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THE ANALYSIS OF THE FOREST FLORA OF THE STRZYŻOWSKIE FOOTHILLS FROM THE PERSPECTIVE OF PRESENCE OF ANTHROPOGENIC SPECIES

Abstract: The anthropogenic pressure of the forest communities of the Strzyżowskie Foothills (the Western Carpathians) was estimated on the basis of phytosociological materials. Carr communities are among the most threatened by invasive and alien species of the forest flora. The phenomenon of invasiveness of native species such as *Calamagrostis epigejos* or *Carex brizoides* was described. The highest number of ancient woodland indicator species was noted in the beech forest.

Key words: kenophytes, archaeophytes, invasive species, forest communities, the Strzyżowskie Foothills

1. INTRODUCTION

For centuries, the area of the Carpathian Foothills has experienced strong anthropogenic pressure, resulting in forest vegetation covering usually only small patches, often limited to pockets in the agricultural landscape (e.g. LOSTER 1991; PRZYBOŚ 1995; STACHURSKA 1998). The importance of these patches of forest vegetation as refugia for a number of plant and animal species is indisputable, and therefore they have remained a principal focus of research, particularly given the ever-changing landscape in areas with human settlements (e.g. DZWONKO, LOSTER 1988; DZWONKO 1993; BANASZAK 2000). The fragmentation of natural plant

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communities increases the exposure to either direct or indirect effects of anthropogenic impacts observable, like changes in the structure and function of these communities (e.g. KORNAŚ 1972; OLACZEK 1972; TRZCIŃSKA-TACIK, STACHURSKA-SWAKOŃ 2002; DYGUŚ 2003; JAKUBOWSKA-GABARA, ZIELIŃSKA 2003).

At present, the vegetation cover of the Strzyżowskie Foothills, situated in the eastern part of the Western Carpathians, is dominated by cultivated fields that occupy ca. 70% of the area (TOWPASZ 1990). Woodlands have survived only in those places less attractive to agriculture; namely, steep slopes, deep valleys, narrow gorges and ravines. Such places constitute ca. 15% of the area and create peculiar habitat islands. On the one hand, small forest patches separated from one another provide refugia for many forest plants and animals, and, on the other hand, they are often subject to strong anthropogenic pressure. Observations of their destruction or degradation can be made (TOWPASZ, STACHURSKA-SWAKOŃ 2008), as well as of their neophytism, occurring via penetration by newcomers (STACHURSKA-SWAKOŃ, TOWPASZ 2008).

The studies pursued in the Strzyżowskie Foothills for more then thirty years, have revealed a relatively high number of forest communities associated with diverse habitat conditions (TOWPASZ 1990; TOWPASZ, STACHURSKA-SWAKOŃ 2008, 2010). The location of the Strzyżowskie Foothills on the border with the Sandomierz Basin reflects in the occurrence of various syntaxonomical units characteristic of both foothill and lowland areas. Among the lowland syntaxa is *Luzulo pilosae-Fagetum*, rarely found in the Carpathian Foothills, and *Calamagrostio arundinaceae-Quercetum*, recorded in the Carpathians for the first time (TOWPASZ, STACHURSKA-SWAKOŃ, unpbl.). An important feature of the forest communities of the Strzyżowskie Foothills, which make the area stand out, is the presence of the East-Carpathian species, such as *Aposeris foetida* or *Cerastium sylvaticum*.

The presented study makes an approach to the problem of anthropogenic pressure to forest communities. The plant taxa alien to forest flora are known to exert degenerating effects on forest communities. This group includes both kenophytes and species from other communities, often introduced accidentally into

the forest flora, or even forest species showing expansive properties and resulting from changing habitat conditions.

The description of the study area was presented in the studies by TOWPASZ (1990) and TOWPASZ and STACHURSKA-SWAKOŃ (2008). The location of the area is shown in Fig. 1.

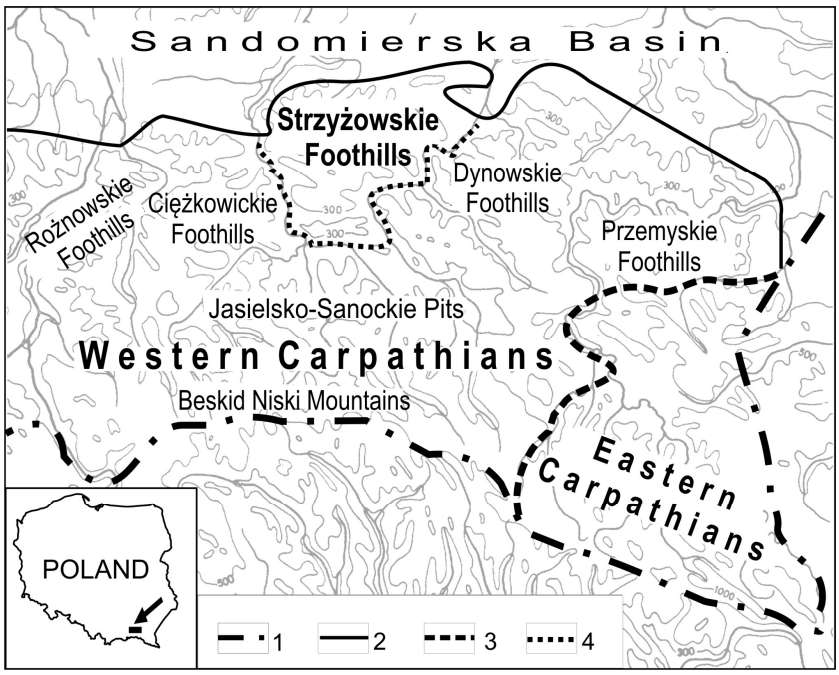

Fig. 1. Location of the Strzyżowskie Foothills against the regional division of the eastern part of the Polish Carpathians (after KONDRACKI 1978): 1 – state boundary, 2 – the northern limits of the Carpathians, 3 – boundary between the Western and Eastern Carpathians, 4 – the area investigated.

2. MATERIAL AND METHODS

The basic material used in this study is the relevés recorded during the years 1978-2009. Most of the material was published in studies conducted by TOWPASZ and STACHURSKA-SWAKOŃ 2008, 2010, STACHURSKA-SWAKOŃ and TOWPASZ 2008 and TOWPASZ *et al*. 2011. This paper also includes materials not yet published, that were obtained mainly in the period 2008-2009. Floristic lists and phytosociological tables were analysed with special attention given to the presence of species alien to

forest flora. The long period covered by the studies allowed conclusions to be drawn, on the changes occurring in forest communities of the Strzyżowskie Foothills. The basis for the classification of kenophytes followed the studies undertaken by ZAJĄC *et al*. 1998 and TOKARSKA-GUZIK 2005. The species regarded as ancient woodland indicator species were also used (following the study of DZWONKO, LOSTER 2001). The methods applied, allowed for identification of forest communities in the Strzyżowskie Foothills, the ones most threatened by alterations in their floristic composition, as well as those whose composition was not disturbed by the participation of invasive species.

3. RESULTS

The naturalized kenophytes, i.e. observed for more than 30 years and showing high constancy in the forests of the Strzyżowskie Foothills, include *Helianthus tuberosus, Impatiens parviflora, Impatiens glandulifera, Reynoutria japonica* and *Solidago gigantea* (Tab. 1). Apart from these, *Echinocystis lobata, Rudbeckia laciniata, Heracleum sosnowskyi, Oxalis stricta* and *Telekia speciosa,* are also found in the area. The majority of these species are found in riparian carr communities, especially in the riparian carrs upon major rivers such as the Wisłok and Wisłoka. The species particularly threatening the local flora of the carrs, include: *Reynoutria japonica, Helianthus tuberosus* and *Solidago gigantea.*

In deciduous woods, *Impatiens parviflora* occurs, locally with considerable cover. This species was recorded in *Tilio-Carpinetum typicum* as well as in beech forests. It is likely that its presence has resulted from a local disturbance associated with a thinning of the forest stand.

Tree and shrub species constitute a large group among the kenophytes recorded in the forests of the Strzyżowskie Foothills, and those used in planting schemes include: *Pinus strobus, Prunus serotina, Robinia pseudoacacia* and *Quercus rubra.* However, the shrub *Ligustrum vulgare,* which also occurs on natural localities in the Strzyżowskie Foothills (primarily in brushwoods with *Prunetalia*), has been accidentally planted to create hedges, was also introduced and observed to establish itself in the community with *Alnus incana.*

Table 1. Alien plant species in the forest communities of the Strzyżowskie Foothills. Abbreviations of the forest communities: A – *Carici remotae-Fraxinetum*, B – *Alnus incana* community, C – *Salicetum triandro-viminalis*, D – *Salicetum albo-fragilis*, E – *Calamagrostio arundinaceae-Quercetum*, F – *Tilio-Carpinetum stachyetosum sylvaticae*, G – *T.-C. stachyetosum* with *Arum orientale*, H – *T.-C. melittetosum*, I – *T.-C. typicum*, J – *T.-C. caricetosum pilosae*, K – *Dentario glandulosae-Fagetum lunarietosum redivivae*, L – *D.-F. typicum*, M – *D.-F.* with *Rubus hirtus*, N – *Luzulo pilosae-Fagetum*, O – *Abies alba-Oxalis acetosella*. In case the constancy of species was higher then I, the occurrence of species is done in brackets.

Forest community	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**Number of forest communities with the species**
Number of releves	**35**	**10**	**5**	**3**	**11**	**14**	**9**	**3**	**39**	**24**	**3**	**20**	**13**	**9**	**12**	
Kenophytes:																
Impatiens parviflora	I		I	I			IV (+-1)		I (+-5)			I	I			7
Solidago gigantea	I		IV (1-4)	V (+-2)					I							4
Helianthus tuberosus			III (+-3)	I												2
Aesculus hippocastanum (a)	I															1
Echinocystis lobata			I													1
Heracleum sosnowskyi			I													1
Impatiens glandulifera			I													1
Ligustrum vulgare (b)		I														1
Oxalis stricta									I							1
Pinus strobus (a)														I		1
Prunus serotina (b)					I											1
Quercus rubra (a)					I											1
Reynoutria japonica			I													1
Telekia speciosa		I														1
Archaeophytes:																
Matricaria maritima subsp. *inodora*			I						I							2
Anthemis arvensis	I															1
Apophytes:																
Equisetum arvense	I	I	I						I	I			I			6
Arctium tomentosum			I	I		I				I						4
Cerastium arvense	I					I			I			I				4
Chelidonium majus							II (+)	I	I							3
Viola canina								I					I	I		3
Arctium lappa			I	I												2
Arctium minus	I	I														2
Cirsium arvense			I	I												2
Rumex conglomeratus			I	I												2
Artemisia vulgaris				I												1
Elymus caninus	I															1
Elymus repens				I												1
Plantago major	I															1
Poa annua	I															1
Poa pratensis					I											1
Potentilla anserina			I													1
Apophytes regarded as expansive:																
Carex brizoides	I								I	I			I		I	5
Calamagrostis epigejos			I													1

A more numerous group of species alien to forest flora, consists of apophytes whose presence is most often associated with gaps in forest canopies, as well in the close vicinity of buildings. This group includes 16 species, including amongst others *Arctium lappa, Cerastium arvense* and *Chelidonium majus* (Tab. 1). Archaeophytes, however, were only rarely recorded. The last group includes only two sporadically found species: *Anthemis arvensis* and *Matricaria maritima* subsp. *inodora*.

The expansion of native species is another interesting phenomenon. The occurrence of a forest species, *Carex brizoides,* in the form of large dense stands, was observed as an effect of habitat alterations, resulting mainly from changing economic activities. In recent years, expansive invasions of *Calamagrostis epigejos,* a species associated with non-forest habitats, have been noted. Because of its development potential, this species alters the character of forest communities.

The highest combined number of species alien to forest flora was noted in riparian willow communities *Salicetum albo-fragilis* (Tab. 2). Their share constituted ca. 4% of this flora. A similar situation was observed in *Salicetum triandro-viminalis*. It is worth noting that despite similar percentage shares in both riparian communities, there were differences in the numbers of kenophytes and apophytes. More kenophytes were observed in the brushwood community *Salicetum triandro-viminalis.* At the same time, these communities had the lowest share of ancient woodland indicator species. The forest communities in whose patches no alien species were found include beech forests, particularly *Dentario glandulosae-Fagetum lunarietosum redivivae*. Also in oak-hornbeam forests; namely: *Tilio-Carpinetum stachyetosum, T.-C. caricetosum pilosae* and *T.-C. melittetosum,* no kenophytes and only a few apophytes were observed. The proportion of ancient woodland indicator species is relatively high there, with the highest numbers noted in the warm subassociation of the *T.-C. melittetosum.*

4. DISCUSSION

The list of kenophytes occurring in the forest communities of the Strzyżowskie Foothills is relatively short, although one should note that it is definitely not complete. This fact is implied from the methodology used in this

study, which derives the presence of species from relevés rather than complete accounts of forest floras. The spots where alien species can penetrate are mostly roads cutting through forest communities, paths, clearings or forest glades (PASZEK, ZAŁUSKI 2000; ZIARNEK 2000). Such places are not usually covered by phytosociological studies or if so, only to a limited extend.

Table 2. Ancient woodland indicator species and alien species in the forest communities of the Strzyżowskie Foothills.

Forest community	**Number of relevés**	**Total number of species**	**Average number of species per relevé**	**Total ancient woodland indicator species**	**% of ancient woodland indicator species**	**Number of alien species**	**% of alien species**
Carici remotae-Fraxinetum	35	197	30	60	30.5	11	5.6
Alnus incana community	10	136	37	48	35.3	6	4.4
Salicetum triandro-viminalis	5	80	19	28	35.0	15	16.3
Salicetum albo-fragilis	3	55	28	10	18.2	9	16.4
Calamagrostio arundinaceae-Quercetum	11	121	29	26	21.5	3	2.5
Tilio-Carpinetum							
T.-C. stachyetosum sylvaticae	14	119	34	49	41.2	2	1.7
T.-C. stachyetosum with *Arum orientale*	9	75	29	35	46.7	2	2.7
T.-C. melittetosum	3	78	41	37	47.4	2	2.6
T.-C. typicum	39	180	27	54	30.0	7	3.9
T.-C. caricetosum pilosae	24	122	29	53	43.4	4	3.3
Dentario glandulosae-Fagetum							
D.-F. lunarietosum redivivae	3	40	25	17	42.5	-	-
D.-F. typicum	20	102	24	43	42.2	2	3.9
D.-F. with *Rubus hirtus*	13	95	21	43	45.3	2	6.3
Luzulo pilosae-Fagetum	9	69	19	25	36.2	1	4.3
Abies alba-Oxalis acetosella	12	78	22	29	37.2	1	2.6

Riparian forest communities are the most vulnerable to alien plant invasion. This is reflected in a relatively high number (compared with other forest communities) of alien species, as well as in the proportion of ancient woodland

indicator species. The phenomenon involving kenophyte invasions of riparian communities is observed in many places in Poland and elsewhere in the world. Quite often, the newcomers appear just in the riparian woodlands. This holds, e.g. for the very expansive *Reynoutria japonica* (TOKARSKA-GUZIK 2005) or *Impatiens glandulifera* (JASNOWSKI 1961), whose first appearance in Poland was recorded in riparian woodlands. The biology of these species, as well as other kenophytes associated with moist habitats, contributes most often to the sudden alterations in the floristic structures of these associations (DRESCHER, PROTS 2003; TOKARSKA-GUZIK 2005; STACHURSKA-SWAKOŃ, TOWPASZ 2008).

Impatiens parviflora, an Asian species which appeared in Europe in 1837 (HEGI 1966), is now treated as a naturalized component of deciduous and mixed forests (FALIŃSKI 1966; KUJAWA-PAWLACZYK 1991). In the first stage, however, it colonizes empty ecological niches and places which are continually destroyed and hence, it is found in oak-hornbeam forests where light penetrates easily through gaps made by logging (e.g. STACHURSKA 1998), in places disturbed by wild boars or on fallen trees or dead tree logs (PISKORZ, KLIMKO 2001). In the studied oak-hornbeam of the Strzyżowskie Foothills, the presence of *Impatiens parviflora* is undoubtedly associated with human economic activity and with the close vicinity of cultivated fields or meadow communities.

The most resistant to the penetration by alien species, are ancient beech forests and ancient oak-hornbeam forests. The patches of these associations in the Strzyżowskie Foothills are situated in large forest complexes, far away from potential sources of diaspores of species of foreign origin. It is where the importance of the forest islands' size for the preservation of their natural properties, as emphasized by many researchers (e.g. MCARTHUR, WILSON 1967; MAY 1975), is manifested.

The lists of ancient woodland indicator species were prepared, in order to determine the approximate dates of the emergence of forest islands for the purpose of assessing the natural quality and value of a given forest – which is of significance to nature conservation (e.g. HERMY *et al*. 1999; HONNAY *et al.* 1999; DZWONKO, LOSTER 2001; ENDELS *et al.* 2007). Applying such distinct lists in this study,

indicates not only which forest communities are the most ancient in the study area, but also highlights the 'resistance' of these associations to the pressure from kenophytes.

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