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Human impact on wetland flora of the Warsaw-Berlin proglacial valley

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Abstract: Central Poland is a region with low wetland richness. Its most valuable meadows and peatlands are situated in the eastern part of the Warsaw-Berlin proglacial valley, between Łowicz and Dąbie. This largest wetland area of Central Poland covers ca. 20 000 hectares, with a mosaic of meadows, forests, various wetlands, and small areas of arable land. Over the last 50 years, a negative impact of agriculture has been observed in the plant cover at the bottom of the proglacial valley, e.g. extinction of many wetland plant species. The main aim of this research was to determine the impact of agriculture on floristic diversity and natural condition of the wetland. In the 77 studied squares (1 km^2 each), we recorded ca. 600 species of vascular plants. The squares greatly varied in species composition and number. The long-term human pressure on the proglacial valley flora caused its significant degradation: with the progress of transformation of the area, the participation of anthropophytes and apophytes increases. Additionally, intensive agriculture in the proglacial valley causes extinction of species from wetland habitats.

Key words: wetland, flora, agriculture, human impact, threatened habitats

1. Introduction

Wetlands are the most precious and at the same time the most endangered ecosystems on a global scale (Dahl 1990; Jones & Hughes 1993; Finlayson & Rea 1999; Whigham 1999; Zhao & Ch 2001; Schuyt 2005). They are key habitats, because they have an impact on functioning of the neighbouring areas (Amezaga *et al.* 2002). Among other things, they determine the quality of flow, filtration and sedimentation of pollution, and the level of groundwater (Hartig *et al.* 1997). In wetlands, many rare species of fauna and flora exist (Kucharski & Pisarek 2001), so they are areas of very high biodiversity (Faizi & Al-Wetaid 1997). Nowadays, as a result of human activities, many adverse trends are observed in wetlands. Research showed that the natural floristic diversity decreases with the growing human pressure on the environment (Sutherland 1998). This effect is reflected in the simultaneous decline of stenotopic species and an increasing number of anthropophytes (Finlayson *et al.* 1997). These dynamic changes eventually blur the differences between floras of particular regions and cause extinction of hemerophobic species, i.e. those sensitive to human activities (Jackowiak 1998).

The purpose of this research was to estimate the influence of agriculture on wetland flora in the Warsaw-Berlin proglacial valley. The valley has been exposed to constant and strong pressure of agriculture for about 200 years.

2. Materials and methods

Field research was carried out in 2005-2007 in the Warsaw-Berlin proglacial valley. It is one of the largest Natura 2000 sites in Poland (23 412.42 ha) and at the same time it is the largest protected wetland area in Central Poland. Natura 2000 site "Warsaw-Berlin Proglacial Valley" (PLB 100001) extends from Dąbie in the west to Łowicz in the east. Its length is about 78 km and the average width reaches 3 km (Fig. 1). From the administrative point of view, the majority of the protected area is situated in the Łódź province, and only a small part (near Dąbie) belongs to the Wielkopolska province. According to the geobotanical division of Poland (Szafer 1977), the study area covers the eastern part of the Wielkopolska-Kujawy region, as well as the western part of the Mazovia region.

The investigated area was divided into 380 squares (1 km^2 each). Three fragments of the proglacial valley, characterized by different levels of transformation of the plant cover, were chosen for a detailed analysis. The western section is best preserved; meadows and wetlands dominate there. The central section is moderately transformed, while the eastern part of the study area is characterized by significant human transformation. In all, 77 squares situated completely within the protected area's boundaries were chosen for a detailed analysis (Fig. 1).

occupied by a particular type of land use were taken as the weights. According to available cartographic materials, four types of land use were distinguished and graded from 1 to 10 (values increasing with intensification of human pressure): (1) coniferous and deciduous forests (grade 1); (2) meadows and wetlands (grade 3); (3) arable lands (grade 7); (4) built-up areas (grade 10).

Statistic analyses were made in STATISTICA 6.0 (StatSoft, Inc. 2003). Only non-parametric tests were used, because our data did not show normal distribution, even after numerous transformations. The Spearman's rank correlation coefficient was calculated in order to check dependence between the anthropization index and floristic index. The correlation was statistically significant ($p<0.05$).

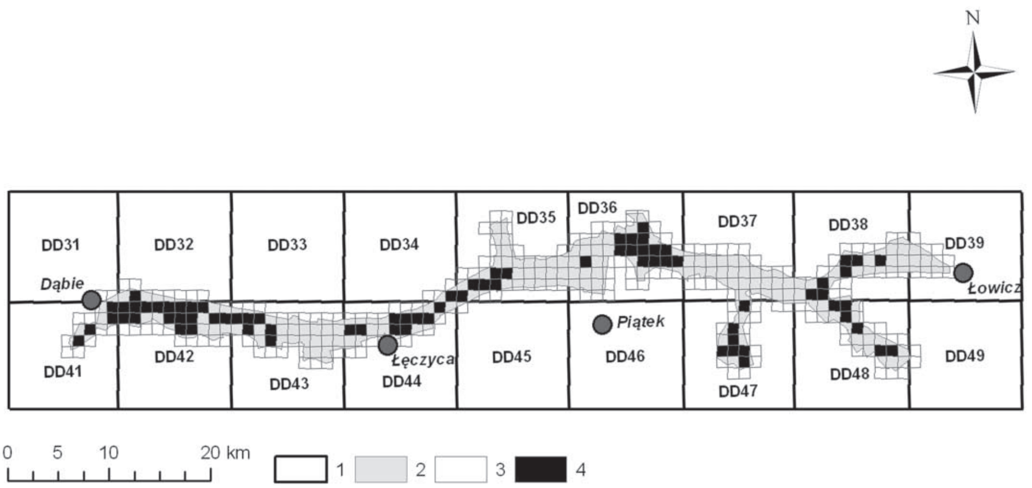

Fig. 1. Warsaw-Berlin proglacial valley – location and division of the study area
Explanations: 1 – ATPOL squares, 2 – Natura 2000 site "Warsaw-Berlin proglacial valley", 3 – study area, 4 – investigated squares

For each square, a complete list of spontaneous vascular flora was made. Next, for every investigated square, indexes of humidity, fertility, hemeroby, and total anthropization were estimated. The total number of species and participation of anthropophytes were also calculated. Indexes of humidity, fertility, hemeroby were calculated as arithmetic means of ecological indicator values of species found in this area (Lindacher 1995). A total anthropization index was calculated according to Jackowiak's (1990, 2006) formula. Moreover, the analysis of flora with regard to socioecological classification in accordance with Van der Maarel's (1971) concept was carried out. The classification of species followed Chmiel (2006).

Each of the 77 investigated squares was also characterized in respect of land use. In ArcInfo 9.1. software, on the basis of a topographic map, a map of land use was made, and then an index of anthropogenic transformation (WAP) was calculated as a weighted mean grade of land use types (Plit 1996). Areas

3. Results

We recorded 617 species of vascular as a result of the research. On average, about 130 species were found in a single square (minimum: 70 species, maximum: 214 species). According to the socioecological classification of Chmiel (2006), those species represented 15 out of 16 classes, as only epiphytic species were absent (Table 1). The richest in species was the class including riverine forests, thickets and tall herb communities, as well as wetlands and aquatic communities (group 6, almost 15% of total species). The number of anthropophytes recorded in particular squares also varied widely (min: 1; max: 32). An average value of total anthropization index in individual squares was about 12.2 (min. 1.0; max. 21.7).

Indexes calculated for each of the 77 squares turned out to be partially dependent on the type of land use and the index of anthropogenic transformation of the study area (Table 2). Analysis of the Spearman's rank

Table 1. Socioecological groups of plant species in the researched areas

No.*	Syntaxonomic groups	Number of species	Participation of species [%]
1.	*Fagetalia sylvaticae, Urtico-Crataegion, Galio-Alliarion, Sambuco-Salicion capreae*	69	11.18
2.	*Quercetalia robori-petraeae, Carici-piluliferae-Epilobion angustifolii, Nardetalia*	49	7.94
3.	*Potentillo albae-Quercion, Trifolio-Geranietea, Festuco-Brometea*	28	4.54
4.	*Dicrano-Pinion, Koelerio-Corynephoretea, Vaccinio-Genistitalia, Saginion procumbentis*	36	5.83
5.	*Alnetea glutinosae, Magnocaricion, Scheuzerio-Caricetea fuscae, Oxycocco-Sphagnetea*	46	7.46
6.	*Salicetea purpureae, Calystegion sepium, Phragmition, Nasturtio-Glycerietalia, Potametea, Lemnetea, Utricularietea*	90	14.59
7.	*Molinietalia, Agropyro-Rumicion crispi*	51	8.27
8.	*Arrhenatheretalia, Cynosurion*	57	9.24
9.	*Thero-Salicornietea, Asteretea tripolium*	5	0.81
10.	*Isoëto durieui-Juncetea bufonii, Bidentetea tripartitae*	24	3.89
11.	*Petasition officinalis, Arction lappae*	22	3.57
12.	*Onopordion acanthii*	21	3.40
13.	*Sisymbrietalia, Eragrostietalia, Matricario-Polygonion arenastri*	26	4.21
14.	*Aperetalia spicae-venti, Papaveretalia rhoeadis*	66	10.70
16.	Species not characteristic for any units	27	4.38
	Together	617	100.00

Explanation: * number and definition of a group in accordance with Chmiel's (2006) classification

correlation indicated that three of the calculated indexes change linearly together with modification of anthropogenic transformation index and type of land use: index of humidity (Fig. 2), hemeroby (Fig. 3) and total

Table 2. Correlations between floristic indexes, degree of anthropogenic transformation (WAP), and types of land use

Name of index	Total anthropization	Hemeroby index	WAP	Buildings	Meadows/ marshes	Arable lands	Coniferous/ deciduous forests
Humidity	**-0.68***	**-0.76***	**-0.58***	**-0.36***	**0.40***	**-0.60***	0.12
Fertility	0.18	0.22	-0.04	0.00	0.17	-0.15	-0.11
Number of species	0.16	0.09	-0.01	0.16	-0.01	0.00	-0.05
Hemeroby index	**0.86***	-	**0.62***	**0.43***	**-0.25***	**0.54***	**-0.35**
Total anthropization	-	**0.86***	**0.52***	**0.42***	**-0.28***	**0.47***	**-0.24***

Explanation: * statistically significant correlation ($p<0.05$)

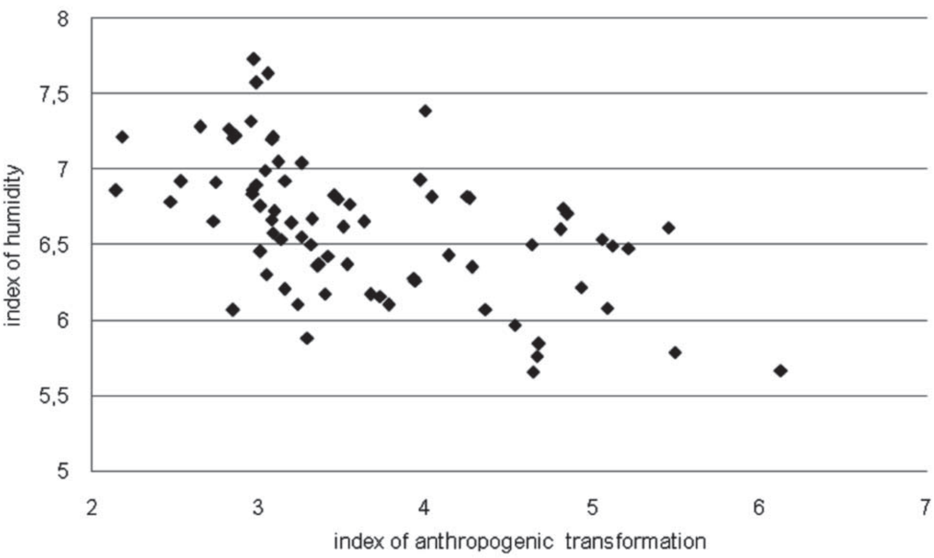

Fig. 2. Dependence of index of humidity and index of anthropogenic transformation (coefficient of Spearman's rank correlation – 0.58, confidence level $p<0.05$)

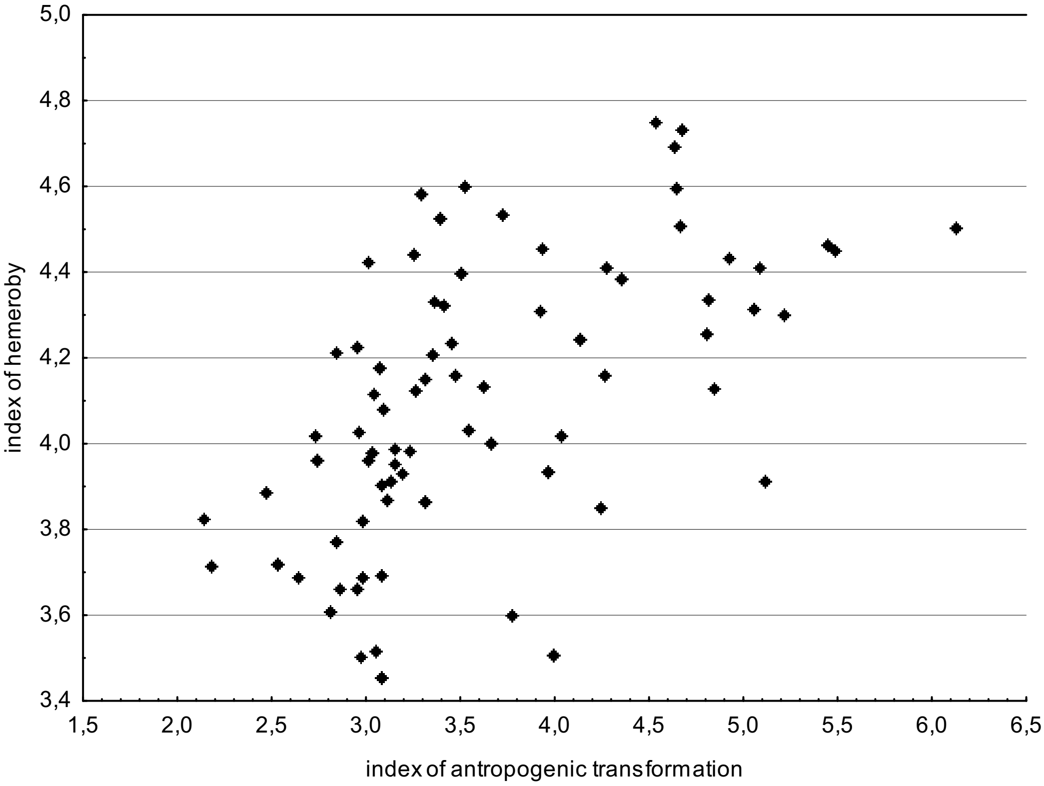

Fig. 3. Dependence of hemeroby index and index of anthropogenic transformation (coefficient of Spearman's rank correlation 0.62, confidence level p<0.05)

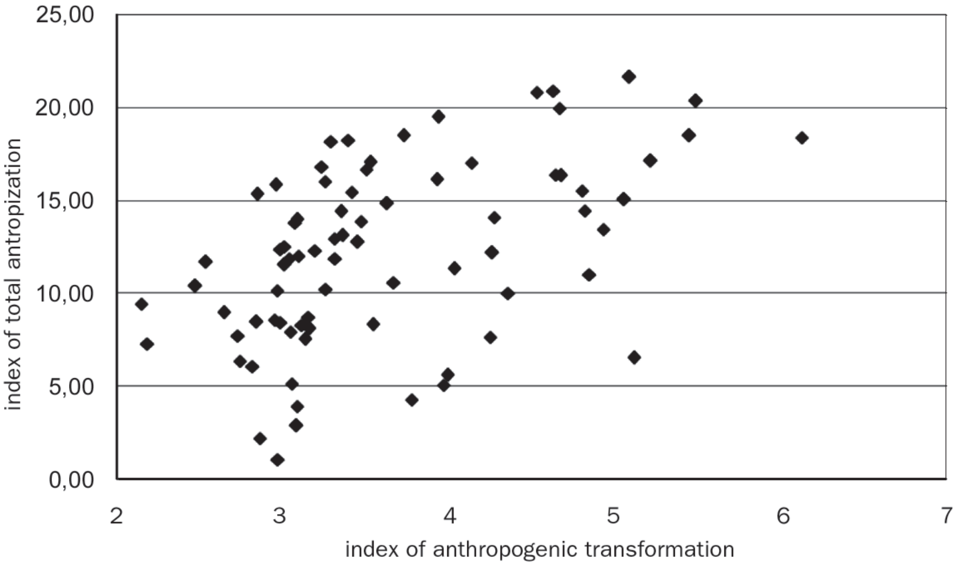

Fig. 4. Dependence of index of total anthropization and index of anthropogenic transformation (coefficient of Spearman's rank correlation 0.52, confidence level p<0.05)

anthropization (Fig. 4). At the same time, fertility index and number of species turned out to be independent of the calculated indexes describing land use and transformation of the proglacial valley.

4. Discussion

Flora of the study area includes over 600 species of vascular plants, and the average number of species in a single square is 130. In earlier research carried out in the northeastern part of the Wielkopolska region (Chmiel 2006), the average number of species of vascular plants per square was 120, while the total flora of the area researched by Chmiel included 1285 taxa. The difference in the number of species is mostly a result of the size of the study area, which in the case of Chmiel's (2006) investigations was nearly 60 times larger. Moreover, the proglacial valley was relatively homogeneous with respect to habitat conditions and characterized by a small diversity of land use types (nearly 90% of the study area is definitely dominated by meadows, pastures and wetlands). Taking this into account, it may be stated that the flora of the proglacial valley is relatively rich. The total anthropization index for the Warsaw-Berlin proglacial valley was lower than for a landscape park in NE Wielkopolska (21.2%, Chmiel 2006), the River Główna catchment (28.5%, Ratyńska 2003) and other areas in Wielkopolska (Chmiel 1993; Celka 1999). These results show that proglacial valley is in a relatively good condition.

As far as the socio-ecological classification is concerned, the flora of the Warsaw-Berlin proglacial valley has many convergent features with the flora of NW Wielkopolska (Chmiel 2006). In both cases, the greatest groups include species of fertile deciduous forests (group 1), shrub communities, wetlands, and aquatic communities (group 2). The major difference is the number of species from group 3, including taxa characteristic for xerothermic communities. In the proglacial valley there are significantly less species characteristic for warm and rich habitats, which is a result of the specific geomorphological conditions.

Traditional and extensive agriculture guarantee the stability of segetal, meadow-pasture and marginal ecosystems. In areas where this kind of land use dominates, biodiversity reaches highest indexes (Kornaś 1981; Kornaś & Medwecka-Kornaś 2002; Guziak & Lubaczewska 2001). However, present agrotechnological progress and changes in agrarian structure have a negative effect on the total richness and floristic diversity of grasslands and wetlands (Chmiel 2006). In the Warsaw-Berlin proglacial valley, the most adverse impact on local biodiversity has been exerted by its drainage for many years. In consequence, disappearance of local populations of many stenotopic species connected with wet and salty habitats, such as *Liparis loeselii*, *Blysmus rufus*, *Spergularia media*, *Juncus ranarius* and *Salicornia herbacea* was observed (Mądalski 1954; Mowszowicz 1964; Olaczek 1974; Winniecki *et al.* 1989; Kucharski 1994). This is confirmed by our research carried out in 2005-2007. Together with the increase in anthropogenic transformation index of a given area, a decrease is noticed in the number of hygrophytes and hydrophytes (index of humidity) (Fig. 2), which are the most precious components of the study area's flora (Kopeć *et al.* 2009). Undoubtedly, it shows a negative impact of intensive agriculture on the floristic diversity of aquatic and marshy habitats. However, as a result of this process, we do not observe a decline in the total number of species – there is no linear relationship between anthropogenic transformation index of the study area and the number of species (Table 2). Thus we can see an exchange of species within a limited group. More and more frequently, eurytopic species appear instead of the stenotopic hygrophyte and hydrophyte species. This is confirmed by significant correlations (Table 2): (*i*) directly by negative correlations between humidity index and both hemeroby index and total anthropization index; and (*ii*) indirectly by positive correlations between hemeroby index and both total anthropization index and index of anthropogenic transformation.

Our results are consistent with Chmiel's (2006) findings. Species diversity – expressed by the number of species – is fostered mainly by a natural variety of habitats, and to a lesser degree by the type of land use and the level of the area's transformation.

5. Conclusions

1. The long-term human pressure on the proglacial valley flora caused its significant degradation: with the progress of transformation of the area, the participation of anthropophytes and apophytes increases.
2. Intensive agriculture in the proglacial valley causes extinction of wetland species. Their number in the investigated areas decreases with an increase in transformation of the area.
3. Many valuable and protected species of vascular plants, which are found in wetlands, became extinct or their presence decreased greatly in the proglacial valley during the last few decades, e.g. *Liparis loeselii* (a species from Annex II Habitats Directive).

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