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Anthropogenic habitats as sites of occurrence of endangered, rare and protected plants on the example of Opole Silesia, SW Poland

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Abstract: The paper presents results of floristic studies conducted on eu- and polyhemerobic anthropogenic habitats in Opole Silesia in years 1997-2003. The subject of the study was occurrence of taxa endangered, rare and protected by law on areas strongly transformed by man, including quarries, gypsum mines, clay-, gravel- and sand-pits, large dam reservoirs, fish-ponds, small anthropogenic ponds, roadsides, railway tracks, channels, walls, boundary strips, harbours, parks, drainage ditches and the remaining urban areas. In the result of the study occurrence in anthropogenic habitats of 198 species from the selected group of 532 plants was stated, including species critically endangered, endangered, vulnerable, near threatened, rare and protected by law. In total, 688 sites of selected plants were documented in anthropogenic habitats, which was ca 11.5% of all sites of chosen species. Analysis of frequency classes of occurrence in anthropogenic habitats in relation to the total number of sites of a given species revealed that most taxa fell in two first classes, i.e. up to 40% of all their sites were located in anthropogenic habitats. Only 18 taxa had a decided majority of sites, i.e. over 80%, in such ecosystems. Anthropogenic habitats richest in sites of the selected species were fishponds and quarries. These species were the scarcest in small ponds, balks and drainage ditches. The author concludes that habitats strongly transformed by man are important in protection of the natural floristic diversity and must not be omitted in strategies of nature conservation.

Keywords: plant conservation, anthropogenic habitats, eu- and polyhemerobic habitats, sozophytes, floristic diversity.

Introduction

In natural environment changing under the influence of man gradually larger areas are covered by transformed or completely destroyed vegetation cover. They are sites both used by man, such as roadsides, drainage ditches, walls, ponds as well as abandoned, such as out of work quarries, gravel- and sand-pits etc. The effect of various economic and management activities are remarkable changes of vegetation cover – plant communities undergo degeneration, stenotopic floristic elements, being in most cases characteristic species of given syntaxa, disappear. The anthropophytes take advantage, expansive species that disturb the floristic composition of communities. Habitat conditions undergo transformation as well, including crucial for functioning of phytocenoses water conditions and soil profiles. At the final stage, orography and landscape of the area are exposed to transformation, which is most visible in the case of opencast excavations, heaps, etc. These changes most often lead to reduction of the natural floristic diversity (GIVEN 1994, SUTHERLAND ed. 1998).

In the rich literature about the influence of human disturbance on conditions of vegetation occurrence there are presented different parameters that reflect the range of man's pressure on the environment, including first of all its intensity, persistence and duration. In the present study the classification of SUKOPP (1969, 1972) was applied. According to habitat, phytosociological and floristic characters he distinguished six stages of transformation of ecosystems: ahemerobic – primeval vegetation, oligohemerobic – close to the potential natural vegetation, mezohemerobic – semi-natural vegetation, euhemerobic – anthropogenic vegetation with high percent of anthropophytes, polyhemerobic – unstable ruderal vegetation and metahemerobic – lack of vegetation. The objects of the present study were eu- and polyhemerobic habitats. Strongly transformed habitats have been a subject of general botanical investigations for years. Increasing interest of botanists in degraded areas has yielded a series of papers focussed on excavations of mineral materials (e.g. BADORA et al. 2003, FABISZEWSKI 1963, STOJANOWSKA 1973, MŁYNKOWIAK & KUTYNA 1999, PIETSCH 1990, KOMPAŁA 1997, SZCZĘŚNIAK 1999, HRABOVSKÝ 1999), industrial waste heaps (e.g. CABAŁA & JARZĄBEK 1999, CABAŁA & STYPIEŃ 1987, SAROSIEK 1957, SZARY 1994, TRZCIŃSKA-TACIK 1966, COHN et al. 2001, TOKARSKA-GUZIK 1996), urban areas (e.g. GUTTE 1971, JACKOWIAK 1993, KORCZYŃSKI 1995, GODEFROID 2001, DANA et al. MOTA 2002, ZERBE et al. 2003, TOKARSKA-GUZIK & ROSTAŃSKI 1998), ponds (*e.g*. KĄCKI & DAJDOK 1998, KUŹNIEWSKI 1989, MICHALAK 1963, ZAJĄC & ZAJĄC 1988), roadsides (*e.g*. CILLIERS & BREDENKAMP 2000), railway tracks (e.g. SENDEK 1973), parks (e.g. SZOTKOWSKI 1992), harbours (SZOTKOWSKI 1988). However, floristic recognition of degraded areas in the context of occurrence of endangered, rare and protected species has not been widely undertaken until present.

Even the analysis of the floristic diversity of the area of Poland, shows apparently that anthropogenic habitats are important sites of occurrence of sozophytes, i.e. rare and endangered species. In the Red Date Book of Vascular Plants of Poland (KAŹMIERCZAKOWA & ZARZYCKI eds. 2001) as much as 59 taxa among the described 296 occurred in anthropogenic habitats. Namely, they are such rare and endangered species as e.g.: *Adonis flammea* JACQ., *Aldrovanda vesiculosa* L., *Asplenium cuneifolium* VIV., *Atriplex calotheca* (RAFN) FR., *Carduus lobulatus* BORBÁS, *Cyperus flavescens* L., *Elatine alsinastrum* L., *Erysimum pieninicum* (ZAPAŁ.) PAWŁ., *Euphorbia epithymoides* L., *Galium pumilum* MURRAY, *Lathyrus latifolius* L., *Lindernia procumbens* (KROCK.) BORBÁS, *Linum austriacum* L., *Ludwigia palustris* (L.) ELLIOTT, *Muscari comosum* (L.) MILL., *Nasturcium microphyllum* (BOENN.) RCHB., *Pilularia globulifera* L., *Pulsatilla vernalis* (L.) MILL., *Reseda phyteuma* L., *Ruppia maritima* L., *Schoenoplectus mucronatus* (L.) PALLA, *Trapa natans* L.s.l., *Woodsia ilvensis* (L.) R. BR. Many species listed in the Red Date Book have their only localities in eu- or polyhemerobic ecosystems, e.g. *Apium nodiflorum* (L.) LAG., *Carex stenophylla* WAHLENB., *Crassula aquatica* (L.) SCHÖNLAND, *Dichostylis micheliana* (L.) NEES, *Dorycnium herbaceum* VILL., *Marsilea quadrifolia* L., *Sagina subulata* (SW.) C. PRESL. Similar phenomena are known, for example, form the area of the Opole voivodship (NOWAK & SPAŁEK eds. 2002), Lower Silesia (KĄCKI ed. 2003) and Slovak and Czech Republic (ČEŘOVSKÝ et al. 1999)

Considering the increase of the surface strongly transformed by human activity and, at the same time, more and more frequent records of occurrence of sozophytes in such sites, an attempt was undertaken to present the role of anthropogenic habitats in distribution and preservation of endangered plants.

Study area

Opole Silesia covers ca 9 500 km^2 and is situated in the south-western part of Poland between E 16^O 53' 40'' – 18^O 41' 50'' and N 49^O 58' 05'' – 51^O 18' 20'' (Fig. 1). The region lies in the mesothermal climatic zone with an average annual temperature of 7.5-8.6^{O}C. Average daily maximum temperatures for the area ranged from -2^O C in January to 18^O C in July, and annual rainfall is about 650 mm. Snow cover lasts about 40 days per year. The voivodeship is inhabited by 1.091 mln people, so about 115 per square kilometre with the highest density of human population in the central part of the region. The natural vegetation of most of the region's lowland part is broad-leaved forest (*Tilio-Carpinetum*, *Galio-Carpinetum*). Alongside rivers and in land depressions different types of wet forest (*Ficario-Ulmetum*, *Fraxino-Alnetum*) should be dominant. In uplands and in the Opawa Mts. (400 – 889 m a.s.l.) beech forests (*Fagion sylvaticae*) are dominant and, in the highest parts, coniferous forests (*Vaccinio-Abietenion*). The flora of the Opole voivodeship comprises 1 350 native vascular plant species with almost 500 considered to be conservation important (NOWAK et al. 2003, NOWAK & SPAŁEK 2002). The region is characterised by agricultural lands, which

cover almost 63% of the voivodeship, forests occupy about 26%, communication areas 3.8%, open waters 2.2%, urbanised, housing and industrial about 5%.

Methods

Areas covered with floristic studies, conducted within the Opole voivodship in 1997-2003, were eu- and polyhemerobic habitats, including e.g. quarries, gypsum mines, clay-, gravel- and sand-pits, large dam reservoirs, fishponds, small anthropogenic ponds, roadsides, railway tracks, channels, walls, harbours, parks, drainage ditches, balks and the remaining urbanised areas. In the study typical anthropogenic localities of archaeophytes in segetal communities were not considered. For example, for *Adonis aestivalis* L. only the locations in harbours, railway tracks, lawns, boundary strips etc. were regarded.

To reflect the percentage of locations in anthropogenic sites within the whole number of sites of a given species in the studied area five frequency ranges were distinguished: I – up to 20%, II – 20-39%, III – 40-59%, IV – 60-79%, V – 80-100%.

In the study floristic data were considered, derived from over 200 publications from the field of florisctics, phytosociology, phytogeography, biosozology and others, assembled in the publication of NOWAK (2000) and than verified and completed during field researches.

Due to the large size of the studied area (9412 km^2), during the fieldwork the selective-systematic method (FALIŃSKI 1990) was applied. A detailed analysis of the literature materials was done and then certain locations were checked systematically, regarding known object of an anthropogenic character.

Selection of species was based on the Red List of the Vascular Plants of the Opole voivodship (NOWAK et al. 2003). The species nomenclature followed MIREK et al. (2002). In the fieldwork phenological aspect were considered. Basic investigations were conducted in May, June and July.

Results

In the effect of the performed investigation of anthropogenic habitats, occurrence of 198 out of the group of selected species was stated (Tab. 1). Among the encountered taxa there were 17 species regarded at present as regionally extinct (RE), 25 critically endangered (CR), 31 endangered (EN), 58 vulnerable (VU), 32 near threatened (NT), 24 of least concern (LC), 3 data deficient (DD) and 8 not threatened. Within these 199 recorded species, 59 is protected by law according to the decree of the Polish Ministry of Environment (2001).

In total, 688 sites on anthropogenic sites were documented, including 123 known before year 1945.

Analysis of frequency classes of occurrence in anthropogenic habitats in relation to the total number of sites of a given species showed that most taxa fell in the first two classes, i.e. up to 40% of all their locations were located in

anthropogenic habitats. Only 18 taxa had a decided majority of sites, i.e. 80%, in such habitats (Fig. 2.).

Anthropogenic habitats richest in sites of the selected species were fishponds and quarries. The endangered, rare and protected species occurred relatively frequently in roadsides, flood embankments, sand-pits, gypsum mines, railway tracks and parks. The scarcest of these species were in small ponds, balks and drainage ditches (Fig. 3).

Discussion

Occurrence of as much as 198 sozophytes, i.e. ca 40% of all taxa from this group (NOWAK et al. 2003), in total at 688 sites (out of 6018 recognised), which is ca 11.5% of all known localities of these species, should be regarded as noteworthy and important in conservation of natural floristic diversity. Among the encountered taxa there were considerable amount of species of different threat category (RE, CR, EN, VU, NT and LC) and many protected by law. The category of threat or the fact of legal protection is thus not related with the occurrence of the selected species in anthropogenic habitats. Both the critically endangered species, that undergo a considerable reduction of their ranges and decrease of the population size (e.g. *Orchis mascula* (L.) L., *Utricularia australis* R. BR., *Gentiana cruciata* L., *Crepis praemorsa* (L.) TAUSCH, *Arctostaphylos uva-ursi* (L.) SPRENG, *Botrychium lunaria* (L.) SW., *Botrychium matricariifolium* (RETZ.) A. BRAUN ex W. D. J. KOCH), as well as these with higher number of locations and lower threat category (e.g. *Vinca minor* L., *Peplis portula* L., *Primula elatior* (L.) HILL, *Polypodium vulgare* L., *Asplenium trichomanes* L. occur in different anthropogenic habitats. The permanent presence of species under law protection in used places, as e.g. railway tracks, harbours, working quarries etc. undoubtedly makes complicated both the economic use and the efficient protection of plants.

Many species, very important for conservation of floristic diversity, have all the present sites in anthropogenic habitats. The examples can be *Lindernia procumbens* (KROCK.) BORBÁS, *Orchis mascula*, *O. militaris* L., *Elatine hexandra* (LAPIERRE) DC., *E. hydropipover* L. emend. OEDER., *E. triandra* SCHKUHR, *Ranunculus platanifolius* L. In the past *Aldrovanda vesiculosa* L., having at present the status of an extinct taxon occurred exclusively in anthropogenic sites (ponds). The percentage of sites in anthropogenic habitats in the total number of sites is presented in Figure 2.

Attractiveness of certain types of habitats for sozophytes results mainly from the level of their analogy with natural biotopes. Silts of pond bottoms or walls of quarries offer almost identical ecological conditions as natural riverine alluvia or rock outcrops, hence frequent occurrence of certain taxa in such sites. It is interesting that the intensity of human activity is not the key determinant of the use of anthropogenic habitats by sozophytes. Both the intensively used working excavations of mineral materials, roadsides, as well as extensively used fishponds, and finally – abandoned quarries or sand-pits are colonised by

endangered, rare and protected species. The quantitative analysis of the number of sites points at a slightly higher attractiveness of habitats of a medium intensity of use (fishponds, extensively used quarries, flood embankments). Probably the frequency of influence is more important than its intensity. More frequent presence of man in certain sites (drainage ditches, sides of main roads, parks, working excavations, railway tracks, harbours, balks) makes them less attractive than places where human activity is limited to short periods in long time intervals (closed excavations, ponds lying fallow). Undoubtedly, general accessibility influences the attractiveness of habitats. Closed sites – mining areas and private ponds are characterised by high density of sozophytes occurrences.

Based on the existing data, it is difficult to assess the dynamics of the process of colonisation of anthropogenic habitats by sozophytes. The phenomenon of occurrence of sozophytes in anthropogenic habitats has been noted well before 1945. German botanists quite often pointed at unnatural habitats of plants. This refers to such species as e.g. *Chondrilla juncea* L. reported from the area of the sugar plant in Otmuchów, the gypsum mine in Dzierżysław and the quarry in Rogów Opolski (FIEK 1881, SCHUBE 1903, 1909, 1912), *Gymnocarpium robertianum* (HOFFM.) NEWMAN found in the quarry in Molestowice (SCHALOW 1932), *Teucrium botrys* known from the quarry in Gogolin and railway areas of Opole (SCHUBE 1903, 1929), *Bromus erectus* HUDS. encountered in the quarry in Opole (SCHUBE 1927), *Adonis flammea* JACQ. reported from the quarry in Opole (SCHUBE 1903), *Campanula bononiensis* L., *Bupleurum falcatum* L., *Thalictrum minus* L., *Dactylorhiza sambucina* (L.) SOÓ, *Anthericum ramosum* L., *Orobanche elatior* SUTTON, *Gentianella ciliata* (L.) BORKH., *Ornithogalum collinum* GUSS., *Festuca valesiaca* SCHLEICH. ex GAUDIN, *Cerastium brachypetalum* PERS., *Laserpitium latifolium* L., *Prunella grandiflora* (L.) SCHOLLER, *Asperula tinctoria* L. known from areas of the gypsum mine in Dzierżysław (WIMMER 1844, FIEK 1881, SCHUBE 1903), *Botrychium lunaria* recorded in the sand-pit in Kozłówki (SCHALOW 1932), *Allium scorodoprasum* L. revealed in the gypsum mine in Dzierżysław, on the embankment of the Oder river in Koźle and on the railway track in Opole (FIEK 1881, SCHUBE 1903, SCHALOW 1932), *Anagalis foemina* MILL. reported from the gypsum mine in Dzierżysław and roadsides of Opole (FIEK 1881, SCHUBE 1903), *Bromus racemosus* L. recorded in the gypsum mine in Dzierżysław and the harbour in Koźle (FIEK 1881, SCHUBE 1903, SCHUBE 1927), *Cerinthe minor* L. stated in the gypsum mine in Dzierżysław and railway areas in Nysa (FIEK 1881, SCHUBE 1903, 1928), *Botrychium lunaria* known from the sand-pit in Kozłówki (SCHALOW 1932), *Salvinia natans* (L.) ALL. reported from ponds in Brynica (FIEK 1881, SCHUBE 1903), *Eleocharis ovata* (ROTH) ROEM. & SCHULT. noted in ponds Sangów and Kalichteich and in Wydrowice (SCHUBE 1903), *Aldrovanda vesiculosa* L. known from Niemodlińskie Ponds (FIEK 1881), *Trapa natans* reported from ponds in Wydrowice and the pond Kalichteich in Opole (FIEK 1881, SCHUBE 1903), *Elatine triandra* stated in a pond in Wydrowice (FIEK 1881, SCHUBE 1903), *Triglochin palustre* L. known from ponds in Wydrowice (SCHUBE 1903), *Cyperus flavescens* L.noted in the pond Kalichteich

in Opole and the mill pond in Trzęsin (WIMMER 1844, FIEK 1881, SCHUBE 1903), *Lindernia procumbens*, *Potamogeton pectinatus* L., *Alisma gramineum* found in the Kalichteich pond in Opole (FIEK 1881, SCHUBE 1903), *Carex bohemica* Schreb. known from the Kalichteich pond and the castle pond in Niemodlin (FIEK 1881, SCHUBE 1903, 1928), *Hypericum hirsutum* L., *Dipsacus laciniatus* L., *Melampyrum cristatum* L. reported from flood embankments in Skorogoszcz, Chróścice and Głębocko (FIEK 1881, SCHUBE 1903, SCHALOW 1933), *Ajuga chamaepitys* (L.) SCHREB. noted on a roadside in Opole (FIEK 1881, SCHUBE 1903), *Plantago arenaria* WALDST. & KIT. encountered in railway areas of Głogówek, Nysa and Biała (FIEK 1881, SCHUBE 1903, 1913, 1929), *Petrorhagia prolifera* (L.) P. W. BALL & Heywood and *Eryngium campestre* L. recorded in railway areas of Opole (SCHUBE 1929) and *Aquilegia vulgaris* L., *Geranium phaeum* L., *Scutellaria hastifolia* L., *Stratiotes aloides* L., *Salix daphnoides* VILL. reported from parks in Otmuchów and Brzeg (FIEK 1881, SCHUBE 1903, 1905, 1906, 1908). The total number of anthropogenic sites revealed before 1945, which amounts to ca 17.3% of all the recorded sites, suggests that there is an increasing tendency in the process of colonisation of anthropogenic habitats by sozophytes. However, it should be borne in mind that this result does not consider the increase of the surface of eu- and polihemerobic ecosystems and intensity of investigations on these habitats, which have become an object of particular interest only recently.

Such a great percentage of sites of sozophytes in anthropogenic habitats prompt to a very serious attitude to the problem of occurrence of rare and endangered species in not natural ecological systems. Present nature conservation should elaborate a proper attitude to sites of valuable species in strongly transformed areas. Such as in the past semi-natural biocenoses, i.e. for example swards, meadows, managed forests, have been recognised as the object of interest for nature conservation, and at present the need for protection of sites of valuable taxa in habitats strongly transformed by man should be taken into consideration. Naturally, protection of such sites is often very difficult in practice, e.g. in the case of communication tracks or roadsides. However, in many cases without any greater problems of an administrative or legal origin it is possible to effectively safeguard valuable sites, for example closed quarries or opencast excavations. Correct attempts are already undertaken to increase the rate of recolonisation by vegetation of degraded areas and than to cover them with special protection (CULLEN et al. 1998) and to analyse biodiversity of transformed areas in the context of preservation of vegetation (ZERBE et al. 2003).

Anthropogenic habitats are often rather temporary shelters than mainstays, from which the plants can expand further. Frequently they play a role of corridors of expansion for taxa and links between natural populations.

Reasons of the presence of sozophytes in ecosystems strongly transformed by man can be traced in several phenomena. Undoubtedly, among the most important direct causes there should be mentioned creation by man of analogous habitats, i.e. similar to natural ones with respect to the structure,

biogeochemical composition and the level of humidity. An example can be silt habitats in fishponds, which are analogues of alluvia of riverine banks that disappear in the effect of regulation of rivers. Another reason, much more difficult to observe, is expanding the geographical range of taxa in the effect of cease of barriers, i.e. the climatic or the orographic ones, competition or parasitism of other species and in consequence – inhabitancy of new areas by a species. Particularly numerous are examples of appearance of rare and endangered species in areas of an inhibited natural succession due to human activity. These are namely mowed roadsides, where, in spite of drastically changed edaphic and water conditions, specialised species as e.g. xerothermophiles remain, thanks to reduction of competitiveness of other plants. Another, difficult to notice, but with no doubt existing, reason of occurrence of plants in anthropogenic habitats are adaptive changes and appearance of new biological characters in plants. The problem of biological and ecological differences between closely related rare and common species was studied by e.g. BASKIN et al. (1997), HAMILTON (1990), KARRON et al. (1988), BEVILL & LOUDA (1999). Their investigations proved that emerging new features referring to e.g. the number of fruits and seeds, year of first flowering, flower structure, surface of leaves, biomass of plants, living form etc. can enable a given taxon to expand into new biotopes, including ecosystems transformed by man.

The reason of maintenance of sozophytes in anthropogenic habitats is also their limited accessibility. Such sites as quarries, railway areas, gravel- or sand-pits, harbours are not widely open for public, similarly as fishponds or ponds which are most often private. Reduction of or exclusion from human penetration of such areas allows for pertaining existence of taxa susceptible to direct negative influence.

Considering the number of endangered, rare and protected areas that occur in habitats strongly transformed by man and the total number of their locations in anthropogenic habitats it seems necessary to recognise thoroughly the occurrence of sozophytes in habitats at the high stage of hemeroby. Moreover, geobotanical studies aimed at characterising the process of synanthropization and apophytization of sozophytes would be necessary.

Conclusions

In the result of systematic studies on eu- and polihemerobic habitats of Opole Silesia occurrence of 198 species was stated out of the selected group of 532 species endangered, rare or covered with law protection. In total, 688 localities of selected plants were documented, which amounted to ca 11.5% of all the sites of species from this group. Expanding anthropogenic habitats in the landscape transformed by man and adaptive abilities of plants cause that places degraded and considered so far to be unfavourable for threatened elements of flora, will play an increasing role as temporal shelters and then permanent biotopes of occurrence for species important for preservation of the floristic diversity. Even at present a number of taxa that are extinct in places of their

natural occurrence, have their last locations in anthropogenic habitats. Many hemerophobic species tolerate and even benefit from the presence of man, whose activity maintains environmental conditions at the stage optimal for a given taxon. It is so, for example, in the case of a group of very rare taxa of alluvial habitats, which have been destroyed in the past by regulation of rivers, at present have been unconsciously restored in fishponds. Such examples induce serious attitude to the role of anthropogenic habitats in preservation of floristic diversity. They also indicate the need to intensify studies on distribution and conditions of occurrence of sozophytes in anthropogenic habitats and processes of their apophytisation and synanthropisation.

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Tab. 1. Sozophytes of the anthropogenic habitats in the Opole Silesia.

A - Threat category **

B - No of localities on anthropogenic habitats

C - Proportion of the anthropogenic habitat locations in total number of occurrences ***

D - The main types of occupied anthropogenic habitats

	Species*	A	B	C	D
1	*Achillea pannonica* Scheele	VU	1	III	River embankments
2	*Achillea ptarmica* L.	LC	2	I	Dammed reservoirs, fish-ponds
3	*Adonis aestivalis* L.	VU	4	II	Balks, lawns
4	*Adonis flammea* Jacq.	RE	3	II	Havens, quarries
5	*Agrimonia procera* Wallr.	EN	1	II	Waysides
6	*Agrostemma githago* L.	LC	2	I	Havens, waysides
7	*Ajuga chamaepitys* (L.) Schreb.	RE	2	II	Railways
8	*Ajuga genevensis* L.	NT	4	III	Quarries, sand-pits
9	*Aldrovanda vesiculosa L.*	RE	3	V	Fish-ponds
10	*Alisma gramineum* Lej.	CR	2	V	Fish-ponds
11	*Allium angulosum* L.	VU	1	I	Waysides
12	*Allium scorodoprasum* L.	EN	6	IV	River embankments, railways, sand-pits and gypsum excavations
13	*Alyssum alyssoides* (L.) L.	NT	1	II	Quarries
14	*Anagalis foemina* Mill.	EN	3	III	Waysides, quarries
15	*Anchusa officinalis* L.	VU	1	III	Waysides
16	*Anthericum ramosum* L.	NT	5	III	Waysides, limestone and gypsum excavations
17	*Anthriscus nitida* (Wahlenb.) Garcke	VU	1	I	Waysides
18	*Aquilegia vulgaris L.*	VU	3	II	Quarries, waysides, parks
19	*Arctostaphylos uva-ursi* (L.) Spreng.	CR	1	II	Sand-pits
20	*Aruncus sylvestris* Kostel.	VU	2	II	Railways, waysides
21	*Asarum europaeaum L.*	-	2	I	Quarries
22	*Asperula tinctoria* L.	EN	1	II	Sand-pits, quarries
23	*Asplenium trichomanes* L.	LC	9	V	Quarries, walls
24	*Astragalus cicer* L.	LC	6	IV	Waysides, quarries
25	*Astragalus danicus* Retz.	CR	1	V	Quarries
26	*Barbarea stricta* Andrz.	VU	2	IV	Quarries
27	*Batrachium circinatum* (Sibth.) Fr.	VU	4	III	Fish-ponds, gravel-pits
28	*Batrachium trichophyllum* (Chaix) Bosch	EN	1	II	Fish-ponds
29	*Blechnum spicant (L.) Roth.*	EN	1	III	Ditches
30	*Botrychium lunaria* (L.) Sw.	CR	2	II	Waysides
31	*Botrychium matricariifolium* (Retz.) A. Braun & W.D.J. Koch	CR	1	III	Waysides
32	*Bromus erectus* Huds.	VU	5	II	Quarries, river embankments, waysides
33	*Bromus racemosus* L.	DD	2	II	Gypsum excavations, havens
34	*Bulboschoenus maritimus* (L.) Palla	VU	6	IV	Fish-ponds, sand-pits, dammed reservoirs
35	*Bupleurum falcatum* L.	CR	1	III	Gypsum excavations
36	*Butomus umbellatus* L.	VU	3	II	Fish-ponds, channels
37	*Calla palustris L.*	LC	4	I	Fish-ponds, channels
38	*Callitriche hamulata* Kütz. Ex W.D.J. Koch	VU	4	IV	Fish-ponds, sand-pits
39	*Camelina microcarpa* Andrz.	NT	3	II	Quarries

40	*Campanula bononiensis* L.	CR	1	III	Gypsum excavations
41	*Campanula glomerata* L.	VU	4	II	Quarries, river embankments, waysides
42	*Carex bohemica* Schreb.	LC	18	V	Fish-ponds, dammed reservoirs
43	*Carex davalliana* Sm.	EN	1	I	Waysides
44	*Carex lasiocarpa* Ehrh.	VU	5	III	Fish-ponds
45	*Carex limosa* L.	CR	1	II	Fish-ponds
46	*Carex oederi* Retz.	NT	3	III	Quarries
47	*Carex praecox* Schreb.	VU	3	III	River embankments, quarries
48	*Carex pseudocyperus* L.	NT	2	II	Quarries, fish-ponds
49	*Carlina acaulis L.*	LC	9	II	Waysides, quarries, gypsum excavations, sand-pits
50	*Centaurium erythraea* Rafn.	NT	10	IV	Quarries, waysides, clay-pits, sand-pits, dammed reservoirs
51	*Centaurium pulchellum* (Sw.) Druce	EN	7	V	Quarries, clay-pits
52	*Cephalanthera damasonium (Mill.) Druce*	EN	1	I	Quarries
53	*Cephalanthera longifolia* (L.) *Fritsch*	VU	1	I	Waysides
54	*Cerastium brachypetalum* Pers.	CR	1	III	Gypsum excavations
55	*Cerinthe minor* L.	VU	7	IV	Quarries, balks, waysides
56	*Chondrilla juncea* L.	EN	4	III	Urbanised areas, quarries, gypsum excavations
57	*Cirsium canum* (L.) All.	VU	1	I	Quarries
58	*Colchicum autumnale L.*	LC	2	I	River embankments, gypsum excavations
59	*Comarum palustre* L.	NT	5	I	Fish-ponds
60	*Convallaria majalis L.*	-	2	I	Quarries
61	*Corydalis solida* (L.) Clairv.	NT	1	I	Parks
62	*Cotoneaster integerrimus* Medik.	VU	1	III	Quarries
63	*Crepis praemorsa* (L.) Tausch	CR	1	IV	Quarries
64	*Cyperus flavescens* L.	RE	3	III	Fish-ponds
65	*Cyperus fuscus* L.	VU	5	IV	Fish-ponds, dammed reservoirs
66	*Cypripedium calceolus L.*	CR	1	V	Waysides
67	*Cystopteris fragilis* (L.) Bernh.	NT	8	V	Quarries, walls
68	*Dactylorhiza incarnata (L.) Soó*	EN	2	II	Waysides
69	*Dactylorhiza majalis* (Rchb.) P.F. Hunt & Summerh.	NT	5	I	Waysides, quarries, fish-ponds
70	*Dactylorhiza sambucina* (L.) Soó	CR	1	I	Gypsum excavations
71	*Daphne mezereum* L.	LC	3	I	Waysides, quarries
72	*Dianthus carthusianorum* L.	NT	4	I	Waysides, quarries, river embankments
73	*Digitalis grandiflora Mill.*	VU	3	I	Waysides
74	*Dipsacus laciniatus* L.	RE	1	III	River embankments
75	*Drosera intermedia Hayne*	RE	2	II	Fish-ponds
76	*Drosera rotundifolia* L.	LC	8	II	Fish-ponds, gravel-pits, sand-pits
77	*Dryopteris cristata* (L.) A. Gray	VU	1	I	Fish-ponds
78	*Elatine hexandra* (Lapierre) DC.	VU	7	V	Fish-ponds, gravel-pits
79	*Elatine hydropiper* L. emend Oeder	EN	3	V	Fish-ponds
80	*Elatine triandra* Schkuhr	VU	6	V	Fish-ponds, gravel-pits
81	*Eleocharis acicularis* (L.) Roem. & Schult.	LC	18	IV	Fish-ponds, quarries, sand-pits, dammed reservoirs
82	*Eleocharis ovata* (Roth) Roem. & Schult.	VU	16	IV	Fish-ponds, dammed reservoirs
83	*Epipactis helleborine (L.) Crantz s.str.*	LC	9	I	Waysides, parks, quarries
84	*Epipactis palustris* (L.) Crantz	VU	6	IV	Quarries, waysides, clay-pits
85	*Equisetum hyemale* L.	VU	1	I	Urbanised areas
86	*Equisetum variegatum* Schleich.	VU	5	IV	Quarries, havens

87	*Eriophorum latifolium* Hoppe	EN	3	III	Quarries
88	*Eryngium campestre* L.	RE	1	II	Railways
89	*Erysimum hieracifolium* L.	-	3	II	Quarries
90	*Euphorbia villosa* Waldst. & Kit. ex Willd. S. Str.	RE	2	II	Waysides, havens
91	*Festuca psammophila* (Hack. Ex Čelak.) Fritsch	DD	2	II	Quarries
92	*Festuca trachyphylla* (Hack.)Krajina	VU	2	II	Quarries
93	*Festuca valesiaca* Schleich. Ex. Gaudin	EN	2	III	Gypsum excavations, sand-pits
94	*Frangula alnus Mill.*	-	1	I	Waysides
95	*Gagea arvensis* (Pers.) Dumort.	VU	3	II	Quarries, waysides
96	*Galanthus nivalis L.*	-	3	I	River embankments, waysides, parks
97	*Galium odoratum* (L.) Scop.	-	1	I	Quarries
98	*Gentiana cruciata* L.	CR	2	II	Quarries, waysides
99	*Gentiana pneumonanthe* L.	VU	1	I	Clay-pits
100	*Gentianella ciliata* (L.) Borkh	CR	1	II	Gypsum excavations
101	*Geranium phaeum* L.	VU	2	I	Waysides, parks
102	*Gymnocarpium robertianaum* (Hoffm.) Newman	VU	4	III	Quarries, walls
103	*Hammarbya paludosa (L.) Kuntze*	RE	1	II	Fish-ponds
104	*Hedera helix L.*	-	9	I	Parks, quarries
105	*Hippuris vulgaris* L.	EN	1	II	Quarries
106	*Hottonia palustris* L.	NT	4	I	Ditches, clay-pits, quarries
107	*Hypericum hirsutum* L.	VU	2	I	River embankments, parks
108	*Hypericum montanum* L.	EN	1	I	Quarries
109	*Inula conyza* DC.	EN	1	II	Quarries
110	*Inula salicina* L.	NT	2	II	River embankments
111	*Isolepis setacea* (L.) R. Br.	VU	3	IV	Railways, fish-ponds, waysides
112	*Juncus bulbosus* L.	EN	1	II	Quarries
113	*Laserpitium latifolium* L.	CR	1	II	Gypsum excavations
114	*Ledum palustre L.*	LC	3	I	Fish-ponds
115	*Lilium martagon* L.	LC	2	I	Waysides, quarries
116	*Lindernia procumbens* (Krock.) Borbás	CR	5	V	Fish-ponds
117	*Linum austriacum* L.	LC	1	V	Waysides
118	*Liparis loeseli (L.) Rich.*	CR	1	V	Waysides
119	*Listera ovata* (L.) R. Br.	NT	4	I	Quarries, waysides, railways
120	*Lonicera periclymenum* L.	VU	1	III	Parks
121	*Lycopodiella inundata* (L.) Holub	EN	6	IV	Sand-pits, gravel-pits, fish-ponds
122	*Lycopodium annotinum* L.	NT	1	I	Fish-ponds
123	*Lycopodium clavatum* L.	NT	3	I	Sand-pits, gravel-pits, waysides
124	*Lysimachia thyrsiflora* L.	LC	7	II	Fish-ponds
125	*Matteucia struthiopteris (L.) Tod.*	EN	1	III	Parks
126	*Melampyrum arvense* L.	VU	2	II	Quarries, waysides
127	*Melampyrum cristatum* L.	RE	1	II	River embankments
128	*Melica uniflora* Retz.	NT	1	I	Quarries
129	*Melittis melissophyllum L.*	VU	1	I	Quarries
130	*Menyanthes trifoliata* L.	VU	4	II	Fish-ponds, channels, ditches
131	*Najas minor* All.	CR	1	III	Fish-ponds
132	*Nonea pulla* (L.) DC.	RE	2	II	Waysides, railways
133	*Nuphar lutea (L.) Sibth. & Sm.*	LC	25	V	Fish-ponds
134	*Nymphaea alba* L.	NT	16	V	Fish-ponds
135	*Ononis spinosa* L.	VU	6	IV	Quarries, railways, havens
136	*Orchis mascula* (L.) L.	CR	1	II	Waysides
137	*Orchis militaris* L.	RE	1	V	Waysides

138	*Ornithogallum umbellatum* L.	NT	3	II	Quarries, waysides
139	*Ornithogalum collinum* Guss.	CR	1	II	Gypsum excavations
140	*Orobanche elatior* Sutton	CR	1	II	Gypsum excavations
141	*Orobanche lutea* Baumg.	EN	1	II	Quarries
142	*Osmunda regalis L.*	VU	3	III	Ditches
143	*Oxycoccus palustris* Pers.	NT	3	I	Fish-ponds
144	*Pedicularis palustris* L.	RE	2	II	Fish-ponds
145	*Peplis portula* L.	LC	4	II	Fish-ponds, dammed reservoirs
146	*Petasites albus* (L.) Gaertn.	LC	8	II	Waysides, quarries
147	*Petasites hybridus* (L.) P.Gaertn., B. Mey. & Schreb.	LC	4	II	Fish-ponds, waysides, quarries, parks
148	*Petrorhagia prolifera* (L.) P.W. Ball & Heywood	EN	3	III	Quarries, railways
149	*Plantago arenaria* Waldst. & Kit.	VU	3	II	Railways
150	*Platanthera bifolia (L.) Rich.*	NT	1	I	Quarries
151	*Polypodium vulgare* L.	LC	11	III	Quarries, ditches, walls
152	*Polystichum aculeatum* (L.) Roth	VU	3	IV	Quarries, waysides
153	*Potamogeton friesii* Rupr.	EN	4	II	Gravel-pits, fish-ponds
154	*Potamogeton obtusifolius* Mert. & W.D.J. Koch	NT	16	III	Fish-ponds, gravel-pits, quarries, small ponds
155	*Potamogeton pectinatus* L.	NT	12	IV	Quarries, channels, fish-ponds
156	*Potamogeton pusillus L.*	CR	1	III	Fish-ponds
157	*Potamogeton trichoides* Cham. & Schltdl.	RE	1	II	Channels
158	*Potentilla alba* L.	VU	1	I	River embankments
159	*Potentilla recta* L.	EN	3	I	Balks, quarries, havens
160	*Primula elatior (L.) Hill*	LC	6	I	Quarries, waysides, parks
161	*Primula veris* L.	NT	3	I	Quarries, railways
162	*Prunella grandiflora* (L.) Scholler	CR	1	I	Gypsum excavations
163	*Pyrola minor* L.	VU	1	II	Quarries
164	*Pyrola rotundifolia* L.	VU	3	I	Quarries, clay-pits, gravel-pits
165	*Ranunculus lingua* L.	VU	4	III	Ditches, fish-ponds, sand-pits
166	*Ranunculus platanifolius* L.	CR	1	V	Waysides
167	*Rhynchospora alba* (L.) Vahl.	VU	1	I	Fish-ponds
168	*Ribes nigrum* L.	NT	3	I	Fish-ponds
169	*Rosa gallica* L.	EN	2	II	River embankments, sand-pits
170	*Salix daphnoides* Vill.	RE	1	I	Parks
171	*Salix rosmarinifolia* L.	VU	2	I	Fish-ponds, dammed reservoirs
172	*Salvia pratensis* L.	NT	2	I	Quarries
173	*Salvinia natans* (L.) All.	VU	17	IV	Fish-ponds, clay-pits
174	*Scirpus radicans* Schkuhr	VU	3	II	Fish-ponds, sand-pits, dammed reservoirs
174	*Schoenoplectus tabernaemontani* (C.C. Gmel.) Palla	DD	2	II	Quarries
175	*Scutellaria hastifolia* L.	RE	1	II	Parks
176	*Serratula tinctoria* L.	NT	2	I	River embankments
177	*Sorbus torminalis (L.) Crantz.*	NT	1	I	Quarries
178	*Sparganium miniumum* Wallr.	EN	1	II	Fish-ponds
179	*Stachys germanica* L.	EN	1	I	Quarries, waysides
180	*Stratiotes aloides* L.	VU	5	II	Gravel-pits, fish-ponds, channels, parks
181	*Teucrium botrys* L.	VU	4	IV	Quarries, railways
182	*Thalictrum lucidum* L.	NT	2	I	Gravel-pits, ditches
183	*Thalictrum minus L.*	EN	3	II	Quarries, gypsum excavations, balks
184	*Thlaspi perfoliatum* L.	EN	3	II	Quarries
185	*Trapa natans L. s.l.*	VU	17	III	Fish-ponds, clay-pits

186	*Triglochin palustre* L.	VU	3	II	Quarries, fish-ponds
187	*Utricularia australis* R. Br.	CR	2	III	Fish-ponds
188	*Utricularia intermedia* Hayne	EN	3	III	Fish-ponds
189	*Utricularia minor* L.	VU	7	IV	Fish-ponds, ditches, gravel-pits
190	*Utricularia ochroleuca* R.W. Hartm.	RE	2	III	Fish-ponds
191	*Vaccinium uliginosum* L.	LC	3	I	Fish-ponds
192	*Verbascum phoeniceum* L.	EN	4	III	Waysides, gypsum excavations, railways
193	*Veronica longifolia* L.	VU	1	I	Ditches
194	*Viburnum opulus L.*	-	3	I	Quarries, clay-pits, fish-ponds
195	*Vicia sylvatica* L.	NT	1	I	Quarries
196	*Vinca minor* L.	LC	6	I	Parks, quarries, havens
197	*Vincetoxicum hirundinaria* Medik.	NT	1	I	River embankments
198	*Zannichellia palustris* L.	CR	1	I	Fish-ponds
	Total		688		

* - the legally protected species were underlined

** - the threat category follows the red list of vascular plants in Opole province (NOWAK, NOWAK, SPAŁEK 2003)

*** - the frequency classes: I – up to 20%, II – 20-39%, III – 40-59%, IV – 60-79%, V – 80-100%.

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Fig. 1. Map of Europe showing the location of the Opole voivodeship.

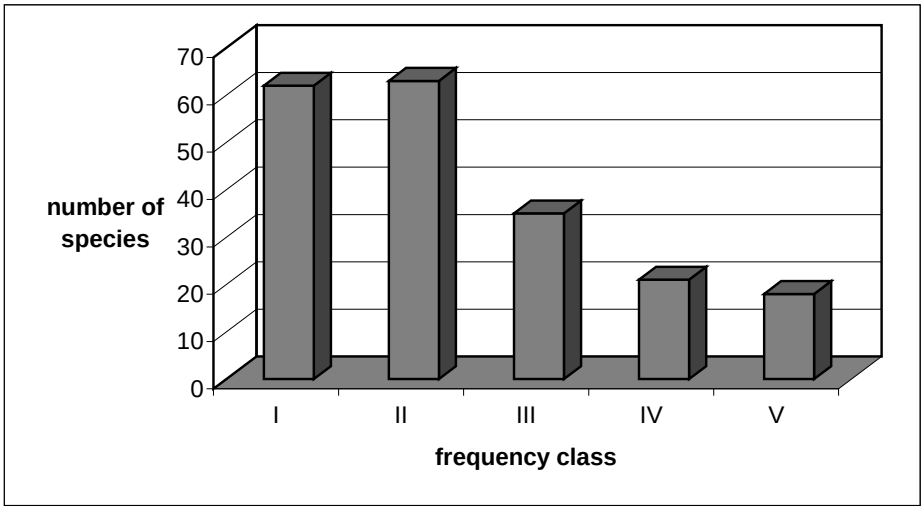

Fig. 2. Frequency of the locations in anthropogenic habitat in total number of occurrences within the province area.

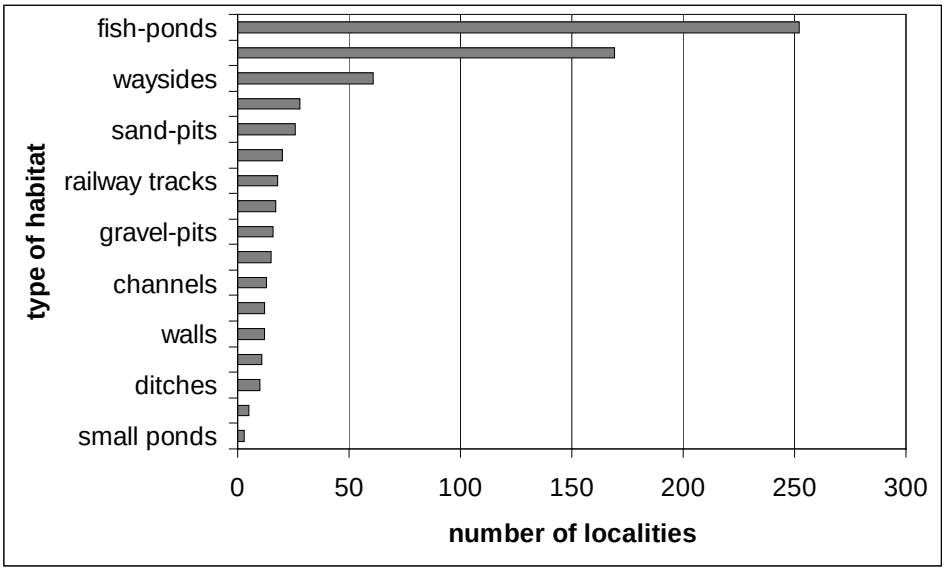

Fig. 3. Number of the chosen species localities in different types of anthropogenic habitats.