90	75	75	y
Density of moss layer D (%)	10	20	0	0	0	0	<1	
Number of species	60	46	33	44	56	36	58	
<b><i>Orobanchе arenaria</i></b>	<b>1</b>	<b>+</b>	<b>1</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>+</b>	<b>V</b>
<b>Ch. Festuco-Brometea</b>								
<i>Artemisia campestris</i>	3	2	4	3	2	3	3	V
<i>Veronica spicata</i>	.	+	+	+	+	+	+	V
<i>Centaurea stoebe</i>	+	+	.	.	+	+	+	IV
<i>Achillea pannonica</i>	+	+	+	+	.	.	.	III
<i>Campanula sibirica</i>	1	1	.	.	.	.	1	III
<i>Euphorbia cyparissias</i>	.	+	.	.	+	.	+	III
<i>Potentilla arenaria</i>	+	1	.	.	.	.	+	III
<i>Alyssum montanum</i>	.	1	.	.	.	.	+	II
<i>Acinos arvensis</i>	1	.	.	.	.	.	+	II
<i>Centaurea scabiosa</i>	+	+	.	.	.	.	+	II
<i>Linum hirsutum</i>	.	.	.	.	+	.	+	II
<i>Phleum phleoides</i>	.	.	+	.	+	.	.	II
<b>Ch. Koelerio glaucae-Corynephoretea canescentis</b>								
<i>Silene otites</i>	+	+	+	+	1	.	.	IV
<i>Trifolium arvense</i>	.	.	2	3	4	3	+	IV
<i>Sedum acre</i>	1	+	.	.	+	.	+	III
<i>Androsace septentrionalis</i>	+	+	.	.	+	.	.	III
<i>Chondrilla juncea</i>	.	.	+	+	.	+	.	III
<i>Helichrysum arenarium</i>	+	.	.	.	.	+	.	II
<i>Plantago arenaria</i>	.	.	.	+	1	.	.	II
<i>Thymus serpyllum</i>	.	1	.	.	.	.	+	II
<b>Ch. Agropyretea intermedio-repentis</b>								
<i>Elymus repens</i>	.	+	2	3	2	4	+	V
<i>Anthemis tinctoria</i>	+	+	.	.	+	+	+	IV
<i>Convolvulus arvensis</i>	.	+	+	+	.	+	.	III
<i>Elymus hispidus</i> subsp. <i>hispidus</i>	.	.	.	.	.	+	+	II
<i>Falcaria vulgaris</i>	.	.	.	.	.	1	+	II
<b>Ch. Molinio-Arrhenatheretea</b>								
<i>Daucus carota</i>	+	+	.	.	+	.	+	III
<i>Festuca rubra</i> s. l.	+	.	.	+	+	2	1	III
<i>Plantago lanceolata</i>	.	+	+	.	.	.	+	III
<i>Rumex acetosa</i>	+	.	+	+	.	+	.	III
<i>Taraxacum officinale</i> s. l.	+	.	+	.	+	.	.	III
<i>Achillea millefolium</i>	.	+	.	.	.	.	+	II
<i>Arrhenatherum elatius</i>	1	.	.	.	.	.	3	II
<i>Dactylis glomerata</i>	.	.	.	+	.	+	.	II
<i>Holcus lanatus</i>	.	.	+	+	.	.	.	II
<i>Lolium perenne</i>	.	.	.	1	2	.	.	II
<i>Vicia cracca</i>	.	.	+	.	.	+	.	II
<b>Ch. Artemisietea vulgaris</b>								
<i>Echium vulgare</i>	+	1	1	+	+	+	+	V
<i>Berteroa incana</i>	+	.	1	+	+	+	.	IV
<i>Melandrium album</i>	+	.	+	+	+	+	.	IV
<i>Oenothera biennis</i>	+	+	.	.	.	+	+	III
<i>Picris hieracioides</i>	+	+	.	.	+	+	.	III
<i>Anchusa officinalis</i>	.	.	.	+	+	+	.	III
<i>Linaria vulgaris</i>	.	.	+	1	+	.	.	III
<i>Tragopogon dubius</i>	+	.	+	.	+	.	.	III
<i>Artemisia vulgaris</i>	.	.	+	.	+	.	.	II
<i>Melilotus officinalis</i>	.	.	.	+	.	.	+	II
<b>Ch. Stellarietea mediae</b>								
<i>Conyza canadensis</i>	+	.	1	+	+	+	.	IV



TABLE 1. Cont.

	1	2	3	4	5	6	7	
<i>Papaver rhoeas</i>	+	+	.	+	+	+	.	IV
<i>Apera spica-venti</i>	+	.	+	.	+	+	.	III
<i>Lathyrus tuberosus</i>	+	.	.	+	+	.	+	III
<i>Consolida regalis</i>	+	.	.	+	.	+	.	III
<i>Descurainia sophia</i>	.	.	.	+	+	.	.	II
<i>Fallopia convolvulus</i>	.	.	+	.	+	.	.	II
<i>Myosotis arvensis</i>	+	.	.	.	.	+	.	II
<i>Raphanus raphanistrum</i>	.	.	.	+	+	.	.	II
<i>Vicia angustifolia</i>	+	.	.	.	.	.	+	II
<i>Vicia hirsuta</i>	.	.	.	.	+	+	.	II
<i>Viola arvensis</i>	.	.	.	+	+	.	.	II
<b>Ch. Trifolio-Geranietea sanguinei</b>								
<i>Medicago falcata</i>	+	1	+	+	.	+	2	V
<i>Coronilla varia</i>	1	+	+	.	+	.	+	IV
<i>Origanum vulgare</i>	.	.	.	+	+	+	+	III
<i>Verbascum lychnitis</i>	.	1	+	1	1	.	.	III
<i>Galium verum</i>	.	+	.	.	.	.	1	II
<b>Others</b>								
<i>Senecio jacobaea</i>	1	+	.	+	+	+	+	V
<i>Hypericum perforatum</i>	.	+	+	+	.	+	+	IV
<i>Erigeron acer</i>	+	+	.	1	+	.	+	IV
<i>Medicago lupulina</i>	+	.	.	1	+	+	+	IV
<i>Arenaria serpyllifolia</i>	1	.	2	2	2	.	.	III
<i>Hieracium pilosella</i>	1	3	.	+	.	.	.	III
<i>Holosteum umbellatum</i>	+	+	.	.	.	.	+	III
<i>Medicago sativa</i>	.	.	2	1	+	.	.	III
<i>Pimpinella saxifraga</i>	+	+	.	.	.	.	+	III
<i>Sedum maximum</i>	.	.	.	.	+	+	+	III
<i>Veronica arvensis</i>	+	+	.	.	+	.	.	III
<i>Calamagrostis epigejos</i>	+	.	.	.	.	.	+	II
<i>Euphorbia esula</i>	.	.	+	+	.	.	.	II
<i>Festuca trachyphylla</i>	+	+	.	.	.	.	.	II
<i>Medicago minima</i>	.	.	.	+	1	.	.	II
<i>Orobanche coerulescens</i>	.	.	.	+	+	.	.	II
<i>Pinus sylvestris</i> B	2	.	.	.	.	.	2	II
<i>Silene vulgaris</i>	+	.	.	.	.	.	+	II
<i>Verbascum densiflorum</i>	+	.	.	.	.	+	.	II

Sporadic: **Ch. Festuco-Brometea:** *Allium oleraceum* 7; *Asparagus officinalis* 5; *Asperula cynanchica* 7; *Brachypodium pinnatum* 7; *Campanula bononiensis* 7; *Carlina vulgaris* 1; *Dianthus carthusianorum* 5; *Eryngium campestre* 1; *Helianthemum nummularium* 2; *Koeleria macrantha* 2. **Ch. Molinio-Arrhenatheretea:** *Agrostis gigantea* 1; *Anthyllis vulneraria* 2; *Galium mollugo* s. 1. 7; *Knautia arvensis* 5; *Pastinaca sativa* 5; *Tragopogon pratensis* 1; *Trifolium pratense* 3. **Ch. Artemisietea vulgaris:** *Carduus acanthoides* 4; *C. crispus* 1; *Melilotus albus* 2. **Ch. Stellarietea mediae:** *Anagallis foemina* 7(r); *Arabidopsis thaliana* 2; *Bupleurum rotundifolium* 7(r); *Ceratodon purpureus* D 1; *Equisetum arvense* 6; *Euphorbia exigua* 7(r); *Geranium pusillum* 1; *Lactuca serriola* 1; *Matricaria maritima* subsp. *inodora* 5; *Melandrium noctiflorum* 4; *Vicia tetrasperma* 5. **Others:** *Ajuga chamaepitys* 7(r); *Alyssum alyssoides* 1(1); *Bromus tectorum* 5; *Bryum* sp. D 1; *Camelina microcarpa* subsp. *sylvestris* 1; *Cardaminopsis arenosa* 2; *Erigeron annuus* 7; *Euphrasia stricta* 2; *Fragaria vesca* 7; *Hypnum cupressiforme* D 1(1); *Lappula squarrosa* 5; *Lavatera thuringiaca* 3; *Ononis arvensis* 7; *Orobanche elatior* 7; *O. picridis* 5; *Pinus sylvestris* A 7(1); *Poa compressa* 2; *Prunus spinosa* C 7; *Pycnothelia papillaria* D 2; *Robinia pseudoacacia* B 1; *Rubus caesius* 6; *Senecio sylvaticus* 1; *S. vernalis* 4; *Thalictrum minus* 7; *Thuidium* sp. D 2; *Veronica verna* 5; *Vincetoxicum hirundinaria* 7.

and the Pasturka village; ATPOL: EF1420 (Fig. 2). The Garb Pińczowski ridge is formed by chalky rocks, covered with loose and strongly limy sands in some places near the base. The distribution of the species is quite dispersed. It consists of three subpopulations scattered over 7,5 ha.

The first subpopulation is located in lower parts of the southern slope and at its foot (Fig. 2). The species grows in fallows and in loose xerothermic grasslands on sands. It neighbours with grasslands and xerothermic shrublands to the north (Festuco-Brometea, Trifolio-Geranietea, Rhamno-Prunetea classes) and with cultivated fields to the south. Approximately 600 specimens were recorded at the locality in 2007. In 2008 the population decreased after intensive ploughing of the fallows. It is very likely that the ploughing caused irregular blossoming of the species: about 70% specimens flowered two weeks later than the rest of the subpopulation. Species characteristic of the Festuco-

Brometea class dominate in vegetation patches located in lower parts of the hill (Table 1 no. 3; Fig. 3) with a more numerous share of species characteristic of Artemisietea vulgaris, Koelerio glaucae-Coryneporetea canescentis, Agropyretea intermedio-repentis. On the other hand, species characteristic of the Koelerio glaucae-Coryneporetea canescentis class dominate in the undergrowth, with a substantial share of species characteristic of the Festuco-Brometea class and Agropyretea intermedio-repentis, Molinio-Arrhenatheretea, Artemisietea vulgaris, in vegetation patches located lower, in deeper sands (Table 1 no. 4 and 5; Fig. 3).

The second subpopulation is located about 150 m SE of the previous one towards an asphalt road from Pińczów to Busko-Zdrój (Fig. 2) in an old fallow between cultivated fields. It consists of approximately 400 specimens. Species of the Agropyretea intermedio-repentis class dominate in

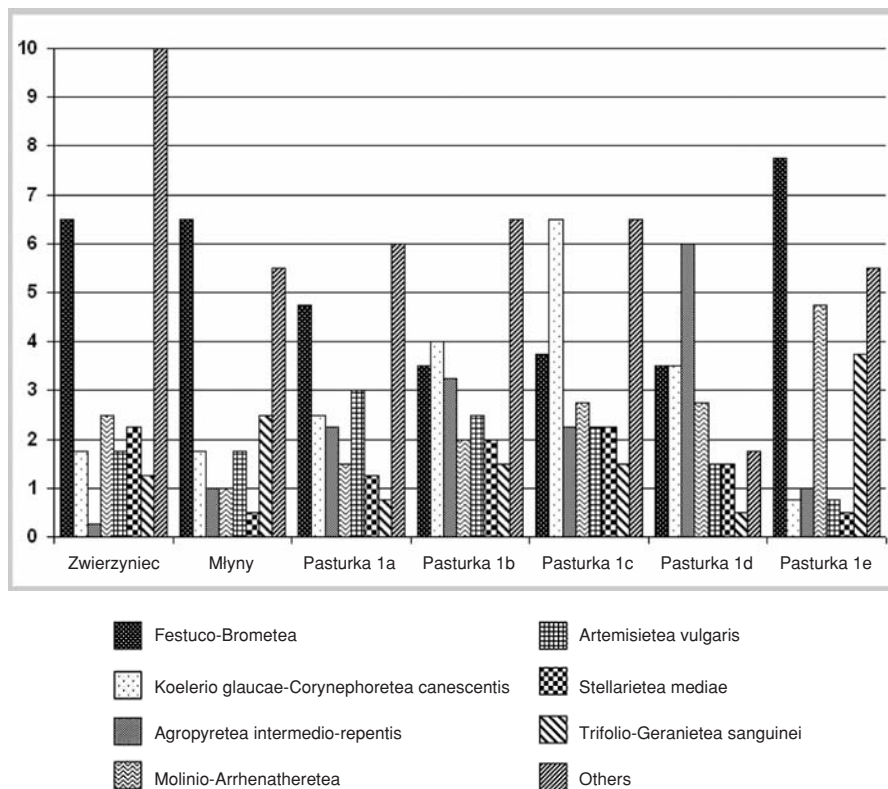


Fig. 3. The presence of species characteristic of individual phytocoenoses at the localities of *Orobanche arenaria* Borkh.

vegetation patches and are associated with species of the Festuco-Brometea and Koelerio glaucae-Coryneporetea canescentis classes (Table 1, no. 6; Fig. 3).

The third subpopulation was discovered on the border between a pine forest and a fallow. It is located about 1 km N of the Pasturka village and about 1 km E and NE of the neighbouring localities (Fig. 2). *Orobanche arenaria* grows on the slope of a 15°-incline hill with an SSE exposure. The grassland is formed on sands over the habitat of an old fallow sparsely overgrown with young pines developed from self-sowing. It borders on xerothermic grasslands to the north, fields to the west and south and a pine forest (known as the "Pasturski Forest") to the east. Approximately 30 specimens were recorded in 2008. Four layers are recorded in the vegetation structure (Table 1 no. 7). Pine occurs in the tree stand with a low crown closure and in the undergrowth. The herb layer is dominated by species characteristic of the Festuco-Brometea class and, further, by: Molinio-Arrhenatheretea, Trifolio-Geranietea sanguinei and Koelerio glaucae-Coryneporetea canescentis (Fig. 3).

A total of ca. 1030 specimens were recorded at the locality near Pasturka.

**Locality II.** Situated in the eastern part of Młyny, between Młyny and the Busko-Zdrój – Kielce road; ATPOL: EF1501 (Fig. 2). The species grows in a xerothermic grassland developed on very fertile calcareous sands, on the slope of a river valley (the Bród river). The area has a considerable incline (20°) with a S and SW exposure. The slope borders on the river valley to the south and the east and on cultivated fields (mainly cereal crops) to the north. Approximately 40 specimens were recorded. The community with *Orobanche arenaria* is dominated by species of the Festuco-Brometea class and much less by the Trifolio-Ge-

ranietea sanguinei or Koelerio glaucae-Coryneporetea canescentis classes (Table 1 no. 2; Fig. 3).

**Locality III.** Discovered N of Zwierzyniec, near Szanec, by an asphalt road from Szanec to the Busko-Zdrój – Chmielnik road, near a gravel pit; ATPOL: EF1510 (Fig. 2). *Orobanche arenaria* grows on sandy fallows sparsely overgrown with *Pinus sylvestris*. It borders on the Busko-Zdrój – Chmielnik road to the north, cultivated fields to the west and the south, and a gravel pit and a pine forest to the east. Approximately 350 specimens were recorded. The species composition of the grassland is similar to that in Młyny. A slightly higher share of species of the Festuco-Brometea, Molinio-Arrhenatheretea and the Stellarietea mediae classes is observed here (Table 1 no. 1; Fig. 3).

## CONCLUSIONS

*Orobanche arenaria* parasitized only *Artemisia campestris* at the localities. The altitudinal range of the populations was between 190 and ca. 240 m. The species was mostly observed as a single specimen or sometimes as clusters consisting of three to ten specimens (especially at locality near Zwierzyniec) in sites immediately adjacent to the previous year's specimens.

At the new localities, the species prefers dry, loose sandy and gravelled substrates with a high calcium carbonate content, often with calcareous stones. It occupies slopes with a different degree of incline (3°-20°), with a southern exposure, or sporadically flat areas. The places are light, well insulated, exceptionally with some mosaic shading from trees, and usually comprise extensively used fields: fallows, pastures, slopes of river valleys as well as secon-

dary habitats such as sand pits and gravel pits. The areas must have been cultivated intensively in the past as the soil horizon shows an arable level.

Specific combinations of thermophilic xerothermic grasslands and grasslands on sands are typical plant formations in which *Orobanche arenaria* occurs. Species of the Festuco-Brometea class and the Cirsio-Brachypodium pinnati association (Table 1 no. 1-3 and 7; Fig. 3), or interchangeably species of the Koelerio glaucae-Corynephoretea canescens class and the Koelerion glaucae association (Table 1 no. 4 and 5; Fig. 3) dominate in the species composition of the communities. Species of the Agropyreteo intermedio-repentis class dominated at one locality (Table 1 no. 6, Fig. 3). Main syntaxonomic groups are frequently associated with Molinio-Arrhenatheretea grassland species, Artemisietea vulgaris ruderal species and Stellarietea mediae segetal species (Fig. 3). This species composition both shows the history of the habitats and is a result of the close proximity to cultivated fields, roads and xerothermic grasslands. However, *O. arenaria* does not enter fields or, importantly, dense xerothermic grasslands. The latter are more stable and denser, and *O. arenaria* loses competition with typical steppe species. An unambiguous classification of phytocoenoses in the area into specific associations defined in the literature cannot be performed.

#### THREATS AND PROTECTION METHODS

Threat symptoms are evident at the new localities. The population of *Orobanche arenaria* at the locality in Młyny is not numerous (40 specimens). The slope, on which the species grows, borders on cultivated fields from which chemical substances flow. As tree and shrub plantations with pines and black locusts grow on the adjacent slopes, the locality is threatened by secondary succession processes.

The locality near Zwierzyniec seems to be under particular threat as it is near an expanding gravel pit. Partial damage of specimens by lorries transporting gravel was observed in 2008. The locality is near an asphalt road, cultivated fields and, especially, a pine forest. Young pine specimens are recorded at the locality and the site is not likely to survive unless active protection is introduced.

The locality in Pasturka is threatened by herbicides, which was observed in 2008. As extensive cultivation is abandoned, and especially as occasional soil scarification is discontinued, the abundance of the field layer increases, which is unfavourable for *Orobanche arenaria*. The type of dissemination is anemohydrochoric (Teryokhin and Kravtsova 1986) and seeds can better penetrate the soil with water after soil treatment has been performed. In 2008 the fallow at the locality in Pasturka was ploughed and alfalfa was sowed. It initially seemed that the locality would be destroyed as the species did not appear in the flowering period or it appeared very weakly and not in large numbers. However, its mass occurrence was observed after approximately a two-week delay. One of the localities in Pasturka is partly situated in the direct vicinity of a pine forest which is a source of pine sowing onto the area with *O. arenaria* triggering off processes of secondary succession.

The locality of *Orobanche arenaria* in Gliniany near Lubiąż (Lower Silesia) is also threatened by processes of se-

condary succession and the adjacent pit can be filled up or can undergo eutrophication (Szczęśniak 2003).

The new localities of *Orobanche arenaria* are some of the most numerous localities in Poland and in central Europe. Importantly, they are located on the northern limit of the range. Although they are situated in the Nida Landscape Park and the Szaniec Landscape Park, the localities should additionally be included in an environmental monitoring programme and should be protected as ecological sites. Active protection measures such as periodical removal of excessively regenerating trees and bushes and inhibiting the development of an expanding herb layer should be introduced. Periodic and controlled soil scarification is also recommended.

#### ACKNOWLEDGEMENTS

The authors thank Ewa Szczęśniak and Zygmunt Dajdok for their help in situating the localities and for providing access to unpublished data on the species in Lower Silesia, and Prof. Adam Zajac for his helpful comments improving the manuscript.

This work was supported by the Ministry of Science and Higher Education (grant no. 3577/B/P01/2007/ 33).

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