Opole Scientific Society
Nature Journal
No 41- 2008: 19–29

Caucalido-Scandicetum (Libb. 1930) R. Tx. 1937 within the area of limestone outcrops in Opole Silesia (SW Poland)

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Abstract: Results of geobotanical studies conducted in the mid-eastern Opole Silesia region (the area of limestone outcrops) in the years 2000–2003 are presented. The main goal of this research was to investigate and obtain a knowledge of calciphilous cereal weed association – *Caucalido-Scandicetum* in two different habitat types developed from two various basement complexes: i.e. Cretaceous and Triassic ones. As a result of phytosociological works nineteen relevés of *Caucalido-Scandicetum* were done, which allowed to present characteristics and occurrence conditions of the one of the rarest plant community in Poland.

Key words: segetal phytocoenosis, calciphilous weed association, limestone outcrops, rendzinas, Cretaceous area, Triassic area.

Introduction

Caucalido-Scandicetum is a thermophilous association of weeds occurring in cereal fields which display an evident attachment to heavy rendzina soils of alkaline reaction. It is remarkable for its interesting floristic composition, comprising rare, calciphilous, southern weeds, such as: *Adonis aestivalis*, *A. flammea*, *Anagallis foemina*, *Bupleurum rotundifolium*, *Caucalis platycarpos*, *Conringia orientalis*, *Euphorbia falcata*, *Fumaria vaillantii*, *Galium tricornutum*, *Scandix pecten-veneris*, *Thymelaea passerina*, and other species (Kornaś 1972; Matuszkiewicz 2001). The optimum conditions for the development of *Caucalido-Scandicetum* prevail in areas with a warmer and more continental climate than generally exists throughout Poland (Kornaś 1972).

In Poland, it is one of the relatively rare phytocenosis. Its largest and typically developed patches were recorded in the warmest, southern regions of Poland (e.g.: Kornaś 1950; Demianowiczowa 1953; Medwecka-Kornaś 1959; Fijałkowski 1963, 1967; Sałata 1965; Wnuk 1976, 1985; Dominiak 1984; Wika 1986, 1996; Dostatny 2000; Nobis *et al*. 2007).

The presence of *Caucalido-Scandicetum* was also noted in Central Poland, although the patches there were always impoverished and covered only small areas (e.g.: Siciński 1974; Warcholińska 1974, 1981; Siciński, Sowa 1980).

The general characteristics and distribution of the association in Poland, its dynamics and predictions concerning its future preservation were presented by Wnuk (1989).

The *Caucalido-Scandicetum* phytocoenoses were also taken as a topic for phytosociological and floristic studies in Opole Silesia (Michalak 1972, 1974; Szotkowski 1981, 1989; Sendek 1989, 1992; Nalewaja 1993; Nowak 2007).

Recently, the recession and disappearance of this association has been observed throughout Poland. This process occurs also in the Opole Silesia region, where the presence of progressively impoverished patches of the association has been noted. At present, it is no longer possible to distinguish the typical form of this association in the region. Perhaps, this fact reflects the farming intensity in the Opole province, which is higher than average in Poland, as well as the technical and technological advancement.

The objective of this study, was to present the structure of one of the rarest calciphilous weed associations in cereal fields classified under the *Caucalidion lappulae* alliance, in the area of Opole Silesia, where outcrops of carbonate rocks occur. Additionally, an attempt was made to discover the factors responsible for the different distribution of the *Caucalido-Scandicetum* association in an area with two types of substrates – Cretaceous and Triassic. Another issue considered was the process of impoverishment of the association as a result of human impact.

Materials and methods

The phytosociological documentation of the *Caucalido-Scandicetum* association was prepared. The material for analyses were nineteen relevés, each done on the area of 50 m^2 (Tab. 1). The phytosociological relevés were done using the Braun-Blanquet (1964) approach.

The syntaxonomical classification was done according to Matuszkiewicz (2001). Other papers were also taken into consideration (Mucina 1993; Pott 1995). The nomenclature of vascular plants follows Mirek *et al.* (2002).

Study area

Geobotanic works were conducted in the central and eastern part of the Opole Silesia region. The investigation area covers ca. 800 km^2. The researches were focused on the area in which limestone outcrops of the Mesozoic origin occur (Fig. 1).

The characteristic feature of the soil cover within the study area is domination of Triassic rendzinas in the eastern part (the Silesian Upland), while around Opole, the prevailing soil type is the calcareous, fertile rendzina on the Cretaceous subsoil (Borkowski, Wojniak 1997a, 1997b).

Results

Phytosociological analyses allow to identify the *Caucalido-Scandicetum* association. The systematic position of that plant community was presented by Matuszkiewicz (2001) as follows:

Class: *Stellarietea mediae* R.Tx., Lohm. et Prsg. 1950
Order: *Centauretalia cyani* R.Tx. 1950
Alliance: *Caucalidion lappulae* R.Tx.1950
Association: *Caucalido-Scandicetum* (Libb.1930) R.Tx. 1937

Characteristics of *Caucalido-Scandicetum* (Libb. 1930) R.Tx. 1937

In the area under study, the above mentioned association is represented by nineteen relevés, containing a total of 96 species of segetal weeds. The number of species in one relevé ranged from 17 to 30 (Tab. 1). The patches of the associations appear in the impoverished form exclusively where Cretaceous humic rendzinas occur in cereal fields, mainly wheat crops. The only exception is a relevé taken in Strzebniów on a brown Triassic rendzina soil. The association develops predominately on heavy and heavy mixed humic rendzinas of soil pH in the range from 7.3 to 8.0. These soils are classified as the good wheat complex (2) and more rarely – as the defective wheat complex (3).

This fragmentary formation of the association in the study area is undoubtedly affected by the increase in farming intensity, the development in agro-technical methods, an increasingly effective cleaning of sowable seed, chemical weed control, and the mechanisation of soil tilling. Also significant are: the allocation of some arable land for non-farming uses (extracting useful minerals) and the expanding urbanisation of the Opole town, which in turn further reduces the range (area of occupation) of this association. The weeds susceptible to new agro-technical practices are eliminated although they have still been spreading together with seed lots.

Among numerous species characteristic for *Caucalido-Scandicetum*, only *Adonis aestivalis* and *Anagallis foemina* were found, with *Adonis aestivalis* being a taxon more often recorded in the study area (V^{th} degree of constancy). *Anagallis foemina* is a rarer species with lower degrees of constancy and coverage. The presence of only two characteristic species and the absence of many taxa diagnostic to the association, showing a high degree of faithfulness, precludes this association from being recognised as fully developed.

The following species which are classified as characteristic for the alliance *Caucalidion lappulae*, and reach high constancies, were noted: *Consolida regalis* (IV), *Euphorbia exigua* (IV), *Avena fatua* (III), *Aethusa cynapium* subsp. *agrestis* (III), and *Lathyrus tuberosus* (III). Among these species, the highest cover rate was attained by *Consolida regalis*. The group of weeds characteristic for this alliance also includes taxa less frequently recorded in patches, and characterised by lower constancy i.e.: *Valerianella dentata* (II), *Sherardia arvensis* (II), *Galium spurium* subsp. *spurium* (II), *Stachys annua* (I), *Fumaria vaillantii* (I), *Chaenorhinum minus* (I), *Melandrium noctiflorum* (I), *Geranium dissectum* (I), and also sporadically occurring: *Ranunculus arvensis*, *Neslia paniculata*, *Silene vulgaris*, and *Kickxia elatine*. Also worthy of attention are the taxa which are recognised as distinguishing the alliance, such as: *Camelina microcarpa* subsp. *sylvestris*, *Campanula rapunculoides*, and *Euphorbia platyphyllos*. Among the characteristic species of the *Centauretalia cyani* order, the highest constancies are attained by *Papaver rhoeas* (V), followed by *Lithospermum arvense* (IV) and *Matricaria maritima* subsp. *inodora* (IV). Out of the weed of the *Stellarietea mediae* class, only *Viola arvensis* (IV) has a high constancy, and among the accompanying species – *Galium aparine* (IV). The patches of the *Caucalido-Scandicetum* association are also distinguished by the presence of the

calciphilous taxa, associated with root crops, i.e.: *Veronica polita, V. opaca*, *V. agrestis*, *Lamium amplexicaule*, which, with the exception of *Lamium amplexicaule,* display low constancies.

In the study area, the *Caucalido-Scandicetum* association does not manifest internal diversification. In crop rotation, *Caucalido-Scandicetum* is coupled with *Lamio-Veronicetum politae*.

In the studied area, the impoverished patches of *Caucalido-Scandicetum* were recorded in cultivated fields in places where formations of Cretaceous limestone outcrops occur. *Caucalido-Scandicetum* were recorded in the right-bank side of Opole in the following quarters: Groszowice, Nowa Wieś Królewska, Zakrzów, Gosławice, Grudzice and Chabry, next between Chrzowice and Chrząszczyce, to the NW and to the W of Chrzowice, and also to the S of the Brzezie locality. The only location situated on an outcrop of Triassic rock is that found in Strzebniów (Fig. 1).

It was also observed that richer and better-developed patches of the association occurred along the edges of cultivated fields rather than inside the fields. The tendency of the species forming the association to 'escape' nearer the baulks or into root crops could be explained, *inter alia*, by the adaptation of these species to new requirements associated with the intensification of farming practices and with the presence of more favourable conditions prevailing at the edges of fields. This phenomenon has been also found by the researchers studying segetal communities (e.g. Siciński, Sowa 1980; Nalewaja 1993).

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Discussion

Phytosociological studies have demonstrated evident differences in the distribution of *Caucalido-Scandicetum* in the two areas compared (the area on the Cretaceous rendzinas and on the Triassic rendzinas). The patches of the association studied were found almost exclusively on the Cretaceous carbonate outcrops while only one relevé out of nineteen was analyzed in the outcrop of Triassic age carbonate rocks (Fig. 1).

Caucalido-Scandicetum is attached to the heavy and warm limestone soils (Kornaś 1972; Matuszkiewicz 2001), therefore an area with outcrops of carbonate rocks of the Cretaceous period with well-formed humic rendzinas, seems to be most suitable for this association. Despite favourable climatic conditions (the warm microclimate of the Opole region) and occurrence of humic rendzinas, the floristic composition of the species forming the association was poor. Among numerous species characteristic for *Caucalido-Scandicetum*, only two were recorded in the study area: *Adonis aestivalis* (V class of constancy) and *Anagallis foemina* (I class). Neither new species of weeds nor those reported earlier in publications, such as *Bupleurum rotundifolium*, *Caucalis platycarpos* or *Galium tricornutum* have been found. Nevertheless, the *Caucalido-Scandicetum* association is characterized by a large proportion of species closely associated with the *Caucalidion lappulae* alliance, among which the following show high degrees of constancy: *Consolida regalis* (IV) and *Euphorbia exigua* (IV), (Tab. 1).

The association described in this study is impoverished compared with the *Caucalido-Scandicetum* association reported earlier from the Cretaceous rendzinas of Opole and its close neighbourhood (Michalak 1972). At present, the following species characterizing the association, such as: *Galium tricornutum*, *Bupleurum rotundifolium* and *Caucalis platycarpos*, which were observed by Michalak in 1968, have not been found. When the current floristic composition of the *Caucalido-Scandicetum* association

has been compared with that from the study by Nalewaja (1993), the former lacks only *Bupleurum rotundifolium* which was observed in the Chabry quarter of Opole as late as in 1991. In his monograph, Szotkowski (1981) also distinguished the impoverished form of the association, in records from the SE area of the Opole province. The association is represented by 6 relevés taken in cultivated fields of grain crops on Triassic rendzinas, of which as many as 5 were obtained in the village of Droszkowice. Among the characteristic species of the *Caucalido-Scandicetum* association, this author recorded *Adonis aestivalis*, *Anagallis foemina*, *Caucalis platycarpos*, *Conringia orientalis* and *Stachys annua*, although these weeds had low degrees of coverage. When relating the results obtained by Szotkowski to the area comprising Triassic age rocks, it was found that the association had been disappearing on the Triassic rendzina soils. Throughout the vast area of the Chełm hump, only one patch representing the impoverished form of the association was found. In the publication by Węgrzynek (2003), who studied the segetal vegetation of the Silesian Upland, the author did not find patches representing *Caucalido-Scandicetum* but only a truncated community of the *Caucalidion lappulae* alliance.

The field observations concerning segetal vegetation in the study area revealed the processes behind the increasing disappearance of stenotopic characteristic species of *Caucalido-Scandicetum,* resulting in a deepening impoverishment of this association. A significant effect has undoubtedly been exerted by the intensification of farming practice in the Opole province an area with a long-standing reputation of sustaining a high level of farming culture. Additionally, a shrinking of the areas where the association occurs, caused by the creeping urbanisation of Opole or by the allocation of arable land to non-farming purposes has resulted in *Caucalido-Scandicetum* becoming an increasingly rare community on rendzina soils. The geological basement on which rendzinas develop is not without significance. The lower content of $CaCO_3$ in soils formed from hard, weathering-resistant limestones and Triassic dolomites with an admixture of sand is – in the opinion of the author – another factor which limits the occurrence of *Caucalido-Scandicetum* patches on the outcrops of carbonate rocks of the Triassic age. On the other hand, the rendzinas originating on Cretaceous formations are generally characterised by the soft and easily weathering material of the parental rock, which provides detrital minerals that are more valuable as soil-forming material. It is also supposed that the differences in air temperatures between the Cretaceous and Triassic areas may play a certain role in the frequency with which thermophilous weeds occur. The results of this study support the view, that the Cretaceous area with its specific microclimate and higher average air temperatures could be more suitable for the development of the *Caucalido-Scandicetum* phytocoenoses.

Conclusions

1. *Caucalido-Scandicetum* develops in warm habitats of alkaline reaction and may be regarded as a good indicator of this type of habitat.
2. *Caucalido-Scandicetum* is a rare, retreating association of cereal weeds which presently does not appear in Opole Silesia in its typical form, despite the potentially favourable habitat conditions occurring there.
3. The studies conducted in two types of carbonate habitats with different geological substrates (Cretaceous and Triassic), have shown that the Cretaceous areas are more suitable for the development and preservation of the calciphilous *Caucalido-Scandicetum* association, than the Triassic area.

Table 1. *Caucalido-Scandicetum* (Libbert 1930) R.Tx. 1937 impoverished form

Successive number of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	CONSTANCY	COEFFICIENT OF COVER
Date: day	9	30	28	2	2	5	27	9	9	7	13	9	16	5	20	20	30	6	6		
month	7	6	5	7	7	7	6	7	7	7	5	5	5	7	6	6	6	5	5		
year	2000	2001	2000	2000	2000	2001	2001	2000	2000	2000	2000	2000	2000	2001	2001	2001	2000	2000	2000		
Locality	CHR	BRZ	OGR	NWK	OGR	OZK	CHR	CHĄ	CHĄ	CHR	OGS	OGS	OCH	OZK	STB	OGD	BRZ	C/C	CHR		
Soil unit	2Rc	2Rc	2Rc	2Rc	2Rc	2Rc	2Rc	2Rc	2Rc	2Rc	2Rc	2Rc	2Rc	2Rc	2Rb	2Rc	2Rc	3Rc	3Rb		
pH of soil (1-5 cm)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	8	7.5	7.3	7.3	7.3	7.5	7.3		
Cover of cultivated plant (in %)	40	30	5	50	70	45	70	40	20	30	80	45	40	40	40	50	20	80	40		
Cover of weeds (in %)	50	70	40	40	40	40	40	50	80	80	30	40	30	60	70	60	60	20	25		
Number of species in the relevé	23	20	27	30	26	17	19	24	19	26	18	22	25	23	22	20	19	17	20		
Cultivated plants																					
Triticum aestivum	3	.	1	3	4	.	4	3	2	3	.	.	3	3	3	3	2	.	.		
Secale cereale	.	.	.	1	.	.	+	+	.	.	.	3	.	.	.	1	+	.	.		
Hordeum vulgare	.	.	.	.	.	.	+	.	.	.	5	.	.	.	.	.	.	.	3		
Brassica napus	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	5	.		
Hordeum distichon	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Ch.Ass. *Caucalido-Scandicetum*																					
Adonis aestivalis	1	1	+	+	2	3	1	1	1	1	1	1	1	1	1	1	+	+	+	V	618
Anagallis foemina	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	8
Ch.(loc.") D.*All. *Caucalidion lappulae*																					
Consolida regalis	.	+	+	2	1	.	2	2	2	2	2	2	2	2	2	2	3	.	.	IV	1242
Euphorbia exigua	.	2	+	1	1	+	+	+	.	+	+	+	+	+	.	.	+	.	.	IV	171
Avena fatua	1	.	.	.	+	+	.	+	1	+	.	.	.	+	1	+	+	+	.	III	100
Aethusa cynapium subsp. *agrestis*	2	2	+	.	+	.	.	.	1	.	.	.	+	1	1	+	+	.	.	III	276
Lathyrus tuberosus	.	+	+	+	+	.	.	.	.	.	+	+	.	+	.	.	.	.	+	III	21
Valerianella dentata	.	.	.	1	.	.	.	.	1	+	.	.	.	.	.	+	.	+	+	II	63
Camelina microcarpa subsp. *sylvestris**	.	.	.	+	.	.	+	.	.	.	.	+	+	.	.	1	.	.	.	II	37
Galium spurium subsp. *spurium*"	+	.	.	+	+	.	+	.	.	.	.	.	.	+	.	.	.	.	.	II	13
Sherardia arvensis	.	.	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	+	.	II	13

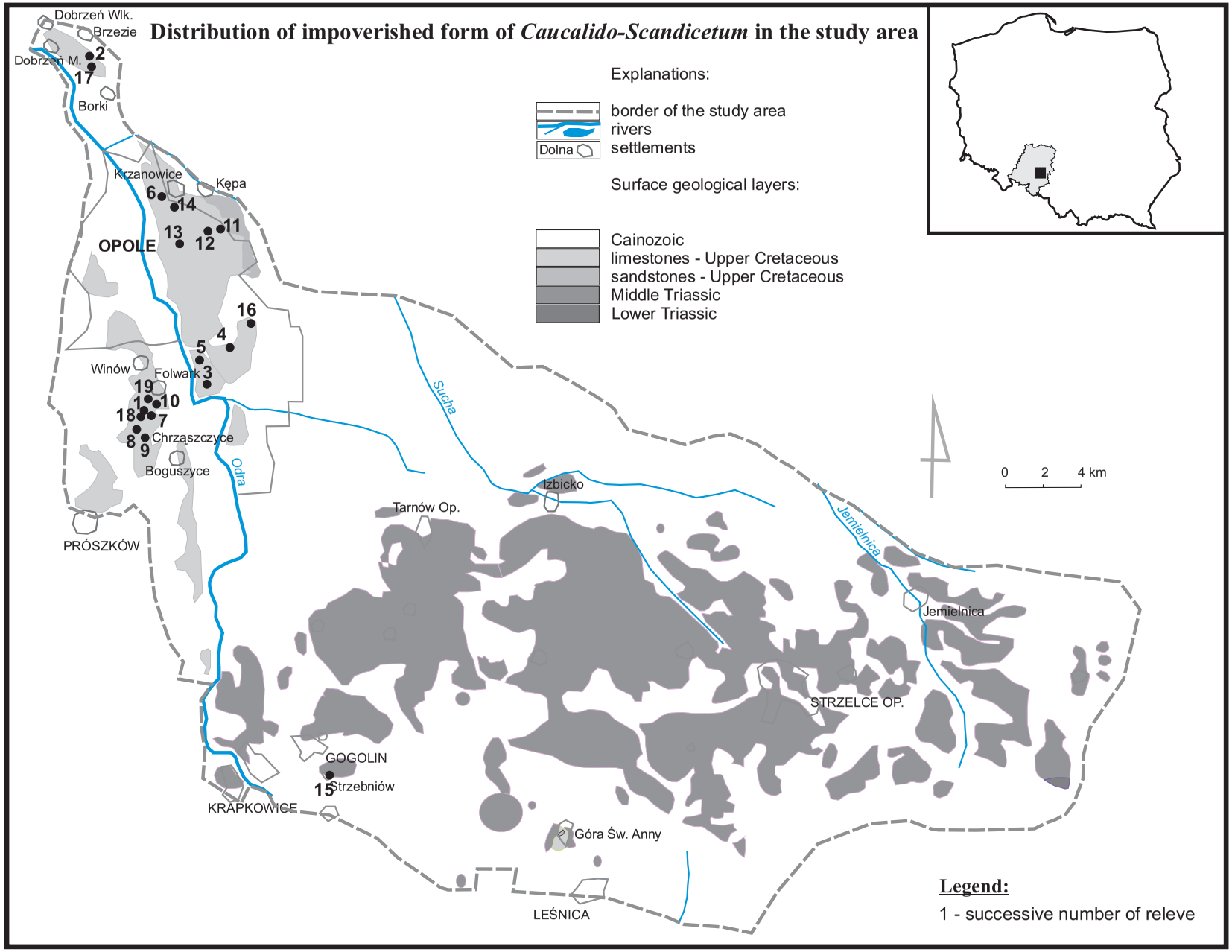
*Campanula rapunculoides**	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I	8
Stachys annua	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	5
Fumaria vaillantii	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I	5
*Euphorbia platyphyllos**	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	I	5
Chaenorhinum minus	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	I	5
Melandrium noctiflorum	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	I	5
Geranium dissectum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	I	5
Ch.O. *Centauretalia cyani*																					
Papaver rhoeas	.	.	3	1	1	1	1	+	1	3	+	1	+	2	3	2	1	1	2	V	1087
Lithospermum arvense	+	.	+	.	+	+	+	1	1	+	.	+	+	1	+	+	.	1	+	IV	134
Matricaria maritima subsp. *inodora*	1	.	.	.	+	.	+	2	3	2	+	1	1	1	.	.	.	+	+	IV	500
Apera spica-venti	1	.	.	.	+	.	.	+	+	+	.	.	.	1	+	1	+	.	.	III	95
Centaurea cyanus	+	.	.	.	1	.	1	.	.	.	.	.	+	.	.	.	1	+	.	II	84
Veronica hederifolia	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	+	+	II	13
Ch.O.*Polygono-Chenopodietalia*																					
Veronica persica	1	.	+	+	+	.	.	+	.	+	+	+	+	+	+	1	1	.	.	IV	105
Lamium amplexicaule	.	+	+	+	+	.	+	.	.	+	+	+	+	.	+	+	.	+	+	IV	34
Euphorbia helioscopia	.	+	+	+	+	+	.	.	.	+	+	+	+	.	+	+	+	.	.	IV	32
Geranium pusillum	.	+	.	.	.	.	+	+	+	.	.	.	.	.	+	.	+	.	.	II	16
Fumaria officinalis	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	+	.	II	82
Veronica polita	.	.	.	.	.	1	1	.	.	.	.	+	.	.	.	.	.	.	.	I	55
Veronica opaca	+	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	I	8
Alopecurus myosuroides	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	I	29
Lamium purpureum	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	I	5
Ch.Cl. *Stellarietea mediae*																					
Viola arvensis	1	+	+	.	.	.	+	+	+	+	+	+	+	+	+	.	.	1	+	IV	84
Fallopia convolvulus	.	2	+	+	+	.	+	.	.	.	+	.	+	.	1	.	+	+	1	III	166
Stellaria media	+	+	+	.	.	.	.	.	+	.	+	+	.	.	+	+	.	.	+	III	24
Anagallis arvensis	.	.	1	1	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	II	61
Thlaspi arvense	.	.	.	+	.	.	.	.	.	+	.	+	+	.	.	.	.	+	.	II	13
Descurainia sophia	+	.	+	.	.	.	.	.	.	.	.	.	+	+	r	.	.	.	.	II	11
Polygonum aviculare s.l.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	II	11

Lapsana communis	.	.	+	.	+	.	.	.	.	.	.	.	.	.	+	.	+	.	.	II	11
Capsella bursa-pastoris	.	.	+	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	.	II	11
Bromus sterilis	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	I	8
Myosotis arvensis	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	+	I	8
Others:																					
Galium aparine	+	.	+	.	.	+	.	+	+	.	+	+	+	+	+	+	.	1	+	IV	58
Arenaria serpyllifolia	.	.	.	.	+	.	.	+	+	1	.	.	.	.	.	.	.	.	+	II	37
Veronica arvensis	+	.	.	.	.	.	.	+	+	.	+	.	.	.	.	+	.	.	.	II	13
Convolvulus arvensis	.	.	.	.	.	.	.	+	+	+	.	+	.	+	.	.	.	.	.	II	13
Artemisia vulgaris	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	I	8
Galeopsis ladanum	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	5
Cirsium arvense	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	I	5
Medicago x *varia*	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I	5
Allium oleraceum	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	I	5
Myosotis discolor	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	I	5
Lolium perenne	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	I	5

Sporadic species: Cultivated plants: *Brassica rapa* subsp. *rapa* 2(3), *Sinapis alba* 8, *Zea mays* 6(3); Ch.All. *Caucalidion lappulae: Kickxia elatine* 5, *Silene vulgaris* 4, *Neslia paniculata* 18, *Ranunculus arvensis* 13; Ch.O. *Centauretalia cyani: Anthemis arvensis* 15; Ch.O. *Polygono-Chenopodietalia: Chenopodium album* 6, *Sonchus asper* 4, *Veronica agrestis* 12; Ch.Cl. *Stellarietea mediae: Amaranthus retroflexus* 6, *Sinapis arvensis* 6, *Sisymbrium altissimum* 6; Others: *Achillea millefolium* 2, *Astragalus cicer* 2, *Berteroa incana* 8, *Campanula trachelium* 3, *Centaurea stoebe* 14, *Centaurea scabiosa* 4, *Cerinthe minor* 19, *Cirsium vulgare* 14, *Coronilla varia* 4, *Daucus carota* 1, *Diplotaxis muralis* 8, *Echium vulgare* 4, *Elymus repens* 1, *Falcaria vulgaris* 3, *Fumaria schleicheri* 4, *Hypericum perforatum* 10, *Linaria vulgaris* 4, *Lolium multiflorum* 6, *Lotus corniculatus* 10, *Medicago falcata* 8, *Medicago lupulina* 14, *Melandrium album* 16, *Poa compressa* 11, *Rubus caesius* (c) 8, *Salvia verticillata* 4, *Sedum maximum* 4, *Taraxacum officinale 2(1), Thlaspi perfoliatum 19, Trifolium pratense* 3, *Vicia tenuifolia* 12.

Localities of relevés: 1, 7 - to the west from Chrzowice; 2, 17 - to the south from Brzezie; 3, 5 - Opole (Groszowice); 4 - Opole (Nowa Wieś Królewska); 6, 14 - Opole (Zakrzów); 8, 9 - to the south-east from Chrząszczyce; 10, 19 - to the north-west from Chrzowice; 11, 12 - Opole (Gosławice); 13 - Opole (Chabry); 15 - Strzebniów; 16 - Opole (Grudzice); 18 - between Chrzowice and Chrząszczyce.

Explanations: Soil-agricultural complexes: 2 - good wheat complex, 3 - defective wheat complex; Type and subtype of soils: Rb - brown rendzinas, Rc - chernozemic rendzinas.


Distribution of impoverished form of *Caucalido-Scandicetum* in the study area
Explanations:
border of the study area
rivers
settlements
Surface geological layers:
Cainozoic
limestones - Upper Cretaceous
sandstones - Upper Cretaceous
Middle Triassic
Lower Triassic
Dobrzeń Wlk.
Brzezie
Dobrzeń M.
Borki
Krzanowice
Kępa
OPOLE
Winów
Folwark
Chrząszczyce
Boguszyce
PRÓSZKÓW
Odra
Sucha
Izbicko
Tarnów Op.
Jemielnica
STRZELCE OP.
GOGOLIN
Strzebniów
KRAPKOWICE
Góra Św. Anny
LEŚNICA
0 2 4 km
Legend:
1 - successive number of releve

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