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AN ATTEMPT AT EVALUATING THE INFLUENCE OF WATER QUALITY ON THE QUALITATIVE AND QUANTITATIVE STRUCTURE OF EPIPHYTIC FAUNA DWELLING ON *STRATIOTES ALOIDES* L., A CASE STUDY ON AN OXBOW LAKE OF THE ŁYNA RIVER*

Krystian Obolewski,
Katarzyna Glińska-Lewczuk, Szymon Kobus

Chair of Land Reclamation and Management
University of Warmia and Mazury in Olsztyn

Abstract

The paper contains the results of a study on the dependence of the qualitative and quantitative structure of the phytophilous macrofauna dwelling on *Stratiotes aloides* L. (water soldier) on the quality of waters in a lentic oxbow lake of the Łyna River. The observations were carried out during the vegetative season (April – June) 2006 at high and moderate water levels. During the study, a total of 18 taxa of invertebrates dwelling on the above plant species were identified, with the exact number of taxa varying in time: 11 taxa were noticed in April and May, and in June their number went up to 13. The examination of hydrochemical parameters of the oxbow lake waters revealed that the density of macrofauna was lower at higher values of proper conductivity and macronutrients, ammonia nitrogen and COD, increasing at high levels of sulphates. High concentrations of ammonia nitrogen and non-organic components coincided with decreased biomass of epiphytic animals on water soldier. Additionally, it has been observed that elevated concentrations of potassium ions have a negative influence on the biomass of most epiphytic animals (except *Erpobdella* sp.).

Key words: epiphytic macrofauna, water chemism, oxbow lake, the Łyna River.

Krystian Obolewski, Chair of Land Reclamation and Management, University of Warmia and Mazury, pl. Łodzki 2, Olsztyn-Kortowo 10-719, Poland, e-mail: obolewsk@apsl.edu.pl

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PRÓBA OCENY WPŁYWU JAKOŚCI WÓD NA STRUKTURĘ JAKOŚCIOWO-ILOŚCIOWĄ EPIFAUNY ZASIEDLAJĄCEJ *STRATIOTES ALOIDES* L. NA PRZYKŁADZIE STARORZECZA ŁYNY

Abstrakt

W pracy przedstawiono wyniki badań nad próbą określenia zależności struktury jakościowo-ilościowej makrofauny fitofilnej zasiedlającej *Stratiotes aloides* L. od jakości wód w lentycznym starorzeczu rzeki Łyny. Badania prowadzono w okresie wegetacyjnym (IV--VI) 2006 r. przy wysokich i średnich stanach wód. W czasie badań zidentyfikowano łącznie 18 taksonów bezkręgowców zasiedlających ten gatunek roślinny, przy czym ilości te podlegały zmienności czasowej: w kwietniu i maju zanotowano 11 taksonów, a w czerwcu 13. Spośród badanych parametrów hydrochemicznych wód starorzecza zagęszczenie makrofauny epifitycznej było niższe w przypadku wysokich wartości przewodnictwa właściwego i makroskładników, azotu amonowego i ChZT, natomiast wzrastało w przypadku wysokich stężeń siarczanów. Wysokie stężenia azotu amonowego i składników nieorganicznych towarzyszyły spadkowi biomasy zwierząt epifitycznych zamieszkujących osokę. Ponadto stwierdzono negatywny wpływ podwyższonych stężeń jonów potasu na biomasę zwierząt naroślinnych (z wyjątkiem *Erpobdella* sp.).

Key words: epifauna, chemizm wody, starorzecze, rzeka Łyna.

INTRODUCTION

Oxbow lakes as ecosystems are valuable for a large number of hydrobionts, which has been given recognition in the Habitat Directive, where the EU has established legal protection of old river beds (Directive 92/43/EEC). Among the EU members, Poland is one of the richest countries regarding the number of oxbow lakes. Therefore, our country should become one of the principal locations where ecology of such habitats is conserved. However, since oxbow lakes are one of the least known parts of river valleys, serious problems occur in the implementation of general European regulations pertaining the environmental conservation of such habitats (Glińska--Lewczuk 2004, Jezierska-Madziar et al. 1999, Obolewski 2006, Obolewski, Strzelczak 2008).

The latest guidelines on the monitoring of natural environment suggest the importance of biological assessments, with chemical assays becoming now a mere background (Kownacki 2000, Kudelska, Soszka 2001, Soszka, Kudelska 2000). Owing to their limited mobility and easy identification, benthos invertebrates appear as a principal object of studies for biological assays involved in bio-monitoring of waters (Kajak 1998).

Oxbow lakes are dynamically changing ecosystems, in which habitat conditions vary depending on a hydrologic season. The period of spring thaws and high water levels induces fresh influx of river waters to oxbow lakes and temporary improvement of dwelling conditions for animals which live in such water bodies (Obolewski 2005). Simultaneously, the merging of river

and oxbow lake waters creates ecological channels, which enable larger animals, for example fish, to migrate and this may largely affect the qualitative and quantitative structure of benthos fauna (JEZIERSKA-MADZIAR et al. 1999). Oxbow lakes are the water bodies where macrolytes develop, which accelerate succession processes and become inhabited by aquatic animals. This is the role that the water soldier (*Stratiotes aloides* L.) plays. This plant grows large leaves, which can sometimes cover up the whole water surface (KRASOWSKA, MIKULSKI 1960, KORNATOWSKI 1976, 1980). As a result, habitats are formed for all kinds of invertebrates migrating from anaerobic benthic waters (LINHART 1999, LINHART et al. 1998, OBOLEWSKI 2005). Such migration of animals must be included in the monitoring of oxbow lakes so as to obtain full information about ecological status of these ecosystems.

The aim of this study has been to try and demonstrate relationships between the qualitative and quantitative composition of epiphytic fauna dwelling on *Stratiotes aloides* and the quality of water in an oxbow lake of the Łyna River, overgrown with plants. In order to focus exclusively on the effect of environmental conditions on the structure of fauna dwelling on plants, trophic relations occurring in this ecosystem were excluded. Thus, the results presented in this paper should be treated as a preliminary step for further research, which will include laboratory experiments.

MATERIAL AND METHODS

The oxbow lake examined (S8) is a water reservoir situated on the left bank of the Łyna River, near the village of Łaniewo, between Dobre Miasto and Lidzbark Warmiński (Figure 1). This lake maintains water all year, with the average annual fluctuations of the water table reaching 1.5 m, which affects the surface area of the lake, its depth and the quality of the lake water. When the water volume is moderate, the maximum depth of the oxbow lake is 2m and the surface area equals 1.8 ha (GLIŃSKA-LEWCZUK 2005). This lake was created as a result of the erosion processes in the valley of the Łyna River. At present, this oxbow lake is separated from the river and represents typical features of the so-called lentic oxbow lakes (GLIŃSKA-LEWCZUK 2008). Its waters are 'refreshed' by high water during the mid-winter and early spring thaw, which nevertheless is not sufficient to halt intensive biogeochemical processes in this lake. Consequently, the lake is being silted up and overgrown by macrophytes.

During our study, conducted in the vegetative season of 2006, the water level was high (April) and medium high (May-June) while the water table was overgrown with communities of pleuston, with two dominant species, *Lemma trisulca* L. and *Spirodela polyrhiza* L., which were accompanied by compact patches of *Stratiotes aloides* L. and *Potamageton natans* L., sur-

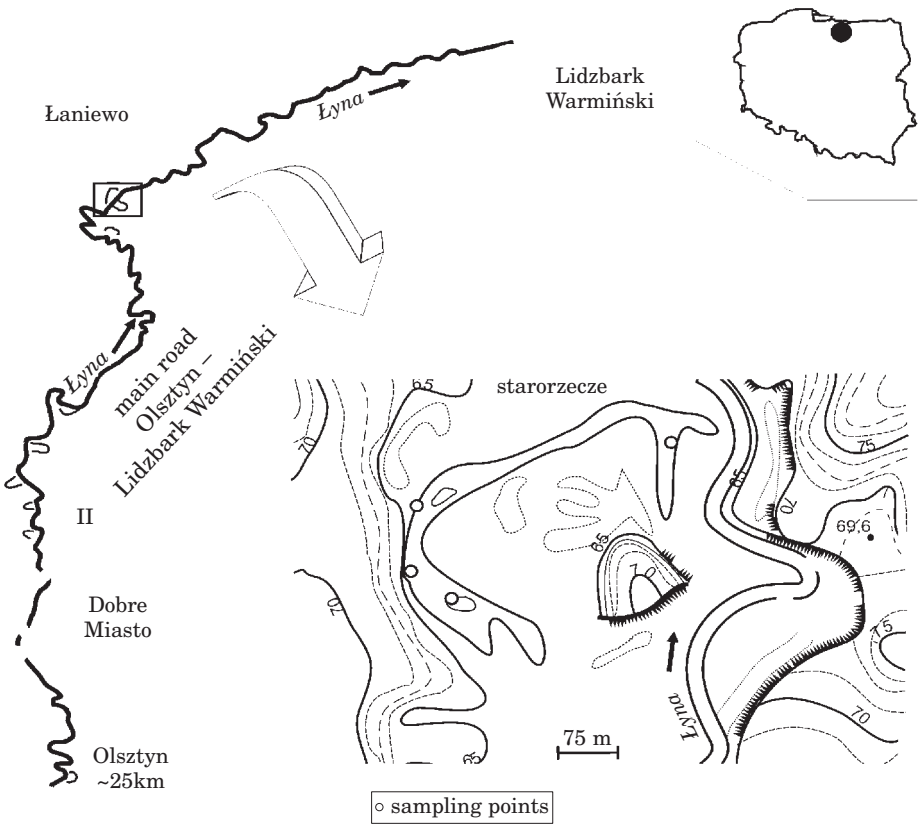

Fig. 1. Location of the oxbow lake and sampling sites in the middle Łyna River valley

rounded by a dense zone of reed *Phragmites australis* (CAV.) TRIN and STUED and *Glyceria maxima* Martman. Water soldier plants when in bloom (maximum emergence) contributed a 20.5% share to the plant cover of the water surface.

The analysis of the epiphytic fauna on *S. aloides* was carried out from April to June 2006 in two series. Each series consisted of 3 samples which included from 12 to 14 cormi of water pineapple. The wet mass of water pineapple ranged from 3.9 to 5.7 kg. The examinations were completed according to the methodology described by OBOLEWSKI (2005), i.e. phytophilous fauna and leaf mining fauna were separated from the plant material and identified under laboratory conditions. The representatives of macrozoobenthos found in the samples were identified to appropriate systematic levels, according to the operation monitoring guidelines.

The sampling of biological material was accompanied by field analyses of the physicochemical parameters of the oxbow lake water (*in situ*) and

collection of water samples for laboratory assays. In field, near the site where water soldier cormi were collected, thermal and oxygen profiles were performed in the vertical column of the water body. In addition, proper electrolytic conductivity and pH of the water were measured. The laboratory analysis of other physicochemical parameters ($N\text{-}NO_2$, $N\text{-}NO_3$, $N\text{-}NH_4$, $P\text{-}PO_4$, COD and major ions) was performed according to the methodology cited by HERMANOWICZ et al. (1999). Chemical quality of the water and the interpretation of the results, including determination of the type of water, were referred to the currently binding classification (Ordinance of the Minister, Journal of Laws 32, item 248). Biocenotic indices, which illustrate structural relationships within a benthos macrofauna community, i.e. domination (D), frequency (F) and ecologic importance indices (Q), were used for the analyses. Dominance Index was computed with reference to density and biomass. The most numerous species as well as the species characterised by the highest biomass in a given assemblage were divided according to the suggestion formulated by KASPRZAK and NIEDBAŁY (1981). In order to assess species diversity, the Shannon-Wiener biodiversity index was computed .

Significance of differences between the average values obtained was tested with Cochran and Cox test applied at the level of significance α=0.05. Cochran and Cox test is helpful in studies which involve few objects whose variations differ significantly, and that was the case in the months covered by our study. On the other hand, lack of differences between compared objects ($C < C_{\&}$) suggests that the samples originate from the same general population, and the differences are accidental.

Cochran and Cox test

$$C = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{E_{\bar{x}_1}^2 + E_{\bar{x}_2}^2}}$$ E = standard deviation error

$$C_\alpha = \frac{E_{\bar{x}_1}^2 \cdot t_{1_\alpha} + E_{\bar{x}_2}^2 \cdot t_{2_\alpha}}{E_{\bar{x}_1}^2 + E_{\bar{x}_2}^2}$$ a = 0.05 (from t-Student test distribution)

The matrix of Pearson's correlation was also established in order to determine the dependence of the density and biomass of epiphytic fauna on the determined physicochemical parameters of water in the oxbow lake of the Łyna River.

RESULTS AND DISCUSSION

Oxbow lakes which are lentic. i.e. contain stagnant waters, are naturally predisposed to strong growth and development of pleuston macrophytes,

which are either capable of travelling vertically in water (water soldier) or float on the surface of a water table (duckweed). The effect produced by these plants on lake ecosystems and their eutrophisation has been largely examined and clarified (Pieczyńska 1988). However, relatively less information is available on the interaction of a biotic substratum, epiphytic animals and abiotic conditions (Giere 1993, Higler 1975, Lalonde, Downing 1992, Linhart 1999, Obolewski 2005, 2006, Tarkowska-Kukuryk 2006).

The quality of water in the examined oxbow lake was low, especially with respect to the amount of dissolved oxygen (Table 1), which is why it was classified as Water Quality Class V. Moreover, the water in this oxbow lake had a very high COD and a very high concentration of phosphates and

Table 1

Hydrological and hydrochemical conditions in the oxbow lake of the Łyna River near Łaniewo in April-June 2006

Parameter	Unit	Month of water sampling			Average±SD
		April	May	June	
Zone of water levels	m	high	mean	mean	
Reaction	pH	8.49	8.20	7.6	8.1±0.4
Temperature	ºC	8.20	13.50	17.9	13.2±0.86
DO	mg O_2 dm^{-3}	11.26	5.48	5.00	7.23±3.50
DO	%O_2	94.70	52.60	52.70	66.67±24.28
COD	mg O_2 dm^{-3}	28.4	56.0	52.4	45.6±15.0
SEC	µS cm^{-1}	364	471	453	429±57.3
TDS	mg dm^{-3}	208	208	204	207±2.3
N-NO_2	mg dm^{-3}	0.0066	0.0088	0.0076	0.0081±0.0011
N-NO_3	mg dm^{-3}	0.088	0.086	0.068	0.081±0.011
N-NH_4	mg dm^{-3}	0.235	0.234	0.195	0.221±0.023
TIN	mg dm^{-3}	0.333	0.329	0.271	0.311±0.035
TP	mg dm^{-3}	0.29	1.09	1.9	1.10±0.81
P-PO_4	mg dm^{-3}	0.12	0.63	1.31	0.68±0.60
Ca	mg dm^{-3}	55.4	68.9	62.6	62.3±6.7
Na	mg dm^{-3}	9.2	6.0	5.6	6.9±2.0
K	mg dm^{-3}	2.4	2.2	1.4	2.0±0.5
Mg	mg dm^{-3}	12.90	10.30	8.9	10.7±2.0
Cl	mg dm^{-3}	12.0	7.0	6.0	8.3±3.2
SO_4	mg dm^{-3}	142.20	6.62	17.71	55.51±75.28
HCO_3	mg dm^{-3}	154	200	196	183±25.5

general phosphorus, which in June was twice as high as the permissible norms of water quality class V waters (Journal of Laws 32, item 284). Such high levels of biogens prove that the lake was strongly eutrophic. In the first month of the study, when young water soldier plants grew rapidly, high levels of sulphates occurred in the water (142.20 mg dm^{-3}), some of which may have been later assimilated by macrophytes and, as SMOLDERSKA et al. (2003) suggest, most likely bounded via iron in bottom sediments.

The development of vascular plants in eutrophic waters makes water bodies shallower. This is due to high production of organic matter, which intensifies decomposition and causes oxygen deficits, thus eliminating oxybionts (KAJAK 1998). This unfavourable influence of macrophytes on oxbow lakes is set off by the fact that they create large areas of biotic substratum, which is inhabited by epiphytic and periphytic fauna. Some of our previous studies on the same oxbow lake (OBOLEWSKI et al. 2006, OBOLEWSKI, STRZELCZAK 2008) made it evident that the poor benthos, in terms of its quality and quantity, was set off by fauna dwelling on water plants, where animals could grow and develop abundantly, thus contributing considerably to the biodiversity of this water body.

The water soldier community growing in the oxbow lake of the Łyna River near Łaniewo was inhabited by 11-13 taxa, whose qualitative composition was typical of macrozoobenthos. As Figure 2 shows, the density of epiphytic fauna ranged from 253 to 917 individuals kg^{-1} and its biomass varied from 2,770.8 to 5,065.9 g_{mm} kg^{-1}. In other oxbow lakes (OBOLEWSKI 2005, OBOLEWSKI et al. 2006), the density and biomass of epiphytic fauna were similar to the above values. The most favourable conditions for the development of epiphytic invertebrates occurred in April, when the density of these animals was 3.6-fold higher than in May. This may have been stimulated by a high level of oxygen dissolved in waters as the oxbow lake waters had merged with the river and thaw water. Another favourable event was the high intensity of photosynthesis during that time.

The intensive growth of young individuals in spring and summer is confirmed by the statistically lower values of their biomass in April (0.607) versus the data obtained in May (0.894) and June (0.847) (Tab. 2). Despite such large variation in the biomass, the oxbow lake showed very little species diversity, which resembled that found only in extremely simple ecosystems (KAJAK 1998). Shannon's index reached values comparable to the ones determined for another oxbow lake, Koński Staw, separated from the river trough of the Słupia River and overgrown with water plants (OBOLEWSKI 2005).

Hirudinea was represented by *Erpobdella* sp., *Helobdella stagnalis* L., *Glossiphonia complanata* L., *Hemiclepsis marginata* O.F. Müller. They made up from 6% in June to 9% in April of the total density of the epiphytic fauna and from 2.5% in May to 28% in April of the total biomass of this fauna dwelling on water soldier (Figure 2). The highest ecological role in this class (Q index) was assigned to *Helobdella stagnalis* (Q=8.7%), at F=100% (Table 2).

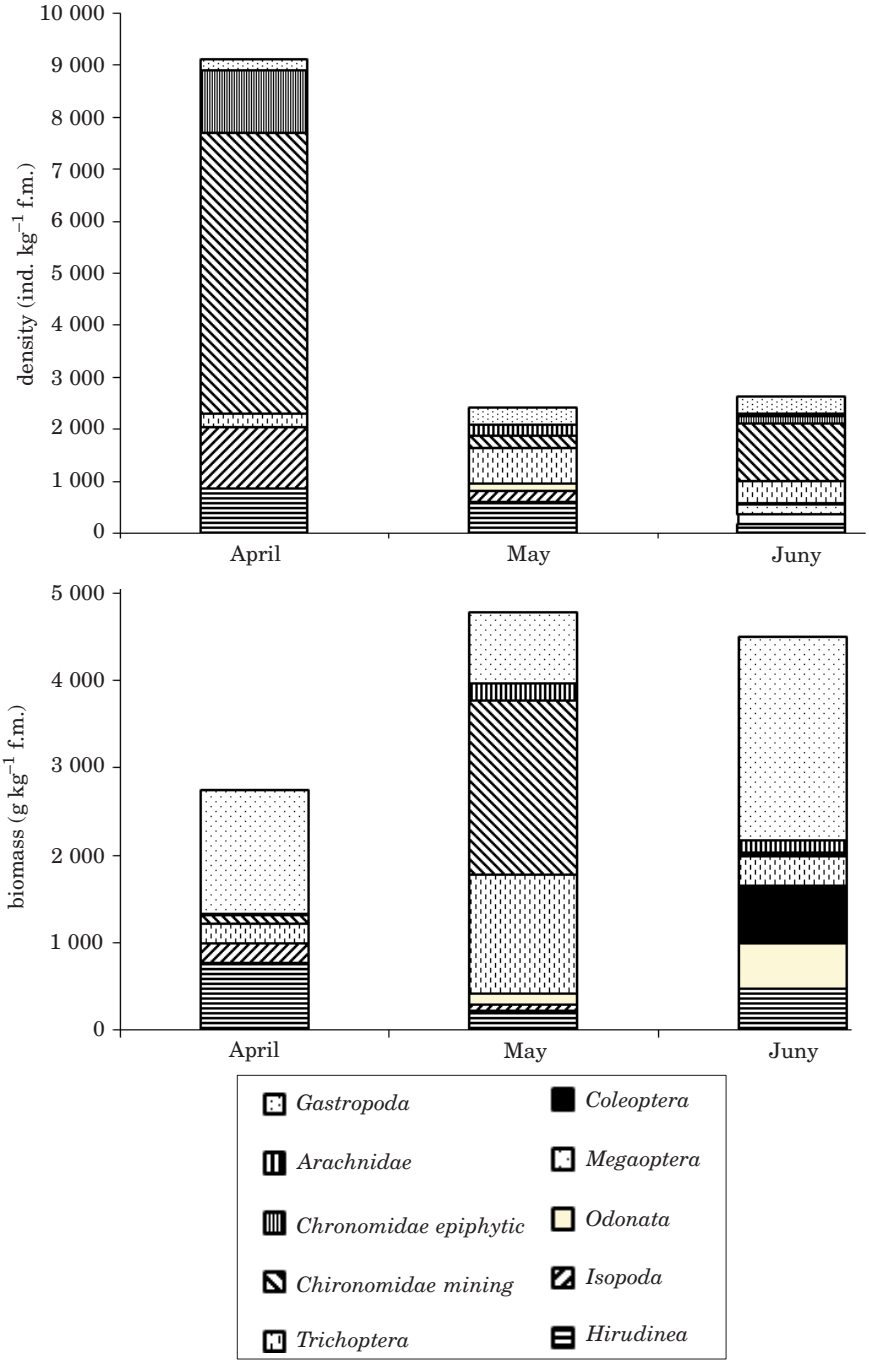

Fig. 2. Density (indiv. kg^{-1} d.m.) and biomass (g kg^{-1} d.m.) of dominant invertebrates dwelling on *S.aloides* in the oxbow lake of the Łyna River

Table 2

Dominance Index (D_A– density, D_B – biomass), frequency (F,%) and ecological importance index (Q) as well as density significance test (a=0.05) of epiphytic fauna on *S.aloides* in the oxbow lake of the Łyna River from April to June 2006

Taxon	April		May		June			
	DA	DB	DA	DB	DA	DB	F	Q
Total Hirudinea	9.4	27.6	24.1	6.4	6.3	10.6		
Erpobdella sp.	3.8	12.7	0.0	0.0	3.5	8.8	67	1.6
Helobdella stagnalis	2.0	5.4	23.3	2.5	0.7	0.6	100	8.7
Glossiphonia complanata	3.6	9.5	0.0	0.0	2.1	1.2	67	1.3
Hemiclepsis marginata	0.0	0.0	0.8	3.9	0.0	0.0	33	0.1
Total Crustacea (*Asellus aquaticus*)	13.0	8.0	8.3	1.3	0.0	0.0	67	4.7
Total Insecta	75.3	13.5	50.6	72.8	81.1	37.6		
Odonata larvae								
Lestes sp.	0.0	0.0	2.1	1.1	2.1	5.8	67	0.9
Aeshna sp.	0.0	0.0	0.5	0.3	0.0	0.0	33	0.1
other Odonata	0.0	0.0	2.5	1.0	4.9	5.5	67	1.7
Megaloptera – *Sialis luteria*	0.0	0.0	0.0	0.0	7.6	0.5	33	0.8
Culex sp.	0.5	0.8	0.0	0.0	0.0	0.0	33	0.1
Trichoptera larvae								
Limnephilus sp.	0.5	3.0	13.3	10.1	7.8	2.1	100	7.2
Ecnomus tenellus	0.3	2.0	3.5	2.6	5.2	1.9	100	3.0
Phryganea grandis	1.5	3.1	4.1	3.6	0.0	0.0	67	1.3
other Trichoptera	0.5	0.8	6.4	10.7	3.2	3.7	100	3.4
Chironomidae larvae – mining	59.0	3.6	9.1	39.5	42.3	0.7	100	36.8
Chironomidae larvae – epiphitic	13.0	0.2	0.0	0.0	4.9	0.1	67	4.0
Arachnida – *Argyroneta* aquatica	0.0	0.0	9.1	3.9	2.3	3.1	67	2.5
Coleoptera – *Dytiscus* sp.	0.0	0.0	0.0	0.0	0.8	14.2	33	0.1
Total Gastropoda	2.3	51.3	17.0	19.5	12.6	51.9		
Lymnaea sp.	1.5	17.1	4.0	11.9	4.2	32.7	100	3.2
Acroloxus lacustris L.	0.0	0.0	0.0	0.0	4.2	3.6	33	0.5
Planorbarius corneus L.	0.2	0.7	3.2	2.1	4.2	15.6	100	2.5
Planorbis planorbis L.	0.6	33.5	0.0	0.0	0.0	0.0	33	0.1
Anisus sp.	0.0	0.0	5.9	2.1	0.0	0.0	33	0.6
Gyraulus sp.	0.0	0.0	4.0	3.4	0.0	0.0	33	0.4
Shannon H' Log Base 10,	0.607		0.894		0.847		0.857	
Shannon index J'	0.583		0.859		0.761		0.671	
Cochran and Cox test (a=0.05)	C=0.233 > C_a=							
			C=0.829 > C_a=					
	C=0.437 > C_a=							

The value of Pearson's correlation coefficient implied the density of leeches was positively correlated with the water reaction but negatively related to the concentration of phosphates (Table 3).

Crustaceans were represented by *Asellus aquaticus* L., which added considerably to the density of epiphytic animals (D_A = 8.3 – 13%) but was not an ecologically important taxon (Q=4.7%). This species is common among benthos fauna in oxbow lakes (Obolewski 2005, 2006). During our study the density and biomass of *A. aquaticus* L., was steadily declining, and in June this species of *Isopoda* was not observed. As early as in May its number fell 20-fold and the biomass decreased by 3.5-fold (Figure 2). The density of *A. aqauticus* was positively correlated with the concentration of chlorides and sodium as well as the concentration of magnesium, which was correlated with the increase in the biomass of this species (Table 3). The concentration of chlorides, sodium and magnesium increased in each consecutive month, which may have been due to the fact that the water level in the Łyna River valley fell to medium high and, as water evaporated from the oxbow lake, the concentration of these ions increased.

The contribution of dragonflies to the average number of biomass of phytophilous fauna of the oxbow lake examined was small and similar to that observed in other old riverbeds (Linhart 1999, Obolewski 2005, 2006). The highest biomass and density of dragonflies occurred in June and the lowest – in May. In April, no dragonflies were noticed (Figure 2). The analysed samples of fauna contained specimens of *Ischmura* sp., *Lestes* sp., *Aeschna* sp., whose decreasing numbers were correlated with the concentration of magnesium and their smaller biomass was associated with the concentration of potassium ions (Table 3). In natural waters, most alkaline ions appear as Na^+ and much fewer are K^+. Potassium ions are intensively used by plants, including water soldier, which can then release potassium to water in the form of extracts (Van der Welle et al. 2007).

Caddisfly larvae (*Limnephilus* sp., *Ecnomus tenellus* (Rambur), *Phryganea grandis* L.) developed the best in May, when *Limnephilus* sp. constituted the group of subdominants (D_A=13.3% and D_B=10.1%) and the whole order played a principal role in shaping the density (27%) and biomass (27%) of the whole population on water soldier (Table 2, Figure 2). In April, the biomass of these larvae was small but increased several-fold in the following month. After reaching the maximum value, the density of caddisfly larvae declined 1.6-fold and their biomass went down by four-fold. Among the analysed physicochemical parameters of the oxbow lake waters, it was only the concentration of nitrites that was positively correlated with the density of caddisfly larvae.

The major group of epiphytic animals living on water pineapple plants in oxbow lakes is composed of *Chironomidae* larvae, which can either dwell on the surface of leaves or drill into them (Obolewski 2005, Obolewski et al. 2006, Prejs et al. 1997, Tarkowska-Kukuryk 2006). *Chironomidae* larvae were

an absolutely permanent inhabitant of water soldier (F=100%), being evidently the principal component of epiphytic fauna (Q=41%), with the leaf-mining individual dominating (Q=36.8%) over the ones on leaf surface (Q=4%). It seems that this was a result of the larvae avoiding being eaten by predators (PREJS et al. 1997) or else the ease of obtaining plant food. *Chironomidae* larvae foraged on nitrogen rich plant tissues, thus incorporating large quantities of this element into their bodies and reaching high biomass. This is what happened in May, when a small density of mining larvae was observed alongside their large biomass, but no larvae were found on leaf surface (Figure 2). A decrease in the density of *Chironomidae* larvae on and inside leaves of water soldier may have been due to the high values of conductivity and COD in the oxbow lake waters (Table 3).

It seems that a high concentration of sulphates in the oxbow lake waters was beneficial for *Chironomidae* larvae dwelling on leaf surface. Sulphates are absorbed by aquatic plants (sulphur is assimilated in cell proteins). In turn, the plants extract substances, which may affect the consumers which dwell on these plants (TUROBOYSKI 1979).

Within the phystophilous fauna found in the oxbow lake, molluscs were represented by six species (*Lymnaea* sp., *Acroloxus lacustris* L., *Planorbarius corneus* L., *Planorbis planorbis* L., *Anisus* sp., *Gyraulus albus* O.F. Müller) typical for water bodies with stagnant waters, overgrown with aquatic plants (OBOLEWSKI et al. 2009, PIECHOCKI 2004), although their contribution to the density of epiphytic fauna was small. However, they affected significantly the biomass of the whole population, making up from D_B=16% (in May) to D_B=52% (in June) of the total value (Table 2). In May, the biomass of specimens belonging to the genera *Lymnaea* and *Planorbic planorbis* L. declined. At the same time, the mass of *Planorbis corneus* L. rose, and this is a typical for the ecology of these species (PIECHOCKI 2004). In the following month, the biomass of slugs increased as the population then comprised large representatives of *Lymneaea* sp. and *Planorbis planorbis* (Table 2). Regarding the analysed physical and chemical parameters of the water in the oxbow lake, it appears that the density of *Gastropoda* was conditioned by the amount of oxygen in the water. The identified species of molluscs breathe atmospheric oxygen, therefore poor oxygen conditions in water, which can be destructive to other epiphytic species, are not an obstacle to their development. The reduction of most of the hydrobionts on water soldier enables pulmonate molluscs to occupy empty habitats. It is interesting that there was no correlation between the structure of *Gastropoda* and the concentration of calcium in the oxbow lake water and that the dependence between these invertebrates and amounts of carbohydrates was moderate (Table 3).

The analysed samples of fauna also comprised ecologically less important (Q index) larvae of the order *Megaloptera* – *Sialis lutaria* (Q=0.8%), *Coleoptera* – *Dytiscus* sp. (Q=0.1%), whose density was proportional to the concentration of ammonia nitrogen and the biomass changed in proportion

Table 3

Pearson's correlation coefficient ($p<0.05$) between the quality of water in the oxbow lake of the Łyna River and the density (A) and biomass (B) of epiphytic fauna on *S.aloides*

	Hirudinea		Isopoda		Odonata		Megaloptera		Trichoptera		Coleoptera		Chironomidae larvae				Culex sp.		Arachnidae		Gastropoda		Total	
													mining		epiphytic									
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
pH	+		+	+	-	- -	-	-			-	-					+	+			-			
Temp.	-		-	-	+	+	+	+			+	+	-		-		-	-			+		-	
O_2	+	+	++	+	-				-				+		+		++	++		-	- -		++	++
% O_2	+	+	++	+	- -				-				++		++		++	++		-	- -		++	++
EC		-	-	-	+				+				- -		- -		- -	- -		++	++		- -	
NO_2		--							++	+			-	+	-		-	-	+	++	+		-	
NO_3	+			+	-	- -	- -	- -			- -	- -							+			-		
NH_4	+					- -	- -	- -			- -	- -										-		
Nmin	+			+	-	- -	-	- -			-	- -										-		
Mg	++		++	++	- -	-	-	-			-	-	+		+		+	+		-	-		+	
Cl	+		++	+	-	-							+		+		+	+		-	-		+	
TDS		-							+	++				++		--						-		
PO_4	- -		-	-	+	+	+	+			+	+			-		-	-	+		+		-	
Pog	-		-	-	+	+	+	+			+	+	-		-		-	-			+		-	
SO_4	+	+	-	+	-				-				++		++		++	++		-	--		++	++
Ca		- -	-						+	+			-	+	-		-	-	-	+	+		-	
Na	+	+	++	+	-	-							+		+		+	+	+	-	-		+	
K	+			+	-	- -	-	-			-	-										-		
ChZT		-	- -	-	+								- -		- -		- -	-		+	++		- -	- -
HCO_3	- -		-	-	+	++	+	+			+	+							+			+		

Correlation coefficient
from 0.75 to 0.99 (+), 1.00 (++), from -0.75 to -0.99 (-), -1.00 (--)

to the levels of ammonia and mineral nitrogen. Larvae of the mosquitoes *Culex* sp. were sensitive to high levels of COD and their considerable density and biomass were correlated with dissolved oxygen and sulphates. The biomass of mosquitoes may also be connected with conductivity (Table 3). Among the fauna living on water soldier, a representative of arachnids, *Argyroneta aquatica* L., appeared. Its biomass was correlated with the high conductivity of the water in the oxbow lake and water dissolved nitrites.

The values of the water reaction, obtained during our study, approximated the level considered dangerous (pH>8.5), at least for some fish species (Turoboyski 1979). As there were no predators in the lake, larger benthos animals could develop in the lake. Excess amounts of phosphorus compounds accelerates eutrophication processes in aquatic ecosystems, which can completely change the biological balance by increasing primary and secondary productivity as well as saprobisation of such water bodies. As for old river beds, they can disappear completely (Olszewski 1971). The lentic character of the oxbow lake we examined did not favour development of macrofauna due to the values of two life essential parameters: access to light, which was drastically limited by the thick cover of pleuston plants, associated with water soldier, on the surface of water and oxygen deficits, common in such ecosystems. Limited access to sunlight stimulating development of phytoplankton and, indirectly, oxygen production. In April, oxygen deficit appears at the depth of 1.2 m, and in the summer, it can be observed at 0.25 m. This means that anaerobic conditions are present in nearly all the water masses, which effectively limits development of all benthos organisms. Under such conditions, water pineapple creates an only remaining habitat, just under the water surface, which can be colonized by mostly aerophilous benthos organisms (Obolewski 2005, Sheffer et al. 1984).

Studies on oxbow lakes as part of the conservation of natural habitats (Directive 92/43/EEC) should include epiphytic fauna, which the Water Directive claims can serve as a bioindicator. The qualitative and quantitative structure of epiphytic communities together with the analysis of abiotic conditions can indicate the ecological status of a given ecosystem (Obolewski 2006). This is another stage in the implementation of the EU guidelines on protection of particularly valuable natural habitats for wildlife.

CONCLUSIONS

1. The hydrochemical and hydroecological examinations carried out in an oxbow lake of the Łyna River, lacking level water exchange with river waters, showed that the major factors limiting the development of epiphytic fauna were periodic or permanent oxygen deficits in water.

2. The quantity and biomass of benthos fauna were positively correlated with aerobic conditions in lentic ecosystems. As the amount of dissolved oxygen and water oxygenation declined in late spring months (June), the number of epiphytic fauna went down.

3. Among the examined parameters, the strongest negative influence on the analysed formations was produced by high values of proper conductivity, COD, ammonia nitrogen and mineral components.

4. The highest density and biomass of epiphytic fauna were obtained by Chironomidae larvae mining water soldier leaves, which can be explained by the fact that they could successfully avoid predators and incorporate into their bodies the nitrogen accumulated in large amounts in the plant tissues.

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