10.2478/umcsbio-2013-0005

ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. LXIX, 1 SECTIO C 2014

MARIA ZIAJA[1], TOMASZ WÓJCIK[2]

Department of Ecology and Nature Protection, Rzeszów University,
ul. Cicha 2 A, 35-326 Rzeszów, Poland, [1]e-mail: mziaja@univ.rzeszow.pl, [2]antomi7@wp.pl

Thermophilic plant communities in Natura 2000 site "Łąki nad Wojkówką" PLH 180051 – Podkarpacie Province

Zbiorowiska roślinności ciepłolubnej na obszarze Natura 2000 „Łąki nad Wojkówką" PLH 180051 – w województwie podkarpackim

SUMMARY

Xerothermic grasslands are among the most valuable and, at the same time, the most vulnerable elements of the natural environment of Poland. Their high natural value is reflected in the presence of numerous species of plants originating from warmer, steppe regions of Europe, which increase the biodiversity of local ecosystems. In our climate circumstances, such plant communities have extrazonal character and only occur in places with specific habitat conditions. The grasslands generally occupy small areas, usually in warm and dry habitats, mainly on slopes exposed to strong sunlight and slopes with southern exposures. The aim of the research was to provide a phytosociological characteristics of the thermophilous grasslands PLH 180051 – "Łąki nad Wojkówką", their distribution and threats as well as the prospects for conservation of the communities. On the study area, a significant share belongs to the communities with species characteristic of the *Festuco-Brometea* class and *Trifolio-Geranietea* class. Lack of species characteristic for lower syntaxonomic units does not allow for them to be classified as an association.

Key words: xerothermic grasslands, nature protection, Carpathians

STRESZCZENIE

Murawy kserotermiczne należą do najcenniejszych, a jednocześnie najbardziej zagrożonych elementów środowiska przyrodniczego w Polsce. O ich wysokiej wartości przyrodniczej świadczy obecność gatunków roślin pochodzących z cieplejszych i stepowych obszarów Europy, które zwiększają różnorodność biologiczną miejscowych ekosystemów. W naszych warunkach klimatycznych zbiorowiska tego typu mają charakter ekstrazonalny i pojawiają się w miejscach o szczególnych warunkach siedliskowych. Murawy zajmują na ogół niewielkie powierzchnie, zazwyczaj w cie-

płych i suchych siedliskach, głównie na silnie nasłonecznionych stokach i zboczach o południowej ekspozycji.

Celem podjętych badań była charakterystyka fitosocjologiczna muraw ciepłolubnych w obszarze PLH 180051 – „Łąki nad Wojkówką", ich rozmieszczenie oraz zagrożenia, jak również możliwości ochrony prezentowanych zbiorowisk. Na badanym terenie znaczny udział mają zbiorowiska z gatunkami charakterystycznymi dla klasy *Festuco-Brometea* i *Trifolio-Geranietea*. Brak gatunków charakterystycznych dla niższych jednostek syntaksonomicznych nie pozwoliło zaklasyfikować ich do żadnego zespołu.

Słowa kluczowe: murawy kserotermiczne, ochrona przyrody, Karpaty

INTRODUCTION

Xerothermic grasslands are thermophilic grassy communities of steppe character which occurrence is conditioned by climatic, soil and orographic factors (5). Xerothermic plant communities in Poland are mainly located in the regions of lower and middle Odra river and Vistula river, on the Kraków-Częstochowa Upland, Małopolska Upland, in the Toruń-Eberswalde Glacial Valley and on the Lublin Upland (17). They are small, insular areas detached from the main range and they constitute refugia of vegetation which reached Poland after the last glaciation. They usually inhabit warm and dry habitats on calcareous substrate on sunny, south facing slopes (4). Occasionally they appear on hillsides of anthropogenic origin, such as slag heaps, railway embankments or artificial ski slopes (5). Xerothermic grasslands are considered one of the richest habitats for flora, clustering numerous, rare and protected species (12, 14) as well as a refuge for threatened thermoxerophilic insect taxa (2, 28).

The communities currently belong to the most precious and, at the same time, the most seriously threatened elements of the natural environment in Poland. Their high natural value is indicated by the presence of species of plants from warmer and steppe regions of Europe, which increases the biodiversity of native ecosystems. Due to their unique values, the habitats were placed in Annex I of the Habitats Directive (8), as sites of special significance to the EEC (5).

In Podkarpacie Province there are a few places of xerothermic grasslands, mainly near Przemyśl (24, 12, 27), in the remaining part of the region they are extremely rare and heavily fragmented. More frequently occur thermophilic forms of meadows in the region of the Przemyśl Foothills and the Słonne Mountains (12, 13) as well as Strzyżowskie Foothills (25).

In Carpathian Foothills xerothermic grasslands are rather rare communities, appearing mainly in the valleys of big rivers, on slopes with southern exposure. They occupy small areas which syntaxonomic affiliation is difficult to classificate, with a large share of species from *Trifolio-Geranietea sanguinei* and *Molinio-Arrhenatheretea* classes (15, 7, 25, 21).

Communities of that type have been recorded on the site of villages of Wojkówka, Rzepnik, Odrzykoń. In order to protect these, a Natura 2000 site "Łąki nad Wojkówką" (PLH 180051) has been established, comprising three meadow-grassland complexes preserved on the sides of small hills above the valley of the Wisłok river.

The aim of the study was to provide phytosociological characteristics of the *Festuco-Brometea* grasslands located in the villages of Wojkówka, Rzepnik and Odrzykoń within the Natura 2000 site "Łąki nad Wojkówką", as well as to recognise the threats of the phytocoenoses and possible methods of their conservation.

STUDY AREA AND METHODS

The study included patches of dry grasslands with a total area of 9,6 ha, located in the Natura 2000 site, namely "Łąki nad Wojkówką" (PLH 180051). The area is located in the Podkarpacie Province, in the district of Krosno (Fig. 1). The main objective of the protection of this area is to maintain thermophilic meadow complexes with fragments of dry grasslands, which are extremely rare in the Carpathians.

According to physical-geographical classification by Kondracki (10), the area lies in two mesoregions: Jasielsko-Krośnieńska Basin and Dynowskie Foothills belonging to the macroregion of Środkowobeskidzkie Foothills, Outer Western Carpathians subprovince and the province of Western Carpathians with Podkarpacie.

The area comprises three meadow-grassland complexes preserved on the slopes of small hills towering above the Wisłok valley, located in the floor of the foothills. The Wojkówka site is located on the slopes of Ptasznik hill (369 m a.s.l.) including a steep bluff above the road and part of the quarry. In Rzepnik another isolated grassland can be found located in the forest on the slopes of Kiczary hill (438 m a.s.l.). Grasslands occupy about 20% of the surface of the steep hillside. On the remaining area dominate submontane fresh meadows, currently not used. The last site is located near the village of Odrzykoń, on the sides of Piekło hill (386 m a.s.l.), and it is a mosaic of grasslands and shrubs (20).

Field studies were carried out in 2012–2013 within the three villages: Rzepnik, Odrzykoń and Wojkówka, during which 37 relevés were recorded, according to the Braun-Blanquet method. The syntaxonomic classification was based on the Matuszkiewicz (16), whereas the nomenclature of vascular plant species was provided according to Mirek et al. (18). The relevés were entered into the Turboveg phytosociological database where they underwent numerical classification by means of the MULVA-5 program – based on the presence of the species (binary scale 0, 1). Later the relevés were grouped on the basis of Ward's method – minimum variance clustering (9).

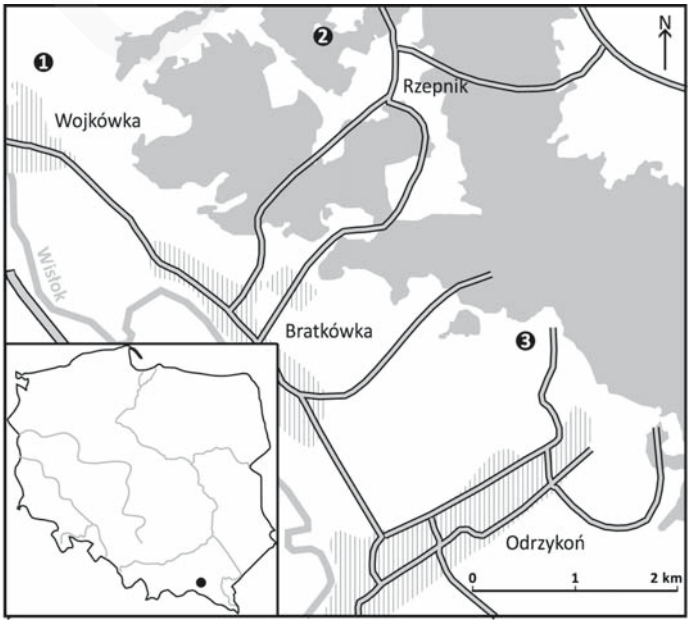

Fig. 1. The location of study area: 1 – Wojkówka, 2 – Rzepnik, 3 – Odrzykoń

RESULTS AND DISCUSSION

As a result of the numerical classification of the relevés, 5 groups were distinguished (Fig. 2), which were later classified into 4 different types of communities (Table 1, 2, 3). In the study area, there were no species specific to the associations recorded in other parts of Poland, but there were noted species characteristic of higher syntaxonomic units (order, class). The classification into communities was guided by the occurence of species which were most strongly represented and had a high degree of coverage.

A total of 111 vascular plant species were recorded in the thermophilic communities in the study area. The structure of the community with *Hieracium bauhinii* is formed by 47 taxa, while a slightly higher number of 52 species makes up the thermophilous plant communities that represent of the *Trifolio-Geranietea sanguinei* class. The community with *Melampyrum arvense-Salvia verticillata* consisted of 62 species and the richest of all was the community with *Centaurea*, *scabiosa*, with as many as 87 taxa recorded.

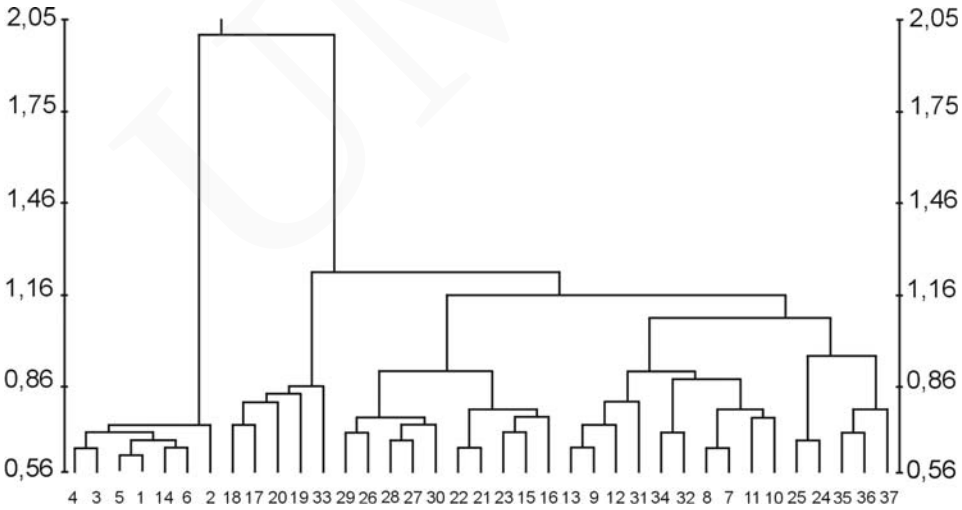

Fig. 2. Classification of relevés: dendrogram based on the species presence/absence, minimum variance clustering method used (Ward's method). The numbers are field numbers of relevés.

Patches of the *Hieracium bauhinii* community (Table 1, relevé 1–7) were formed on steep 50° slopes of SW exposure. 18 to 32 species were present in the relevés, with an average of 24. The coverage is high and amounts to 80% – 90%. The physiognomy of the patches is shaped by *Hieracium bauhinii* which is accompanied by species of the *Festucetalia valesiacea* order – *Melampyrum*

arvense, and less frequently, *Salvia verticillata*. Among taxa characteristic of the *Festuco-Brometea* class, only one species was noted with high phytosociological constancy V – *Euphorbia cyparissias*. Other species typical for the class *Trifolio-Geranietea sanguinei* also occurred in the patches of the community: *Origanum vulgare* (V), *Agrimonia eupatoria* (IV), and less frequently: *Coronilla varia* and *Trifolium medium* (III). The presence of a relatively large number of species of the order *Arrhenatheretalia* and of the class *Molinio-Arrhenatheretea,* like *Arrhenatherum elatius, Galium mollugo, Lotus corniculatus, Knautia arvensis, Plantago lanceolata* and *Vicia cracca* (V), indicates the fact that the community is evolving into a thermophilous form of fresh meadow. Noteworthy is the presence of other, especially thermophilous species such as: *Sanguisorba minor, Ranunculus polyanthemos, Polygala comosa, Medicago sativa, Echium vulgare.*

The community of the *Trifolio-Geranietea sanguinei* class (Table 1, relevé 8–12) is represented by just 5 relevés. It has developed in Odrzykoń and Wojkówka mainly on the plateau and top areas of the hillside with a slope between 10 and 50 degrees and varied NE, E, or S exposure. The number of species in the relevés ranged from 22 to 24, with an average of 23, whereas the cover of the herbaceous layer was between 80 and 100%. The community was distinguished due to occurrence of a high number of species characteristic of the *Trifolio-Geranietea* class. A constant element in the patches are *Origanum vulgare, Agrimonia eupatoria*, *Galium verum*, *Clinopodium vulgare*, less frequently appear *Coronilla varia* (II). Species typical of the class *Festuco-Brometea* occur rarely: *Centaurea scabiosa*, *Hieracium bauhinii*, *Melampyrum arvense*, *Euphorbia cyparissias* i *Gentiana cruciata* (I–II). The order *Arrhenatheretalia* is most numerously represented by: *Arrhenatherum elatius*, *Galium mollugo* and *Knautia arvensis*, while the class *Molinio-Arrhenatheretea* is represented by *Vicia cracca* and *Festuca rubra*. The patches are especially valuable since they are the only place on the study area where *Gentiana cruciata* has its habitat.

The community with *Melampyrum arvense-Salvia verticillata* (Table 2) has been noted from the sunny and warm sides of the hill in Odrzykoń, on slopes of S, SE and SW exposure and inclination of up to 5^{o}–30^{o}. The share of species in the relevés is considerably high and ranges between 22 to 36, with an average of 30; the plant cover is dense and reaches 100%. The structure is dominated by species characteristic of the *Festucetalia valesiacea* order. *Melampyrum arvense* and *Salvia verticillata* have been noted with the highest constancy and abundant, *Hieracium bauhinii* occurs more rarely. The *Festuco-Brometea* class is most represented by *Euphorbia cyparissias* (V) and *Plantago media* (IV), less frequently by *Centaurea scabiosa* (III), *Allium oleraceum* and *Poa compressa* (II). Species typical of thermophilous forest margin of the *Trifolio-Geranietea*, such as: *Origanum vulgare*, *Galium verum*, *Agrimonia eupatoria*, *Coronilla varia* remain a

constant element. Species of the order *Arrhenatheretalia*, typical for the thermophilous variant, are also frequent, especially *Arrhenatherum elatius*, whereas the remaining species like *Galium mollugo*, *Dactylis glomerata*, *Achillea millefolium*, *Knautia arvensis*, *Leucanthemum vulgare* occur here permanently, however, they do not attain a high degree of cover. Patches of the community are marked by the presence of bushes characteristic of thermophilic facies of the *Rhamno-Prunetea* class, such as: *Rosa canina*, *Prunus spinosa, Crataegus monogyna*, *Cornus sanguinea* and *Acer campestre* achieving II constancy, which indicates the process of slow succession.

The community with *Centaurea scabiosa* (Table 3) is the most frequent on the area under investigation and has been reported from Wojkówka, Rzepnik and Odrzykoń. It developed on 5º – 45º slopes of varied NE, S, SE, SW exposure. The community was characterized by high species richness of 87 taxa; the number of species in the relevés ranged from 19 to 36, with an average of 28. The plant cover was between 75 and 100%. A considerable share in the structure of the community belongs to the species typical for the class, *Centaurea scabiosa* was noted with V constancy and a very high degree of cover. *Euphorbia cyparissias*, *Plantago media* and *Poa compressa* were noted with II and IV constancy. The order *Festucetalia valesiaceae* was represented by 2 species, which are frequent and abundant: *Melampyrum arvense* and *Salvia verticillata*. Among the species of the *Trifolio-Geranietea* class common are: *Origanum vulgare*, *Agrimonia eupatoria*, *Galium verum*, *Coronilla varia* (IV), less frequent *Medicago falcata* (III), *Clinopodium vulgare* and *Trifolium medium* (II). An increased share of meadow species was observed, especially of the order *Arrhenatheretalia*. Constant elements were *Arrhenathereum elatius, Achillea millefolium*, less frequent and less numerous were *Galium mollugo, Knautia arvensis, Daucus carota, Dactylis glomerata*. Among the *Molinio-Arrhenatheretea* class, the most common was *Festuca rubra* (IV). Within this community there were no shrubs or trees observed, apart from isolated individuals. A considerable share of other and sporadic species indicates high floristic richness of the communities.

The Podkarpacie is a region where xerothermic communities are relatively rare and occur in the form of small, scattered patches which structure is often simplified and lacks of characteristic species for a given community reported from other parts of Poland. This is the reason that communities with a dominant species are distinguished (27), which was observed on the research area.

Including such atypical grasslands in the syntaxonomic system through giving them a rank and assigning the impoverished form to a specific community, seems problematic. Therefore, the authors have proposed a broad approach in the range of the community by indicating the dominant species.

In the Carpathians, grassland species do not have its centre of distribution. Unlike for example the Małopolska Upland, typical xerothermic grasslands have

not developed here. The majority are anthropogenic and semi-natural habitats, hence in the submontane level the communities occur with impoverished taxonomic composition, which has been confirmed by Oklejewicz (21) from the area of Jasło-Sanok Basin as well as Towpasz (25) from the Strzyżów Foothills, where fragments of xerothermic patches can be encountered on dry and sunny slopes in the valleys of big rivers (Wisłoka and Wisłok) of southern exposure (25).

In the patches of the studied communities, species of the *Molinio-Arrhenatheretea* class have a high share, which may confirm their transitional character. Phytocoenoses of similar structure with species of the classes *Molinio-Arrhenatheretea* and *Festuco-Brometea* from the Przemyśl Foothills, have been recorded as a mountain meadow in the subcommunity of thermophilous fresh meadow *Arrhenatheretum elatioris centauretosum scabiosae* (11,13). Kucharzyk (2010) notes that the thermophilic communities of the Carpathian Foothills are of an intermediate character between xerothermic grasslands and thermophilous fresh meadow. The regular occurence of the following species: *Centaurea scabiosa*, *Agrimonia eupatoria*, *Allium oleraceum*, *Origanum vulgare*, *Euphorbia cyparissias*, distinguishes them from typical fresh meadow, and species contribute for *Molinio-Arrhenatheretea* class which distinguishes them from typical xerothermic grasslands. Barabasz-Krasny (3) describes a thermophilous variant from the same area as *Arrhenatheretum elatioris brizetosum mediae*, similarly to Towpasz (25) from the Strzyżów Foothills, who noted that the community is more common on the banks of big river valleys (Wisłok, Wisłoka) and it is characterized by the presence of numerous examples of xerothermic species, e.g., *Coronilla varia, Clinopodium vulgare* and *Medicago falcata*. In the xerothermic patches of the Natura 2000 site "Łąki nad Wojkówką" the share of *Briza media* was insignificant, hence it has not been classified as this type of community. Xerothermic grasslands with grass species of the *Molinio-Arrhenatheretea* class, Babczyńska-Sendek (1) has observed from Silesian Upland, and distinguished community *Centaurea scabiosa-Agrimonia eupatoria* classified in the *Festuco-Brometea* class.

The *Trifolio-Geranietea* community is one of the most common thermophilous forest margin. It is a characteristic component of ecotone systems of forest-shrubland and grassy communities (16). Several patches of this community were noted in the investigated area, dominated by *Origanum vulgare, Agrimonia eupatoria, Galium verum* and *Clinopodium vulgare*, while the percentage of species of the *Festuco-Brometea* class was inconsiderable. A similar phytocoenosis from the Przemyśl Foothills, but with a high number of species of the *Trifolion* alliance and the *Festuco-Brometea* class, was classified by Barabasz-Krasny (3) as *Trifolio-Agrimonietum eupatoriae* typicum.

The distribution of communities demonstrates regularities arising from the diversity of habitats. Patches of xerothermic grasslands develop on hillsides of

varied exposure. On plateaus and top sections of hills as well as at the foot of the hills appear grasslands with a high proportion of species typical of fresh meadows and forest margin.

There are few studies in literature concerning xerothermic flora of the Carpathian Foothills. So far, the best characterised are the communities from the area of Przemyśl Foothills, where thermophilic phytocoenoses are well developed (11, 12, 13, 27). The studies from the Strzyżów Foothills (25) and the Jasło-Sanok Basin (21) include an analysis of the flora as well as a general characteristic of geobotany. Thus, the research of the Wojkówka meadows constitutes an important addition to the characterisation of xerothermic communities in the submontane Carpathians.

THREATS AND CONSERVATION

The disappearance of grasslands can be observed in recent decades both in Poland and in other areas in Europe. These are valuable communities with rare and protected plant species and their degradation and extinction is a serious loss to the environment. The major reason for the process is abandonment of traditional methods of land use such as mowing and pasturing. The communities are of semi-natural character and when left alone, they undergo the process of secondary succession. The result is their overgrowing with trees and shrubs eliminating xero- and photophilous species, which in turn leads to the conversion of dry grasslands into mesophilous and herbaceous associations (22, 19, 26).

"Łąki nad Wojkówką" has been listed as the Natura 2000 site (PLH 180051), with xerothermic grasslands (habitat – 6210) as one of its main values (23). In spite of the grasslands occupying only a small area, their presence is of extreme importance for the preservation of the habitats and maintaining biodiversity.

The main threat to the existing grasslands is lack of appropriate land use (mowing, grazing) which results in appearance of shrubs (*Rosa canina*, *Prunus spinosa, Crataegus monogyna, Cornus sanguinea*). It is followed by the process of secondary succession which leads to an increase in humidity and trophism of the habitat (19). Maintaining the community and preserving its floristic richness requires taking active protection measures involving restoration and maintenance of the original, extensive forms of land use. In case of grasslands the best solution is grazing, mowing can be also used temporarily, in controlled conditions burning can be applied, but only once every 7–8 years. In the areas of shrub encroachment, the bushes ought to be removed as they tend to overshadow the habitat excessively (20).

These treatments determine preserving of the appropriate composition and structure of the communities whereas increased humidity and appearance

of species of the *Molinio-Arrhenatheretea* class leads to transformation of the grassland patches into meadow or shrub communities. The result of these processes is disappearance of species characteristic of associations and alliances as well as reduction in the size of area of the typical grasslands communities. We observed an increase in the number impoverished communities and the development of communities with species characteristic of higher syntaxonomic units.

CONCLUSIONS

1. Within the grasslands 4 communities were distinguished: with *Hieracium bauhinii*, *Trifolio-Geranietea sanguinei* class, with *Melampyrum arvense-Salvia verticillata* and with *Centaurea scabiosa*.

2. In total, 111 vascular plant species were present in the relevés. They were the most numerous in the community with *Centaurea scabiosa* – 87 species (average 28 species), the lowest number of taxa was reported from the community with *Hieracium bauhinii* – 47 (average 24 species).

3. On the study area, patches of the community with *Centaurea scabiosa* prevail, which have been noted in all the sites. They are formed on steep slopes up to 45º and varied NE, S, SE, SW exposure. The structure of the community is formed by species of the *Festuco-Brometea* class, which achieve a high degree of stability and high coverage.

4. The grasslands are usually accompanied by communities of the *Trifolio-Geranietea sanguinei* class. Moreover, their permanent feature is the presence of species from the *Molinio-Arrhenatheretea* class, which emphasizes their transitional character.

5. The main threat to the existing grasslands is the lack of traditional farming methods which results in appearance of shrub species (*Rosa canina*, *Prunus spinosa, Crataegus monogyna, Cornus sanguinea*), and process of succession towards communities of the *Rhamno-Prunetea* class.

6. Grazing, mowing and possibly controlled burning aids maintenance of xerothermic grasslands since through these protective measures the development of trees and bushes can be avoided. None of these procedures have been reported on the site.

ACKNOWLEDGMENTS

The authors thank Dr hab. B. Barabasz-Krasny for the execution of numerical classification and dendrogram.

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Table 1. Community with *Hieracium bauhinii* and community of *Trifolio-Geranietea sanguinei* class

Succesive number	1	2	3	4	5	6	7	Constancy	8	9	10	11	12	Constancy
Relevé no.	4	3	5	1	14	6	2		18	17	20	19	33	
Locality	W	W	W	W	W	W	W		O	O	O	O	W	
Date (day, month, year)	18 06 12	18 06 12	18 06 12	18 06 12	18 06 12	18 06 12	18 06 12		24 06 12	24 06 12	24 06 12	24 06 12	08 07 12	
Slope aspect	SW	SW	SW	SW	W	SW	SW		E	S	S	NE	NE	
Inclination (°)	50	45	45	45	20	45	45		20	50	45	55	10	
Altitude m (a.s.l.)	268-271	270-273	265-268	257-260	272	272-274	261-263		362	363-365	364-366	366-368	298	
Relevé area (m^2)	100	100	100	100	100	100	100		100	100	100	100	100	
Cover of shrub layer b (%)	-	20	-	-	-	-	10		-	-	-	-	-	
Cover of herb layer (%)	95	90	95	90	80	90	90		95	80	90	80	100	
Number of species	24	32	20	25	24	18	29		23	22	22	23	24	
ChO. *Festucetalia valesiacae*														
Hieracium bauhinii	**3**	**4**	**3**	**3**	**3**	**3**	**2**	**V**	.	.	4	.	.	**I**
Melampyrum arvense	2	1	1	1	1	1	1	**V**	.	.	.	2	.	**I**
Salvia verticillata	+	+	.	.	+	+	.	**III**	.	.	.	.	.	-
ChCl. *Festuco-Brometea*														
Euphorbia cyparissias	4	+	2	+	2	+	1	**V**	.	.	.	1	.	**I**

Centaurea scabiosa	.	.	.	.	.	.	.	**-**	.	.	.	+	+	**II**
Allium oleraceum	.	.	.	.	.	.	.	**-**	+	.	.	.	.	**I**
Arabis hirsuta	.	.	.	.	.	.	.	**-**	.	+	.	.	.	**I**
Gentiana cruciata	.	.	.	.	.	.	.	**-**	.	.	.	.	+	**I**
ChCl. *Trifolio-Geranietea sanguinei*														
Origanum vulgare	1	2	3	1	1	1	2	**V**	**3**	**4**	**2**	**1**	**2**	**V**
Agrimonia eupatoria	+	1	.	+	.	+	+	**IV**	+	+	+	+	+	**V**
Coronilla varia	1	+	.	+	.	1	.	**III**	.	.	1	+	.	**II**
Galium verum	.	.	.	.	.	.	.	**-**	.	+	+	+	+	**IV**
Clinopodium vulgare	.	.	.	.	.	.	.	**-**	.	1	+	+	1	**IV**
Trifolium medium	.	+	.	+	.	+	.	**III**	.	.	.	.	.	**-**
ChO. *Arrhenatheretalia*														
Arrhenatherum elatius	2	2	2	3	2	2	3	**V**	3	2	3	3	2	**V**
Galium mollugo	1	1	1	2	1	1	1	**V**	1	+	1	1	1	**V**
Lotus corniculatus	1	1	1	1	1	1	1	**V**	.	.	+	.	+	**II**
Knautia arvensis	1	+	+	+	+	+	+	**V**	+	+	+	.	+	**IV**
Achillea millefolium	.	.	+	+	+	.	.	**III**	+	.	.	+	+	**III**
Dactylis glomerata	.	+	+	.	.	.	+	**III**	.	+	+	.	.	**II**
Daucus carota	.	.	.	.	.	.	.	**-**	+	+	+	.	.	**III**
Leucanthemum vulgare	.	.	.	.	.	.	.	**-**	.	+	+	+	.	**III**
ChCl. *Molinio-Arrhenatheretea*														
Plantago lanceolata	+	+	1	+	+	.	1	**V**	+	.	.	+	.	**II**
Vicia cracca	1	1	+	+	+	+	+	**V**	+	+	+	+	+	**V**
Leontodon hispidus	.	.	+	+	.	.	+	**III**	.	.	.	.	.	**-**
Festuca rubra	.	.	.	.	.	.	.	**-**	+	+	+	.	+	**IV**
Lathyrus pratensis	.	.	.	.	.	.	.	**-**	+	+	+	.	.	**III**

Other														
Sanguisorba minor	1	2	1	2	2	1	1	**V**	.	.	.	.	.	-
Ranunculus polyanthemos	+	1	+	1	1	1	1	**V**	.	.	+	.	.	**I**
Polygala comosa	.	+	+	1	+	+	+	**V**	.	.	.	.	.	-
Thymus pulegioides	+	r	+	+	.	.	.	**III**	.	.	.	.	.	-
Echium vulgare	+	r	1	+	+	.	.	**IV**	.	.	.	+	.	**I**
Medicago sativa	1	1	+	1	.	+	1	**V**	.	.	.	.	.	-
Trifolium campestre	+	+	.	1	+	.	.	**III**	.	.	.	.	.	-
Hypericum perforatum	.	+	.	.	+	.	.	**II**	+	+	.	+	+	**IV**
Convolvulus arvensis	r	+	.	.	.	.	.	**II**	+	+	.	.	1	**III**
Solidago virgaurea	+	.	.	+	.	.	+	**III**	+	.	.	.	.	**I**
Fraxinus excelsior	+	+	.	.	.	.	+	**III**	.	.	.	.	.	-
Mentha arvensis	.	.	.	+	.	.	+	**II**	+	.	+	+	.	**III**
Vicia grandiflora	.	.	.	.	.	.	.	-	+	+	.	+	+	**IV**
Melilotus officinalis	.	.	.	.	.	.	.	-	+	.	+	.	.	**II**
Veronica chamaedrys	.	.	.	.	.	.	.	-	+	+	+	+	.	**IV**

Sporadic species: ChCl. *Trifolio-Geranietea sanguinei*: *Medicago falcata* 9/+, ChO. *Arrhenatheretalia*: *Crepis biennis* 8/+, *Trifolium dubium* 10/+, ChCl. *Molinio-Arrhenatheretea*: *Festuca pratensis* 12/3, *Potentilla reptans* 9/+, ChCl. *Rhamno-Prunetea*: *Cerasus avium* (b) 7/+, *Cornus sanguinea* (b) 2/+, 7/1, *Crataegus monogyna* (b) 1/+, 2/1, *Euonymus europaea* 7/+, *Ligustrum vulgare* (b) 2/+, 7/+, *Prunus spinosa* (b) 2/+, *Rosa canina* (b) 2/+, 7/+, Other: *Allium vineale* 11/+, *Artemisia vulgaris* 12/+, *Briza media* 1/1, *Calamagrostis epigejos* 5/1, 12/+, *Cichorium intybus* 7/+, *Cruciata glabra* 11/+, *Dianthus deltoides* 8/+, *Equisetum arvense* 8/1, 12/+, *Erophila verna* 3/+, *Glechoma hederacea* 11/+, *Lathyrus tuberosus* 12/1, *Linum catharticum* 5/+, 6/+, *Medicago lupulina* 10/+, *Melilotus albus* 5/+, *Ononis arvensis* 2/+, 4/+, *Pimpinella saxifraga* 8/+, 9/+, *Potentilla anserina* 12/+, *Potentilla recta* 12/+, *Pyrus pyraster* (b) 2/+, *Quercus robur* (b) 7/+, *Rubus caesius* (b) 7/+, *Sedum maximum* 9/+, 11/1, *Solidago gigantea* 7/+, *Torilis japonica* 12/+.

Explanation: Locality: W – Wojkówka, O – Odrzykoń

Table 2. Community with *Melampyrum arvense-Salvia verticillata*

Succesive number	1	2	3	4	5	6	7	8	9	10	**Constancy**
Relevé no.	29	26	28	27	30	22	21	23	15	16	
Locality	O	O	O	O	O	O	O	O	O	O	
Date (day, month, year)	24 06 12	24 06 12	24 06 12	24 06 12	24 06 12	24 06 12	24 06 12	24 06 12	24 06 12	24 06 12	
Slope aspect	S	S	SE	SW	SE	S	S	SE	SE	SE	
Inclination (°)	30	5	10	20	5	10	10	10	20	10	
Altitude m (a.s.l.)	351-352	389	352	353	349	364	363	365	343-344	347	
Relevé area (m^2)	100	100	100	100	100	100	100	100	100	100	
Cover of shrub layer (%) b	15	10	10	15	5	-	5	-	-	-	
Cover of herb layer (%)	100	100	100	100	100	100	100	100	90	100	
Number of species	22	31	36	36	29	23	27	35	31	27	
ChO. *Festucetalia valesiacae*											
Melampyrum arvense	**2**	**2**	**2**	**2**	**3**	**1**	**1**	**2**	**4**	**3**	**V**
Salvia verticillata	3	1	1	2	1	1	+	1	2	1	**V**
Hieracium bauhinii	+	+	.	1	+	.	.	.	+	.	**III**
ChCl. *Festuco-Brometea*											
Euphorbia cyparissias	1	1	+	+	1	+	1	+	1	+	**V**
Plantago media	+	.	+	+	+	.	+	+	+	.	**IV**
Centaurea scabiosa	.	.	1	.	1	.	+	2	+	+	**III**

Allium oleraceum	.	.	+	1	.	.	+	.	.	3	**II**
Poa compressa	.	+	+	.	.	.	.	+	.	.	**II**
ChCl. *Trifolio-Geranietea sanguinei*											
Origanum vulgare	+	1	+	1	+	1	1	+	1	1	**V**
Galium verum	1	1	1	+	1	1	+	1	+	+	**V**
Agrimonia eupatoria	+	1	1	+	+	1	+	+	+	+	**V**
Coronilla varia	.	1	+	+	.	+	+	+	+	.	**IV**
Medicago falcata	.	.	+	+	+	.	.	.	.	+	**II**
Clinopodium vulgare	.	.	+	.	+	.	.	.	+	+	**II**
ChO. *Arrhenatheretalia*											
Arrhenatherum elatius	3	3	3	3	1	3	3	3	2	2	**V**
Galium mollugo	.	+	1	+	1	+	1	.	+	1	**V**
Dactylis glomerata	+	+	+	+	+	+	+	+	.	+	**V**
Achillea millefolium	+	+	.	+	+	+	+	1	+	1	**V**
Knautia arvensis	+	.	+	+	.	+	.	+	+	+	**IV**
Leucanthemum vulgare	+	+	+	+	.	+	.	+	+	.	**IV**
Lotus corniculatus	.	.	.	.	1	.	.	+	2	+	**II**
Daucus carota	.	.	+	.	.	+	.	.	+	+	**II**
ChCl. *Molinio-Arrhenatheretea*											
Festuca rubra	.	.	1	+	1	2	3	2	1	2	**IV**
Vicia cracca	.	+	.	+	.	+	+	+	+	.	**III**
Lathyrus pratensis	.	.	+	.	.	.	+	+	+	+	**III**
Centaurea jacea	.	+	+	.	+	.	.	+	+	.	**III**
Potentilla reptans	.	+	.	+	.	.	+	+	.	+	**III**
Plantago lanceolata	+	+	.	.	+	.	.	+	.	.	**II**
ChCl. *Rhamno-Prunetea*											

Rosa canina (b)	1	+	1	1	1	.	.	.	.	.	**III**
Prunus spinosa (b)	1	+	1	2	.	.	.	.	.	.	**II**
Crataegus monogyna (b)	.	1	+	+	+	.	.	.	.	.	**II**
Cornus sanguinea (b)	+	.	.	.	+	.	.	+	.	.	**II**
Acer campestre (b)	.	+	.	.	.	.	+	+	.	.	**II**
Other											
Briza media	1	1	1	1	+	.	1	+	+	+	**V**
Mentha arvensis	+	1	2	.	1	2	+	1	.	.	**IV**
Melilotus officinalis	+	1	1	.	.	1	+	1	1	.	**IV**
Ranunculus polyanthemos	.	.	+	+	1	.	.	+	.	+	**III**
Convolvulus arvensis	.	.	+	+	.	+	+	+	.	+	**III**
Allium vineale	.	+	+	+	.	+	+	+	.	.	**III**
Veronica chamaedrys	.	.	+	+	1	.	.	+	+	+	**III**
Primula veris	+	.	1	+	1	.	.	.	.	.	**II**
Thymus pulegioides	.	+	.	1	.	.	.	+	+	.	**II**
Cruciata glabra	+	.	+	+	+	.	.	.	.	.	**II**
Pyrus pyraster (b)	.	+	+	+	.	.	.	.	.	.	**II**
Consolida regalis	.	+	.	.	.	r	+	.	.	.	**II**

Sporadic species: ChO. *Arrhenatheretalia*: *Trifolium dubium* 4/+, 9/+, ChCl. *Molinio-Arrhenatheretea*: *Festuca pratensis* 7/+, 10/+, *Leontodon hispidus* 8/+, ChCl. *Rhamno-Prunetea*: *Cerasus avium* (b) 2/+, Other: *Carex pairae* 6/+, 7/+, *Cichorium intybus* 10/+, *Cirsium arvense* 10/+, *Echium vulgare* 9/+, *Fragaria vesca* 3/+, 4/+, *Hypericum perforatum* 8/+, *Linum catharticum* 9/+, *Medicago lupulina* 9/+, *Pimpinella saxifraga* 9/+, *Sedum maximum* 4/+, *Silene vulgaris* 8/+, *Trifolium campestre* 2/+, *Vicia hirsuta* 6/+, *Viola odorata* 4/+, 5/+.

Explanation: Locality: O – Odrzykoń

Table 3. Community with *Centaurea scabiosa*

Succesive number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**Constancy**
Relevé no.	13	9	12	31	34	32	8	7	11	10	25	24	36	35	37	
Locality	W	W	W	O	W	W	W	W	W	W	O	O	R	R	R	
Date (day, month, year)	18 06 12	18 06 12	18 06 12	24 06 12	08 07 12	08 07 12	18 06 12	18 06 12	18 06 12	18 06 12	24 06 12	24 06 12	08 07 12	08 07 12	08 07 12	
Slope aspect	NE	S	S	SE	SW	SE	SE	SE	S	S	SE	S	SW	SW	SW	
Inclination (°)	10	20	10	5	15	20	10	10	30	30	20	10	35	35	45	
Altitude m (a.s.l.)	293	288	313	341	296	301	282	282	288	286	350	357	407	407	401	
Relevé area (m^2)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
Cover of herb layer (%)	90	100	100	75	100	100	100	100	100	100	100	100	100	100	100	
Number of species	27	23	29	27	23	30	32	29	19	22	35	29	36	35	27	
ChO. *Festucetalia valesiacae*																
Melampyrum arvense	3	2	2	2	2	2	1	1	+	.	+	+	.	.	.	**IV**
Salvia verticillata	1	2	1	1	+	.	1	1	.	3	.	.	+	.	1	**IV**
ChCl. *Festuco-Brometea*																
Centaurea scabiosa	**1**	**3**	**3**	**+**	**2**	**1**	**3**	**3**	**2**	**2**	**2**	**1**	**2**	**2**	**4**	**V**
Euphorbia cyparissias	1	1	1	1	.	+	.	.	1	2	.	r	+	+	+	**IV**
Plantago media	1	1	.	.	1	.	1	1	+	.	+	+	1	+	+	**IV**
Poa compressa	+	.	+	.	1	+	.	.	+	.	+	.	+	1	.	**III**

Allium oleraceum	.	.	.	.	.	+	.	.	.	.	1	+	.	+	.	**II**
ChCl. *Trifolio-Geranietea sanguinei*																
Origanum vulgare	2	1	2	+	1	2	2	3	3	2	1	1	.	.	.	**IV**
Agrimonia eupatoria	+	1	.	.	1	+	+	+	1	1	+	+	+	+	1	**IV**
Galium verum	+	+	+	1	1	+	.	.	1	.	1	1	1	2	1	**IV**
Coronilla varia	.	+	+	+	.	+	+	+	.	+	1	+	+	+	+	**IV**
Medicago falcata	.	1	+	+	2	4	.	.	.	+	+	.	.	.	+	**III**
Clinopodium vulgare	.	.	.	.	+	+	.	.	.	.	.	.	1	2	+	**II**
Trifolium medium	+	.	+	.	.	.	.	.	.	.	.	.	+	1	.	**II**
ChO. *Arrhenatheretalia*																
Arrhenatherum elatius	2	2	2	.	3	2	4	4	4	3	2	4	3	3	2	**V**
Achillea millefolium	1	1	2	+	+	+	+	1	1	1	1	2	+	+	.	**V**
Galium mollugo	+	1	.	1	+	+	+	2	1	1	.	.	.	+	+	**IV**
Knautia arvensis	+	+	+	+	.	+	+	1	+	+	.	.	+	+	+	**IV**
Daucus carota	.	.	.	+	+	+	+	+	+	+	+	.	+	+	+	**IV**
Dactylis glomerata	+	.	+	+	+	.	+	+	+	+	+	+	.	+	.	**IV**
Lotus corniculatus	2	1	+	.	.	.	+	+	.	.	1	1	+	.	+	**III**
Leucanthemum vulgare	+	.	+	+	.	.	+	.	.	.	.	.	+	+	1	**III**
ChCl. *Molinio-Arrhenatheretea*																
Festuca rubra	+	1	.	+	.	1	1	1	1	+	1	.	+	1	.	**IV**
Centaurea jacea	.	.	.	+	.	+	.	.	.	.	1	1	1	+	1	**III**
Plantago lanceolata	.	.	+	1	.	.	+	+	.	.	+	+	.	.	+	**III**
Leontodon hispidus	.	.	+	.	+	.	+	.	.	.	1	1	.	+	.	**II**
Lathyrus pratensis	.	.	.	.	.	.	.	+	.	+	1	+	+	.	.	**II**
Phleum pratense	.	.	.	.	+	+	+	.	.	.	+	+	.	+	.	**II**

Others																
Thymus pulegioides	2	1	1	1	.	.	1	.	.	1	+	.	2	1	+	**IV**
Ranunculus polyanthemos	2	1	1	+	+	+	+	+	.	+	+	+	+	.	.	**IV**
Polygala comosa	+	+	+	+	.	.	+	+	.	.	+	.	.	.	.	**III**
Briza media	+	1	.	.	.	.	.	.	.	.	+	+	1	+	+	**III**
Melilotus officinalis	.	1	1	2	+	1	.	.	.	1	.	.	+	.	.	**III**
Allium vineale	.	.	.	.	.	.	.	+	+	.	+	+	+	.	1	**II**
Hypericum perforatum	.	.	.	+	+	+	.	.	.	.	.	+	+	+	.	**II**
Cichorium intybus	.	.	.	+	+	.	.	.	.	.	r	+	.	+	+	**II**
Anthoxanthum odoratum	+	+	.	.	.	.	+	+	.	.	.	+	.	.	.	**II**
Pimpinella saxifraga	.	.	r	+	.	.	.	.	.	.	.	.	+	+	+	**II**
Carex spicata	.	.	.	.	.	+	.	.	+	.	.	.	+	+	.	**II**
Convolvulus arvensis	.	.	.	.	+	+	.	.	.	+	.	.	.	+	.	**II**

Sporadic species: ChO. *Arrhenatheretalia*: *Crepis biennis* 10/+, 11/+, 12/+, *Tragopogon pratensis* 11/+, 12/1, *Trifolium repens* 11/+, 12/+, ChCl. *Molinio-Arrhenatheretea*: *Carex hirta* 15/+, *Festuca pratensis* 9/+, *Poa trivialis* 14/1, *Potentilla reptans* 10/+, 13/+, 15/+, *Trifolium pratense* 3/+, *Vicia cracca* 4/+, 12/+, 13/+, ChCl. *Rhamno-Prunetea*: *Cornus sanguinea* (b) 3/+, *Crataegus monogyna* (b) 3/r, *Rosa canina* (b) 15/+, Other: *Artemisia vulgaris* 6/+, 8/+, 9/+, *Bromus inermis* 6/+, *Calamagrostis epigejos* 7/+, 13/+, 14+, *Carduus acanthoides* 15/+, *Cirsium arvense* 8/+, 11/+, *Consolida regalis* 8/r, *Cruciata glabra* 13/+, 14/+, *Dianthus armeria* 14/+, *Echium vulgare* 1/+, 4/+, *Elymus repens* 6/+, 7/+, *Euphorbia esula* 6/+, 7/+, 8/+, *Fragaria vesca* 1/+, 15/2, *Galium aparine* 14/+, *Geranium dissectum* 13/+, 14/+, *Linum catharticum* 1/1, 13/+, *Medicago lupulina* 8/+, *Medicago sativa* 5/+, *Melilotus albus* 7/+, *Mentha arvensis* 12/1, 13/+, *Ononis arvensis* 11/1, *Pastinaca sativa* 7/+, 8/+, *Polygonum convolvulus* 14/+, *Potentilla recta* 2/r, 3/1, 6/+, *Primula veris* 11/+, *Pyrus pyraster* (b) 13/+, *Rubus caesius* (b) 8/+, *Sanguisorba minor* 3/+, *Sedum acre* 4/+, *Senecio jacobaea* 1/+, *Silene vulgaris* 11/r, *Trifolium campestre* 3/+, 7/+, 13/+, *Verbascum nigrum* 6/+, 10/+, *Veronica chamaedrys* 7/+, 8/r, 11/+, *Vicia grandiflora* 7/+, *Viola odorata* 7/1.

Explanation: Locality W – Wojkówka, O – Odrzykoń, R – Rzepnik