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Sozophytes (red-listed species) in Silesian anthropogenic habitats and their role in nature conservation

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Abstract: Floristic research was conducted in anthropogenic habitats in Silesia in 1997-2005 and it focused on occurrence of red-listed taxa in habitats strongly transformed by man. As a result of the study, 362 sozophyte species of various threat categories were found in man-made biotopes. An analysis of frequency classes of occurrence in anthropogenic habitats in relation to the total number of sites of a given species revealed that almost 100 sozophyte taxa have over 66% of their locations in anthropogenic habitats. The study confirmed that anthropogenic habitats can serve as the last refuges for many threatened species, which are extinct in natural or semi-natural habitats. The investigations show that man-made habitats could shift the range limits of threatened species and support their dispersal. Out of the 362 analysed species, 164 were recognised to occur in other than typical plant communities. Man-made habitats create particular environmental conditions for development of specific plant communities, which are not found in natural biotopes in surrounding areas or even not described before. Thus the habitats strongly transformed by man are important for protection of the natural floristic diversity and must not be omitted in strategies of nature conservation.

Key words: plant conservation, anthropogenic habitats, sozophytes, floristic diversity

1. Introduction

Land use directly and indirectly influences environmental conditions, which play a major role in the dynamics and changes in floristic diversity (Sukopp 1969; Sukopp & Starfinger 1994). These changes most often lead to a reduction of the natural floristic diversity (Given 1994; Sutherland 1998) and cause significant qualitative and quantitative changes in the flora and vegetation (Tüxen 1961; Sukopp &Trautmann 1976).

However, it has been shown on a worldwide scale that several anthropogenic and disturbed habitats can provide alternative or complementary habitats for many species, including threatened and rare plants (Solon 1995; Masero 2003).

In Poland, human impact on the flora and vegetation is well studied mainly in natural and semi-natural ecosystems (e.g. Kaźmierczakowa & Zarzycki 2001). Relatively little effort is made to investigate the qualitative and quantitative changes of the threatened flora in degraded habitats, like quarries, small artificial ponds, roadsides, walls, and the remaining urban areas. Especially the role of these habitats in biodiversity conservation is not sufficiently studied and conditions of occurrence of red-listed species in transformed phytocoenoses are not fully recognised. Nevertheless, strongly transformed habitats have been a subject of several botanical investigations (e.g. Jackowiak 1993).

The analysis of floristic diversity in the area of Poland shows apparently that anthropogenic habitats are important sites of occurrence of sozophytes, i.e. rare and endangered plant species of the IUCN categories EX, CR, EN, VU, NT, LC and DD (IUCN 2001). This term comes from the Greek root *sōzō*, which means to rescue or protect. It was earlier implemented in nature conservation by W. Goetel (Poland) and A. Borza (Romania). The first idea to introduce this term was to enable comparisons of endangerment levels and various plant protection approaches in Central European countries, for instance to elaborate the sozophytisation index (Nowak 2004).

Many questions have emerged while considering the occurrence of sozophytes in anthropogenic habitats. How should this adaptation influence the procedure of evaluating threat categories of the species? What are the environmental conditions in the new, anthropogenic

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sites of the chosen species? Are sozophytes in such habitats components of plant communities typical for them, or they occur in different types of vegetation? Can anthropogenic habitats serve as stable refuges for threatened plants? How frequent are sozophytes in man-made habitats in comparison to natural ones? Which anthropogenic habitats are the richest in sozophytes?

This study was aimed to answer some of the above-mentioned questions and to show the increasing role of anthropogenic habitats in plant conservation. Hopefully some properly managed artificial habitats as a potential place of occurrence of endangered species could increase the effectiveness of plant conservation, which in Opole Silesia is very low (Nowak & Nowak 2004).

2. Material and methods

The areas covered by this floristic study, conducted from 1997 to 2005 in Silesia, were anthropogenic habitats, i.e. the sites where human impact had caused complete removal of primary vegetation. In total, 654 sites and 1378 vegetation plots with sozophytes were studied by using the phytosociological Braun-Blanquet's (1964) approach. While analysing the average abundance of the species in anthropogenic versus natural habitats, published phytosociological data were used as well as original relevés.

The phytosociological relevés were made in 16 types of anthropogenic habitats: quarries (including small areas where stones or the soil were extracted in a traditional manner without industrial mechanisation), sandpits, gravel-pits, clay-pits, road verges (only those where construction process or traffic had caused a complete removal of primary vegetation), dam reservoirs (large flooded areas), artificial ponds (including fish-ponds, small water bodies like fire emergency ponds or garden ponds, urban recreational ponds, and sedimentation ponds), railway tracks, canals, embankments (including river banks and dams), walls, harbours, drainage ditches, arable fields (including those of cereals and root crops, and also different types of other plantations, for instance energy willow plantations), artificial lawns and industrial heaps.

The analysed group of species (sozophytes) were established by using the IUCN approach (IUCN 2001) through compilation of a list of threatened vascular plant species. During the evaluation process also local red lists were used (Bernacki *et al.* 2000; Kącki *et al.* 2003; Nowak *et al.* 2003). The species nomenclature followed Mirek *et al.* (2002). In the field work, the phenological aspect was considered. Basic investigations were conducted from May to July. The syntaxonomic classification is given according to Matuszkiewicz (2001). Analyses of the local ranges were conducted by using the *Distribution atlas of vascular plants in Poland* (Zając & Zając 2001).

To reflect the contribution of anthropogenic sites to the total number of sites of a given species in the study area, three frequency classes were distinguished: I = below 33%, II = 33% to 66%, III = over 66%.

3. Results

Altogether on the surveyed 16 types of anthropogenic habitats, 362 sozophytes were found, representing 28 phytosociological classes and various threat categories (Fig. 1).

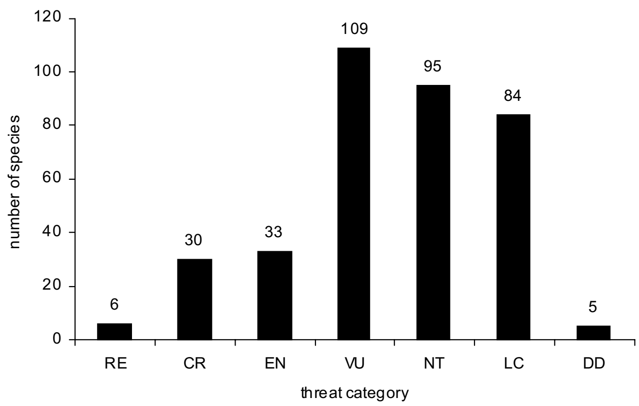

Fig. 1. Participation of threat categories in the group of recorded species
Explanation: symbols of threat categories according to IUCN (2001)

3.1. Changes in local ranges

Results of the investigations show that the creation of man-made habitats can result in an expansion of the range limits of some red-listed species. Threatened plants are still able to disperse and settle in favourable conditions even in the area outside the former natural range. There are examples of species expanding northwards (e.g. *Galium saxatile*, *Glyceria declinata*), southwards (e.g. *Callitriche stagnalis*, *Medicago minima*, *Ruppia maritima*), westwards (e.g. *Chamaecytisus ruthenicus*, *Nonea pulla*), eastwards (e.g. *Vicia lathyroides*), and to intermediate directions, for example: *Catabrosa aquatica*, *Stratiotes aloides* (SW); *Allium angulosum*, *Lindernia procumbens*, *Cerastium brachypetalum*, *Vulpia myuros* (NE); *Androsacae septentrionalis*, *Melica transsylvanica*, *Muscari comosum*, *Scrophularia scopoli* (NW). In many cases anthropogenic habitats cause an increase in the density of localities within the distribution range, e.g. for *Cyperus fuscus*, *Botrychium lunaria*, *Blechnum spicant*, *Equisetum variegatum*, *Gagea arvensis*, *Hippuris vulgaris*, *Leersia oryzoides*, *Polystichum aculeatum*, *Potamogeton obtusifolius*, and others. For some species, human influence makes it possible to spread to lower altitudes (e.g. *Asplenium trichomanes*, *Galium saxatile*, *Ranunculus platanifolius*), to higher altitudes (*Callitriche stagnalis*, *Ruppia maritima*) or to form new stands far away from the natural range (e.g. *Astragalus danicus*). The quantitative changes in species distribution ranges are shown in Fig. 2.

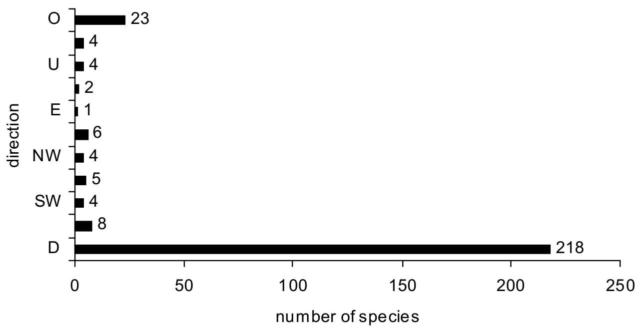

Fig. 2. Changes in local ranges for the studied group of species
Explanations: O – far away from natural range; L – to lower altitudes; U – to higher altitudes; W – westwards; E – eastwards; NE – to north-east; NW – to north-west; N – northwards; SW – to south-west; S – southwards; D – increased density in former range

3.2. Changes in syntaxonomic amplitudes

Many species found in anthropogenic habitats serve as diagnostic taxa in phytosociological classification. But on man-made sites they sometimes occur in completely different communities. Out of the 362 analysed species, 164 sozophytes were recognised to occur in other than typical plant communities, e.g. *Adonis aestivalis* (typical for *Caucalido-Scandicetum*, found in *Sisymbrietalia*, *Artemisietea vulgaris* and *Agropyretea*), *Cephalanthera damassonium* (typical for *Fagion*, found in pine plantations), *Epipactis palustris* (typical for *Caricion davallianae*, found in disturbed *Phragmitetea* and *Molinio-Arrhenatheretea*), *Equisetum telmateia* (typical for *Alno-Ulmion*, found in *Agropyretea* and *Stellarietea mediae*), *Bromus secalinus* (typical for *Centauretalia cyani*, found in *Agropyretea*), *Elatine hexandra*, *E. triandra* (typical for *Eleocharetum ovatae*, found in *Littorelletea*), *Cephalanthera rubra* (typical for *Cephalanthero rubrae-Fagetum*, found in pine and spruce plantations).

3.3. Creation of new biotopes for development of specific plant associations

Man-made habitats create particular environmental conditions for development of specific plant communities, which are absent from natural biotopes in surrounding areas or even not described before. Unusual hydrologic, edaphic, light or humidity conditions as well as removal of primary vegetation in quarries, sand-, gravel- and clay-pits and other anthropogenic habitats supports the development of unusual plant associations, like pure *Epilobium palustre* stands, *Potamogeton nodosus* community, *Potamogeton alpinus* community, *Potamogeton berchtoldii* community, *Lycopodiella inundata-Drosera rotundifolia* community, *Epipactis palustris-Solidago graminifolia* community, *Elatine hexandra* community, *Elatine triandra* community, and others.

3.4. Creation of refugees and diversity hot-spots

One of the most interesting results of the study is the confirmation that anthropogenic habitats can serve as the last refugees for many threatened species, which are extinct in natural or semi-natural habitats (forests, meadows, lakes). When analysing the frequency of sozophytes in man-made habitats, a high percentage of species in class III was recorded, as almost 100 species had over 66% of their localities in unnatural biotopes. This group includes *Lycopodiella inundata*, *Jovibarba sobolifera*, *Potamogeton acutifolius*, *P. perfoliatus*, *Vicia pisiformis*, *Vulpia myuros*, *Orchis mascula* and others. About a half of the group (50 species) occurs exclusively in anthropogenic places, e.g. *Lindernia procumbens*, *Elatine* sp., *Ajuga chamaepitys*, *Potamogeton praelongus*, *Astragalus danicus*, and *Muscari comosum*.

The frequency of occurrence in anthropogenic habitats of all sozophytes found is presented in Fig. 3.

Almost all habitat groups of species were found in alternative biotopes of anthropogenic origin (Table 1), so a great part of natural plant diversity could be supported by habitats created by man.

Table 1. Vicarious habitats for the recorded sozophytes

Natural habitats	Anthropogenic habitats
River bank silts	Silts and mud banks of ponds and quarry bottoms, sedimentation ponds
Gravel banks	Gravel pits, bottoms and escarpments of stone quarries
Slopes with xerothermic swards	Escarpments of excavation sites, river banks, industrial heaps and transportation routes
Peat bogs	Overgrowing artificial reservoirs and ponds
Lakes	Ponds and other artificial water bodies
Rocks	Quarry walls, walls
Rivers	Canals
Forests	Old, closed quarries
Tall-herb fens	Quarry bottoms, road verges, drainage ditches
Thickets	Unused excavation sites
Sea shores	Sedimentation ponds
Riverine rushes	Surroundings of artificial water bodies, ditches

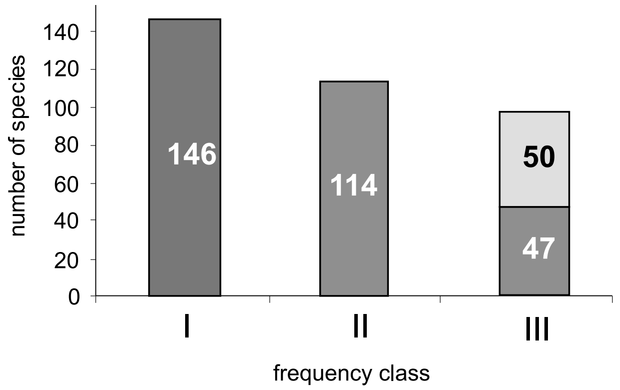

Fig. 3. Frequency of sozophytes in anthropogenic habitats
Explanations: Frequency classes: I – below 33%, II – 33-66%, III – over 66%. In frequency class III, species occurring exclusively in anthropogenic habitats are shown in light grey

4. Discussion

Why do sozophytes prefer habitats highly influenced by man and form rich refugees in disturbed areas? A contributing factor to this is that anthropogenic landscape offers various types of habitats in relatively small areas. For the city of Düsseldorf, Gödde *et al.* (1995) reported that highly disturbed sites, such as wastelands and gravel-pits, had the highest species richness of vascular plants, butterflies, grasshoppers, land snails and woodlice. Also the specific urban climate seems to play a significant role, especially due to the reduced by 10-20% wind speeds, raised temperature by up to 9^{O}C (0.5-2.0^{O}C on average), lower humidity, and increased precipitation (Sukopp 2004).

The finding that about half of all red-listed plant species in Silesia occur in man-made habitats is crucial for plant conservation and also for evaluating the threat categories. There are some reports about significant fluctuations of threat categories for the same species within a given period of time. This phenomenon was named the Lazarous effect (Keith & Burgmann 2004). Supposedly this effect is caused by synanthropisation of sozophytes.

Anthropogenic habitats play an important role in the spreading of threatened species and are interesting investigation sites for biogeographers. Also from the phytosociological point of view there are many attractive topics to be researched. Focusing on syntaxonomic plant affiliation, it is to be discovered if in changed habitat conditions under many stress factors the grouping model could be different from the typical model, leading to creation of new plant communities.

It is important that anthropogenic habitats could be the only choice for many sozophytes where natural habitats are unavailable. Fifty threatened plant species have their last populations in man-made biotopes in Silesia. This has to be taken into account in implementation of plant conservation strategy.

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