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Short research contribution

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## HUMAN IMPACT ON PLANT COMMUNITIES IN URBAN AREA ASSESSED WITH HEMEROBY GRADES

**ABSTRACT:** Paper presents a scale of hemeroby of 86 plant communities constituting the vegetation cover of Szczecin (northwestern Poland), studied in the years 1999–2002. The applied nine-grade hemeroby scale expresses the anthropogenic transformation of habitats and enables the presentation of the vegetation resilience to human impact.

The hemeroby spectrum of the analysed syntaxa differs from one grade in case of highly specialised communities (either semi-natural or synanthropic, like *Typhetum latifoliae* and *Eragrostio-Polygonetum*) to six grades – for communities found both on semi-natural and highly modified habitats, usually occupying eutrophic biotopes (like *Urtico-Calystegietum* and *Urtico-Aegopodietum*).

**KEY WORDS:** urban vegetation, anthropopression, hemeroby scale

The nine-grade scale of hemeroby (Kowarik 1988) was applied to determine a spectrum of anthropogenic transformations of habitats occupied by particular plant communities. This enabled the presentation of the range of anthropogenic habitat transformations within which particular plant communities can develop and exist.

The city of Szczecin is situated in the north-western part of Poland (53°25'N,

14°35'E). Of the total area of the city, amounting to 301 km<sup>2</sup> only one third is occupied by built-up areas and wastelands. The rest of the area is covered by agricultural land (25%), forests (18%) and open water (24%). The city is dissected by the wide Odra river valley. At present it has slightly more than 400 thousand inhabitants. Szczecin used to be called 'the green city'. Large part of the city is occupied by parks, cemeteries, gardens, lawns and avenues with greenery belts.

Earlier investigations carried out within the city limits concerned mainly the natural and semi-natural habitats. The synanthropic vegetation has been recognised only for limited number of habitats, such as railroads (Ćwikliński 1974) and harbour area (Misiwicz 1976).

Field investigations of the synanthropic vegetation were carried out in the years 1999–2002 in 17 test study areas, distributed within Szczecin city. Borders of the areas were adjusted to the existing grid of ATPOL squares – the cartogramme used for the "Distribution Atlas of Vascular Plants in Poland" (Zajac 1978). The basic unit of the grid is a 10 × 10 km square. The grid of squares covers the entire area of Poland. The ATPOL grid system is used commonly in floristic investi-

gations in Poland. It is also a good reference system for several other geobotanical works. For this reason the ATPOL cartogramme has been used in this project to present the results of phytosociological research.

The study areas covered 1 km<sup>2</sup>, 0.5 km<sup>2</sup> or (in one case) 0.25 km<sup>2</sup> and amounted to 11.25 km<sup>2</sup> in total. Each area was divided further into the elementary study plots of the size 250 × 250 m. The selected test plots represented all types of urban landscape occurring in Szczecin, including the areas with different building forms (street-side apartment buildings, separate apartment blocks, individual family houses); areas of service and transportation functions and areas of city greenery and the sub-urban enclaves of semi-natural vegetation (e.g. forest, meadow and aquatic communities). In each study plot the vegetation records were taken in all encountered phytocoenoses and hemeroby stages. For the syntaxa occurring commonly in a particular plot, only three records per plot were taken. For the spectrum analysis only plant communities documented with more than four phytosociological records, were included.

For each phytocoenosis, documented with a vegetation record, a hemeroby grade was determined. This has allowed a subsequent determination of a hemeroby spectrum for all syntaxa found in the study area as well as the evaluation of their preferences in respect to anthropogenic habitat transformation.

The term hemeroby covers all consequences of conscious and unconscious human impacts on an ecosystem (Sukopp 1976). The evaluation of the degree of anthropogenic transformation by use of the hemeroby scale is based on the analysis of the vegetation cover and the properties of habitats.

The concept of hemeroby has been introduced by Jalas (1953, 1955) who proposed the first hemeroby scale of four grades. The scale has been extended to six grades by Sukopp (1972, comp. Falińska 2004) by an addition of a very strong and extreme anthropogenic transformations of the environment, which occur in urban and industrial areas. For specific urban areas Kunick (1974) has supplemented the definitions of the particu-

lar grades of the scale. Blume and Sukopp in 1976 have further extended the scale by dividing the euhemerobic stage into  $\alpha$ - and  $\beta$ -euhemeroby. Finally, Kowarik (1988) have extended the scale to nine grades. Application of this scale have enabled the precise classification of meso- and euhemerobic habitats, most commonly found in the cities (according to Jalas 1953 and Sukopp 1972) in 3 or 5 different grades, respectively. The wide scale of hemeroby was used in this work.

Plant communities registered in the studied areas in Szczecin develop on habitats ranging from the least to the strongest transformed (Table 1). Oligo- and meso-hemerobic habitats (H2–4) are occupied by wet forests, reed-beds and tall forbs as well as by water-plant communities. Habitats graded H5–7 are dominated by synanthropic communities of *Sisymbrium* alliance (class *Stellarietea*), communities of perennials (class *Artemisieteae*) and grass-dominated communities of the classes *Molinio-Arrhenatheretea* and *Agropyreteae*. In places with the strongest anthropoppression carpet communities prevail, as well as the communities of *Stellarietea* class, developing on rubble heaps, railroads etc. The widest spectrum, comprising six hemeroby grades, display the following syntaxa: *Urtico-Calystegietum* – range from H2 to H6 and *Arrhenatheretum elatioris*, *Poa pratensis-Festuca rubra* community, *Urtico-Aegopodietum* and *Convolvulo-Agropyretum* – occupying habitats ranging from H3 to H8.

The dynamics of vegetation and its reaction to various human impact has been a subject of botanical and ecological studies already for tens of years. Until now, however, only the descriptive methods were used for determination of the degeneration phases (taking into account both the properties of the habitat and the floristic composition) or basing upon the floristic transformations of plant communities (e.g. Faliński 1966, 1969, Olaczek 1972, 1974).

The hemeroby scale applied in the present work has been used mainly in floristic investigations, both for strongly transformed systems (Jackowiak 1990, 1993, 1998, Hill *et al.* 2002 have used it for the studies of urban floras) or for semi-natural environ-

Table 1. Spectrum of hemeroby grades of plant communities in Szczecin city.

• – less than ¼ of all occurrences of the syntaxon, ● – from ¼ to ½ of all occurrences of the syntaxon, ● – more than ½ of all occurrences of the syntaxon

H2 – oligo- to mesohemerobic grade, H3 – mesohemerobic grade, H4 – meso- to b-euhemerobic grade, H5 – b-euhemerobic grade, H6 – b-euhemerobic to a-euhemerobic grade, H7 – a-euhemerobic grade, H8 – a-euhemerobic to polyhemerobic grade, H9 – polyhemerobic grade.

Syntaxon	Hemeroby grades								
	H2	H3	H4	H5	H6	H7	H8	H9	
<i>Salicetum pentandro-cinereae</i>	●	•							
<i>Ribeso nigri-Alnetum</i>	•	●							
<i>Glycerietum maximae</i>	•	•	•						
<i>Phalaridetum arundinaceae</i>	•	•	•						
<i>Scirpetum sylvatici</i>	•	•	•						
<i>Caricetum gracilis</i>	•	●							
<i>Caricetum acutiformis</i>	•	●							
<i>Fraxino-Alnetum</i>	•	●	•						
Community with <i>Lemna minor</i>	•	●	•						
<i>Phragmitetum australis</i>	•	●	•		•				
<i>Urtico-Calystegietum</i>	•	•	•	•	•	•			
<i>Typhetum latifoliae</i>		●							
<i>Filipendulo-Geranium</i>		●							
<i>Trifolio-Agrimonetum</i>		●							
<i>Acoretum calami</i>		●							
<i>Angelico-Cirsietum oleracei</i>		●	•						
<i>Holco mollis-Cytisetum scoparii</i>		●	•						
<i>Alopecuretum pratensis</i>		●	•						
Community with <i>Holcus mollis</i>		●	•	•					
<i>Salicetum triandro-viminalis</i>		●		•					
<i>Salicetum albo-fragilis</i>		●		•					
<i>Fago-Quercetum petraeae</i>		●	•						

Syntaxon	Hemeroby grades							
	H2	H3	H4	H5	H6	H7	H8	H9
<i>Rubo fruticosi-Prunetum spinosae</i>		●	●					
<i>Sparganio-Glycerietum fluitantis</i>		●	●					
<i>Leucobryo-Pinetum</i>		●	●	●				
<i>Galio odorati-Fagetum</i>		●	●	●				
<i>Spergulo-Corynephorretum</i>		●	●	●				
<i>Epilobio-Salicetum capreae</i>		●	●	●	●			
<i>Diantho-Armerietum</i>		●	●	●	●	●		
<i>Stellario-Carpinetum</i>		●	●	●				
<i>Lemnetum gibbae</i>		●	●	●				
<i>Rubetum idaei</i>		●	●	●				
<i>Arrhenatheretum elatioris</i>		●	●	●	●	●	●	
Community with <i>Holcus lanatus</i>		●	●	●	●			
<i>Agropyro-Urticetum dioicae</i>		●	●	●	●	●		
Community <i>Poa pratensis-Festuca rubra</i>		●	●	●	●	●	●	
<i>Impatientetum parviflorae</i>		●	●	●	●	●		
<i>Urtico-Aegopodietum</i>		●	●	●	●	●	●	
Community with <i>Calamagrostis epigejos</i>		●	●	●	●		●	
<i>Convolvulo-Agropyretum</i>		●	●	●	●	●	●	
Community with <i>Juncus bufonius</i>		●	●	●	●	●		
<i>Sambucetum nigrae</i>		●		●	●	●		
Community with <i>Cirsium arvense</i>		●			●			
Community with <i>Medicago</i> sp.		●			●	●		
Community <i>Bidens tripartita-Polygonum persicaria</i>			●					
Community with <i>Rubus caesius</i>			●	●	●			
<i>Convolvulo-Brometum inermis</i>			●	●	●			

Syntaxon	Hemeroby grades							
	H2	H3	H4	H5	H6	H7	H8	H9
<i>Chelidonio-Robinietum</i>			•	●	•	•		
<i>Artemisio-Tanacetetum</i>			•	•	●	•		
<i>Anthriscetum sylvestris</i>			•	•	•			
<i>Lolio-Cynosuretum</i>			•	•	•			
Community with <i>Dactylis glomerata</i>			•	•		•		
<i>Convolvulo-Brometum carinati</i>			•	•	●	•		
<i>Dauco-Picridetum</i>			•	•	•	•	•	
<i>Echio-Melilotetum</i>			•	•	•	•	•	
<i>Potentilletum reptantis</i>			•		•	•	•	
<i>Leonuro-Ballotetum</i>				●	•			
Community with <i>Helianthus tuberosus</i>				●	•			
Community <i>Humulus lupulus-Urtica dioica</i>				●	•	•		
Community with <i>Solidago canadensis</i>				•	●			
Community with <i>Reynoutria</i> sp.				•	•	•		
Community with <i>Bunias orientalis</i>				•	●			
<i>Arctio-Artemisietum</i>				•	●	•		
<i>Sisymbrietum sophiae</i>				•	●	•		
<i>Galeopsido-Chelidonetum</i>				•	•	•		
<i>Hordeo-Brometum</i>				•	•	•	•	
<i>Echinochloo-Setarietum</i>				•	•	●		
<i>Lolio-Plantaginetum</i>				•	•	●	•	•
Community with <i>Lycium barbarum</i>					●	•		
<i>Berteroëtum incanae</i>					●	•	•	
<i>Aphano-Matricarietum</i>					•	●	•	
<i>Oxalido-Chenopodietum</i>					•	●		•

Syntaxon	Hemeroby grades							
	H2	H3	H4	H5	H6	H7	H8	H9
<i>Potentilletum anserinae</i>					•	•	•	
<i>Sieglingio-Agrostietum</i>					•	•	●	
<i>Galinsogo-Setarietum</i>					•	●	•	
<i>Sisymbrietum loeseli</i>					•	●	•	•
<i>Sileno conicae-Cerastietum semidecandri</i>					•	•	•	•
<i>Poëtum annuae</i>					•	•	•	•
<i>Tunico-Poëtum</i>					•	•	●	•
<i>Urtico-Malvetum</i>						●	•	
<i>Erigeronto-Lactucetum</i>						•	•	
<i>Erigeronto-Bryetum</i>						•	●	•
<i>Polygono-Matricarietum</i>						•	●	•
Community <i>Polygonum aviculare-Poa annua</i>						•	•	•
<i>Bryo-Saginetum</i>						•	•	●
<i>Eragrostio-Polygonetum</i>								●

ments (Chmiel 1993). The references to the hemeroby scale are found also in some phytosociological works (e.g. Dierssen 1982, Wołejko 1991). The present publication contains the first trial to use the hemeroby to study the dynamics of plant communities in urban areas. It gives the opportunity to show the spectrum of human impact intensity which is specific for a particular plant community.

The hemeroby spectrum of the analysed syntaxa varies from one grade in case of highly specialised communities to six grades – for communities found both on semi-natural and highly modified habitats. The group of syntaxa showing the highest tolerance to the degree of anthropogenic pressure represent plant communities preferring wet and eutrophic sites (e.g. *Urtico-Aegopodietum*, *Urtico-Calystegietum*) and the grass-dominated communities of moist habitats (e.g. *Arrhenatheretum elatioris*, *Poa pratensis-Fes-*

*tuca rubra* community). Such syntaxa form a stable element of urban landscape, characterised by relatively constant floristic composition, largely independent from the intensity of man's impact.

Plant communities characterized by a narrow hemeroby spectrum (noted within only one hemeroby grade or clearly preferring one grade) are represented by syntaxa sensitive to changes in the intensity of anthropoppression. Such specialised communities develop both on semi-natural habitats (e.g. reeds and riverside tall-forbs communities) and in places undergoing the extreme anthropoppression (*Eragrostio-Polygonetum* and *Bryo-Saginetum*).

The application of hemeroby scale for presentation of antropogenic transformation of habitats enables a clear determination of the synanthropisation degree of particular syntaxa. Under urban conditions, besides the already expected synanthropic character of

associations from *Stellarietea* and *Artemisietea* classes, there is observed also a remarkable attachment to highly transformed sites of such associations as *Tunico-Poëtum* and *Sileno conicae-Cerastietum semidecandri*.

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