Flora and vegetation of walls in the town of Krosno Odrzańskie (Poland)

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Abstract

Boratyński, A., H. Ratyńska, B. Waldon, A. Bartczak (2003). Flora and vegetation of walls in the town of Krosno Odrzańskie (Poland). *Collect. Bot. (Barcelona)* **26**: 129-139.

The flora and vegetation of walls in Krosno Odrzańskie (West Poland) is described based on field research conducted in 1999 and 2000. The vascular flora consists of 96 species from 35 families. Predomination of apophytes and plants capable of vegetative propagation was observed. Associations of *Asplenietum trichomano-rutae-murariae* and *Cymbalarietum muralis* are reported for the first time from this region of Poland.

Key words: *Asplenium ruta-muraria, Asplenium trichomanes, Cymbalaria muralis*, geobotanical analysis, synanthropic vegetation, urban flora.

Resumen

Boratyński, A., H. Ratyńska, B. Waldon, A. Bartczak (2003). Flora and vegetation of walls in the town of Krosno Odrzańskie (Poland). *Collect. Bot. (Barcelona)* **26**: 129-139.

A partir del trabajo de campo realizado entre 1999 y el 2000 se describe la flora y la vegetación de las paredes en Krosno Odrzańskie (Polonia Occidental). 96 especies de 35 familias constituyen la flora vascular. Predominan los apófitos y plantas capaces de reproducirse vegetativamente. Las asociaciones *Asplenietum trichomano-rutae-murariae* y *Cymbalarietum muralis* se citan por vez primera para esta región de Polonia.

Palabras clave: *Asplenium ruta-muraria, Asplenium trichomanes, Cymbalaria muralis*, análisis geobotánico, vegetación sinantrópica, flora urbana.

Introduction

Walls of buildings and of other constructions made of bricks, stones or concrete belong to specific, polyhemerobic habitats, which can be a substitute habitats for rock plants. They are common but rarely colonized, because of their vertical and even surface, characterized by unfavourable water and temperature regimes and recurrent conservation of the walls. The insufficient inflow of diaspores can also be a reason for slow colonization of walls, especially in centres of large agglomerations. The spores of cryptogams (i.e. ferns and bryophytes) and lichens are easily transported by wind over long distances, so these organisms are normally first to colonize walls. Besides, they are less sensitive to unfavourable thermal and water conditions. Only the heavily polluted parts of large cities and industrial constructions are lichen deserts. Vascular plants can normally grow on sites where at least a small amount of humus has accumulated. This kind of substrate is formed in calcium-containing mortar or slits and fissures of the walls, previously colonized by lichens and mosses.

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The flora and vegetation of walls of various buildings has been the object of botanical investigations for a long time. Some of the first botanical descriptions of such habitats, dating from the 19th century, are concerned with walls of ancient Roman constructions, such as the Coliseum, or the historic walls of Palermo and Naples, (WERETELNIK, 1982). Several works were published later in Germany (ULBRICH, 1939, BRANDES, 1987, 1992, 1995, 1996), the United Kingdom (WOODELL and ROSSITER, 1959), France (SEGAL, 1969), Italy (CELESTI GRAPOW et al., 1993) and Poland (WERETELNIK, 1973, 1982; CEYNOWA-GIEŁDON, 1988; ŚWIERKOSZ, 1993; GALERA and SUDNIK-WÓJCIKOWSKA, 2000a, 2000b).

The aim of the present work was to make a geobotanical analysis of the flora and vegetation of walls in Krosno Odrzańskie, a town on the Oder River, located at the mouth of the Bóbr River. Krosno Odrzańskie is a small but old town, established in the 13th century. The walls of the ruined castle were partly constructed at that time, but all other buildings are less than 200 years old. About 65% of the town was destroyed in 1945, at the end of the 2nd World War, and many new buildings have been constructed in place of the destroyed ones. Now it is inhabited by about ten thousand people.

The intermediate, oceanic-continental climate is characteristic of the region, with the growing season lasting 218-220 days and annual precipitation of 570-650 mm. The mean annual temperature is over 8°C, with 30 frosty days and about 100 days with hoarfrost per year. Westerly winds prevail, and are frequently strong (GUMIŃSKI, 1948; BARTKOWSKI, 1970).

MATERIAL AND METHODS

Field investigations were carried out in the growing seasons of 1999 and 2000. The flora of vascular plants, mosses and lichens, and their associations developed on the walls of the old part of the town were studied. Geobotanical analyses included affiliation of vascular plants to the geographic-historical groups (after JACKOWIAK, 1990), to Raunkiaer's

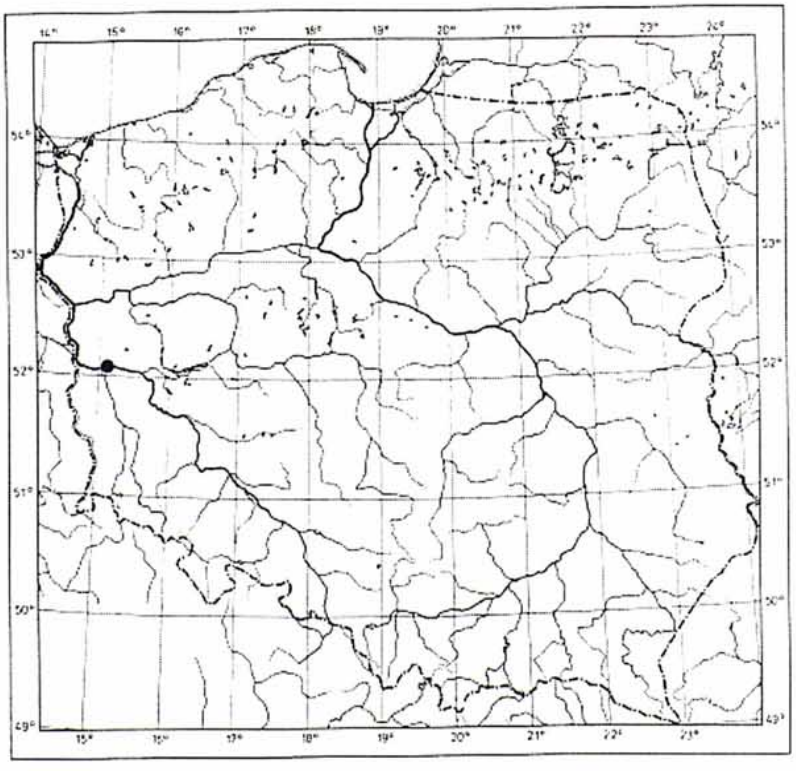

Fig. 1. Location of Krosno Odrzańskie

life-forms (JACKOWIAK, 1990; ROTHMALER, 1994), capability for vegetative propagation (MDALSKI, 1930-1970; RUTKOWSKI, 1995) and geographical character of the natural ranges of taxa (MEUSEL et al., 1965, 1978, 1992; HULTÉN & FRIES, 1986; ROTHMALER, 1994). Names of vascular plants are used after MIREK et al. (1995), mosses after OCHYRA and SZMAJDA (1978) and lichens after NOWAK and TOBOLEWSKI (1975).

Phytosociological records were made according to the Braun-Blanquet method modified by BARKMAN et al. (1964). The syntaxonomy of plant communities follows that proposed by BRZEG & WOJTERSKA (1996).

RESULTS AND DISCUSSION

Flora

The flora of vascular plants is rather poor. It consists of only 96 taxa (Table 1). The relatively small number of taxa is probably due to the small area of the town and the small number of walls that offer habitats suitable for plants. The numbers of species reported from such habitats in neighbouring lands were greater: 188 on walls of castle ruins in Lower Silesia (WERETELNIK, 1982), 146 in Wrocław (ŚWIERKOSZ, 1993), 111 on the Palace of Culture and Science in Warsaw (GALERA & SUDNIK-WÓJCIKOWSKA, 2000a) and 149 in Germany (BRANDES, 1996).

The plants found on walls in Krosno Odrzańskie belong to 35 families, mainly to the *Asteraceae* (15 taxa), *Poaceae* (13) and *Rosaceae* (6). The largest numbers of species belonged to the genera: *Poa, Festuca, Lamium, Plantago, Polygonum* and *Potentilla.*

Most of the species found on walls occur quite commonly in the whole town. *Cymbalaria muralis* (reported from Krosno by DECKER in 1912) and two *Asplenium* species were observed exclusively on walls. Those three species grow most frequently on walls of historical buildings outside mountainous regions, and even exclusively on walls in the lowlands of Central Europe (ULBRICH, 1939; ANIOŁ-KWIATKOWSKA, 1974; WERETELNIK, 1982; CEYNOWA-GIEŁDON 1988; TERPÓ & BALINT, 1988; WERNER et al., 1989; BRANDES, 1987, 1992, 1996; WITTING, 1991; ŚWIERKOSZ, 1993).

Additionally, 18 species of lichens and 14 species of mosses were found on walls in Krosno. The relatively large number of lichens could indicate a low level of pollution in the town, but most of them belong to taxa with a wide ecological scale.

Native vascular plant species (spontaneophytes) predominate, accounting for about 73% of all taxa, but only 5% can be treated as typical non-synanthropic ones (Fig. 2). This is consistent with the reports of many authors mentioned above. The typical spontaneophytes (mesohemerospontaneophytes after JACKOWIAK, 1990) are: *Brachypodium sylvaticum, Festuca gigantea, Lamium maculatum* and *Lysimachia nummularia.* All other spontaneous plant species are apophytes. The forest, thicket and meadow taxa were the most common among the spontaneous plant species found there. In the case of Silesian castles, where these types of plants also dominate, the situation was explained as arising from the close neighbourhood of forest, xerothermic thickets and meadows (WERETELNIK, 1982). Among aliens, archaeophytes were the most numerous, as on walls in other regions (WERETELNIK, 1982; GALERA & SUDNIK-WÓJCIKOWSKA, 2000a).

Most of the taxa recorded on walls in Krosno can be identified as hemicryptophytes (RAUNKIAER, 1934), which constitute more than 40% of the total flora (Fig. 3). Therophytes rank second (27%), but woody plants (phanerophytes) are also significant, with a contribution of 11%. Proportions of plant life-forms were different in various regions. For example, on the Palace of Culture and Science in Warsaw, 40% of plant species were

Table 1. Geobotanical characteristics of plants growing on the walls in Krosno Odrzańskie
Geographic-historical groups of species (Ghgs): Ap – apophyte; Ar – archeophyte; Ef – ephemerophyte; Kn – kenophyte; Sp – nonsynanthropic spontaneophyte.
Raunkiaer's life-forms (Rlf): C – cryptophyte; C(G) – geophyte; Ch – chameophyte; H – hemicryptophyte; L – liana; M – megaphanerophyte; MN – mezo- and/or nanophanerophyte; N – nanophanerophyte; TH – therophyte.
Ability to vegetative propagation (Avp): - – without; + – inconsiderable: ++ – considerable; +++ – common and very important.
Geographic elements (Ge): CAUC – Caucasic; CB – Cicumboreal; CE – Central-European; COSM – Cosmopolite; EAS – East-Asiatic; ES – Euro-Siberian; ES(E) – Euro-Siberian with center of range in Europe; HORT – horticultural; IT – Irano-Turanian; NAM – North American; SATL – Sub-Atlantic; SM – Sub-Mediterranean; in brackets () are marked occurrence of the species outside the main parts of their ranges.

Nº	Species	Ghgs	Rlf	Avp	Ge
1.	*Acer platanoides* L.	Ap	M	-	CE
2.	*Achillea millefolium* L.	Ap	H	+	ES
3.	*Agropyron repens* (L.) P. Beauv.	Ap	C(G)	+++	ES
4.	*Alliaria petiolata* (M. Bieb.) Cavara et Grande	Ap	H	-	S(E)-(IT)
5.	*Anagallis arvensis* L.	Ar	TH	-	COSM
6.	*Anthriscus sylvestris* (L.) Hoffm.	Ap	H	-	COSM
7.	*Antirrhinum majus* L.	Ef	TH	-	HORT
8.	*Arenaria serpyllifolia* L.	Ap	TH	-	ES(E)
9.	*Artemisia vulgaris* L.	Ap	Ch	+	ES
10.	*Asplenium ruta-muraria* L.	Ap	H	+	CB
11.	*Asplenium trichomanes* L.	Ap	H	+	CB
12.	*Ballota nigra* L.	Ar	Ch	++	ES(E)
13.	*Berteroa incana* (L.) DC.	Ap	H	-	ES-(IT)
14.	*Betula pendula* Roth	Ap	M	-	ES
15.	*Brachypodium sylvaticum* (Huds.) P. Beauv.	Sp	H	+	COSM
16.	*Bromus inermis* Leyss.	Ap	H	+++	CB
17.	*Calystegia sepium* (L.) R. Br.	Ap	C(G)	++	COSM
18.	*Campanula rapunculoides* L.	Ap	H	+	ES
19.	*Carex praecox* Schreb.	Ap	C(G)	+	ES
20.	*Centaurea jacea* L.	Ap	H	+	ES(E)
21.	*Cerastium holosteoides* Fr. em. Hyl.	Ap	C	-	COSM
22.	*Chaerophyllum temulum* L.	Ap	TH	-	ES(E)-(SM)
23.	*Chelidonium majus* L.	Ap	H	+	ES
24.	*Chenopodium album* L.	Ap	TH	-	COSM
25.	*Clematis vitalba* L.	Kn	N(L)	+	ES(E)-SM
26.	*Convolvulus arvensis* L.	Ar	C(G)	+++	COSM
27.	*Conyza canadensis* (L.) Cronquist	Kn	TH	-	NAM
28.	*Corylus avellana* L.	Ap	N	++	ES(E)
29.	*Crataegus monogyna* Jacq.	Ap	NM	-	ES(E)-SM
30.	*Crepis capillaris* (L.) Wallr.	Sp	TH	-	SATL
31.	*Cymbalaria muralis* P. Gaertn., B. Mey. et Scherb.	Kn	C	+	SATL
32.	*Dactylis glomerata* L.	Ap	H	+	ES
33.	*Epilobium adenocaulon* Hausskn.	Kn	H	++	NAM

Table 1. Cont.

N°	Species	Ghgs	Rlf	Avp	Ge
34.	*Erigeron acris* L.	Ap	TH	-	CB
35.	*Euphorbia peplus* L.	Ar	TH	-	COSM
36.	*Fagus sylvatica* L.	Kn	M	-	CE
37.	*Fallopia convolvulus* (L.) Á. Löve	Ar	TH	-	COSM
38.	*Festuca gigantea* (L.) Vill	Sp	H	+	ES
39.	*Festuca rubra* L.	Ap	H	++	CB
40.	*Festuca trachyphylla* (Hack.) Krajina	Ap	H	+	CE
41.	*Fragaria vesca* L.	Ap	H	++	CB
42.	*Geum urbanum* L.	Ap	H	+	ES(E)
43.	*Glechoma hederacea* L.	Ap	H	+++	ES
44.	*Gnaphalium sylvaticum* L.	Ap	H	+	CB
45.	*Helianthus annuus* L.	Ef	TH	-	NAM
46.	*Hieracium pilosella* L.	Ap	H	+++	ES(E)
47.	*Hordeum murinum* L.	Ar	TH	-	ES(E)-SM-IT
48.	*Humulus lupulus* L.	Ap	H	+	CB
49.	*Impatiens parviflora* DC.	Kn	TH	-	(EAS)
50.	*Knautia arvensis* (L.) J. M. Coult.	Ap	H	+	ES(E)
51.	*Lactuca serriola* L.	Ar	H	+	ES
52.	*Lamium album* L.	Ar	H	++	ES
53.	*Lamium maculatum* L.	Sp	H	+	ES(E)
54.	*Lapsana communis* L.	Ap	TH	-	CE
55.	*Leucanthemum vulgare* Lam. s.s.	Ap	H	+	ES
56.	*Lolium perenne* L.	Ap	H	+	CE-SM
57.	*Lycium barbarum* L.	Kn	N	++	EAS
58.	*Lysimachia nummularia* L.	Sp	C	+	ES(E)
59.	*Medicago lupulina* L.	Ap	TH	-	COSM
60.	*Oxalis stricta* L.	Ef	TH	-	COSM
61.	*Papaver somniferum* L.	Ef	TH	-	HORT
62.	*Plantago lanceolata* L.	Ap	H	+	ES
63.	*Plantago major* L.	Ap	H	+	COSM
64.	*Plantago media* L.	Ap	H	+	ES-IT
65.	*Poa annua* L.	Ap	TH	+	COSM
66.	*Poa compressa* L.	Ap	H	+	ES(E)
67.	*Poa nemoralis* L.	Ap	H	++	CB
68.	*Poa pratensis* L.	Ap	H	+	CB
69.	*Polygonum aviculare* L.	Ap	TH	-	COSM
70.	*Polygonum persicaria* L.	Ap	TH	-	ES(E)
71.	*Potentilla argentea* L.	Ap	H	++	ES
72.	*Potentilla reptans* L.	Ap	H	+++	ES-(SM)-(IT)
73.	*Ranunculus bulbosus* L.	Ap	C(G)	-	CE
74.	*Ranunculus repens* L.	Ap	H	+++	ES
75.	*Rubus caesius* L.	Ap	N	+++	ES-(IT)
76.	*Rumex acetosa* L.	Ap	H	+	CB
77.	*Rumex acetosella* L.	Ap	C(G)	+	ES
78.	*Sagina procumbens* L.	Ap	C	+	ES-NAM
79.	*Salix alba* L.	Ap	M	+	ES-(IT)
80.	*Sambucus nigra* L.	Ap	N	+	ES(E)
81.	*Sedum spurium* M. Bieb.	Ef	C(G)	+	CAUC

Table 1. Cont

Nº	Species	Ghgs	Rlf	Avp	Ge
82.	*Senecio vulgaris* L.	Ar	TH	-	CB
83.	*Sisymbrium officinale* (L.) Scop.	Ar	TH	-	ES(E)
84.	*Solanum dulcamara* L.	Ap	ChN	++	ES-(IT)
85.	*Sonchus arvensis* L.	Ap	C(G)	+++	ES
86.	*Sonchus oleraceus* L.	Ar	TH	-	ES
87.	*Stellaria media* (L.) Vill.	Ap	TH	-	COSM
88.	*Syringa vulgaris* L.	Kn	N	++	CE(BA)
89.	*Taraxacum officinale* F. H. Wigg.	Ap	H	+	COSM
90.	*Taxus baccata* L.	Ef	MN	+	SATL-SM
91.	*Taxus* x *media* Rehder	Ef	MN	-	HORT
92.	*Trifolium repens* L.	Ap	Ch	++	COSM
93.	*Urtica dioica* L.	Ap	H	+++	COSM
94.	*Veronica arvensis* L.	Ap	TH	-	ES(E)
95.	*Veronica hederifolia* L.	Ap	TH	-	CE
96.	*Viola odorata* L.	Ap	H	++	SATL-SM

therophytes and 22% were phanerophytes (GALERA & SUDNIK-WÓJCIKOWSKA, 2000a), while on walls in the old town of Wrocław only 19 and 25%, respectively (ŚWIERKOSZ, 1993).

The specific conditions on the walls are also a reason for the limited number of species that can survive and clomplete their life-cycle there. The woody species (phanerophytes), for example, were observed only in the seedling stage. Their appearance depends on the permanent supply of diaspores from the neighbourhood. Seeds of phanerophytes are delivered by birds (ornithochory) or by wind (anemochory). The immediate neighbourhood of parental specimens is due to the occurrence of at least some barochorous species. The most commonly occurring herbaceous plants growing, flowering and fruiting in wall fissures, produce large amounts of light, anemochorous seeds. Also, myrmecochorous species are frequent on walls (ULBRICH, 1939).

Most of the recorded plant species (63%) are capable of vegetative propagation (Fig. 4).

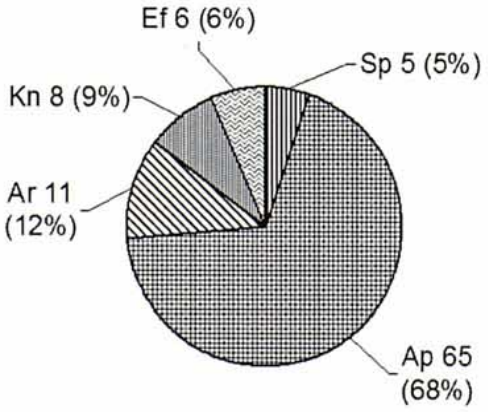

Fig. 2. Proportion of geographic-historical groups of species (description see table 1)

The composition of geographic elements of the flora is more or less typical for central Europe, where plants with Euro-Siberian, Circum-Boreal and central-European ranges of distribution prevail (Fig. 5).

Vegetation

Two pioneer plant communities were found on walls in Krosno Odrzańskie: *Asplenietum trichomano-rutae-murariae* and *Cymbalarietum muralis* (Table 2). Both of them are quite widespread in the town, although *Asplenietum trichomano-rutae-murariae* is rare and *Cymbalarietum muralis* is extremely rare in the Wielkopolska Lowland and Lubuska Upland. The associations of ferns are natural auxochorous plant communities, while *Cymbalarietum muralis* is a ruderal, extremely specialized community (FALIŃSKI, 1969; BRZEG and WOJTERSKA, 1996). The latter community seems to be a syntaxon associated with the sunnier southern and western exposures, as it was also reported from Silesia (WERETELNIK, 1982). The intensive insolation is probably the reason for a rather poor floristic composition of the community. Only six species of vascular plants were recorded there and only 13 together with lichens and mosses. It must be noted that 1 to 8 taxa (5 on average) were found in individual phytosociological records.

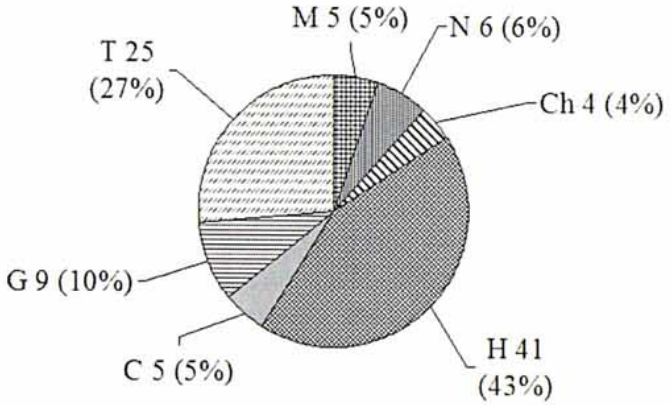

Fig. 3. Proportion of Raunkiaer's life-forms (description see table 1)

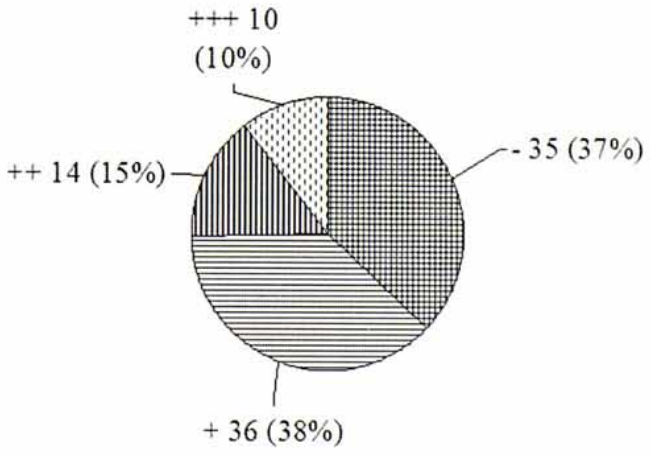

Fig. 4. Ability of vegetative reproduction (description see table 1)

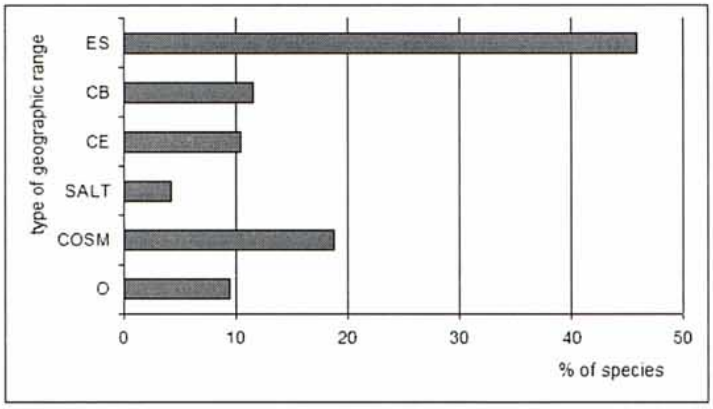

Fig. 5. Geographic elements of flora (description see table 1).

Asplenietum trichomano-rutae-murariae is found mostly on east-facing walls, which are more shaded. The layer of mosses and lichens is better developed and the floristic composition of the phytocoenoses is richer, as 10 to 19 (15 on average) taxa were found there. The 25 taxa of vascular plants, 5 of lichens and 4 of mosses were found in patches of this plant community in Krosno Odrzańskie. The plant communities described from the walls of Krosno Odrzańskie are relatively poor and their patches cover smaller areas than in other regions (ANIOŁ-KWIATKOWSKA, 1974; ZAJAC, 1974; RATYŃSKA, 2000; CEYNOWA-GIEŁDON, 1994), and especially when compared with the walls of castle ruins in Silesia (WERETELNIK, 1982).

Most of the taxa found in the two associations described above, were represented by single specimens. This attests to their accidental composition, which is also unstable and heterogeneous, especially in the case of *Cymbalarietum muralis*. Apart from *Cymbalaria muralis,* no other species occurs in all phytosociologic records. Only seedlings of *Taxus* sp., *Viola odorata*, the lichens *Lecanora albescens* and *Lepraria incana* and the mosses *Brachytecium salebrosum* and *B. rubulatum* have a high constancy.

CONCLUSIONS

1. Old walls are specific polyhemerobic sites. The composition of the flora of both the seed and spore plants of this habitat is diversified and includes a few specific taxa, while the others are framework taxa of the flora of the town.

2. In spite of the fact that walls are eminently anthropogenic sites, their flora is composed mostly of native plants (spontaneophytes). This indicates that walls made of stones or bricks joined with mortar containing calcium are specific habitats, which act as 'vicars' of natural rocky sites for rock plants. On this kind of sites, rock plants find their only possibility of growing and enlarging their range of distribution in lowlands, where natural rocks are absent (see ZAJAC & ZAJAC, 1973, 2001).

3. The walls are sites that are not very susceptible to colonization by anthropophytes.

4. The great participation of species capable of vegetative propagation shows that this adaptation plays a considerable role in the colonization of walls. Production of large quantities of small seeds, anemochory and myrmecochory are other specific characters of plants growing on walls.

5. The investigation of the survival rate of plants growing on walls would be a very interesting phenomenon to examine on permanent plots.

Table 2. *Cymbalarietum muralis* (rel. 1-3) and *Asplenium trichomano–rutae-murariae* (rel. 4-6) on the walls in Krosno Odrzańskie

N° of relevé	1	2	3	4	5	6
Cover of herb layer in %	20	40	20	20	10	10
Cover of moss layer in %	-	1-	-	zn	5	10
Esposition	S	S	W	E	W	E
Area of relevé in m^2	1	10	3	15	20	12
Number of species in relevé	1	8	6	10	17	19
Ch. Ass.						
Cymbalaria muralis	2b	3	2b			
Asplenium trichomanes				2b	1	2a
Asplenium ruta-muraria				+		
Others						
Sedum spurium			+			
Calystegia sepium			+			
Brachypodium sylvaticum			+			
Ranunculus repens			+			
Viola odorata			+		+	+
Taxus baccata				r	+	+
Sambucus nigra				r		
Artemisia vulgaris				r		
Humulus lupulus				r		
Festuca rubra					+	
Leucanthemum vulgare					+	
Cerastium holosteoides				+		
Lamium album					+	+
Taraxacum officinale					+	
Trifolium repens					+	
Convolvulus arvensis					+	
Poa annua					+	
Campanula rapunculoides					+	+
Conyza canadensis						+
Bromus inermis						+
Sonchus oleraceus						+
Euphorbia peplus						+
Epilobium adenocaulon						+
Chelidonium majus						+
Oxalis stricta						+
Bryum caespiticium		+				+
Tortula muralis		+				+
Lecanora albescens		+		+	+	+
Lepraria incana				+	+	+
Caloplaca decipiens		1			+	
Caloplaca citrina		+			+	
Verrucaria muralis		+				
Phaeophyscia orbicularis						+
Brachythecium selebrosum				+	+	1
Brachythecium rutabulum		+		1		+

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REFERENCES

ANIOŁ-KWIATKOWSKA, J. (1974). Flora i zbiorowiska synantropijne Legnicy, Lubina i Polkowic. *Acta Univ. Wratisl. 229, Prace Bot.* 19: 3-153.

BARKMAN, J. J., H. DOING & S. SEGAL (1964). Kritische Bemerkungen und Vorschlage zur quantitativen Vegetationsanalyse. *Acta Bot. Neerl.* 13: 394-419.

BARTKOWSKI, T. (1970). Wielkopolska i Środkowe Nadodrze. PWN, Warszawa. pp.: 383.

BRANDES, D. (1987). Zur Flora der Burgen im nördlichen Harzvorland. Braunschweig. *Naturk. Schriften* 2 (4): 797-801.

BRANDES, D. (1992). Flora und Vegetation von Stadtsmauern. *Tuexenia* 12: 315-339.

BRANDES, D. (1995). The Flora of old town centres in Europe. In: Sokopp H., Numata M., Huber A. (eds). Urban Ecology as the basis of Urban Planning. SPB Akademic Publ., Amsterdam. pp. 49-58.

BRANDES, D. (1996). Burgruinen als Habitatsinseln. Ihre Flora und Vegetation sowie die Bedeutung für Sukzessionsforschung und Naturschutz dargestellt unter Berücksichtigung der Burgruinen des Harzgebietes. *Braunschweig. Naturk. Schriften* 5 (1): 125-163.

BRZEG, A. & M. WOJTERSKA (1996). Przeglad systematyczny zbiorowisk roślinnych Wielkopolski wraz z ocena stopnia ich zagrożenia. *Bad. Fizjogr. nad Polska Zach., Ser. B*, 45: 7-40.

CELESTI GRAPOW, L., E. PIGNATII & S. PIGNATII (1993). Ellenbergs Zeigewerte zur ökologischgen Bewertung der archälogischen Zonen in Rom. *Phytocoenologia* 23: 291-299.

CEYNOWA-GIEŁDON, M. (1988). Szata roślinna obiektów obronnych dawnej twierdzy Toruń. *Acta Universitatis Nicolai Copernici, Ser. Biol.* 32.69: 23-40.

CEYNOWA-GIEŁDON, M. (1994). Roślinność fortyfikacji dawnej twierdzy Toruń. Pr. Popularnonauk. *Towarzystwa Naukowego Toruńskiego* 62: 1-97.

DECKER, P. (1912). Beiträge zur Flora der südlichen Neumark und östlichen Niederlausitz. I. *Verh. Bot. Ver. Prov. Brandenburg* 33: 87-269.

FALIŃSKI, J. B. (1969). Zbiorowiska autogeniczne i antropogeniczne. Próba określenia i klasyfikacji. Dyskusje ekologiczne. 4. *Ekol. Polska, Ser. B* 15 (2): 173-182.

GALERA, H. & B. SUDNIK-WÓJCIKOWSKA (2000a). The flora of the Palace of Culture and Sciences in Warsaw. *Acta Soc. Bot. Pol.* 69 (1): 41-54.

GALERA, H. & B. SUDNIK-WÓJCIKOWSKA (2000b). Szczególnie interesujace grupy roślin we florze Pałacu Kultury i Nauki w Warszawie. *Fragm. Florist. Geobot., Ser. Polonica* 7: 117-128.

GUMIŃSKI, R. (1948). Próba wydzielenia dzielnic rolniczo-klimatycznych w Polsce. *Przeglad Meteor. i Hydrol.* 1: 7-20.

HULTÉN, E. & M. FRIES (1986). Atlas of North European Vascular Plants, 1-3. Koeltz Scientific Books, Königstein. pp. 1172.

JACKOWIAK, B. (1990). Antropogeniczne przemiany flory roślin naczyniowych Poznania. UAM, Poznań. pp. 234.

MADALSKI, J. (1930 – 1970). Atlas Flory Polskiej. Wyd. im. Ossolińskich, Lwów; PWN, Kraków – Warszawa – Wrocław.

MEUSEL, H. & E. JÄGER (1992). Vergleichende chorologie der Zentral-Europäischen Flora, 3. Karten. G. Fischer, Jena – Stuttgart – New York.

MEUSEL, H., E. JÄGER, S. RAUSCHERT & E. WIENERT (1978). Vergleichende chorologie der Zentral-Europäischen Flora. 2. Karten. G. Fischer, Jena.

MEUSEL, H., E. JÄGER & E., WIENERT (1965). Vergleichende chorologie der zentraleuropäischen Flora, 1. Karten. G. Fischer, Jena.

MIREK, Z., H. PIEKOŚ-MIRKOWA, A. ZAJAC & M. ZAJAC (1995). Vascular Plants of Poland: A Checklist. Polish Botanical Studies, Guidebook Ser. 15. pp. 303.

NOWAK, J. & Z. TOBOLEWSKI (1975). Porosty Polskie. PWN, Warszawa-Kraków, pp. 1177.
OCHYRA, L. & P. SZMAJDA (1978). An Annotated list of Polish Mosses. *Fragm. Florist. Geobot.* 24, 1: 93-145.
RATYŃSKA, H. (2000). Roślinność Poznańskiego Przełomu Warty i jej antropogeniczne przemiany. Wydawnictwo Akademii Bydgoskiej im. Kazimierza Wielkiego, Bydgoszcz. pp. 466.
RAUNKIAER, C. (1934). The Life Forms of Plants and Statistical Plant Geography. Clarendon Press, Oxford. pp. 632.
ROTHMALER, W. (1994). Excursionsflora von Deutschland. 4. Gefässpflanzen: Kritischen Band. G. Fischer, Jena-Stuttgart.
RUTKOWSKI, L. (1998). Klucz do oznaczania roślin naczyniowych Polski Niżowej. PWN, Warszawa. pp. 812.
SEGAL, S. (1969). Ecological Notes on Wall Vegetation. Junk Publ., Den Haag.
ŚWIERKOSZ, K. (1993). Flora i zbiorowiska roślinne murów miasta Wrocławia. *Acta Univ. Wratisl. 1480, Prace Bot.* 53: 19-58.
TERPÓ, A. & K. BALINT (1998). Special urban habitats of colonizing spontaneous flora. In. Symposium Synanthropic Flora and Vegetation 5, Martin, pp.: 257-261.
ULBRICH, E. (1939). Deutsche Myrmekochoren. Beobachtungen über die Verbreitung heimischer Pflanzen durch Ameisen. *Repert. Spec. Nov. Regni. Veg., Beih.* 117: 4-60.
WERETELNIK, E. (1973). Flora starych murów Lubania Ślalskiego. *Chrońmy Przyr. Ojcz.* 29 (1): 41-45.
WERETELNIK, E. (1982). Flora i zbiorowiska roślin murów niektórych miast i zamków na Dolnym Ślasku. *Acta Univ. Wratisl. 354, Prace Bot.* 25: 63-110.
WERNER, W., M. GÖDE & N. GRIMBACH (1989). Vegetation de Mauern am Niederrhein un ihre Standortverhälnisse. *Teuxenia* 9: 57-73.
WITTIG, R. (1991). Ökologie der Grosstadtflora. G. Fischer, Stutgart.
WOODELL, S. R. J. & J. ROSSITER (1959). The flora of Durham walls. *Bot. Soc. British Island* 3: 253-257.
ZAJAC, A. & M. ZAJAC (red.) (2001). Atlas rozmieszczenia roślin naczyniowych w Polsce. Uniwersytet Jagielloński, Kraków. pp. 714.
ZAJAC, E. U. & A. ZAJAC (1973). Badania nad zasiagami roślin synantropijnych. 3. *Corydalis lutea* DC., 4. *Linaria cymbalaria* (L.) Mill. 5. *Impatiens roylei* Walp. *Zeszyty Nauk. Uniw. Jagiellońskiego 316, Prace Bot.* 1: 41-55.