UNIVERSITY OF SILESIA

THREATS, PROTECTION AND TRANSFORMATION OF VEGETATION OF THE UPPER SILESIA AND ADJACENT AREAS

Edited by
Stanisław Wika and Gabriela Woźniak






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This publication is devoted to memory of Professor Florian Celiński, the supervisor of Department of Geobotany and Nature Protection.
To celebrate the 5th anniversary of Professor Florian Celiński's death, the Department of Geobotany and Nature Protection (Faculty of Biology and Environmental Protection, University of Silesia) organised in Katowice, 14-15 September 2006, an International Conference under the title "The role of geobotany in the protection of biological diversity".

The authors are responsible for the quality of English translation of the papers

Cover photos:
Agnieszka Błońska, Gabriela Woźniak
The photo of Professor Florian Celiński
- delivered by Mrs. Teresa Rukasz-Celińska - Professor Celiński's wife

Typografic design: Joanna Chwoła
Prepared to the print by the Wydawnictwo VERSO
Impression: 150

ISBN 978-83-906910-9-1
Printed in Poland

Editor: Jerzy B. Parusel

Published by the Upper Silesian Nature Heritage Centre
Katowice 2007

PROF. ZW. DR HAB. FLORIAN CELIŃSKI

(1924-2001)

In 2006 we have celebrated the fifth anniversary of prof. Florian Celiński's death. He was the coorganizer of the Faculty of Biology and Environmental Protection, and was the supervisor of the Department of Geobotany and Nature Protection at the University of Silesia. For a long time he was also a president of the Voivodship Comission of the Nature Protection in Katowice and an active member of the Comission in Opole, as well.

His scientific career was connected with two academic centers: Poznań and Katowice. Prof. Florian Celiński was particularly interested in research on flora and vegetation of Pomorze Zachodnie, Ziemia Lubuska, Wielkopolska, Podlasie and the South Macroregion (Wyżyna Śląska, Pogórze Cieszyńskie, Wyżyna Krakowsko-Wieluńska and Beskidy).

Prof. Florian Celiński has written numerous papers and synthesis about termophilous oak forests, beech forests and the non-forest vegetation (particularly the halophilous, meadow and xerothermic). He has been also an author of a few plant communities, new for science. He was very enthusiastic propagator of the idea of creation the Częstochowski National Park and the Szczeciński National Park. He had a great influence on the increase of the Babiogórski and the Woliński National Parks. Prof. Florian Celiński prepared the projects of 50 nature reserves. Many of them were established. He was, with his co-workers, a member of the scientific crew working out the national project of mapping the potential vegetation of Poland 1:100000. He cooperated with his masters: prof. Z. Czubiński and prof. W. Matuszkiewicz, his colleagues – professors: B. Adamczyk, Z. Denisiuk, M. Filipek, St. Myczkowski, H. Piotrowska, K. Rostański, A. Sendek, K. Tobolewski, T. Wojterski and with his students: B. Babczyńska-Sendek, S. Balcerkiewicz, S. Cabała, A. Czylok, M. Kraska and S. Wika as well.

Prof. F. Celiński maintained numerous scientific contacts with foreign scientists: J. Braun-Blanquet, J. Géhu, R Tüxen, E. Balátova-Tuláčkova and M. Kincl.

As a good organizer he helped in establishing of the Ecology Department on the Faculty of Biology and Earth Sciences at the University of Adam Mickiewicz in Poznań and the Department of Geobotany and Nature Protection on the Faculty of Biology and Environmental Protection at the University of Silesia in Katowice.

Prof. dr hab. Stanisław Wika

PREFACE

We would like to present the next book which is dedicated to our Master - Prof. dr hab. Florian Celiński, the supervisor of Department of Geobotany and Nature Protection. The first one "Silesian voivodeship forests – yesterday, today and tomorrow" (Lasy województwa śląskiego – wczoraj, dziś, jutro) was published seven years ago.

The presented book "Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas" is published on the fifth anniversary of Prof. Celiński's death. The book title and the content of 15 papers, contributed by his co-workers, friends, students and colleagues, include the wide spectrum of Profesor's scientific interests.

That way, we as his scholars, would like to express our gratitude for the comprehensive knowledge and creative power which he bequeathed us during his work at the University.

We would like also to convince the reader that none of our Professor's ideas was lost or forgotten. The research he started will be continued in the fields of geobotany, nature protection, environmental protection, as well as, the studies on vascular flora.

Prof. dr hab. Stanisław Wika
Dr Gabriela Woźniak

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ISBN 978-83-906910-9-1

THE POSSIBILITIES OF META-PLANTATION OF *COCHLEARIA POLONICA* IN THE VICINITY OF WATER-HEADS OF JAWORZNIK STREAM IN THE SILESIAN UPLAND

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ABSTRACT. *Cochlearia polonica* is an endemic species of Poland. The natural location of *Cochlearia polonica* in the Błędów Desert was destroyed in the second half of 20th century. It was caused by man-induced changes in the natural habitat conditions as a result of increasing sand exploitation for industry purposes. As a result of preliminary fieldwork observations carried out in the spring 2003 it was stated that potential habitats for *Cochlearia polonica* meta-plantation can be located in water-heads of Jaworznik stream (Silesian Upland, Twardowice Plateau).
The aim of the study was to describe plant communities associated with water-heads of the Jaworznik stream, as well as, the water analysis in the selected sites to examine possibilities of *Cochlearia polonica* meta-plantation in new location in the Silesian Upland.
The vegetation usually occurs below the head-streams of the Jaworznik stream. *Cardamino amarae-Beruletum erecti*, *Nasturtietum officinalis* and rarer phytocoenoses: *Glycerietum maximae*, *Scirpetum sylvatici* and *Mentho longifoliae-Juncetum inflexi* were recorded in the upper parts of the stream.

KEY WORDS: *Cochlearia polonica*, meta-plantation, higrophilous non-woodland plant communities, Silesian Upland

INTRODUCTION

Cochlearia polonica E. Fröhl. is biennial, hemicryptophyte belonging to *Brassicaceae* (*Cruciferae)* family. This is an endemic species from the group of apoendemic species (KAŹMIERCZAKOWA 2004) – which the only natural stand was located near Olkusz close to south-western margin of Błędów Desert (the Kraków-Częstochowa Upland), in the area of springs and upper section of Biała river, left tributary of Biała Przemsza river (PIECH 1924). As KWIATKOWSKA (1957, 1962) reports, as well as later KWIATKOWSKA and KAŹMIERCZAKOWA (1992), the species was noted along a few of right tributaries of Biała river and in the upper section of

Sztolnia Ponikowska – an anthropogenic water course, formed due to water drainage by zinc and lead mines in Pomorzany near Olkusz in 17th century.

The natural stand of *Cochlearia polonica* was destroyed in the second half of 20th century because of man-induced changes in natural conditions in consequences of increasing sand exploitation in the Błędów Desert for industry purposes (BURSKA 1995, after KWIATKOWSKA 1993). In 1970 more than ten specimens were introduced into the vicinity of water-head of Centuria stream, where the plant established and formed sustainable and expanding population. Using plant material from this stand, 16 attempts of meta-plantation have been made yet. Only two of them have succeeded: head-streams of Wiercica in Złoty Potok near Częstochowa and in water-head of Rajecznica river close to Koniecpol (KWIATKOWSKA 2001, KAŹMIERCZAKOWA l.c.). Both secondary populations are not abundant – numbers of individuals in populations are estimated to several tens. Furthermore, they are characterized by weak viability, and they do not increase in abundance. The survival of this species requires both conservation its existing stands (especially that one in water-heads of the Centuria river, because this population is likely to develop permanently) including constant monitoring, as well as new attempts to create substitute stands in the area of the Kraków-Częstochowa Upland (KAŹMIERCZAKOWA 2004).

As a result of initial fieldwork observations carried out in spring 2003 it was stated that potential habitats for purposes of meta-plantation of *Cochlearia polonica* can be located in water-heads of Jaworznik stream. They are situated in Będziński administrative district in the central part of Silesian province. According to geomorphological division of the Silesian Upland (GILEWSKA 1972) the valley of Jaworznik lies within Twardowice Plateau occupying its western part. The mentioned area was strongly transformed with regard to hydrology. There was a sand-pit, exploiting quite thick layer of sand covering the stream valley (GILEWSKA 1963). It is characterized by well-developed system of springs. The conditions occurring in the head-streams and in its upper section are similar to those reported in the existing locality of *Cochlearia polonica* in Hutki-Kanki where Centuria river begins. The aim of the work was to characterize plant communities associated with water-heads of Jaworznik stream.

MATERIAL AND METHODS

Studies on vegetation overgrowing head-streams of upper parts of water courses forming stream Jaworznik, as well as water analysis in selected sites were conducted to examine possibilities of meta-plantation of *Cochlearia polonica* in new stand in the Silesian Upland. The phytosociological research were performed in one vegetation season (in 2005) from the half of June till the half of September. In total 30 phytosociological relevés using Braun-Blanquet method were made (FUKAREK 1967, SCAMONI 1967). Only homogenous patches were chosen; the transitory zones between plant communities were omitted. Twenty eight relevés were arranged in phytosociological tables. The classification and nomenclature of syntaxa follow "The guide for plant communities of Poland" (MATUSZKIEWICZ 2002). Only in case of *Cardamino amarae-Beruletum erecti* the suggestion given by BRZEG (1990) was used.

During the studies two analyses of physical-chemical properties of water: 3rd May and 30th August 2005 were carried out. The samples were taken from the head-streams of Centuria in Hutki-Kanki and from the three springs of the Jaworznik valley (for the first time only two sites were taken into analyses). In the area of the described valley sites for water analysis were chosen based on morphology of water-heads and river-bed, the efficiency of springs and type of substratum. The physical-chemical studies included: pH, conductivity, neutrality, chlorides, nitrites, ammonia, iron, phosphates, phosphorus, ammonium nitrogen, and nitrite nitrogen. The

studies were conducted using tests and reagents of Merck company. Also water temperature was measured.

Results

1. Characteristics of plant communities of the study area

5 association and 1 plant community were distinguished as a result of phytosociological studies on vegetation of water-heads and upper part of Jaworznik stream. Their syntaxonomical affinity and phytosociological characteristics are introduced below.

Class: *Phragmitetea* R. Tx. et Prsg 1942
Order: *Phragmitetalia* Koch 1926
Alliance: *Phragmition* Koch 192
Association: *Glycerietum maximae* Hueck 1931
Alliance: *Sparganio-Glycerion fluitantis* Br.-Bl. et Miss. in Boer 1942
Association: *Nasturtietum officinalis* (Seib. 1962) Oberd. et al. 1967
Association: *Cardamino amarae-Beruletum erecti* Turoňová 1985
Class: *Molinio-Arrhenatheretea* R. Tx. 1937
Order: *Trifolio fragiferae-Agrostietalia stoloniferae* R. Tx. 1970
Alliance: *Agropyro-Rumicion crispi* Nordh. 1940 em. R. Tx. 1950
Association: *Mentho longifoliae-Juncetum inflexi* Lohm. 1953 n.inv.
Order: *Molinietalia caeruleae* W. Koch 1926
Community: *Chaerophyllum hirsutum*
Alliance: *Calthion palustris* R. Tx. 1936 em. Oberd. 1957
Association: *Scirpetum sylvatici* Ralski 1931

Glycerietum maximae Hueck 1931

The rush with *Glyceria maxima* as a dominant occurs in the Jaworznik valley quite rarely. The only found phytocoenosis occurs on sandy-organic shoal in the meander of the river. In the found vegetation patch 1 phytosociological relevé was done: the relevé no. 1/005; date 14.07.2005; area – 20 m^2; herb layer cover c – 95%; species richness – 5. Ch. *Ass. + *Phragmitetea*: **Glyceria maxima* (5.5), *Veronica beccabunga* (+.2); Accompanying species: *Equisetum arvense* (+.2), *Mentha longifolia* (1.2), *Myosotis palustris* (1.2).

The cover-abundance of herb layer is almost complete – 95%. The floristic composition is very poor and dominated by *Glyceria maxima*. Apart from it, the *Phragmitetea* class is represented by *Veronica beccabunga*. Amongst accompanying species only character species for the alliance *Agropyro-Rumicion crispi*, wet grasslands, from the class *Molinio-Arrhenatheretea*: *Mentha longifolia* and *Myosotis palustris* are present.

Nasturtietum officinalis (Seib. 1962) Oberd. et al. 1967 (Tab. 1)

The low-herb rush community formed by *Nasturtium officinale* occurs quite frequently, occupying banks of slow-flowing (sometimes with very slow flow) clear and cool water courses and sandbars within current or along ditches. The water level within mentioned phytocoenoses was quite differentiated, ranged from 0 to 20 cm. During the studies 7 phytosociological relevés were done.

The cover of ground flora is high – from 70 to 100% (on the average 90%). *Nasturtium officinale* plays the crucial role in its structure and determines the appearance of the community. It is accompanied by many species of the *Phragmitetea* class (*Mentha aquatica* is characterized by a high constancy and a high cover-abundance), and especially *Veronica beccabunga*, *Glyceria fluitans* from the alliance *Sparganio-Glycerion fluitantis*. Such species composi-

tion, appropriate in relation to syntaxonomical affinity to *Nasturtietum officinalis*, is also represented by the group of species of the class *Molinio-Arrhenatheretea* (*Ranunculus repens* and *Agrostis stolonifera* from the alliance *Agropyro-Rumicion crispi* are very frequent). The moss layer is developed in some patches and is characterized by rather low coverage (10-20%).

Cardamino amarae-Beruletum erecti Turoňová 1985 (Tab. 2)

The association *Cardamino amarae-Beruletum erecti*, for the first time described by TUROŇOVÁ (1985), is the most frequent plant community within the river-beds of water courses of the valley of Jaworznik. Its phytocoenoses were located in small water courses – both in streams and in ditches with flowing water – and in the vicinity of the head-streams. Also emerging patches but close to the current were observed. These parts grew on sandbars within or along banks of the stream. Water, with which aforementioned vegetation is associated, was typified by purity, low temperature and apparent flow. Its depth varied between 0 (in the case of complete emergence) to 30 cm. In total 13 phytosociological relevés were made. All patches were developed in shaded sites, on nutrient-poor mineral (sandy) habitats and were of small size (area estimated to 2-15 m^2, on the average 7 m^2).

The phytocoenoses *Cardamino amarae-Beruletum erecti* have low coverage of herb plants 70-95% (only one patch had lower cover – 60%) and are species-poor: 5-13 species, mean species richness estimates to *ca*. 8. The moss layer usually is not developed or is insignificant. Such species poverty results from the dominance of *Berula erecta* or of *Mentha aquatica*. The distinguishing species *Cardamine amara* occurs only in some patches which were very frequently free from *Berula erecta*. The floristic composition of depicted phytocoenoses is enriched by the representatives of classes: *Phragmitetea* and *Molinio-Arrhenatheretea*. The collected relevés can be divided into two groups, differed in biotopic and floristic aspects, what further became the basis of distinguishing of two variants. The typical variant (relevés 1-6) include the patches growing the channel beds of water courses, permanently flooded with fast flow. There, *Berula erecta* predominates but contribution of species of the class *Molinio-Arrhenatheretea* or differentiation of these species is low. The variant with *Myosotis palustris* (relevés: 7-13) are the phytocoenoses of sandbars, which emerge above the surface of water. There are never flooded but only moist and characterized by the dominance of *Mentha aquatica*, the lack of *Berula erecta*, the presence of *Cardamine amara* and stable diversified participation of species from the *Molinio-Arrhenatheretea*. The additional reason for distinguishing the variant with *Myosotis palustris* is the abundant occurrence of this species, treated as locally distinguishing taxon of the mentioned association, what was underlined by KĄCKI et al. (1998).

Mentho longifoliae-Juncetum inflexi Lohm. 1953 n. inv. (Tab. 3)

Mentho longifoliae-Juncetum inflexi is the community strongly associated with the stream. Its patches occupied first of all habitats of mineral (sandy) or organic-mineral sandbars emerging above the water surface, as well as in the neighbourhood of the head-stream. The water of mentioned biotopes was clean, cool and slow.

The patches of *Mentho longifoliae-Juncetum inflexi* are characterized by permanent, high coverage of the herb layer (90-100%). Amongst plants characteristic for the association *Mentha longifolia* is species of quite high constancy. Its abundance in particular relevés is different (from 2 to 5). The another character species *Juncus inflexus* – which scores the occurrence optimum in this community, was noted only in half number of relevés (as a dominant only in one relevé). The essential group is composed by species from the *Molinio-Arrhenathretea* class (more frequently in 1 and 2 relevés), among others: *Equisetum palustre* and *Agrostis stolonifera*. Species of *Agropyro-Rumicion crispi* have lower contribution there. Rush species,

the representatives of the *Phragmitetea* class e.g. *Scropularia umbrosa* or *Mentha aquatica*, make larger contribution. Amongst accompanying species *Eupatorium cannabinum* distinguishes itself by a high constancy and cover-abundance.

Community *Chaerophyllum hirsutum* (Tab. 4)

Along one of the studied streams below water-head the community with *Chaerophyllum hirsutum* has been formed. Both patches occupied habitats situated near the stream, were very humid, and partially flooded. Only two relevés were made in this community. The phytocoenoses, distinguished on the basis of the domination of *Chaerophyllum hirsutum*, are characterized by the considerable participation of the herb layer (90-95%). Apart from *Chaerophyllum hirsutum*, higher contribution to the structure of the community is made by *Urtica dioica* and *Rubus plicatus*, and from mosses – *Sciuro-hypnum oedipodium.* Not abundantly the species from the *Molinio-Arrhenathretea* class are present. The patches of the mentioned community are of small size (*ca*. 10-30 m^2).

Scirpetum sylvatici Ralski 1931

On the moist and silted up sandbar, above the stream surface, within the river-bed of the stream only one patch of *Scirpetum sylvatici* was recorded. It has occupied small area westwards from water reservoir in Rogoźnik. Only 1 phytosociological record was collected there: relevé no. 2/020; date: 02.09.2005, area – 10 m^2, cover layer of herbs c – 95%, number of species – 7; Ch. Ass.: *Scirpus sylvaticus* (5.5); Ch. *Agropyro-Rumicion crispi* + *Molinio-Arrhenatheretea*: *Agrostis stolonifera* (+.2), *Carex hirta* (1.2), *Ranunculus repens* (+); Accompanying species: *Cardamine amara* (1.2), *Equisetum arvense* (1.2), *Solanum dulcamara* (1.2). The dense and compact layer of the ground flora is mainly composed by *Scirpus sylvaticus*. Another distinguishing group are species from the class *Molinio-Arrhenatheretea*, characteristic for the alliance *Agropyro-Rumicion crispi*. Their role in phytocoenosis, likewise other remaining accompanying species (e.g. *Cardamine amara*, *Solanum dulcamara*) is small. These plants indicate moist, flooded nature of this community.

The dominance of *Scirpus sylvaticus* and poor species richness, as well as swampy nature of biotopes correspond with typical variant distinguished by Cabała and Greń (2002).

2. Characteristics of habitat conditions of the head-streams

The sites of water-heads selected for physical-chemical analyses of water on the basis of field observations have the traits appropriate for development of *Cochlearia polonica*. These are: the adequate sandy (sandy-organic) substratum, not too fast flowing water, efficiency of water-heads which do not undergo considerable fluctuations. The results of water quality survey sampled from the three springs of Jaworznik and from the head-stream of substitutive stand of *Cochlearia polonica* in Hutki-Kanki was introduced in the Table 5.

The possible success of meta-plantation of *Cochlearia polonica* and the sense of this activity depends on some factors. The most important, apart from habitat requirements of the species, are the abiotic conditions: morphology of head-streams and of river-beds, efficiency of springs, type of substratum, chemical and physical traits, temperature of water, and light conditions. The first three factors were included during selection of water-heads for studies. All stands meet these requirements. However, physical-chemical properties of water with regard to some aspects differ from the substitutive stand of *Cochlearia polonica*. The most significant differences concern water hardness, neutrality, conductivity, as well as contents of dissolved organic matter. High values were reported in the case of phosphorus and phosphates in Twardowice-Góra Siewierska. However, there is no information about negative impact of these factors on growth and development of *Cochlearia polonica*. The most important parameters for persist-

ence of the species i.e. pH and water temperature are similar in all sites: pH is neutral, temperature of water does not exceed 10.5º C (mean 9.0º C), in spite of quite high temperatures during daytime. These temperatures favors development of *Cochlearia polonica*.

The light requirements occurring in head of stream and in upper part of water courses result from vegetation growing there. In surrounding of the head-streams there are only forest communities. Their canopy is dense which would be able to affect negatively the possible future population of the studied species. The most favourable conditions exist in the area of Rogoźnik-pond. It is associated with considerable area of heads of stream and therefore shading there is lower. However, vegetation of springs is not strongly differentiated. The area of vauclusian springs is usually not grown by vegetation (what can reflect unfavourable conditions), though in Rogoźnik-pond the domination of *Scrophularia umbrosa* is apparent. On one hand it makes this area more attractive for plants, and on the other hand the presence of such expansive species probably discourages the sense of meta-plantation. There is a lack of typical spring communities of the *Montio-Cardaminetea* class. The vegetation develops the most frequently in the front of the springs or in upper parts of water courses. These are mainly *Cardamino amarae-Beruletum erecti* and *Nasturtietum officinalis* and rarely *Glycerietum maximae*, *Scirpetum sylvatici* and community *Mentho longifoliae-Juncetum inflexi*.

The sites chosen for meta-plantation of *Cochlearia polonica* do not differ significantly in relation to biotopic conditions as in current stand in head of streams of Centuria. Also some dominant species observed in phytocoenoses of the valley of Jaworznik, are to be found in *Cochlearietum polonicae* in Hutki-Kanki, e.g. *Berula erecta* and *Mentha longifolia.* This is important for purposes of meta-plantation of *Cochlearia polonica.* Although all 3 sites seem to be appropriate for realization of the project, the best conditions occur in the head-streams in Rogoźnik-pond. Before meta-plantation of *Cochlearia polonica* the problem of shading and presence – and in the case of Rogoźnik-pond – the expansion of light-demanding species *Scrophularia umbrosa* (ZARZYCKI et al. 2002) should be solved. Perhaps thinning of tree stand could help this situation. The surroundings of water reservoirs in Rogoźnik with head-streams of Jaworznik are proposed to became the protected landscape area.

The established plans of spatial management of Bobrowniki, suggest their protection within the SPA (Special Protection Areas). This causes localization of any objects which might contaminate underground waters to be forbidden. It is planned to preserve natural river-bed of Jaworznik and protection of springs (Studium uwarunkowań... 1998). Before the attempt of meta-plantation is made it is advisable to protect additionally an area of spring of Rogoźnik-pond. The planned protection forms ought to guarantee preservation of appropriate conditions for development of *Cochlearia polonica* population in new stands of the species.

CONCLUSIONS

1. The area of vauclusian springs of the Jaworznik in the Silesian Upland is very frequently free of vegetation. Only in the area of Rogoźnik-pond there is massive occurrence of *Scrophularia umbrosa*. There are no typical plant communities of the *Montio-Cardaminetea* class.
2. The vegetation usually occurs below the head-streams. In upper parts of streams these are the patches: *Cardamino amarae-Beruletum erecti* and *Nasturtietum officinalis* and rarer phytocoenoses: *Glycerietum maximae*, *Scirpetum sylvatici* and *Mentho longifoliae-Juncetum inflexi*.
3. In all studied water-heads of the stream Jaworznik favourable conditions for development of *Cochlearia polonica* were recorded: pH and temperature of water.
4. In analysed head-streams and in upper sections of water courses there are unfavourable light

conditions. The shading is caused by the presence of adjoining forest communities. The necessary treatment preceeding meta-plantation seem to be thinning of tree stand in the vicinity of head-streams.

5. The conditions occurring in springs in the valley of Jaworznik, both in floristic and biotopic aspects, are similar to those occurring in the present stand of *Cochlearia polonica* in the head-streams of Centuria.
6. The best site for meta-plantation is the area of Rogoźnik-pond which after this treatment should be protected as an area of ecological interest.

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Table 1. *Nasturtietum officinalis* (Seib. 1962) Oberd. et al. 1967

Successive number of relevé	1	2	3	4	5	6	7	CONSTANCY
No. of relevé	1/003	5/012	6/012	3/014	2/021	4/014	6/022	
Date	30.06. 2005	17.08. 2005	17.08. 2005	22.08. 2005	05.09. 2005	22.08. 2005	09.09. 2005	
Cover of herb layer c in %	100	90	70	95	95	90	80	
Cover of moss layer d in %	-	-	20	zn	10	-	-	
Area of relevé in m^2	10	2	10	10	6	6	5	
The number of species in the relevé	6	5	7	8	9	7	12	
Ch. *Nasturtietum officinalis*								
Nasturtium officinale	5.5	5.5	3.3	3.4	5.5	2.2	4.4	V
Ch. *Sparganio-Glycerion fluitantis* ^ + *Phragmitetea*								
Mentha aquatica	.	2.2	3.3	3.3	.	1.2	1.2	IV
Veronica beccabunga ^	.	+	1.2	.	2.2	5.5	2.2	IV
Glyceria fluitans ^	.	1.2	.	4.4	.	.	2.3	III
Berula erecta ^	+	.	.	.	.	.	1.2	II
Phragmites australis	+	.	.	.	.	.	1.2	II
Carex acutiformis	+	.	.	.	.	.	.	I
Ch. *Agropyro-Rumicion crispi* ° + *Molinio-Arrhenatheretea*								
Ranunculus repens °	.	.	.	2.2	+	2.2	+.2	III
Agrostis stolonifera °	.	.	.	+.2	2.3	.	.	II
Cirsium oleraceum	.	.	.	.	.	2.2	.	I
Myosotis palustris	.	.	.	.	.	.	+.2	I
Accompanying species								
Equisetum arvense	.	.	.	+	+	+	.	III
Epilobium parviflorum	.	1.2	.	.	.	.	1.2	II
Solanum dulcamara	.	.	2.2	.	1.2	.	.	II
Cratoneuron filicinum d	.	.	.	+.2	2.2	.	.	II

Species with 1 occurrence: *Epilobium roseum* 3 (1.2); *Eupatorium cannabinum* 1; *Geranium robertianum* 5 (1.2); *Lemna minor* 1 (2.2); *Lycopus europaeus* 3 (1.2); *Pellia epiphylla* 3d (2.3); *Polygonum hydropiper* 6; *Ranunculus flammula* 7; *R. sceleratus* 7; *Rumex obtusifolius* 7; *Stellaria media* 4 (1.2); *Urtica dioica* 5 (1.3).

Table 2. *Cardamino amarae-Beruletum erecti* Turoňová

Succesive number of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	CONSTANCY
No. of relevé	3/020	4/004	2/003	2/007	2/009	3/007	7/022	2/010	5/021	4/021	2/016	5/013	8/010	
Date	02.09. 2005	08.07. 2005	30.06. 2005	20.07. 2005	08.08. 2005	20.07. 2005	09.09. 2005	10.08. 2005	05.09. 2005	05.09. 2005	27.08. 2005	19.08. 2005	10.08. 2005	
Cover of herb layer c in %	90	95	95	80	80	95	60	90	90	70	95	80	70	
Cover of moss layer d in %	-	-	-	-	-	-	45	zn	-	-	zn	-	-	
Area of relevé in m²	15	5	10	5	5	6	4	5	2	10	6	5	8	
The number of species in the relevé	7	8	7	7	5	5	9	13	5	8	13	7	8	
Variant (with)	typical						*Myosotis palustris*							
Ch. + D. *Cardamino amarae-Beruletum erecti* °														
Berula erecta	5.5	4.4	5.5	5.5	5.5	2.3	2.2	2.2	.	.	.	.	.	IV
Cardamine amara °	.	.	.	.	.	.	.	+	2.3	2.3	+	+.2	.	II
Ch. *Phragmitetea*														
Mentha aquatica	.	3.3	.	2.3	.	5.5	.	4.4	2.2	3.4	4.4	5.5	4.4	IV
Phragmites australis	.	+	+	.	1.2	.	1.2	.	.	.	.	2.2	.	II
Glyceria plicata	.	.	2.2	.	.	.	1.2	.	.	.	.	+	.	II
Sporadic species: *Carex acutiformis* 2 (1.2), 13; *C. pseudocyperus* 7 (2.2), 8 (1.2); *Equisetum fluviatile* 2.														
Ch. *Molinietalia* [a] + *Molinio-Arrhenatheretea*														
Myosotis palustris [a]	.	.	+	.	.	.	.	2.3	5.5	2.3	1.2	2.2	1.2	III
Agrostis stolonifera	.	.	.	.	.	+	.	2.3	1.2	.	2.3	.	+.2	II
Equisetum palustre	.	.	r	+	.	.	2.3	.	.	.	.	.	.	II
Juncus effusus [a]	.	.	.	.	.	.	.	1.2	.	.	2.3	.	+	II
Sporadic species: *Carex hirta* 11, 13; *Cirsium oleraceum* [a] 10 (2.3); *C. palustre* [a] 7 (1.2); *Deschampsia caespitosa* [a] 10 (1.2), 12 (1.3); *Mentha longifolia* 1 (3.4), 7 (3.4); *Poa trivialis* 11; *Ranunculus repens* 10 (1.2), 11; *Scirpus sylvaticus* [a] 2 (3.3).														
Accompanying species														
Equisetum arvense	.	+.2	.	1.2	+	3.3	.	+.2	.	1.2	+.2	.	.	III
Eupatorium cannabinum	1.2	.	.	1.2	.	1.2	1.2	1.2	.	.	.	.	.	II
Epilobium parviflorum	+	.	+	.	.	.	.	+.2	.	.	.	.	+	II
Lycopus europaeus	.	1.2	.	4.4	2.3	.	.	.	.	.	.	.	.	II
Solanum dulcamara	2.2	.	1.2	.	.	.	.	.	.	+	.	.	.	II
Sporadic species: *Alnus glutinosa* 13 (1.2); *Bryum pseudotriquetrum* 11d; *Carex elongata* 8; *Cratoneuron filicinum* 8d; *Epilobium hirsutum* 8 (1.2); *E. obscurum* 11; *E. roseum* 9, 12; *Equisetum variegatum* 4; *Mentha arvensis* 5; *Palustriella commutata* 7d (3.4); *Pellia epiphylla* 11d; *Rumex conglomeratus* 1 (1.2); *Solidago serotina* 11; *Tussilago farfara* 1.														

Table 3. *Mentho longifoliae-Juncetum inflexi* Lohm. 1953 n. inv.

Successive number of relevé	1	2	3	4	5	6	CONSTANCY
No. of relevé	4/007	8/001	4/010	9/001	2/002	2/015	
Date	20.07. 2005	23.06. 2005	10.08. 2005	23.06. 2005	28.06. 2005	25.08. 2005	
Cover of herb layer c in %	90	100	100	95	95	100	
Cover of moss layer d in %	zn	-	-	10	-	zn	
Area of relevé in m^2	5	20	10	25	10	5	
The number of species in the relevé	15	11	7	12	7	13	
Ch. *Mentho longifoliae-Juncetum inflexi*							
Mentha longifolia	.	2.3	5.5	2.2	3.3	2.3	V
Juncus inflexus	5.4	+.2	+.2	.	.	.	III
Ch. *Agropyro-Rumicion crispi* ^ + *Molinio-Arrhenathereta*							
Equisetum palustre	+	4.4	+	1.2	.	.	IV
Agrostis stolonifera ^	2.3	.	.	.	1.2	.	II
Cirsium oleraceum	+	.	.	1.2	.	.	II
Sporadic species: *Carex hirta* ^ 2 (1.2); *Cirsium palustre* 1; *Galium uliginosum* 1 (r); *Juncus effusus* 1; *Lythrum salicaria* 1; *Poa trivialis* 4.							
Ch. *Phragmitetea*							
Scrophularia umbrosa	.	.	.	3.3	1.2	1.2	III
Carex acutiformis	.	.	1.2	.	.	2.3	II
Mentha aquatica	.	.	3.3	.	.	2.3	II
Veronica beccabunga	.	2.3	.	.	+	.	II
Sporadic species: *Carex pseudocyperus* 3; *Peucedanum palustre* 1; *Typha latifolia* 1.							
Accompanying species							
Eupatorium cannabinum	2.2	+.2	.	2.2	3.3	4.4	V
Epilobium hirsutum	.	.	+.2	3.3	.	+.2	III
Equisetum arvense	r	.	.	.	1.2	+	III
Solanum dulcamara	2.2	+	.	+	.	.	III
Tussilago farfara	.	3.3	.	.	1.2	+	III
Galium aparine	.	.	.	+	.	+.2	II
Sporadic species: *Brachythecium rutabulum* 4d (2.3); *Calamagrostis epigejos* 2 (1.2); *Caliergonella cuspidata* 1d; *Chaerophyllum hirsutum* 6 (3.3); *Cratoneuron filicinum* 6d; *Geranium robertianum* 4 (r); *Lycopus europaeus* 1 (1.2); *Moehringia trinervia* 6; *Plagiomnium affine* 6d; *Polygonum amphibium* 2; *Rumex obtusifolius* 2; *Urtica dioica* 4.							

Table 4. *Chaerophyllum hirsutum* community

Succesive number of relevé	1	2
No. of relevé	3/015	4/015
Date	25.08.2005	25.08.2005
Cover of herb layer c in %	95	90
Cover of moss layer d in %	10	5
Area of relevé in m^2	8	15
The number of species in the relevé	7	12
D. community		
Chaerophyllum hirsutum	5.5	5.5
Ch. *Molinio-Arrhenatheretea*		
Ranunculus repens	+.2	+
Angelica sylvestris	·	2.2
Filipendula ulmaria	·	1.2
Heracleum sphondylium	1.1	·
Accompanying species		
Rubus plicatus	1.2	1.2
Urtica dioica	2.2	2.2
Equisetum arvense	·	+
Galeopsis pubescens	·	+
Mentha aquatica	+	·
Pteridium aquilinum	·	1.2
Solanum dulcamara	·	1.2
Quercus robur	·	+
Sciuro-hypnum oedipodium d	2.2	1.2

Table 5. The results of water quality survey sampled from the springs of Jaworznik and from the head stream of substitutive stand of *Cochlearia polonica* in Hutki-Kanki

Locality / Parameter	Hutki-Kanki		Twardowice-Góra Siewierska		Rogoźnik-pond		Podmłynie-pond	
	May	August	May	August	May	August	May	August
pH	7.2	6.8	7.0	7.1	6.9	7.5	-	7.0
Conductivity µS/cm	330	510	780	800	730	720	-	780
Dissolved matter mg/dm^3	160	250	380	390	360	350	-	380
Water hardness mg $CaCO_3$/dm^3	76	77	230	350	185	355	-	360
Phosphates mg/dm^3	1.26	1.06	2.74	0.30	1.22	0.51	-	0.43
Phosphorus mg/dm^3	0.411	0.346	0.893	0.098	0.398	0.166	-	0.140
Neutrality mg $CaCO_3$/dm^3	90	115	255	275	225	245	-	240
Chlorides mg/dm^3	21	18	38	21	39	25	-	23
Iron mg/dm^3	0.05	0.02	0.27	0.19	0.18	0.21	-	0.24
Nitrite nitrogen mg/dm^3	0.04	0.19	0.18	0.33	0.30	0.21	-	0.38
Nitrites mg/dm^3	0.13	0.63	0.59	1.09	0.99	0.69	-	1.25
Ammonium nitrogen mg/dm^3	0.10	0.04	0.08	0.03	0.07	0.01	-	0.08
Ammonia mg/dm^3	0.121	0.049	0.097	0.036	0.085	0.012	-	0.087
Temperature °C	9.0	9.0	8.5	9.0	9.0	8.5	-	10.5

Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

GÓRY BARAŃSKIE MTS. – IMPORTANT REFUGE OF BIODIVERSITY IN THE AREA OF MIDDLE PART OF THE KRAKÓW-WIELUŃ UPLAND

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ABSTRACT. The paper presents geomorphological characteristics of Góry Barańskie Mts. against the background of diversity of vegetation and flora of this area. In total 229 vascular plant species of various habitat requirements were recorded. Also the attention was paid to protected species (montane and endangered species in the regional scale). This area was proposed to protection as nature reserve.

KEY WORDS: the Smoleń-Niegowonice Range, the Góry Barańskie Mts., vascular plant flora, *Salvia glutinosa*, *Aruncus sylvestris*

INTRODUCTION

Amongst many Jurassic refuges of the middle part of the Kraków-Wieluń Upland (PARUSEL 2002, WIKA 1986) the worthy attention is the area of predominance of tall-herb vegetation, situated directly northeastern from Cisowa, called Góry Barańskie Mts. It was the object of our geomorphological and botanical studies due to its characteristic relief (6 ravines, steep limestone walls, interfluvial sites), differentiated biotopic conditions (rendzinas, loesses, waste-mantle, limestone debris, landslides, south and north facing slopes), rich vegetation (forest communities in various stage of regeneration, fragments of overgrowing grasslands, scrub, thermophilous and nitrophilous fringe vegetation and moist meadows at the bottom of the calcareous hill.

The goal of the present study is to show environmental values of this area and indicate a necessity of further detailed investigations for the purpose of its conservation.

RESULTS

1. Physiographic characteristics of the study area

The name of the Góry Barańskie Mts. concern only western, steep slope situated northeastern from Cisowa (Fig. 1), which is integral part of meridionally oriented hummock of limestone hills, located directly to the north from eastern part of Smoleń-Niegowonice Range. The characteristic feature of the mentioned hummock is a distinct asymmetry of slopes: the west-

ern ones are short and quite steep (18-20º), the eastern ones are long and gentle. The length of the Góry Barańskie Mts. amounts to more than 1.5 km and their width varies between 200 and 400 meters. The highest point in the area is estimated to be at 432.0 m a.s.l. The differences of relative altitiude within the Góry Barańskie Mts. are quite considerable; in northern part are about 45 meters but in upper and southern part amounts to ca. 70 meters. From the west to the north towards dewatering valley of Pilica, the narrow and dry valley with the width about 100 meters adjoins the hill. The mentioned valley is distinctly asymmetric: its eastern slope with gentle inclination gradually become the slope of other asymmetric hummock. This slope is dismembered by numerous small valleys of erosion and denudation origin which end in the meridional valley. The valley-floors are broken by forms with the character of gullies, undoubtedly of anthropogenic origin. Also gentle sloping hill situated eastwards from the Góry Barańskie Mts. is broken by several dry denudational valleys. These are wide and relatively shallow. Therefore they do not distinguish themselves distinctly. The Góry Barańskie Mts. are a well-marked morphological contrast in the mentioned area and they diversify the landscape (Fig. 2). The steep slope of this geomorphological object is not homogenous with regard to shape. The surface of the slope is covered by waste-mantle, build by rock debris and clay-stones. This situation was used in the past and is used nowadays by denudational processes, especially rill wash. For instance, they caused dissection of the slope in many sites and led to the creation of forms similar to typical gullies. Two different types of forms with transverse profile can be distinguished. The first are v-shaped small valleys. Their slopes have inclination varied between 40-45º, the bottoms are narrow (even several tens of centimeters), incised in substratum what is manifested by an inclination of slopes with height ca. 1 m and 60-70º (Fig. 3). The longitudinal profiles of these valley-floors are very unequal and full of breaks of profile with height up to 1 m. The traces of flowing water are visible. Large amount of water result in – due to lateral erosion – small landslides which flatten slopes.

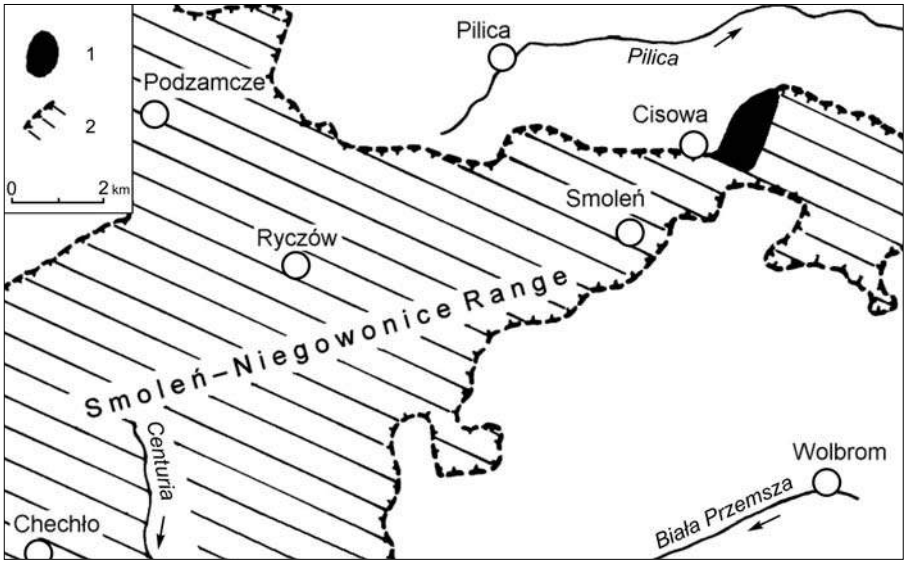

Fig. 1. Localization of the Góry Barańskie Mts. (1) againts the background of the Orle Gniazda Landscape Park (2)

Fig. 2. Geomorphological characteristics of the Góry Barańskie Mts. and its surrounding
Explanations: 1 – a gentle slopes of calcareous ridges, 2 – steep slopes of calcareous ridges (the Góry Barańskie Mts.), 3 – shallow erosion-denudational valleys, 4 – main crest lines, 5 – deeply incised and narrow erosion-denudational valleys, 6 – ski slope.

The second type of small valleys are older forms in relation to morphological development. Their transverse profile is similar to u-shape; the bottom is rounded and wide (2-3 m). The valleys slopes are of 38-40º (Fig. 4). The longitudinal profile is equal, there are no rock curves. Such shape of the described forms results from long-term slope processes.

Fig. 3. V-shaped erosion-denudational valley (phot. T. Szczypek)

Fig. 4. U-shaped erosion-denudational valley (phot. T. Szczypek)

Both types of small valleys are incised down to ca. 8-10 meters and clearly diversify the surface of the Góry Barańskie Mts. Apart from it, their east-west orientation lead to presence of different in temperature and moisture conditions (south and north-facing slopes). Owing to that, including also sites between valleys, there are appropriate conditions for mountainous and protected plants.

2. Up to the present studies on vascular plant flora

The research on vascular plant flora of the Góry Barańskie Mts. was conducted during two vegetation seasons 1993 and 2005. In total 229 vascular plant species were recorded in the area of 0.5 km^2. Majority of them occupy shaded sites or semi-shaded places. Almost 24% of species were observed in open places with full sunlight. Taking into account ecological species indicators for Poland it can be stated that as many as 160 of the observed species tend to grow on fresh and moist soils, 143 prefer neutral or basic, and 94 require nutrient-rich soils for their development (ZARZYCKI et al. 2002).

In degenerated forest communities (oak-beech woodlands, birch and larch woodlands) ancient deciduous forest species indicators predominate (DZWONKO, LOSTER 2001). Totally 64 species were recorded what makes 41% of total number of such species for whole country. Their presence indicate long forest habitat continuity. Despite of the destruction of some forests in recent decades (the area of the Góry Barańskie Mts. is the private property of many owners) what is manifested by abandoned arable fields and traces of terracing of plots, contemporary this area is covered by forests. In the past, isolated woodland probably occurred there, where plants gradually colonized fallows in their vicinity; in the meantime man reafforested them.

Amongst existing nowadays xerothermic grasslands and termophilous thickets the following species are worthy attention: *Ajuga genevensis*, *Digitalis grandiflora*, *Inula conyza*, *I. salicina*, *Sesleria uliginosa*, *Thymus austriacus*, *Vicia sylvatica.* In deeply incised erosion-denudational valleys *Aruncus sylvestris* and *Salvia glutinosa* grow abundantly and protected fungi – *Langermannia giganthea* was recorded. On day 29.09.2006 more than 20 fruiting bodies were counted. The tallest specimen amounted to 33 cm of diameter and 30 cm of height. Taking into consideration information given in the Table 1 it can be concluded that 20% of local flora are precious species from environmental point of view. These are protected plant species (Rozporządzenie Ministra Środowiska 2004), elements of montane flora (ZAJĄC 1996), endangered on the scale of Silesian province and the Upper Silesian Region (BERNACKI et al. 2000, PARUSEL et al. 1996), and rare plants on the scale of the Kraków-Częstochowa Upland (URBISZ 2004).

FINAL REMARKS

This important Jurassic refuge ought to be protected (the best form will be nature reserve) for the maintenance of biodiversity in this part of the Kraków-Wieluń Upland. This site is endangered due to man's activity. It is reflected by illegal dumping sites situated in lower and upper sections of the gullies and many trampled paths. The human-induced disturbance of this area also results from founded at the beginning of January 2006, the longest in the region ski hill-side with ski-lift (Fig. 2).

Table 1. Interesting species of vascular plants from the Góry Barańskie Mts.

Characteristic / Name of the species	Legal status	Mon-tane	Threat degree		Number of squares	Ancient woodlands (s.l.)	Frequency
			a	b			
	1	2	3a	3b	4	5	6
Abies alba		!			149		r
Actaea spicata			R	VU	150	s.l.	+
Alchemilla glabra		!			81		r
Aruncus sylvestris	§§		R	LR	70		+ + 90 specimens exclusively in ravines
Asarum europaeum	§				241	s.l.	+ +
Asperula cynanchica			R	LR	155		+
Bromus benekenii			R	LR	20	s.l.	r
Carlina acaulis	§§		R	lok.	229		+ +
Centaurium erythrea ssp. *erythrea*	§§		V	lok.	114		+
Cephalanthera damasonium	§§		V	VU	88	s.l.	+
Cephalanthera longifolia	§§		E	EN	39	s.l.	r
Cerinthe minor			V	VU	46		+
Cystopteris fragilis			R		125		+
Daphne mezereum	§§		V	lok.	142	s.l.	+
Digitalis grandiflora	§§		R	lok.	67		+
Epipactis helleborine	§§		R	lok.	213	s.l.	+ +
Euonymus verrucosa			V	lok.	219		+
Frangula alnus	§				411		+ +
Galium odoratum	§				199	s.l.	+ +
Gentanella ciliata	§§		E	LR	80		+
Hedera helix	§				207		+ + +
Hepatica nobilis	§§				201	s.l.	+ +
Inula conyza			V	LR	34		+ +
Inula salicina			R	LR	25		+ +
Lilium martagon	§§		R	lok.	128	s.l.	r
Mellitis melissophyllum	§§		R	LR	111	s.l.	r
Neottia nidus-avis	§§		V	lok.	78	s.l.	+
Orthilia secunda			R		169	s.l.	+
Platanthera bifolia	§§		V	VU	40		r
Polypodium vulgare	§§		R	lok.	89		r
Polystichum aculeatum	§§		R	LRVU	50	s.l.	+
Primula elatior	§		R	LR	70	s.l.	+
Primula veris	§		R	lok.	192	s.l.	+ +
Pyrola minor			V		104		+
Ribes alpinum		!	R		109		+ +
Salvia glutinosa		!	E	LR	10		+ + 170 specimens exclusively in ravines
Sambucus racemosa		!			235		+
Senecio ovatus		!			129		+ +
Sesleria uliginosa					2		+
Thymus austriacus			V	LR	36		+
Veronica agrestis			V		43		r

Table 1. (continued)

Name of the species	1	2	3a	3b	4	5	6
Viburnum opulus	§				283		+ +
Vicia sylvatica			R	LR	71		+
Vicia tenuifolia			V		77		+
Vincetoxicum hirundinaria			R		126		+
Viola mirabilis			R	LR	70	s.l.	r

Title and explanatory note for the tables:

1 – Legal status in Poland: §§ – strictly protected, § – partly protected.

2 – Montane (!).

3a – Threat degree in the Upper Silesia Region (PARUSEL et al. 1996): E – Endangered, V – Vulnerable, R – Rare.

3b – Threat degree in Silesia province (BERNACKI et al. 2000): EN – Endangered, VU – Vulnerable, LR – Lower Risk species, lok. – locally threatened plants in Silesia Voivodeship.

4 – Number of squares of the Kraków-Częstochowa Upland (URBISZ 2004).

5 – Ancient woodlands (s.l.) (DZWONKO, LOSTER 2001).

6 – Frequency in the Góry Barańskie Mts.: + + + – mass occurrence of species on large acreages; + + – numerous occurrence of species on small acreages; + – single occurrence of species on small acreages; r – sporadic occurrence of species within the described area.

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Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

BRYOFLORA OF THE "PAPROCANY" SITE OF ECOLOGICAL INTEREST IN THE TYCHY COMMUNE (SILESIAN PROVINCE, S POLAND)

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ABSTRACT. As a result of bryological investigations 11 species of liverwort and 67 species of moss have been discovered. The flora is briefly assessed: most important components including threatened bryophytes in Silesia and those protected and/or threatened in Poland are indicated. Life strategies of recorded species are analyzed and additionally ecological preferences of species in the investigated area are discussed. The most interesting species recorded are the liverworts *Ricciocarpos natans*, *Scapania irrigua* and the mosses *Campylium polygamum*, *C. stellatum*, *Orthotheciella varia*, *Pleuridium subulatum*, *Polytrichum strictum*, *Sphagnum girgensohnii*, *S. inundatum* and *S. papillosum.*

KEY WORDS: Marchantiophyta, Bryophyta, hepaticoflora, muscoflora, ecology, Silesia

INTRODUCTION

Silesian province is one of the most environmentally degraded regions in Poland. The concentration of heavy industry, especially of coal mining and smelting industry as well as a high population density affect negatively natural environment of the region. As a result of various anthropogenic activities the profound changes in vegetation and fauna of Silesia took place. Also flora of mosses and liverworts, plant particular sensitive to human impact, sustained a loss – numerous species are extinct, and additionally many taxa are endangered or reveal weak viability and/or minimal range (e.g. JĘDRZEJKO 1985, 1990; STEBEL 1998).

Many fragments of the area which are still characterized by high environmental values were encompassed within the network of protected areas. One of them is the site of ecological interest "Paprocany", situated in Tychy commune. Although some taxa of liverworts and mosses were recorded (e.g. JĘDRZEJKO 1985, 1990; STEBEL 1997), the mentioned protected area does not have published bryoflora. The aim of this work was to analyze the diversity of bryoflora of

mosses and liverworts of the site of ecological interest "Paprocany" and to characterize the ecological preferences of bryophytes.

General characteristic of the study area

„Paprocany" site of ecological interest was founded No. 7/03 of a decision by Silesian Authorities from 17.06.2003 for a purpose of protection of environmental-landscape values, including many succession, degeneration and regeneration transitory phases or ecotones between meadow and forest, meadow and bog, rush and aquatic vegetation as well as of stands of many regionally rare species (Wika, Kaczmarek 1996; Wika et al. 1996). It covers 19.6 ha and is situated in SW part of Tychy town in the area of former Pszczyna Primeval Forest (Fig. 1). It lies on the border of the Silesian Upland and the Oświęcim Basin (Kondracki 2002). This area is dewatered by some drainage ditches supplying Gostynia river, which is the left tributary of Vistula river. Podzolic soils, included to V and VI of soil quality classes, and marshy soils are present there. In the described area 30 communities of vascular plants and 367 plant species were observed. In flora, dominated by meadow and forest species, the major role is played by bog and typical species for aquatic and rush habitats. There is a plentiful group of protected species (eg. *Blechnum spicant*, *Dactylorhiza majalis*, *Pedicularis sylvatica*) and rare in the territory of Silesian province (e.g. *Najas minor*, *Schoenoplectus tabernaemontani*, *Zannichellia palustris* ssp. *pedicellata*). Worthy attention are phytocoenoses of *Nupharo-Nymphaeetum albae*, *Parvopotamo-Zannichellietum*, *Sparganietum erecti* and *Equisetetum fluviatilis* which are rare amongst aquatic and rush communities in the Upper Silesia (Celiński et al. 1997). In the landscape of the study area, the patches of overgrowing nutrient-rich mesic and wet meadows are strongly marked, especially fragments of *Cirsietum rivularis*. Also bog hollows and oligotrophic to mesotrophic fens, among them, rare on the scale of the Silesia – *Menyantho-Sphagnetum terestis* and *Sphagno recurvi-Eriophoretum angustifolii*. Around of ponds, meadows and mires woodlands are spread with dominant forest community *Calamagrostio villosae-Pinetum* (Wika et al. 1996).

Materials and methods

The studies on flora of bryophytes were conducted using floristic-ecological relevé method, which were repeated several times (during whole vegetation season) both in all types of plant communities and habitats. Each time frequency of particular species was estimated their viability, presence of generative organs, and first of all – their contribution to the structure of specific plant communities and in overgrowing on different types of substratum and habitats were noted. The occurrence of all taxa is documented by herbarium specimens which are stored in Sosnowiec (SOSN). The characteristic of life strategies of mosses were adopted after During (1979, 1992) and Dierßen (2001). The criteria of threat in the Silesian province follow Stebel (1998) and on the scale of Poland – follow Klama (2006a) and Żarnowiec et al. (2004). The nomenclature for liverworts is given after Klama (2006b), and Ochyra et al. (2003) with regard to mosses.

Results

1. Bryophyte flora characteristics – general data

In the analyzed area total 78 bryophytes, including 11 liverwort species and 67 mosses were observed (Table 1). The liverworts represent 11 genera and mosses – 46. The most abundant group are bryophytes rarely recorded in the study area (60% of bryoflora; 73% of hepaticoflo-

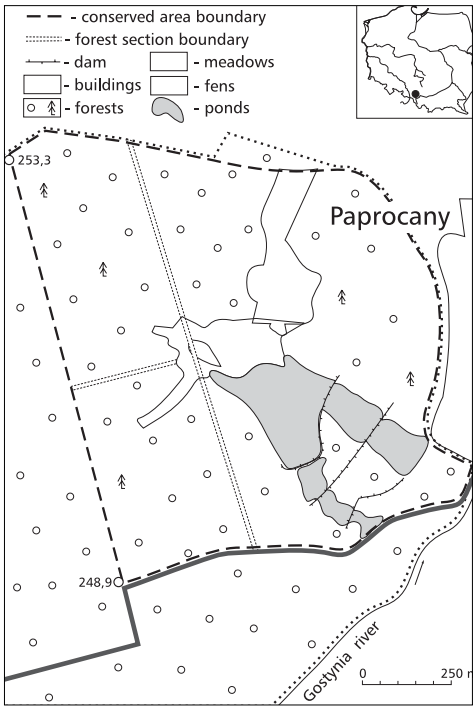

Fig. 1. Map of the "Paprocany" site of ecological interest

ra; 58% of muscoflora), however, the common are 14% of the analyzed flora (9% of hepaticoflora; 15% of muscoflora) (Fig. 2). Most species were noted on epigeic habitats (80%), and next at the tree bases (41%), on decaying wood (40%), on stones protruding from soil (27%), in water (10%) and on tree trunks (9%).

2. Life strategy analysis

Bryophytes of the investigated site represented 9 life strategy categories (liverworts 4 and mosses 9) (Fig. 2). Numerously species of potential life span of a few years (in total 94%, liverworts 82% and mosses 96%) prevail on species of potential life span shorter than year. Long-lived bryophytes are important constituent of the most precious plant communities in the study area (bog hollows and oligotrophic to mesotrophic fens, pine forests, alder forests, nutrient-rich mesic and wet meadows), whilst short-lived bryophytes are established in periodically flooded litoral habitats, roadside slopes and abruptness or they start secondary succession in ruderal habitats. Liverworts mostly belong to colonists s.l. group – 82% of the hepaticoflora (colonists s.s. – 55%, pioneer colonists – 27%), and remaining represent the strategy of annual shuttle – 18%. Amongst mosses perennials s.l. dominate – 55% of the muscoflora, considerably fewer colonists s.l. are represented – 21% and long-lived shuttle – 18%, and remaining life strategy categories have one or two representatives.

3. Most important flora components

Ten bryophytes, endangered on the scale of Silesian province, occur there (Stebel 1998). This group contains liverworts – *Ricciocarpos natans* (category I – uncertain status), *Scapania irrigua* (R – rare) and mosses – *Campylium polygamum* (I), *C. stellatum* (R), *Orthotheciella varia* (I), *Plagiomnium elatum* (I), *Pleuridium subulatum* (R), *Polytrichum strictum* (E – en-

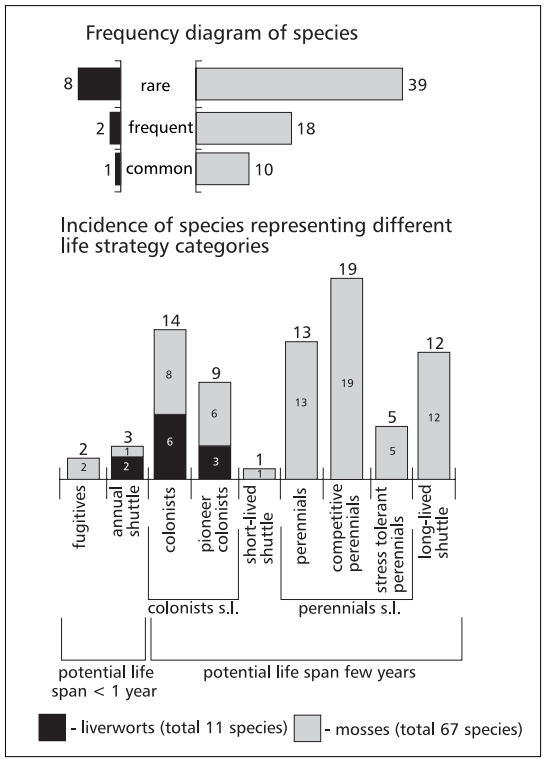

Fig. 2. Frequency diagram of species and incidence of taxa representing different life strategy categories

dangered), *Sphagnum girgensohnii* (R) as well as *S. papillosum* (V – vulnerable). The last one, *Sphagnum papillosum*, is endangered in Poland and posses category I (ŻARNOWIEC et al. 2004). The mentioned species are rare in the investigated area and majority of them have not-abundant populations. In the site of ecological interest "Paprocany" 18 protected taxa grow (Rozporządzenie Ministra Środowiska 09.07.2004; Dz. U. Nr 168, poz. 1764, 2004). The strictly protected are *Sphagnum cuspidatum*, *S. fimbriatum*, *S. girgensohnii*, *S. inundatum*, *S. palustre* and *S. papillosum* (totally 6 species); all belong to rare components of the flora, whereas there are 12 partially protected taxa, i.e.: *Aulacomnium palustre*, *Calliergonella cuspidata*, *Climacium dendroides*, *Dicranim scoparium*, *Eurhynchium angustirete*, *Pleurozium schreberi*, *Polytrichum commune*, *P. strictum*, *Rhytidiadelphus squarrosus*, *Sphagnum fallax*, *S. squarrosum* and *Thuidium delicatulum*. In the study area these species make large mats, tufts and cushions.

4. Diversity of the bryoflora on secondary terrain microforms and on different kind of substrates

The richest flora of mosses and liverwort occupy roadside slopes and abruptness (42% of bryoflora) and in forest paths (36%). The tree fall depressions (31%) and tree rooststock hummocks (29%) are characterized by less diversified flora of mosses and in sites strongly manmade there are fewest of them (24%) (Table 1). The roadside slopes and abruptness are places of the occurrence of rare liverwort and moss species. The most-preferred is open mineral soil

(accumulation horizon and topsoil) where 53% of the bryoflora occurred. Numerous species grow on the base of trees (41%), bark of logs (36%) and decaying stumps (33%), and the lowest species diversity concern pond waters (10%) and bark of upper parts of tree trunks (9%). The remaining substrata are typified by mean differentiated bryoflora. The most valuable species appear on peat soils, open mineral soil and on decaying logs.

5. Diversity of the bryoflora in vascular plant communities

The bryophytes play a important role in the structure of plant communities of the study area. They are essential element of their floristic composition, and in some – particularly in pine forests and in moss-sedge fens as well as in swamps – they make the considerable part of biomass. The most bryophytes-rich are forest phytocoenoses – alder forests (51% of observed flora) and pine forests (50%), and next – nitrophilous trampled communities (29%), bog hollows and oligotrophic to mesotrophic fens (26%), heathlands and acidic grasslands (23%), meadow on mineral soils (22%), rushes (18%) and aquatic plant communities (9%) (Table 1). The most precious constituents of bryoflora occur in fens and swamps, pinewoods and in alder forests.

FINAL REMARK AND CONCLUSIONS

The site of ecological interest „Paprocany" is characterized by very rich and precious bryoflora, which reflect a high diversity of habitats array and well condition of vegetation. This small area contains 78 bryophyte species (18% of bryoflora known from Silesian province), including 11 liverwort (15% of hepaticoflora of the region) and 67 mosses (19% of the muscoflora of the region). The frequency of species and spectrum of the life strategies represented in the investigated bryoflora are typical for temperate man-induced transformed areas. There is quite abundant group of bryophytes endangered in the region and protected in Poland. The most precious components of bryoflora are associated with phytocoenoses of swamps and moss-sedge mires as well as with pinewoods and alder floodplain forest. The preservation of full diversity of plant communities and biotopes has fundamental importance for the maintenance of bryofloristic diversity of the mentioned area. This object is important site on bryofloristic map of the Silesian province.

Table 1. List of liverworts and mosses of the "Paprocany" site of ecological interest

Name of species	Frequency	Vascular plant communities								Secondary terrain microforms					Substrates													Notes
		1	2	3	4	5	6	7	8	1	2	3	4	5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
LIVERWORTS – MARCHANTIOPHYTA																													
Calypogeia azurea	fr	·	·	·	·	·	·	+	+	+	·	+	·	·	·	+	·	·	+	·	·	·	+	·	+	·	+	·	·
Cephalozia bicuspidata	fr	·	·	·	·	·	·	+	+	·	·	+	+	·	·	+	·	·	+	·	·	·	+	+	+	+	+	·	G
Cephaloziella divaricata	r	·	·	+	·	·	·	+	·	·	·	+	+	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	G
Jungermannia gracillima	r	·	·	+	·	·	·	+	·	·	·	+	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Lepidozia reptans	r	·	·	·	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	·	·	·
Lophocolea heterophylla	v	·	·	·	·	·	+	+	+	+	+	+	+	·	·	+	·	·	+	+	+	+	+	+	+	+	+	+	S
Marchantia polymorpha ssp. *ruderalis*	r	·	·	+	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	S
Pellia epiphylla	r	·	·	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Riccia fluitans	r	+	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Ricciocarpos natans	r	+	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Scapania irrigua	r	·	·	·	·	·	·	+	·	·	·	·	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Total number of liverworts:		2	2	3	0	0	1	8	3	3	1	6	6	1	2	3	0	0	7	3	1	1	4	2	4	2	3	1	

Table 1. (continued)

Name of species	Frequency	Vascular plant communities								Secondary terrain microforms					Substrates													Notes
		1	2	3	4	5	6	7	8	1	2	3	4	5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
MOSSES – BRYOPHYTA																													
Amblystegium serpens	v	·	·	+	·	·	+	+	+	·	+	+	+	+	·	+	+	·	·	·	+	·	+	+	+	·	+	·	S
Atrichum undulatum	v	·	·	·	·	·	+	+	+	+	·	+	+	+	·	·	·	·	+	+	·	·	·	·	·	+	+	·	S
Aulacomnium palustre	r	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Barbula convoluta	r	·	·	+	·	·	+	·	·	·	·	·	+	+	·	+	+	·	·	+	·	·	·	·	·	·	·	·	·
Barbula unguiculata	r	·	·	+	·	·	·	·	·	·	·	+	+	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·
Brachytheciastrum velutinum	v	·	·	+	·	·	+	+	+	+	·	+	+	·	·	+	·	·	+	+	·	+	+	+	+	+	+	·	S
Brachythecium albicans	r	·	·	+	·	·	+	·	·	·	·	+	+	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·
Brachythecium rutabulum	fr	·	·	·	+	·	·	·	+	·	+	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	+	·	S
Brachythecium salebrosum	v	·	·	+	+	·	+	+	+	+	·	+	+	+	·	+	+	·	+	·	·	·	+	+	+	+	+	+	S
Bryum argenteum	fr	·	·	+	·	·	+	·	·	·	·	·	+	+	·	+	+	·	·	+	·	·	·	·	·	·	·	·	S
Bryum caespiticium	fr	·	·	+	·	·	+	·	·	+	·	+	+	+	·	+	+	·	·	+	·	·	·	·	·	+	·	·	S
Bryum pseudotriquetrum	r	·	+	·	+	+	·	·	+	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·
Callicladium haldanianum	r	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	+	·	S
Calliergon cordifolium	r	+	+	·	+	·	·	·	+	·	+	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Calliergonella cuspidata	fr	+	+	+	+	+	·	·	+	·	+	+	+	·	+	·	·	·	+	·	·	·	+	+	+	·	+	·	·
Campylium polygamum	r	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Campylium stellatum	r	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Ceratodon purpureus	v	·	·	+	·	·	+	+	·	+	+	+	+	+	·	+	+	·	+	+	·	·	+	+	+	+	+	+	S
Climacium dendroides	r	·	+	·	+	·	·	·	+	·	+	+	·	·	·	·	·	·	+	·	·	+	·	·	·	·	+	·	·
Dicranella cerviculata	r	·	·	·	·	+	·	+	+	·	+	+	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	S
Dicranella heteromalla	v	·	·	+	·	·	+	+	+	+	+	+	+	+	·	+	·	·	+	+	+	·	+	+	+	+	+	·	S
Dicranum scoparium	r	·	·	·	·	·	+	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	·	S
Drepanocladus polycarpos	r	·	+	·	+	·	·	·	+	·	·	+	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·
Eurhynchium angustirete	r	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	+	·	·	·	·	·	·	·	+	·	·
Funaria hygrometrica	r	·	·	+	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	S
Herzogiella seligeri	fr	·	·	·	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	+	·	+	+	+	·	+	·	S
Hypnum cupressiforme	fr	·	·	·	·	·	·	+	+	·	·	+	·	·	·	+	+	·	·	·	·	·	+	·	+	·	+	·	S
Leptobryum pyriforme	r	·	·	+	·	·	·	·	·	·	·	·	+	+	·	·	·	·	·	+	·	·	·	·	·	·	·	·	S,G
Leptodictyum riparium	r	+	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	S
Mnium hornum	r	·	·	·	·	·	·	·	+	+	·	+	·	·	·	·	·	·	+	·	·	·	·	·	+	·	+	·	·
Orthodicranum montanum	r	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	+	·	+	·	·	·	+	+	·
Orthotheciella varia	r	·	+	·	+	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	+	·	+	·	·
Oxyrrhynchium hians	fr	·	·	+	·	·	·	·	+	·	+	·	+	+	·	·	·	·	+	+	·	·	·	·	·	·	+	·	·
Plagiomnium affine	v	·	·	+	·	·	+	+	+	+	+	+	+	·	·	+	·	·	+	·	+	+	+	+	+	+	+	·	·
Plagiomnium cuspidatum	fr	·	·	+	·	·	+	+	+	+	·	+	+	+	·	+	+	·	+	+	·	·	+	·	+	+	+	·	S
Plagiomnium elatum	r	·	+	·	+	+	·	·	+	·	+	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·
Plagiomnium undulatum	fr	·	·	·	+	·	·	·	+	·	+	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	+	·	·
Plagiothecium denticulatum	fr	·	·	·	·	·	·	+	+	·	·	+	+	·	·	·	·	·	·	·	·	·	+	+	+	·	+	·	S
Plagiothecium laetum	v	·	·	·	·	·	·	+	+	+	+	+	·	·	·	+	·	·	+	+	+	+	+	+	+	+	+	+	S,G
Plagiothecium nemorale	r	·	·	·	·	·	·	+	+	+	·	+	·	·	·	·	·	·	+	·	·	·	·	·	+	+	+	·	·
Platygyrium repens	r	·	·	·	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	+	+	S,G
Pleuridium subulatum	r	·	·	+	·	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	S
Pleurozium schreberi	fr	·	·	·	·	·	+	+	·	+	·	·	·	·	·	·	·	·	+	·	+	+	+	·	+	·	·	·	·
Pohlia nutans	v	·	·	+	·	+	+	+	+	+	+	+	+	+	·	+	+	·	+	+	+	·	+	+	+	+	+	·	S
Polytrichastrum formosum	v	·	·	+	+	+	+	+	+	+	+	+	+	+	·	·	·	+	+	+	·	+	+	+	+	+	+	·	S

Table 1. (continued)

Name of species	Frequency	Vascular plant communities								Secondary terrain microforms					Substrates												Notes
		1	2	3	4	5	6	7	8	1	2	3	4	5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Polytrichum commune	fr	·	·	·	+	+	·	·	+	·	+	·	·	·	·	·	·	+	+	+	·	·	·	·	·	·	·	·	S
Polytrichum strictum	r	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Rhizomnium punctatum	fr	·	·	·	·	·	·	+	+	+	+	·	·	·	·	+	·	·	·	·	+	·	+	+	+	·	+	·	S
Rhynchostegium murale	r	·	·	+	·	·	·	·	·	·	·	·	+	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Rhytidiadelphus squarrosus	fr	·	·	·	+	·	+	+	·	·	·	+	+	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·
Rosulabryum laevifilum	r	·	·	·	·	·	·	+	+	·	·	+	·	·	·	·	·	·	·	·	·	·	+	·	·	+	·	+	G
Sanionia uncinata	r	·	·	·	·	·	·	+	+	·	·	·	·	·	·	+	·	·	·	·	·	·	+	·	+	·	·	·	S
Schistidium apocarpum	r	·	·	·	·	·	·	·	·	·	·	·	·	+	·	+	+	·	·	·	·	·	·	·	·	·	·	·	S
Sciuro-hypnum oedipodium	fr	·	·	·	·	·	·	+	+	+	+	+	·	·	·	·	·	·	+	·	+	+	+	·	·	·	·	·	S
Sphagnum cuspidatum	r	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Sphagnum fallax	fr	·	·	·	+	+	·	+	+	·	+	·	·	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·
Sphagnum fimbriatum	r	·	·	·	·	+	·	+	+	·	+	·	·	·	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·
Sphagnum girgensohnii	r	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	+	+	·	·	+	·	·	·	·	·	·	·
Sphagnum inundatum	r	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Sphagnum palustre	r	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Sphagnum papillosum	r	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Sphagnum squarrosum	r	·	+	·	+	+	·	·	+	·	+	·	·	·	·	·	·	+	+	·	·	+	·	·	·	·	·	·	·
Straminergon stramineum	r	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Tetraphis pellucida	fr	·	·	·	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	+	·	+	+	+	+	·	·	S,G
Thuidium delicatulum	r	·	·	·	·	·	·	+	·	+	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·	·	+	·	·
Warnstorfia exannulata	fr	+	+	·	·	+	·	·	·	·	·	·	·	·	+	·	·	+	+	·	·	·	·	·	·	·	·	·	·
Warnstorfia fluitans	r	+	+	·	·	+	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·
Total number of mosses:		5	12	20	17	20	17	31	37	20	23	27	22	18	6	17	11	19	34	15	11	15	24	15	22	14	29	6	
Total number of liverworts and mosses combined:		7	14	23	17	20	18	39	40	23	24	33	28	19	8	20	11	19	41	18	12	16	28	17	26	16	32	7	

Explanations:

frequency: v – common, fr – frequent, r – rare; vascular plant communities: 1 – aquatic fresh-water communities (*Lemnetea minoris*, *Potametea*) and phytocoenoses of periodically flooded litoral habitats (*Bidentetea tripartiti*, *Isoëto-Nanojuncetea*), 2 – rush communities (*Phragmitetea*), 3 – nitrophilous communities of trampled grounds (*Plantaginetalia majoris*), 4 – nutrient-rich mesic and wet hay meadows and pastures (*Molinio-Arrhenatheretea*), 5 – communities of bog hollows and oligotrophic to mesotrophic fens (*Scheuchzerio-Caricetea nigrae*), 6 – heathlands and acidic grasslands (*Nardo-Callunetea*), 7 – pine forests (*Dicrano-Pinion*), 8 – alder forests (*Alno-Ulmion*); secondary terrain microforms: 1 – tree rootstock hummocks, 2 – tree fall depressions, 3 – roadside slopes and abruptness, 4 – forest paths, 5 – ruderal places (dumpled clay, rubble etc.); substrates: 1 – water in ponds, 2 – stones protruding from soil, 3 – concrete walls, 4 – peat, 5 – topsoil, 6 – subsoil, 7 – mobile wood rests, 8 – mixed litter, 9 – bark on decaying logs, 10 – wood of decaying logs, 11 – tree stumps, 12 – root systems of fallen trees, 13 – tree bases, 14 – tree trunks; notes: S – sporophytes and G – gemmae were observed.

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Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

CARPET PLANT COMMUNITIES OF KATOWICE

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ABSTRACT. The study presents phytosociological characteristics of carpet plant communities formed in the city of Katowice. Investigations were carried out in 1999-2002 using the method of Braun-Blanquet. Indirect analysis of the habitat occupied by these communities was also performed using Zarzycki's ecological indicator values. The occurrence of 4 carpet communities from the order *Trifolio-Plantaginetalia* (class *Molinio-Arrhenatheretea*) as well as 4 therophytic communities from the class *Polygono-Poëtea* was recorded in Katowice. There is a significant difference in floristic composition and therophyte share in communities belonging to these two classes.

KEY WORDS: phytosociology, carpet plant communities, *Trifolio-Plantaginetalia* order, *Polygono-Poëtea* class, Katowice

INTRODUCTION

The natural environment in Katowice, a city located in the centre of the Upper Silesia Industrial District, has for a long time been the subject of intense transformations caused by human commercial activity (ŻMUDA 1971; SENDEK 1981; JĘDRZEJKO 1987; SZCZYPEK, WIKA 1987; PRZYBYLSKI 1991; SZCZYPEK, WACH 1992). The most important form of anthropopressure in the area of Katowice was heavy industry linked to bituminous coal mining and non-ferrous (zinc and lead) metalworking. It has negatively influenced the abiotic components of the environment and has caused deep transformations of terrain relief. This is caused on one hand by storage of industrial waste material on spoil heaps or earth sedimentation tanks for mine drainage water, on the other hand by the progress of the excavation process itself leading to continuous and discontinuous deformations occurring e.g. as inundation holes or graves (GRESZTA, MORAWSKI 1972; MACIAK 1999). It is also impossible to underestimate the impact on the present city appearance of the progressive encroachment of urban development and expansion of the whole communal infrastructure with a dense network of transportation pathways – both roads and railways. In the peripheries of the city, the landscape was shaped until recently by the currently declining agriculture, which is conspicuously mirrored in fallow fields and abandoned meadows. As a consequence of these diverse forms of anthropopressure, trans-

formations occur in the plant cover at various levels of its organisation – from the flora through plant communities all the way up to the landscape (FALIŃSKI 1972). The multitude of habitats linked to the multifunctional utilisation of the urban space creates propitious conditions for formation of spontaneous vegetation and leads to the appearance of a mosaic of small-surface phytocoenoses, a fact noticed also by CHOJNACKI (1991) and BORYSIAK et al. (2000). In habitats subjected to various mechanical influences, most often in the form of treading or driving over, so-called carpet plant communities are formed, composed of species that are resistant to mechanical damage and grow in low sod-like clusters. They are the subject of the present study which aims at the phytosociological and ecological characterisation of carpet plant communities in Katowice.

MATERIAL AND METHODS

Field studies were performed in 1999-2002 within the administrative boundaries of Katowice. A total number of 104 phytosociological relevés were taken by the generally accepted method of BRAUN-BLANQUET (1964) in communities occurring in trampled sites. They were subsequently collected in phytosociological tables arranged using the geobotanical analysis computer software package "Profit 2.0" (BALCERKIEWICZ, SŁAWNIKOWSKI 1998). These tables formed the basis for drawing up a synthetic table reflecting the full diversity of analysed communities in the area of Katowice. Floristic composition of individual plant communities was subjected to ecological analysis using indicator values (ZARZYCKI et al. 2002) in order to determine the relation between the occurrence of each specific community and habitat conditions. Nomenclature of vascular plants was adopted from MIREK et al. (2002). The presented syntaxonomic treatment and phytosociological affiliation of individual species is compatible with the suggestions of BRZEG and WOJTERSKA (2001).

RESULTS

Eight carpet plant communities have been recorded from the area of Katowice. Four of them represent permanent plant communities from the order *Trifolio-Plantaginetalia* and class *Molinio-Arrhenatheretea*, while the remaining four are pioneering therophytic phytocoenoses from the class *Polygono-Poëtea* (Tab. 1). Syntaxonomic position of the analysed plant communities may be presented as follows:

Cl. *MOLINIO-ARRHENATHERETEA* R. Tx. 1937 em. 1970
O. *Trifolio repentis-Plantaginetalia majoris* (R. Tx. et Preising in R. Tx. 1950 em. Sissingh 1969) Brzeg 1991 ex Balcerkiewicz et Pawlak 2001
All. *Cynosurion* R. Tx. 1947 em. Brzeg et M. Wojterska 1996
Ass.: *Lolio-Plantaginetum* Beger 1932 em. Sissingh 1969
Ass.: *Juncetum macri* (Diemont, Sissingh et Westhoff 1940) Schwickerath 1944 ex R. Tx. 1950
All. *Agropyro-Rumicion crispi* Nordhagen 1940 em. R. Tx. 1950
Ass.: *Potentilletum anserine* Rapaics 1927 em. Pass. 1964
Ass.: *Potentilletum reptantis* Eliaš 1974
Cl. *POLYGONO-POËTEA* Rivas-Martinez 1975 corr. Rivas-Martinez et al. 1991
O. *Polygono arenastri-Poëtalia annuae* R. Tx. in Gehu et al. 1972 corr. Rivas-Martinez et al. 1991
All. *Matricario matricarioides-Polygonion arenastri* Rivas-Martinez 1975 corr. Rivas-Martinez et al. 1991

Ass.: *Poëtum annuae* Felföldy 1942
Ass.: *Matricario matricarioides-Polygonetum arenastri* Th. Müller in Oberd. 1971
Ass.: *Puccinellio-Chenopodietum glauci* Krippelová 1971
All. *Saginion procumbentis* R. Tx. et Ohba in Gehú et al. 1972
Ass.: *Sagino procumbentis-Bryetum argentei* Diemont, Sissingh et Westhoff 1940.

Phytocoenoses of *Lolio-Plantaginetum* were encountered most frequently in the study area. They are distributed in a uniform manner across the whole territory of the city. They occur in housing estates, playgrounds, sport fields, cemeteries, along transportation pathways. In some of the analysed relevés, the share of therophytes from the class *Polygono-Poëtea* is considerable, which provided the need to distinguish the subassociation *L-P. polygonetosum*. Patches of this subassociation are formed in sites which are subject to intensive mechanical damage in the form of treading or driving over, and in the majority of cases they are found in a complex with communities from the class *Polygono-Poëtea* which may explain the presence of therophytes in these patches. The occurrence of a facultative halophyte, *Puccinellia distans*, in some phytocoenoses is also of interest. Vegetation patches with its participation are formed on periodically salt-containing habitats, associated with the application of sodium chloride against ice and frost in winter road maintenance – thus, these phytocoenoses were recorded mainly on roadsides, parking lots and in the vicinity of garages. Ecological analysis of components of this community indicates its broad ecological scale with regard to the preferred moisture and trophic conditions (Fig. 1, 2).

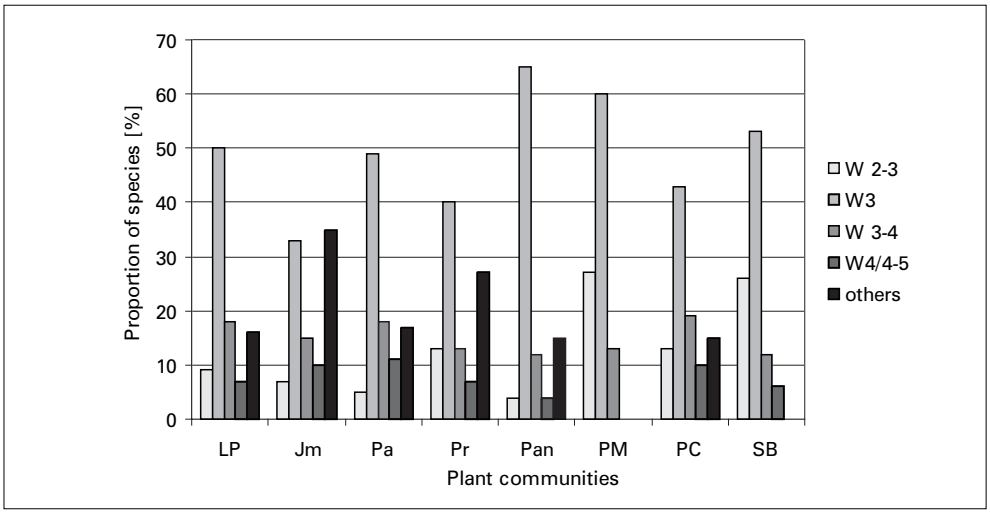

Fig. 1. Proportion of species with various requirements with regard to substrate moisture in carpet plant communities of Katowice
Explanations: Jm – *Juncetum macri*, LP – *Lolio-Plantaginetum*, PM – *Matricario-Polygonetum*, Pa – *Potentilletum anserinae*, Pan – *Poëtum annuae*, Pr – *Potentilletum reptantis*, PC – *Puccinellio-Chenopodietum*, SB – *Sagino--Bryetum*. W – soil moisture value: 2 – dry, 3 – fresh, 4 – moist, 5 – wet.

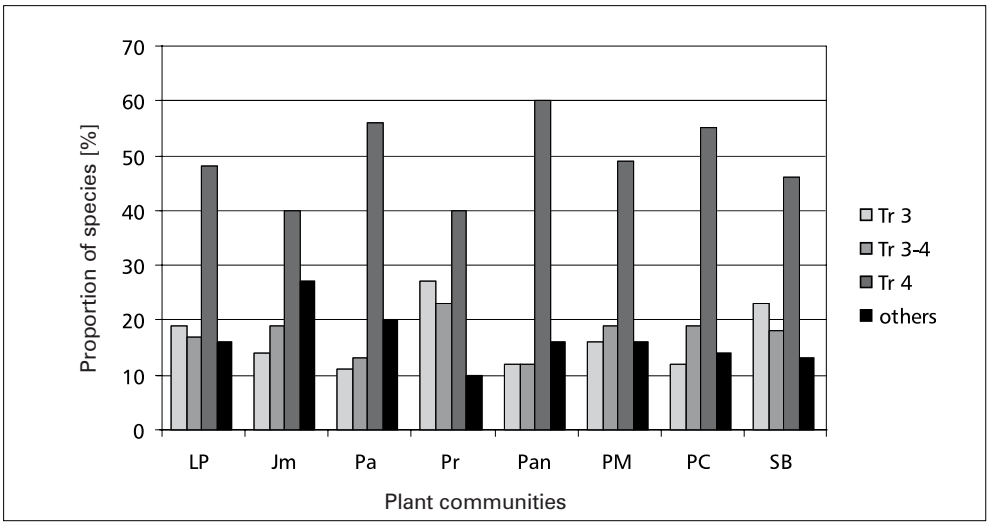

Fig. 2. Proportion of species with various trophic requirements in carpet plant communities of Katowice

Explanations: Jm – *Juncetum macri*, LP – *Lolio-Plantaginetum*, PM – *Matricario-Polygonetum*, Pa – *Potentilletum anserinae*, Pan – *Poëtum annuae*, Pr – *Potentilletum reptantis*, PC – *Puccinellio-Chenopodietum*, SB – *Sagino--Bryetum.* Tr – trophy value: 3 – soil moderately poor (mesotrophic), 4 – soil rich (eutrophic).

The xenospontaneous community with *Juncus tenuis*, an alien species in the flora of Poland (ZAJĄC et al. 1998), as the major physiognomic component is formed on roadsides and dirt roads as well as in the vicinity of water bodies where it occurs as large-surface patches. These patches occupy relatively poor habitats (Fig. 2). Their core is formed by species from the order *Trifolio-Plantaginetalia* and class *Molinio-Arrhenatheretea*. The majority of localities of this association are found in the southern part of the city which is less industrialised and subject to weaker urban pressure.

Phytocoenoses of *Potentilletum anserinae* occur relatively rarely in the area of Katowice. They are formed on small surfaces in roadsides, housing estate squares and in the vicinity of garages. Within the group of communities from the order *Trifolio-Plantaginetalia*, they occupied the sites which were most exposed to the action of mechanical factors, which probably accounts for the presence of therophytes from the class *Polygono-Poëtea* in their structure. This community occupies an intermediate position between *Lolio-Plantaginetum* and *Matricario-Polygonetum* (Tab. 1). This fact is further confirmed by observations made by BRZEG (1989) and PAWLAK (1997) who point to the links between this association and *Lolio--Plantaginetum* on one side and between it and communities from the class *Polygono-Poëtea*. The presence of *Lolium perenne* was the decisive factor in classifying the patches from the territory of Katowice to the subassociation *Potentilletum anserinae lolietosum* in agreement with the notion expressed by FALIŃSKI (1966), ROSTAŃSKI and GUTTE (1971), GUTTE (1972) as well as PAWLAK (1997). In some patches which are characterised by more loose structure, the presence of *Puccinellia distans* and increased proportion of ruderal species from the class *Artemisietea* were recorded.

Phytocoenoses of *Potentilletum repentis* were recorded least often within the city. They occupied sunny, weakly trampled, sandy sites. In patches of this association, the creeping cin-

quefoil dominates, accompanied by carpet plant species from the order *Trifolio-Plantaginetalia*, meadow and ruderal species. This community shows a preference for habitats of transportation pathways – both roads and railways.

Patches dominated by *Poa annua* are mainly linked with the compact tenement building complex in the city – their presence was recorded predominantly in the city centre of Katowice. They occupy humid, shady, intensely trampled habitats. Compared to other analysed carpet plant communities, phytocoenoses of this association are characterised by most abundant occurrence of plants which prefer eutrophic and moist soils (Fig. 2). The major part of plant coverage is accounted for by therophytes from the classes *Polygono-Poëtea* and *Stellarietea mediae* (Tab.1, Fig. 3). Presence of species from the order *Trifolio-Plantaginetalia*, ruderal plants and overall species poverty all combine to suggest that a ruderal facies of the *Poëtum annuae* association described by PAWLAK (1997) from the Konin Coal Basin is formed within the city. It is difficult to agree with the suggestion of MATUSZKIEWICZ (2001) that the aggregation with *Poa annua* constitutes an early spring or rump facies of *Lolio-Plantaginetum*. Observations carried out in the course of several years have confirmed that the patches where physiognomy is determined by the speargrass are compositions of species that are reproducible, distinct with regard to their floristic content and persist throughout the vegetative season in the special ecological conditions of a big city.

Phytocoenoses of *Matricario-Polygonetum* belong to the most common short-lived carpet plant communities in Katowice. They are formed in habitats subject to constant and intensive influence of the mechanical factor preventing the development of more persistent patches composed of perennial plants from the order *Trifolio-Plantaginetalia*. Influence of the mechanical factor on the substrate and vegetation is also the reason for the floristic poverty of analysed patches. Apart from characteristic species of the association: *Polygonum aviculare* and *Chamomilla suaveolens*, remaining components do not play a significant role in the plant cover.

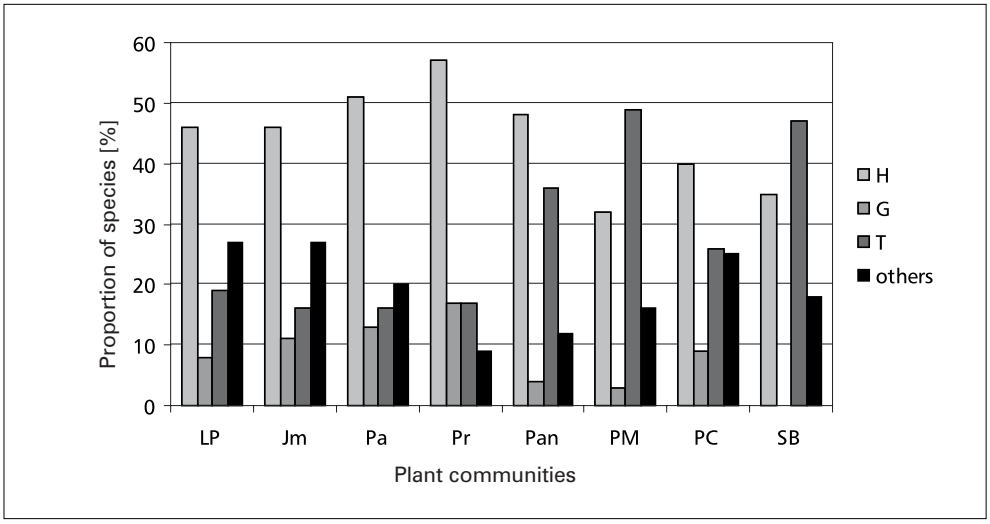

Fig. 3. Proportion of life forms in carpet plant communities of Katowice
Explanations: Jm - *Juncetum macri*, LP – *Lolio-Plantaginetum*, PM – *Matricario-Polygonetum*, Pa – *Potentilletum anserinae*, Pan – *Poëtum annuae*, Pr – *Potentilletum reptantis*, PC – *Puccinellio-Chenopodietum*, SB – *Sagino-Bryetum*. H – hemicryptophyte, G – geophyte, T – therophyte.

Table 1. Diversity of carpet plant communities in Katowice

Unit no.		1	2	3	4	5	6	7	8
Community		Pr	Jm	LP	Pa	PM	Pan	PC	SB
Number of releves in table		2	12	30	10	10	9	15	6
Number of species in the table		30	80	80	56	38	25	91	19
		Trifolio-Plantaginetalia				*Polygono-Poëtea*			
Ch. *Trifolio-Plantaginetalia*									
Potentilla reptans	c	V 7500							
Juncus tenuis	c		V 5208		I 5		I 6	I 3	
Lolium perenne	c	V 275	III 175	V 3343	IV 175	IV 130	III 128	III 27	III 175
Potentilla anserina	c	III 25	II 54	I 95	V 7000	I 55	I 6	I 7	I 8
Trifolium repens	c	III 25	IV 642	IV 627	V 360	II 65	II 256	V 223	
Plantago major	c	IV 362	V 425	V 445	V 565	V 194	V 47	I 83	
Leontodon autumnalis	c	III 167	I 78	I 5		I 6	II 13		
Carex hirta	c	III 96	I 20	I 10			I 10		
Phleum pratense	c	II 88	I 22	I 5					
Odontites serotina s. s.	c	II 50					II 13		
Agrostis stolonifera	c	II 233							
Ch. *Molinio-Arrhenatheretea*									
Taraxacum officinale	c	V 50	III 25	V 475	IV 130	V 180	IV 39	III 53	I 8
Achillea millefolium	c	III 875	II 54	IV 518	III 30	I 10	II 67	IV 63	II 167
Plantago lanceolata	c	III 25	III 96	III 340	II 15	I 5		II 17	
Poa pratensis	c		I 4	I 70	II 105		I 6		
Ranunculus acris s. s.	c	III 25	II 12	I 75	II 15			I 3	
Ranunculus repens	c		III 58	I 55	I 10		II 11	I 40	
Trifolium pratense	c	III 25	III 21	III 298	II 20		I 6	II 73	
Vicia cracca	c	V 50	I 4	I 78	I 10	I 5		I 3	
Arrhenatherum elatius	c	III 250		I 18				I 7	
Dactylis glomerata	c		I 8	II 92	I 10				
Deschampsia caespitosa	c		II 50					I 33	
Lotus corniculatus	c		II 12	I 33	I 10			III 113	
Poa trivialis	c	III 25							
Ch. *Polygono-Poëtea*									
Chamomilla suaveolens	c			II 88	II 60	V 1145	III 22	II 13	
Polygonum aviculare	c		I 8	III 248	III 70	V 6425	V 389	IV 667	III 250
Poa annua	c	III 25	II 233	III 212	IV 130	V 520	V 7361	II 17	III 6000
Chenopodium glaucum	c							V 1090	I 2
Puccinellia distans	c		II 154	II 362	I 55	I 10		V 2617	
Sagina procumbens	c			I 2					III 585
Bryum argenteum	d								III 1542
Herniaria glabra	c								I 292
Ceratodon purpurens	d					I 5			I 83
Ch. *Artemisietea vulgaris*									
Daucus carota	c	III 25	I 8	II 225	II 20	I 5	I 6	IV 70	
Artemisia vulgaris	c			III 55	IV 35	II 15	I 6	IV 160	I 8
Cirsium arvense	c	III 25	I 4	I 7	IV 35			IV 40	
Medicago lupulina	c	III 25	II 12	II 95	II 60	I 5		IV 93	
Melandrium album	c		I 4	II 43	I 5	II 15		II 13	
Tanacetum vulgare	c	III 25	II 50	I 3	I 10			III 27	
Melilotus alba	c	III 25	I 4	I 3				I 7	

Table 1. (continued)

Unit no.		1	2	3	4	5	6	7	8
Pastinaca sativa	c		I 4	II 83				I 10	
Solidago canadensis	c		I 4	I 3	II 20	I 5		III 30	
Convolvulus arvensis	c	III 25		I 5	I 5				
Elymus repens	c	III 250	I 46	I 3					
Tussilago farfara	c		I 8	I 5	I 5			II 13	
Urtica dioica	c			I 22	I 10		II 11		
Others									
Chenopodium rubrum	c							III 323	
Atriplex patula	c							II 250	
Atriplex prostrata subsp. *prostrata*	c							III 227	
Bidens frondosa	c							II 17	
Calamagrostis epigejos	c	V 50	II 12	I 3	I 10		I 6	I 7	
Capsella bursa-pastoris	c			I 133	I 10	I 10	II 67	I 7	II 17
Cardaminopsis arenosa subsp. *arenosa*	c	III 250		I 2	I 5	I 5		I 7	I 8
Carex spicata	c	III 25	I 42						
Centaurium erythraea subsp. *erythraea*	c		II 17					I 3	
Chenopodium album	c			I 22	I 10	IV 35	I 6	IV 380	
Chenopodium polyspermum	c							II 160	
Conyza canadensis	c	III 25		I 8		I 10		III 27	I 8
Euphorbia cyparissias	c	III 25							
Fallopia convolvulus	c	III 25			I 5				
Holcus lanatus	c	III 25	V 154	I 2	I 10			II 77	
Agrostis capillaris	c	III 250	III 212	I 20	II 65	I 10		II 157	
Galinsoga ciliata	c		I 4	I 7	I 5		II 111	I 3	
Galinsoga parviflora	c					II 15		I 3	
Juncus articulatus	c		III 96						
Juncus bufonius	c		II 17					I 3	
Juncus compressus	c		II 88					I 3	
Matricaria maritima subsp. *inodora*	c		II 50	I 23		I 10		IV 127	
Poa compressa	c	V 275	I 8	I 17		I 5		IV 187	
Polygonum persicaria	c		I 8	I 5				II 50	
Sisymbrium officinale	c			I 5	I 10	I 10	III 22		I 8
Sonchus arvensis subsp. *arvensis*	c							III 120	
Stellaria media	c		I 4	I 3			II 167		
Vicia tetrasperma	c	III 25		I 2		I 50			

Explanations: Jm – *Juncetum macri*, LP – *Lolio-Plantaginetum*, PM – *Matricario-Polygonetum*, Pa – *Potentilletum anserinae*, Pan – *Poëtum annuae*, Pr – *Potentilletum reptantis*, PC – *Puccinellio-Chenopodietum*, SB – *Sagino-Bryetum*.

Patches with a high proportion of reflexed alkaligrass and oak-leaved goosefoot in the study area were considered to be identical to the association *Puccinellio-Chenopodietum glauci*. They occupied weakly trampled, flat, sunny sites and showed a strong preference for the industrial complex and transportation pathways in the city. They were recorded mainly on post-industrial waste ground – sediment tanks of mine drainage water, coal mine areas, spoil heap approaches, more rarely on roadsides, parking lots and railway terrain. Apart from characteristic species of the association, the patches are composed of therophytes from the class *Polygono-Poëtea* and short-lived ruderal species from the order *Sisymbrietalia*. The ruderal character of habitats occupied by analysed patches of vegetation, occurrence of species from the class *Polygono-Poëtea* and lack of riparian therophytes from the class *Bidentetea tripartitae* were instrumental in the classification of these patches applied in the present work.

Phytocoenoses of *Sagino-Bryetum* are linked to the compact tenement building complex in the city centre of Katowice. Patches of this association develop usually on small surfaces, in gaps between sidewalk slabs or cobblestones. They occupy the driest habitats among analysed carpet plant communities in Katowice (Fig. 1, 2). Phytocoenoses of this association are characterised by strong development of the moss layer with considerable proportion of *Bryum argenteum* and *Ceratodon purpureus.* The herb layer, on the other hand, is weakly developed; it is mainly composed of therophytes from the class *Polygono-Poëtea*: *Poa annua*, *Polygonum aviculare*, *Sagina procumbens* (Tab. 1, Fig. 3). The poorest habitats in Katowice were occupied by patches of the subassociation with *Ceratodon purpureus*, while the more fertile ones favoured the development of subassociation with *Capsella bursa-pastoris*. These units were also recorded by PAWLAK (1997) from the region of Wielkopolska.

CONCLUSIONS

1. Cosmopolitan associations *Lolio-Plantaginetum* and *Matricario-Polygonetum* are most broadly distributed within the city.
2. The relatively large diversity of carpet plant communities in Katowice results from the broad spectrum of various human influences on the landscape and on the plant cover.
3. It is worth noting that a facultative halophile – *Puccinellia distans* – participates in phytocoenoses of *Lolio-Plantaginetum*, *Juncetum macri*, *Potentilletum anserinae*, *Puccinellio-Chenopodietum*, *Matricario-Polygonetum* which are formed on roadsides or waste ground related to bituminous coal mining.
4. The broadest ecological scale with regard to habitat humidity is displayed by *Lolio-Plantaginetum* and *Puccinellio-Chenopodietum glauci*.
5. Studies on carpet plant communities in Katowice show the distinct character of communities from the order *Trifolio-Plantaginetalia* and therophytic aggregations from the class *Polygono-Poëtea*.
6. Carpet plant communities from the order *Trifolio-Plantaginetalia* and class *Polygono-Poëtea* are conspicuously differentiated by the ratio of hemicryptophytes to therophytes. The higher proportion of therophytes in communities from the class *Polygono-Poëtea* is especially prominent in terms of plant coverage.
7. When analysing carpet communities grouped in the order *Trifolio-Plantaginetalia*, especially patches growing on housing estate lawns and are subjected to intentional care and management interventions. An important problem of phytosociological treatment of such urban greenery areas must be addressed, because they constitute an important element of the urban plant cover.

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Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

THE RUDERAL PLANT COMMUNITIES OF THE DĄBROWSKA BASIN (SILESIAN UPLAND)

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ABSTRACT. The short-lived and perennial ruderal plant communities of the *Stellarietea mediae*, *Bidentetea tripartiti* and *Artemisietea* classes which develop in the Dąbrowska Basin (Silesian Upland) were presented in the paper. The collected phytosociological relevés were classified with the use of the minimum variance in new clusters method (using the Euclidean distance coefficient). The synoptic table was made in order to show the floristic composition of phytocoenoses. The most widely spread and differentiated are plant communities which belong to the *Onopordion acanthii* alliance and the *Dauco-Melilotenion* suballiance. The plant communities of the *Oenothero-Berteroenion* suballiance are not common and some differential species were not found in the patches. They were not recorded plant communities of the *Onopordenion acanthii* suballiance. Nitrophilous ruderal plant communities of the *Arction lappae* are less frequent. Some character species of the association were not recorded in many of patches.

KEY WORDS: ruderal vegetation, phytosociology, Silesian Upland, *Artemisietea vulgaris*, *Stellarietea mediae*, *Bidentetea tripartiti*

INTRODUCTION

The Dąbrowska Basin is situated in the Silesian Upland. As a result of the dissection of the Próg Środkowotriasowy the Józefka Basin and the Przemsza Basin, which comprises the Biskupi Bór and Dąbrowska Basins, were formed (GILEWSKA 1972). The great differentiation of the land relief caused two parts of this geomorphological unit to be distinguished: the western part – wavy (undulating), which is divided by many valleys and the eastern part which is more flat and covered with dunes.

Historical data (KANTOR-MIRSKI 1931) revealed that the Zagłębie Dąbrowskie was covered with forest communities (primeval deciduous and coniferous forests) until the XV century. Excavation of silver, gold and iron ores started in the XIV century. In the XVIII century hard coal excavation also began. In the beginning it was extracted by stripping the upper layer of the rock from the seam deposits which were on the surface. The increased demand for hard coal by lead and zinc smelters initiated its extraction from the deep layers by building shafts. These

changes had a great influence on the transformation of agricultural-farming settlements (such as Stara Dąbrowa) into mining and industrial towns with the mine at the centre and some labourer and clerk settlement around it. Subsequently, the mining settlements which where scattered around the coal mine were connected into a whole. The excavation of non-iron, iron ores and hard coal, as well as the development of the steel industry caused a lot of negative transformations in the land relief, geology, hydrology, soils and vegetation cover of this region (DULIAS 1991). The negative changes in the natural environment of the Dąbrowska Basin were also connected with the extraction of backfilling sands which were used to fill the empty spaces formed underground as a result of coal extraction (PAPRZYCKI, JAROMIN 1956). In the landscape many new, anthropogenic forms were created such as: heaps, sedimentation tanks, canals, ditches, open-casts, railway escarpments and roads which were used during sand transportation. The mining activity also caused drainage and ground water logging of the neighbouring areas. In many parts of the Dąbrowska Basin (Kazimierz Górniczy, Sosnowiec-Zagórze, Klimontów, Sosnowiec-Jęzor), the ground became lower by up to 9 m (OLEŚ 1987). Coal extraction also led to the formation of subsidence troughs in Ostrowy Górnicze, Sosnowiec--Zagórze and Klimontów (SZCZYPEK, WIKA 1987). Most water courses (Czarna Przemsza, Bobrek, Potok Malinowicki and Trzebyczka) were irreversibly transformed through their regulation, changes in their proper course, channel deepening, covering with concrete and sealing of their bottom and banks. Moreover, many artificial canals and water reservoirs were built in order to hold sewage and mining water discharge and for industrial and recreational needs. However, detailed phytosociological research has not yet been conducted, which allows the differentiation of plant communities of the area to be seen and the degree of their transformation to be evaluated.

The aim of research was:

– to show the differentiation of the ruderal vegetation of the *Artemisietea*, *Bidentetea tripartiti* and *Stellarietea mediae* classes,
– to compare these phytocoenoses with these which were recorded in other countries.

METHODS

The field work on the ruderal vegetation of the Dąbrowska Basin was carried out during 1995-2001. The study area was divided into 2-kilometre squares according to the rules of the carthogramme method ATPOL (ZAJĄC 1978) on the basis of topographic maps to the scale 1:50000 (521.4 Tarnowskie Góry, 522.3 Zawiercie, 531.2 Katowice, 532.1 Jaworzno). Using the approach of Braun-Blanquet method (BRAUN-BLANQUET 1964), 104 phytosociological relevés were made in order to examine the floristic diversity of ruderal vegetation which had developed in urban (roadsides, building sites, railway scarps and ditches) and post-industrial wastelands (sand-pits) (KOMPAŁA 2000).

The minimum variance in new clusters method (using the Euclidean distance coefficient) was applied in order to classify the collected phytosociological relevés. Moreover, a synoptic table was created in order to compare ruderal plant communities from the investigated area using the Profit 2.0 computer programs (BALCERKIEWICZ, SŁAWNIKOWSKI 1998). Each species in the table was given a value of constancy (in percentages) and a coefficient cover (PAWŁOWSKI 1977).

Affiliation of species to the syntaxonomical unit of Braun-Blanquet system was based on BRZEG and WOJTERSKA (2001). The names of phytosociological units were used according to the rules of the Code of Phytosociological Nomenclature (BARKMAN et al. 1995). The names of vascular plants follow MIREK et al. (2002).

RESULTS

1. The differentiation of the plant communities of the *Artemisietea* class (Table 1)

The classification of phytosociological relevés from the *Artemisietea vulgaris* class allowed two groups to be distinguished. The first group comprises phytocoenoses which represent the *Onopordion acanthii* alliance and the second the nitrophilous ruderal communities from the *Arction lappae* alliance.

a) The phytocoenoses of the *Onopordion acanthii* alliance

In the *Onopordion acanthii* alliance, the communities of the *Dauco-Melilotenion* suballiance are numerous and well-developed. The *Dauco-Picridetum* phytocoenoses are highly differentiated and heterogeneous. Some patches with *Potentilla intermedia* or *Reseda lutea* were also included. *Dauco-Picridetum* phytocoenoses in the Dąbrowska Basin occupy different wastelands such as: roadsides, squares and fallows located in large towns such as Sosnowiec-Zagórze, Dąbrowa Górnicza-Korzeniec and Będzin-Ksawera. They are confined to dry, sunny sites. Skeletal parts such as stones and gravel were found at the sites, which are very frequently covered by mosses. The main components of patches are differentials of the *Dauco-Melilotenion* suballiance and the *Onopordion acanthii* alliance and meadow species of the *Molinio-Arrhenatheretea* class which occur in the upper layer. *Poa compressa*, *Medicago lupulina*, *Lotus corniculatus* occur in the lower layer. The moss layer is well developed. Very frequently, the rosettes of *Picris hieracioides* are found in this layer. According to MUCINA (1981), *Dauco-Picridetum* communities have an intermediate position between ruderal plant communities from the *Dauco-Melilotenion* and fresh meadows from the *Arrhenatherion* alliance. Some phytocoenoses have some affiliation to the subassociation with *Crepis biennis*, which has been described from the Podunajská Lowland (MUCINA 1981) and to the richer *Dauco-Picridetum* phytocoenoses which were examined in a clay mine (STANISŁAWEK 1995). In some patches segetal plants from the *Stellarietea mediae* class have a higher share. The *Dauco-Picridetum* phytocoenoses grow close to other communities from the *Artemisietea* class (*Rubo-Calamagrostietum epigeji*, *Solidago canadensis* community).

Melilotetum albo-officinalis phytocoenoses develop in disturbed places such as roadsides, post-industrial wastelands, playgrounds and railway yards. They prefer dry, sunny sites, flat or slightly sloped with skeletal particles (gravel, stones, and bricks). Both character species, *Melilotus alba* and *M. officinalis* were recorded in the patches. They were accompanied by *Calamagrostis epigejos*, *Solidago canadensis* and *Cirsium arvense.* In the field *Melilotetum albo-officinalis* phytocoenoses occur in the vicinity of *Rubo-Calamagrostietum epigeji* and phytocoenoses created by alien species such as *Solidago canadensis.*

MUCINA (1981) described three associations from the *Dauco-Melilotion* alliance which have something in common with reference to their floristic composition: *Echio-Verbascetum*, *Epilobio dodonaei-Melilotetum albae*, which are confined to natural habitats, and *Melilotetum albae-officinalis*. In the Dąbrowska Basin *Chamaenerion palustre* was recorded in sand-pits (Kuźnica Warężyńska, Klimontów), on reclaimed wastelands and on places of gravel deposition. However, this species cannot create a repeated combination of species in the field. KOPECKÝ (1982), who examined *Melilotus* stands in Prague, classified them into two different communities. The phytocoenoses which developed along railways, roadsides, in quarries on sites which contain skeletal particles, in the floristic composition of which occur character and differential species of the *Dauco-Melilotion* alliance are grouped into the *Echio-Melilotetum* association. The phytocoenoses which are found on earth deposition, heaps, on building sites, mine areas or newly built roads, the patches of which are negatively distinguished by lack of character species of the asso-

ciation and their have some affiliation in relation to their floristic composition are grouped into the *Onopordion acanthii*, *Arction lappae* or the *Sisymbrion officinalis* alliance. According to the deductive method of plant communities' classification, they should be classified as the basal community *Melilotus alba-Melilotus officinalis* and included into the *Dauco-Melilotion* alliance. The phytocoenoses in the synoptic table (Table 1) show similarities to this unit. Reclamation work conducted on post-industrial areas can have some influence on the spread of the *Melilotus* community (KOPECKÝ 1982; BALCERKIEWICZ, PAWLAK 1990; CABAŁA, JARZĄBEK 1999).

Phytocoenoses with *Tanacetum vulgare* as a dominant grow on roadsides, near fences, escarpments and fallows. They are confined to sunny, overdried, flat or slightly sloped places. Some patches with a higher abundance of *Artemisia vulgaris* were also included into the *Artemisio-Tanacetetum.* According to some authors, patches with *Artemisia vulgaris* as a dominant should be included into the *Tanaceto-Artemisietum arctietosum* subassociation or described as a separate association – the *Arctio-Artemisietum* (BRZEG, PAWLAK 1998), as a derivate community with an affiliation to the *Arction lappae* alliance (KOPECKÝ 1984). The extremely heterogeneous floristic composition of phytocoenoses causes their connection to many other communities and is a fact that has a great influence on its syntaxonomical position (KOPECKÝ 1984). In most papers, *Artemisio-Tanacetetum* phytocoenoses are grouped into the *Eu-Arction* alliance (GUTTE, HILBIG 1975; ŚWIĘS 1985; KOTOWSKA 1988). According to BORYSIAK et al. (1992), some patches can be classified into the *Agropyretalia repentis* order (or *Convolvulo-Agropyrion* alliance). In other papers, *Artemisio-Tanacetetum* is classified into the *Dauco-Melilotion* alliance (KOPECKÝ, HEJNÝ 1990) or into the *Onopordion acanthii* alliance and the *Dauco-Melilotenion* suballiance (BRZEG, PAWLAK 1998). Some patches which were included into this group have a middle position between ruderal plant communities from the *Artemisietea* class and meadow communities of the *Molinio-Arrhenatheretea* class. *Solidago canadensis-Solidago gigantea* community, *Rubo-Calamagrostietum epigeji* and *Helianthetum tuberosi* phytocoenoses were frequently found in its vicinity.

Poo compressae-Tussilaginetum R. Tx. 1931 nom. invers. phytocoenoses develop in disturbed sites where the vegetation has been removed or fresh soil has been deposited. The patches are confined to loamy soils with some participation of skeletal particles. The constant and abundant component of patches is *Tussilago farfara*. Such traits as: high ecological plasticity, anemochory, generative and vegetative reproduction, light and numerous seeds, a high germination rate, phalanx and guerrilla life strategies, enable it to successfully colonize new, open or disturbed habitats, regenerate very quickly after some disturbance and utilise accessible resources (KOPECKÝ 1982, NAMURA-OCHALSKA 1993 a, b). This species is accompanied by hemicryptophytes and rhizomatous geophytes from the *Artemisietea* class and meadow species from the *Molinio-Arrhenatheretea* class. Such differentials of the associations were found in patches as *Agrostis stolonifera*, *Equisetum arvense*, *Holcus lanatus*, *Poa compressa* and *Ranunculus repens*. The differentiated floristic composition of *Tussilago farfara* patches formed by species with different ecological preferences caused some difficulties with their classification. The phytocoenoses with *Tussilago farfara* and *Senecio viscosus* were described as *Senecioni-Tussilaginetum* and included into the *Chenopodietea* or the *Rudero-Secalietea* classes (FIJAŁKOWSKI 1978, KUCZYŃSKA et al. 1982, KUCHARCZYK 1985, KOTOWSKA 1988). Czech scientists, who used the deductive method of plant communities classification, classified the *Tussilago farfara* phytocoenoses as basal (Basalgesellschaften) or derivate communities (Derivatgesellschaften), which in reference to the composition of accompanying species can be classified as: Dg. *Tussilago farfara*-[*Dauco-Melilotion/Agropyro-Rumicion crispi*] (KOPECKÝ

1982); KOPECKÝ, HEJNÝ (1990), Dg. *Tussilago farfara*-[*Sisymbrietalia*] (MUCINA 1981), Dg. *Tussilago farfara*-[*Agrostietalia stoloniferae*] (VIŠNAK 1996) and the Bg. *Tussilago farfara*-[*Agropyretea repentis*], Dg. *Tussilago farfara*-[*Convolvulo-Chenopodietalia*] (VIŠNAK 1996), Dg. *Tussilago farfara*-[*Chenopodietea*] (VIŠNAK 1996). BRANDES (1986) grouped *Tussilago farfara* phytocoenoses from Eastern Europe into the *Convolvulo-Agropyrion* alliance and pointed out their connection with communities from the *Dauco-Melilotion* or the *Agropyro-Rumicion crispi* alliance. The phytocoenoses of the investigated area were placed into the *Dauco-Melilotenion* suballiance, the *Onopordetalia acanthii* order and the *Artemisietea* class according to BRZEG and PAWLAK (1998). During succession the patches can transform into the *Artemisio-Tanacetetum*, *Melilotetum albo-officinalis*, *Convolvulo-Agropyretum* or *Calamagrostis epigejos* community (ZAJĄC 1974, PYŠEK 1977, KOPECKÝ 1982). *Helianthetum tuberosi*, *Solidago canadensis* community, *Potentilletum anserinae* phytocoenoses develop in their vicinity.

The phytocoenoses with *Medicago lupulina* were found on urban lawns, roadsides and wastelands. Most species recorded in patches were small in size because they were susceptible to trampling or mechanical damage caused by vehicles. So in the floristic composition of patches species of the *Trifolio-Plantaginetalia majoris* order have a higher share. Possibly, the phytocoenoses represent a variant or a successional stage of the *Lolio-Plantaginetum* association. PAWLAK (1997) found *Lolio-Plantaginetum typicum* subassociation in the Konin Brown Coal Basin, phytocoenoses which are distinguished positively by the presence of *Medicago lupulina* in patches. The patches with legumes have already been examined by BALCERKIEWICZ, PAWLAK (1990) and WOŹNIAK (1998). FALIŃSKI (1966) described *Medicago lupulina* ssp. *Jalasii* stands which grew on railway areas in Białowieża.

Some patches with *Pastinaca sativa* were also included into the *Dauco-Melilotenion* suballiance. They develop on roadsides and post-industrial wastelands.

The *Berteroetum incanae* and the *Oenothera flaemingina* community are not frequently found in the investigated area. In their floristic composition species from the *Oenothero-Berteroenion* suballiance, where these phytocoenoses are included (BRZEG, PAWLAK 1998) have a lower share. *Berteroetum incanae* phytocoenoses in the Dąbrowska Basin build small patches on the roadsides and less disturbed sites situated in railway areas. They prefer sunny and overdried, sandy or sandy-gravel habitats. *Berteroa incana* and in some patches *Centaurea stoebe* can build some facies. The character combination of the community is created by ruderal species of the *Onopordetalia acanthii* order, meadow species of the *Molinio-Arrhenatheretea* class, termophilous species from the *Festuco-Brometea* and psammophilous of the *Koelerio-Corynephoretea* classes. The one relevé represents *Berteroetum incanae typicum*, which developed in the vicinity of the impoverished *Trifolium arvense* community. The second, because of presence in the patch of some psammophilous and xerothermic species and distinctly lower share of the ruderal species of the *Onopordion acanthii* alliance, approximates the *Berteroetum incanae centaureetosum stoebes* subassociation (BRZEG, PAWLAK 1998). *Centaureo-Berteroetum* with *Centaurea diffusa* as a character species and such differentials as: *Reseda lutea*, *Senecio viscosus*, *Silene vulgaris* is another association with *Berteroa incana* which is described in the phytosociological papers. Their phytocoenoses are mainly confined to railway areas. According to MUCINA and BRANDES (1985), the phytocoenoses of the *Centaureo-Berteroetum* should be included into the *Berteroetum incanae* eastern race with *Centaurea stoebe* because they have many species in common and a similar area of distribution.

In the impoverished *Oenothera flaemingina* patches species of the *Dauco-Melilotenion* suballiance have a distinctly higher participation, so they were classified on the dendrogram

next to *Melilotetum albo-officinalis* phytocoenoses. The phytocoenoses were recorded in Dąbrowa Górnicza on sandy wastelands near the sand-pit (Kuźnica Warężyńska) and artificial water reservoirs. The main constituent of patches is a hybrid *Oenothera rubricaulis* x *Oenothera jueterbogensis*, which is included along with *Oenothera acutifolia*, *Oe. albipercurva*, *Oe. fallax*, *Oe. hoelscheri*, *Oe. issleri*, *Oe. jueterbogenis*, *Oe. paradoxa*, *Oe. punctulata*, *Oe. wienii* in the group of hybrids, which are spread locally (ROSTAŃSKI, TOKARSKA-GUZIK 1998). It is accompanied by species from the *Onopordion acanthii* alliance (particularly *Dauco-Melilotenion* suballiance), psammophilous species from the *Koelerio-Corynephoretea* class and termophilous ones from the *Festuco-Brometea* class. The species of *Oenothera* are significant components of many plant communities, which are classified in a community rank or as a separate association *Artemisio-Oenotheretum rubricaulis* (PASSARGE 1977; ŚWIĘS, KUCHARCZYK 1982; TOKARSKA-GUZIK 1986; BRZEG, PAWLAK 1998). The phytocoenoses of the investigated area, because of the presence in patches of species from the *Onopordion acanthii* alliance (particularly *Dauco-Melilotenion* suballiance) approximate *Artemisio-Oenotheretum rubricaulis melilotetosum*, which was described from the area of Wielkopolska region (BRZEG, PAWLAK 1998). However, such character species of the *Artemisio-Oenotheretum rubricaulis* as *Oenothera rubricaulis* or *Oenothera biennis* were not recorded; therefore, they were classified in the community rank with affiliation to the *Onopordion acanthii* alliance and the *Oenothero-Berteroenion incanae* alliance (BRZEG, PAWLAK 1998).

b) The phytocoenoses of the *Arcion lappae* alliance

The *Leonuro cardiacae-Ballotetum nigrae* Slavnić 1951 phytocoenoses are found along fences, roadsides, stony walls surrounding allotments or houses. They form on moderately moisture sites which are frequently shaded by trees or shrubs, for instance *Sambucus nigra.* The character species of the association – *Ballota nigra*, whose dense growing stems are entwined by *Convolvulus arvensis*, gives patches a specific physiognomy and in this way limits the amount of light which falls to the ground. Another archeophyte – *Leonurus cardiaca* occurs in patches less frequently. Such locally character species as *Nepeta cataria* and *Arctium minus* were not recorded in patches (BRZEG, PAWLAK 1998). Some meadow species of the *Molinio-Arrhenatheretea* class occurred in patches, because of the vicinity of fresh meadow community – *Arrhenatheretum elatioris.* Similar patches were examined by PAWLAK (1981). In terms of floristic composition (presence of *Aethusa cynapium*, *Anthriscus sylvestris*), the phytocoenoses of the Dąbrowska Basin approximate in some way the *Leonuro-Ballotetum typicum* described from Germany by GUTTE (1972). Disturbance caused by mechanical damage to the soil, waste disposal or mowing causes the elimination of more expansive species such as *Urtica dioica* or *Anthriscus sylvestris* (KOPECKÝ 1984).

The phytocoenoses of the *Lycietum halimifolii* Felf. 1942 in the Dąbrowska Basin develop in sunny places, very frequently on road escarpments. The number of species which are found in the patches is rather low and most of them occur in the border of the patch because *Lycium halimifolium* individuals grow very close to each other and create a dense canopy. In the floristic composition of patches the main components are species of the *Arction lappae* alliance, nitrophilous fringe communities of the *Convolvuletalia sepium* order and the *Artemisietea* class. Contrary to WOJTERSKA (1990) and ANIOŁ-KWIATKOWSKA (1974), the short-lived ruderal species of the *Stellarietea mediae* class are of low importance. The phytocoenoses can be considered as a ruderal part of this association similar to WOJTERSKA (1990). The *Lycietum halimifolii* phytocoenoses grow near *Solidago canadensis*, *Solidago gigantea* phytocoenoses, the *Urtica dioica* community and the *Leonuro-Ballotetum* patches. *Lycium halimifolium* phytocoenoses

are classified into the *Arction lappae* and the *Artemisietea* class (BRZEG, PAWLAK 1998). MORAVEC et al. (1995) pointed out that *Lycium halimifolium* patches should be included into the *Robinietea* class, along with *Chelidonio-Robinietum*, *Impatienti-Robinietum* or *Balloto nigrae-Robinietum* associations. Because of the distinct floristic differences between the *Lycietum halimifolii* from the Dąbrowska Basin and *Lycio-Syringetum* examined in Germany (BORNKAMM 1974), the phytocoenoses of the investigated area cannot be classified into the *Querco-Fagetea* class or, as was suggested by BORNKAMM (l.c.), into the *Berberidion* alliance and the *Rhamno-Prunetea* class.

The *Arctietum lappae* Felföldy 1942 patches develop in sites shaded by trees, close to old houses, roadsides and near fences or small yards situated near human settlements. The sites were not manured by organic wastes and were susceptible to mechanical damage or trampling. *Arctium tomentosum* covers more than 90% of the patches so other species such as: *Arctium lappa*, *Artemisia vulgaris*, *Tanacetum vulgare*, *Cirsium arvense*, *Elymus repens* were recorded only occasionally. In the lower layer, apart from the ruderal species of the *Artemisietea* class, species of trampled places of the *Trifolio-Plantaginetalia* order and meadow species of the *Molinio-Arrhenatheretea* class occurred frequently. The *Arctietum lappae* from the Dąbrowska Basin has an impoverished floristic composition in comparison with similar communities described from other regions of Poland. Apart from *Arcium tomentosum*, they were not recorded in patches other character species of the association such as *Conium maculatum*, *Leonurus cardiaca* or *Ballota nigra* (BRZEG, PAWLAK 1998). ZAJĄC (1974) had already pointed out the occurrence of impoverished patches of *Arctietum lappae* in the area of large towns. Some patches of *Arctietum lappae* can develop in places which had been previously occupied by pioneer communities of the *Stellarietea mediae* class (the *Sisymbrietum sophiae*). This syntaxon approximates the *Arctio-Ballotetum* described from Western Europe because of presence in the floristic composition of patches of such species as *Aegopodium podagraria*, *Dactylis glomerata*, *Achillea millefolium*, *Lolium perenne* and *Ballota nigra* (ZAJĄC 1974). BRANDES (1980) did not classify phytocoenoses with a dominance of *Arctium tomentosum* as a separate association but grouped them into the *Arctio-Artemisietum* association as a subcontinental race with *Arctium tomentosum.* He also mentioned the truncated *Arctium tomentosum* phytocoenoses which develop on arable land.

Urtica dioica belongs to the most frequently found species in the Dąbrowska Basin. Its wide ecological tolerance causes the species to occur with higher abundance both in some nitrophilous plant communities (*Urtico-Convolvuletum sepium*, *Agropyro-Aegopodietum podagrariae*) and ruderal ones (*Arctietum lappae*), thickets (*Aegopodio-Sambucetum nigrae*) so it cannot be considered as a character species of only one association. Moreover, in the Dąbrowska Basin patches with a dominance of *Urtica dioica* were also recorded, which cannot be univocally classified into defined units of the Braun-Blanquet system. They develop in disturbed places such as scarps of water courses, neglected lawns or meadows. Some indicators of soils rich in nutrients were found in patches. *Urtica dioica* is a strong competitor even in comparison to such species as *Cirsium arvense*, *Elymus repens*, *Artemisia vulgaris* or *Calamagrostis epigejos* (ŠRŮTEK, TECKELMANN 1998). Such traits as allelopathy and a thick litter layer enable it to compete with other plants. The dominant species is accompanied by the species of the *Arction lappae* alliance, nitrophilous fringe communities of the *Convolvuletalia sepium* order and the *Artemisietea* class and meadow plants of the *Molinio-Arrhenatheretea* class. The patches approximate *Agropyro-Urticetum* (HADAČ 1984, BRZEG 1989, ŚWIERKOSZ 1993), which according to BRZEG (1989), can be considered as a truncated *Agropyro-Aego-*

podietum, which has some floristic affiliation to the plant communities of the *Arction lappae* alliance. DIERSCHKE (1974), BRZEG and NOWAKOWSKI (1981) pointed out that *Urtica dioica* can build truncated plant communities with an affiliation to such units as the *Arction lappae*, *Calystegion sepium*, *Galio-Alliarion* or *Petasition officinalis* alliances.

2. The differentiation of the plant communities of the *Stellarietea mediae* and *Bidentetea tripartiti* classes (Table 2)

Hyoscyamo nigri-Malvetum neglectae Aichinger 1933 phytocoenoses develop in the Dąbrowska Basin both in industrial towns (Sosnowiec or Dąbrowa Górnicza-Gołonóg) and in sites which are situated far from the city centre. The patches grow on roadsides, near fences and close to „wild" rubbish dumps. They phytocoenoses are confined to flat areas or to the slopes of small hills which were created by soil deposition. They are different with reference to soil compaction from a loose to a very compact substratum. A combination of anthropogenic and zoogenic factors have a great influence on saving the character combination of species of the *Hyoscyamo nigri-Malvetum neglectae* phytocoenoses which can be found in rural settlements. When these factors are restricted or eliminated the phytocoenoses can change into ruderal plant communities of the *Artemisietea* class or phytocoenoses of trampled places (KOPECKÝ 1986). Some therophytes of the *Sisymbrietalia* order are replaced by perennial ruderal plants of the *Artemisietea* class. Such patches are classified as the *Malvetum neglectae ballotetosum nigrae* subassociation KOPECKÝ (1986). The phytocoenoses from the investigated area approximate to this unit. The patches of the Dąbrowska Basin also have something in common with the variant with *Galinsoga parviflora*, with such differentials as: *Chenopodium album*, *Capsella bursa-pastoris* and *Geranium pusillum* which has been described by PAWLAK (1981) from the village of Kłodzino. A patch with a higher abundance of *Datura stramonium*, which is considered as character species of the *Daturo-Malvetum*, was also included in this association. The floristic composition of this phytocoenoses, the lack of other character species such as *Chenopodium murale*, *Ch. hybridum*, *Amaranthus chlorostachys*, *Artemisia annua*, *Descurainia sophia*, *Hyoscyamus niger* did not allow it to be classified into the *Daturo-Malvetum* association, which is considered to be a geographical vicariant of *Hyoscyamo nigri-Malvetum* in warmer areas of central and eastern Europe (GUTTE, HILBIG 1975).

The *Elymo repentis-Sisymbrietum loeselii* Mucina 1993 phytocoenoses were found in the Dąbrowska Basin on roadsides and squares situated within human settlements. They were not included *Sisymbrium officinale* phytocoenoses which develops along roadsides. The sites were overdried, sunny and loamy-sandy with a different level of skeletal particles. The community has a three-layered structure. The topmost layer is built by *Sisymbrium loeselii*, which is accompanied by *Cirsium arvense*, *Oenothera biennis*, *Rumex obtusifolius* or *Epilobium hirsutum*. Such species as *Apera spica-venti*, *Chenopodium album*, *Descurainia sophia* occur in the middle layer. The bottommost layer composes of terophytes from the *Polygono-Poëtea* class, species of trampled places of the *Trifolio-Plantaginetalia majoris* and ruderal plants of the *Artemisietea* class. Their phytocoenoses occur near thickets of the *Aegopodio-Sambucetum* and at the edge of the *Cirsietum rivularis* phytocoenoses. Patches with *Sisymbrium loeselii* are frequently included into the *Sisymbrietum sophiae* association and treated as its variants or facies (ZAJĄC 1974; KĘPCZYŃSKI 1975; KUCHARCZYK 1985; KUCZYŃSKA, ANIOŁ-KWIATKOWSKA, MĄDROSZKIEWICZ 1982). ROSTAŃSKI, GUTTE (1971) and GUTTE (1972) postulated that phytocoenoses with a higher abundance of *Sisymbrium loeselii* or a partial lack of *Descurainia sophia* should be allocated into a separate syntaxon. KOPECKÝ (1980) distinguished two types of the association: one with an archeophyte *Descurainia sophia* whose phytocoenoses are con-

fined to the old parts of towns and a neophitic one with *Sisymbrium loeselii* whose phytocoenoses are confined to building areas. Czech scientists classified them as a basall community (Basallgesellschaft) with an affiliation to the *Sisymbrion* alliance (KOPECKÝ, HEJNÝ 1990; VIŠŇÁK 1996) or as an association *Sisymbrietum loeselii* (MUCINA 1982, PYŠEK 1977).

BRZEG and WOJTERSKA (2001), taking into account the habitat conditions, floristic composition and distribution of phytocoenoses with *Sisymbrium loeselii*, *Sisymbrium altissimum* or *Descurainia sophia*, distinguished three separate associations *Sisymbrietum sophiae*, *Sisymbrietum loeselii* and *Lactuco-Sisymbrietum altissimi.*

The *Erigeronto-Lactucetum serriolae* Lohmeyer in Oberd. 1957 community has wide ecological amplitude and is confined to sites which have undergone human disturbances such as: rubble heaps, gravel or slag disposal, fallows and wastelands (MUCINA 1978). It occupies areas of building sites which are overdried and contain a higher percentage of skeletal particles (gravel and small stones). The community has a three-layered structure. The topmost layer is made of *Lactuca serriola* and *Conyza canadensis*, the middle by meadow and ruderal species, the bottommost by species of trampled places such as: *Potentilla anserina*, *Plantago major* and *Medicago lupulina.* In the floristic composition of phytocoenoses hemicryptophytes predominate on therophytes. During the succession of the community the character species of the *Sisymbrion* alliance and the *Stellarietea mediae* class will probably disappear and in their place components of the perennial meadow communities from the *Molinio-Arrhenatheretea* and ruderal species from the *Artemisietea* class will successively appear. MUCINA (1978), in relation to habitat conditions and floristic diversity, distinguished two subassociations of the *Erigeronto-Lactucetum*: *E-L. typicum* and *E-L. cirsietosum arvense.* The patches of the Dąbrowska Basin has some affiliation to these units because of the presence in the floristic composition of the character species of the *Onopordetalia acanthii* order and the *Artemisietea* class.

The *Sisymbrio-Atriplicetum nitentis* Oberd. 1957 ex Mahn. et Schubert 1962 phytocoenoses are not frequently found in the Dąbrowska Basin. They were recorded in Dąbrowa Górnicza (Mydlice, Gołonóg). They prefer loamy places which were created by soil deposition. In the floristic composition of patches, apart from the short-lived ruderal species of the *Sisymbrion* alliance and the *Stellarietea mediae* class, species of the perennial ruderal communities of the *Artemisietea* class also have a distinct share.

GUTTE (1972), who examined the *Atriplicetum nitentis* phytocoenoses in Germany, distinguished patches with *Lepidium latifolium* and typical ones. Such differential species as: *Lepidium latifolium*, *Atriplex hastata*, *Chenopodium rubrum* or *Carduus crispus* were not recorded in the patches so the phytocoenoses from the Dąbrowska Basin approximate the second unit. According to GUTTE (1972), phytocoenoses which were described from western Poland are distinctly poorer in species in comparison with patches examined in the Central Germany and they can be considered as *Atriplex nitens* facia. Possibly, the succession of the community leads to the perennial ruderal plant communities of the *Artemisietea vulgaris.*

The *Sisymbrium officinale* communities develop on roadsides, along pavements or stony walls. Their phytocoenoses are confined to overdried, flat or slightly inclined loamy soils with skeletal particles. *Sisymbrium officinale*, *Chenopodium album*, *Atriplex patula* or *Artemisia vulgaris* create the upper sublayer of the community. Species of trampled places, both therophytes from the *Polygono-Poëtea* class and of the *Trifolio-Plantaginetalia* order and species of the *Stellarietea mediae* class, are constituents of the bottommost sublayer. The phytocoenoses with *Sisymbrium officinale* can be considered as a pioneer community which plays important part in the first period of establishment on a "bare" substratum with varied chemical and phy-

sical conditions (KOPECKÝ 1982). Weaker competitors belong to the dominant (GRÜLL 1984). The further succession of the community depends on the method of management, physical and chemical conditions and the vicinity of other communities (KOPECKÝ 1982). In the case of the investigated area, their succession leads to communities of trampled places or perennial communities of the *Artemisietea* class. The floristic combination of species allows the group *Sisymbrium officinale* phytocoenoses only in a community rank with an affiliation to the *Sisymbrion* alliance. In spite of the lack *Descurainia sophia*, *Sisymbrium loeselii*, *S. altissimum* in patches, they are sometimes classified as the impoverished the *Sisymbrietum sophiae* phytocoenoses, which develop in the area of towns. Scientists (KOPECKÝ 1982; GRÜLL 1984; KOPECKÝ, HEJNY 1990) classified *Sisymbrium officinale* stands as a derivate community with intermediate position between the *Plantaginetalia* and the *Sisymbrietalia* orders.

Small patches with *Stellaria media* were recorded in parks, allotments, yards, at the edges of arable fields or on the rubbish dumps. These sites were frequently shaded by trees. *Stellaria media* very frequently builds truncated communities. Such traits as: an ability for generative and vegetative reproduction (fragmentation), a possibility for growth in lower temperatures, seed banks in the soil and varied strategies of seed germination enable the species to occupy given habitat conditions (SOBEY 1981).

The *Chenopodietum glauco-rubri* (Weevers 40) Lohm. 50 ap. Oberd. 57 phytocoenoses were recorded in roadside ditches near human settlements. They prefer wet places, therefore, in their floristic composition species of the *Phragmitetea* class and short-lived species of the *Bidentetea* class occur.

Because of the presence of *Chenopodium rubrum*, *Atriplex patula* and character species of the *Stellarietea mediae* class in the patches, the phytocoenoses have some affiliation to *Chenopodio rubri-Atriplicetum patulae* (GUTTE 1972; GUTTE, HILBIG 1975; PAWLAK 1985; JEHLÍK 1986). Most scientists classify the *Chenopodietum glauco-rubri* phytocoenoses into the *Chenopodion fluviatile* alliance (= *Chenopodion rubri* according to Code of Phytosociological Nomenclature) and the *Bidentetea tripartiti* class. HEJNÝ (1974) suggested that the phytocoenoses which developed in overmanured places or on sites with higher salt content in the soil should be included into the *Bidentetea tripartiti* class and into a separate the *Chenopodion glauci* alliance with such character species as: *Chenopodium glaucum*, *Ch. serotinum*, *Ch. urbicum* and *Atriplex hastata.* HADAČ (1978), who found some similarities between the *Chenopodion glauci* alliance and the *Sisymbrietalia* order, proposed that this syntaxon should be included into the *Chenopodietea* class. The florisitic composition of the community does not let univocally classify the phytocoenoses of the Dąbrowska Basin. Some species of the *Chenopodion fluviatile* alliance or the *Bidentetea tripartiti* class were not recorded in the patch. *Chenopodium rubrum* is confined to this community. PYŠEK (1974) also found *Chenopodium rubrum* in other plant communities such as: *Chenopodietum ruderale*, *Erigeronto-Lactucetum* or *Atriplicetum nitentis.* However, this species occurred with lower frequency. FALIŃSKI (1966) observed the higher share of *Chenopodium rubrum* in *Bidenti-Polygonetum hydropiperis.*

CONCLUSIONS

1. As a result of scientific research 18 ruderal plant communities from the *Artemisietea*, *Stellarietea mediae*, *Bidentetea tripartitae* classes were recognized in the area of the Dąbrowska Basin (Silesian Upland).
2. The common and most widely distributed are plant communities of the *Dauco-Melilotenion* suballiance. Among them the most heterogeneous are phytocoenoses of *Dauco-Picridetum*.

3. Some differential species of the *Oenothero-Berteroenion* suballiance do not occur in the floristic composition of communities which develop on sandy, dry habitats.
4. The ruderal plant communities which represent the *Onopordenion acanthii* suballiance were not found in the Dąbrowska Basin.
5. Nitrophilous ruderal plant communities of the *Arction lappae* are less frequent. Most patches have impoverished floristic composition. In many of them they were not recorded some character species of the association.
6. Some phytocoenoses had impoverished florisitic composition so they were grouped only in a community rank (*Medicago lupulina* community, *Oenothera flaemingina* community, *Sisymbrium officinale* community, *Urtica dioica* community).
7. The further research is needed in case of alien species. They can be a component of some ruderal plant communities. Some examples are *Erigeron annuus* in *Dauco-Picridetum*, *Melilotetum albo-officinalis* phytocoenoses, *Aster* x *salignus*, *Reynoutria japonica*. Many of the can eliminate native components of patches and finally completely transform floristic composition of a given plant community. They are frequently components of the nitrophilous fringe communities. However, most of such phytocoenoses lost the specific physiognomy and they occupy often synathropic habitats. The nitrophilous fringe communities are nowadays subject of scientific research which is conducted in the Upper Silesian Industrial District.
8. Plant communities with *Atriplex nitens* or *Sisymbrium loeselii* increase the number of localities.

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Table 1. The synoptic table of the plant communities of the *Artemisietea* class

Community		D-P		Ma-o		Ml		A-T		P-T		Ps		Bi		Of		U		Lh		L-B		Al	
Number of relevés in the table		9		9		5		11		6		5		3		2		5		3		2		10	
Number of species in the table		86		95		70		116		80		64		46		42		54		24		26		90	
Mean number of species in the relevé		27		25		25		24		26		26		20		24		17		11		14		22	
Mean cover b [%]																				100					
Mean cover c [%]		68		98		97		100		86		91		73		100		100		13		92		89	
Mean cover d [%]		13		8		4		2		5		7		7		2								0	
Daucus carota ’	c	89	711	67	83	40	450	36	255	67	108	80	372	33	167	50	25							30	15
Oenothera sp.’	c	67	436	11	6	20	10	18	2					33	17			20	10					20	2
Echium vulgare ’	c	44	450	11	56	20	10	9	5					33	17										
Picris hieracioides ’	c	33	1172	33	67					33	17	40	110	33	583										
Carduus acanthoides ’	c	33	17	11	6																			10	50
Hieracium sabaudum	c	33	8	11	6			9	45																
Potentilla intermedia	c	22	11																						
Melilotus alba ’	c	33	67	100	7639	40	110	18	50	17	8													10	5
Melilotus officinalis ’	c	11	6	44	72			9	1			20	10												
Oenothera biennis ’	c			22	11																				
Medicago lupulina ’	c	67	133	67	133	100	6250	27	14	67	33	40	20	67	183	50	25							20	10
Sonchus oleraceus *	c	11	1			40	20																	10	5
Cerastium holosteoides ^	c	11	6	22	11	40	110					40	20												
Tanacetum vulgare ’	c	67	133	56	78	40	20	100	5845			60	30	33	17									30	15
Tussilago farfara ’	c	56	28	67	83	40	20	18	9	100	7083	20	10											10	5
Ranunculus repens ^	c			11	6	20	10	9	5	83	808	40	110					40	20			50	250	40	235
Rumex crispus ^	c			11	6	20	10	18	9	50	25							20	2					10	5
Pastinaca sativa ’	c	33	67	67	79	20	10	27	14	17	8	100	4010	67	33									10	50
Cichorium intybus ’	c							9	5			40	20												
Pimpinella major ^	c											40	360					20	10						
Berteroa incana ’	c	11	6											100	4750										
Arrhenatherum elatius ^	c	22	111	11	6			27	55			40	20	67	183					33	17				
Carex hirta ^	c	11	6			20	10	18	50	17	8	20	10	67	183	50	250								
Setaria viridis ^	c													33	17										
Descurainia sophia *	c													33	17										
Lathyrus sylvestris	c													33	17										
Linaria vulgaris ’	c													33	17										

Table 1. (continued)

Community		D-P		Ma-o		Ml		A-T		P-T		Ps		Bi		Of		U		Lh		L-B		Al	
Oenothera flaemingina ’	c															100	3750								
Rumex acetosella	c	11	6					9	5					33	17	100	275								
Artemisia absinthium ’	c															100	50								
Trifolium arvense	c	22	11	11	6	40	20									100	275								
Urtica dioica "	c							36	59	17	8							100	8750	100	200	50	250	60	165
Lamium album "	c																	60	300	33	17				
Echinocystis lobata "	c																	20	10						
Galeopsis pubescens "	c																	20	10						
Alliaria petiolata "	c																	20	10						
Lycium barbatum "	b																			100	7917				
Chelidonium majus "	c													33	17			20	10	67	33				
Malva neglecta *	c																			33	17			10	1
Glechoma hederacea "	c																			33	167				
Chaerophyllum aromaticum "	c																			33	17				
Ballota nigra #	c																	20	10	33	17	100	8750		
Leonurus cardiaca #	c																					50	250		
Aethusa cynapium *	c																					50	250	10	5
Torilis japonica "	c									17	8											50	25	10	5
Arctium tomentosum #	c	11	6	11	6	20	10	27	55			20	10					20	10	33	17			100	6430
Potentilla anserina ^	c			33	12	20	10	18	9	33	300	20	10											60	30
Galium aparine "	c							9	5									100	230	100	50	50	25	33	15
Artemisia annua *	c							9	5															20	10
Ch. *Onopordion acanthii* ’ + *Arction lappae* # + *Artemisietea* "																									
Elymus repens	c	56	178	33	117	60	30	91	700	67	542	80	470	67	33	100	1900	80	1210	67	750	50	25	80	390
Solidago canadensis	c	100	250	78	189	60	22	82	573	83	117	80	122	33	167			60	120	33	17			40	20
Artemisia vulgaris	c	100	200	100	50	60	120	100	1950	83	192	80	40			50	25	100	230	33	17	100	275	90	2260
Rubus caesius	c	22	111	11	194	20	10	36	59	17	8			33	167	50	250	20	10	33	17			20	10
Convolvulus arvensis	c	11	6	11	56			27	136			40	20	67	183	50	25	60	120	67	33	50	875	20	55
Melandrium album	c	44	72	11	6	60	30	45	23	17	8	40	12			50	250	60	30					30	15
Equisetum arvense	c	56	78	22	61			45	145	83	42	20	10			50	25	60	120						
Cirsium arvense	c	78	39	67	133	60	30	82	318	83	475	80	130	67	20			20	10	33	17			50	285
Calystegia sepium	c	11	6	11	6	20	2	36	100	17	8													10	175

Table 1. (continued)

Community		D-P		Ma-o		Ml		A-T		P-T		Ps		Bi		Of		U		Lh		L-B		Al	
Arctium lappa #	c	11	6			20	10			17	8	20	10					40	20			50	250	50	25
Erigeron annuus	c	22	422	44	22			9	5					33	17										
Aster x salignus	c			11	56			18	50	17	83	40	20	33	17									10	5
Aegopodium podagraria	c							18	345	17	8							20	10	33	167			30	230
Rumex obtusifolius #	c																	20	10					40	155
Ch. *Molinio-Arhenatheretea* ^																									
Achillea millefolium	c	78	239	78	239	80	130	82	205	67	108	80	650	100	500	50	250					50	25	50	70
Taraxacum officinale	c	100	100	67	33	100	140	36	18	67	650	100	50	33	17			20	10	33	17			90	550
Agrostis gigantea	c	11	6	33	67			55	459	50	383	20	100			50	250					50	25	10	5
Festuca rubra s.s.	c	67	272	67	922	40	20	36	100	17	8	60	120	100	500			40	200					20	10
Vicia cracca	c	22	11	56	78	20	10	64	73	67	108	20	10			50	25							20	10
Lolium perenne	c	78	328	33	17	100	140	27	14	50	100	100	140	33	167							50	25	80	1010
Rumex acetosa	c	44	68	33	17			45	64	33	17	40	360			50	25	20	10						
Holcus lanatus	c	22	11	44	72			9	5	33	92	20	10	33	17									10	5
Centaurea jacea	c	22	11	11	6			18	50			40	20	33	17									10	5
Lotus corniculatus	c	33	306	44	211			18	50	50	25	60	30	33	17										
Odontites serotina	c	33	17	22	11	20	100	9	5	33	17	20	10												
Plantago lanceolata	c	33	17	44	72	60	120	27	14	17	8	60	30	33	17	50	25							20	10
Plantago major	c	44	18	44	22	60	1110	9	5	33	92													60	705
Poa palustris	c	11	6	22	111	40	20	9	5											33	17			30	15
Poa pratensis	c			11	6	60	210	9	5	33	167	60	120					20	10					22	180
Trifolium pratense	c	67	183	22	111	60	1110	9	5	17	83	20	10											20	10
Trifolium repens	c	56	78	22	11	100	320	27	14	33	17	60	30											30	60
Leontodon autumnalis	c	22	11	33	17					17	8	40	20												
Festuca pratensis	c					40	1100	9	45			20	350			50	25								
Crepis biennis	c	33	17	33	17			18	9	33	92	80	130									50	25	50	25
Dactylis glomerata	c			33	17	20	350	55	27	17	83	60	30					60	120			50	250	40	110
Lysimachia vulgaris ^	c			11	6					17	8					50	25								
Cl. *Stellarietea mediae* *																									
Matricaria maritima subsp. *inodora*	c	11	6	22	61	20	10	9	5	17	8	20	10											20	10
Conyza canadensis	c	56	23	11	1	40	20	36	59	33	17	20	10	33	3	50	25							10	5

Table 1. (continued)

Community		D-P		Ma-o		Ml		A-T		P-T		Ps		Bi		Of		U		Lh		L-B		Al	
Chenopodium album	c			11	6	20	2	9	5					33	17	50	25	20	10					20	55
Apera spica-venti	c			22	11	20	10									50	25							10	5
Vicia hirsuta *	c	11	6	11	6			9	5	17	83	20	10	33	17									20	10
Fallopia convolvulus	c							9	5					33	3			20	10						
Atriplex patula *	c			11	6	20	2	9	45	17	8							20	10			50	25	20	6
Vicia tetrasperma *	c	11	56					9	5	17	83					50	25								
Sonchus asper	c									33	17													10	1
Geranium pusillum	c													33	17			20	10						
Sisymbrium officinale *	c																					50	25	40	435
Others																									
Poa compressa	c	89	572	56	367	80	220	36	100	83	400	60	120	67	183	50	250					50	25	20	55
Calamagrostis epigejos	c	78	39	78	839	20	10	64	686	50	308	60	30	33	17			20	100					10	5
Agrostis capillaris	c	33	17	22	11			27	55	17	83	20	100											10	175
Bidens frondosa	c			11	6	20	2	9	45	33	17													10	5
Arenaria serpyllifolia	c	22	11			40	20					20	10	33	17	50	25								
Coronilla varia	c	11	6	11	56	20	10	18	164					33	17										
Cardaminopsis arenosa	c	44	22	11	6	40	20																		
Artemisia campestris	c											20	10	33	17	50	250								
Chamomilla suaveolens	c					40	20	9	5															20	10
Erigeron acris	c			11	1			9	5					33	17	50	25								
Fraxinus excelsior	c	11	6															40	20	33	3				
Hypericum perforatum	c	44	22	22	7							20	100												
Medicago falcata	c			11	6			9	5					33	167										
Myosotis arvensis	c	11	6							33	17														
Poa annua	c			11	6	40	20			17	8							20	10					30	430
Polygonum aviculare	c			11	6	20	10	9	5			20	10	33	167									30	15
Euphorbia cyparissias	c	11	6					9	5					33	17	50	875								
Hieracium pilosella	c	22	11													50	25								
Ceratodon purpureus	d	11	194			40	450									50	250								

Explanations: D-P – *Dauco-Picridetum*; Ma-o – *Melilotetum albo-officinalis*; Ml – *Medicago lupulina* community; A-T – *Artemisio-Tanacetetum*; P-T – *Poo-Tussilaginetum*; Ps – *Pastinaca sativa* community; Bi – *Berteroetum incanae*; Of – *Oenothera flaemingina* community; U – *Urtica dioica* community; Lh – *Lycietum halimifolii*; L-B – *Leonuro-Ballotetum*; Al – *Arctietum lappae*.

Table 2. The synoptic table of the plant communities of the *Stellarietea mediae* and *Bidentetea tripartiti* classes

Community		E-L		E-S		So		H-M		S-A		Sm		Chg-r	
Number of releves in the table		3		4		3		3		2		2		2	
Number of species in the table		65		60		37		45		53		36		47	
Mean number of species in the relevé		32		24		17		21		32		15		30	
Mean cover c [%]		53		100		93		75		95		80		65	
Mean cover d [%]				9						5					
Conyza canadensis ^^	c	100	2417	50	25					50	25				
Lactuca serriola ^^	c	100	350							50	25				
Cardaminopsis arenosa	c	67	20												
Lepidium ruderale	c	33	167												
Agrostis gigantea !	c	33	167												
Rorippa palustris	c	33	167												
Armoracia rusticana *	c	33	17												
Papaver rhoeas ^	c	33	17												
Senecio viscosus ^	c	33	17												
Senecio vulgaris ^	c	33	17												
Agrostis stolonifera !	c	33	17												
Crepis biennis !	c	33	17												
Rumex acetosella	c	33	17												
Silene vulgaris	c	33	17												
Corispermum leptopterum ^	c	33	17												
Potentilla reptans !	c	33	17												
Cichorium intybus *	c	33	3												
Sisymbrium loeselii ^	c	67	183	100	5000										
Poa trivialis !	c			50	563										
Ranunculus acris !	c			25	13										
Rumex acetosa !	c			25	13										
Oenothera biennis *	c			25	125										
Polygonum hydropiper	c			25	125										
Verbascum phlomoides *	c			25	13										
Rubus caesius *	c			25	13										
Chaerophyllum aromaticum **	c			25	13										
Descurainia sophia ^^	c			25	13										
Ballota nigra *	c			25	13										
Sisymbrium officinale ^	c	33	17	75	28	100	6250	33	17	50	25				
Atriplex patula ^	c					100	2950	33	167	50	875	50	5		
Lathyrus pratensis !	c					33	167								
Galeopsis bifida **	c					33	17								
Myosoton aquaticum **	c					33	17								
Vicia sepium	c					33	17								
Sambucus nigra	c					33	17								
Malva neglecta ^	c							100	4333						
Galinsoga parviflora ^	c							100	2000						
Lolium perenne !	c	67	183			33	17	100	3100	50	25			50	25
Lamium purpureum ^	c							67	33						
Glechoma hederacea	c							33	1250						
Geranium pusillum ^	c							33	1250						
Datura stramonium ^	c							33	583						
Leontodon autumnalis !	c							33	167						

Table 2. (continued)

Community		E-L		E-S		So		H-M		S-A		Sm		Chg-r	
Veronica persica ^	c							33	167						
Cosmos bipinnatus	c							33	17						
Solanum nigrum ^	c							33	17						
Veronica arvensis ^	c							33	17						
Atriplex nitens ^	c	33	17							100	7500				
Ranunculus repens !	c	33	167	25	125					100	50				
Aethusa cynapium ^	c	33	17							100	50				
Impatiens parviflora	c									50	250				
Stellaria media ^	c	33	17					67	183	50	25	100	6250	50	25
Geum urbanum												100	275		
Chenopodium glaucum	c	33	17											100	1900
Matricaria maritima subsp. *inodora* ^	c	67	33	25	3	33	17			50	25			100	1880
Puccinellia distans	c													100	275
Sonchus asper ^	c													100	30
Tanacetum vulgare *	c	33	17					33	17					100	30
Bidens frondosa	c									50	25			100	30
Chenopodium rubrum	c													50	250
Ch. *Sisymbrietalia* ^^ + *Stellarietea mediae* ^															
Chenopodium album	c	67	33	75	688	100	500	67	333	100	500	50	250	100	275
Fallopia convolvulus	c	33	17	50	25	67	33	67	33	100	50	50	25		
Polygonum persicaria	c			25	3	33	17	33	167	50	25				
Amaranthus retroflexus	c					33	17	33	583					50	25
Artemisia annua	c			50	25	33	17	33	17	50	25				
Capsella bursa-pastoris	c			75	28	33	17	67	333	100	50	50	250	50	25
Sonchus oleraceus	c	67	33			33	167							50	25
Apera spica-venti	c	67	33	25	13									50	25
Erysimum cheiranthoides	c	67	33							100	500				
Euphorbia helioscopia	c	33	3											50	25
Galinsoga ciliata	c							33	17					50	25
Sinapis arvensis	c					33	17	33	17						
Viola arvensis	c					33	17					50	25		
Ch. *Onopordetalia acanthii* *+ *Artemisietea* **															
Melandrium album *	c	33	17	25	13	67	33	67	33	50	25	50	25	50	25
Elymus repens	c	67	33	75	575			33	167	50	25	50	25	100	50
Artemisia vulgaris *	c	100	50	75	263	100	50	67	183	100	50			100	50
Medicago lupulina *	c	100	50	25	13					100	50	50	25	100	30
Cirsium arvense	c	100	200	75	963			33	17	50	25			50	25
Solidago canadensis	c	67	33	50	138					50	25	50	5	50	25
Equisetum arvense *	c	33	167	25	125	33	17	33	17						
Aegopodium podagraria	c			25	13	33	167			50	0	50	250		
Urtica dioica	c			50	25	33	167	33	167						
Pastinaca sativa *	c	33	17	25	13	33	17								
Arctium lappa *	c	67	33	25	13	33	17								
Melilotus alba *	c	67	33	25	13									50	250
Epilobium hirsutum	c	33	17	25	125									50	25
Chelidonium majus	c			25	3			33	17	50	25				
Rumex obtusifolius *	c	33	17	50	450			33	17						

Table 2. (continued)

Community		E-L		E-S		So		H-M		S-A		Sm		Chg-r	
Tussilago farfara *	c									100	50			100	50
Eupatorium cannabinum	c									50	25			50	250
Daucus carota *	c			25	13					50	25				
Cirsium vulgare *	c			25	13					50	25				
Melilotus officinalis *	c			50	25					50	25				
Arctium tomentosum *	c			75	575									50	25
Heracleum sphondylium	c			25	3	33	17					50	25		
Ch. *Molinio-Arhenatheretea* !															
Achillea millefolium	c	67	33	75	28	33	17	33	17	50	25			50	25
Taraxacum officinale	c	100	200	75	38	67	33	67	600	50	25	100	275		
Plantago major	c	100	50	50	25	67	33	67	33	100	50	50	25	100	275
Trifolium repens	c	67	33			33	17	67	33					50	25
Poa palustris	c	33	17	25	13									50	25
Cerastium holosteoides	c	33	17	50	138							50	25	50	25
Dactylis glomerata	c	33	17	25	13	33	17					50	250		
Potentilla anserina	c	33	17					67	183	50	25				
Plantago lanceolata	c					33	17	33	17					50	25
Rumex crispus	c			25	13			33	17	50	25			50	25
Trifolium pratense	c			50	25					50	25			50	25
Poa pratensis	c	33	17	50	25							50	25		
Vicia cracca	c	67	183							50	25				
Festuca rubra	c												50	250	
Others															
Poa annua	c	33	17	50	25	67	33	33	17	50	25			50	25
Polygonum aviculare	c	67	183	75	150	67	33	67	33	100	275			100	50
Polygonum lapathifolium subsp. *lapathifolium*	c	33	17	50	25			33	17					100	275
Chamomilla suaveolens	c	67	20	50	25			67	33						
Acer negundo	c	33	17							50	25				
Poa compressa	c	33	583	25	125							50	250		

Explanations: E-L – *Erigeronto-Lactucetum*; E-S – *Elymo repentis-Sisymbrietum loeselii*; So – *Sisymbrium officinale* community; H-M – *Hyoscyamo nigri-Malvetum neglectae*; S-A – *Sisymbrio-Atriplicetum nitentis*; Sm – *Stellaria media* community; Chg-r – *Chenopodietum glauco-rubri.*

Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

THE AQUATIC AND RUSH COMMUNITIES IN THE PRZECZYCKO-SIEWIERSKI DAMMED RESERVOIR

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ABSTRACT. The paper presents the aquatic, swamp and tall fen communities of the *Potametea* and the *Phragmitetea* classes, which developed at the Przeczycko-Siewierski dammed reservoir (Silesian Upland). The phytosociological relevés were ordinated with the used of Correspondence Analysis (CA). It let detect the major gradient connected with the soil moisture. It was reflected in the floristic composition of patches. The number of wet meadow species increased in plant communities which developed in drier sites. The result were superimposed on phytosociological classification of communities and presented in the synoptic table. The most frequently occurred phytocoenoses of *Phalaridetum arundinaceae*, *Eleocharitetum palustris*, *Polygonetum natantis.* The most interesting are *Leersietum oryzoidis* phytocoenoses. *Leersia oryzoides* is considered as a rare species in the Upper Silesia (PARUSEL et al. 1996).

KEY WORDS: dammed reservoir, Silesian Upland, aquatic phytocoenoses, rush vegetation, phytosociology, CA

INTRODUCTION

Surface and underground waters which occur in the Upper Silesian Industrial Region have been undergone strong transformations for many years because of the development of industry and urbanisation, water contamination by sewage and industrial effluents or as a result of air pollution, the increase of water runoff into industries or human settlements or changes in the level of the ground water table (JANKOWSKI 1987). Underground and open-cast mining have great influence on water resources, overlying structures and surface land. They cause changes in the natural, local water circuit, waterlogging and lead to formation of subsidence troughs or sinkholes, which could be filled with water. In this way some artificial reservoirs were created, which number is estimated around 1707. Their cover the area of 4310 ha (JANKOWSKI 1987). They are used in different way such as: fish ponds, recreational reservoirs, flood-control reservoirs, anti-fire reservoirs and for industry activity (coal-mine sedimentation pools, washings and flotation tanks, industrial sewage treatment plants, reservoirs of cooling water, slime separators, storage reservoirs for industrial production) or as dammed reservoirs. Nowadays, the

dammed reservoirs play very important role in water economy of the Upper Silesian Industrial Region. Previously they were used as water reservoirs for mills, sawmills or as a fish ponds (JANKOWSKI 1999).

The aim of the paper was to describe the aquatic and rush vegetation of the Przeczycko-Siewierski dammed reservoir and to show their diversity.

THE STUDY AREA

The Przeczyce reservoir (Zalew Przeczycko-Siewierski) is situated in the Silesian Upland (Tarnogórski Prominence), which eastern part belongs to urban-industrial agglomeration called Upper Silesian Industrial Region (KONDRACKI 2000). Przeczycko-Siewierski dammed reservoir was built on the Czarna Przemsza river in 1964 and occupied the area of 4.70 km^2 (470 ha). It has capacity of 20.7 mln m^3. It has appropriate physico-chemical conditions because of its location far from emission sources (RZĘTAŁA M., RZĘTAŁA A. 1998). Originally, it was assigned to supply cooling waters for Łagisza Power Station in Będzin and for flow equalization of the Czarna Przemsza River (NITKIEWICZ-JANKOWSKA 2004). It is multipurpose reservoir with storage, industrial, recreational functions. The significant influence of the reservoir on the local climate (changes in air circulation, the decrease of annual air temperature range, the increase of radiation balance) has been found (GALICKA 1999). It was recorded the raise of average annual temperature by 0.2-0.3 Celsius degree, lower average annually minima by 0.1-0.2 °C and the increase of the frost-free period in the Przemsza valley.

MATERIAL AND METHODS

The scientific research on vegetation of Przeczycko-Siewierski reservoir was carried out during 2001-2006. 149 phytosociological relevés (40 of them in aquatic and reed and swamp communities) with the use of BRAUN-BLANQUET (1964) method were made in order to recognise plant communities. The collected relèves were then ordinated with the use of Correspondence Analysis (CA) (GAUCH 1982), using the CANOCO 4.0 package (TER BRAAK, ŠMILAUER 2002; JONGMAN et. al. 1995). The synoptic table was made in order to show the floristic composition of aquatic and rush phytocoenoses with the means of the computer software "Profit" 2.0 (BALCERKIEWICZ, SŁAWNIKOWSKI 1998). Each species in the table was given constancy degree and coefficient cover (PAWŁOWSKI 1977).

The names of plant communities and their affiliation to the phytosociological units were based on MATUSZKIEWICZ (2001), BRZEG and WOJTERSKA (2001).

Names of vascular plants follow MIREK et al. (2002).

RESULTS

12 plant communities belonging to the *Potametea* and the *Phragmitetea* classes were recorded in the Przeczycko-Siewierski dammed reservoir (Tab. 1, 2). They represent the *Nymphaeion*, *Phragmition*, *Magnocaricion* and *Sparganio-Glycerion fluitantis* alliances.

The recorded reed and swamp communities have something in common in reference to their physiognomy and the floristic composition. Mostly, they are dominated by one species of graminoid, sedge or forb and accompanied by aquatic, rush and wet meadow species. Synanthropic species of the *Artemisietea* class occur in patches of the *Eleocharitetum palustris*, *Phalaridetum arundinaceae* and *Caricetum gracilis* phytocoenoses. However they abundance in patches is relatively low.

Indirect gradient analysis CA of 40 samples revealed two major gradients in species data

which are of similar importance. The first of them (eigenvalue 0,687) is closely related to the gradient from communities which are confined to wet, periodically inundated places to sedge communities, which develop in drier sites situated far from the lake border. It was indicated by higher share of species of the *Bidentetea tripartiti* class and flood soils of the *Agropyro--Rumicion crispi* alliance in plant communities which develop in sites susceptible to waterlogging (Fig. 1a, 1b). On the other site meadow species of the *Molinio-Arrhenatheretea* class distinguish plant communities which develop far from the lake border.

Polygonetum natantis phytocoenoses are widely distributed in Przeczycko-Siewierski dammed reservoir. The patches are overwhelmingly dominated by *Polygonum amphibium*. The species posses a lot of traits which enable it to establish and spread such as: vegetative reproduction by rhizomes and stems, dispersal via anthropochore, zoochore, hydrochore, and possibility to cope with changing water level during the year (PARTRIDGE 2001). The aquatic species of the *Potametea* class occur with lower frequency and abundance. *Potamogeton pectinatus* was found in some patches which developed in deeper sites with stagnant water. In the floristic composition of patches the higher frequencies have species of the *Phragmitetea* class or species of flooded soils of the *Agropyro-Rumicion crispi* alliance. *Polygonum amphibium* var. *terrestre* is a frequent component of other reed-swamps and tall-herb fens such as: *Scirpetum maritimi*, *Eleocharitetum palustris*, *Glycerietum maximae*, *Phalaridetum arundinaceae* or phy-

Table. 1. Aquatic vegetation of the *Potametea* class and reed and swamp plant communities of the *Phragmitetea* class

The plant community	Min, max and (mean) number of species in the relevé	Min, max and (mean) surface of the patch (m^2)	Plant communities occurring in the vicinity
Polygonetum natantis	2-14 (9)	15-40 (32)	Ep, R-A, Pa
Eleocharitetum palustris	5-21(12)	12-50(26)	Pha, Pn, Lo, Tl, Ea, Pa
Leersietum oryzoides	11-18(14)	20-25	Ea, Ep, Pha
Phalaridetum arundinaceae	9-24(14)	15-45(29)	Cg, Ep, Pa, RA, Pr, Ss, Ru-A
Caricetum gracilis	5-22(15)	25-300(98)	E-R, Ce, Pha
Phragmitetum communis	12-18(15)	25-300(162)	Ce, E-R, E-J, Cn, A-T
Caricetum acutiformis	11	50	Cg, Ep, R-A
Typhetum angustifoliae	9	200	Pha
Typhetum latifoliae	8	30	Ep, Sm
Scirpetum maritimi	12	15	Pha, Ea, Tl
Mentha aquatica com.	16	25	Pa, E-R
Alisma plantago--aquatica com.	9	15	Pa, Ea

Explanations: A-T – *Artemisio-Tanacetetum*, Ce – *Calamagrostis epigejos* community, Cg – *Caricetum gracilis*, Cn – *Carex nigra* community, Ea – *Eleocharis acicularis* community, E-R – *Elymo-Rubetum caesii,* E-J – *Epilobio--Juncetum effusi*, Ep – *Eleocharitetum palustris*, Lo – *Leersietum oryzoides*, Pa – *Potentilletum anserinae*, Pha – *Phalaridetum arundinaceae*, Pn – *Polygonetum natantis*, Pr – *Potentilletum reptantis*, R-A – *Ranunculo--Alopecuretum geniculati*, Ru-A – *Rumici-Alopecuretum*, Ss – *Scirpetum sylvatici*, Sm – *Scirpetum maritimi*, Tl – *Typhetum latifoliae.*

Table 2. The synoptic table of the plant communities of the *Phragmitetea* and *Potametea* classes

Succesive number		1		2		3		4		5		6	
Plant community		Lo		Ep		Pha		Cg		Pa		Pn	
Number of relevés in the table		6		9		10		6		2		7	
Number of species in the table		33		39		59		48		28		33	
Cl. *Phragmitetea*													
Leersia oryzoides	c	V	5708	II	833	I	175						
Eleocharis palustris	c	V	1250	V	7361	III	540	II	92	1	25	IV	1050
Phalaris arundinacea	c	V	475	V	572	V	8000	III	100			III	264
Carex gracilis	c					II	15	V	8750	1	25		
Phragmites australis	c									2	8750		
Carex acutiformis	c									1	875		
Alisma plantago-aquatica	c	V	192	IV	511	II	110	II	17			III	0
Galium palustre	c			I	6	II	15	I	83	1	250	II	79
Poa palustris	c					I	55	II	167	1	25		
Typha latifolia	c			I	56	I	5			1	25		
Scutellaria galericulata	c					I	5	I	8	1	25		
Cl. *Molinio-Arrhenatheretea*+ O. *Molinietalia* ^ + All. *Agropyro-Rumicion crispi* *													
Lythrum salicaria ^	c	V	117	III	122	III	75	IV	108	1	25	I	7
Potentilla anserina *	c	V	42	V	144	IV	420	I	83			III	336
Lysimachia vulgaris ^	c	II	17	II	11	II	60	III	25	2	500		
Agrostis stolonifera *	c	II	92	III	261	III	375	III	100			IV	407
Carex hirta *	c	IV	317	II	17	III	245	II	17	1	25	III	329
Stachys palustris ^	c	I	8			III	25	I	83			I	7
Equisetum palustre ^	c			I	6	I	50	II	167	1	250	I	7
Plantago major *	c	I	8	II	17	I	5					I	71
Rorippa austriaca *	c	III	1417	I	6	I	5					II	14
Rorippa sylvestris *	c			I	56	I	10			1	25	III	86
Vicia cracca	c					I	10	II	92	1	25		
Lysimachia nummularia ^	c			I	6	I	5	II	92	1	25		
Cl. *Bidentetea tripartiti*													
Rorippa palustris	c	I	83	II	200	II	105						
Bidens frondosa	c	II	17	III	78	III	120					II	14
Bidens tripartita	c	II	17			I	5					I	7
Bidens cernua	c	II	17			I	10					I	7
Cl. *Artemisietea*													
Equisetum arvense	c			II	11	II	105	II	17	1	250	I	7
Cirsium arvense	c			II	11	II	105	II	92				
Elymus repens	c			I	6	I	55	I	8			II	14
Galium aparine	c			II	11	I	50	I	8				
Others													
Salix alba	b/c	/II	17	/II	11	I[5]/II	185						
Polygonum amphibium	c	V	200	V	678	IV	125	IV	33			V	6607
Mentha aquatica	c	II	17	V	44	IV	35			1	25	II	14
Salix fragilis	c	II	17	I	6	I	10	II	17			I	7
Lycopus europaeus	c	III	175	III	172	I	5	II	17				
Solanum dulcamara	c	I	83	I	6	I	5	II	92				
Mentha arvensis	c	IV	467	II	306	I	55						
Eleocharis acicularis	c	II	92	I	56	I	180						
Juncus articulatus	c	II	17	II	117					1	25		
Salix purpurea	c	I	8	I	6							II	14
Calamagrostis epigejos	c							II	92	1	25		

Explanations: Lo – *Leersietum oryzoidis*, Ep – *Eleocharitetum palustris*, Pha – *Phalaridetum arundinaceae*, Cg – *Caricetum gracilis*, Pa – *Phragmitetum australis*, Pn – *Polygonetum natantis.*

tocoenoses of the *Bidentetea tripartiti* class (*Chenopodietum glauco-rubri*, *Xanthio-Chenopodietum rubri*) (BORYSIAK 1994, PROĆKÓW 1998).

Eleocharitetum palustris phytocoenoses occur both in the sites with stagnant water in the proximity of *Polygonetum natantis* phytocoenoses and in places which are periodically inundated and occupy the area close to trampled plant communities of flooded soils such as *Potentilletum anserinae*. According to TOMASZEWICZ (1979), *Eleocharis palustris* has wide ecological tolerance in reference to water reaction, trophy of the water. However, as a result of the accumulation of organic sediments in the reservoir, it is replaced by more competitive rush and swamp species. *Eleocharitetum palustris* phytocoenoses with higher share of *Alisma plantago-aquatica* approximate in some way phytocoenoses described by KWIATKOWSKA-FARBIŚ and WRZESIEŃ (1996).

The patches with *Leersia oryzoides* as a dominant cover large areas in the Przeczycko-Siewierski dammed reservoir. They grow in the vicinity of plant communities of the *Isoëto-Nanojuncetea* and *Bidentetea tripartiti* classes from one side and swamp and tall fen communities from the other. The floristic composition of phytocoenoses comprises reed and swamp species, wet meadow species and species of flooded soils from the *Agropyro-Rumicion crispi* alliance. The share of species belonging to *Bidentetea tripartiti* class is of a low importance. *Leersia oryzoides* is considered as a rare species (R) in the Upper Silesia (PARUSEL et. al. 1996). Such factors as: the disappearance of wet grasslands and swamp habitats of the species, low number of inflorescences and their incomplete development, overlooking of the species were probably responsible for the small number of its localities (ROSTAŃSKI 1997). However, the continuous increase in number of its localities in Przeczycko-Siewierski dammed reservoir has been recorded during the six years of study. MATUSZKIEWICZ (2001) described two associations with *Leersia oryzoides* as a character species: *Leersio-Bidentetum* which patches are confined to muddy edges of ditches and *Leersietum oryzoidis*, which phytocoenoses develop in water courses. Phytocoenoses from the study area approximate the second mentioned community. *Leersia oryzoides* stands were found by LOSTER (1976) at the edges of Rożnowskie Lake. They were classified as the *Leersio-Polygonetum* association. Species of the *Bidentetea tripartiti* class were constant or frequent component of patches. *Leersia oryzoides* was also accompanied by species of flooded soils of the *Agropyro-Rumicion* alliance, however some of them occurred with low cover. According to LOSTER (1976), the association can be considered as a stadium of succession which leads into the *Rumici-Alopecuretum* association in drier, sometimes trampled sites, situated far from the water or *Rumex aquaticus* community in wet habitats with more coarse alluvial sediments. The *Leersia oryzoides* is also a component of other plant communities which occur in the area under study such as: *Eleocharitetum palustris* and *Phalaridetum arundinaceae*.

The meadow species of the *Molinio-Arrhenatheretea* class and species of flooded soils of the *Agropyro-Rumicion crispi* alliance have higher share in the species-rich patches of the *Phalaridetum arundinaceae*, whereas rush species of the *Phragmitetea* class were recorded with lower frequency. In the floristic composition of patches which develop in drier habitats species of fallows from the *Onopordetalia acanthii* order were recorded more frequently. Therophytes of the *Bidentetea tripartiti* class and rush plants of the *Phragmitetea* class occurred more frequently in other phytocoenoses.

Higher share of species of flooded soils of the *Agropyro-Rumicion* alliance and meadow species of the *Molinio-Arrhenantheretea* class was also recorded in the *Phalaridetum arundinaceae* patches, which developed in the valley of the Wisła River, in sites periodically inundated by running waters (FABISZAK, KĘPCZYŃSKI 1978).

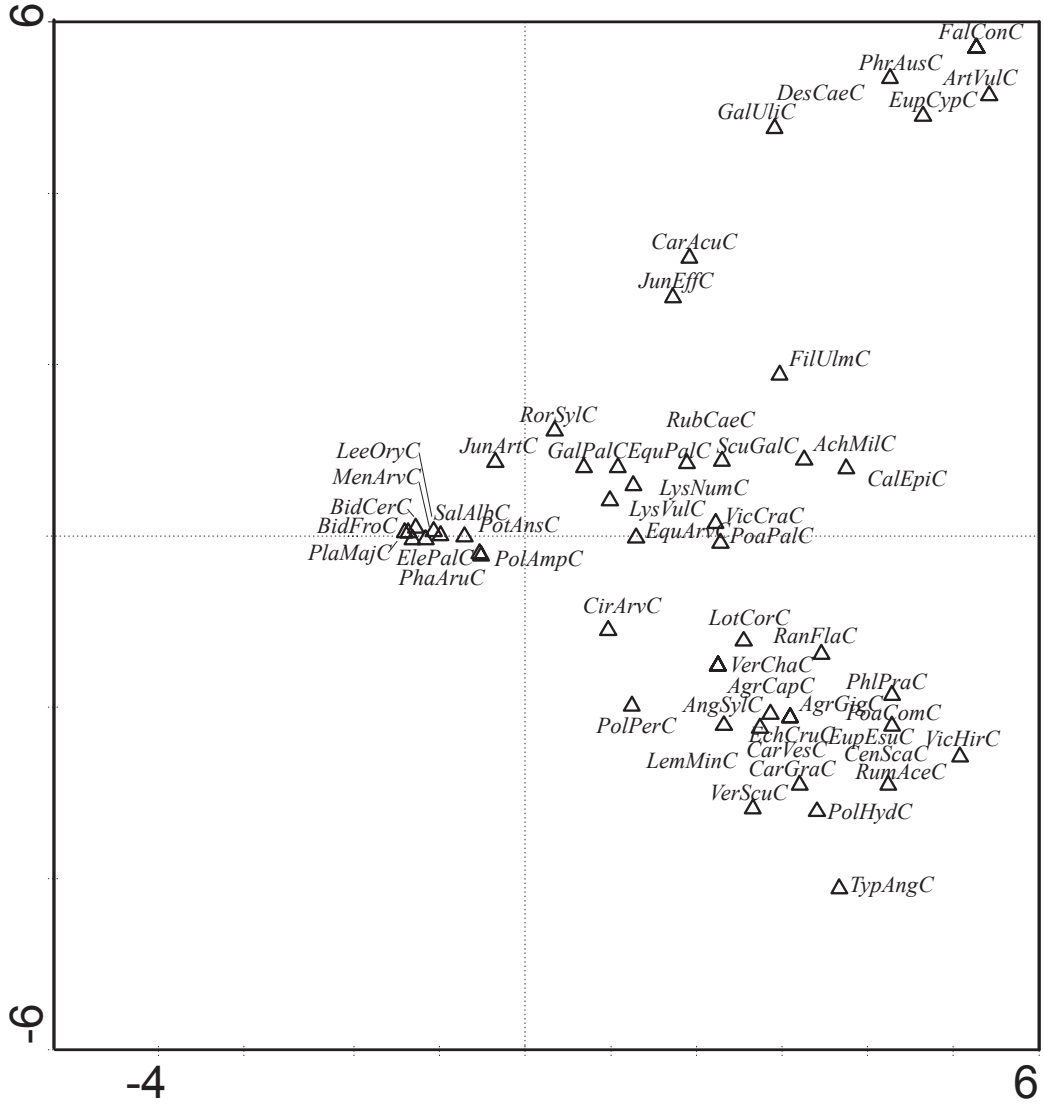

Fig. 1a. CA ordination of the rush and swamp communities occurring in the Przeczycko-Siewierski dammed reservoir - species

Explanations: first 3 letters – names of genus; further 3 – names of species, the last one – the layer of species occurrence.

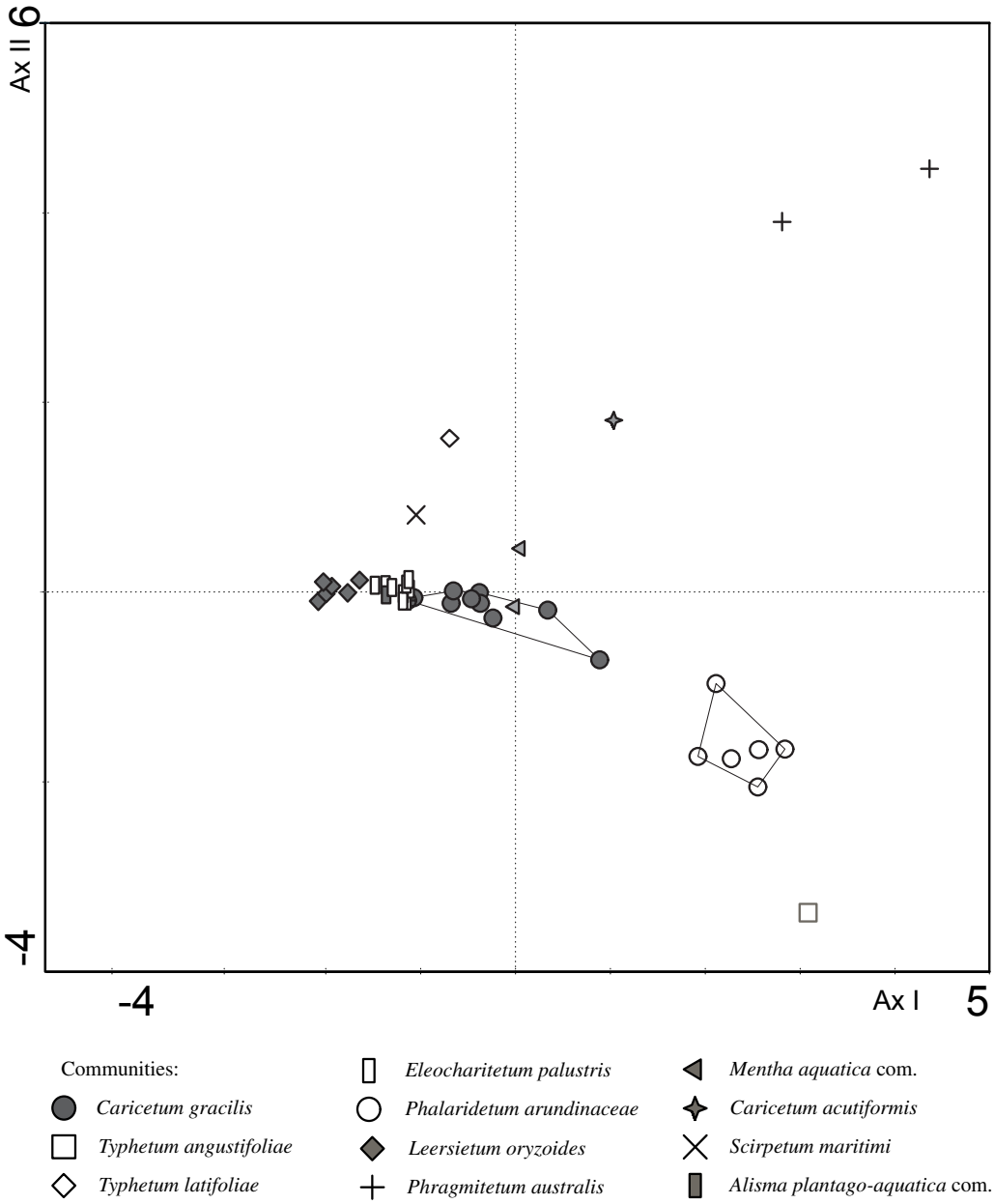

Fig. 1b. CA ordination of the rush and swamp communities occurring in the Przeczycko-Siewierski dammed reservoir - relevés

Phalaris arundinacea belongs to species which can transform existing combination of species. It is able to eliminate other components of patches and create hardy monotypic stands. It has a lot of attributes which can help it to compete with other plants such as: clonal growth, long growing period, and broad tolerance to environmental variability (MAURER et al. 2003). During six years of observations it has been recorded that the species significantly spreads and encroaches into other rush communities such as *Leersietum oryzoidis* and *Eleocharitetum palustris*, where it occurs with higher frequency. However, the influence of *Phalaris arundinacea* on the floristic composition of other communities needs further research. GRZELAK (2004) pointed out that the increase of the number of species in the floristic composition of the *Phalaridetum arundinaceae* patches, particularly species of wet meadows should be the result of changes in the water regime caused by drainage and by climate changes.

The syntaxonomic position of the *Phalaridetum arundinaceae* phytocoenoses is not clear. Some phytosociologists grouped them into the *Phragmition* alliance (FIJAŁKOWSKI 1966; SZOSZKIEWICZ 1967; KRZYWAŃSKI 1974; CELIŃSKI, WIKA 1976). Other put them into the *Magnocaricion* alliance (TOMASZEWICZ 1979, MATUSZKIEWICZ 2001). MORAVEC et al. (1995) classified the *Phalaridetum arundinaceae* patches into the *Caricion gracilis* alliance and to the *Magnocaricetalia* order, which comprises phytocoenoses which develop in shallow, stagnant or slightly flowing water courses. According to NOWIŃSKI (1967), the *Phalaridetum arundinaceae* association has intermediate position between reed-swamps of the *Phragmition* alliance and meadows of the *Molinion* alliance. DUBIEL (1973) grouped the *Phalaris arundinacea* community into the *Calthion* alliance and *Molinietalia* order. According to KOPECKÝ and HEJNÝ (1965) *Phalaridetum arundinaceae* association should be included into a separate alliance *Phalaridion*, which comprises reed-swamp communities which occur in the littoral zone of river valleys or in sites where sediments were accumulated by rivers during floods or at the high river stage. The species of the *Phragmition* and the *Caricion gracilis* alliance occur occasionally or at all in the floristic composition of patches. Secondarily, the phytocoenoses developed in substitute habitats, where they occupy large areas on the river alluvia, in riverside carries on sandy places at the lake border. KOPECKÝ (1991) pointed out that *Phalaris arundinacea* can also establish on the anthropogenic habitats and as a result of apophytization process, new species combination which are made of species of the *Phragmitetea* and the *Molinio-Arrheantheretea* classes are recorded. *Phalaris arundinacea* phytocoenoses which develop in the anthropogenic, nitrophilous sites are classified as derivate communities of the *Galio-Urticetea* class (KOPECKÝ, HEJNÝ 1990).

In the floristic composition of *Caricetum gracilis* patches, which develop in sites which are not inundated, *Carex gracilis* is accompanied by wet meadow species of the *Molinietalia* order. Such patches were classified into *C. g. filipendulosum ulmariae* subassociation. However, the patches are species-poor in comparison to phytocoenoses found in the Warta valley (DENISIUK 1967).

The *Phragmitetum communis* patches develop along water reservoirs in moderately euthrophic sites, hard, calcareous and base-rich waters (KŁOSOWSKI 1992). The phytocoenoses were also found on wastelands formed as a result of underground or open-casts mining activity (WOŹNIAK 1998, KOŁODZIEJEK 2001). The species posses broad ecological tolerance in relation to different disturbance caused by fluctuation of water table and nutrient resources in the soils (BJÖRK 1967, TOMASZEWICZ 1979). It can be reflected in individual and population variability of *Phragmites australis* (the changes in the length of stem and panicle or the way of reproduction) and in probably internal nutrient cycle, clonal growth form (LIPPERT et al. 1999;

DĄBROWSKA, SAWILSKA 2002). The patches with share of ruderal species of the *Artemisietea vulgaris* and the *Stellarietea mediae* classes were recorded in Warta River Poznan Ravine by RATYŃSKA (2001), BORYSIAK and RATYŃSKA (1984, 1986) along the Malta Lake in Poznań. *Phragmites australis* can also invade meadow and fen communities of the *Filipendulion*, the *Molinion caeruleae* and the *Caricion davallianae* alliances (GÜSEWELL, KLOTZLI 1998; KÖPPITZ, KÜHL 2000).

Some phytocoenoses, such as *Caricetum acutiformis*, *Typhetum angustifoliae*, *T. latifoliae*, *Potametum natantis*, *P. lucentis* occurred sporadically.

Scirpetum maritimi phytocoenoses occupy small area along border of the reservoir and in its part which is used as a fish pond. Their floristic composition is rather poor (ill-defined). The main component of patches is *Bulboschoenus maritimus* which is accompanied by other reed species and species which grow on periodically flooded mud of the *Bidentetea tripartiti* class. *Schoenoplectus tabernemontani*, which is considered as other character species of the association, was not found. During spring or after heavy rains the water occurred on the surface. However, the level of water decreases during summer period, so the significant inundation does not occur. The similar patches with *Bulboschoenus maritimus* were also found in standing waters, in ditches, along water courses and rivers by FABISZAK and KĘPCZYŃSKI (1978), PROCKÓW (1998) and FIJAŁKOWSKI (1978).

Alisma plantago-aquatica is accompanied by rush species, species of the *Bidentetea tripartiti* class and plants of flooded soils of the *Agropyro-Rumicion crispi* alliance. *Alisma plantago-aquatica* patches confined to nitrophilous habitats were found by KWIATKOWSKA-FARBIŚ and WRZESIEŃ (1996). *Alisma plantago-aquatica* forms also some facies in the *Typhetum angustifoliae*, *Eleocharitetum palustris*, *Sagittario-Sparganietum emersi* associations. The *Alisma plantago-aquatica* community was also recorded by SOLIŃSKA (1963) and NORYŚKIEWICZ (1988). According to SOLIŃSKA (1963), the *Alisma plantago-aquatica* patches develop periodically in the flood area and can be considered as pioneer community of the *Phragmition* alliance.

Mentha aquatica stands were recorded on south-facing, slightly inclined slopes of the reservoir. It was accompanied by ruderal species and species of nitrophilous fringe communities and plants of the *Agropyro-Rumicion crispi* alliance. The *Mentha aquatica* patches were also recorded by PROĆKÓW (1998) in the wet sites at the edges of the Strachowice Lake. However, in comparison to patches from the investigated area, the higher shares in the floristic composition of patches have meadow species of the *Molinio-Arrhenatheretea* class and species of drier habitats of the *Artemisietea vulgaris* class.

CONCLUSIONS

1. The floristic composition of phytocoenoses and their diversity reflects their position in reference to the water edge and the vicinity of other aquatic and reed and swamp communities. Aquatic, reed species and plant of mud places distinguish patches which develop close to the water edge. Wet meadow species from the *Molinietalia* order or species of flooded soils from the *Agropyro-Rumicion crispi* alliance distinguish patches which develop further from the lake border.
2. Such aquatic, rush and swamp phytocoenoses as *Phalaridetum arundinaceae*, *Eleocharitetum palustris*, *Leersietum oryzoidis*, *Caricetum gracilis* and *Polygonetum natantis* are common in the area under study. Among them the largest areas are covered by the *Phragmitetum communis* and *Caricetum gracilis* associations.

3. *Leersietum oryzoides*, *Eleocharitetum palustris* and some patches of the *Phalaridetum arundinaceae* have a lot of in common in reference to their floristic composition and the habitat preferences.
4. Some grass species such as *Leersia oryzoides* or *Phalaridetum arundinaceae* increased the number of locations and invaded other rush and swamp communities. However, their floristic composition is impoverished in comparison to phytocoenoses recorded in other regions of Poland.

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Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

CHANGES OF PHYTOCOENOSES OF MIDFIELD SCRUB AT THE BEGINNING OF THEIR FORMING

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ABSTARCT. The present paper demonstrates a continuation of the previous studies on dynamics of changes in midfield scrub that spontaneously encroaches into abandoned arable fields in the eastern part of the Silesian Upland. In majority of patches vertical structure typical for midfield scrub occurred (distinct in cover of specific species groups) but relics of previous phytocoenoses are represented to some degree extend. On the post agriculture lands, the most often recorded plant communities are the *Euonymo-Prunetum spinosae* patches.

KEY WORDS: shrub communities, permanent research plots, developmental stages, Silesian Upland

INTRODUCTION

Increase of interest of phenomenon and processes, connected with changes of vegetation in time is proceeded by long term ecological research on the permanent study plots. Focusing on changes in plant communities based exclusively on their vicinity, as used before, is frequently misleading and knowledge about majority of ecological processes requires observations so long as the formation press of biological systems (FALIŃSKI 2001).

The present paper demonstrates a continuation of the previous studies on dynamics of midfield scrub that spontaneously encroaches into abandoned arable fields in the eastern part of the Silesian Upland (WIKA, BŁOŃSKA, TURULA 1999; TURULA, WIKA 2003). At present, particular attention is paid to characteristics of structure of studied phytocoenoses, their species composition and floristic diversity, as well as subsequent phases of succession of these scrub communities.

The permanent study plots established in 1997 facilitate detailed analyses of these phenomena because they are in spatial contact with meadows, fallows, thermophilous forest edges and fragments of xerothermic grasslands.

The similar studies of temporal changes in vegetation of abandoned arable fields and meadows were conducted by FALIŃSKA (1991) and FALIŃSKI (1986a, b, 2001). They collected data from 27 years long observations carried out in nature reserve "Jelonka" (FALIŃSKI 1.c.) as well as – 17 years long from Uroczysko Reska Forest (FALIŃSKA 1.c.).

However, they concerned objects located in pinewood habitats (*Peucedano-Pinetum*) or ash-alder alluvial forest (*Fraxino-Alnetum*) where other type of scrub formed (juniper scrub, willow scrub). Nevertheless, there is a lack of long term research on, very frequent in our landscape, temperature mesophilous and xerophilous scrub of the *Rhamno-Prunetea* class.

METHODS

The observations on changes in species composition and structure of vegetation were conducted in the years 1997-1999 and 2002-2003. In the first year of field survey 15 permanents study plots located in 5 localities of eastern part of the Silesian Upland were laid out. The plots in shape of rectangles 3 x 4 m were determined by covered area by patches of particular development phases. Up to 2002 two plots in Rogoźnik were destroyed, therefore in further investigations data were gathered only from 13 study plots.

The phytocoenoses in the study plots represented three phases of development of young scrub. The plots assigned by number 1 were characterized by single shrubs penetrating herbaceous plant communities, plots with number 2 indicated patches at the beginning of initial phase of succession of scrub community, and 3 – represented a typical initial phase.

In both periods of the studies changes in floristic composition of plant communities (phytosociological relevés), mean layer of shrubs and height of the tallest individuals, on the plots with number 2 shoots of phanerophytes were counted, and the plots with number 1 encroaching shrubs and trees were mapped.

Detailed results of the investigations i.e. phytosociological tables, full characteristics of the study plots, their neighbourhood and location as well as calculations are given elsewhere (TURULA 2001; TURULA, WIKA 2003; KACPEREK 2004).

Syntaxonomic nomenclature and affiliations were adopted after BRZEG and WOJTERSKA (2001), however, division into lower syntaxa – variants and subvariants took into account the obtained data on midfield scrub of this area (TURULA 2001).

RESULTS AND DISCUSSION

Analysing changes of phytocoenoses of midfield scrub at the beginning of their assembly between the periods 1997-99 and 2002-2003 a special attention is paid to unequal rate of succession in particular study plots. The largest differences are observed at the phase of shrubs encroachment. Figure 1 demonstrates the study plot where the most rapid increase of number of shoots (from 3 in 1997 to 113 in 2003). Fast development of young phanerophytes is caused by neighbourhood with bunch of trees (mainly beech and hornbeam) and numerous patches of European hazel.

In the study plot in Jaworzno Jeleń (Fig. 2) one can observe an inhibition by large perennial *Pteridium aquilinum*. Shoots number increased from 7 in 1997 to 34 in 2003. The occurring vegetation patch is still at phase of shrubs encroachment (Table 1). Also in the study plot no. V/2 inhibition of phanerophyes growth by *Pteridium aquilinum* which occupies more than 50% and outcompeted grassland species (Table 1). *Pteridium aquilinum* in this cases is a dominant plant and is responsible for phenomenon treated as spatial occupancy (BEGON, MORTIMER 1981 after FALIŃSKA 1996). Similar succession inhibitor may be *Urtica dioica*, which forms dense thick layers and hinders other species in abandoned meadows (FALIŃSKA 1996). Sedges *Carex caespitosa* and *C. acutiformis* – causes higher necromass accumulation and tree seedlings do not germinate (FALIŃSKA 1991).

Vegetation changes in the study plot II/1 show that influence of large-sized species may last not too long. In the years 1997-99 nitrophilous patch with *Chaerophyllum aromaticum* occurred there. It hampered encroachment of shrubs from dense patch of scrub. However in second phase of the studies in the years 2002-2004 decrease of abundance of competitive species, fast growth of *Prunus spinosa* patches and assembly of initial community *Euonymo-Prunetum spinosae* were observed (Table 1).

Sometimes accidental events may influence succession rate. Shrubs on the plot I/3 were infected by pathogens, therefore cover of this layer decreased and in herb layer number of species of the *Trifolio-Geranietea* and *Molinio-Arrhenatheretea* classes.

In course of scrub succession number of species decreased in the analyzed patch. The present study shows that distinct decrease of species number occurred in these patches which were determined as an optimal phase of the plant association *Euonymo-Prunetum spinosae* (plots II/3, IV/3, V/3 in Table 1). Scrub at the initial phase are characterized by species-rich composition of young trees of the *Rhamno-Prunetea* class, forbs of xerothermic grasslands, forest edges, ruderal and segetal communities and the most numerous meadow species. Development of shrubs and their dominance in relation to cover occurs owing to elimination of species of other syntaxa. The species of the *Festuco-Brometea* class disappeared. The percentage of light-demanding species (light indicator 5) decreases and shadow-tolerant species increases (light indicator 3).

Table 1. Changes in plant communities in the study plots between 1997-1999 and 2002-2003

Study plot	Phase of shrubs encroachment		Initial stage	
			Beginning phase	Typical phase
I/1 Niegowonice	1997-1999 community *Origanum vulgare – Avenula pubescens*		2002-2003 community with high contribution of meadow species (e.g. *Avenula pubescens*), in which forming of scrub dominated by *Prunus spinosa* occurs	
II/1 Będzin Grodziec	1997-1999 *Convolvulo arvensis-Agropyretum repentis* (class *Artemisietea*) and nitrophilous community with *Chaerophyllum aromaticum*			2002-2003 initial phase of *Euonymo-Prunetum spinosae,* variant with *Galium aparine*, typical subvariant
IV/1 Sławków	1997-1999 xerothermic grassland with participation of *Libanotis pyrenaica*		2002-2003 communities of the *Trifolio-Geranietea* with considerable contribution of *Libanotis pyrenaica*	
V/1 Jaworzno Jeleń	1997-1999 xerothermic grassland with *Phleum phleoides* (*Cirsio-Brachypodion*)	2002-2003 patch with *Pteridium aquilinum* altering xerothermic grassland		

Table 1 (continued)

Study plot	Initial stage	
	Beginning phase	Typical phase
I/2 Niegowonice	1997-1999 community of the *Trifolio-Geranietea* (the *Trifolion medii*) with high participation of *Origanum vulgare*	2002-2003 initial phase of *Euonymo-Prunetum spinosae*, typical variant
II/2 Będzin Grodziec	1997-1999 community of the *Onopordion acanthii* (suballiance *Dauco-Melilotenion*) and edge community with *Rubus caesius*	2002-2003 initial phase of *Euonymo-Prunetum spinosae*, typical variant
III/2 Rogoźnik	1997-1999 remnants of xerothermic grassland with abundand occurrence of *Libanotis pyrenaica*	2002-2003 initial stage of *Euonymo-Prunetum spinosae,* variant with *Poa angustifolia*, subvariant with *Elymus repens*
IV/2 Sławków	1997-1999 remnants of xerothermic grassland with abundant occurrence of *Libanotis pyrenaica*, which is inhabited by *Prunus spinosa*, *Rosa canina* and *Rubus caesius*	2002-2003 initial stage of *Euonymo-Prunetum spinosae,* variant with *Poa angustifolia*, subvariant with *Elymus repens*
V/2 Jaworzno Jeleń	1997-1999 patch with *Pteridium aquilinum* with numerous species of the *Festuco-Brometea* class 2002-2003 patch with *Pteridium aquilinum*	

Study plot	Initial stage		Optimal stage	
	Typical phase		Beginning phase	Typical phase
I/3 Niegowonice	1997-1999 initial stage of *Euonymo-Prunetum spinosae*, variant with *Poa angustifolia*, subvariant with *Elymus repens*	2002-2003 initial stage of *Euonymo-Prunetum spinosae*, variant with *Poa angustifolia*, subvariant with *Elymus repens*		
II/3 Będzin Grodziec	1997-1999 initial stage of *Euonymo-Prunetum spinosae*, variant with *Galium aparine*, typical subvariant			2002-2003 *Euonymo-Prunetum spinosae*, typical variant
IV/3 Sławków	1997-1999 initial stage of *Euonymo-Prunetum spinosae*, variant with *Poa angustifolia*, subvariant with *Elymus repens*		2002-2003 *Euonymo-Prunetum spinosae*, typical variant (with abundant occurrence of *Rubus caesius*)	
V/3 Jaworzno Jeleń	1997-1999 initial stage of *Euonymo-Prunetum spinosae*, variant with *Poa angustifolia*, typical subvariant			2002-2003 *Euonymo-Prunetum spinosae*, typical variant (with abundant occurrence of *Pteridium aquilinum*)

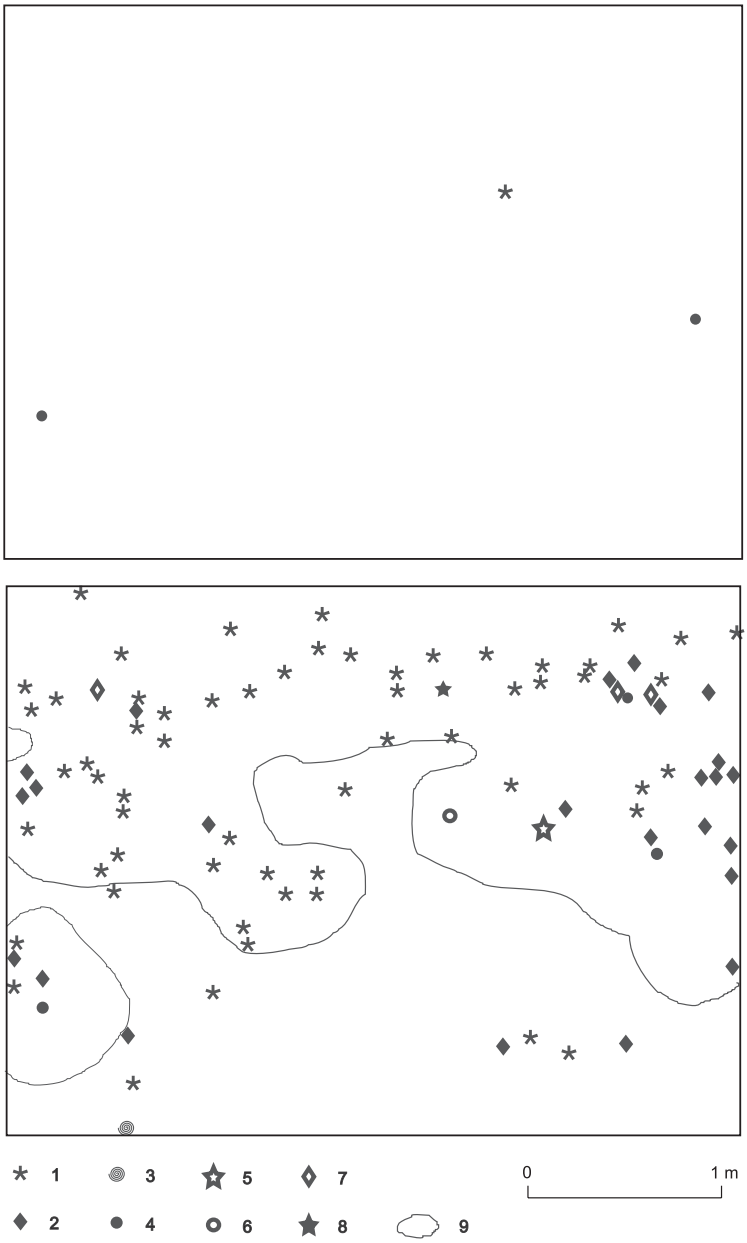

Fig. 1. Increase of shoots of shrubs and trees between 1997 (upper figure) and 2003 (lower figure) in the study plot I/1 (Niegowonice)
Explanations: 1 – *Prunus spinosa*, 2 – *Cornus sanguinea*, 3 – *Acer pseudoplatanus*, 4 – *Crataegus monogyna*, 5 – *Rosa canina*, 6 – *Crataegus ripidophylla*, 7 – *Carpinus betulus*, 8 – *Corylus avellana*, 9 – projection of stocked shrubs.

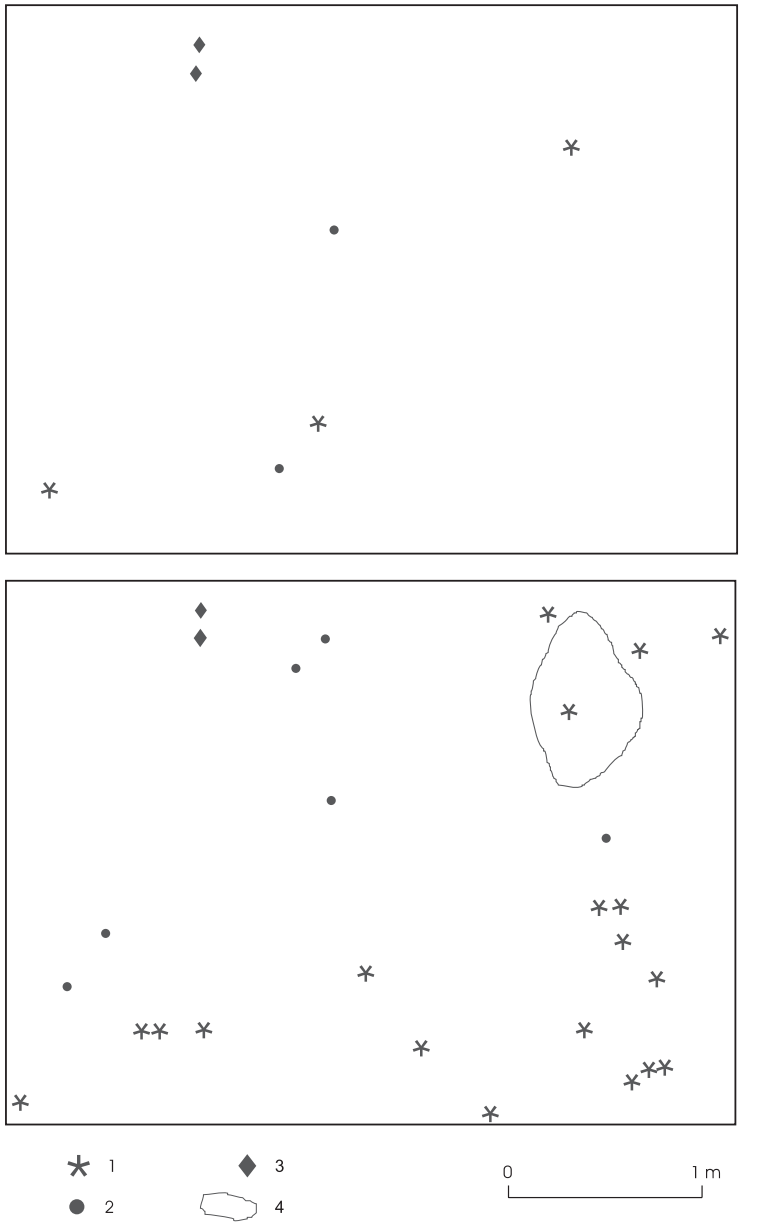

Fig. 2. Increase of shoots of shrubs between 1997 (upper figure) and 2003 (lower figure) in the study plot V/1 (Jaworzno Jeleń)
Explanations: 1 – *Prunus spinosa*, 2 – *Crataegus xsubsphaericea*, 3 – *Rhamnus catharcticus*, 4 – projection of stocked shrubs.

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Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

ABANDONED MEADOW AFTER *SOLIDAGO CANADENSIS* L. AND *SOLIDAGO GIGANTEA* AITON INVASION

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ABSTRACT. Noxious and invasive plant species threaten the success in many of our native plant communities. Alien plants penetration into plant communities is a nearly universal phenomenon. *Solidago canadensis* and *S. gigantea* belong to the most common alien invaders.
The aim of this study is to analyse the floristic composition of abandoned meadows after the *Solidago canadensis* and *S. gigantea* invasion. The collected material has been divided into three tables. The first one gathered the *Arrhenatheretum elatioris* community patches, while the second one presents fresh meadow patches which lose their precise community identity and can be defined only as representing the *Arrhenatheretalia* order from the *Molinio-Arrhenatheretea* class. The third table presents the *Scirpetum sylvatici* association from the *Molinietalia* order. The analyse of the floristic composition shows, that at the dynamic stage when *Solidago canadensis* and *S. gigantea* are present in the abandoned meadow patches with abundance up to 25%, the changes in the species composition enable some ruderal and nitrophilous species (*Artemisietea vulgaris* class) to penetrate the patches. During the period of *Solidago* species flowering the physiognomy of the patches is radically changed. They resemble herbaceous vegetation more than a meadow one. Anyway, the core of species composition represents *Molinio-Arrhenatheretea* class and the meadow communities were still recognisable.

KEY WORDS: *Solidago canadensis* L., *Solidago gigantea* Aiton, plant invasion, plant community, biodiversity protection

INTRODUCTION

Since the Elton book (1958) (ELTON 1967) biological invasions have attracted the interest of ecologists, botanists and conservation biologists. In recent decades many investigations have been conducted to record and analyse the mechanisms of biological invasions. Alien plants penetration into plant communities is a nearly universal phenomenon (WEBER 1997; WEBER, SCHMID 1998). The success of alien species in migration beyond their primary range should be

considered also from the biocoenotic (phytocoenotic) point of view (FALIŃSKI 1998). Alien invasive plants were recognised as the main plants that become established on man-made habitats (KORNAŚ, MEDWECKA-KORNAŚ 1986), moreover most alien plants are considered as pioneer species that are able to colonise disturbed areas.

Both the *Solidago* species appear all over Poland (ZAJĄC, ZAJĄC 2001). In the Upper Silesia the two species occur in different plant communities and on various habitats either as accompanying species or as dominants. Both the *Solidago* species are frequent on ruderal and even post-industrial sites. However, on post-industrial sites *Solidago canadensis* is more frequent (WOŹNIAK 2001, 2003). *Solidago canadensis* and *S. gigantea* have the biological potential to invade plant communities which in particular circumstances maintains stabilised vertical and horizontal structure like e.g. meadows.

The aim of this study is to analyse the floristic composition of abandoned meadows after the *Solidago canadensis* and *S. gigantea* invasion.

MATERIAL AND METHODS

The paper presents only part of a bigger project dealing with *Solidago canadensis* and *S. gigantea* species occurrence in plant communities. This study is concerning meadow plant communities in which the *Solidago* species cover less than 25% of the vegetation patch. The investigation has been carried out for two years (2000-2002) on the plant cover in Chorzów town. The relevés were made by using the Braun-Blanquet method (BRAUN-BLANQUET 1951). Species were classified into phytosociological classes according to MATUSZKIEWICZ (2001). The nomenclature of the Polish vascular flora was used according to MIREK et al. (2002) and the latest kenophytes list (ZAJĄC et al. 1998). The term kenophytes was used according to SUDNIK-WÓJCIKOWSKA and KOŹNIEWSKA (1988). The English term for the alien plants have been used according to LINCOLN et al. (1998). The ecological characteristics of the species is based on indicator values according to ZARZYCKI (1984) and ZARZYCKI et al. (2002).

The records collected from meadow phytocoenoses have been divided into three tables. The first one gathered the *Arrhenatheretum elatioris* community patches, while the second one presents meadow patches have lost their precise community identity and can be defined only as representing the *Arrhenatheretalia* order. The third table presents the *Scirpetum sylvatici* association from the *Molinietalia* order.

THE ECOLOGICAL CHARACTERISTICS OF *SOLIDAGO CANADENSIS* AND *SOLIDAGO GIGANTEA*

The ecological indicators for *Solidago canadensis* and *Solidago gigantea* are very similar: these plants are hemicryptophytes or geophytes (H,G), they have many localities throughout the country (A-4); with hundreds of individuals (n-4) (ZARZYCKI 1984), they are very expansive (+3); *Solidago canadensis* and *Solidago gigantea* prefer sites of full light only periodically shaded (L-4), moderately warm climatic conditions (lowland and lower mountain levels) (T-4), they are neutral to the continentality (K-3); considering soil indictors these species prefer fresh and moist (W-3-4) and eutrophic soils (Tr-4) (ZARZYCKI et al. 2002). *Solidago canadensis* and *Solidago gigantea* belong to the group of "common" kenophytes.

RESULTS

In Table 1, apart from *Arrhenatherum elatius*, another characteristic species *Pastinaca sativa* occur with higher frequency (III). They both represent the group of diagnostic species for the association *Arrhenatheretum elatioris*. The group of the alliance characteristic species, is

represented only by *Crepis biennis* (sporadic species). In the analyzed patches *Daucus carota*, *Dactylis glomerata*, *Taraxacum officinale*, *Lotus corniculatus* and *Holcus lanatus* are the species from the *Arrhenatheretalia* order. The numerous group of species represents the *Molinio-Arrhenatheretea* class: *Vicia cracca*, *Festuca rubra*, *Agrostis gigantea*, *Centaurea jacea*, *Trifolium pratense*, *Plantago lanceolata*, *Poa trivialis* and *Rumex acetosa.* There are also some species, which represent the *Agropyro-Rumicion crispi*, *Cynosurion*, *Filipendulion ulmariae* and *Polygonion avicularis* alliances.

Three lower units have been distinguished. The first one (relevé 1-8) is characterised by almost exclusive presents of *Vicia cracca*, *Pastinaca sativa* and *Festuca rubra.* In the same group of relevé (1-7) *Tanacetum vulgare* is present (from the *Artemisietea vulgaris* class) and *Bromus inermis* (from the accompanying species group). In the second distinguished group (relevé 12-16) the occurrence of *Centaurea jacea* and *C. pseudophrygia* has been recorded. The occurrence of *Berteroa incana* (from the *Artemisietea vulgaris* class) suggests that the habitat conditions in those patches are drier. *Plantago lanceolata* appeared only in four relevés (8-11).

In the analysed patches of Table 1 some species from the *Artemisietea vulgaris* class were recorded. Most of them occur with low (1.1) and very low (r, +) abundance. Only *Solidago canadensis* and *Solidago gigantea* are very frequent in the patches and the abundance varies from 1% to 25%. Single species such as: *Melilotus alba*, *Echium vulgare* and *Cirsium arvense* occur more abundantly. The frequency and abundance of *Calamagrostis epigejos* in the group of accompanying species is noteworthy. Among the accompanying sporadic species some other single kenophytes (neophytes) were recorded such as: *Helianthus tuberosus* and seedlings of *Acer negundo*.

Table 2 presents patches of fresh meadows from the *Arrhenatheretalia* order. The following *Arrhenatheretalia* order diagnostic species were recorded: *Achillea millefolium*, *Taraxacum officinale*, *Lotus corniculatus*, *Dactylis glomerata* and *Daucus carota*. In the species composition of the analysed table some *Agropyro-Rumicion crispi* alliance species were recorded: *Elymus repens*, *Potentilla anserina*, *Ranunculus repens*, *Agrostis stolonifera*, *Carex hirta* and *Rumex crispus*. Many of the recorded species are considered as characteristic for the *Molinio-Arrhenatheretea* class: *Lathyrus pratensis*, *Plantago lanceolata*, *Agrostis gigantea*, *Holcus lanatus*, *Festuca rubra*, *Vicia cracca*, *Trifolium pratense*, *Rumex acetosa*, *Cerastium holosteoides*, and *Poa trivialis.* The *Artemisietea vulgaris* class, apart from both *Solidago* species is represented by few species. Almost all of them appear with very low abundance. There are only three exceptions. *Cirsium arvense* in relevé 12, *Artemisia vulgaris* in relevé 7 and *Cirsium vulgare* in relevés 8 and 11. One kenophyte *Aster novi-belgii* is present in this group.

In relevés 2-5 abundant presence of *Festuca trachyphylla* has been recorded. From the group of accompanying species also *Calamagrostis epigejos* occur abundantly in relevé 1-3. Among the *Artemisietea vulgaris* class species *Cirsium vulgare* cover up to 75% of the vegetation patch (relevé 8). The meadow species *Plantago lanceolata* in relevé 7 and *Agrostis stolonifera* in relevé 6 occur abundant (up to 50% of the patch).

Apart from *Festuca trachyphylla* and *Calamagrostis epigejos,* the accompanying species are neither frequent nor abundant. The group of sporadic species is quite numerous. In the patches of relevé 2-5 together with *Festuca trachyphylla*, *Aegopodium podagraria* and *Tussilago farfara* are present. Two kenophytes with very poor abundance were recorded: *Conyza canadensis* and *Reynoutria japonica.*

Scirpetum sylvatici (Tab. 3) is a meadow community that indicates wet habitat, often with shallow water level above the soil surface. The patches are not very rich in species. The num-

ber of plants in patches varies from 17-18. The species composition of all the analysed patches is very similar. There is a big group of meadow species present in almost all patches: *Scirpus sylvaticus* and *Juncus effusus* from the *Calthion palustris* alliance, *Elymus repens* and *Potentilla anserina* from the *Agropyro-Rumicion crispi* alliance, *Lotus corniculatus* from the *Arrhenatheretalia* order and *Lathyrus pratensis* as well as *Festuca rubra* from the *Molinio-Arrhenatheretea* class. The *Artemisietea vulgaris* class, apart from *Solidago canadensis* and *Solidago gigantea*, is represented by *Cirsium arvense*, *Calystegia sepium* and *Epilobium hirsutum*, which occur with very low abundance up to 1% in the patch.

There are only four accompanying species. The most abundant *Calamagrostis epigejos* and frequent *Phleum pratense*, while less frequent and less abundant (up to 5%) are: *Vicia sepium*, and *Ranunculus acris*.

Table 4a and 4b present the comparison of the plant composition of the three invaded meadow communities. The meadow (*Molinio-Arrhenatheretea* class) species are the most frequent. *Arrhenatherum elatius* and *Daucus carota* reach the fifth constancy degree. *Elymus repens*, *Achillea millefolium (*column 1, Tab. 4a) and *Vicia cracca* occur with the fourth constancy degree. Numerous is the group of meadow species, which appear with the third constancy degree: *Achillea millefolium (*column 2, Tab. 4a), *Vicia cracca*, *Dactylis glomerata* (in two first columns in Table 4a), as well as *Festuca rubra*, *Pastinaca sativa*, *Lotus corniculatus*, *Plantago lanceolata*, *Taraxacum officinale*, *Agrostis gigantea*, *Trifolium pratense*, *Deschampsia caespitosa*, *Holcus lanatus*, and *Ranunculus repens.*

In the group of ruderal species (*Artemisietea vulgaris* class), apart from *Solidago canadensis* and *S. gigantea,* only *Cirsium arvense* and *Artemisia arvensis* occur with the fifth constancy degree. The fourth constancy degree reach two species: *Cirsium vulgare* and *Eupatorium cannabinum.* Three species *Picris hieracioides*, *Oenothera biennis* and *Tanacetum vulgare* occur with the third constancy degree.

The accompanying species were not very frequent. Only *Calamagrostis epigejos* reaches in column 1 (Tab. 4b) the fifth constancy degree and in column 2 (Tab. 4b) the third one. Moreover, the third constancy degree was recorded for *Lathyrus tuberosus* and *Tussilago farfara.*

Discussion

Meadows are semi-natural communities. To maintain their rich species plant composition they need to be mown and fertilized. Abandoned meadows undergo ecological transformation. The habitat is becoming to be more fertile because hay is not taken away. The lack of mowing enables good competitors, the aliens (such as *Solidago canadensis* and *Solidago gigantea*) and the native (such as *Calamagrostis epigejos*) to expand in meadow communities. At the time of investigation the meadow communities were still recognisable in terms of the phytosociological criteria, however during the period of *Solidago* flowering the physiognomy of the patches is radically changed. At the dynamic stage when *Solidago canadensis* and *S. gigantea* are present in the abandoned meadow patches with abundance up to 25%, they change the floristic composition and enable some ruderal (from the *Artemisietea vulgaris* class) species to penetrate the patches.

Arrhenatheretum elatioris Br.-Bl. ex Scherr. 1925 community (Tab. 1) is typical of *Arrhenatherion elatioris* alliance. These meadows should be mown few times a year. They represent a well fertilized and fresh lowland meadow. This community occurs on fertile and fine-grained brown soils (Matuszkiewicz 2001). *Solidago canadensis* and *S. gigantea* participation in

Arrhenatheretum elatioris phytocoenoses is not higher than 25%. At this stage the meadow species are still more abundant. The *Scirpetum silvatici* patches are invaded mostly by *Solidago gigantea.* This species covered up to 25% of the patch area. This result suggest the moisture tolerance of *Solidago gigantea* is wider than is was expected (ZARZYCKI et al. 2002).

Although, KORNAŚ (1996) mentioned that the occurrence of the newcomer *Solidago gigantea* subsp. *serotina* in Europe was a spectacular invasion, long term observations show that *Solidago canadensis* is more frequent and abundant than *Solidago gigantea* on the investigated sites.

Solidago canadensis is very successful in invading wide spectrum of non-forest habitats: abandoned arable land, meadows, waste sites already covered by plants. This species is not a pioneer (WOŹNIAK 1998, 2001, 2003). CORNELIUS (1990) attributed the success of *Solidago canadensis* on disturbed habitats to two factors: the easy dispersal of propagules and vegetative reproduction that ensures further spread under favourable conditions providing stronger competition. Some detailed investigations were done on the ecology of *Solidago gigantea.* It was found that biomass production was determined mainly by water supply, especially by rainfall in the first part of the growing season. The plants respond to summer drought by reduction their leaf area. The rate of leaf decline is influenced by the amount of rainfall, while rainfall has no effect on the formation of leaves (BOTTA-DUKAT, DANCZA 2001).

CONCLUSIONS

At the dynamic stage when *Solidago canadensis* and *S. gigantea* occur in the abandoned meadow patches with abundance up to 25%, the changes in the species composition enable some ruderal and nitrophilous species (*Artemisietea vulgaris* class) to penetrate the patches. However, the core of species composition represents *Molinio-Arrhenatheretea* class and the meadow community were still recognisable.

Long time lack of mowing will lead to further *Solidago canadensis* and *S. gigantea* expansion. The species composition will become poorer and poorer and the biodiversity will decline.

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Table 1. *Arrhenatheretum elatioris* (Br.-Bl. ex Scherr. 1925)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Number of relevé in the field	107	108	109	118	119	120	121	104	136	94	95	77	76	90	74	75	64	65	CONSTANCY
Date day	29	29	29	8	8	8	8	29	19	21	21	26	26	20	26	26	24	24	
Date month	9	9	9	10	10	10	10	9	10	9	9	8	8	9	8	8	8	8	
Date year	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	01	
Town	CHORZÓW																		
Cover of the herb layer in %	100	100	100	90	85	90	90	80	95	80	100	100	100	95	90	95	95	90	
Area of relevé in m^2	25	25	25	16	16	16	16	25	20	25	25	16	20	20	16	16	20	20	
Inclination in °	-	-	-	45	45	45	45	-	-	-	-	45	45	40	45	45	30	30	
Number of species in relevé	22	23	21	23	23	25	24	28	23	27	26	17	17	21	17	18	25	24	
I. Ch. Ass. *Arrhenatheretum elatioris* ° + Ch. *Molinio-Arrhenatheretea*																			
Arrhenatherum elatius °	1.2	1.1	2.2	3.3	3.3	3.3	2.3	1.2	2.2	1.1	1.1	2.3	2.2	3.3	3.3	3.3	2.2	1.2	V
Daucus carota	r	+	r	r	+	+	+	+	+	.	.	+	+	r	+	1.1	r	+	V
Achillea millefolium	+	+	r	.	+	1.1	1.1	3.2	2.2	.	.	1.1	.	+	1.1	1.1	1.1	+	IV
Elymus repens	.	.	.	1.1	1.1	1.1	1.1	+	2.2	1.1	+	.	.	2.2	.	.	1.2	1.1	IV
Dactylis glomerata	.	.	.	+	.	+.2	+.2	.	2.2	+.2	+.2	.	+.2	.	r	.	.	.	III
Taraxacum officinale	.	.	.	+	+	+	+	+	2.2	1.1	.	.	.	.	.	.	.	.	II
Agrostis gigantea	+	+	+	.	.	.	.	.	.	1.2	1.2	.	.	.	.	.	.	.	II
Trifolium pratense	+	+	+	.	.	.	.	1.1	+	.	.	.	.	.	.	.	.	.	II
Vicia cracca	1.2	2.2	1.2	1.1	+	+	+	.	+	+	+	.	.	.	.	.	.	+	IV
Pastinaca sativa °	r	r	r	+	r	r	r	.	.	.	.	.	.	.	.	.	r	+	III
Festuca rubra	1.2	2.2	3.3	2.2	1.2	2.2	2.2	2.2	.	.	.	.	.	.	.	.	.	.	III
Centaurea jacea	.	.	.	.	.	.	.	.	.	.	.	2.2	2.2	+	2.2	3.2	.	.	II
Centaurea pseudophrygia	.	.	.	.	.	.	.	.	.	.	.	+	1.1	.	1.2	+	.	.	II
Plantago lanceolata	.	.	.	.	.	.	.	2.2	+	2.3	3.3	.	.	.	.	.	.	.	II
II. Ch. *Artemisietea vulgaris*																			
Solidago canadensis	**2.2**	**2.2**	**1.2**	**1.2**	**+**	**+**	**1.1**	**1.2**	**2.2**	**2.2**	**2.2**	**1.2**	**2.2**	**1.2**	**2.2**	**2.2**	**2.2**	**2.2**	**V**
Solidago gigantea	**1.2**	**1.2**	**1.2**	**2.2**	**2.2**	**2.2**	**2.2**	**1.2**	**r**	**2.2**	**2.2**	**+**	**+**	**.**	**.**	**.**	**2.2**	**2.3**	**V**
Artemisia vulgaris	+	r	r	+	+	+	+	+	2.2	+	+	+	r	+	+	.	r	+	V
Cirsium arvense	+	+	.	+	r	+	+	r	.	2.2	2.2	+	+	.	1.1	1.1	+	+	V
Picris hieracioides	.	.	r	.	r	r	r	.	r	r	+	r	+	.	r	+	+	r	III
Oenothera biennis	.	.	.	+	+	+	+	+	.	.	.	r	+	+	.	r	1.1	+	III
Tanacetum vulgare	+	1.1	+	1.1	1.1	1.1	1.2	.	.	.	.	.	.	+	.	.	.	.	III
Echium vulgare	.	.	.	.	.	.	.	.	r	.	.	1.1	+	.	1.2	2.1	+	+	II

Table 1. (continued)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Melandrium album	.	.	.	+	.	r	+	.	.	.	.	.	.	.	.	r	+	+	II
Melilotus alba	2.2	2.2	2.2	.	.	+	.	r	+	.	.	.	.	.	.	.	.	.	II
Berteroa incana	.	.	.	.	.	.	.	.	.	.	.	+	1.1	+	+	r	.	.	II
III. Accompanying species																			
Calamagrostis epigejos	4.3	4.3	3.3	1.1	1.1	1.1	1.1	3.2	.	+	+	2.2	2.1	2.2	1.2	1.1	2.2	2.2	V
Lathyrus tuberosus	2.2	1.2	2.2	.	+	.	.	.	+	+	+	.	.	.	.	.	2.2	2.2	III
Hieracium sabaudum	.	.	.	+	1.1	+	r	r	.	.	.	.	.	.	+	r	.	.	II
Vicia sepium	.	.	.	+	+	+	1.2	.	.	.	.	.	.	.	.	.	r	r	II
Convolvulus arvensis	.	.	.	.	.	.	.	.	.	.	.	1.1	+	+	1.1	+	.	.	II
Equisetum arvense	.	.	.	2.2	2.2	2.2	2.3	.	.	.	.	.	.	4.4	.	.	.	.	II
Silene vulgaris	r	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	II
Acer pseudoplatanus	r	r	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	II
Bromus inermis	.	1.1	1.1	1.1	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Conyza canadensis	.	.	.	.	.	.	.	.	+	+	r	.	.	+	.	.	.	.	II
Medicago lupulina	+	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	II

Sporadic species:

I: *Agrostis stolonifera* 8 (1.1); *Crepis biennis* 10, 11; *Deschampsia caespitosa* 10 (1.2), 11 (+.2); *Holcus lanatus* 8 (1.2), 10 (+.2), 11(+.2); *Leontodon autumnalis* 14; *Lolium perenne* 9 (3.3); *Lotus corniculatus* 17, 18 (+.2); *Lysimachia vulgaris* 14; *Poa trivialis* 8, 15, 16 (r); *Potentilla reptans* 17; *Rumex acetosa* 4 (r), 5 (r), 17 (r); *Rumex crispus* 1, 2 (r), 3 (r); *Stachys palustris* 8 (1.1), 18 (r); *Trifolium repens* 9 (2.2), 10, 11;

II: *Arctium lappa* 9 (r); *Cirsium vulgare* 9, 12, 13 (r); *Erigeron ramosus* 5, 6 (1.1), 7; *Eupatorium cannabinum* 11 (r); *Galium aparine* 12 (r), 13; *Linaria vulgaris* 14, 17, 18; *Tragopogon dubius* 4 (r); *Verbascum densiflorum* 4 (r), 6 (r), 7 (r);

III: *Acer negundo* 8 (r); *Crataegus monogyna* 17 (1.1), 18 (1.2); *Euphorbia cyparissias* 18 (2.1); *Fallopia convolvulus* 14 (r); *Helianthus tuberosus* 1, 3 (1.1); *Hypericum perforatum* 17 (1.1); *Luzula multiflora* 17 (1.2); *Odontites serotina* 8, 9; *Phragmites australis* 8 (2.1); *Pimpinella saxifraga* 8; *Plantago major* 10, 11; *Poa annua* 9 (1.2); *Poa compressa* 8 (2.2), 9; *Trifolium arvense* 17, 18 (r); *Tussilago farfara* 10, 11; *Viola arvensis* 17.

Table 2. Community from the *Arrhenatheretalia elatioris* (Pawł. 1928) order

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	12	
Number of relevé in the field	103	15	18	20	21	6	135	71	96	44	70	32	CONSTANCY
Date day	29	12	15	15	15	7	19	26	21	23	26	16	
Date month	9	8	8	8	8	8	10	8	10	8	8	8	
Date year	01	01	01	01	01	01	01	01	01	01	01	01	
Town	CHORZÓW												
Cover of the herb layer in %	85	100	100	100	100	70	100	100	100	70	85	100	
Area of relevé in m²	20	15	18	20	20	25	20	20	25	100	20	16	
Inclination in °	-	45	45	45	45	-	-	-	-	-	-	-	
Number of species in relevé	27	25	32	32	34	41	17	15	20	32	16	7	
I. Ch. *Arrhenatheretalia elatioris* ˙ + Ch *Molinio-Arrhenatheretea*													
Elymus repens	.	1.1	2.1	1.1	1.1	+	.	1.1	1.1	.	2.2	3.3	IV
Achillea millefolium ˙	2.2	r	r	.	.	r	2.2	.	2.2	+	.	.	III
Plantago lanceolata	1.1	.	+	r	+	+	3.3	.	.	r	.	.	III
Taraxacum officinale ˙	+	.	1.1	r	+	+	1.2	.	.	.	+	.	III
Agrostis gigantea	.		1.1	1.1	+	+.2	.	.	1.2	+	.	.	III
Holcus lanatus	1.2	+.2	1.2	r	+.2	.	.	.	+	.	.	.	III
Vicia cracca	.	1.2	+	r	2.2	r	.	.	+	.	.	.	III
Dactylis glomerata ˙	.	.	.	r	+.2	.	1.3	.	+	.	.	2.2	III
Deschampsia caespitosa	.	.	.	.	.	+.2	+	2.2	.	2.2	2.2	.	III
Lotus corniculatus ˙	.	+	1.1	1.1	2.2	r	.	.	.	.	.	.	III
Ranunculus repens	.	.	+	1.1	r	.	.	2.2	.	.	2.3	.	III
Trifolium pratense	.	.	r	r	r	r	+	.	.	.	.	.	III
Agrostis stolonifera	+.2	.	.	.	.	3.3	.	+	.	.	2.2	.	II
Arrhenatherum elatius	.	+	.	.	.	.	+	.	1.2	+.2	.	.	II
Daucus carota ˙	r	.	.	.	.	.	1.1	.	+	+	.	.	II
Lathyrus pratensis	.	.	.	1.2	1.2	.	.	+	.	.	+	.	II
Lolium perenne	.	.	2.3	1.2	1.2	.	2.3	.	.	.	.	.	II
Stachys palustris	+	.	.	.	.	r	.	r	.	.	r	.	II
Pastinaca sativa	.	.	r	1.1	.	.	.	.	r	.	.	.	II
II. Ch. *Artemisietea vulgaris*													
Solidago canadensis	**1.2**	**2.2**	**1.2**	**1.1**	**1.1**	**2.1**	**2.2**	**2.2**	**.**	**1.1**	**2.2**	**1.2**	**V**
Solidago gigantea	**2.2**	**1.1**	**+**	**+**	**+**	**2.3**	**2.2**	**+**	**1.1**	**2.1**	**+**	**2.2**	**V**
Artemisia vulgaris	r	+	1.1	+	1.1	+	2.2	1.1	.	r	1.1	.	V
Cirsium arvense	r	1.1	+	+	1.1	r	.	+	+	.	+	2.1	V
Cirsium vulgare	.	.	r	r	r	r	r	4.4	r	.	2.2	.	IV
Eupatorium cannabinum	.	1.1	+	+	+	r	.	r	.	r	1.2	.	IV
Picris hieracioides	+	.	.	.	.	r	.	.	+	+	r	.	III
Calystegia sepium	.	.	r	r	+	r	.	.	.	.	.	.	II
Aster novi-belgii	.	.	.	r	1.2	+	.	.	.	.	.	.	II
Melandrium album	.	+	.	.	.	r	.	r	.	.	.	.	II
Oenothera biennis	+	.	r	.	.	.	.	.	.	+	.	.	II
Urtica dioica	.	.	.	+	r	.	.	.	.	.	.	+	II
III. Accompanying species													
Calamagrostis epigejos	4.3	4.3	2.2	.	+	r	.	.	1.1	+	.	.	III
Tussilago farfara	.	1.1	2.1	+	1.1	+	.	.	.	.	.	.	III
Aegopodium podagraria	.	1.1	+	+	+	.	.	.	.	.	.	.	II
Festuca trachyphylla	.	3.3	4.4	4.4	3.3	.	.	.	.	.	.	.	II
Hieracium sabaudum	+	r	.	.	r	.	.	.	.	+	.	.	II
Mentha arvensis	.	+	.	.	.	r	.	+	.	.	2.1	.	II
Hypericum perforatum	.	.	.	+	+	r	.	.	.	.	.	.	II
Lathyrus tuberosus	.	.	.	.	1.2	+	+	.	.	.	.	.	II
Medicago lupulina	+	.	1.1	.	.	r	.	.	.	.	.	.	II
Poa compressa	1.2	.	.	.	.	.	.	.	+	1.1	.	.	II

Table 2. (continued)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	12	
Salix caprea	.	.	1.2	r	r	.	.	.	.	.	.	.	II
Vicia sepium	.	.	r	.	+	.	.	.	+	.	.	.	II

Sporadic species:
I: *Carex hirta* 2 (1.1); *Cerastium holosteoides* 3 (r); *Crepis biennis* 6 (r); *Festuca rubra* 1 (1.2), 10 (1.2); *Galium mollugo* 6 (r); *Juncus tenuis* 6 (+.2); *Leontodon autumnalis* 1; *Lysimachia vulgaris* 1 (1.2); *Poa trivialis* 1; *Potentilla anserina* 2 (1.1), 3 (1.1); *Rumex acetosa* 9 (1.2), 10 (r); *Rumex crispus* 4, 5 (1.1); *Trifolium repens* 6;
II: *Arctium minus* 6 (r); *Berteroa incana* 7; *Echium vulgare* 1,10 (r); *Epilobium hirsutum* 2 (r), 5 (r); *Galium aparine* 12; *Rumex obtusifolius* 1 (r); *Saponaria officinalis* 12 (1.2); *Tanacetum vulgare* 1, 6; *Tragopogon dubius* 12 (r);
III: *Acer pseudoplatanus* 6, 10 (r); *Aesculus hippocastanum* 3 (r); *Astragalus glycyphyllos* 2 (1.2); *Cardaminopsis arenosa* 10; *Corynephorus canescens* 10 (+.2); *Chamaenerion angustifolium* 2 (r), 6; *Conyza canadensis* 6, 7; *Crataegus monogyna* 10 (1.1); *Epilobium ciliatum* 2 (r), 8; *Equisetum arvense* 3, 4 (2.1); *Epilobium adnatum* 6 (r); *Euphorbia cyparissias* 2 (2.2); *Fraxinus excelsior* c 1 (+.2); *Herniaria glabra* 10 (2.2); *Hieracium pilosella* 10 (3.3); *Leontodon hispidus* 10; *Linum catharticum* 10; *Luzula multiflora* 1 (1.2); *Matricaria inodora* ssp. *inodora* 6 (1.1); *Odontites serotina* 1, 6 (1.1); *Phragmites australis* 1 (2.1); *Pimpinella saxifraga* 12; *Phleum pratense* 4 (r), 5; *Plantago major* 6, 7; *Potentilla arenaria* 10 (1.2); *Quercus robur* 10; *Reynoutria japonica* 3 (r), 5 (r); *Rumex acetosella* 10 (1.1); *Rumex stenophyllus* 1; *Senecio ovatus* 10 (r); *Silene vulgaris* 10 (1.1); *Sonchus arvensis* 2 (1.1); *Solidago virgaurea* 10 (1.2); *Trifolium hybridum* 6, 8 (r); *Verbascum thapsus* 5 (r), 6 (r).

Table 3. *Scirpetum sylvatici* (Ralski 1931)

Number of relevé in the table	1	2	3	4
Number of relevé in the field	122	123	124	125
Date: day	8	8	8	8
Date: month	10	10	10	10
Date: year	01	01	01	01
Town	CHORZÓW			
Cover of the herb layer in %	100	100	100	100
Area of relevé in m^2	12	12	12	12
Inclination in °	-	-	-	-
Number of species in relevé	17	18	17	17
I. Ch. Ass. *Scirpetum silvatici* α + Ch. *Molinio-Arrhenatheretea*				
Scirpus sylvaticus α	2.1	1.2	1.1	2.2
Juncus effusus	+.2	2.2	2.2	2.2
Deschampsia caespitosa	+.2	+.2	+.2	+.2
Elymus repens	+	+	+	+
Potentilla anserina	+	+	+	+
Lotus corniculatus	1.2	1.2	1.2	1.2
Lathyrus pratensis	1.2	2.2	2.2	1.2
Festuca rubra	1.2	1.2	1.2	1.2
II. Ch. *Artemisietea vulgaris*				
Solidago canadensis	**1.1**	**+.2**	**1.1**	**1.1**
Solidago gigantea	**2.2**	**2.2**	**1.2**	**2.2**
Cirsium arvense	+	+	+	+
Calystegia sepium	r	+	+	+
Epilobium hirsutum	+	+	+	r
Rumex obtusifolius	r	r	.	r
III. Accompanying species				
Calamagrostis epigejos	4.5	3.3	3.3	3.3
Vicia sepium	1.2	1.2	2.2	.
Phleum pratense	1.1	1.2	1.2	1.1
Ranunculus acris	.	r	+	+

Table 4a. The comparison of the floristic composition of the investigated communities (meadow species)

Number of table	1	2	3
Number of relevé in the table	18	16	4
Town		CHORZÓW	
Cover of the herb layer in %	85-100	70-100	100
Area of the relevé in m^2	16-25	12-100	12
Inclination in °	30-45	45	-
Number of species in relevés	74	101	18
I. Ch. *Molinio-Arrhenatheretea*			
Elymus repens	IV (+ - 1.2)	IV (+ - 3.3)	4 (+)
Festuca rubra	III (1.2-3.3)	I (1.2)	4 (1.2)
Lotus corniculatus	I (+ - +.2)	III (r –2.2)	4 (1.2)
Deschampsia caespitosa	I (+.2-1.2)	III (+ - 2.2)	4 (+.2)
Arrhenatherum elatius	V (1.1-3.3)	II (+-1.2)	-
Daucus carota	V (r – 1.1)	II (r – 1.1)	-
Achillea millefolium	IV (r – 3.2)	III (r – 2.2)	-
Vicia cracca	IV (+ - 2.2)	III (r – 2.2)	-
Dactylis glomerata	III (r – 2.2)	III (r – 2.2)	-
Pastinaca sativa	III (r - +)	II (r – 1.1)	-
Plantago lanceolata	II (+ - 3.3)	III (r – 3.3)	-
Taraxacum officinale	II (+ - 2.2)	III (r – 1.2)	-
Agrostis gigantea	II (+ - 1.1)	III (+ - 1.2)	-
Trifolium pratense	II (+ - 1.1)	III (r - +)	-
Agrostis stolonifera	I (1.1)	II (+ - 3.3)	-
Holcus lanatus	I (+.2-1.2)	III (r – 1.2)	-
Lolium perenne	I (3.3)	II (1.2-2.3)	-
Stachys palustris	I (r – 1.1)	II (r - +)	-
Centaurea jacea	II (+ - 3.2)	-	-
Centaurea pseudophrygia	II (+- 1.2)	-	-
Ranunculus repens	-	III (r - 2.3)	
Lathyrus pratensis	-	II (+ - 1.2)	4 (1.2 –2.2)
Potentilla anserina	-	I (1.1)	4 (+)
Juncus effusus	-	-	4 (+.2-2.2)
Scirpus sylvaticus	-	-	4 (1.1-2.2)
Other sporadic species	8	11	-

Table 4b. The comparison of the floristic composition of the investigated communities (*Artemisietea vulgaris* class and accompanying species)

Number of table	1	2	3
Number of relevé in the table	18	16	4
Town		CHORZÓW	
Cover of the herb layer in %	85-100	70-100	100
Area of the relevé in m^2	16-25	12-100	12
Inclination in °	30-45	45	-
Number of species in relevés	74	101	18
II. Ch. *Artemisietea vulgaris*			
Solidago canadensis	**V (+ - 2.2)**	**V (1.1-2.2)**	**4 (+.2-1.2)**
Solidago gigantea	**V (r - 2.3)**	**V (+ - 2.3)**	**4 (1.2-2.2)**
Cirsium arvense	V (r – 2.2)	V (r – 2.1)	4 (+)
Artemisia vulgaris	V (r – 2.2)	V (r - 2.2)	-
Picris hieracioides	III (r - +)	III (r - +)	-
Oenothera biennis	III (r – 1.1)	II (r - +)	-
Tanacetum vulgare	III (+ - 1.2)	I (+)	-
Echium vulgare	II (r – 1.2)	I (r - +)	-
Melandrium album	II (r - +)	II (r - +)	-
Berteroa incana	II (r – 1.1)	I (+)	-
Cirsium vulgare	I (r - +)	IV (r – 4.4)	-
Eupatorium cannabinum	I (r)	IV (r – 1.2)	-
Melilotus alba	II (r – 2.2)	-	-
Aster novi-belgii	-	II (r - +.2)	-
Urtica dioica	-	II (r - +)	-
Calystegia sepium	-	II (r - +)	4 (r - +)
Epilobium hirsutum	-	II (r - +)	4 (r - +)
Rumex obtusifolius	-	I (r)	3 (r)
Other sporadic species	6	5	-
III. Accompanying species			
Calamagrostis epigejos	V (+ - 4.3)	III (r – 4.3)	4 (3.3-4.5)
Vicia sepium	II (r – 1.2)	II (r - +)	3 (r – 2.2)
Equisetum arvense	II (2.2-4.4)	I (+ -2.1)	-
Lathyrus tuberosus	III (+ - 2.2)	II (+ - 1.2)	-
Hieracium sabaudum	II (r – 1.1)	II (r - +)	-
Acer pseudoplatanus	II (r)	I (r - +)	-
Conyza canadensis	II (r - +)	I (+)	-
Silene vulgaris	II (r - +)	I (1.1)	-
Tussilago farfara	I (+)	III (+ - 2.1)	-
Medicago lupulina	II (+)	II (r –1.1)	-
Hypericum perforatum	I (1.1)	II (r - +)	-
Poa compressa	I (+ - 2.2)	II (+ -1.2)	-
Phleum pratense	-	I (r - +)	4 (1.1-1.2)
Bromus inermis	II (1.1)	-	-
Convolvulus arvensis	II (+ - 1.1)	-	-
Aegopodium podagraria	-	II (+ - 1.1)	-
Festuca trachyphylla	-	II (3.3-4.4)	-
Mentha arvensis	-	II (r – 2.1)	-
Salix caprea	-	II (r –1.2)	-
Ranunculus acris	-	-	3 (r - +)
Other sporadic species	13	30	-

Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

ANTHROPOPHYTES IN THE VASCULAR FLORA OF THE SELECTED NATURE RESERVES OF THE SILESIAN PROVINCE (POLAND)

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ABSTRACT. This paper presents the results of the studies on the contribution of alien species to the floras of 5 nature reserves, situated within the Silesian Province. A total of 20 species of anthropophytes were identified within these reserves. Alien species contributed most significantly to the floras of the nature reserves located within cities, near housing estates.
Most anthropophytes (16 species) were noted on the edges of the nature reserve. Some alien species occurred along forest roads and paths and in habitats associated with illegal rubbish dumps. Some, such as *Aesculus hippocastanum*, *Impatiens parviflora* and *Symphoricarpos albus*, penetrated the interior of the forest. The most common anthropohyte (noted in 4 objects) is *Impatiens parviflora.*

KEY WORDS: anthropophytes, flora, nature reserves, the Silesian Province

INTRODUCTION

The Silesian Province is regarded as a strongly degraded area in Poland. The development of industry and advancing urbanisation have resulted in massive changes in all environmental elements of this region: air, soil, water, vegetation, fauna and the landscape. Nevertheless, there still exist localities which can boast environmental assets, where fragments of natural plant associations have been preserved. To protect these valuable areas, 61 nature reserves have been created in the Silesian Province. Most of them protect forest communities.

As located in the vicinity of urban and industrial areas, many nature reserves of the Silesian Province suffer from strong anthropopressure, which results in synathropisation of their plant cover. This process involves disappearance of indigenous species, especially those rare and protected. Moreover, alien species, or anthropophytes, tend to penetrate and spread within natural plant associations. Their presence in the phytocenoses of nature reserves is connected mainly with the presence of people and with migration from areas surrounding the reserves.

This study attempts to assess the contribution of alien species to the floras of selected nature reserves within the Silesian Province of different anthropopressure intensity. Particular attention was directed to the types of habitats preferred by such plants.

STUDY AREA

The research was conducted in 5 nature reserves in the Silesian Province: Kopce, Lasek Miejski nad Puńcówką, Segiet, Skarpa Wiślicka and Zadni Gaj (Fig. 1). Some of them are situated close to housing estates and transport routes, some others are surrounded by meadows and forests. They protect forest communities, mainly beech woods and hornbeam forests. They are home to many protected and endangered plant species, rare both to this region and to Poland.

Kopce Nature Reserve was created in 1953 for educational and scientific purposes to protect a fragment of mixed forest with the lime-tree and rare herbaceous plants. It is located in Cieszyn-Marklowice, a district of the town of Cieszyn, far from built-up areas (DORDA, MIJAL 2002).

Lasek Miejski nad Puńcówką is another sylvan-floristic nature reserve located in Cieszyn. It was founded in 1961 to protect a stand of *Hacquetia epipactis* (Scop.) DC., a species rare to Poland and marked by a very limited range. The reserve protects also an old hornbeam wood (DORDA, MIJAL 2002).

Fig. 1. The location of the examined nature reserves
Explanations: 1 – Segiet, 2 – Skarpa Wiślicka, 3 – Zadni Gaj, 4 – Kopce, 5 – Lasek Miejski nad Puńcówką.

Segiet Nature Reserve was created in 1953 in the town of Bytom. This reserve protects an orchidaceous beech wood, rare to the Silesian Upland. Many rare and protected plant species occur in the herb layer, including some orchids. In the area of the reserve there are remnants of the former mining activity: depressions, shafts and workings (TOKARSKA-GUZIK 1997).

Skarpa Wiślicka Nature Reserve is situated in the immediate vicinity of the Katowice – Wisła fast road. It was founded in 1996 to protect beech stands and floodplain forest with majestic beeches and ash-trees (DORDA, MIJAL 2002).

Zadni Gaj Nature Reserve lies at an altitude of 519 m above sea level, almost fully surrounded by forests. It was established in 1957 to protect a natural stand of *Taxus baccata* L. The prevailing plant community is a degenerated form of the fertile Carpathian beech wood (DORDA, MIJAL 2002).

MATERIAL AND METHODS

Floristic studies were carried out in the years 2003-2005 in the five selected nature reserves. For each alien species, the type of habitat was recorded where the species was found.

The plant names follows MIREK et al. (2002). The geographical-historical classification of anthropophytes is based on the division presented by KORNAŚ and MEDWECKA-KORNAŚ (1986) and ZAJĄC et al. (1998). To evaluate the contribution of alien species to the floras of the studied nature reserves, the following indices were used: total flora anthropophytisation index and permanent flora anthropophytisation index (JACKOWIAK 1990).

RESULTS

In the studied nature reserves, 20 antropophytes were found. Among them kenophytes were by far the largest group (14 species), followed by ergasiophygophytes (5 species). Additionally, in Lasek Miejski nad Puńcówką, one archaeophyte was identified (Tab. 2).

The total flora anthropophytisation index and permanent flora anthropophytisation index were highest in Lasek Miejski nad Puńcówką (11.68; 9.02). The lowest values of the indices were obtained for the flora of Zadni Gaj Nature Reserve (0.79; 0.79) (Tab. 1).

The most common kenophyte, recorded in 4 nature reserves, was *Impatiens parviflora*.

Table 1. The values of the total flora anthropophytisation index and the permanent flora anthropophytisation index in the examined nature reserves

Nature reserve	Area in ha	Surrounding of the nature reserve				Total number of species	Number of anthropophytes	Total flora anthropophytisation index (%)	Permanent flora anthropophytisation index (%)
		HE	TR	MF	F				
Kopce	14.76	-	-	+	-	152	4	2.63	1.99
Lasek Miejski nad Puńcówką	6.96	+	-	-	-	137	16	11.68	9.02
Segiet	24.70	+	-	-	+	124	6	4.84	4.84
Skarpa Wiślicka	24.17	-	+	+	+	132	5	3.79	3.79
Zadni Gaj	5.77	-	-	+	+	127	1	0.79	0.79

Explanations: HE – housing estates, TR – transports routes, MF – meadows / fields, F – forests.

Solidago canadensis, *Reynoutria japonica* and *Robinia pseudoacacia* were found in 3 objects. The remaining species were recorded in 1 or 2 nature reserves (Tab. 2).

Most of the anthropophytes (16 species) occurred at the edges of the reserves. Some alien species (10) were recorded along forest paths and roads. Three kenophytes were found in illegal rubbish dumps (*Impatiens parviflora*, *Reynoutria japonica* and *Solidago canadensis*). The following alien species penetrated the interior of forests: *Aesculus hippocastanum*, *Impatiens parviflora* and *Symphoricarpos albus* (Tab. 2).

Table 2. The occurrence of anthropophytes in different types of habitats in the investigated nature reserves

Name of species	Historical-geographical group	Nature reserve					Type of habitat
		Kopce	Lasek Miejski nad Puńcówką	Segiet	Skarpa Wiślicka	Zadni Gaj	
Acer negundo L.	Kn		+				2
Aesculus hippocastanum L.	Kn		+	+			1, 2, 3
Capsella bursa-pastoris (L.) Medik.	Ar		+				2
Galinsoga ciliata (Raf.) S. F. Blake	Kn			+			1
Impatiens parviflora DC.	Kn	+	+		+	+	1, 2, 3, 4
Impatiens glandulifera Royle	Kn				+		2
Juncus tenuis Willd.	Kn		+				1
Juglans regia L.	Er		+				2
Ligustrum vulgare L.	Er		+				2
Malus domestica Borkh.	Er		+				2
Oxalis fontana Bunge	Kn		+				1
Parthenocissus inserta (A. Kern.) Fritsch	Kn		+				2
Pinus strobus L.	Er		+				1
Prunus domestica subsp. *syriaca* (Borkh.) Janch.	Er	+					2
Quercus rubra L.	Kn		+	+			1, 2
Reynoutria japonica Houtt.	Kn		+	+	+		1, 2, 4
Robinia pseudoacacia L.	Kn	+	+		+		2
Solidago canadensis L.	Kn	+	+	+			1, 2, 4
Solidago gigantea Aiton	Kn			+	+		1, 2
Symphoricarpos albus (L.) S. F. Blake	Kn		+				2, 3

Explanations: Ar – archaeophyte, Kn – kenophyte, Er – ergasiophygophyte, 1 – forest path and road, 2 – forest edge, 3 – typical forest habitat, 4 – illegal rubbish dump.

Discussion

Anthropopressure-induced detrimental changes in the plant cover have already been noted in many nature reserves in Poland. The tendency for alien species, i.e. anthropophytes, to invade and spread within floras of protected areas seems to be increasing (Michalik 1990). Penetration of alien species into protected phytocoenoses of nature reserves has also been recorded in objects located in the Silesian Province (Rostański, Tokarska-Guzik 1994, 1995; Żarnowiec et al. 1997).

Some alien species were found in all the studied nature reserves. Their contribution to the floras of particular reserve varied. They were most numerous in the nature reserves located in the immediate vicinity of built-up areas.

The considerable number of anthropophytes in the flora of Lasek Miejski nad Puńcówką is connected with the location of this nature reserve within the town of Cieszyn. This small object borders an urban park, recreation and sports areas and housing estates. The inhabitants use the nature reserve for leisure activities and relaxation. By contrast, the contribution of anthropophytes to the flora of Segiet Nature Reserve is markedly lower. Although Segiet is also situated within a large town, it is separated from built-up areas with a buffer zone, which to a large extent reduces anthropopressure and prevents invasion of alien plants.

Also the presence of a busy road in the immediate vicinity of a nature reserve makes it easier for anthropophytes to penetrate protected phytocenoses. It can be assumed that some alien species entered Skarpa Wiślicka Nature Reserve from the roadsides of the adjacent fast road.

The smallest number of anthropophytes was found in the nature reserves situated far from housing estates and transport routes. This was true to Zadni Gaj Nature Reserve, almost all of which is located in a dense forest complex, and to Kopce Nature Reserve, which is a forest enclave surrounded by meadows and fields.

In all the studied nature reserves, many alien species were found to grow at the edges of the objects. Therefore, it can be inferred that anthropophytes enter nature reserves mainly from the immediately adjacent areas and then many of them migrate along forest paths and roads. Thus, synanthropisation of the flora of nature reserves is further intensified by the impact of people in the protected areas. Moreover, alien species occur also in sites where refuse and debris are illegally dumped.

The most common alien plant *Impatiens parviflora* occurs in large numbers along forest roads and paths, at the edges of the nature reserves and around illegal rubbish dumps. It was also recorded in the interior of forests, where it sometimes eliminates other species of the herb layer.

Conclusions

1. Anthropophytes contributed most significantly to the floras of the nature reserves situated within towns, in the immediate vicinity of housing estates.
2. The largest number of alien species in the studied nature reserves was observed along forest roads and paths and at the edges of forests.
3. Some anthropophytes were found to migrate from these habitats to forest phytocoenoses.
4. In some nature reserves, the most invasive alien species was *Impatiens parviflora*. It was recorded along forest paths and roads, at the edges of the reserves and in illegal rubbish dumps and sometimes in the interior of forests.

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Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

ECOLOGICAL AND PHYTOSOCIOLOGICAL SPECTRUM OF *BROMUS CARINATUS* HOOK. & ARN. OCCURENCE IN THE CITY OF KATOWICE (SILESIAN UPLAND)

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ABSTRACT. *Bromus carinatus* is a North American species which was brought into Poland in the 1960s and shows a tendency to spread in the whole country. The object of this study was to indicate the habitats currently occupied by this species within the area of the city of Katowice, to determine its occurrence with regard to the type of land management, to identify plant communities it invades and to describe the spectrum of ecological requirements of these communities.

Bromus carinatus has been observed in Katowice predominantly within patches of *Lolio-Plantaginetum* which develop in open, well-insolated sites on moist and mesotrophic habitats. A significant negative correlation was observed between the coverage index values of *Bromus carinatus* and *Lolium perenne*. Its localities are concentrated chiefly within the sparsely built-up housing zone in the northern part of the city, while its occurrence was recorded more rarely on agricultural land and in zones with other land management. Its presence was not recorded in semi-natural and natural habitats within the city.

KEY WORDS: *Bromus carinatus*, Katowice, Silesian Upland, city, phytosociology

INTRODUCTION

The genus *Bromus* is represented by ca. 150 species which occur predominantly in the temperate zone of the Northern Hemisphere and in mountains of the tropical zone (SZWEYKOWSKA, SZWEYKOWSKI 2003). Seven native representatives of the genus *Bromus* occur in Poland. Moreover, the checklist of vascular plants of Poland (MIREK et al. 2002) includes 8 alien species from the genus *Bromus* which are naturalised and 12 species which appear ephemerically. Listed among these alien species is *Bromus carinatus* Hook. & Arn. Its land of origin is the western part of North America (GLEASON, CRONQUIST 1991; ZAJĄC et al. 1998). In its homeland, it occurs along a broad altitude gradient – from lowland area to the subalpine level. It can

be found in sunny forests with scrubs, in steppe-like communities, in meadows and on waste land. In some of these communities, this *Bromus* species plays a dominant role (HERZMAN et al. 1959). It has most probably inadvertently brought to Europe with seed material (SMITH 1980). Since the beginning of the 20th century, its localities have been known from Sweden, Belgium, the Netherlands and Germany (PALLAS 1994; BORKOWSKY, HARTWIG 1997). It has been cultivated in Poland since the 1960's (SULINOWSKI 1972). It has been recorded from various regions of the country (SCHWARZ 1967; ĆWIKLIŃSKI 1970; KRAWIECOWA, ROSTAŃSKI 1976; SENDEK 1981).

In 1984, the presence of this species was recorded in synanthropic habitats in the environs of Kraków (MIREK 1984). As late as the 1980s, *Bromus carinatus* was still included on the list of ephemerophytes of Poland (ROSTAŃSKI, SOWA 1986-87). Currently, its status is that of a permanently naturalised plant (a kenophyte) (ZAJĄC et al. 1998) and it shows a tendency to spread throughout the country (TOKARSKA-GUZIK 2003). Its expansion is facilitated by a number of characteristics, including resistance to low temperatures, rapid additionally stimulated by mowing, quick maturation to reproduction stage, ability to reproduce both vegetatively and generatively (STUBBENDIEK et al. 1992). The current distribution of *Bromus carinatus* in Poland is shown in Fig.1. Its localities are concentrated chiefly in the central and southern part of the country (ZAJĄC, ZAJĄC 2001).

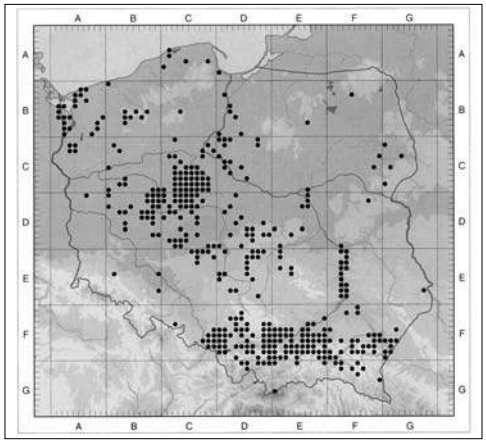

Fig. 1. Distribution of *Bromus carinatus* in Poland (ZAJĄC, ZAJĄC 2001)

It is commonly recorded in synanthropic habitats (roadsides, trodden ground, ruderal habitats, agricultural land, urban areas, railway terrain) (JACKOWIAK 1993; KOMPAŁA, WOŹNIAK 2001; WOŁKOWYCKI 2001; MISIEWICZ 2001; PAWLAK 2003; WRZESIEŃ 2005; WITOSŁAWSKI 2005; PASIERBIŃSKI et al. 2005). Sporadically, its participation was noted in semi-natural communities from the class *Molinio-Arrhenatheretea* (KOMPAŁA, WOŹNIAK 2001; BUDYŚ, DOBRZYŃSKA 2004) and in mid-field forest patches (BUDYŚ, DOBRZYŃSKA 2004).

Because of the naturalisation and invasiveness of this species in Poland, research on the distribution of *Bromus carinatus* in the city of Katowice was initiated. Hitherto, this species has only been recorded from ruderal habitats in the city (waste ground, roadsides). It has been recorded for the first time (2 localities) in the 1970s (SENDEK 1981, 1984) and its occurrence has subsequently been confirmed in the 1990s (TOKARSKA-GUZIK, ROSTAŃSKI 1997).

The objective of the study was to indicate the habitats currently occupied by this species within the area of the city, to determine its occurrence with regard to the type of land management and to identify the species composition of plant communities which it is able to invades. An attempt was also made to describe the spectrum of ecological requirements of plant assemblages with *Bromus carinatus*.

Area of study

The city of Katowice is located on the Silesian Upland in the centre of Upper Silesia Industrial District – one of the regions of Poland and Europe most strongly transformed from the development of heavy industry. Because of extensive industrialisation and urbanisation of the city, the local vegetation is exposed to constant and multifactorial transformations. Apart from habitats directly connected to human activity (urban terrain, post-industrial waste ground, transportation pathways), areas of agricultural land, fallow fields, meadows and forests also occur, mainly in the southern part of the city.

Field research and data analysis

In the 2005 vegetation season, field studies were carried out within the city of Katowice. Phytosociological releves were performed by the classic method of Braun-Blanquet (1964) in patches with occurrence of *Bromus carinatus* in various habitat types. The coverage index for *Bromus carinatus* on study plots ranged from less than 10% to 90%. In order to classify the phytosociological releves, cluster analysis was performed using the average linkage method and Euclidean square distance. Based on the results of this analysis, the releves were ordered in a phytosociological table using the geobotanical analysis software package "Profit 2" (Balcerkiewicz, Sławnikowski 1998). For each species, the degree of constancy and coverage index was calculated (Pawłowski 1977). Syntaxonomic affiliation of species was derived from the study of Brzeg and Wojterska (2001), while plant names were taken from Mirek et al. (2002). The collected data was subjected to numerical analysis (PCA) using the CANOCO computer programme (Lepš, Šmilauer 1999; Ter Braak, Šmilauer 2002). Indirect habitat analysis of plant assemblages with occurrence of *Bromus carinatus* was also performed based on Ellenberg's indicator values (Ellenberg et al. 1991). The following indicator values were included in the analysis: light (L), humidity (F), substrate pH (R) and nutrient content (N). Sites of *Bromus carinatus* occurrence were localised by means of a GPS receiver and marked on a city map with a background of land management zoning complexes using the MAPINFO computer programme. The following zoning complexes were distinguished within the area of the city: compact tenement building zone, sparse tall building zone – blocks of flats, sparse low building zone – residential housing, industrial enterprise area, post-industrial terrain, parks and other organised greenery areas, gardens and orchards, railway terrain, agricultural ground, other areas with ruderal character as well as meadows and forests.

Results

Bromus carinatus has been recorded within the city of Katowice predominantly in patches of *Lolio-Plantaginetum* which develop in open, well-insolated sites on moist mesotrophic habitats which undergo moderate mechanical damage. This species prefers housing estate squares and roadsides. *Bromus carinatus* in analysed plots reached a coverage index values ranging from less than 10% up to 90%. Apart of species from the order *Trifolio-Plantaginetalia*, it is accompanied in some study plots by therophytes from the classes *Polygono-Poëtea* and

Stellarietea mediae as well as by ruderal species from the class *Artemisietea vulgaris* (Tab. 1)*.

In order to identify the dependence between the occurrence of *Bromus carinatus* and of other species and to compare the species composition of phytosociological releves taken in the field, principal component analysis was performed. Total sample variability is of 56.4% determined by the two first component axes (Tab. 2). Eigenvectors for *Bromus carinatus* and *Lolium perenne* are to a large extent linked to the first component (Fig. 2). These species show a negative correlation with each other, reciprocally influencing their coverage index in the samples (Fig. 3). PCA analysis indicates the co-occurrence of *Bromus carinatus* with species from trodden soil communities from the order *Trifolio-Plantaginetalia* and therophytes from the class

Table 2. Results of principal component analysis based on the correlation matrix of the species data

Axis	1	2	3	4
Eigenvalues	0,5642	0,1473	0,0584	0,0515
Cumulative % of variance	56,4	71,1	77,0	82,1
Bromus carinatus	0,9463	-0,3172	-0,0194	-0,0299
Lolium perenne	-0,8544	-0,5042	-0,0741	-0,0665

Polygono-Poëtea. In this group of relevés, *Bromus carinatus* has lower coverage index values, whereas a major role in plant cover is played by *Lolium perenne*. This relationship is also conspicuous in the phytosociological table (Tab. 1). In some patches, apart from treading-resistant species (order *Trifolio-Plantaginetalia*), nitrophilous plants appear*: Urtica dioica*, *Elymus repens*, *Arctium lappa*, *Chenopodium album*, *Stellaria media*, *Artemisia vulgaris*. Concurrently, the coverage index of *Bromus carinatus* increases. This group of communities (relevés 4-16, Tab. 1) developed on neglected lawns in more shaded locations. Another group of three releves of ruderal character is conspicuously distinct (relevés 1-3, Tab. 1). In their structure, the share and coverage index of species from the order *Trifolio-Plantaginetalia* decreases in favour of ruderal plants: *Solidago canadensis*, *Bromus inermis*, *Conyza canadensis*. *Bromus carinatus* does not exert a negative influence on the number of native species in the community. No decrease of number of species was shown for samples with increasing coverage index of *Bromus carinatus* (Fig. 4).

Ecological spectrum of plant assemblages with *Bromus carinatus*, prepared on the basis of Ellenberg's ecological indicator values, shows that they prefer well-insolated, moist, weakly acidic to weakly alkaline habitats. The analysed patches show broadest tolerance with regard to nutrient content (Fig. 5).

Bromus carinatus displays a non-homogeneous distribution within the city of Katowice. Its localities are concentrated predominantly within the sparsely built-up zone of blocks of flats housing in the northern part of the city (Fig. 6). Its sporadic occurrence was also recorded on agricultural land in the southern part of the city as well as in other zoning complexes, such as the compact tenement building zone and sparse low building zone. No occurrence of *Bromus carinatus* was noted in meadows or in forest communities within the Katowice.

* Table 1 is placed on the pages 115-116.

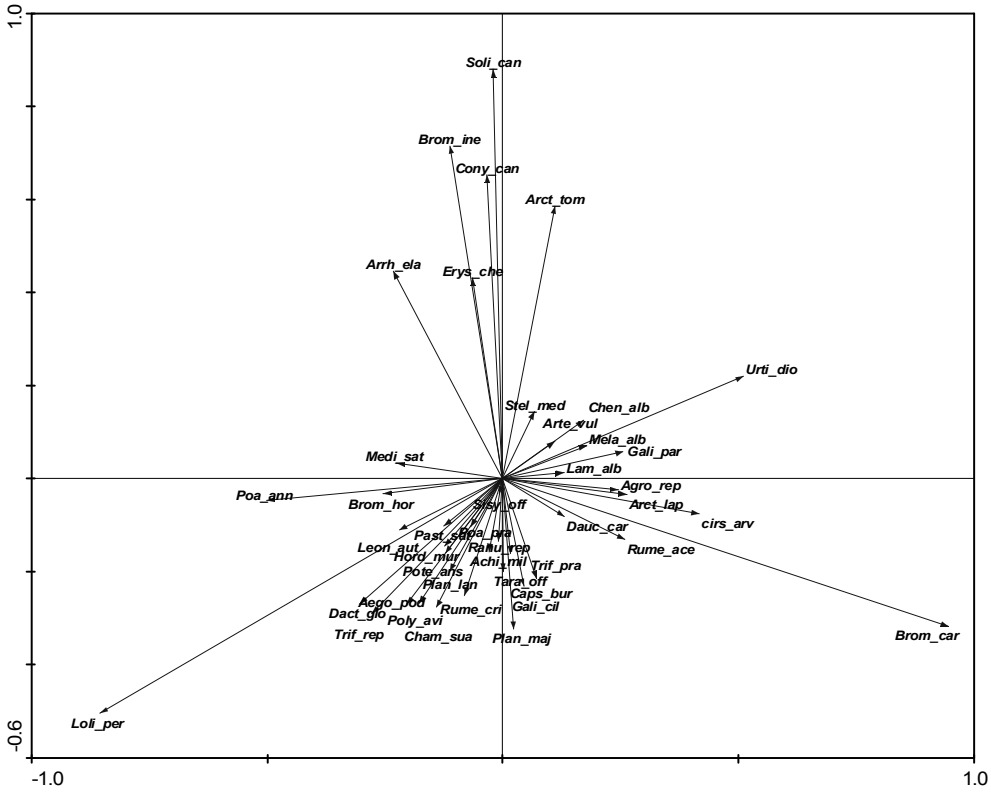

Fig. 2. PCA ordination of floristical composition of phytocoenoses with *Bromus carinatus* occurring in the Katowice city

Species abbreviation – first 4 letters – the genus name, further 3 letters – the species name.

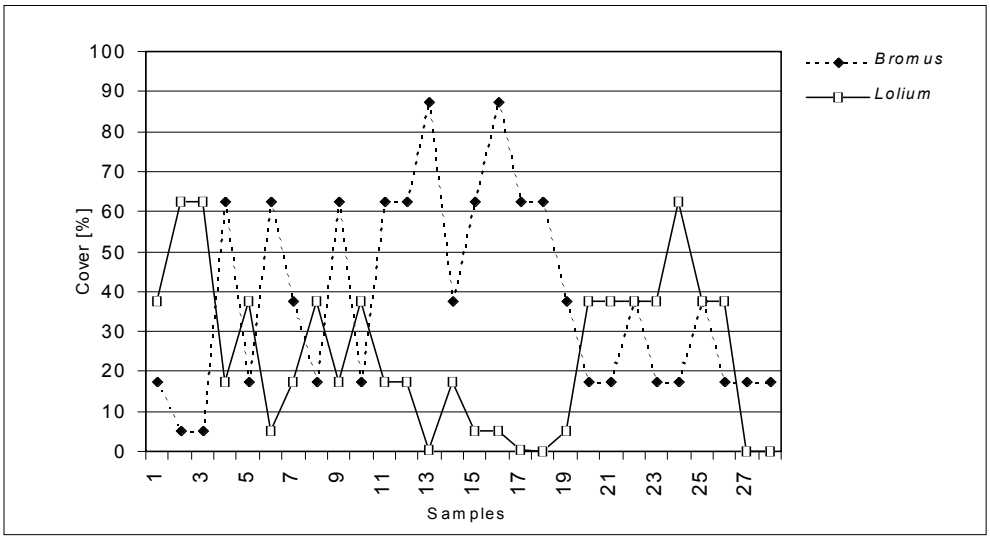

Fig. 3. The relationship between the cover of *Bromus carinatus* and *Lolium perenne* in the studied samples

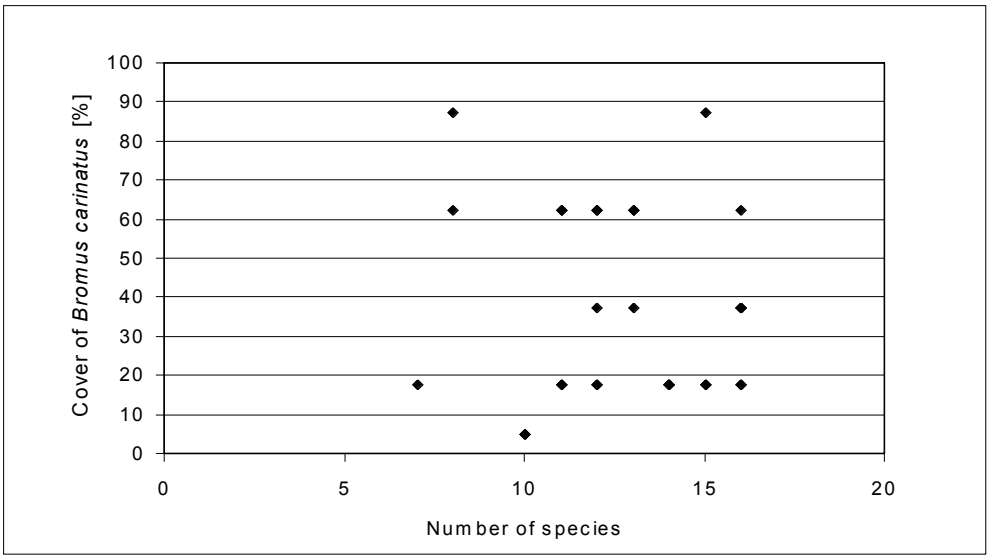

Fig. 4. The relationship between the cover of *Bromus carinatus* and number of species in the studied samples

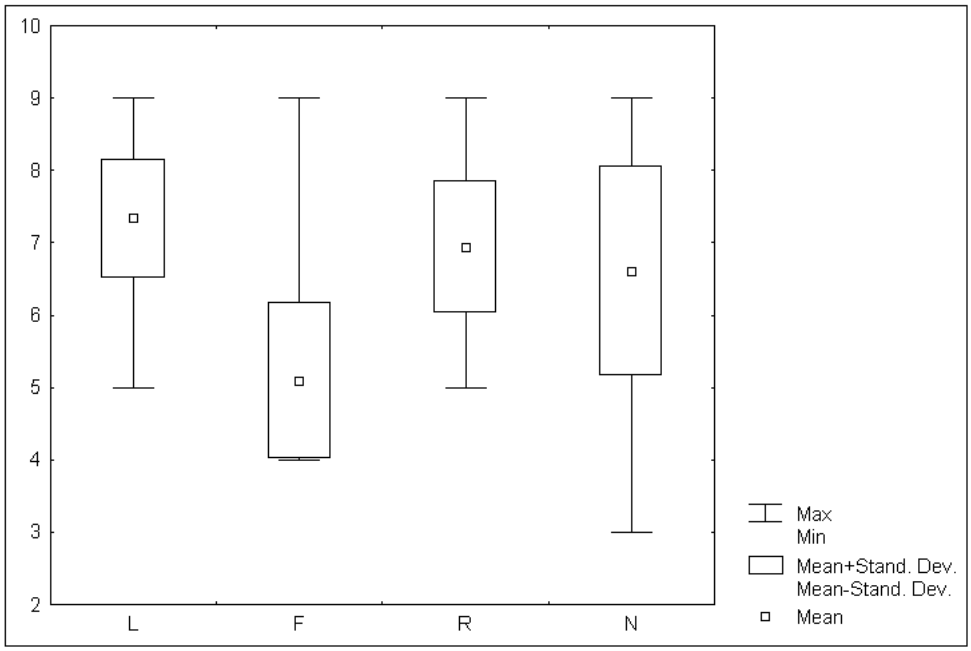

Fig. 5. Ecological spectrum of plant assemblages with *Bromus carinatus* occurrence based on Ellenberg's indicator values (ELLENBERG et al. 1991)
Explanations: L – light, F – humidity, R – substrate pH, N – nutrient content.

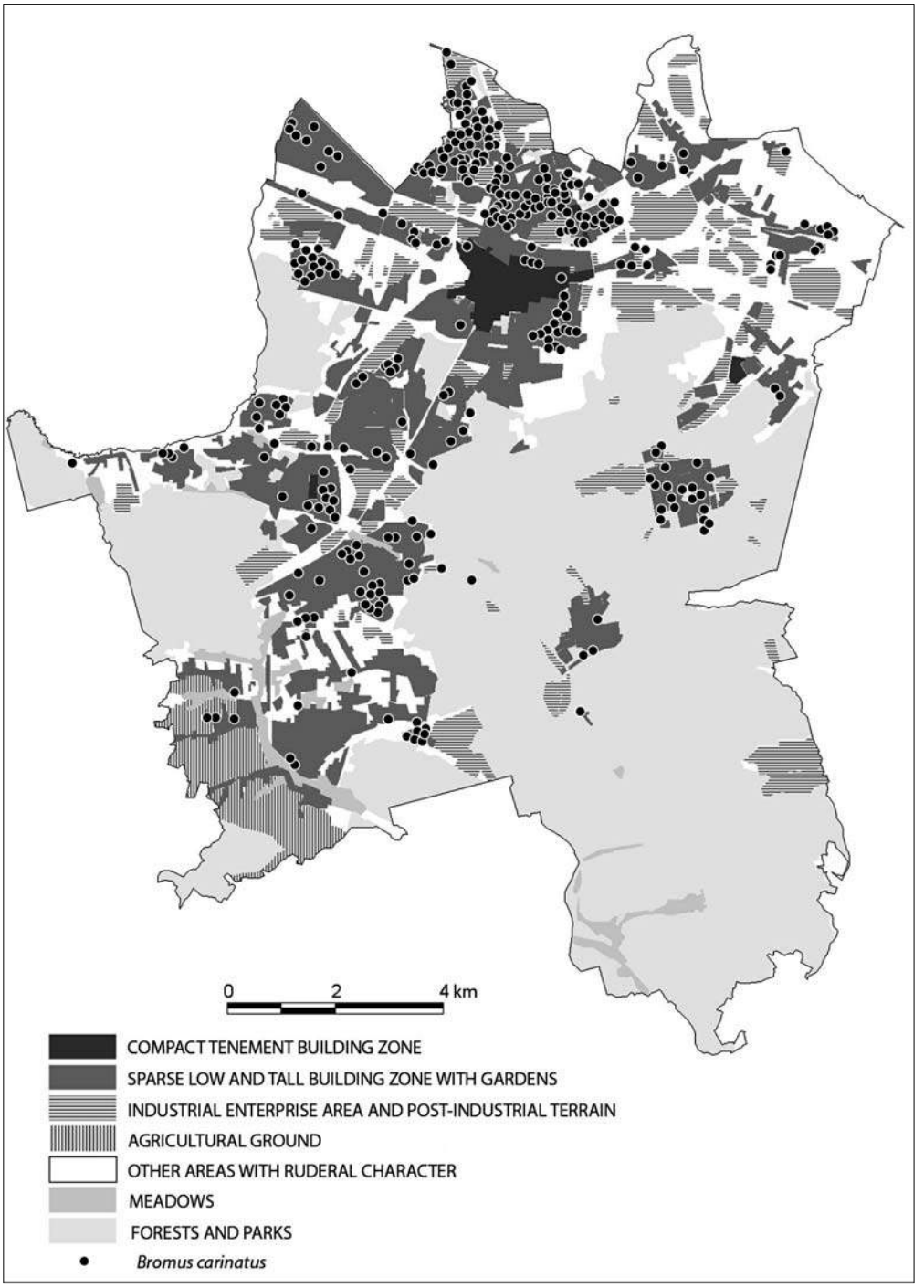

Fig. 6. Distribution of *Bromus carinatus* on the background of land management zoning complexes in the Katowice city

Discussion

The problem of plant cover synanthropisation has often been studied by researchers in recent years. One of features of this process is the extinction of native species with a narrow ecological tolerance scale, while other species, including alien plants, spread. Some of these plants have originally been introduced for cultivation and subsequently began to invade various types of plant communities.

Naturalisation of alien species in their new homeland usually takes place in distinct stages. Initially, the species enriches the floristic composition of plant communities that it enters, in time leading to the transformation of original phytocoenotic dispositions and to creation of aggregational communities (Faliński 1968). It is assumed (Faliński 1969) that alien species gradually out-compete native components of the invade plant community, thus leading to its floristic impoverishment. In the course of present research, no such relationship could be observed. It can only be asserted that increased share of *Bromus carinatus* caused a decrease in coverage index for other species. This is especially conspicuous in the case of coverage index of *Lolium perenne*.

Based on the data on the first recorded localities of this species in Poland (Schwarz 1967, Ćwikliński 1970), its current distribution in the country (Zając, Zając 2001), and taking into account the fact of its occurrence in various types of habitats (ruderal, segetal), *Bromus carinatus* was classified as an invasive species using the criteria given by Pyšek et al. (2004). This conclusion is supported by results of studies on the occurrence of this species in Katowice. Its co-occurrence with species from the order *Trifolio-Plantaginetalia* and its presence predominantly on urban squares and lawns suggests the conjecture that this species has been at least partially introduced together with seed material (in grass mixtures), which is confirmed also by the work of Sulinowski (1972) and Mirek (1984). The isolated recorded localities of *Bromus carinatus* in ruderal-type communities formed on roadsides, waste ground and arable field edges point to the ability of this species to spread in urban areas. The broad ecological scale of *Bromus carinatus* as well as literature data on its occurrence from the area of Poland (Budyś, Dobrzyńska 2004) and other European countries (Borkowsky, Hartwig 1997) all suggest that, with passing time, this species may also appear in meadow and forest communities in Katowice. Therefore, its distribution should be monitored in order to identify the pathways of migration of this species within the city area.

Lack of presence of this species in semi-natural habitats in Katowice and scarce reports of its occurrence in such habitats in Poland allow us to classify *Bromus carinatus* in the "not harmful" group, although recorded localities on arable field edges in the southern part of Katowice may suggest future directions of its invasion.

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Table 1. The floristic comparison of plant assemblages with *Bromus carinatus* occurrence in the city of Katowice

Relevé number		1	2	3	NUMBER OF OCCURRENCE	COVER COEFFICIENT	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	CONSTANCY	COVER COEFFICIENT
Relevé field number		28	21	27			18	15	16	12	13	20	32	14	19	5	9	8	1	2	11	3	6	25	17	4	22	26	23	24	33	10		
Day		11	13	11			16	5	8	5	5	16	19	5	16	10	9	8	9	9	10	10	8	12	16	8	12	11	12	12	10	9		
Month		8	8	8			8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	9	8	8	8	8	8	8	8	8	8	8		
Year		5	5	5			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		
Locality		Katowice					Katowice																											
Slope exposure								E								E					E	NE									W		
Inclination [°]								10								3					2	5									5		
Relevé area		10	10	10			15	10	15	10	10	20	20	10	20	20	15	15	15	20	20	20	15	20	15	15	20	20	20	20	20	20		
Cover of herb layer c [%]		100	90	80			100	90	100	100	100	100	100	100	80	90	100	100	90	100	100	100	100	80	90	100	100	80	80	100	90	90		
Cover of moss layer d [%]																													+					
Number of species per relevé		8	15	12			14	9	13	9	16	14	14	17	13	17	12	13	12	17	17	17	16	17	13	16	11	12	15	15	11	12		
Bromus carinatus	**c**	**2**	**2**	**2**	**3**	**1750**	**4**	**4**	**4**	**5**	**5**	**4**	**3**	**3**	**3**	**4**	**4**	**4**	**4**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**2**	**V**	**4093**
Cl. *Molinio-Arrhenatheretea* + O. *Trifolio-Plantaginetalia**																																		
*Lolium perenne**	c	.	.	.			+	.	1	1	+	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	4	3	3	4	4	3	V	2550
Taraxacum officinale	c	.	.	.			1	+	1	+	+	2	2	+	+	1	1	1	1	1	1	1	1	+	+	2	1	1	.	1	1	+	V	436
*Trifolium repens**	c	.	.	.			+	.	.	.	.	+	.	1	1	+	1	2	1	.	2	2	1	+	2	2	+	1	1	1	.	1	V	478
*Plantago major**	c	.	+	.	1	17	.	.	.	.	1	.	1	+	+	+	1	1	+	1	1	1	+	+	+	1	+	+	.	.	.	1	IV	185
Achillea millefolium	c	.	.	.			.	.	.	.	+	1	.	+	1	2	+	+	.	1	.	+	1	1	2	+	.	.	+	.	+	.	III	239
Poa pratensis	c	.	.	.			.	2	1	.	+	1	.	1	.	.	.	.	+	.	1	.	.	.	.	1	.	2	.	2	+	.	III	294
Trifolium pratense	c	.	.	.			1	.	.	.	.	.	1	.	.	1	.	.	.	2	.	+	.	.	1	.	.	.	.	+	.	+	II	144
Plantago lanceolata	c	.	.	.			.	.	.	.	.	.	.	.	.	+	+	.	.	2	.	+	.	+	.	.	+	.	+	.	.	1	II	93
Dactylis glomerata	c	.	.	.			.	.	.	.	.	.	.	.	.	.	+	.	.	1	+	+	+	.	.	.	1	.	.	.	.	+	II	46
*Leontodon autumnalis**	c	.	.	.			.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	1	.	.	.	.	.	+	.	.	+	+	II	28
Arrhenatherum elatius	c	2	.	2	2	1167	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	2	.	.	I	130
*Bellis perennis** 28 (r); *Centaurea jacea* 26; *Elymus caninum* 24 (1); *Festuca rubra* s. s. 3; *Geranium pratense* 11; *Lolium multiflorum* 26; *Lotus corniculatus* 3 (1); *Phleum pratense** 20; *Poa trivialis* 3 (1); *Potentilla anserina** 5, 6, 10, 17 (1), 20 (1); *Ranunculus acris* s. s. 11; *R. repens* 14 (1), 23 (1); *Rumex acetosa* 9, 13; *R. crispus** 17, 18;																																		
Cl. *Polygono-Poëtea*																																		
Polygonum aviculare	c	.	1	.	1	167	.	.	+	.	+	+	1	+	1	2	2	1	1	1	1	1	+	.	+	.	2	.	.	+	1	3	IV	496
Poa annua	c	.	1	1	2	333	.	.	+	.	.	.	2	.	.	1	.	.	1	.	1	.	1	1	.	2	2	.	1	+	2	2	III	457
Capsella bursa-pastoris	c	.	.	.			.	+	.	.	+	.	.	.	.	+	.	.	.	.	.	.	+	.	.	+	.	.	.	+	.	.	II	11
Chamomilla suaveolens	c	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	+	.	.	.	.	.	.	I	9

Table 1. (continued)

Relevé number		1	2	3			4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29		
Cl. *Artemisietea vulgaris*																																		
Artemisia vulgaris	c	+	+	+	3	50	1	+	+	.	+	+	.	+	.	.	+	+	+	+	.	.	+	+	1	+	.	.	.	.	+	.	III	63
Urtica dioica	c	1	1	.	2	333	2	1	2	1	1	.	1	+	.	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	III	213
Arctium lappa	c	.	.	.			+	+	1	+	.	.	.	.	+	.	.	+	.	+	.	+	+	.	.	+	.	.	.	.	.	.	II	35
Melandrium album	c	.	.	.			+	.	.	.	+	+	+	.	+	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	.	.	II	15
Solidago canadensis	c	2	2	2	3	1750	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		
Bromus inermis	c	2	2	1		1333	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	+	.	.	.	.	.	I	67
Aegopodium podagraria 6, 7, 8, 17 (2), 27 (2); *Arctium tomentosum* 1, 3, 9; *Armoracia rusticana* 8; *Chelidonium majus* 2 (r); *Cichorium intybus* 23; *Cirsium arvense* 4, 7; *Convolvulus arvensis* 15 (1); *Daucus carota* 11, 13; *Elymus repens* 6 (1), 7, 18; *Lamium album* 8 (1), 11 (2); *Pastinaca sativa* 6 (1), 11, 21, 26 (1), 27 (1); *Reynoutria japonica* 1 (3); *Rumex obtusifolius* 22; *Tussilago farfara* 2;																																	
Cl. *Stellarietea mediae*																																		
Sisymbrium officinale	c	.	+	.	1	17	.	.	.	.	.	+	+	+	2	+	.	+	1	+	.	1	.	r	.	1	.	.	.	.	.	.	III	132
Hordeum murinum	c	.	.	.			.	.	.	.	1	.	1	.	1	1	.	.	.	.	2	3	.	.	.	.	.	+	1	.	.	.	II	298
Bromus hordeaceus	c	.	.	.			.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	+	.	.	.	1	1	.	.	+	II	124
Conyza canadensis	c	.	1	1	2	333	+	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	+	.	+	.	.	.	.	+	.	.	II	11
Chenopodium album	c	.	+	+	2	33	+	.	.	+	.	+	.	.	+	+	.	+	.	.	.	+	.	.	+	.	.	.	.	.	+	.	II	17
Amaranthus retroflexus 26 (r), *Atriplex patula* 21 (r); *Erysimum cheiranthoides* 3, 27; *Galinsoga ciliata* 16 (1), 18 (1), 28; *G. parviflora* 4 (2), 8, 9; *Lactuca serriola* 2 (r); *Malva neglecta* 10; *Matricaria maritima* subsp. *inodora* 18; *Stellaria media* 5, 10 (2), 21, 23;																																	
Others: *Calamagrostis epigejos* 2 (2); *Medicago sativa* 25, 26; *Sonchus arvensis* subsp. *arvensis* 4; *Ceratodon purpureus* d 26 (1).																																	

Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

SOLIDAGO CANADENSIS L. AND *SOLIDAGO GIGANTEA* AITON PARTICIPATION IN PLANT COMMUNITIES OF RUDERAL HABITATS

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ABSTRACT. *Solidago canadensis* and *S. gigantea* are amongst the most common alien plant invaders in Poland and the whole of Europe. Phytosociologically both the species represent *Convolvuletalia sepium* order species, characterised as natural nitrophilous fringe communities typical of hydrophilous, occasionally flooded habitats along rivers. In Upper Silesia *Solidago canadensis* and *S. gigantea* occur in different plant communities and in various habitats either as accompanying species or as dominants. Both the *Solidago* species are frequent on ruderal and even post-industrial sites.

The aim of this study is to recognise plant communities developing on ruderal sites in which *Solidago canadensis* and *S. gigantea* occur and to analyse their floristic composition. The study was carried out in Chorzów, a town of the Upper Silesia conurbation. The vegetation samples were recorded in each homogeneous patch in which *Solidago canadensis* and/or *S. gigantea* was growing.

The paper presents the participation of *Solidago canadensis* and/or *S. gigantea* in the following plant communities: *Artemisio-Tanacetetum vulgaris*, *Dauco-Picridetum hieracioidis*, *Echio-Melilotetum* association and communities with *Calamagrostis epigejos* and *Elymus repens* as well as three *Solidago canadensis* dominated plant communities.

KEY WORDS: *Solidago canadensis* L., *Solidago gigantea* Aiton, plant invasion, plant community, ruderal habiatats

INTRODUCTION

The spread and penetration of alien plants, whether deliberately or accidentally introduced, is an almost universal phenomenon. In recent decades many investigations have been conducted to record and analyse the mechanisms of biological invasions (ADAMOWSKI et al. 1998, WEBER 1997). The success of alien species in migrating beyond their primary range should be considered not only in terms of biogeography (WEBER 1998) or evolution (VAN KLEUNEN, SCHMID 2003), but also from the biocoenotic (phytocoenotic) point of view (FALIŃSKI 1998, 2004).

Solidago canadensis and *S. gigantea* phytosociologically represent the *Convolvuletalia sepium* order of species (MATUSZKIEWICZ 2001). This unit represents natural nitrophilous fringe communities typical of hydrophilous, occasionally flooded habitats along rivers. *Solidago canadensis* and *S. gigantea* appear all over Poland (ZAJĄC A., ZAJĄC M. eds. 2001). Such habitat characteristics suggests that the species of the *Convolvuletalia sepium* order are only occasionally recorded in ruderal habitats, and extremely rare in dry and warm ones. In Upper Silesia, the species occur in different plant communities and in various habitats either as accompanying species or as dominants. Both the *Solidago* species are frequent on ruderal sites including postindustrial ones.

The aim of this study is to present plant communities developing on ruderal habitats in which *Solidago canadensis* and/or *S. gigantea* occur and to analyse their floristic composition; to recognise species which are present in the *Solidago canadensis* and/or *S. gigantea* dominated patches; to analyse in which ruderal vegetation types *Solidago canadensis* and/or *S. gigantea* occur abundantly.

MATERIAL AND METHODS

The paper presents only part of a larger project dealing with the occurrence of *Solidago canadensis* and *S. gigantea* species in plant communities. The investigation was carried out for two years (2000-2002) on the plant cover in Chorzów town. The relevés were made by using the Braun-Blanquet method (BRAUN-BLANQUET 1951). The vegetation samples were recorded in each homogeneous patch in which *Solidago canadensis* and/or *S. gigantea* was growing. Species were classified into phytosociological units according to MATUSZKIEWICZ (2001). The nomenclature of the Polish vascular flora was used according to MIREK et al. (2002) and the latest kenophytes (neophytes) list (ZAJĄC et al. 1998). The term kenophytes was used according to SUDNIK-WÓJCIKOWSKA and KOŹNIEWSKA (1988). The collected vegetation records from the phytocoenoses of ruderal sites have been divided into eight phytosociological tables.

RESULTS

In Table 1 patches of the *Artemisio-Tanacetetum vulgaris* community in which *Solidago canadensis* and *S. gigantea* were recorded, are presented. Neither *Tanacetum vulgare* nor *Artemisia vulgaris* (the characteristic species of the community) are dominants in any of the analysed patches (1-25 %). Both the species are very frequent (V constancy class), but there are also other very frequent species such as *Solidago canadensis*, *Achillea millefolium* and *Calamagrostis epigejos.* In the phytocoenoses described by four relevés (1, 4, 5, 6) *Solidago canadensis* covered up to 50% of the patch. Less frequent (IV constancy class) are: *Cirsium vulgare*, *C. arvense*, *Solidago gigantea* and *Picris heiracioides. Cirsium vulgare* and *Solidago gigantea* managed to cover up to 25% of the phytocoenoses. In one relevé (5) *Solidago gigantea* covered as much as 50% of the patch. Single *Convolvuletalia sepium* order species, *Eupatorium cannabinum*, *Aster novi-belgii* were present in more than half of the analysed patches, and *Aster* covered up to 25% of two of the patches (4, 5).

In the first group of species apart from *Solidago canadensis* and *S. gigantea,* only *Eupatorium cannabinum* and *Aster novi-belgii* are biennials representing the diagnostic species of the *Convolvuletalia sepium* order. In the same group four other species *Melandrium album*, *Oenothera biennis*, *Picris hieracioides* and *Melilotus alba* were recorded and they are diagnostic of *Onopordetalia acanthii* order (vegetation typical of dry and warm habitats). However, the last group of species were not abundant and covered up to 5% of the patch area.

In the *Molinio-Arrhenatheretea* class with high frequency but low abundance, *Achillea millefolium* (V) and *Vicia cracca* occurred. *Plantago lanceolata* and *Agrostis stolonifera* were present in the analysed patches with third constancy class. *Elymus repens* influenced the physiognomy of the phytocoenose described in relevé 1, covering up to 75% of the patch.

Among the accompanying species the most frequent and abundant (+ – 5.5) is *Calamagrostis epigejos.* The remaining accompanying species occur with low frequency (III – I) and low abundance (r – 2.2).

Some of the analysed patches are very rich in species: one phytocoenoses had 28 species and another had 34 species. In Table 1, besides both *Solidago* species, the following neophytes were recorded: *Aster novi-belgii*, *Erigeron ramosus* (*Artemisietea vulgaris* class) and *Conyza canadensis*, *Epilobium ciliatum* (accompanying species).

In the *Dauco-Picridetum hieracioidis* community diagnostic species of analysed phytocoenoses (Tab. 2) were frequent, but not very abundant. *Daucus carota* and *Picris hieracioides* occurred with the V constancy class. *Echium vulgare*, *Melilotus alba* and *Cirsium arvense* were recorded at the IV constancy class. The other diagnostic species: *Oenothera biennis* (III), *Melilotus officinalis* (I) and *Cichorium intybus* (I) occurred less frequent. *Solidago canadensis* is present in all of the analysed patches and covers from 1 to 50% of the patch area. *Solidago gigantea* reached only the third constancy class. The *Artemisietea vulgaris* class species: *Artemisia vulgaris*, *Cirsium arvense*, *Reseda lutea* covered very little of the patch area – from few individuals to 5%.

Some meadow species were quite frequent: *Pastinaca sativa* (V), *Arrhenatherum elatius* (V), *Achillea millefolium* (IV), *Taraxacum officinale*, *Plantago lanceolata*, *Trifolium pratense* and *Agrostis gigantea* (constancy class III).

In the group of the most frequent accompanying species the following should be noted, *Medicago lupulina* (V), *Calamagrostis epigejos* (IV) and *Poa compressa* (IV). Among the accompanying species, two neophytes were recorded – *Acer negundo* (II) and *Epilobium ciliatum* (sporadic species).

The patches described in Table 2 could be divided into two main groups. The first main group of relevé 1-7 had fresh meadow species such as *Achillea millefolium*, *Taraxacum officinale*, *Plantago lanceolata*, *Trifolium pratense* and some *Artemisietea vulgaris* class species such as *Cirsium arvense* and *Solidago gigantea* were present. There was variation within the first group where *Elymus repens*, *Rumex acetosa* and *Cerastium holosteoides* in relevés 2-4 covered very little of the patch area, while accompanying species such as: *Equisetum arvense*, *Festuca ovina*, *Tussilago farfara* and *Trifolium arvense* covered from 1 to 50%. The second group (relevés 8-11) is characterised by *Chamaenerion palustre* (25% of the patch) as well as *Verbascum thapsus*, *Acer negundo*, *Cardaminospsis arenosa*, *Senecio viscosus*, and *Lactuca serriola.* Noticeable is also the lower participation of meadow species. The phytocoenosis represented by relevé 7 was distinguished by an abundance of *Festuca rubra* (up to 100%, among sporadic species) as well as tree shrubs such as *Betula pendula*, *Populus tremula*, *P. nigra*, *Salix alba*, *S. caprea* and *S. purpurea* was recorded. This relevé (7) had also the highest number of species (31).

The next analysed vegetation patches are not typical of the *Echio-Melilotetum* community (Tab. 3). There are only a few diagnostic species present in the patches: *Melilotus alba* (V), *Daucus carota* (V), *Echium vulgare* (IV), *Picris hieracioides* (III) and *Oenothera biennis* (III). *Solidago canadensis* is frequently present but its cover is very low. *Solidago gigantea* reached the constancy class III and in one patch (relevé 4) covered up to 25% of the area. Apart from

Melilotus alba, none of *Artemisietea vulgaris* class species is abundant. Meadow species *Achillea millefolium* and *Plantago lanceolata* are present in all of the analysed patches.

The most frequent in the accompanying group of species is *Calamagrostis epigejos* (V) and *Tussilago farfara* (IV). Table 3 can be divided into three groups on the basis of their species composition. The first group (relevé 1-3) could be characterised by the presence of *Picris hieracioides*, *Oenothera biennis*, *Deschampsia caespitosa*, *Centaurea jacea*, *Cerastium holosteoides* as well as *Odontites serotina*, *Silene vulgaris*, *Hieracium sabaudum*, *H. piloselloides*, *Festuca ovina* and *Betula pendula*. The second group (relevés 4, 5) is distinctive because of the presence of *Artemisia vulgaris*, *Melandrium album* and *Arrhenatherum elatius* as well as the abundance of *Festuca rubra.* In relevé 4 two neophyte species were noticed: *Erigeron ramosus* and *Conyza canadensis.* The third group is represented by relevés 6 and 7. In those two phytocoenoses the number of *Echio-Melilotetum* community diagnostic species is the lowest. This group is distinctive because of the presence of meadow species: *Agrostis gigantea*, *Ranunculus repens*, *Holcus lanatus* and *Pastinaca sativa* as well as *Eupatorium cannabinum* – a *Convolvuletalia sepium* order species.

The phytocoenoses dominated by *Calamagrostis epigejos* are presented in Table 4. *Calamagrostis epigejos* cover in those patches was between 75 and 100% of their area. The *Artemisietea vulgaris* class is most frequently represented by *Solidago canadensis* and *Cirsium arvense* (constancy class V), *Oenothera biennis* and *Artemisia vulgaris* (IV constancy class). *Solidago gigantea* is remarkably less frequent (II). None of the *Artemisietea vulgaris* class species is abundant. From the *Molinio-Arrhenatheretea* class only *Achillea millefolium* (IV) is frequently represented. All the meadow species cover a very small area of the patch. The phytocoenoses can be divided into two parts on the basis of species number. In relevé 1 to 5, many plant species were recorded, the number varying from 15 to 21. The second group, relevés 6 and 7, are species poor. Moreover, in relevés 1-3 exclusively, the following species were present: *Poa compressa*, *Hieracium sabaudum*, *Hypericum perforatum*, *Tussilago farfara*, *Deschampsia caespitosa*, *Festuca rubra* and *Poa trivialis.* In the group of accompanying species *Helianthus tuberosus* and another neophyte *Conyza canadensis* were recorded. The second group of relevés (6 and 7) in Table 4, describe species poor phytocoenoses with only 10 and 11 vascular plant species respectively. Wet and fresh habitat species were present only in the second group of patches and included *Phragmites australis*, *Polygonum lapathifolium* ssp. *lapathifolium*, *Arctium minus*, *Solidago gigantea*, *Dactylis glomerata* and *Stachys palustris.*

In almost all patches described in Table 5 *Elymus repens* is the dominant. It most often covers about 50% of the analysed patches. Besides *Elymus repens* in all the patches *Solidago canadensis*, *S. gigantea* as well as *Cirsium arvense* (from the *Artemisietea vulgaris* class) were also present. Because of the number of species and the co-dominant species, two groups of patches can be distinguished. Samples 1-4 are constituted of 19-28 species and the co-dominant species are: *Aster novi-belgii*, *Helianthus tuberosus* and *Vicia sepium.* The phytocoenoses described in relevé 5-6 are poorer. Apart from the dominant *Elymus repens* and co-dominants *Solidago canadensis*, *S. gigantea*, two other species, *Dactylis glomerata* and *Urtica dioica*, are present in those patches. The most species rich patch is composed of 13 meadow (*Molinio-Arrhenatheretae* class) species. Besides *Solidago* species, three other neophyte species were recorded in table 5: *Aster novi-belgii*, *A. x salignus* and *Helianthus tuberosus*.

The distinctive feature of *Solidago canadensis* dominated phytocoenoses presented in Table 6 (*Solidago canadensis* up to 75%) is the high number of species recorded in the analysed patches. The number of species, 17 and 18, respectively for the *Artemisietea vulgaris* and *Molinio-*

Arrhenatheretea class, was recorded in the patches. Apart from the dominants and *Calamagrostis epigejos*, *Rubus caesius*, *Cirsium vulgare* and *Sonchus arvensis*, none of the 48 species listed in Table 6 covered up to 25% of the patch area. The *Convolvuletalia sepium* order is represented by *Solidago canadensis*, *S. gigantea*, *Eupatorium cannabinum*, *Saponaria officinalis* and *Calystegia sepium.*

Table 7 presents phytocoenoses dominated by one of the *Solidago* species – *S. gigantea* (there are more than 5 species per patch). In those patches the number of meadow species is remarkably lower (only 3) comparing with the number of *Artemisietea vulgaris* class species (9). Among the listed accompanying species only *Calamagrostis epigejos*, ash tree seedlings *Fraxinus excelsior* and *Arrhenatherum elatius* covered up to 25% of the patch area. Two samples were dominated only by *Solidago gigantea* (relevé 8, 10), while in five samples the abundantly growing *Solidago canadensis* was only accompanied by *Solidago gigantea.*

Table 8 represents the most species poor phytocoenoses (there are less than 5 species per patch). In this table all together only 9 species were listed. The samples are covered in 100% but this is almost exclusively by both *Solidago* species. From the *Convolvuletalia sepium* order *Eupatorium cannabinum* was recorded in only one sample. The meadow species are represented only by *Elymus repens.* The most frequent accompanying species is *Calamagrostis epigejos*.

DISCUSSION

In ruderal habitats *Solidago* species are frequently and abundantly recorded. The vegetation types with *Solidago* species presence were classified to *Artemisio-Tanacetetum vulgaris*, *Dauco-Picridetum hieracioidis*, *Echio-Melilotetum* association and communities with *Calamagrostis epigejos* and *Elymus repens* as well as three *Solidago canadensis* dominated plant communities.

The first three associations represent the *Dauco-Melilotenion* suballiance and *Onopordetalia acanthii* order. *Onopordetalia acanthii* order represents thermophilous tall perennial plant species resistant to drought. The presence of *Solidago canadensis* and *S. gigantea – Convolvuletalia sepium* order species, characterised as growing in natural nitrophilous communities typical on hydrophilous habitats of rivers banks subjects of occasional flooding, in *Onopordetalia acanthii* order communities, should from theoretical point of view, be a surprise. Field observation and the presented results provide evidence that *Solidago canadensis* particularly, as well as *Solidago gigantea* presence in some of these community patches (*Artemisio-Tanacetetum vulgaris*, *Dauco-Picridetum hieracioidis*, *Echio-Melilotetum* association) was abundant. The participation of *Solidago* species in the three last listed association was varied. The frequency was the highest in all those assemblages: V constancy class for *Solidago canadensis* and IV-III constancy class for *Solidago gigantea. Solidago canadensis* and *Solidago gigantea* are the most abundant in *Artemisio-Tanacetetum vulgaris* association patches, less abundant in *Dauco-Picridetum hieracioidis* and cover most often up to 5% of the *Echio-Melilotetum* association patches area. This part of the obtained result show that the *Solidago* species are able to survive on dry thermophilous habitats as many *Dauco-Melilotenion* species do.

The *Calamagrostis epigejos* and *Elymus repens* communities represent different syntaxonomical situation. It is difficult to present the syntaxonomical position of the *Calamagrostis epigejos* and *Elymus repens* community patches. Nevertheless, vegetation with abundant *Calamagrostis epigejos* participation on ruderal sites is very common. In many of them *Solidago canadensis* (less frequent *S. gigantea*) is present as a co-dominant species. The accompanying species are mostly a set of cosmopolitic species, which according to MATUSZKIEWICZ (2001)

represent the *Molinio-Arrhernatheretea* and *Artemisietea vulgaris* class. Such situation is particular common, when open ruderal habitats are vegetated e.g. post industrial sites (WOŹNIAK 2005). The *Calamagrostis-Solidago* vegetation represents the last stage of herb layer development before the shrubs grow higher then the herbs. *Calamagrostis epigejos* community patches develop in varied habitats (wet, dry acidic, base rich, fine and coarse grained).

Elymus repens community are less common (than *C. epigejos*) on ruderal sites and uncommon on post-industrial ones. The accompanying species represent the same ruderal meadow species mixture as this described by the *Calamagrostis* dominated vegetation.

The presence of *Solidago canadensis* and/or *S. gigantea* dominated vegetation patches became particularly common in the last decades. It is strongly connected with the abandonment of agricultural lands and meadows. There are many sites were the abundance of *Solidago* is increasing. Tables 6-8 show the changes in species composition along with the development of *Solidago* species population. This *Solidago* phenomenon is rather omitted in vegetation studies.

In terms of *Solidago canadensis* and *S. gigantea* participation in vegetation samples from post-industrial sites 23 papers were analysed. The results of the analyses are summarised in Table 9. *Solidago canadensis* and *S. gigantea* were recorded only on few sites (CABAŁA, JARZĄBEK 1999; KUCZYŃSKA et al. 1984; WIKA, SENDEK 1993; WOŹNIAK 2003; KOMPAŁA et al. 2004). It is remarkable that in none of the old papers which report post-industrial vegetation studies (DOBRZAŃSKA 1955; SAROSIEK 1957; WILKOŃ-MICHALSKA, SOKÓŁ 1968; BOJARCZUK, KLUCZYŃSKI 1972; GOŁDYN 1972; FURDYNA 1974) *Solidago* species are mentioned.

CONCLUSIONS

Solidago canadensis and *S. gigantea* are frequently and sometimes also abundantly present in vegetation on ruderal sites. Most of the sites where very far from river embankments (so the vegetation do not represent the *Convolvuletalia sepium* order).

The obtained results show that the analysed *Solidago* species are able to survive and develop in dry thermophilous habitats as many *Dauco-Melilotenion* species do.

The occurrence of *Solidago canadensis* and/or *S. gigantea* in such communities like: *Artemisio-Tanacetetum (Tanaceteto-Artemisietum vulgaris)*, *Dauco-Picridetum hieracioidis*, *Echio-Melilotetum (Melilotetum albo-officinalis)* and *Calamagrostis epigejos* was recorded also by other authors.

The wide spectrum of different vegetation types in which *Solidago canadensis* and/or *S. gigantea* occur suggests that they diagnostic importance of *Solidago canadensis* and *S. gigantea* in the *Convolvuletalia sepium* order should be revised.

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Table 1. *Artemisio-Tanacetetum vulgaris* (Br.-Bl. 1931 corr. 1949)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	CONSTANCY
Number of relevé in the field	27	141	140	143	142	99	110	111	112	7	73	
Date day	18	19	19	19	19	29	29	29	29	7	26	
Date month	08	10	10	10	10	09	09	09	09	08	08	
Date year	01	01	01	01	01	01	01	01	01	01	01	
Cover of the herb layer in %	100	85	85	100	100	75	95	90	95	65	65	
Area of relevé in m²	20	25	25	20	20	20	25	25	25	25	20	
Inclination in °	-	-	-	-	-	-	-	-	-	-	-	
Number of species in the relevé	18	12	12	15	15	28	17	18	18	34	15	
I. Ch. *Artemisio-Tanacetetum* °+ Ch. *Artemisietea vulgaris*												
Artemisia vulgaris °	2.2	+	+	+	2.2	+	1.1	1.2	+	2.2	+	V
Tanacetum vulgare °	2.2	1.1	1.1	2.2	2.2	+	2.2	2.2	1.2	2.2	+	V
Solidago canadensis	3.2	2.2	2.2	3.3	3.3	3.3	2.2	2.2	2.2	2.3	2.3	V
Solidago gigantea	.	1.2	1.1	2.3	3.3	.	2.2	2.1	1.2	2.3	.	IV
Cirsium vulgare	r	r	.	r	.	+	r	+	.	r	2.2	IV
Cirsium arvense	1.1	+	+	+	+	+	.	.	.	1.1	1.1	IV
Eupatorium cannabinum	.	.	.	2.2	+	1.1	1.2	2.2	2.2	.	+	IV
Picris hieracioides	.	.	.	1.1	1.1	.	r	+	+	r	r	IV
Melandrium album	.	.	.	.	.	.	r	+	r	r	r	III
Melilotus alba	.	1.2	1.1	1.1	1.1	2.2	.	.	.	.	.	III
Aster novi-belgii	.	.	.	2.2	2.3	1.1	.	.	.	.	.	II
Oenothera biennis	.	.	.	.	.	.	1.1	1.1	+	.	.	II
II. Ch. *Molinio-Arrhenatheretea*												
Achillea millefolium	1.1	+	+	+	+	+	+	+	+	2.1	.	V
Vicia cracca	.	.	.	1.2	+	.	+	+	+	+	.	III
Elymus repens	4.3	.	.	.	.	+	.	.	.	1.1	2.2	II
Plantago lanceolata	2.2	.	.	.	.	r	+	+	+	+	.	III
Agrostis stolonifera	2.2	.	+	.	.	+	.	.	.	+.2	+	III
III. Accompanying species												
Calamagrostis epigejos	.	5.5	5.5	4.4	4.4	1.1	4.4	4.4	4.4	+	.	V
Hieracium sabaudum	.	.	.	+	+	.	+	+	+	.	.	III
Tussilago farfara	.	.	.	1.1	1.1	r	.	.	.	+	.	II
Hypericum perforatum	.	.	.	.	.	+	+	r	1.2	.	.	II
Lathyrus tuberosus	.	.	.	.	.	.	+.2	+.2	1.2	+	.	II
Medicago sativa	.	.	.	.	.	.	.	+	+	.	r	II
Odontites verna ssp. *verna*	.	+	+	.	.	+	.	.	.	r	.	II

Sporadic species:

I: *Epilobium adnatum* 1 (r), 10 (+); *Linaria vulgaris* ° 7 (+), 11 (1.1); *Arctium lappa* 1 (+); *Chareophyllum aromaticum* 6 (+); *Erigeron ramosus* 6 (+); *Galium aparine* 1 (r); *Torilis japonica* 1 (r); *Tragopogon dubius* 6 (r); *Verbascum densiflorum* 1 (r);

II: *Crepis biennis* 6 (r), 10 (r); *Daucus carota* 1 (1.2), 6 (+); *Pastinaca sativa* 1 (+), 11 (r); *Stachys palustris* 9 (r), 10 (r); *Taraxacum officinale* 6 (1.1), 10 (+); *Trifolium pratense* 1 (+), 6 (+); *Agrostis gigantea* 10 (+.2); *Carex hirta* 6 (+); *Holcus lanatus* 6 (1.2); *Lathyrus pratensis* 11 (+); *Lysimachia vulgaris* 7 (1.2); *Cerastium holosteoides* 1 (+); *Centaurea jacea* 10 (r); *Dactylis glomerata* 6 (1.2); *Galium mollugo* 10 (+.2); *Lotus corniculatus* 10 (r); *Ranunculus repens* 11 (2.2); *Trifolium repens* 10 (2.3);

III: *Lycopus europeus* 2 (+), 3 (+); *Poa compressa* 5 (+); 6 (1.2); *Salix viminalis* 2 (1.1), 3 (1.1); *Acer*

Table 1. (continued)

pseudoplatanus 10 (r); *Conyza canadensis* 10 (1.1); *Epilobium ciliatum* 9 (1.1); *Equisetum arvense* 6 (1.1); *Matricaria inodora* ssp. *inodora* 10 (1.1); *Medicago lupulina* 10 (+); *Mentha arvensis* 11 (+); *Phleum pratense* 10 (+.2); *Plantago major* 10 (+); *Poa annua* 6 (2.2); *Populus canescens* 10 (r); *Trifolium hybridum* 10 (+).

Table 2. *Dauco-Picridetum hieracioidis* (Fab. 1933) Görs 1966

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	C
Number of relevé in the field	137	117	116	115	129	130	82	40	41	42	43	O
Date day	19	29	29	29	10	10	27	19	19	19	19	N
Date month	10	09	09	09	10	10	09	08	08	08	08	S
Date year	01	01	01	01	01	01	01	01	01	01	01	T
Cover of the herb layer in %	60	50	40	50	55	95	95	40	45	30	35	A
Area of relevé in m ^{2}	20	25	25	25	16	16	100	20	20	16	16	N
Inclination in $^\circ$	-	-	-	-	-	-	-	-	-	-	-	C
Number of species in the relevé	22	24	25	24	21	20	31	22	22	21	18	Y
I. D. Ass. *Dauco-Picridetum* · Ch. *Artemisietea vulgaris*												
Daucus carota ·	+	+	r	+	+	+	1.1	2.1	2.1	2.1	2.1	V
Picris hieracioides ·	+	1.1	1.1	1.1	+	+	+	+	+	r	r	V
Echium vulgare ·	1.2	2.1	1.2	1.1	.	.	+	+	+	.	r	IV
Oenothera biennis ·	+	.	.	.	+	.	.	1.1	1.1	1.1	1.1	III
Melilotus alba ·	+	r	+	+	3.3	3.3	r	.	.	.	.	IV
Solidago canadensis	2.2	2.2	2.2	2.2	2.2	3.2	+	2.1	1.1	+	1.1	V
Artemisia vulgaris	1.1	+	1.1	+	r	+	r	r	r	r	.	V
Cirsium arvense	+	r	r	+	r	+	r	.	.	.	.	IV
Solidago gigantea	1.2	+	r	+	1.1	.	.	.	.	.	.	III
Reseda lutea	.	.	.	.	.	.	1.2	r	r	r	.	II
II. Ch. *Molinio-Arrhenatheretea*												
Pastinaca sativa	.	+	r	+	+	+	+	r	+	+	1.1	V
Arrhenatherum elatius	.	1.1	1.1	1.1	.	+	+	2.2	2.2	1.2	+	V
Achillea millefolium	+	+	+	2.2	1.1	1.1	+	.	.	.	.	IV
Taraxacum officinale	2.2	1.2	1.2	1.2	+	+	.	.	.	.	.	III
Plantago lanceolata	+	+	r	+	.	.	1.1	.	.	.		III
Trifolium pratense	+	+	+	+	+	+	.	.	.	.	.	III
Agrostis gigantea	.	.	.	.	+	1.2	+	.	1.1	+	+	III
Dactylis glomerata	+.2	.	.	.	1.2	1.2	.	.	.	.	.	II
Vicia cracca	r	.	.	.	+	+	.	.	.	.	.	II
Elymus repens	+	+	+	+	.	.	.	.	.	.	.	II
Rumex acetosa	.	r	r	r	.	.	.	.	.	.	.	II
Cerastium holosteoides	.	+	+	+	.	.	.	.	.	.	.	II
III. Accompanying species												
Medicago lupulina	r	+	+	+	1.2	1.2	+	r	r	r	.	V
Calamagrostis epigejos	2.2	.	.	.	2.3	2.2	1.1	1.2	1.2	+	+	IV
Poa compressa	1.2	.	.	.	+.2	+.2	+	1.2	1.2	1.2	+.2	IV

Table 2. (continued)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	
Verbascum thapsus	r	.	.	.	.	.	.	r	r	+	r	III
Chamaenerion palustre	.	.	.	.	.	.	.	2.2	2.2	2.2	1.2	II
Acer negundo	.	.	.	.	.	.	.	.	r	r	r	II
Cardaminopsis arenosa	.	.	.	.	.	.	.	.	r	+	r	II
Senecio viscosus	.	.	.	.	.	.	.	.	r	+	+	II
Lactuca serriola	.	.	.	.	.	.	.	r	r	r	+	II
Hieracium sabaudum	.	.	.	.	.	+	.	r	r	.	.	II
Odontites verna ssp. *verna*	.	.	+	+	+	+	.	.	.	.	.	II
Equisetum arvense	.	+	r	r	.	.	.	.	.	.	.	II
Festuca ovina	.	3.2	2.2	3.2	.	.	.	.	.	.	.	II
Tussilago farfara	.	2.2	2.2	2.2	.	.	+	.	.	+	.	III
Trifolium arvense	.	2.2	2.2	2.2	.	.	r	.	.	.	+	III
Silene vulgaris	.	+	+	.	.	.	+	.	.	.	.	II

Sporadic species:
I: *Cichorium intybus* ˙ 7 (r); *Cirsium vulgare* 1 (r); *Linaria vulgaris* 8 (r); *Urtica dioica* 8 (r); *Melandrium album* 7 (r); *Melilotus officinalis* ˙ 4 (+); *Tanacetum vulgare* 7 (+);
II: *Centaurea jacea* 5 (+), 7 (+); *Crepis biennis* 5 (+), 6 (+); *Poa trivialis* 8 (+); *Deschampsia caespitosa* 8 (+); *Festuca rubra* 7 (5.5); *Leontodon autumnalis* 1 (+);
III: *Chaenorhinum minus* 8 (+), 9 (r); *Epilobium ciliatum* 10 (+), 11 (r); *Hieracium piloselloides* 8 (r), 9 (+); *Rumex acetosella* 2 (+), 3 (+); *Betula pendula* 7 b (1.2); *Corynephorus canescens* 10 (+); *Hypericum perforatum* 7 (+); *Populus tremula* 7 b (1.2); *Populus nigra* 7 b (1.1); *Salix alba* 7 b (1.2); *Salix caprea* 7 b (1.2); *Salix purpurea* 7 b (1.2).

Table 3. *Echio-Melilotetum* R. Tx. 1947

Number of relevé in the table	1	2	3	4	5	6	7	CONSTANCY
Number of relevé in the field	134	133	132	88	102	97	98	
Date day	10	10	10	20	29	21	21	
Date month	10	10	10	09	09	09	09	
Date year	01	01	01	01	01	01	01	
Cover of the herb layer in %	55	50	50	90	100	100	100	
Area of relevé in m^2	20	20	20	20	25	25	25	
Inclination in °	-	-	-	40	-	-	-	
Number of species in the relevé	20	22	21	23	22	21	22	
I. Ch. Ass. *Echio-Melilotetum* °+ D. Ass. *Echio-Melilotetum* * + Ch. *Artemisietea vulgaris*								
Melilotus alba °	2.2	2.2	2.2	3.3	4.4	4.4	4.4	V
Daucus carota *	+	+	+	.	r	+	+	V
Solidago canadensis	+	+	+	.	+.2	+	+	V
Echium vulgare *	1.1	+	+	1.1	r	.	.	IV
Picris hieracioides *	+	1.1	1.1	.	1.2	.	.	III
Oenothera biennis *	+	1.1	+	r	.	.	.	III
Cirsium arvense	.	.	.	2.1	+	r	+	III
Solidago gigantea	.	.	.	2.2	.	+	1.2	III

Table 3. (continued)

Number of relevé in the table	1	2	3	4	5	6	7	
Tanacetum vulgare	.	.	.	r	.	r	r	III
Eupatorium cannabinum	.	.	.	.	.	r	r	II
Artemisia vulgaris	.	.	.	+	+	.	.	II
Melandrium album	.	.	.	r	r	.	.	II
II. Ch. *Molinio-Arrhenatheretea*								
Achillea millefolium	1.1	1.1	1.2	+	2.2	+	+	V
Plantago lanceolata	+	+	1.1	.	1.1	+	+	V
Dactylis glomerata	1.2	+.2	+.2	.	.	+	+	IV
Deschampsia caespitosa	2.2	2.2	2.2	.	+.2	.	.	III
Centaurea jacea	1.1	1.1	1.1	.	.	.	.	III
Cerastium holosteoides	+	+	+	.	.	.	.	III
Arrhenatherum elatius	.	.	.	1.2	1.2	1.2	1.2	III
Festuca rubra	.	.	.	4.4	3.3	3.3	2.3	III
Taraxacum officinale	.	r	.	+	.	+	+	III
Agrostis gigantea	.	.	.	.	.	1.1	+	II
Ranunculus repens	.	.	.	.	.	+	+	II
Holcus lanatus	.	.	.	.	.	+.2	+.2	II
Pastinaca sativa	.	.	.	.	.	+	r	II
Trifolium repens	.	.	.	.	1.2	.	+	II
III. Accompanying species								
Calamagrostis epigejos	2.2	2.2	2.2	2.3	2.2	1.2	1.2	V
Tussilago farfara	+	+	+	.	.	1.1	+	IV
Poa compressa	+.2	+	+.2	+.2	.	.	.	III
Odontites serotina	+	1.1	+	.	+	.	.	III
Silene vulgaris	1.2	+	+	.	.	.	.	III
Hieracium sabaudum	+	+	r	.	.	.	.	III
Hieracium piloselloides	+	+	+	.	.	.	.	III
Festuca ovina	1.2	1.2	+.2	.	.	.	.	III
Betula pendula	.	r	+	.	.	.	.	II
Medicago lupulina	.	.	.	.	1.2	+	+	III
Plantago major	.	.	.	.	.	+	+	II

Sporadic species:
I: *Berteroa incana* 4 (+); *Cirsium vulgare* 4 (r); *Erigeron ramosus* 4 (r); *Fallopia dumetorum* 4 (+); *Reseda lutea* 4 (r);
II: *Elymus repens* 4 (1.2); *Rumex acetosa* 5 (r); *Trifolium pratense* 5 (1.1); *Vicia cracca* 5 (+);
III: *Conyza canadensis* 4 (+); *Fallopia convolvulus* 4 (+); *Sonchus oleraceus* 4 (r); *Trifolium arvense* 5 (+); *Viola arvensis* 4 (r).

Table 4. Community with *Calamagrostis epigejos*

Number of relevé in the table	1	2	3	4	5	6	7	C
Number of relevé in the field	85	86	87	89	101	138	139	O
Date day	15	15	15	20	29	19	19	N
Date month	09	09	09	08	09	10	10	S
Date year	01	01	01	01	01	01	01	T
Cover of the herb layer in %	95	95	95	85	100	100	100	A
Area of relevé in m^2	16	16	16	20	25	20	20	N
Inclination in °	-	-	-	40	-	-	-	C
Number of species in the relevé	15	17	16	21	20	10	11	Y
Calamagrostis epigejos	**5.5**	**5.5**	**5.5**	**4.4**	**4.5**	**4.5**	**4.5**	**V**
I. Ch. *Artemisietea vulgaris*								
Solidago canadensis	**1.1**	**1.1**	**1.1**	**2.2**	**+**	**1.2**	**1.2**	**V**
Cirsium arvense	1.1	1.1	1.1	+	+	1.1	1.1	V
Oenothera biennis	r	r	.	+	.	r	+	IV
Artemisia vulgaris	r	+	r	1.1	2.2	.	.	IV
Melandrium album	.	r	r	r	r	.	.	III
Calystegia sepium	r	r	+	.	.	.	.	II
Tanacetum vulgare	.	.	.	r	+	.	.	II
Arctium minus	.	.	.	.	.	r	r	II
Solidago gigantea	.	.	.	.	.	1.2	1.1	II
II. Ch. *Molinio-Arrhenatheretea*								
Achillea millefolium	+	1.1	1.1	r	1.1	.	.	IV
Daucus carota	+	r	+.2	2.2	.	.	.	III
Deschampsia caespitosa	+.2	+	+	.	.	.	.	III
Festuca rubra	1.2	1.2	2.1	.	r	.	.	III
Poa trivialis	+	+	+	.	.	.	.	III
Dactylis glomerata	.	.	.	.	+	1.2	1.2	III
Stachys palustris	.	.	.	.	.	1.1	1.1	II
III. Accompanying species								
Poa compressa	.	+	+	.	+	.	.	III
Hieracium sabaudum	+	1.1	1.1	.	.	.	.	III
Hypericum perforatum	1.2	+.2	+.2	.	.	.	.	III
Helianthus tuberosus	1.1	+	+	.	.	.	.	III
Tussilago farfara	.	+	1.1	.	.	.	.	II
Conyza canadensis	.	.	.	+	r	.	.	II
Phragmites australis	.	.	.	.	.	2.3	2.2	II
Polygonum lapathifolium	.	.	.	.	.	+	+	II
ssp. *lapathifolium*								

Sporadic species:
I: *Arctium lappa* 7 (+); *Fallopia dumetorum* 4 (r);
II: *Arrhenatherum elatius* 4 (1.2); *Elymus repens* 4 (1.1); *Plantago lanceolata* 5 (+); *Taraxacum officinale* 4 (+); *Trifolium pratense* 5 (1.2); *Vicia cracca* 5 (r);
III: *Aegopodium podagraria* 1(+); *Convolvulus arvensis* 4 (+); *Fallopia convolvulus* 4 (+); *Lactuca serriola* 4 (r); *Medicago lupulina* 5 (+); *Odontites verna* ssp. *verna* 5 (+); *Pimpinella saxifraga* 4 (+); *Silene vulgaris* 4 (1.1); *Sonchus oleraceus* 4 (+); *Trifolium hybridum* 5 (1.2).

Table 5. Community with *Elymus repens*

Number of relevé in the table	1	2	3	4	5	6	C
Number of relevé in the field	126	127	128	100	33	34	O
Date day	9	9	9	29	18	18	N
Date month	10	10	10	09	08	08	S
Date year	01	01	01	01	01	01	T
Cover of the herb layer in %	95	95	95	75	100	100	A
Area of relevé in m^2	20	16	16	20	16	16	N
Inclination in °	-	45	45		-	-	C
Number of species in the relevé	19	21	19	28	6	8	Y
Elymus repens	**2.3**	**3.3**	**2.3**	**2.2**	**5.4**	**4.5**	**V**
I. Ch. *Molinio-Arrhenatheretea*							
Arrhenatherum elatius	+	1.2	1.2	+	.	.	IV
Vicia cracca	+	+.2	+	+	.	.	IV
Achillea millefolium	+	+	+	.	.	.	III
Agrostis gigantea	1.2	1.2	1.1	.	.	.	III
Dactylis glomerata	.	.	.	.	1.2	1.2	II
II. Ch. *Artemisietea vulgaris*							
Solidago canadensis	**1.1**	**+**	**1.1**	**3.2**	**2.2**	**3.3**	**V**
Solidago gigantea	**+**	**+**	**+**	**.**	**1.2**	**1.1**	**V**
Cirsium arvense	+	+	+	+	1.2	1.1	V
Artemisia vulgaris	+	+	+	+	.	.	IV
Aster novi-belgii	3.2	3.2	3.3	1.2	.	.	IV
Cirsium vulgare	+	r	r	r	.	.	IV
Oenothera biennis	+	+	+	+	.	.	IV
Tanacetum vulgare	.	r	+	+	.	.	III
Urtica dioica	.	.	.	.	+	2.2	II
III. Accompanying species							
Calamagrostis epigejos	+	+	+	+.1	.	.	IV
Aster x salignus	+	+.2	+	.	.	.	III
Helianthus tuberosus	4.3	3.3	3.3	.	.	.	III
Lathyrus tuberosus	1.2	+	1.2	.	.	.	III
Mentha arvensis	+	+	+	.	.	.	III
Vicia sepium	1.2	3.3	3.3	.	.	.	III

Sporadic species:
I: *Agrostis stolonifera* 4 (+); *Carex hirta* 4 (+); *Crepis biennis* 4 (+); *Daucus carota* 4 (r); *Holcus lanatus* 4 (1.2); *Lathyrus pratensis* 2 (1.2); *Lysimachia vulgaris* 4 (+); *Pastinaca sativa* 4 (r); *Plantago lanceolata* 4 (+); *Rumex acetosa* 4 (+);
II: *Chaerophyllum aromaticum* 4 (+); *Galium aparine* 6 (+); *Melilotus alba* 4 (2.2); *Verbascum densiflorum* 6 (r);
III: *Equisetum arvense* 4 (1.2); *Hypericum perforatum* 4 (+); *Poa annua* 4 (2.2); *Poa compressa* 4 (1.2); *Tussillago farfara* 4 (r); *Verbascum thapsus* 1 (r).

Table 6. Community with *Solidago canadensis* (*Solidago canadensis* up to 75%)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	C
Number of relevé in the field	24	23	22	72	92	11	12	60	78	79	29	O
Date day	15	15	15	26	21	11	11	24	27	27	18	N
Date month	08	08	08	08	09	08	08	08	08	08	08	S
Date year	01	01	01	01	01	01	01	01	01	01	01	T
Cover of the herb layer in %	100	95	100	80	100	100	100	100	100	100	100	A
Area of relevé in m^2	16	16	15	20	16	12	12	20	20	20	20	N
Inclination in °	40	40	40	-	-	-	-	-	-	-	-	C
Number of species in the relevé	18	19	19	15	12	17	17	7	10	10	5	Y
I. Ch. *Artemisietea vulgaris* + Ch. *Galio-Urticenea**												
Solidago canadensis*	**4.4**	**4.4**	**4.4**	**3.3**	**4.5**	**4.5**	**4.5**	**4.5**	**1.2**	**2.2**	**4.5**	**V**
Solidago gigantea*	**.**	**.**	**.**	**.**	**2.2**	**+**	**2.1**	**.**	**3.4**	**3.3**	**2.2**	**III**
Artemisia vulgaris	+	+	+	1.1	1.2	1.1	r	1.1	+	+	.	V
Cirsium arvense	+	1.1	.	1.1	+	r	r	1.1	1.1	r	1.1	V
Urtica dioica	.	.	.	.	+	.	.	.	1.1	1.1	+	II
*Eupatorium cannabinum**	.	.	.	+	+	r	+	.	.	.	.	II
Melandrium album	r	+	r	r	.	.	.	.	.	.	.	II
*Aster novi-belgii**	+	+	r	.	.	.	.	.	.	.	.	II
II. Ch. *Molinio-Arrhenatheretea*												
Achillea milefolium	+	+	r	.	.	+	+	.	r	+	.	IV
Daucus carota	+	+	+	.	+	+	+	.	.	.	.	III
Pastinaca sativa	r	r	+	.	.	+	r	.	.	.	.	III
Taraxacum officinalis	+	+	+	.	.	+	r	.	.	.	.	III
Elymus repens	+	+	1.1	.	.	.	.	.	.	.	+	II
Arrhenatherum elatius	1.2	1.2	+	.	.	.	.	.	.	.	.	II
Poa trivialis	+	+	1.1	.	.	.	.	.	.	.	.	II
Vicia cracca	1.2	+	1.2	.	.	.	.	.	.	.	.	II
III. Accompanying species												
Calamagrostis epigejos	2.1	2.1	2.1	.	1.2	2.3	2.3	2.2	3.3	2.2	.	V
Convolvulus arvensis	1.1	1.1	2.1	.	.	.	.	.	.	.	.	II
Hieracium sabaudum	1.1	+	2.1	.	.	.	.	.	.	.	.	II
Rubus caesius	2.2	2.2	2.2	.	.	.	.	.	.	.	.	II
Hypericum perforatum	1.1	.	1.1	.	.	.	.	.	.	r	.	II
Equisetum arvense	.	.	.	.	.	.	.	+	+	+	.	II

Sporadic species:

I: *Oenothera biennis* 2 (r), 3 (+); *Saponaria officinalis** 6 (+), 7 (+); *Torilis japonica** 9 (+), 10 (r); *Verbascum densiflorum* 3 (r), 6 (r); *Arctium lappa* 5 (r); *Calystegia sepium** 7 (1.1); *Cirsium vulgare* 4 (2.3); *Picris hieracioides* 4 (r); *Reseda lutea* 9 (r);

II: *Agrostis gigantea* 6 (+), 7 (+); *Dactylis glomerata* 6 (+.2), 7 (+.2); *Poa palustris* 6 (+), 7 (+); *Agrostis stolonifera* 4 (+); *Carex hirta* 4 (1.2); *Centaurea oxylepis* 2 (r); *Deschampsia caespitosa* 5 (+.2); *Lathyrus pratensis* 4 (1.1); *Ranunculus repens* 4 (+); *Stachys palustris* 4 (+);

III: *Medicago lupulina* 6 (+), 7 (+); *Odontites serotina* 6 (+), 7 (+); *Aegopodium podagraria* 5 (+); *Epilobium adenocaulon* 4 (+); *Lathyrus tuberosus* 8 (r); *Mentha arvensis* 4 (+); *Pimpinella saxifraga* 5 (r); *Polygonum lapathifolium* ssp. *lapathifolium* 8 (r); *Sonchus arvensis* 4 (2.2).

Table 7. Community dominated by *Solidago canadensis* and/or *S. gigantea* (there are more than 5 species per patch)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	C
Number of relevé in the field	28	59	105	106	81	46	50	48	49	47	45	O
Date day	18	24	29	29	27	23	23	23	23	23	2^3	N
Date month	08	08	09	09	08	08	08	08	08	08	08	S
Date year	01	01	01	01	01	01	01	01	01	01	01	T
Cover of the herb layer in %	100	100	95	95	100	100	100	100	100	100	100	A
Area of relevé in m^2	25	20	25	25	20	20	25	20	20	20	20	N
Inclination in °	-	-	-	-	-	-	-	-	-	-	-	C
Number of species in the relevé	6	6	7	7	10	8	8	7	8	6	7	Y
I. Ch. *Artemisietea vulgaris* + Ch. *Galio-Urticenea**												
Solidago canadensis*	**5.5**	**5.5**	**5.5**	**5.5**	**5.5**	**5.5**	**5.5**	**.**	**5.5**	**.**	**5.5**	**V**
Solidago gigantea*	**+**	**.**	**2.2**	**2.2**	**1.1**	**.**	**2.1**	**5.5**	**1.1**	**5.5**	**.**	**IV**
Urtica dioica	1.1	.	.	.	+	r	+	r	+	.	+	IV
Cirsium arvense	+	+	+	+	+	.	.	.	.	.	.	III
Artemisia vulgaris	.	.	+	1.1	1.1	.	.	.	.	.	.	II
*Eupatorium cannabinum**	.	.	.	.	1.1	+	1.1	r	.	.	.	II
II. Accompanying species												
Equisetum arvense	+	r	.	.	+	+	+	+	+	1.1	1.1	V
Calamagrostis epigejos	.	2.2	.	.	1.2	+	.	1.1	+	1.1	+	IV
Acer pseudoplatanus	.	.	.	.	.	1.1	r	r	r	1.1	1.1	III
Fraxinus excelsior	.	.	.	.	.	.	r	.	1.1	2.1	1.1	II
Aegopodium podagraria	.	.	.	.	.	1.1	.	1.1	.	+	1.1	II
Betula pendula	.	.	.	.	.	1.1	1.1	.	1.1	.	.	II

Sporadic species:
I: *Oenothera biennis* 3 (+), 4 (r); *Picris hieracioides* 3 (r), 4 (r); *Torilis japonica** 5 (+);
II: *Lathyrus tuberosus* 2 (r); *Polygonum lapathifolium ssp. lapathifolium* 2 (r);
Species from the *Molinio-Arrhenatheretea*: *Arrhenatherum elatius* 3 (1.1), 4 (2.1); *Achillea milefolium* 5 (+); *Elymus repens* 1 (r).

Table 8. Community dominated by *Solidago canadensis* and/or *S. gigantea* (there are 5 and less species per patch)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	C
Number of relevé in the field	54	53	30	57	58	113	114	51	52	55	56	O
Date day	24	24	18	24	24	29	29	24	24	24	24	N
Date month	08	08	08	08	08	09	09	08	08	08	08	S
Date year	01	01	01	01	01	01	01	01	01	01	01	T
Cover of the herb layer in %	100	100	100	100	100	100	100	100	100	100	100	A
Area of relevé in m^2	15	16	15	16	20	25	25	15	16	15	20	N
Inclination in °	-	-	-	-	-	-	-	-	-	-	-	C
Number of species in the relevé	1	1	4	4	5	4	4	2	2	2	5	Y
I. Ch. *Artemisietea vulgaris* + Ch. *Galio-Urticenea**												
Solidago canadensis*	**5.5**	**5.5**	**5.5**	**5.5**	**5.5**	**+**	**1.1**	**5.5**	**5.5**	**5.5**	**5.5**	**V**
Solidago gigantea*	**.**	**.**	**.**	**.**	**.**	**5.5**	**5.5**	**+**	**1.1**	**+**	**1.2**	**III**
Cirsium arvense	.	.	+	r	+	r	r	.	.	.	.	II
II. Accompanying species												
Calamagrostis epigejos	.	.	.	+	1.1	+	+	.	.	.	+	III

Sporadic species:
I: *Eupatorium cannabinum** 11(+); *Urtica dioica* 3 (1.1); *Melandrium album* 5 (r);
II: *Polygonum lapathifolium* ssp. *lapathifolium* 4 (r), 5 (r);
Species from the *Molinio-Arrhenatheretea*: *Elymus repens* 3 (+).

Table 9. *Solidago canadensis* and *S. gigantea* participation in vegetation samples from post-industrial sites

Name of the analysed vegetation assemblages and communities	Number of analysed paper									
	5		10		13		20		22	
	Participation of species [in %]									
	S.g.	*S.c.*	*S.g.*	*S.c.*	*S.g.*	*S.c.*	*S.g.*	*S.c.*	*S.g.*	*S.c.*
Calamagrostis epigejos	100		80	40						
Agrostis capillaris – Conyza canadensis	100									
Senecioni-Tussilaginetum	40				30					
Tanaceto-Artemisietum vulgaris (Artemisio-Tanacetetum)	100				70					
Deschampsia flexuosa			25	75						
Betula pendula					30					
Calluna vulgaris					50					
Chaenorhinum minus – Salsola kali	25									
Chenopodietum glauco-rubri	30									
Corispermum intermedium	50									
Dauco-Picridetum hieracioidis			45	65						
Diplotaxis muralis										25
Medicago sativa	60									
Melilotetum albo-officinalis (Echio-Melilotetum)				50						
Myricaria germanica– –Epilobium dodonaei							10			
Poa compressa					45					

Table 9. (continued)

Name of the analysed vegetation assemblages and communities	5		10		13		20		22	
	S.g.	*S.c.*	*S.g.*	*S.c.*	*S.g.*	*S.c.*	*S.g.*	*S.c.*	*S.g.*	*S.c.*
Poa nemoralis					20					
Urtica dioica					25					
Solidago gigantea			100	100						
Solidago canadensis									30	15
Anthyllis vulneraria										
Atriplicetum nitentis										
Carex hirta										
Caricetum acutiformis										
Chenopodium botrys										
Cirsium arvense – Tussilago farfara										
Convolvulo-Agropyretum										
Corispermo-Brometum tectorum										
Eleocharitetum palustris										
Equisetum arvense										
Erigeronto-Lactucetum										
Lathyrus pratensis										
Isoëto-Nanojuncetea										
Medicago sp. and *Dactylis glomerata*										
Lotus corniculatus										
Molinio-Arrhenatheretea										
Papaveretum argemones										
Poo-Tussilaginetum										
Polygono-Matricarietum										
Potentillo-Artemisietum absinthii										
Potentilletum reptantis										
Fabaceae species community										
Rubus caesius										
Salsoletum ruthenicae										
Sisymbrietum sophiae										
Typha – Phragmites										
Vicietum tetraspermae										
Trifolium repens										

Explanations:
S.g. – Solidago gigantea, S.c. – Solidago canadensis.
The numbers in table are the percentage cover of *Solidago gigantea* and *S. canadensis* in the analysed vegetation samples.
The number of papers in which *Solidago gigantea* and *Solidago canadensis* was not recorded in the investigated vegetation samples: 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 14, 15, 16, 17, 18, 19, 21, 23.
List of the analysed papers: 1. Balcerkiewicz et al. 1984; 2. Balcerkiewicz, Pawlak 1990; 3. Balcerkiewicz, Pawlak 1991; 4. Bojarczuk, Kluczyński 1972; 5. Cabała, Jarząbek 1999; 6. Cabała, Sypień 1987; 7. Dobrzańska 1955; 8. Furdyna 1974; 9. Gołdyn 1972; 10. Kompała et al. 2004; 11. Krzaklewski 1979; 12. Krzaklewski 1986; 13. Kuczyńska et al. 1984; 14. Mazaraki 1956; 15. Molenda, Chmura 2003; 16. Pawlak 1985; 17. Sarosiek 1957; 18. Szary 1994; 19. Tokarska-Guzik et al. 1991; 20. Wika, Sendek 1993; 21. Wilkoń-Michalska, Sokół 1968; 22. Woźniak 2003; 23. Woźniak et al. 2003.

Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

SOLIDAGO CANADENSIS L. AND *SOLIDAGO GIGANTEA* AITON IN PLANT COMMUNITIES DEVELOPED ON OLD FALLOWS

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ABSTRACT. Alien plants penetration into plant communities is a nearly universal phenomenon. *Solidago canadensis* and *S. gigantea* belong to the most common alien invaders.

The aim of this study is to characterise and analyse the floristic composition of long time abandoned meadows after the *Solidago canadensis* and *S. gigantea* invasion. The paper presents only phytocoenoses in which the *Solidago* species cover exceeds 50% of the vegetation patch area. The collected material has been divided into three tables.

The analyses show, that the changes in the species composition after long lasting *Solidago* invasion are remarkable. Apart from both *Solidago* species, many other ruderal species (*Artemisietea vulgaris* class) have penetrated the patches. The most resistant species which are able to co-exist with abundant *Solidago canadensis* and *S. gigantea* stands are *Arrhenatherum elatius*, *Achillea millefolium*, *Vicia cracca*, *Agrostis gigantea* and *Elymus repens* from the group of meadow species as well as *Artemisia vulgaris*, *Cirsium arvense*, *Eupatorium cannabinum* and *Calamagrostis epigejos* from the ruderal accompanying group.

KEY WORDS: *Solidago canadensis* L., *Solidago gigantea* Aiton, plant invasion, plant community, abandoned meadow, biological invasions, biodiversity protection

INTRODUCTION

Biological invasions has attracted an interest of ecologists, botanists, and nature conservationists (PYŠEK et al. 2004, RICHARDSON et al. 2000). The penetration of alien species into native plant communities has become a worldwide phenomenon (ADAMOWSKI et al. 1998; WEBER 1997a, 1997b, 1998; WEBER, SCHMID 1998). The investigations of invasion success of particular plants requires, apart from deep knowledge about invasion biology, also biocoenotic (phytocoenotic) approach (FALIŃSKI 1998). It is believed that biota of alien origin establish, in the easiest way, in man-made habitats (KORNAŚ, MEDWECKA-KORNAŚ 1986). In Upper Silesia alien species can be found in variety of plant communities and both as accompanying species and as

dominants. Both *Solidago canadensis* as well as *S. gigantea* are capable to penetrate fallow meadow vegetation.

The objective of this work is to present the floristic structure of plant communities exploited in the past as hay meadows, currently invaded by *S. canadensis* and *S. gigantea*. The paper contributes phytosociological characteristics of meadow vegetation where cover-abundance of *Solidago* species exceeded 50% of each studied vegetation patch.

METHODS

The field studies were conducted in years 2000-2002. The participation of kenophytes in vegetation of Chorzów town (Upper Silesian Industrial District) was analysed. The paper presents only part of a larger project dealing with the occurrence of *Solidago canadensis* and *S. gigantea* species in plant communities of this town. Phytosociological records were collected using BRAUN-BLANQUET (1951) method. The syntaxonomical affiliation was adopted after MATUSZKIEWICZ (2001). Latin names of plants follows MIREK et al. (2002) and the current list of kenophytes after ZAJĄC et al. (1998). Definition of "kenophyte" sensu KORNAŚ and MEDWECKA-KORNAŚ (1986) is used in the presented study. The contribution of species of the genus *Solidago* to various types of habitats was analysed. For the purpose of this work only those relevés are presented in which percent cover of *Solidago* species was higher than 50% of the plot area. The relevés were listed in three phytosociological tables. To avoid subjective estimation, the determination of habitat type (hay meadow), where observed phytocoenoses occurred, was adopted after the legend of map of Chorzów (1999).

RESULTS

The relevés in the Table 1 demonstrate vegetation patches which could be classified to the *Arrhenatheretum elatioris* association due to constant, although, low coverage of *Arrhenatherum elatius* and *Pastinaca sativa.* Furthermore, the essential role in these phytocoenoses is played by characteristic species group of the *Arrhenathetretalia* order and the *Molinio-Arrhenatheretea* class. However, because of low cover of characteristic species for the *Arrhenatheretum elatioris* association, species composition is showing transformation. The analysed phytocoenoses were finally classified as a community within the order *Arrhenatheretalia*.

S. canadensis and *S. gigantea* are dominants in the characterised patches. Some other species of the *Artemisietea vulgaris* class are frequent. With high constancy *Artemisia vulgaris* was recorded. Whilst, with lower constancy (III-IV) the following species were noted: *Cirsium arvense*, *Melandrium album*, *Cirsium vulgare* and *Eupatorium cannabinum.* The highest constancy, amongst accompanying species, concern *Calamagrostis epigejos*. Table 1 can be divided into three parts. The first one is represented only by 1 relevé which describes the most species-rich patch (35 species). Its physiognomy is determined by Canadian goldenrod, *Lotus corniculatus* and *Calamagrostis epigejos*. The distinctiveness of the second part of Table 1 (relevés 2-4) is caused by the occurrence of *Festuca rubra* which covers from 25 to 75% of the patch and *Potentilla reptans* with the cover up to 25%. The relevés (6-8) are distinguished only by the absence of *Pastinaca sativa* and *Vicia cracca*.

The phytocoenoses, classified as representing the class *Molinio-Arrhenatheretea*, described in the Table 2 have undergone strong alternation. In this patches the most frequent were *Agrostis gigantea*, *Elymus repens* and *Dactylis glomerata.* Despite the frequent occurrence, these species did not play major role in the studied patches. *Vicia cracca* in relevés 1-6 is present and in relevés 1-5 *Potentilla reptans* was noted. Both the species reached the third constancy

degree. The remaining meadow species occurred with lower constancy and cover-abundance.

Amongst representatives of the *Artemisietea vulgaris* class with high coverage (up to 50%) and the highest constancy *Solidago canadensis* and *S. gigantea* occurred. In the group of nitrophilous plants, the following species *Cirsium arvense*, *Eupatorium cannabinum* and *Artemisia vulgaris* are present with high constancy but small contribution to the structure of the patches. In relevés 1-4 *Arctium lappa* is present and it forms characteristic outspread clumps. *Melilotus alba* together with *Solidago canadensis* make the appearance of the patch described in relevé 6. Amongst the accompanying species the highest constancy is revealed by *Calamagrostis epigejos*, *Medicago lupulina* and *Poa compressa.*

In the phytocoenoses, presented in the Table 3, *Solidago canadensis* and *S. gigantea* cover is higher than 75%. In the group of meadow species (with II-III constancy degree) few diagnostic species of the *Arrhenatheretum elatioris* association, the *Arrhenatheretalia* order, the *Agropyro-Rumicion crispi* alliance as well as the *Molinio-Arrhenatheretea* class were recorded. The most frequent species in these phytocoenoses are: *Elymus repens* and *Achillea millefolium*. However, cover of *Achillea millefolium* does not exceed 5% per patch. The species of the *Artemisietea vulgaris* class are abundant. *Solidago canadensis*, *S. gigantea*, *Artemisia vulgaris* and *Cirsium arvense* are species which occurred with the highest constancy. Amongst these species *Solidago canadensis* is the most abundant. In relevés 9-11 it grows with 100% cover of the patch area. *S. gigantea*, *Artemisia vulgaris* and *Cirsium arvense* were recorded with frequent occurrence. Only in relevé 6 *Solidago gigantea* were the dominant and covered up to 75% of the patch area. From the group of accompanying species *Lathyrus tuberosus* has reached the highest constancy. Apart from *Solidago* species there are also some other kenophytes recorded such as: *Epilobium ciliatum*, *Aster novi-belgii*, *Lolium multiflorum*, *Reynoutria japonica* and *Aesculus hippocastanum.* However, both constancy and abundance of the kenophyte species are insignificant. The patches of the highest 100% participation of *Solidago* species resemble herbaceous vegetation more than a meadow one. The core *Molinio-Arrhenatheretea* class species composition is still represented but the meadow community is recognisable only in spring and early in summer.

The Table 4 (a and b) shows, that the number of meadow species (37) is larger than number of ruderal species (26). The meadow species are characterized by lower constancy but higher cover in most of the analysed patches. The most resistant species which are able to co-exist with abundant *Solidago canadensis* and *S. gigantea* stands are *Arrhenatherum elatius*, *Achillea millefolium*, *Vicia cracca*, *Agrostis gigantea* and *Elymus repens* from the group of meadow species as well as *Artemisia vulgaris*, *Cirsium arvense*, *Eupatorium cannabinum* and *Calamagrostis epigejos* from the ruderal accompanying group.

DISCUSSION

The comparison of *Solidago canadensis* and *S. gigantea* participation in tables 1 and 2 may suggest that presented communities are similar. However, the patches in the table 1 preserved more properties of meadow communities.

Many authors pay attention to the invasiveness *of Solidago canadensis*. It results, among others, from clonal growth type, phalanx strategy, vegetative reproduction ability, production of huge amount of light seeds, long dispersal by wind (REBELE 1996). Internal nitrogen cycle amounting to 50% favors colonization of extremely dry and nutrient-poor habitats (WERNER 1983). The numerous field observations indicate that such massive spread (presented particular in Table 3) was possible due to the cessation of land cultivation and lack of mowing.

Also dynamics of spread of *Solidago* species in Europe was investigated. The attempt of creation on invasion model of studied alien species was undertaken (WEBER 1998). Phenotypical plasticity and diversity in *Solidago gigantea* and *S. canadensis* in Europe was characterized (WEBER 1997a, b).

Many other issues concerning biology, genetics, adaptive capabilities, distribution in new range was described in literature. However, yet it is not fully known how do these species influence the natural and semi-natural plant communities. The American *Solidago* species are rarely pioneer plants on post-industrialized sites (WOŹNIAK 2001, 2003).

CONCLUSIONS

The meadow communities formerly exploited are very frequently invaded by such alien species as *Solidago canadensis* and *S. gigantea*.

The floristic structure of such communities in the course of time is being impoverished and the phytocoenoses lose their typical structure and physiognomy.

With increase of *Solidago canadensis* and *S. gigantea* contribution the number of meadow species decreases but number of ruderal species increases. In patches where *Solidago* make large contribution (higher than 75%) participation of other kenophytes was observed. Apart from goldenrods there are: *Epilobium ciliatum*, *Aster novi-belgii*, *Lolium multiflorum*, *Reynoutria japonica* and *Aesculus hippocastanum* present.

The most resistant species which are able to co-exist with abundant *Solidago canadensis* and *S. gigantea* stands are *Arrhenatherum elatius*, *Achillea millefolium*, *Vicia cracca*, *Agrostis gigantea* and *Elymus repens* from the group of meadow species as well as *Artemisia vulgaris*, *Cirsium arvense*, *Eupatorium cannabinum* and *Calamagrostis epigejos* from the ruderal accompanying group.

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Table 1. Community from the *Arrhenatheretalia elatioris* order

Number of relevé in the table	1	2	3	4	5	6	7	8	CONSTANCY
Number of relevé in the field	19	61	62	63	69	80	1	93	
day	15	24	24	24	25	27	4	21	
Date month	8	8	8	8	8	8	8	9	
year	01	01	01	01	01	01	01	01	
Cover of the herb layer in %	100	100	100	100	95	100	100	100	
Area of relevé in m ^{2}	18	16	16	20	20	20	16	16	
Inclination in $^\circ$	45	-	30	30	40	-	-	-	
Number of species in the relevé	35	20	19	17	22	11	24	11	
I. Ch. *Molinio-Arrhenatheretea*									
Arrhenatherum elatius	.	+	1.1	1.1	1.2	1.1	1.1	1.1	V
Achillea millefolium	.	1.1	+	+	+	r	1.1	.	IV
Dactylis glomerata	.	+	+	+	.	+.2	1.2	+	IV
Pastinaca sativa	r	r	+	+	r	.	.	.	IV
Vicia cracca	r	+	2.1	+	r	.	.	.	IV
Agrostis gigantea	+	+	+	.	.	.	1.2	.	III
Festuca rubra	.	3.2	4.4	3.3	.	.	.	.	II
Potentilla reptans	.	2.2	1.1	1.1	.	.	.	.	II
Elymus repens	1.1	.	.	.	.	.	3.3	1.2	II
Lotus corniculatus	2.2	.	.	.	.	.	+.2	.	II
Trifolium pratense	1.1	.	.	.	.	.	1.1	.	II
Plantago lanceolata	+	+	.	.	.	.	+	.	II
Daucus carota	.	.	.	.	+	.	.	+	II
II. Ch. *Artemisietea vulgaris*									
Solidago canadensis	**3.2**	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.2**	**3.5**	**V**
Solidago gigantea	**+**	**2.2**	**2.3**	**3.3**	**3.2**	**3.3**	**2.1**	**2.2**	**V**
Artemisia vulgaris	+	3.2	+	+	+	+	2.2	2.1	V
Cirsium arvense	+	.	+	.	r	+	1.1	1.1	IV
Melandrium album	.	+	r	+	+	.	1.1	.	IV
Cirsium vulgare	r	.	.	+	r	r	.	.	III
Eupatorium cannabinum	r	.	.	.	+	+	.	+	III
Urtica dioica	1.2	.	.	.	.	1.1	.	+	II
Picris hieracioides	.	+	r	r	.	.	.	.	II
Melilotus alba	.	1.2	.	.	r	.	.	.	II
Linaria vulgaris	.	+	.	.	+	.	.	.	II
Calystegia sepium	r	.	.	.	.	.	r	.	II
III. Accompanying species									
Calamagrostis epigejos	2.2	+	+	1.1	1.1	2.2	2.2	.	V
Tussilago farfara	2.1	.	.	.	r	.	.	+	II
Lathyrus tuberosus	.	.	2.1	2.2	.	.	1.2	.	II
Equisetum arvense	1.1	.	.	r	.	.	.	.	II
Silene vulgaris	.	.	r	1.1	.	.	.	.	II

Sporadic species:

I: *Agrostis stolonifera* 7 (1.2); *Carex hirta* 7 (1.2); *Crepis biennis* 5 (+); *Deschampsia caespitosa* 5 (+.2); *Heracleum sphondylium* 1 (2.2); *Holcus lanatus* 1 (r); *Lathyrus pratensis* 1 (r); *Lolium perenne* 1 (1.2); *Lysimachia vulgaris* 2 (+); *Phleum pratense* 7 (+); *Plantago major* 1 (+); *Potentilla anserina* 1 (r); *Rumex crispus* 1 (r); *Ranunculus repens* 1 (+); *Rumex acetosa* 2 (+); *Taraxacum officinale* 1 (1.1); *Valeriana officinalis* 5 (1.2);

Table 1. (continued)

II: *Arctium tomentosum* 6 (1.1); *Arctium lappa* 1 (1.2); *Oenothera biennis* 4 (+); *Tanacetum vulgare* 7 (4.2); *Torilis japonica* 2 (r);
III: *Acer pseudoplatanus* 8 (r); *Aegopodium podagraria* 8 (1.1); *Aesculus hippocastanum* 8 (r); *Chamaenerion angustifolium* 8 (r); *Convolvulus arvensis* 5 (r); *Coronilla varia* 8 (2.2); *Epilobium adnatum* 8 (r); *Festuca trachyphylla* 8 (3.4); *Hieracium sabaudum* 1 (r); *Mentha arvensis* 6 (+); *Odontites serotina* 1 (1.1); *Poa compressa* 4 (+); *Scabiosa ochroleuca* 6 (r); *Trifolium hybridum* 8 (r); *Verbascum thapsus* 8 (r).

Table 2. Meadow community with *Solidago* sp. participation up to 50% in the patch cover

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	CONSTANCY
Number of relevé in the field	36	35	37	38	39	131	13	31	83	5	
day	19	19	19	19	19	10	11	18	27	7	
Date month	8	8	8	8	8	10	8	8	8	8	
year	01	01	01	01	01	01	01	01	01	01	
Cover of the herb layer in %	75	75	80	80	75	50	100	100	100	65	
Area of relevé in m ^{2}	20	16	16	20	20	16	15	15	16	25	
Inclination in $^\circ$	-	-	-	-	-	-	-	-	-	-	
Number of species in the relevé	19	16	19	20	19	21	16	7	8	29	
I. Ch. *Molinio-Arrhenatheretea*											
Agrostis gigantea	1.1	2.2	1.1	+.2	1.2	1.2	+.2	.	1.1	1.2	V
Elymus repens	2.3	1.1	2.1	2.1	2.2	.	.	1.1	2.2	1.1	IV
Dactylis glomerata	.	1.2	+.2	+.2	+.2	2.2	+.2	3.3	.	.	IV
Vicia cracca	r	+	1.2	1.1	+	1.2	.	.	.	.	III
Potentilla reptans	2.2	1.1	2.1	2.1	1.2	.	.	.	.	.	III
Lolium perenne	+	.	+	+	+	.	.	.	.	.	II
Deschampsia caespitosa	.	.	+.2	+.2	+.2	.	.	.	.	.	II
Achillea millefolium	.	+	.	.	.	1.1	+	.	.	1.1	II
Pastinaca sativa	.	.	.	.	.	+	1.1	.	.	.	I
Daucus carota	.	.	.	.	.	+	+	.	.	.	I
II. Ch. *Artemisietea vulgaris*											
Solidago canadensis	**3.3**	**3.3**	**3.3**	**3.3**	**3.3**	**3.2**	**3.4**	**3.3**	**3.3**	**2.3**	**V**
Solidago gigantea	**1.2**	**2.3**	**2.3**	**2.3**	**2.2**	**+**	**3.4**	**1.1**	**3.3**	**3.3**	**V**
Cirsium arvense	+	1.1	.	.	.	+	r	2.1	1.1	r	IV
Eupatorium cannabinum	r	.	r	+	r	.	+	.	1.2	r	IV
Artemisia vulgaris	.	.	.	.	.	+	1.1	+	+	+	III
Arctium lappa	2.2	1.2	2.2	2.2	.	.	.	.	.	.	II
Tanacetum vulgare	.	.	+	+	1.1	.	.	.	.	+	II
Melilotus alba	r	.	.	r	.	3.3	.	.	.	.	II
Melilotus officinalis	.	.	r	.	r	.	.	.	.	r	II
III. Accompanying species											
Calamagrostis epigejos	1.1	+	+	1.1	+	2.2	2.2	.	.	+	IV

Table 2. (continued)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	
Medicago lupulina	+	r	r	+	+	1.2	+	.	.	r	IV
Poa compressa	+	+	r	+	+	+.2	.	.	.	.	IV
Bromus sterilis	1.2	+	+	+	.	.	.	.	.	.	II
Odontites serotina	.	.	.	.	.	+	+	.	.	r	II

Sporadic species:
I: *Poa trivialis* 4 (r), 5 (+); *Potentilla anserina* 1 (r), 2 (+); *Rumex crispus* 4 (r), 5 (r); *Trifolium pratense* 6 (+), 10 (+); *Crepis biennis* 6 (+), 10 (r); *Taraxacum officinale* 6 (+), 10 (+); *Agrostis stolonifera* 5 (+); *Centaurea jacea* 10 (+); *Galium mollugo* 10 (1.2); *Lotus corniculatus* 10 (r); *Phleum pratense* 10 (+.2); *Plantago lanceolata* 10 (1.1); *Poa palustris* 7 (+);
II: *Arctium tomentosum* 1 (2.2), 5 (2.2); *Picris hieracioides* 6 (+), 10 (r); *Arctium minus* 3 (1.2); *Cirsium vulgare* 10 (r); *Melandrium album* 4 (r); *Oenothera biennis* 6 (+); *Reseda lutea* 10 (r); *Saponaria officinalis* 7 (+); *Urtica dioica* 8 (+);
III: *Lathyrus tuberosus* 9 (1.3), 10 (1.1); *Rumex acetosella* 1 (r), 3 (r); *Acer pseudoplatanus* 10 (r); *Elymus caninus* 2 (1.1); *Conyza canadensis* 10 (+); *Hieracium sabaudum* 6 (+); *Matricaria maritima* subsp. *inodora* 10 (+); *Trifolium hybridum* 10 (+.2); *Tussilago farfara* 10 (1.1); *Verbascum thapsus* 7 (+).

Table 3. Meadow community with *Solidago* sp. participation up to 75% in the patch cover

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	CONSTANCY
Number of relevé in the field	17	16	14	66	68	67	26	25	2	3	4	
Date day	15	15	12	25	25	25	18	18	7	7	7	
Date month	8	8	8	8	8	8	8	8	8	8	8	
Date year	01	01	01	01	01	01	01	01	01	01	01	
Cover of the herb layer in %	100	100	100	95	95	90	100	100	100	100	100	
Area of relevé in m^2	18	16	15	16	20	20	18	15	16	16	16	
Inclination in °	45	45	45	40	40	40	-	-	-	-	-	
Number of species in the relevé	28	26	24	21	21	22	15	16	20	12	10	
I. Ch. *Molinio-Arrhenatheretea*												
Achillea millefolium	+	+	r	1.1	r	+	+	1.1	1.1	+	r	V
Elymus repens	+	1.1	2.1	+	.	1.1	3.3	3.3	3.3	1.1	1.1	V
Arrhenatherum elatius	+	.	.	1.1	1.1	1.1	1.2	+	.	.	.	III
Vicia cracca	+	.	.	1.1	r	.	.	.	r	1.1	1.1	III
Heracleum sphondylium	.	.	.	2.2	2.2	2.2	.	.	.	.	.	II
Plantago lanceolata	.	.	.	.	.	.	3.3	+	+	.	+	II
Daucus carota	1.1	1.1	2.1	.	+	.	.	.	.	.	.	II
Pastinaca sativa	.	r	.	r	.	+	.	.	.	.	.	II
II. Ch. *Artemisietea vulgaris*												
Solidago canadensis	**4.5**	**4.5**	**4.5**	**4.5**	**4.5**	**2.2**	**4.2**	**4.3**	**5.5**	**5.4**	**5.5**	**V**
Solidago gigantea	**1.1**	**1.1**	**2.2**	**2.2**	**2.1**	**4.3**	**r**	**1.1**	**2.3**	**2.3**	**2.2**	**V**
Artemisia vulgaris	1.1	1.1	+	+	+	+	r	+	2.1	2.3	2.1	V
Cirsium arvense	2.1	1.1	1.1	r	r	.	1.1	1.1	1.1	+	+	V

Table 3. (continued)

Number of relevé in the table	1	2	3	4	5	6	7	8	9	10	11	
Eupatorium cannabinum	+	2.2	2.2	1.1	+	1.1	.	.	+	+	.	IV
Urtica dioica	+	+	+	.	.	.	.	+	.	.	.	II
Picris hieracioides	.	.	+	r	+	r	.	.	.	.	.	II
Melandrium album	.	.	.	r	r	r	.	.	.	r	.	II
Calystegia sepium	.	+	+	.	.	.	.	.	.	.	1.1	II
Cirsium vulgare	+	.	.	.	+	r	.	.	.	.	.	II
Epilobium hirsutum	r	r	r	.	.	.	.	.	.	.	.	II
Linaria vulgaris	.	.	.	r	r	r	.	.	.	.	.	II
III. Accompanying species												
Lathyrus tuberosus	+	+	r	.	r	.	+	1.1	r	+	1.1	V
Calamagrostis epigejos	1.1	2.2	2.2	+	+	1.1	.	.	1.1	1.2	.	IV
Equisetum arvense	3.5	3.4	3.5	.	.	.	1.1	1.1	.	.	.	III
Hieracium sabaudum	+	+	+	.	r	+	.	.	.	.	.	III
Tussilago farfara	1.1	.	.	+	r	.	.	.	1.1	.	.	II
Epilobium adnatum	.	r	.	.	.	.	r	r	r	.	.	II
Aegopodium podagraria	2.2	+	+	.	.	.	.	.	.	.	.	II
Epilobium ciliatum	.	.	r	.	r	r	.	.	.	.	.	II
Festuca trachyphylla	3.3	3.3	2.1	.	.	.	.	.	.	.	.	II

Sporadic species:

I: *Agrostis gigantea* 5 (+), 6 (+); *Carex hirta* 4 (r), 9 (2.3); *Dactylis glomerata* 7 (1.2), 8 (+.2); *Taraxacum officinale* 7 (+), 8 (r); *Cerastium holosteoides* 7 (+), 8 (+); *Crepis biennis* 5(r), 6 (+); *Poa trivialis* 4 (r), 6 (r); *Potentilla anserina* 1 (1.1), 2 (1.1); *Stachys palustris* 1 (r), 2 (r); *Valeriana officinalis* 4 (1.1), 6 (+), *Agrostis stolonifera* 7 (1.1); *Deschampsia caespitosa* 4 (+.2); *Juncus effusus* 9 (+.2); *Lolium perenne* 2 (2.2); *Lotus corniculatus* 1 (+); *Phleum pratense* 6 (r);

II: *Armoracia lapathifolia* 9 (r), 10 (r); *Aster novi-belgii* 1 (1.2), 3 (1.2); *Galium aparine* 2 (+), 3 (r); *Melilotus alba* 6 (r); *Reynoutria japonica* 2 (+), 3 (r); *Tanacetum vulgare* 9 (1.1);

III: *Lolium multiflorum* 2 (+.2), 3 (1.2); *Mentha arvensis* 1 (+), 4 (+); *Aesculus hippocastanum* 2 (r); *Carex vulpina* 9 (+.2); *Chamaenerion angustifolium* 3 (+); *Convolvulus arvensis* 8 (r); *Lycopus europaeus* 9 (r); *Populus* x *canescens* 1 (r); *Populus nigra* 1 (r); *Salix caprea* 1 (r); *Scabiosa ochroleuca* 9 (r).

Table 4a. The comparison of the floristic composition of the investigated communities (meadow species)

Number of table	1	2	3
Number of relevés in table	8	10	11
Cover of the herb layer in %	95 - 100	50 - 100	90 - 100
Area of relevé in m^2	16 - 20	15 - 25	15 - 20
Inclination in °	30 - 45	-	40 - 45
Number of species in the relevé	67	56	62
I. Ch. *Molinio-Arrhenatheretea*			
Arrhenatherum elatius	V (+ - 1.2)		III (+ - 1.2)
Achillea millefolium	IV (r – 1.1)	II (+.1.1)	V (r – 1.1)
Dactylis glomerata	IV (+ - 1.2)	IV (+.2 – 3.3)	I (+.2 - 1.2)
Pastinaca sativa	IV (r - +)	I (+ - 1.1)	II (r - +)
Vicia cracca	IV (r – 2.1)	III (r – 1.2)	III (r – 1.1)
Agrostis gigantea	III (+ - 1.2)	V (+.2 – 2.2)	I (+)
Elymus repens	II (1.1 – 3.3)	IV (1.1 – 2.3)	V (+ - 3.3)
Plantago lanceolata	II (+)	I (1.1)	II (+ - 3.3)
Daucus carota	II (+)	I (+)	II (+ - 2.1)
Lotus corniculatus	II (+.2 – 2.2)	I (r)	I (+)
Lolium perenne	I (1.2)	II (+)	I (2.2)
Deschampsia caespitosa	I (+.2)	II (+.2)	I (+.2)
Potentilla anserina	I (r)	I (r - +)	I (1.1)
Crepis biennis	I (+)	I (r - +)	I (r - +)
Taraxacum officinale	I (1.1)	I (+)	I (r - +)
Agrostis stolonifera	I (1.2)	I (+)	I (1.1)
Phleum pratense	I (+)	I (+.2)	I (r)
Potentilla reptans	II (1.1 – 2.2)	III (1.1 – 2.2)	
Trifolium pratense	II (1.1)	I (+)	
Rumex crispus	I (r)	I (r)	
Heracleum sphondylium	I (2.2)		II (2.2)
Carex hirta	I (1.2)		I (r - 2.3)
Valeriana officinalis	I (1.2)		I (+ - 1.1)
Poa trivialis		I (r - +)	I (r - +)
Festuca rubra	II (3.3 – 4.4)		
Holcus lanatus	I (r)		
Plantago major	I (+)		
Lathyrus pratensis	I (r)		
Ranunculus repens	I (+)		
Lysimachia vulgaris	I (+)		
Rumex acetosa	I (+)		
Centaurea jacea		I (+)	
Galium mollugo		I (1.2)	
Poa palustris		I (+)	
Cerastium holosteoides			I (+)
Stachys palustris			I (r)
Juncus effusus			I (+.2)

Table 4b. The comparison of the floristic composition of the investigated communities (ruderal and accompanying species)

Number of table	1	2	3
Number of relevés in table	8	10	11
Cover of the herb layer in %	95 - 100	50 - 100	90 - 100
Area of relevé in m^2	16 - 20	15 - 25	15 - 20
Inclination in °	30 - 45	-	40 - 45
Number of species in the relevé	67	56	62
Ch. *Artemisietea vulgaris*			
Solidago canadensis	**V (3.2 -3.5)**	**V (2.3 – 3.4)**	**V (2.2 – 5.5)**
Solidago gigantea	**V (+ - 3.3)**	**V (+ – 3.4)**	**V (r – 4.3)**
Artemisia vulgaris	V (+ - 3.2)	III (+ - 1.1)	V (r – 2.3)
Cirsium arvense	IV (r - 1.1)	IV (r – 2.1)	V (r – 2.1)
Eupatorium cannabinum	III (r - +)	IV (r – 1.2)	IV (+ - 2.2)
Melandrium album	IV (r – 1.1)	I (r)	II (r)
Cirsium vulgare	III (r - +)	I (r)	II (r - +)
Urtica dioica	II (+ - 1.2)	I (+)	II (+)
Picris hieracioides	II (r - +)	I (r - +)	II (r - +)
Melilotus alba	II (r – 1.2)	II (r – 3.3)	I (r)
Tanacetum vulgare	I (4.2)	II (+ - 1.1)	I (1.1)
Linaria vulgaris	II (+)		II (r)
Calystegia sepium	II (r)		II (+ - 2.2)
Arctium tomentosum	I (1.1)	I (2.2)	
Arctium lappa	I (1.2)	II (1.2 – 2.2)	
Oenothera biennis	I (+)	I (+)	
Sporadic species present only in one table	1	5	4
Accompaying species			
Calamagrostis epigejos	V (+ - 2.2)	IV (+ - 2.2)	IV (r – 2.2)
Lathyrus tuberosus	II (1.2 – 2.2)	I (1.1 – 1.3)	V (r – 1.1)
Tussilago farfara	II (r – 2.1)	I (1.1)	II (r – 1.1)
Hieracium sabaudum	I (r)	I (+)	III (r - +)
Equisetum arvense	II (r – 1.1)		III (1.1 – 3.5)
Aesculus hippocastanum	I (r)		I (r)
Chamaenerion angustifolium	I (r)		I (+)
Convolvulus arvensis	I (r)		I (r)
Mentha arvensis	I (+)		I (+)
Epilobium adnatum	I (r)		II (r)
Festuca trachyphylla	I (3.4)		II (2.1 – 3.3)
Scabiosa ochroleuca	I (r)		I (r)
Acer pseudoplatanus	I (r)	I (r)	
Poa compressa	I (+)	IV (r - +.2)	
Trifolium hybridum	I (r)	I (+.2)	
Odontites serotina	I (1.1)	II (r - +)	
Aegopodium podagraria	I (1.1)		II (+ - 2.2)
Sporadic species present only in one table	3	6	8

Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

NEW LOCALITY OF *POLYPODIUM VULGARE* L. IN THE SUCHY POTOK VALLEY, MIĘDZYBRODZIE BIALSKIE, CZERNICHÓW COMMUNE, THE BESKID MAŁY RANGE (WESTERN CARPATHIANS)

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ABSTRACT. The paper presents original data concerning the new for the Beskid Mały locality of *Polypodium vulgare* L. which was found in 2005, then confirmed in 2006, in the Suchy Potok Valley – ATPOL DF94. The valley is located within boundaries of Międzybrodzie Bialskie, Czernichów commune, Silesian voivodship, Poland. New locality does not change the distribution pattern of the species in the ATPOL's 10 x 10 km grid, but fulfills a set of the species localities within the range. A proposal for protection of the locality within the area of ecological use called "The Suchy Potok Valley" is given.

KEY WORDS: *Polypodium vulgare*, Beskid Mały Range, the Suchy Potok Valley, distribution, protection

INTRODUCTION

Polypodium vulgare L. (Polypodiaceae) represents circumboreal element in Polish flora. It occurs in Europe, with exception of areas the most exposed to the south, and in Central Asia. It is acknowledged as relatively rare in North America. This quite common species in Poland is regularly distributed, especially in the Carpathians, but less regularly in other parts of the country (ZAJĄC, ZAJĄC 2001; PIĘKOŚ-MIRKOWA, MIREK 2003).

Hitherto, its recorded localities have been reported for the Beskid Mały Range from the west to the east at ATPOL's grid as: DF93 (Straconka), DF94 (Żarnówka Mała, Bujakowska Góra), DF95 (Przełęcz Kocierska), DF96 (Żurawnica, Mucharz-Upalisko), DF97 (Mucharz Upalisko), DF05 (Łysina). All squares make latitudinal stripe through the central part of the range and localities are vertically differentiated between 290 and 730 m a.s.l. Despite wide distribution at ATPOL's grid, the mentioned localities are not numerous and the species is described as not frequent in the Beskid Mały Range (KOTOŃSKA 1991).

The species can be found in various forest communities in Poland representing such classes as: the *Querco-Fagetea*, the *Vaccinio-Piceetea*, the *Quercetea robori-petraeae* and the *Asplenietea rupestria*. It prefers moderately shadowed habitats, stems of old trees, middle-forest creviced rocks, rock bases, escarpments, ravines, steep stony slopes *etc.* (PIĘKOŚ-MIRKOWA,

MIREK 2003). In the Beskid Mały it occurs in forests on shallow soils and near streams on sandstone outcrops (KOTOŃSKA 1991).

Populations are usually not numerous: from a few to several dozen of specimens, rarely make large patches. Resources of the species are well preserved at national parks and reserves (PIĘKOŚ-MIRKOWA, MIREK 2003).

Polypodium vulgare L. is strictly protected plant in Poland, therefore seems to be one of important indicators of the area value (MINISTER'S… 2004). It can be endangered by forest management, shrinking of natural forest habitats, old trees cutting (when epiphytic or accompanying), collecting specimens for decoration purposes, uprooting. Its rhizomes are sweet and edible after peeling.

MATERIAL AND METHODS

Studies were conducted in 2005 and 2006 and focused on recognition of widely understanding values of the Suchy Potok Valley. Attention was especially paid to rare and protected plants occurring along the stream. Preliminary lists of vascular plants were made, so *Polypodium vulgare* L. has been acknowledged as one of the most spectacular, but not exclusive attractions of the valley.

The locality has been recognized as new one based upon the paper by KOTOŃSKA (1991) and CELIŃSKI et al. (1994), which up to now are comprehensive elaborations concerning flora of this area. Moreover, the locality has been verified following ZAJĄC (1978a,b), ZAJĄC and ZAJĄC (2001) ATPOL's grid 10 x 10 km. Fresh, single leaves of *Polypodium vulgare* L. have been counted twice (in 2005 and 2006). Studies concerning the phytosociological documentation of the valley as well as these regarding structure and dynamics of *Polypodium vulgare* population will be proceeding.

In the paper, names of vascular plants follow MIREK et al. (2002), names of vegetation units follow MATUSZKIEWICZ (2001).

RESULTS

New locality of *Polypodium vulgare* L. was found in the western part of the Beskid Mały Range called Pasmo Magurki Wilkowickiej with its highest top – Czupel (933 m a.s.l.); over the stream named the Suchy Potok (in Międzybrodzie Bialskie, Czernichów commune). The stream is not very large water course which falls from the west into the artificial lake – Jezioro Międzybrodzkie. It consists of a few smaller arms which drain slopes of Suchy Wierch (799 m a.s.l.) and Rogacz (898 m a.s.l.) – rising in the immediate vicinity of Czupel.

The locality was found in the upper part of the Suchy Potok's right arm, orographically on the right slope, 370 m a.s.l. The slope is exposed to the north and strongly inclined (30-40°). Its base is shaped by the stream during heavy rains or floods, but its middle and upper parts are well stabilized by hornbeams (*Carpinus betulus*) and young firs (*Abies alba*). The locality takes depressed part of the slope and is well preserved against accidental penetration by people, because the whole area makes a ravine. Moreover, natural processes of erosion are impeded there by relatively young trees, at II-III age classes, which are strongly rooted and form dense, one-layered canopy.

According to ATPOL's grid, the locality belongs to DF94 square (Fig.1) and is the most exposed to the south among all found at this square (comp. KOTOŃSKA 1991).

The locality of *Polypodium vulgare* L. is an interesting example of occurrence the protected species in rare for the area forest community. The *Tilio-Carpinetum* association (*Fagetalia*

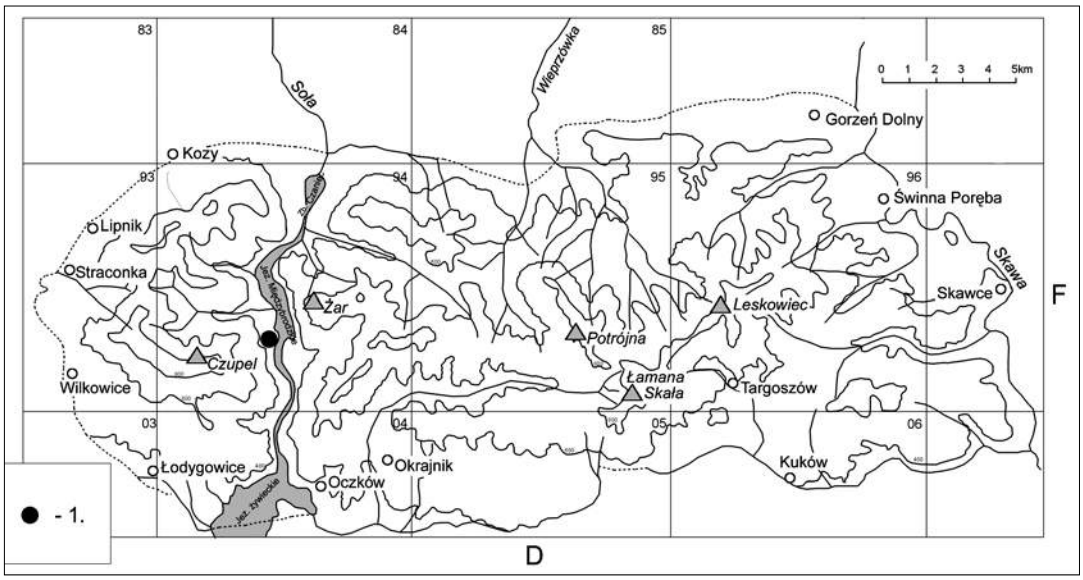

Fig. 1. New locality of *Polypodium vulgare* in the Beskid Mały at ATPOL's (ZAJĄC 1978a,b) grid – DF94. Base map by KOTOŃSKA (1991) – changed
Explanation: 1 – the localization of the species.

order, *Querco-Fagetea* class) seems to be such community for the Beskid Mały Range (MYCZKOWSKI 1958, CABAŁA et al. 1994, BARĆ 2002). This type of forest was exploited for ages for various purposes, because it occurred in submontane, easily achievable area, on fertile soils and consisted of valuable and useful tree species (SOSNOWSKI 1925, KAWECKI 1939, NYREK 1975). In the Beskid Mały Range, its potential habitats have been destroyed also in the particular way i.e. by water of artificial lake – Jezioro Międzybrodzkie, which in some places completely changed contact zones between forest and water (BARĆ 2004, 2005). Moreover, the *Tilio-Carpinetum* association is included into the list of habitat types deserving the protection as areas of NATURE 2000, Code No 9170, Appendix 1 (MINISTER'S…2005).

Tilio-Carpinetum is strongly changed and rather poor in species at all forest layers in the area studied. Its canopy is predominated by *Carpinus betulus*, without admixture of *Tilia cordata* and *Quercus robur.* The locality of *Polypodium vulgare* is directly connected with 5 specimens of young *Carpinus betulus*, with diameter at brest high: 19, 12, 14, 17 and 26 cm respectively. The shrub layer is created by single *Abies alba* specimens. Matured trees are not growing in the patch with *Polypodium vulgare*, but in the vicinity. *Carpinus betulus*, *Abies alba* and *Picea abies* seedlings and saplings can be noticed at the herb layer, but the most valuable component of this layer is *Asarum europaeum* – partly protected vascular plant in Poland. The species takes middle and basal part of the slope.

Polypodium vulgare occurs in a few clusters around and nearby the foot of *Carpinus betulus* stems, so the spatial relationship with trees is close and well noticeable. It does not exceed of 1,5 m distance from the each tree. Population is medium numerous; 321 single leaves were counted in 2005. Actually, it consists of 8 clusters of *Polypodium vulgare* with: 5, 11, 12, 15, 32, 42, 102, 123 fresh leaves in each cluster (342 in total in 2006). The structure and dynamics of the population will be studied.

Discussion

The locality of *Polypodium vulgare* in the Suchy Potok Valley is medium abundant, but the species usually forms not numerous clusters and it is found in bigger patches only occasionally (Piękoś-Mirkowa, Mirek 2003). Its occurrence close to *Carpinus betulus*, not *Fagus sylvatica* or *Acer pseudoplatanus*, is also worth of notice, as well as the presence of *Tilio-Carpinetum* in the vicinity. *Tilio-Carpinetum* is actually quite rare association in the Beskid Mały, especially near Międzybrodzie Bialskie and Żywieckie or Czernichów (Barć 2004, 2005).

The locality of *Polypodium vulgare* is not the only attraction of the Suchy Potok Valley. Strictly protected pteridophytes are also represented by tussocks of *Polystichum aculeatum* and *Blechnum spicant.* From among of partly protected species of vascular plants *Asarum europaeum* and *Galium odoratum* should be mentioned, while protected bryophytes are represented by *Leucobryum glaucum*. In the Suchy Potok Valley, just below the ravine with the locality of *Polypodium vulgare*, there is a great windthrow of *Populus nigra*, 129 cm in diameter, which as a living tree deserved the protection (Kasprzak 2005). Actually, all its smaller branches have been cut, but its basal part, together with the root system, should be left as a decaying wood in order to rise the local biodiversity. This is not the one specimen of the species: three others grow at the upper outlet of the ravine and have: 62, 64 and 69 cm in diameter. According to Kotońska (1991) this is rare species in the Beskid Mały and its localities from ATPOL's square DF94 hitherto have not been reported.

Moreover, in the Suchy Potok Valley both effects of erosion processes (e.g. Carpathian flysch outcrop) and well stabilized slopes can be seen (the vicinity of *Polypodium vulgare* locality). All this makes the area extremely interesting, not only because of the presence of some rare and protected plants, but also because active geomorphological processes which can be observed in natural conditions. All these facts support the idea of protection, at least the part of the valley, with the locality of *Polypodium vulgare*, within the system of protection forms following Polish Nature Protection Law from 16th of April 2004, Art. 6.1. point 8. The area of ecological use seems to be the best solution for the protection of this place, actually owned and used by local forest-pasture unity. Taking under protection of the law will help to preserve all different living and inanimate values of this place and will help the local forest-pasture unity in effective fight with spontaneous and illegal deposition of rubbish, which in some places steps forward and causes serious devastation of the area.

Conclusions

1. New locality of *Polypodium vulgare* in the Beskid Mały Range found in the Suchy Potok Valley (ATPOL DF94) deserves the protection as an area of ecological use.
2. The area of ecological use should be named "The Suchy Potok Valley" and for many reasons can become the tourist attraction.
3. The value of the object is high because of rare and protected species occurrence, as well as by phenomena and natural processes which can be observed there.
4. Despite the occurrence of *Polypodium vulgare* in DF94, it does not change ATPOL's pattern of the species distribution in the Beskid Mały Range. However, the species plays an important role as strong local indicator of the area value.
5. Further studies concerning the structure and dynamics of *Polypodium vulgare* are needed in order to describe the developmental tendencies of the population.

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Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

SEARCHING OF *DENTARIO GLANDULOSAE-FAGETUM LUNARIETOSUM* SUB-ASSOCIATION AT THE BABIA GÓRA RANGE

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ABSTRACT. This paper presents the problem of distribution of the sub-association *Dentario glandulosae-Fagetum lunarietosum* in the Beskid Śląski Mts. and the Beskid Żywiecki Mts. of the Western Carpathians Mts. as well as a review of Polish literature devoted to the floristic structure and the range of this sub-association. The analysis of available phytosociological relevés has revealed that fertile Carpathian beech forest with *Lunaria rediviva* may occur also in Babia Góra Range.

KEY WORDS: phytosociology, *Dentario glandulosae-Fagetum lunarietosum*, *Lunario-Aceretum*, distribution in Western Carpathians

INTRODUCTION

The fertile beech woods *Dentario glandulosae-Fagetum lunarietosum* with abundant occurrence of *Lunaria rediviva*, in which sycamore is a considerable constituent of tree stand, occupy both typical for sycamore forests – steep slopes of valleys and slopes in upper parts – typical for beech woods, according to DZWONKO (1986)[1], KOZŁOWSKA and MATUSZKIEWICZ (1993), and J. M. MATUSZKIEWICZ (2001)[2] are limited in the range to the Eastern Carpathians. However, the phytocoenoses of the sub-association were observed in the Beskid Śląski Mts. and Żywiecki Beskid Mts. by LUDERA (1965), CABAŁA and OLESIŃSKI (1986), CABAŁA and WILCZEK (1991) as well as WILCZEK (1995).

CELIŃSKI and WOJTERSKI (1978) did not report this sub-association from the Babia Góra Mt. but there patches found of beech community with *Lunaria rediviva* were included also to *Dentario glandulosae-Fagetum lunarietosum* (STUCHLIK 1968, PARUSEL 1985). *Lunaria rediviva* is also component of montane sycamore communities *Lunario-Aceretum*, what additionally make syntaxonomical diagnosis of fertile deciduous forests in lower zone of the Carpathians, more difficult.

[1] DZWONKO (l.c.), citing only work by LUDERA (1965), however, pointed out the occurrence of this sub-association within the Western Carpathians, only and rarely in the Beskid Śląski Mts. Whilst KOZŁOWSKA and MATUSZKIEWICZ (l.c.) did not take into account the data by LUDERA (l.c.) as well as by CABAŁA and OLESIŃSKI (1986) from the Western Beskidy Mts.

[2] J. M. MATUSZKIEWICZ (l.c.) did not assume an attitude towards information, by LUDERA (l.c.), CABAŁA and OLESIŃSKI (l.c.) as well as by WILCZEK (1995), on the occurrence of this sub-association in the Western Beskidy Mts.

The aim of our work is a review of phytosociological data collected in forest with contribution of *Lunaria rediviva* in Polish Carpathians Mts. and a comparison of similarities and differences in floristic structure of phytocoenoses from the Babia Góra Range and others Carpathian forests.

Diagnostic traits of beech woods and sycamore woods with the participation of *Lunaria rediviva* in the Carpathians Mts.

The montane forests with the contribution of *Lunaria rediviva* caught an interest of Kozłowska and Matuszkiewicz (1993). On the basis of analytical calculations, the authors presented regional and habitat differences between fertile beech woods and sycamore woods, which for the Carpathians Mts. is presented as follows.

The Western Carpathian sub-association *Dentario glandulosae-Fagetum typicum* differ from the Western Carpathian form of *Lunario-Aceretum* in significant admixture of sycamore (up to 40%) and being beech forest, also in higher participation of *Polystichum aculeatum*, *Prenanthes purpurea*, *Dentaria bulbifera*, *Rubus hirtus*, *Isopyrum thalictroides* and *Corydalis cava*. Only in Carpathian beech forest the following species occurred: *Abies alba*[3], *Symphytum cordatum*, *Polystichum brauni*[3], *Cephalanthera alba*, *Festuca altissima*[3], *Luzula sylvatica*, *Vaccinium myrtillus*, *Phegopteris connectilis*[3] and *Hieracium murorum*. *Lunario-Aceretum* distinguish itself as sycamore forest with the large admixture of beech (up to 60%) and by higher contribution of *Ulmus scabra* to tree stand. Compared to *Dentario glandulosae-Fagetum typicum* it differs in higher constancy and cover-abundance of *Lunaria rediviva* and *Urtica dioica*. Only in *Lunario-Aceretum* association *Hordelymus europaeus* occurred. The two species occurred with the same constancy: *Allium ursinum* and *Dentaria glandulosa* – characteristic species for fertile beech forest.

The Eastern Carpathians sub-association *Dentario glandulosae-Fagetum lunarietosum* compared to the Western Carpathian form of *Lunario-Aceretum* is beech forest with high admixture of fir, sycamore, Scotch elm in tree stand and higher participation of *Isopyrum thalictroides*, *Corydalis cava* and *Allium ursinum*[3]. Only in this community *Abies alba*[3] and *Phyllitis scolopendrium* were recorded. *Lunario-Aceretum* differ from the Eastern sub-association *Dentario glandulosae-Fagetum lunarietosum* in large admixture of beech (up to 60%) and being sycamore forest and in sporadical occurrence of Scotch elm and higher contribution of *Lunaria rediviva*.

In aforementioned analysis Kozłowska and Matuszkiewicz (1.c.) claim that domination of beech in phytocoenoses of fertile Carpathian beech wood is apparent likewise dominance of sycamore in communities included into the *Acerenion pseudoplatani* sub-alliance. Moreover, constant participation of spring geophytes in sub-association *Dentario glandulosae-Fagetum lunarietosum* is much more higher with the comparison of *Lunario-Aceretum.*

The similarities and differences in floristic structure of forests with the participation of *Lunaria rediviva* in Polish Carpathians

Taking into account the characteristics of *Lunario-Aceretum* and beech forest with *Lunaria rediviva* as well as phytosociological data, included into works by Dzwonko (1986), Kozłowska and J. M. Matuszkiewicz (1993), J. M. Matuszkiewicz (2001), and W. Matuszkiewicz (2001), comparison of obtained material (see Table 1) with the data originating from

[3] Including data by Wilczek (l.c.), this result should be corrected: *Abies alba*, *Polystichum brauni*, *Festuca altissima* and *Phegopteris connectilis* were also reported in *Lunario-Aceretum* and *Allium ursinum* shows high constancy in this association.

other regions of the occurrence of depicted syntaxa and with the original material (GRÜNEBERG and SCHLÜTER 1957, OBERDORFER 1992) was performed. The results of the comparison were shown in the Table 2.

The highest discordance of above mentioned diagnostic features occurred in case of comparison of beech woods and sycamore forests in the Beskid Śląski Mts. The participation of beech, sycamore, Scotch elm and *Lunaria rediviva* is not considerably higher than in *Lunario-Aceretum*[4]. The contribution of *Rubus hirtus*, *Polystichum lobatum*, *Allium ursinum*, *Isopyrum thalictroides* is similar in both syntaxa. The spring geophytes occurs only in *Lunario-Aceretum* and not in *Dentario glandulosae-Fagetum lunarietosum.* In both associations *Dentaria glandulosa* occurs with high constancy[5]. Analyzing phytosociological relevés from the study area in relation to the concordance with previously mentioned features, some of them – included to *Dentario glandulosae-Fagetum lunarietosum* – represent probably *Lunario-Aceretum* (e.g. relevés 2 and 3 by LUDERA with domination of sycamore and maple – but collected in flat area), and others – included to *Lunario-Aceretum* – represent probably *Dentario glandulosae-Fagetum lunarietosum* (e.g. relevés nos. 4, 13, 15 and 16 by WILCZEK – with domination of beech).

LUNARIA REDIVIVA IN FORESTS OF THE BABIA GÓRA RANGE

In the study area *Lunaria rediviva* is sporadic species occurring in Carpathian beech forest and fertile fir forest, but not forming there large patches (PARUSEL 2003). The locality of this species close the Jałowiecka valley within the Babia Góra range, previously reported by ZAPAŁOWICZ (1880), probably does not exist anymore (PARUSEL 1985). *Lunaria rediviva* is known to be occur somewhere on northern slopes of Sokolica (KASPROWICZ 1996)[6].

The first phytosociological relevé with *Lunaria rediviva* from the Polica range was published by STUCHLIK (1968), which, according to the author, presents the patch similar to subassociation *Fagetum carpaticum lunarietosum*[7]. To this community also PARUSEL (1985) included the patch with abundant occurrence of *Lunaria rediviva*, found in 1983 close to Babia Góra National Park. This patch was again found in 1984 by ŁUSZCZYŃSKI and ŁUSZCZYŃSKA (1990) and described by them as *Lunario-Aceretum*. This classification is concordant with the further classification by KASPROWICZ (1996), who, in his review work, listed short synoptic table of *Lunario-Aceretum*, based on both published relevés by PARUSEL (l.c.) and by ŁUSZCZYŃSKI and ŁUSZCZYŃSKA (l.c.). He treated the following species as diagnostic ones for the association: *Lunaria rediviva*, *Asarum europaeum* and *Scrophularia nodosa*[8].

The conservation plan of Babia Góra National Park (SZWAGRZYK et al. 1999a) contains characteristics of *Lunario-Aceretum* based on 3 relevés, taken in 119 forest section on slope of Jaworzyna Mt. (SZWAGRZYK et al. 1999b). However, these relevés represent or very weakly formed fragments of the association, either the patches of fertile Carpathian beech forest and sycamore forest. *Lunaria rediviva* – characteristic species of the described association, occurred only in two relevés, and with cover-abundance 1 and 2; also the participation of species of the *Alno-Ulmion* alliance is considerable. The weak steepness of slopes (20-25°) and

[4] Furthermore in the Beskid Śląski Mts. patches of beech forests with maple and ash without *Lunaria rediviva* were observed (LUDERA 1965; HOLEKSA, WILCZEK 1992), which LUDERA (l.c.) includes to sub-association *Dentario glandulosae-Fagetum aceretosum.*

[5] Such result of comparison can be yielded from that WILCZEK (1995) included patches of transitional community between *Dentario glandulosae-Fagetum* and *Lunario-Aceretum* to the sub-association *Dentario glandulosae-Fagetum lunarietosum.*

[6] The first author knows very small patch at the bottom of Sokolica in forest section no. 6 in Babia Bóra National Park which can be classified as beech forest with *Lunaria rediviva.*

[7] This releve was classified to typical sub-association both by DZWONKO (1986) and KOZŁOWSKA and MATUSZKIEWICZ (1993).

[8] The occurrence of *Lunario-Aceretum* in Babia Góra Mt. was confirmed by J. M. MATUSZKIEWICZ (2001), however, W. MATUSZKIEWICZ (2001) did not mention it. DZWONKO (1986) did not distinguished this association within the Western Carpathians Mts.

lack of an abundantly occurrence of *Lunaria rediviva* do not fit characterization of the association given by KOZŁOWSKA and MATUSZKIEWICZ (1993), therefore it should be discussed whether these relevés are a document of this association.

During the geobotanical studies, collected by the first author in the area proposed to be a part of Babia Góra National Park (PARUSEL 2003), the forest patches with *Lunaria rediviva* documented by 3 new phytosociological relevés. These patches were classified as *Lunario-Aceretum* followed syntaxonomical diagnosis by ŁUSZCZYŃSKI and ŁUSZCZYŃSKA (1990). Nevertheless, the relevé by STUCHLIK (1968) and relevés from the conservation plan of Babia Góra National Park (SZWAGRZYK et al. 1999b) indicate the presence of the patches, which can not be classified as sycamore forest community. Perhaps these are fragments of the sub-association of fertile beech forest or other forest communities, or represent new sub-association of Carpathian beech forest – with *Lunaria rediviva* (STUCHLIK himself compares the found patch to the Eastern-Carpathian subassociation with *Lunaria rediviva*). On the distribution map of plant communities of areas projected to be included to Babia Góra National Park (PARUSEL 2003) each encountered patches were classified as *Lunario-Aceretum.* However, during more detailed mapping, the differentiation of beech forest with *Lunaria rediviva* is possible. The question arises if such sub-association of beech forest occurs in Babia Góra range and still requires further investigations.

RECAPITULATION

The diagnostic traits of beech forest and sycamore woods given by KOZŁOWSKA and MATUSZKIEWICZ (1993) in the studied Babia Góra Range turn out to be inefficient. Species composition of tree stand and percentage of particular species resulted from forest management practices, and participation of spring geophytes is so low, that these plants can not be helpful during diagnosis of beech and sycamore forests.

In the light of comparison of floristic structure of woods with *Lunaria rediviva* one can admit that fertile Carpathian beech forest needs a new review including differentiation into subassociations in Western Carpathians and determination of habitat-floristic traits for purposes of diagnosis of forest communities from the alliances *Fagion sylvaticae* and *Tilio platyphyllis--Acerion pseudoplatani* with *Lunaria rediviva.* Furthermore, determination of the range of these communities in whole Carpathians should be conducted. This review should contain all available phytosociological materials from this area and the latest syntaxonomical approach of the *Fraxino-Aceretum pseudoplatani* (OBERORFER 1992 and POTT 1992).

The diagnostic species of sycamore forest ought to be search amongst the following species: *Acer platanoides*, *A. pseudoplatanus*, *Actaea spicata*, *Cardamine flexuosa*, *Epilobium montanum*, *Fraxinus excelsior*, *Geranium robertianum*, *Lamium maculatum*, *Mercuralis perennis*, *Mycelis muralis*, *Polystichum aculeatum*, *Pulmonaria obscura*, *Ribes uva-crispa*, *Scrophularia nodosa*, *Senecio ovatus*, *Ulmus glabra* and *Urtica dioica*. Whilst species distinguishing of sub-associations of fertile Carpathian beech forest requires establishment.

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Table 1. Comparison of floristic structure of the forests with the participation of *Lunaria rediviva* in the Carpathians Mts. (Shortened synthetical table)

Syntaxonomical unit		*Dentario glandulosae-Fagetum lunarietosum*					*Lunario-Aceretum*								*F-A*
Mountain range		BŚ		BŻ		K	BŚ		BŻ			K	S	N	N
Succesive number[1]		1	2	3	4	5	6	7	8	9	10	11[2]	12	13	14
Number of phytosociological relevés		4	9	6	1	9 + 19	15	35	5	3	3	15	9	14	67
Inclination of patches	[%]	0-15	25-45	20-30°	20		0-50	0-50	35-45	20-25	25-45	0-50			
Altitude a.s.l.	[m]	l.d.	525--750	do 760	1005		500--900	450--870	825--875	834--849	870--900	500--900		320--560	400--1310
Number of plant species in the table		19	54	41	42		92	117	47	34	62	92	92	123	137
bryophytes of them		l.d.	1	0	1		9	8	1	l.d.	5	9	6	8	26
Average number of species in the relevé		11	17	20	42	30-29	21	20	27	19	34	21		38	
Ch. *Dentario glandulosae-Fagetum*															
Dentaria glandulosa		1	V	V	1	V/IV	V	V	I 10	1	1/17	V	.	.	.
Symphytum cordatum		.	.	.	1	V	.	.	.	.	.	.	.	.	.
Ch. *Lunario-Aceretum*															
Lunaria rediviva		4	V	V	1	IV/V	V	V	V 8250	2	3/5583	V	III	III	V
D. *Lunario-Aceretum*															
Mercurialis perennis		.	II	V	.	V/IV	IV	IV	V 3750	3	3/3083	IV	V	V	V
Geranium robertianum		.	II	II	1	III	II	I	V 50	2	3/200	II	II	V	IV
Cardamine flexuosa		.	I	III	1	.	I	I	III 30	.	3/50	I	.	II	.
Asarum europaeum		.	II	.	.	II/I	II	II	III 30	.	.	I (II)	II	I	I
Scrophularia nodosa		.	.	.	.	.	I	I	II 20	.	.	I	I	III	I
Ch. *Fagion sylvaticae*															
Fagus sylvatica	a	4	V	V	1	V	III	IV	IV 1210	.	2/2933	III	III	V	II
Fagus sylvatica	a1	.	.	.	.	.	.	.	"	.	1/1250	.	.	.	.
Fagus sylvatica	a2	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Fagus sylvatica	b	.	I	.	.	III	II	II	I 10	1	1/167	II	III	II	I
Fagus sylvatica	c	.	II	IV	.	II/III	I	.	III 30	.	2/33	(I)	"	III	I
Dentaria bulbifera		.	IV	V	1	V	II	III	III 30	1	2/33	II	I	II	I
Festuca altissima		.	.	.	.	.	.	I	.	.	1/17	.	II	III	I
Luzula luzuloides		.	.	.	.	.	.	I	.	.	1/17	.	I	II	.
Prenanthes purpurea		.	.	.	.	I/-	I	I	I 10	.	1/17	I	III	II	I
Rubus hirtus		.	I	.	.	V/III	I	I	I 10	.	1/17	I	.	.	.
Petasites albus		.	II	II	1	II/III	III	II	.	2	.	III	V	.	I

Table 1. (continued)

Succesive number[1]		1	2	3	4	5	6	7	8	9	10	11[2)]	12	13	14
Corydalis cava		.	.	.	1	II	I	.	.	.	.	I	.	.	.
Festuca drymeja		.	.	.	.	II/-	.	.	.	.	.	.	.	.	.
Melica uniflora		.	.	.	.	.	.	.	.	.	.	.	.	IV	I
Dentaria enneaphyllos		.	I	V	.	.	.	.	.	.	.	.	I	.	.
D. *Fagion sylvaticae*															
Senecio ovatus		3*	II*	V	1	III/IV*	III*	III*	V 230*	1*	3/200	III*	V*	III	III
Ch. *Lunario-Acerenion pseudoplatani*															
Polygonatum verticillatum		.	I	.	1	I	I	I	.	.	1/17	I	III	II	I
Ch. *Tilio platyphyllis-Acerion pseudoplatani*															
Acer pseudoplatanus	a	4	I	.	.	V	V	IV	V 3350	.	2/1253	V	V	V	V
Acer pseudoplatanus	a1	.	.	.	.	.	.	.	"	2	1/1250	.	.	.	.
Acer pseudoplatanus	a2	.	.	.	.	.	.	.	"	1	1/17	.	.	.	.
Acer pseudoplatanus	b	.	III	.	.	II/I	I	I	III 30	.	.	IV (I)	IV	II	II
Acer pseudoplatanus	c	.	.	I	.	IV/III	IV	IV	"	2	3/200	"	"	V	II
Ulmus glabra	a	.	I	.	.	I	I	I	.	.	.	II (I)	I	IV	V
Ulmus glabra	b	.	.	.	.	I	.	I	.	.	.	I (-)	III	III	II
Ulmus glabra	c	.	.	.	.	-/II	I	.	.	.	.	"	"	III	I
Tilia platyphyllos	a	.	.	.	.	.	.	.	.	.	.	.	.	I	IV
Tilia platyphyllos	b	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Tilia platyphyllos	c	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Polystichum aculeatum		2	I	I	1	IV/I	I	II	III 30	1	3/37	I	II	I	I
Pulmonaria obscura		.	.	.	.	IV/V	I	I	IV 40	1	2/33	I	III	III	I**
Actaea spicata		.	II	IV	1	III	II	II	IV 130	.	1/17	II	IV	III	II
Anthriscus nitida		.	.	.	.	-/II	I	I	.	.	.	I	III	.	I
Ch. *Alno-Ulmion*															
Stellaria nemorum		3	I	.	1	IV/III	II	I	V 910	3	3/767	(II)	III	I	I
Impatiens noli-tangere		3	III	V	1	III/IV	III	III	V 3050	3	2/750	III	V	III	II
Veronica montana		.	I	V	1	IV/II	II	II	.	3	2/183	II	.	I	.
Chrysosplenium alternifolium		.	.	.	1	II/I	I	I	III 120	1	1/17	I	II	I	I
Circaea alpina		2	I	.	.	.	I	I	.	.	.	I	I	I	.
Circaea lutetiana		.	II	I	.	II/III	I	I	.	.	.	I	.	.	I
Circaea intermedia		.	.	.	.	.	.	.	.	3	.	.	.	.	.
Plagiomnium undulatum	d	.	.	.	.	.	I	I	.	.	.	I	?	I	II

Table 1. (continued)

Succesive number[1]		1	2	3	4	5	6	7	8	9	10	11[2]	12	13	14
Ch. *Querco-Fagetea* et *Fagetalia sylvaticae*															
Acer platanoides	a	3	.	.	.	-/I	.	.	.	.	.	.	I	IV	II
Acer platanoides	b	.	.	.	.	-/I	.	.	.	.	.	I (-)	II	I	I
Acer platanoides	c	.	I	.	.	-/I	I	I	.	.	.	"	"	IV	I
Fraxinus excelsior	a	1	.	.	.	I/II	IV	III	.	.	.	IV	II	III	IV
Fraxinus excelsior	b	.	.	.	.	-/II	II	II	.	.	.	III (II)	II	I	II
Fraxinus excelsior	c	.	I	.	.	I/IV	III	II	.	1	.	"	"	III	II
Tilia cordata	a	.	.	.	.	.	.	.	.	.	.	.	I	II	.
Tilia cordata	b	.	.	.	.	.	.	I	.	.	.	.	I	II	.
Tilia cordata	c	.	.	.	.	.	.	.	.	.	.	.	"	I	.
Cerasus avium	a	.	.	.	.	II/I	.	.	.	.	.	.	.	.	.
Cerasus avium	b	.	.	.	.	.	.	.	.	.	.	.	.	II	.
Cerasus avium	c	1	.	.	.	.	.	.	.	.	.	.	.	I	.
Corylus avellana	b	.	I	.	.	II/III	.	.	.	.	.	.	III	II	II
Corylus avellana	c	.	.	.	.	-/III	.	.	.	.	.	.	"	.	.
Ribes alpinum	b	.	.	.	.	.	.	.	.	.	.	.	.	II	I
Ribes alpinum	c	.	.	.	.	.	.	.	.	.	1/17	.	.	.	.
Lonicera xylosteum	b	.	.	.	.	.	.	.	.	.	.	.	II	I	IV
Lonicera xylosteum	c	.	.	.	.	-/I	.	.	.	.	.	.	"	.	.
Daphne mezereum	b	.	.	.	.	.	.	.	.	.	.	.	II	III	I
Daphne mezereum	c	.	.	.	.	I	.	.	.	.	.	.	"	.	.
Galeobdolon luteum		1	IV	V	1	IV/V	IV	IV	V 2050	2	3/917	IV	IV	V	V
Dryopteris filix-mas		.	V	II	1	V	V	V	V 910	3	3/50	V	IV	V	IV
Galium odoratum		3	III	V	1	IV	V	IV	III 30	.	2/2250	V	IV	IV	IV
Carex sylvatica		.	I	II	1	II/I	I	I	I 10	.	2/33	I	III	I	I
Epilobium montanum		.	.	.	.	.	I	I	II 20	1	1/17	I	III	V	I
Melandrium rubrum		.	.	.	.	.	I	.	.	.	1/17	I	II	.	I
Milium effusum		.	I	.	1	I/III	I	I	.	.	1/17	I	III	III	II
Mycelis muralis		.	.	.	.	I/-	.	I	II 20	.	1/17	.	I	V	II
Paris quadrifolia		.	II	I	1	IV/II	I	I	I 10	1	1/17	I	II	I	I
Phyteuma spicatum		.	.	.	.	I/-	I	I	.	.	1/17	I	II	III	.
Poa nemoralis		.	.	.	.	.	I	I	.	.	1/17	I	II	I	I

Table 1. (continued)

Succesive number[1]	1	2	3	4	5	6	7	8	9	10	11[2]	12	13	14
Salvia glutinosa	.	.	II	.	IV/III	II	I	.	.	1/17	II	.	.	I
Viola reichenbachiana	.	I	.	.	II/-	I	I	.	.	1/17	I	I	IV	I
Lilium martagon	2	I	.	.	.	I	I	.	.	.	I	III	II	I
Allium ursinum	.	II	.	.	.	I	II	.	.	.	I	II	.	.
Anemone nemorosa	.	II	.	1	II	I	I	.	.	.	I	I	I	I
Stachys sylvatica	.	II	IV	1	IV/II	II	II	.	.	.	(II)	III	III	II
Corydalis solida	.	II	.	.	.	.	I	.	.	.	.	.	.	.
Isopyrum thalictroides	.	I	.	1	I/II	I	I	.	.	.	I	.	.	.
Brachypodium sylvaticum	.	.	.	.	-/I	II	II	.	.	.	II	I	II	I
Aegopodium podagraria	.	.	.	.	III	II	II	.	.	.	II	III	I	I
Adoxa moschatellina	.	.	.	.	I/-	.	I	.	.	.	.	III	.	I
Anemone ranunculoides	.	.	.	1	.	I	I	.	.	.	I	.	.	.
Euphorbia amygdaloides	.	.	.	1	II/I	I	I	I 10	.	.	I	.	.	.
Galanthus nivalis	.	.	.	1	-/I	I	I	.	.	.	(I)	.	.	.
Ranunculus lanuginosus	.	.	.	.	III/I	.	I	.	.	.	.	II	.	I
Sanicula europaea	.	.	.	1	II/I	.	I	.	.	.	.	.	.	.
Symphytum tuberosum	.	.	.	1	II/I	.	I	.	1	.	.	.	.	.
Primula elatior	.	.	.	1	II/-	.	.	.	.	.	.	I	I	I
Polygonatum multiflorum	.	.	.	.	I/II	.	.	.	.	.	.	I	.	I
Glechoma hirsuta	.	.	.	.	IV	.	.	.	.	.	.	.	.	.
Carex digitata	.	.	.	.	II/-	.	.	.	.	.	.	I	I	.
Galium sylvaticum	.	.	.	.	.	.	.	.	.	.	.	.	IV	I
Campanula trachelium	.	.	.	.	.	.	.	.	.	.	.	II	IV	II
Melica nutans	.	.	.	.	.	.	.	.	.	.	.	I	IV	.
Stellaria holostea	.	.	.	.	.	.	.	.	.	.	.	I	III	I
Lathyrus vernus	.	.	.	.	.	.	.	.	.	.	.	I	III	I
Hepatica nobilis	.	.	.	.	.	.	.	.	.	.	.	.	III	.
Euphorbia dulcis	.	.	.	.	.	.	.	.	.	.	.	III	.	.
Alliaria officinalis	.	.	.	.	-/I	.	.	.	.	.	.	.	I	II
Atrichum undulatum d	.	.	.	.	.	I	I	.	.	2/33	I	II	I	.
Ch. *Betulo-Adenostyletea*														
Lonicera nigra b	.	.	.	.	.	.	.	.	.	.	.	.	IV	.

Table 1. (continued)

Succesive number[1]		1	2	3	4	5	6	7	8	9	10	11[2]	12	13	14
Lonicera nigra	c	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calamagrostis arundinacea		.	I	.	.	.	II	I	.	.	1/17	II	I	I	.
Ranunculus platanifolius		.	.	.	.	.	.	.	.	.	.	.	II	.	.
Ch. *Epilobietea angustifolii* et *Atropetalia*															
Sambucus racemosa	b	.	I	V	.	-/I	.	.	I 10	.	.	.	III	IV	II
Sambucus racemosa	c	.	.	IV	.	-/I	.	.	"	1	1/17	.	"	.	.
Sambucus nigra	b	.	.	.	.	II	II	I	.	.	.	II	.	I	IV
Sambucus nigra	c	.	.	.	.	IV/III	I	I	.	.	.	" (I)	.	.	.
Rubus idaeus		.	II	I	.	I/-	II	.	III 30	2	2/33	II	II	.	I
Fragaria vesca		.	.	.	.	II/-	.	.	I 10	.	.	.	II	r	I
Bromus ramosus		.	.	.	.	.	.	.	.	.	.	.	.	III	I***
Hypericum hirsutum		.	.	.	.	.	.	.	.	.	.	.	.	II	.
Acompanying species															
Picea abies	a	2	II	.	1	.	I	I	V 2950	.	2/2100	I	II	II	I
Picea abies	a1	.	.	.	.	.	.	.	"	2	1/167	.	.	.	.
Picea abies	a2	.	.	.	.	.	.	.	.	.	1/3	.	.	.	.
Picea abies	b	.	.	.	1	.	I	.	.	.	.	I	I	.	I
Picea abies	c	.	.	.	.	-/I	I	I	.	1	.	"	"	r	I
Abies alba	a	.	II	V	.	III/IV	.	I	V 1560	.	2/33	.	I	I	.
Abies alba	a1	.	.	.	.	.	.	.	"	.	.	.	.	.	.
Abies alba	a2	.	.	.	.	.	.	.	.	.	1/583	.	.	.	.
Abies alba	b	.	II	V	1	III/II	.	.	.	.	1/3	.	II	II	.
Abies alba	c	.	II	.	.	I/IV	.	I	II 20	.	2/33	.	"	II	.
Ribes uva-crispa	b	.	.	.	.	.	.	.	.	.	.	.	.	III	I
Ribes uva-crispa	c	.	.	.	1	I/III	I	I	.	.	.	I	.	.	.
Sorbus aucuparia	a	.	.	.	.	I/-	.	.	.	.	.	.	.	.	.
Sorbus aucuparia	b	.	.	.	.	"	.	.	.	.	.	I (-)	II	r	.
Sorbus aucuparia	c	.	.	.	1	.	I	I	.	.	1/17	"	"	.	I
Oxalis acetosella		1	IV	V	1	V/III	III	III	V 4350	3	3/1750	III	IV	IV	II
Athyrium filix-femina		.	III	V	1	V	III	IV	V 140	3	3/200	III	III	IV	I
Dryopteris dilatata		.	III	I	1	-/I	I	II	IV 40	3	2/33	I	.	II	I
Urtica dioica		1	I	II	.	II/IV	IV	III	V 320	3	2/33	IV	IV	IV	IV
Ajuga reptans		.	.	I	.	II/I	I	I	.	1	1/17	I	II	II	I

Table 1. (continued)

Succesive number[1]	1	2	3	4	5	6	7	8	9	10	11[2]	12	13	14
Dryopteris carthusiana	.	II	I	.	III/I	I	I	.	.	1/17	I	III	.	.
Phegopteris connectilis	.	.	.	.	.	.	I?	II 20	.	1/17	.	II	.	.
Polypodium vulgare	.	.	.	.	.	.	.	.	.	1/17	.	II	I	.
Gymnocarpium dryopteris	.	I	I	.	.	I	I	I 10	.	.	I	II	.	.
Lamium maculatum	.	.	I	1	II/I	.	I	.	.	.	.	II	I	II
Myosotis palustris	.	.	.	.	.	.	.	.	2	.	.	.	.	.
Geranium phaeum	.	.	.	.	II	.	.	.	.	.	.	.	.	.
Galeopsis speciosa	.	.	.	.	-/I	.	.	.	.	.	.	.	II	I
Vicia sepium	.	.	.	.	.	.	.	.	.	.	.	.	III	I
Lapsana communis	.	.	.	.	.	.	.	.	.	.	.	.	II	.
Chelidonium majus	.	.	.	.	.	.	.	.	.	.	.	.	II	I
Dryopteris linnaeana	.	.	.	.	.	.	.	.	.	.	.	.	II	.
Galeopsis pubescens	.	.	.	.	.	.	.	.	.	.	.	.	III	.
Aconitum lycoctonum	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Plagiomnium affine d	.	.	.	.	.	.	.	I 10	.	1/17	.	.	II	.
Eurhynchium zetterstedtii	.	.	.	.	.	.	.	.	.	.	.	II	.	.
Plagiochila asplenioides	.	.	.	.	.	.	.	.	.	.	.	II	.	II
Eurhynchium striatum	.	.	.	.	.	.	.	.	.	.	.	.	I	II
Ctenidium molluscum	.	.	.	.	.	.	.	.	.	.	.	.	.	III
Rhytidiadelphus triquetrus	.	.	.	.	.	.	.	.	.	.	.	.	.	II

Explanations:
1) 1 – (LUDERA 1965), 2 – (WILCZEK 1995), 3 – variant with *Dentaria enneaphyllos* (CABAŁA, OLESIŃSKI 1986), 4 – (STUCHLIK 1968), 5 – Eastern Carpathian form, fertile variant (DZWONKO 1986), 6 – (WILCZEK, CABAŁA 1989), 7 – (WILCZEK 1995), 8 – (KASPROWICZ 1996), 9 – (SZWAGRZYK i in. 1999b), 10 – (PARUSEL 2003), 11 – Carpathian form, mountain forest belt form (KOZŁOWSKA, MATUSZKIEWICZ 1993), 12 – Sudeten form (KOZŁOWSKA, MATUSZKIEWICZ 1993), 13 – ass. nova (GRÜNEBERG, SCHLÜTER 1957), 14 – *Fraxino-Aceretum*, sub-association with *Lunaria rediviva* (OBERDORFER 1992).
2) In this column are placed phytosociological materials by WILCZEK and CABAŁA (1989), which are incorrectly citied by KOZŁOWSKA and MATUSZKIEWICZ (1993) (compare with column 6 of Beskid Śląski). These mistakes in brackens are given.
* et *S. nemorensis*, ** et *P. officinalis*, *** et *B. benekenii*
BŚ – Beskid Śląski Mts., BŻ – Beskid Żywiecki Mts., K – Carpathian Mountains, S – Sudety Mountains, N – Germany.

Table 2. Comparison of floristic structure and contribution of diagnostic species of the forests with the participation of *Lunaria rediviva* in Carpathians Mts

Syntaxons	Mountain Ranges	Number of species:			Contribution of diagnostic species
		common	only occurred in:		
			first unit	second unit	
Dentario glandulosae -Fagetum lunarietosum	Eastern Carpathians Babia Góra Range	39 (42%)*	50 (54%)	4 (4%)	Lack of: *Acer pseudoplatanus*, *Ulmus glabra*, *Urtica dioica*, *Prenanthes purpurea* and *Rubus hirtus*, sporadic participation of *Abies alba* and presence of *Symphytum cordatum* in the Babia Góra Range.
Dentario glandulosae-Fagetum lunarietosum	Beskid Śląski Mts. Babia Góra Range	29 (42%)	26 (38%)	14 (20%)	Lack of: *Acer pseudoplatanus*, *Ulmus glabra*, *Rubus hirtus*, *Allium ursinum*, *Corydalis solida* and *Urtica dioica*, and minute participation of *Abies alba* in the Babia Góra Range.
Dentario glandulosae-Fagetum lunarietosum	Beskid Żywiecki Mts. Babia Góra Range	24 (41%)	17 (29%)	18 (30%)	Exclusive occurrence of *Corydalis cava* and *Thalictrum aquilegiifolium* in the Babia Góra Range and higher participation of *Abies alba* in the Beskid Żywiecki Mts.
Dentario glandulosae-Fagetum lunarietosum Lunario-Aceretum	Eastern Carpathians Babia Góra Range	47 (42%)	41 (36%)	25 (22%)	Lack of: *Ulmus glabra*, *Symphytum cordatum*, *Corydalis cava*, *Galanthus nivalis* and *Thalictrum aquilegiifolium*, sporadic participation of *Dentaria glandulosa* and *Rubus hirtus*, higher participation of *Urtica dioica* and exclusive occurrence of *Phegopteris connectilis* and *Festuca altissima* in the Babia Góra Range.
Dentario glandulosae-Fagetum lunarietosum Lunario-Aceretum	Beskid Śląski Mts. Babia Góra Range	40 (44%)	16 (18%)	34 (38%)	Lack of: *Prenanthes purpurea*, *Phegopteris connectilis* and *Festuca altissima*, higher participation of *Dentaria glandulosa*, decided smaller participation of *Urtica dioica* and *Abies alba*, and exclusive participation of *Ulmus glabra*, *Allium ursinum* and *Corydalis solida* in the Beskid Śląski Mts.
Dentario glandulosae--Fagetum lunarietosum Lunario-Aceretum	Babia Góra Range	30 (35%)	12 (14%)	44 (51%)	Lack of: *Acer pseudoplatanus*, *Ulmus glabra*, *Prenanthes purpurea*, *Rubus hirtus*, *Urtica dioica*, *Phegopteris connectilis*, *Festuca altissima* and sporadic participation of *Abies alba* as well as presence of spring geophytes in *Dentario glandulosae-Fagetum lunarietosum.*
Lunario-Aceretum	Beskid Śląski Mts. Babia Góra Range	63 (45%)	65 (47%)	11 (8%)	Exclusive occurrence of *Ulmus glabra*, *Corydalis cava*, *C. solida*, *Thalictrum aquilegiifolium*, *Anemone ranunculoides* and *Galanthus nivalis*, decided higher participation of *Dentaria glandulosa*, smaller participation of *Polystichum aculeatum* and *Urtica dioica* as well as sporadic participation of *Abies alba* in the Beskid Śląski Mts.

Table 2. (continued)

Syntaxons	Mountain Ranges	Number of species:			Contribution of diagnostic species
		common	only occurred in:		
			first unit	second unit	
Lunario-Aceretum	Thuringian Forest (Germany) Babia Góra Range	52 (36%)	71 (49%)	22 (15%)	Lack of: *Ulmus glabra*, decided higher participation of *Abies alba* and *Polystichum aculeatum*, smaller participation of *Festuca altissima* as well as exclusive participation of *Dentaria glandulosa*, *Phegopteris connectilis* and *Rubus hirtus* in the Babia Góra Range.
Lunario-Aceretum Dentario glandulosae--Fagetum lunarietosum	Beskid Żywiecki Mts. Babia Góra Range	24 (37%)	23 (36%)	17 (27%)	To pay attention a little participation of species distinguished as diagnostic for both syntaxons. Only *Abies alba*, *Acer pseudoplatanus* and *Urtica dioica* occured in them (the last two species with higher participation in *Lunario-Aceretum*).

* percent of total flora of both compared units

Wika S. and Woźniak G. (eds.)
Threats, protection and transformation of vegetation of the Upper Silesia and adjacent areas
University of Silesia, Katowice

ISBN 978-83-906910-9-1

ALTITUDINAL DISTRIBUTION OF THE *PETASITETUM KABLIKIANI* PHYTOCOENOSES ON THE NORTHERN SLOPES OF THE BABIA GÓRA MASSIF (HIGH BESKID, WESTERN CARPATHIANS)

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ABSTRACT. *Petasitetum kablikiani* was described from the Babia Góra massif by Walas (1933) as the subalpine association. In spite of many floristical and phytosociological studies from this area, none of the authors mentioned about untypical altitudinal distribution of the community. At this paper the distribution of studied patches is described. Moreover the phenomenon analysis in respect to its reasons is considered.

KEY WORDS: *Petasitetum kablikiani*, discontinuity, altitudinal distribution, subalpine zone, the Babia Góra Mt.

INTRODUCTION

Phytocoenoses of the *Petasitetum kablikiani* association, found within the Babia Góra massif, form (on specified type of habitat) two separate succession ranges, depending on plant and climatic belt they occur in. The investigated association, which can be an initial succession phase, transforms, in the specified geomorphological conditions, into alder forests with butterbur (*Alnetum incanae* with *Petasites kablikianus*) in scarp-foot of the massif, and into tall-herb association (*Adenostyletum alliariae*) in subalpine zone. Simultaneously the *Petasitetum* phytocoenoses are forming all range of transitional stages. Up to now only the highest zone of the massif was investigated, butterbur tall-herbs from the scarp-foot were not taken into account (WALAS 1933; CELIŃSKI, WOJTERSKI 1963, 1983). So nobody proved that *Petasitetum kablikiani* in this area is characterised by untypical discontinuity in altitudinal distribution of the association patches. This study on the one hand fills the gap, and on the other one, makes a historical sketch of resources of *Petasitetum kablikiani* from before 1997, when numerous stands of butterbur tall-herbs and alder forests with *Petasites kablikianus* which occurred on the stream-banks were destroyed by the flood.

METHODS

Field investigations were carried out between 1992 and 1995. The studied area spread on the northern slopes of the Babia Góra massif (because there *Petasites kablikianus* occurs upper

the timber line) and also included a slope-foot as far as a point where two biggest streams of Babia Góra – Jałowiecki and Jaworzyna – make a junction. Analysed phytocoenoses were located with a topographical map in the scale 1:10 000. Distributional map illustrated the only stands on natural habitats (Fig. 1). The stands on anthropogenic habitats were not regarded on the map. Altitudinal limits of the lower and upper zone of investigated association's occurrence were stated. The altitude a.s.l. in all analysed plots was fixed with AVOCET hypsometer.

RESULTS

Phytocoenoses with *Petasites kablikianus* were found on the northern slopes of Babia Góra massif, in two separated altitudinal zones. They had no intermediate stands (Fig. 1). Associations with *Petasites kablikianus* as a dominant species are distributed only along stream-banks flowing from the northern slopes, in the lower zone. It has to be noted that *Petasites kablikianus* constantly occurs on the roadsides, which skirt along each stream valley. The species forms wide, dense phytocoenoses on natural habitats, while on the anthropogenic ones – just small clusters of specimens occur. However distribution of the associations in particular stream valleys is irregular and scattered. It also depends on management and topographic features of each valley. The most optimal conditions for butterbur vegetation occur in these parts of the valley where slope inclination decreases, and a valley-floor becomes wider and more flat. After the spring water rise, during vegetation season, fast flowing streams expose wide strip of the gravel heaps, creating convenient habitat for tall-herbs with butterbur. Also essential factor is human impact. The more the valley is cultivated and the more human activities are distinct, the less butterburs are on the stream-side. The *Petasitetum kablikiani* association founds the best growth conditions in the Jaworzyna stream valley (600-850 m a.s.l.), Rybny stream valley (640-785 m a.s.l.) and partly on the Marków stream-side (630-780 m a.s.l.). In these valleys the most advantageous geomorphological conditions and the faintest anthropopressure were stated.

In the altitudinal zone above timberline, *Petasitetum kablikiani* association is not represented with such abundance like on the scarp-foot of the Babia Góra Mt. There were observed approximately twenty patches. They were in different succession stages. Most of them occurred near by the „Akademicka Perć" (yellow touristic route), on the northern slopes of the massif. They covered the small areas on the steep slopes, moist, shaded chutes and natural depressions covered up with shredded weathering rock material. The most initial stadium (separate clumps of butterburs) – were observed in chute Piarżysty Żleb. There is one of the most mobile and unstable habitats occupied by *Petasites kablikianus* above the timberline. Almost every year some new landslipes occur there. The lowest, situated in that zone, plots of butterbur tall-herbs occurred above upper limit of subalpine forests with mountain ash *Athyrio-Sorbetum* (BORYSIAK 1985). The highest situated phytocoenoses were found about 1600 m a.s.l. – in the chute Poszukiwaczy Skarbów, which runs from the top (Diablak) and in the cirque below the Kościółki – a point on western part of the massif ridge; the place of the longest snow-cover lying.

On the base of field investigations, the discontinuity in altitudinal distribution of natural *Petasitetum kablikiani* phytocoenoses was found. The lower zone of their occurrence is contained between 500 to 800 m a.s.l., the higher one – between 1400-1600 m a.s.l. Against the background of the vertical plant zonation on the Babia Góra Mt., it was found that *Petasitetum kablikiani* patches occured in the lower parts of the forest zone and in the central part of the

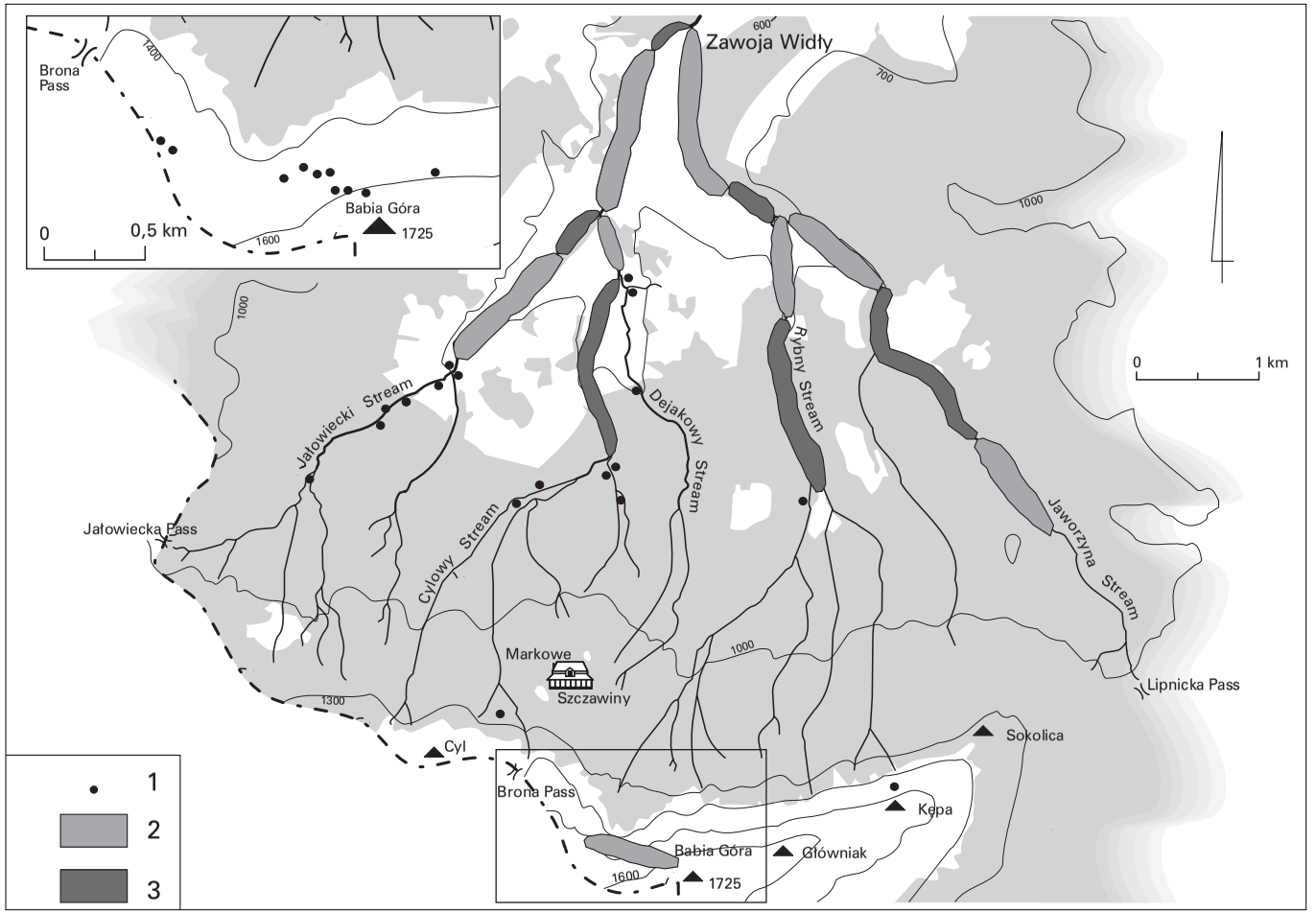

Fig. 1. The map of the *Petasitetum kablikiani* phytocoenoses distribution on the northern slopes of the Babia Góra Mt.
Explanation: 1 – Single localities, 2 – Zone of separated patches of *Petasitetum kablikiani*, 3 – Zone of continuous distribution of the studied patches.

subalpine zone (Fig. 2). Difference between the lowest altitude of upper zone and the highest point of lower zone was about 600 meters. *Petasitetum kablikiani* phytocoenoses have not been found in the altitudinal belt 900-1400 m a.s.l.

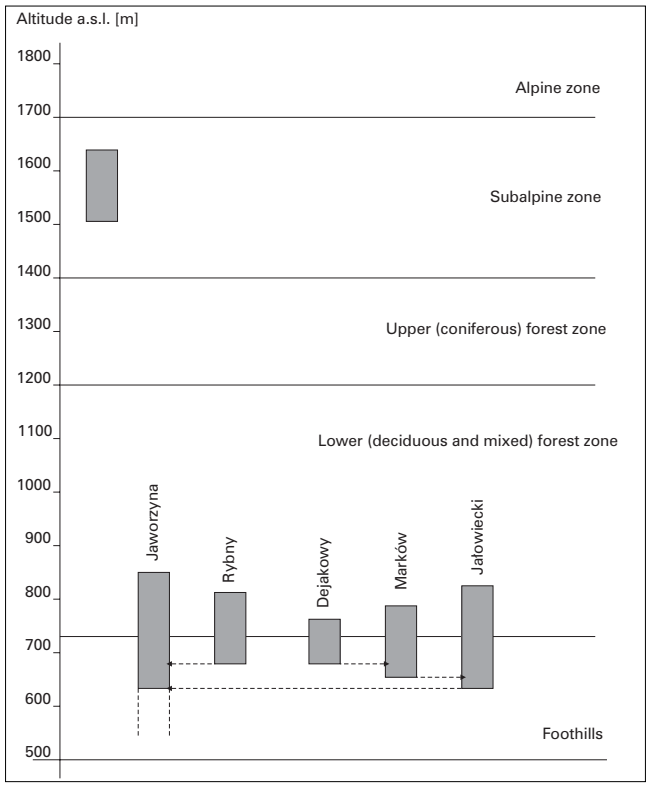

Fig. 2. Altitudinal distribution of the studied community

DISCUSSION

Analysis of *Petasitetum kablikiani* distribution on the northern slopes of the Babia Góra Mt. proved discontinuity in its altitudinal distribution. What is striking – it is a shortage of any information about such type of the community distribution in the papers concerned as well with the Babia Góra Mt., as well with other mountains vegetation.

Typical plots of *Petasitetum kablikiani* association first time was described from subalpine zone of the Babia Góra Mt. by WALAS (1933). Recently the association is often omitted in the papers treated of mountain vegetation. Perhaps the reason is floristical poverty of the community. There is a lack of information about particular analysis of altitudinal distribution of the association in the other mountains. Only communities occured on the stream-banks, in the forest zone, were described as typical, within the whole geographical range (SZAFER et al. 1925; PAWŁOWSKI et al. 1927; ZLATNIK 1928; PAWŁOWSKI 1946; BORZA 1963; ŠMARDA 1963; BORZA, BOSCAIU 1965; MAGIC et al. 1966; PACYNA et al. 1966; ŠMARDA, RAUŠER 1966; MICHALIK 1967; STUCHLIK 1968; STOJKO et al. 1982; DENISIUK 1985; SANDA et al. 1986; BRZEG 1989; MIREK

1993; KORNAŚ et al. 1995; MIREK, PIĘKOŚ-MIRKOWa 1995). Occurrence of the vegetation plots with *Petasites kablikianus* as a dominant species in the subalpine zone was observed just by ŠOUREK in Karkonosze Mts. (1969), WALAS (1933), CELIŃSKI, WOJTERSKI (1963), SZWED (1986) on Babia Góra massif, MIREK and PIĘKOŚ-MIRKOWA (1995), and UNAR at all. (1985) in Tatra Mts. and also HADAČ (1969) in Bielskie Tatra Mts. MIREK and PIĘKOŚ-MIRKOWA qualified the occurence frequency of the association in the subalpine zone in Tatra Mts. as sporadic. It may be that character of the subalpine plots (small area, the rate of their transforming into the optimal in subalpine zone tall-herbs associations) causes, that they are omitted in vegetation registers from other mountains areas, or are described as the other associations (i. e. *Petasito-Senecietum nemorensis* – HADAČ 1969). Comparison of *Petasites kablikianus* distribution in different mountain ranges confirms altitudinal discontinuity within Babia Góra massif (Fig. 3). However delimitation of the species altitudinal distribution is made often on a base of extreme stands mentioned by the authors, without analysis of transitional positions.

The question – if this discontinuity is universal but not observed phenomenon, or if it is a local phenomenon, specific for the Babia Góra Mt. – without complex investigations, remains unanswered.

Analysis of habitat conditions (UZIĘBŁO 1997, unpbl.) allowed to state that *Petasites kablikianus* is a pioneer species, not proof enough against ecological competition. Therefore it occurs on habitat devoided of the competition such as: landslides, roadsides and especially on the stream gravel-heaps. The seed germination at the same season (PODBIELKOWSKI 1995) enables rapid occupancy of each initial habitat. Dynamic internodes growth causes habitat stabilization, and then it is possible for other species to settle the area down. The pioneer character of the association phytocenoses is confirmed by accidental floristic composition depending on neighbouring communities.

On the gravel heaps in lower zone, forest and meadow species are not enough competitive to very expansive *Petasites kablikianus*, which appears as one of the first species overgrowing new habitat (UZIĘBŁO 2001). In subalpine zone tall perennial plants (*Adenostyles alliaria*, *Cicerbita alpina*, *Doronicum austriacum*, *Geranium sylvaticum*, *Ranunculus platanifolius)* are more competitive. In this vegetation belt *Petasitetum kablikiani* occurs as small, isolated plots, characterized by dynamic succession into optimal subalpine vegetation (*Adenostyletum alliariae*). Floristic similarity *Petasitetum* to *Adenostyletum* from Babia Góra Mt. was mentioned by WALAS (1933), CELIŃSKI and WOJTERSKI (1963) as well.

Characterization of habitats occupied by analysed association obtained during investigations carried out on the northern slopes of the Babia Góra Mt. (UZIĘBŁO 1997, unpbl.) allows to state the type of habitat preferred by particular phytocenoses. The main conditions for the presence of the *Petasitetum kablikiani* patches are the following:

· unconsolidated substratum (stone rubble) mixed with fine soil particules,

· considerable humidity and insolation,

· faint intraspecific competition.

Differentiation in such habitat factors as: soil composition, acidity, content of biogenic elements (Mg, K, P, N, C) and organic matter indicates considerable ecological tolerance of the dominant species. Phytocenoses of the *Petasitetum kablikiani* were described from habitats with different soil substratum – limestone, serpentine marble, quartzite, granite, flysch, sandstone (BORZA 1963; TOMAN, STARÝ 1966; ŠMARDA, RAUŠER 1966; STUCHLIK 1968; HADAČ 1969; ŠOUREK 1969; STOJKO et al. 1982; SANDA et al. 1986; UZIĘBŁO 1997, unpbl.). It is supposed that chemical properties are not important enough to determine the community distribu-

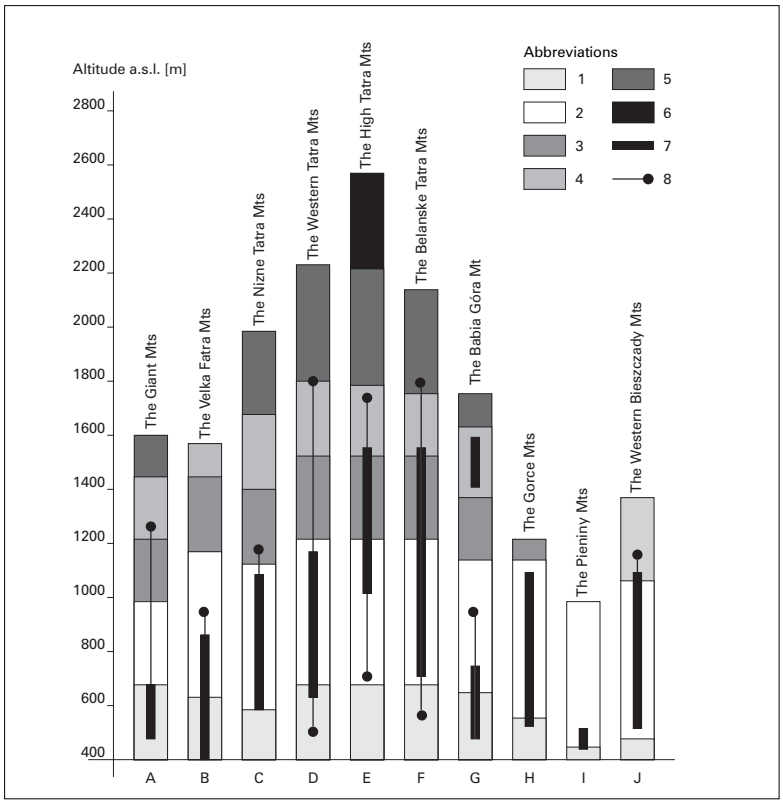

Fig. 3. Altitudinal ranges of the communities with *Petasites kablikianus* from different mountain areas

Explanation: 1. – foothills, 2. – forest zone, 3. – spruce forest zone, 4. – subalpine zone, 5. – alpine zone, 6. – subnival zone, 7. – range of the *Petasitetum kablikiani* patches, 8. – range of the species *Petasites kablikianus.*

A – Šourek (1969); B-D – Toman, Starý (1966); E – Mirek, Piękoś-Mirkowa (1995); F – Toman, Starý (1966), Hadač (1969); G – Walas (1933), Szwed (1986), Uziębło (1996); H – Kornaś (1957, 1967); I – Šourek (1962), J – Jasiewicz (1965).

tion. They may influence on floristic composition of species accompanying *Petasites kablikianus*, and these differences are noticed in *Petasitetum kablikiani* patches from various mountain areas (Uziębło 1997, unpbl.).

Formation and dynamics of *Petasitetum kablikiani* phytocoenoses observed during field investigations partly explain the altitudinal discontinuity or their shortage in the upper mountain (spruce forest) zone and lower part of subalpine zone. In the forest zone mentioned above, occupied by dense belt of forest vegetation, suitable habitats are practically absent. Development of *Petasitetum kablikiani* phytocoenoses is prevented on the one hand by physiographical features (slopes inclination, valleys configuration, shortage of gravel heaps) and on the other one, by insolation and competition of the optimal to this zone species. Tall herbs communities with *Aruncus dioicus* or *Petasitetum albi* patches occur in lower part of forest zone (750-1150 m a.s.l.), whereas the *Athyrietum alpestris* patches occupy analogous habitats in spruce zone (1150-1330 m a.s.l.). It is possible that these species equally expansive like

Petasites kablikianus are too competitive. Forest vegetation is characteristic also to lower part of subalpine zone (1330-1400 m a.s.l.), and also there *Petasitetum kablikiani* phytocoenoses appeare above line of forest with *Sorbus aucuparia* var. *glabrata* range (1440 m a.s.l.), (*Athyrio-Sorbetum* – BORYSIAK 1985). Other fact is the occurrence of analysed phytocoenoses in low part of forest zone (600-800 m a.s.l.) on landslides, always nearby the streams. Probably the mechanism of seed dispersion (anemochory) makes the penetration of forest areas too difficult, if the landslides are too distant from the stream valleys.

Biometric analysis of *Petasites kablikianus* specimens proved a similarity between specimens from subalpine population and specimens from the lowest plots (about 500-600 m a.s.l.), (UZIĘBŁO 1997, unpbl.). This fact would confirm the primary character of subalpine population. It is possible that its diaspores driven by strong descending air current, settled the lowest situated gravel heaps. An angle of northern slopes is so considerable, that anemochoric fruits of *Petasites kablikianus* have to cross relatively short distance, to land beyond forest belt. They could spread in the valley interior owing to valley wind (PACYNA et al. 1966), people or animals. The similar way of *Petasites paradoxus* dispersion was observed in the Alps (WALAS 1938, HORVAT et al. 1974, ELLENBERG 1978). It is difficult to say how long is duration of *Petasites kablikianus* expansion. WALAS (1933) describing subalpine *Petasitetum kablikiani* mentioned, that he observed "only a few small plots" with *Petasites kablikianus* on the streambanks at the foot of the Babia Góra Mt. It is really striking in relation to contemporary distribution of the phytocoenoses in this zone. Maybe the main reason was road-building along stream valleys and across the Lipnicka Pass. Stream gravel was used for road surficing. It could be possible that intensive gravel harvesting spoiled natural valley layout and made a secondary settlement for subalpine population.

It is impossible to univocally say, how widespread the phenomenon of this altitudinal discontinuity is. But it is important to lay out emphasis on the fact that Babia Góra Mt. has separate character. ŁAJCZAK recited (1995) the following individual characteristics:

- isolation of the massif from the others,
- the biggest height in the Polish part of the Western Carpathians (except Tatra Mts.),
- specific microclimate,
- and in exceptional cases, good preservation of primary phytocenotic relations.

All that gives the impression that the Babia Góra Mts. is the some kind of natural phenomenon, which could not be compared to other mountains. Its specific character is reflected in vegetation. There are the one of two stands of *Laserpitium archangelica* in Poland and only one of *Cerastium alpinum*. Some kind of specific character have also associations *Saxifrago-Festucetum versicoloris babiogorense*, *Junco trifidi-Festucetum airoides* and *Deschampsio-Luzuletum*, described from the Babia Góra Mt. (CELIŃSKI, WOJTERSKI 1963, 1983), and other like: *Chaerophylletum hirsuti*, *Salicetum silesiacae*, *Sorbo-Aceretum* supposed as endemic plant associations.

Summarising the discussion – the question, if discontinuity of altitudinal distribution of *Petasitetum kablikiani* is universal, is still unanswered, because of a lack of particular information. It also could not be excluded that the discontinuity is specific to the Babia Góra Mt.

CONCLUSIONS

Analysis of ecological conditions of *Petasites kablikianus* occurrence on the northern slopes of the Babia Góra Mt proved as following:

1. discontinuity of altitudinal distribution of the *Petasitetum kablikiani* patches,

2. *Petasites kablikianus* is pioneer species; it allows to settle specific type of habitat, but simultaneously it restricts the possibilities of expansion of the species,
3. analysed reasons of the discontinuity phenomenon may suggest the primary character of subalpine population,
4. detailed analysis of altitudinal distribution of communities with *Petasites kablikianus* within whole range of this species is essential to state, if the discontinuity is universal phenomenon.

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