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Orobanche bohemica Čelak. (Orobanchaceae) at the eastern limit of its geographical range: new data on its distribution in Poland

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Abstract: A new locality of *Orobanche bohemica* Čelak., one of the rarest representatives of the family Orobanchaceae in Central and South-Western Europe, is reported from Poland. This is the first confirmed record of the species in Poland. It is the easternmost site known for the species, so it extends its distribution range. The species was recorded in Zawiercie-Bzów in the Częstochowa Upland (Wyżyna Częstochowska) in July 2010. Its host, abundance, and habitat preferences at the new locality are described, and a supplemented map of its distribution in Europe and Poland is given. Its taxonomic position as well as some diagnostic features that distinguish *O. bohemica* from *O. purpurea* are also discussed.

Key words: *Orobanche bohemica*, distribution, habitat, host, Częstochowa Upland, Poland

1. Introduction

Orobanche bohemica Čelak., Bohemian broomrape, has been reported so far from a few dozen localities in Central and South-Western Europe, i.e. Germany, Poland, the Czech Republic, Austria, Switzerland, France, Italy, and Spain (Pusch 2006; Pusch & Günther 2009). The full extent of its distribution is not known, as the taxon is not distinguished from *O. purpurea* s.l. by some authors.

Orobanche bohemica was described from the Czech Republic – Veliká hora near Karlštejn (*locus classicus*) (Čelakovský 1879). It was considered to be endemic to Central Europe (Holub & Zázvorka 1999; Pusch 2006). However, the species has recently been reported from South-Western Europe (Carlón *et al.* 2008; Pusch & Günther 2009).

The occurrence of *Orobanche bohemica* in the area of Poland was first mentioned by Römer (1907), who reports: „…die beste Entdeckung aber im Jahre 1904 gemacht: *Orobanche bohemica* Čel. Sie steht zwischen *Artemisia vulgaris* L. auf dem Schlossberge, einer alten Burgruine in einem Bauerngarten des Dorfes Gross-Zarnow." [„…but he made his best discovery in 1904: *Orobanche bohemica* Čel. It stands among *Artemisia vulgaris* L. on a castle hill in the ruins of a mansion in a cottage garden in Gross-Zarnow village"; the current name of the village is Czarnowo]. The species (as *Orobanche bohemica* or *O. purpurea* var. *bohemica*) was later reported after Römer also by Müller (1911), Hayek (1914) and Beck (1930). As the herbarium material is unavailable, it cannot be verified whether the species actually occurred in Czarnowo. Römer reports *Artemisia vulgaris* as its host, while *O. bohemica* is recorded on *A. campestris*.

The aim of this paper is to describe a new locality of *Orobanche bohemica* in Poland. The taxonomy, biology, ecology, and distribution of the species are also briefly discussed below.

2. Materials and methods

Field research was carried out in July 2010. Localities of this species are situated in the Częstochowa Upland (Wyżyna Częstochowska), belonging to the Kraków-Częstochowa Upland (Wyżyna Krakowsko-Częstochowska), and in the valley of the lower Oder (Kondracki 2001). Its distribution was mapped using the ATPOL grid based on cartogram units 10 km × 10 km (Zając 1978).

The nomenclature of the vascular plant species listed in the phytosociological table follows Mirek *et al*. (2002) and the nomenclature of syntaxa follows Matuszkiewicz (2006). Phytosociological relevés (of 20 m^2 each) were made using the Braun-Blanquet (1964) method.

3. Taxonomic problems, biology and ecology

3.1. Taxonomic problems

Orobanche bohemica Čelakovský 1879, Össterr. Bot. Z. 29: 362.

Syn.: *Orobanche purpurea* var. *bohemica* (Čelak.) Beck 1890, Bibl. Bot. 19: 126; *Phelipaea bohemica* (Čelak.) Čelak. 1897, Anal. Květ. Čech., Moravy a rakouského Slezska, ed. 3: 236; *Phelipanche bohemica* (Čelak.) Holub & Zázvorka 1979, Preslia 51: 282; *Phelipanche purpurea* (Jacq.) Sojak subsp. *bohemica* (Čelak.) Zázvorka in Kirschner & Zázvorka 2000, Preslia 72: 88. Lectotype of *O. bohemica*: leg. Čelakovský 1/3 Juli 1879, Veliká hora near Karlstein, PR 142614. Number of chromosomes: $n = 12$ ($2n = 24$) (Albers & Pusch 1999).

By some authors, *O. bohemica* is included in *O. purpurea* s.l. The use of the generic name, *Orobanche* or *Phelipanche*, is still being disputed. Considerable uncertainty and the lack of clarity in the approach to the taxonomic group treated as *O. purpurea* s.l. are very confusing.

Orobanche bohemica was first described as a separate species by Čelakovský (1879). It was later classified at different taxonomic ranks, e.g. as a variety by Hayek (1914), Beck (1930), Haeupler & Muer (2000), a subspecies by Zázvorka (2000), Carlon *et al*. (2008), and a species by Holub (1979), Holub & Zázvorka (1999), Pusch (2006), Pusch & Günther (2009).

A species morphologically similar to *O. bohemica*, and generally also to *O. purpurea* s. str., is *O. arenaria*. Like *O. bohemica*, it parasitizes *Artemisia campestris* and frequently prefers similar habitats. Both can be recorded in close proximity. Pubescence of the anthers is a good diagnostic character distinguishing the species even when dry. *O. arenaria* is distinguished by having dense, long, and villous pubescence of the anthers, while they are glabrous or sparsely and shortly hairy in *O. bohemica* and *O. purpurea* s.str. Morphological differences between *O. purpurea* and *O. bohemica* are summarized in Table 1, based on the keys available (Zázvorka 2000; Pusch 2006) and my observations of specimens from Polish populations and herbarium data from Prague (PR and PRC). Plant habit of the 2 taxa is shown in Fig. 1a, 1b.

Fig. 1. Plant habit of (a) *Orobanche bohemica* (Zawiercie-Bzów, 11 July 2010) and (b) *O. purpurea* s.str. (Chrzanów, district Kąty, 18 June 2009) (photograph by R. Piwowarczyk)

Table 1. A comparison of the main characters distinguishing *Orobanche purpurea* and *O. bohemica*

Character	*O. purpurea*	*O. bohemica*
Height (cm)	15-40 (-50)	(15) 25-50 (-70)
Anther pubescence	sparse (hairs short, not villous), rarely glabrous	glabrous
Length of 5th calyx tooth (mm)	0-2	(3) 4-7
Number of flowers per cm of inflorescence axis	1.1-2.0	2.3-4.1
Total number of flowers	5-30(-50)	20-60
Position of flowers	± patent horizontally	ascending
Colour of stigma	white	yellow-white
Host (Central Europe)	*Achillea* spp. or rarely *Artemisia vulgaris*	*Artemisia campestris*

3.2. Biology, habitat, and plant communities

Orobanche bohemica is probably monophagous, as it parasitizes only *Artemisia campestris* (Holub & Zázvorka 1999; Pusch 2006). It has been reported from Spain on *A. campestris* var. *glutinosa* (Carlón *et al.* 2008). Unlike Central European individuals, the Spanish specimens of *O. bohemica* have a more intensive pigmentation (based on a photograph by Carlón *et al.* 2008). *O. purpurea* s.str. parasitizes different species, mostly belonging to the genus *Achillea* sp.

Orobanche bohemica on *Artemisia campestris* was successfully cultured in an experiment yielding 30-40 cm tall, flowering plants. No plants developed when *O. bohemica* was planted with the presumptive host *Achillea millefolium* s.l. The gardening experiment and observations made in nature confirm divergent host selection of these 2 taxa (Pusch 2006).

Orobanche bohemica flowers in June in Central Europe. It does not develop annually (Holub & Zázvorka 1999; Pusch 2006). The species prefers xerothermic habitats, on sun-exposed, rocky or shrub-covered slopes on carbonate rocks or basalts, on sandy or stony soils, in communities of the orders *Festucetalia valesiacae* and *Helianthemo cani-Festucion pallentis* (Holub & Zázvorka 1999; Zázvorka 2000; Pusch 2006). However, *O. arenaria* and *O. coerulescens* also occupy similar habitats (Zázvorka 1989). Phytosociological relevés given in a study by Pusch (2006) indicate that *O. bohemica* prefers communities of the alliance *Festuco-Stipion*, with a contribution of xerothermic grasses, especially *Stipa* and *Festuca* species, i.e. *Stipa capillata*, *Festuca* cfr. *rupicola*. *O. bohemica* mostly chooses continental, dry grasslands, and *O. purpurea* occurs in more mesophilic habitats (Pusch 2006). The highest localities are in northern Eyrs in southern Tyrol (Italy), ca. 1500 m a.s.l. (Pusch & Günther 2009).

4. Results and discussion

During a revision of the species belonging to the genus *Orobanche*, in the herbarium KRAM in Kraków in 2009, I found a specimen correctly labelled as *O. purpurea* var. *bohemica*, collected together with the host *Artemisia campestris* (leg. det. K. Piech, "on a field margin near Jurrasic rocks E of Zawiercie, near the village of Bzów", 19.07.1924, KRAM, 095385). I was successful in finding the locality in the field in the growing season of 2010 (Fig. 1a). The local population has persisted since at least 1924. It is situated in the Częstochowa Upland in southern Poland (Fig. 2). The site is located N of a surfaced road from Bzów (now a district of Zawiercie) to Karlin, at the base of a calcareous monadnock known as Skała Rzędowa, on S and SSE-facing slopes, ca. 420 m a.s.l., in ATPOL square:

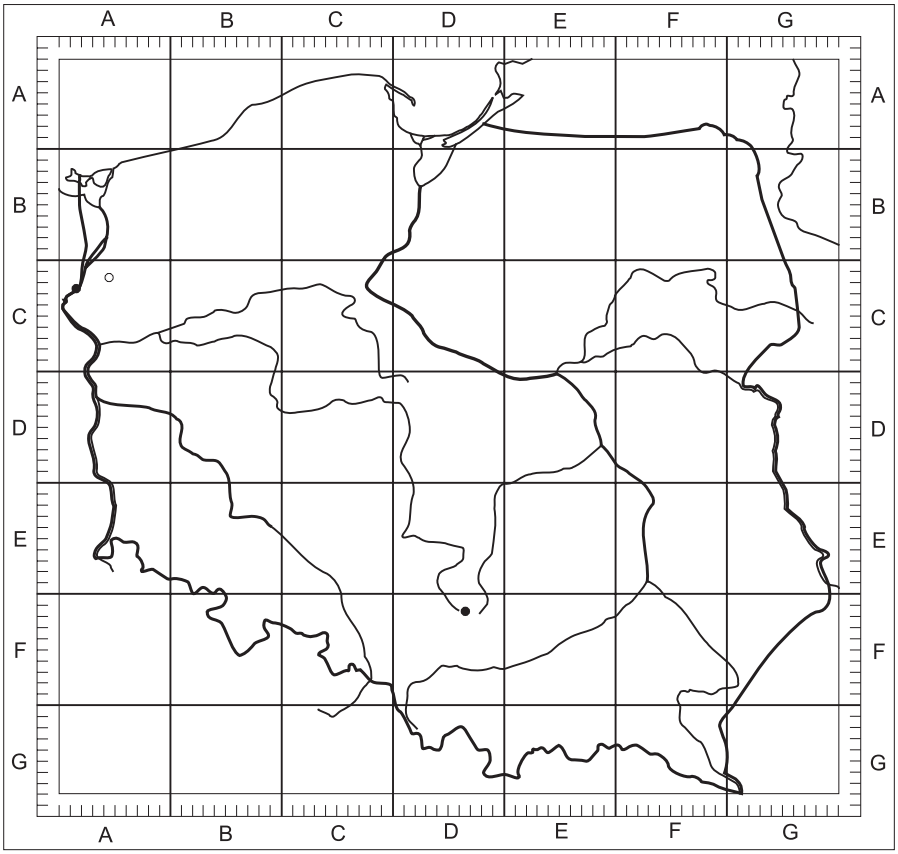

Fig. 2. Distribution of *Orobanche bohemica* Čelak. in Poland
Explanations: ● – new locality, ○ – locality not confirmed at present and uncertain

Table 2. Plant communities with *Orobanche bohemica* Čelak. in Zawiercie-Bzów

Number of relevé	1	2	3	4
Date	11.07.2010	11.07.2010	13.07.2010	13.07.2010
Exposure	S	SSE	SSE	SSE
Inclination (º)	10	5	-	5
Altitude a.s.l. (m)	423	419	412	423
Density of herb layer C (%)	80	85	80	60
Number of species	49	43	49	36
Orobanche bohemica	+	+	+	+
Ch. *Festuco-Brometea*				
Artemisia campestris	3	3	3	2
Centaurea stoebe	1	+	+	+
Phleum phleoides	3	2	3	.
Centaurea scabiosa	+	+	+	.
Dianthus carthusianorum	+	+	+	.
Scabiosa ochroleuca	+	.	+	.
Seseli annuum	+	.	+	.
Veronica spicata	.	+	+	.
Euphorbia cyparissias	+	.	.	+
Ch. *Molinio-Arrhenatheretea*				
Festuca rubra s.l.	2	3	3	2
Arrhenatherum elatius	1	2	1	.
Achillea millefolium s.l.	1	+	.	+
Trifolium pratense	+	+	+	.
Trifolium repens	+	+	+	.
Leontodon hispidus	.	1	+	.
Crepis biennis	.	+	+	.
Dactylis glomerata	.	+	+	.
Daucus carota	.	+	+	.
Lotus corniculatus	+	.	+	.
Ch. *Trifolio-Geranietea sanguinei*				
Medicago falcata	+	+	+	+
Coronilla varia	+	+	+	.
Fragaria viridis	+	+	+	.
Vicia tenuifolia	.	+	+	+
Agrimonia eupatoria	+	.	+	.
Clinopodium vulgare	+	+	.	.
Ch. *Stellarietea mediae*				
Consolida regalis	+	+	+	+
Vicia tetrasperma	1	1	1	
Apera spica-venti	+	.	.	+
Myosotis arvensis	+	.	.	+
Vicia hirsuta	.	+	+	.
Ch. *Artemisietea vulgaris*				
Artemisia vulgaris	.	1	2	+
Cirsium arvense	+	+	+	+
Picris hieracioides	+	1	+	
Melandrium album	.	.	+	+
Ch. *Koelerio glaucae-Corynephoretea canescentis*				
Trifolium arvense	2	1	2	2
Trifolium campestre	+	+	1	.
Ch. *Agropyretea intermedio-repentis*				
Convolvulus arvensis	+	2	+	+
Equisetum arvense	1	.	.	+
Others				
Arenaria serpyllifolia	+	+	+	+
Conyza canadensis	+	+	.	+
Galium mollugo s.l.	+	+	+	.
Pimpinella saxifraga	+	+	+	.
Thymus pulegioides	+	+	+	.
Tussilago farfara	.	+	+	+
Peucedanum oreoselinum	1	.	+	.
Erigeron acris	+	.	+	.
Erigeron annuus	.	+	+	.
Hypericum perforatum	+	+	.	.
Orobanche arenaria	.	.	+	+
Senecio jacobaea	+	.	+	.

Sporadic: **Ch. *Festuco-Brometea:*** *Allium oleraceum* 3, *Asperula cynanchica* 1, *Acinos arvensis* 2, *Filipendula vulgaris* 2, *Gentiana cruciata* 1, *Plantago media* 2; **Ch. *Trifolio-Geranietea sanguinei:*** *Verbascum lychnitis* 3, **Ch. *Stellarietea mediae:*** *Anchusa arvensis* 4, *Anthemis arvensis* 4, *Descurainia sophia* 4, *Fallopia convolvulus* 4, *Papaver argemone* 4, *P. rhoeas* 4, *Polygonum aviculare* 4, *Silene vulgaris* 1, *Thlaspi arvense* 4, *Vicia villosa* 4, *Viola arvensis* 4; **Ch. *Molinio-Arrhenatheretea*:** *Festuca pratensis* 1, *Lolium perenne* 2, *Rumex acetosa* 4, *Tragopogon pratensis* 3, *Vicia cracca* 1, *Plantago lanceolata* 1, *Taraxacum officinale* agg. 4; **Ch. *Koelerio glaucae-Corynephoretea canescentis:*** *Rumex acetosella* 4; **Ch. *Agropyretea intermedio-repentis:*** *Falcaria vulgaris* 4; **Others:** *Prunus spinosa* C 1(2), *Anthyllis vulneraria* 3, *Calamagrostis epigejos* 3, *Capsella bursa-pastoris* 4, *Medicago lupulina* 1, *Orobanche lutea* 2, *Potentilla heptaphylla* 1

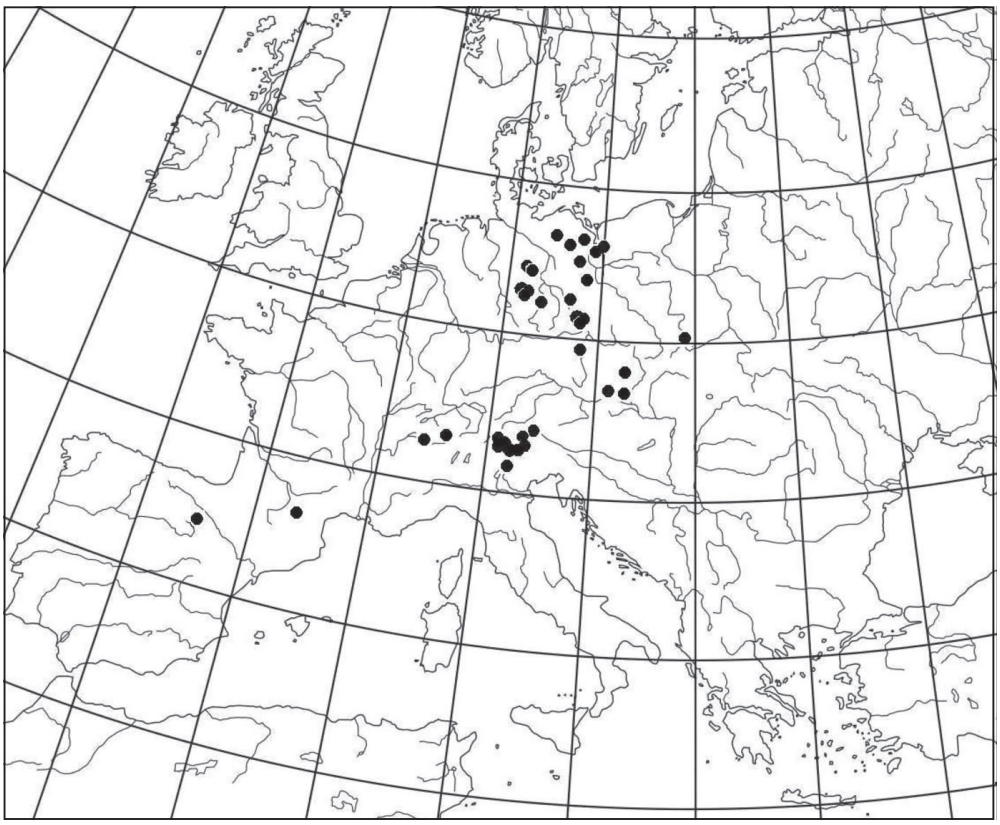

Fig. 3. Distribution of *Orobanche bohemica* Čelak. in Europe (after Pusch & Günther 2009, modified and supplemented)

DF16. The population is not abundant, as in 2010 it consisted of less than 10 shoots. The species grows in the ecotone zone of xerothermic grasslands, wastelands, and arable fields. Xerothermic species of the class *Festuco-Brometea* and meadow species of the class *Molinio-Arrhenatheretea* dominate in the community, with an admixture of thermophilous species of the class *Trifolio-Geranietea sanguinei*, segetal species of the class *Stellarietea mediae*, ruderal species of the class *Artemisietea vulgaris* and sporadically of the classes *Koelerio glaucae-Corynephoretea canescentis* and *Agropyretea intermedio-repentis* (Table 2). The soils are calcareous rendzinas with a sand fraction. The species occurs together with *O. arenaria* at the locality. *O. lutea* grows abundantly on a more mesophilic habitat nearby.

Another locality of the species has also been recorded in north-western Poland near Raduń (near Chojna), slopes of river Oder on a hill (65 m a.s.l), in the plant association *Stipetum capillatae* on fallow ca. 15 shoots on *Artemisia campestris* (S. Rätzel, oral comm. and photo, 2010) (Figs. 2-3).

Molecular-phylogenetic analyses based on nuclear ITS sequences have revealed differences in DNA sequence between *Orobanche purpurea* s.str. and *O. bohemica* (Carlón *et al*. 2005; Schneeweiss *et al*. 2004). Thus the occurrence of many subspecies, also those newly described within *O. purpurea* s.l. (e.g. Carlón *et al*. 2005, 2008), requires further examinations. The number of samples used in such tests should be increased and they should be geographically diversified.

Orobanche purpurea parasitizing *Artemisia vulgaris* should be examined in greater depth. It is recorded infrequently in the Czech Republic and Slovakia, mostly in ruderal sites. *O. purpurea* plants are more sturdy and have a longer inflorescence with many flowers. This may be caused by its parasitism on a considerably larger species of *Artemisia* and thus greater access to nutritive substances. As noticed by Zázvorka (1997, 2000), this morphotype is similar to *O. bohemica* and *O. arenaria*, and should be studied further. Mądalski (1973) did a drawing based on the specimen collected on *A. vulgaris* near Pianowice, Sambor administrative region (Ukraine). His drawing also presents a very tall plant with a long inflorescence having many flowers. *A. vulgaris* is reported as a host of *O. purpurea* s.l. from other countries, e.g. Germany (Pusch & Günther 2009), Austria (Beck 1892; Janchen 1956-1966), Estonia (Eilart *et al*. 1973), and Greece (Halácsy 1902).

Morphological, ecological and molecular differences suggest that *Orobanche bohemica* is a separate species. It parasitizes only *Artemisia campestris*, unlike *O. purpurea*, which infects mainly *Achillea* sp. In the Czech Republic, *O. purpurea* s.str. does not colonize *A. campestris* growing nearby, and *O. bohemica* does not occur together with *O. purpurea*. This shows the stability of

host selection by these 2 taxa (Zázvorka 1989). Their laboratory culture (Pusch 2006) and observations from Poland also confirm this.

Only some 40 localities of *O. bohemica* have been reported worldwide so far (Fig. 3). The populations are very small and less than half of them still exist. Some localities have not been confirmed. Many local populations have disappeared when pasturing was abandoned or due to secondary succession (especially by invasive grasses, e.g. *Arrhenatherum elatius* or *Bromus erectus*, and shrubs), afforestation, eutrophication, or the influence of weed-killers from adjacent fields (Holub & Zázvorka 1999; Pusch 2006). Confirmed localities are known to date only from Germany (6), the Czech Republic (2), Austria (2), Switzerland (1), northern Italy (5), Spain (2) (Pusch 2006; Pusch & Günther 2009) and Poland (2).

Orobanche bohemica is one of the rarest species in Europe. It is classified as critically endangered in Poland (Piwowarczyk 2012), the Czech Republic (Holub & Zázvorka 1999; Procházka 2001) and Italy (Wilhalm & Hilpold 2006), and as a strongly endangered species in Central Europe (Schnittler & Günther 1999; Welk 2002). A total of 200 specimens of *O. bohemica* are estimated to occur in Germany during an average growing season and fewer than 500-1000 specimens worldwide, which is closely correlated with the seed pool produced subsequently (Pusch 2006).

Considerable archaeological material was discovered near the rock Skała Rzędowa, especially NE of it, during preliminary studies. Other archaeological findings are also available for the area. The site was occupied by either Funnelbeaker culture settlements in the Neolith or Corded Ware culture settlements in the early Bronze Age, later inhabited by a population of the Lusatian culture as a permanent settlement in the Hallstatt period. There are also some traces of a medieval settlement dating back to the 13th-14th centuries (Muzolf 1994). The vicinity of Skała Rzędowa is an interesting cultural and botanical site. The local flora, including *Orobanche bohemica, O. arenaria*, and *O. lutea*, may reflect conditions resulting from former use coupled with the current influence of the surrounding area.

The close proximity of arable fields and susceptibility to chemical agents are a threat to *Orobanche bohemica* at the newly discovered locality. The progressing colonization by other herbs and shrubs may threaten the existence of the species in future. The vicinity of Skała Rzędowa is also a very popular tourist area (a climbing spot), located close to a road, which poses additional threat. The locality should be closely monitored and protected as an ecological site.

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