Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2016, 13, 123–129

INFLUENCE OF HABITAT CONDITIONS ON THE OCCURRENCE OF EPIPHYTIC INVERTEBRATE FAUNA IN OXBOW LAKES

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Abstract. The relationships between epiphytic fauna and habitat conditions were studied in three oxbow lakes of Wieprz River (eastern Poland). Fauna associated with macrophytes showed low species richness (range 8–11 taxa dependently on site and season) usually observed in lakes of high water trophy. Densities of fauna were high (mean 71–5250 ind. 100 g DW^{-1}), typical for shallow lakes with well developed submerged vegetation. In the domination structure prevailed Gastropoda (relative abundance 23–100%) and Chironomidae (relative abundance 8–87%). Redundancy analysis showed the significance of four environmental variables – temperature, dissolved oxygen, P_{tot} and $P\text{-}PO_4$ as determinants of abundance of epiphytic fauna.

Key words: oxbow lakes, environmental conditions, macrophytes, epiphytic fauna

INTRODUCTION

Oxbow lakes are small water reservoirs, which evolved naturally within the river valley or were formed as a result of modification of river channel. These lakes constitute a part of the floodplain network, which is composed of many interconnected water bodies [Obolewski and Glińska-Lewczuk 2011, Wilk-Woźniak *et al*. 2013]. Habitat conditions of oxbow lakes change dynamically and are closely related to hydrologic season [Dembowska and Napiórkowski 2012]. Due to low water table depth, oxbow lakes are usually overgrown with macrophytes and thus maintain highly diverse microhabitats similar to those observed in shallow macrophyte-dominated lakes [Wojciechowska 2006, Mihaljević *et al*. 2010]. Up to now studied on relationships between environmental variables (water quality) and the components of trophic structure of oxbow lakes mostly focused on phytoplankton and zooplankton [Strzałek and Koperski 2009, Wilk-Woźniak *et al*.

2013, Dembowska and Napiórkowski 2015], zoobenthos [Obolewski 2011] or investigated potential of a single macrophyte species as habitat for invertebrate fauna [Obolewski 2014], but the habitat conditions which determine the structure of epiphytic macroinvertebrates in such reservoirs are still not sufficiently recognized.

The objective of our investigation was to assess the effects of environmental factors on the abundance and species diversity of fauna associated with macrophytes in three oxbow lakes formed in the Wieprz River valley (eastern Poland).

STUDY AREA, MATERIAL AND METHODS

Studies were conducted in three oxbow lakes of Wieprz River (eastern Poland). All the reservoirs were formed naturally within the river valley. At present the oxbows did not have any connection with river and are supplied with rain and groundwater. They are shallow (maximum depth about 1.0 m) and densely overgrown by soft macrophytes (mostly submerged *Ceratophyllum demersum* and floating *Lemna minor* and *Lemna trisulca*). Environmental conditions of the studied oxbows are presented in Table 1.

Table 1. Mean values (± SD) of environmental parameters of studied oxbow lakes

Specification	Oleśniki I	Oleśniki II	Wał
Temperature, ^{o}C	16.3 ±6.2	17.9 ±3.1	16.6 ±3.8
pH	8.2 ±0.1	7.8 ±0.1	7.6 ±0.2
Conductivity, µS cm^{-1}	374 ±18	349 ±26	884 ±28
Dissolved oxygen, mg dm^{-3}	8.4 ±0.4	8.1 ±0.3	6.8 ±0.4
N-NH_4, mg dm^{-3}	0.227 ±0.039	0.183 ±0.029	2.005 ±2.394
N-NO_3, mg dm^{-3}	0.016 ±0.011	0.011 ±0.003	0.026 ±0.025
P-PO_4, mg dm^{-3}	0.021 ±0.013	0.034 ±0.013	0.542 ±0.441
P_{tot}, mg dm^{-3}	0.135 ±0.129	0.233 ±0.314	1.186 ±1.505

Samples of epiphytic fauna were collected in September and November 2015 as well in May 2016 from three oxbow lakes, designated as Oleśniki I, Oleśniki II and Wał (Fig. 1). Fauna associated with macrophytes was sampled using floristic anchor and cylindrical apparatus (diameter 15 cm, length 30 cm, net mesh size 250 µm). At each site three samples were collected. Macrophytes were sampled by an anchor, next transferred into the apparatus, put into the plastic bag and transported to the laboratory. At the laboratory invertebrates were selected from macrophyte samples and preserved in 4% formaldehyde solution. Collected fauna was counted and identified; nomenclature of taxa was accepted after

Wiederholm [1983] and Kołodziejczyk and Koperski [2000]. Densities were calculated per 100 g of DW of plant.

Water for physical and chemical analysis was taken together with biological samples, at the same sampling sites and dates. In situ, using YSI 556 MPS multiparameter, were recorded temperature, pH, conductivity and dissolved oxygen. At the laboratory, using spectrophotometric methods were analysed concentrations of $N\text{-}NO_3$ (PN-C-04576-4), $N\text{-}NH_4$ (PN-C-04576-4: 1994), TP (PN-EN 1189: 2000) and $P\text{-}PO_4$ (PN-EN 1189: 2000).

Fig. 1. Location of the studied oxbows in the Wieprz River Valley (Eastern Poland). 1 – Oleśniki I; 2 – Oleśniki II; 3 – Wał

The influence of site and season on species diversity and abundance of epiphytic invertebrates was verified by means of two way ANOVA. Redundancy analysis (RDA) was performed in order to specify the most important environmental variables determining the abundance of epiphytic invertebrate taxa in oxbow lakes. Automatic forward selection of environmental variables, (Monte Carlo permutation test) was used to determine significant variables. Ordination analyses were performed using CANOCO 4.5 software.

RESULTS AND DISCUSSION

In the studied oxbow lakes total number of epiphytic taxa was low and amounted from 8 to 11 taxa and depended on the site and season. Similar, low

species richness of invertebrate fauna observed Obolewski *et al*. [2009] in oxbow lakes of Słupia River (northern Poland), these values are typical for shallow highly eutrophic lakes [Kornijów *et al*. 2002, Tarkowska-Kukuryk 2014a].

The density of epiphytic invertebrates varied significantly between sites ($P = 0.004$) and seasons ($P < 0.001$) (Fig. 2). At sites Oleśniki II and Wał, the lowest densities were noted in September (1613 and 2533 ind. 100 g DW^{-1}, respectively) and the highest in May (71 and 5250 ind. 100 g DW^{-1}, respectively). At site Oleśniki I we observed the opposite pattern, density of macrofauna decreased from September (2000 ind. 100 g DW^{-1}) to May (83 ind. 100 g DW^{-1}). Seasonal changes of density of epiphytic fauna are probably related to availability of potential food resources. Most often the highest density is noted in late summer and autumn, at time in lakes and reservoirs are observed the intensive development of periphytic algae and detritus, the basic components of the food base of epifauna [Maasri *et al*. 2008, Tarkowska-Kukuryk 2014b].

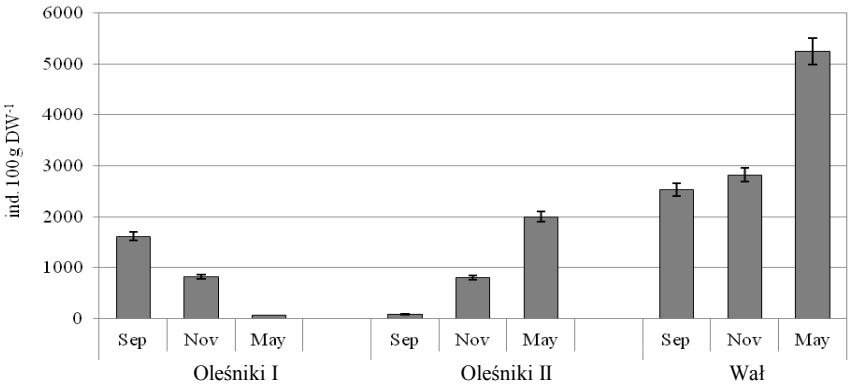

Fig. 2. Seasonal changes of densiy (±SE) of fauna associated with submerged macrophytes in studied oxbow lakes

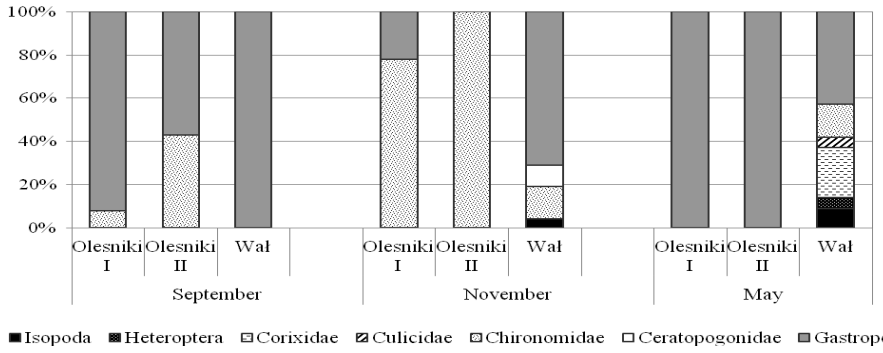

Fig. 3. Relative abudances of taxa of fauna asociated with submerged macrophytes in studied oxbow lakes

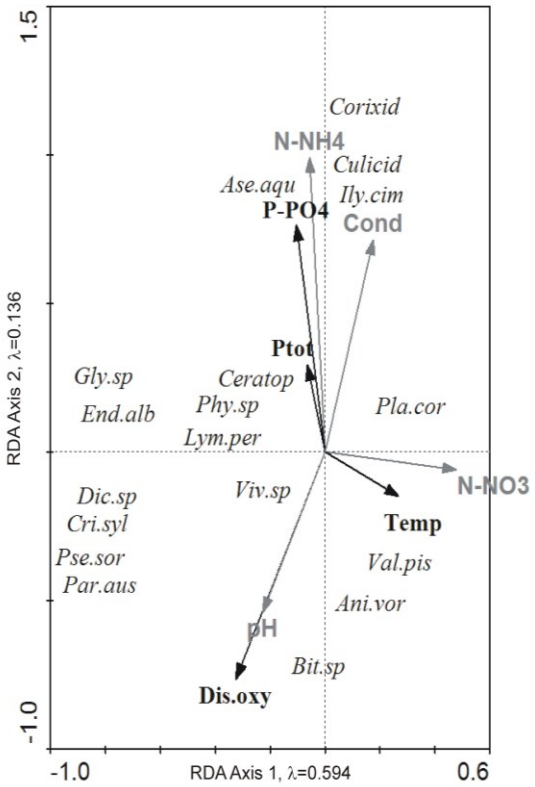

Fig. 4. Redundancy analysis biplot showing abundance of taxa of epiphytic fauna and environmental variables. Solid arrows indicate significant variables based on Monte Carlo permutation test ($P < 0.05$). Temp-water temperature; Cond-conductivity; dis.oxy – dissolved oxygen; $N\text{-}NH_4$ – ammonium nitrogen; $N\text{-}NO_3$ – nitrate nitrogen; $P\text{-}PO_4$ – dissolved orthophosphates; P_{tot} – total phosphorous; Taxa codes: *Ani.vor-Anisus vortex, Ase.aqu-Asellus aquaticus, Bit.sp-Bithynia sp., Ceratop*-Ceratopogonidae*, Corixid*-Corixidae*, Cri.syl-Cricotopus sylvestris; Culicid*-Culicidae*, Dic.sp – Dicrotendipes sp., End.alb-Endochironomus albipennis, Gly.sp-Glyptotendipes sp., Ily.cim-Ilyocoris cimicoides; Lym.per-Lymnaea peregra, Par.aus-paratanytarsus austriacus, Pla.cor-Planorbarius cormeus, Phy.sp-Physa sp., Pse.sor-Psectrocladius sordidelus, Val.pis-Valvata piscinalis, Viv.sp-Viviparus sp.*

Epifauna of the oxbow lakes was dominated by Gastropoda (Fig. 3), mostly *Anisus vortex*, *Lymnaea peregra* and *Planorbarius corneus*. The percentage of snails amounted from 23% (November, Oleśniki I) up to 100% (May Oleśniki I and II; September Wał) of the total density of epiphytic fauna. The second important taxon of epifauna constituted larvae of Chironomidae, *Cricotopus* sp. (gr. *sylvestris*), *Dicrotendipes* sp., *Endochironomus albipennis*, *Paratanytarsus austriacus*. Their relative abundance amounted from 8% (September, Oleśniki I) to 87% (November, Oleśniki II).

The RDA analysis showed the significant effect of four environmental variables on the abundance of epiphytic fauna in oxbow lakes (Fig. 4). On the biplot,

temperature (P = 0.004) and dissolved oxygen (P = 0.030) showed the significant effect on the abundance of gastropods, *Anisus vortex, Bithynia* sp., *Valvata piscinalis, Viviparus* sp. and chironomids, larvae of *Cricotopus* sp. (gr. sylvestris), *Dicrotendipes* sp., *Paratanytarsus austriacus* and *Psectrocladius* sp (gr. *sordidellus*). P_{tot} (P = 0.020) and P-PO_4 (P = 0.004) affected the density of Isopoda (*Asellus aquaticus*), Ceratopogonidae, gastropods (*Lymnaea peregra, Physa* sp.) and chironomids (*Endochironomus albipennis, Glyptotendipes* sp.). The role of P and dissolved oxygen as parameters regulating the abundances of chironomid larvae was reported previously in river estuaries [Ozkan *et al*. 2010] and polymictic shallow lakes [Wazbinski *et al*. 2013]. The distribution of Gastropoda in small water reservoirs is significantly influenced by the concentration of dissolved oxygen and the occurrence of macrophytes [Lewin 2014].

CONCLUSION

The results of the present study have shown that habitats created by submerged macrophytes in oxbow lakes don't support high diversity of epiphytic fauna. It is probably a result of unfavourable habitat conditions (high concentrations of total P and P-PO_4, low proportions of dissolved oxygen), typical for hypertrophic lakes. This observation confirmed ordination analysis which showed significant role of dissolved oxygen and phosphorous compounds as main determinants of the structure epiphytic fauna.

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WPŁYW PARAMETRÓW SIEDLISKOWYCH NA WYSTĘPOWANIE NAROŚLINNEJ FAUNY BEZKRĘGOWEJ W STARORZECZACH

Streszczenie. Zależności pomiędzy parametrami siedliskowymi a strukturą fauny naroślinnej badano w trzech starorzeczach rzeki Wieprz (wschodnia Polska). Fauna zasiedlająca makrofity cechowała się niskim bogactwem gatunkowym (8–11 taksonów w zależności od stanowiska i sezonu), obserwowanym zazwyczaj w jeziorach o znacznej żyzności. Zagęszczenia epifauny były bardzo wysokie (średnio 71–5250 osobn. 100 g s.m.$^{-1}$), typowe dla płytkich jezior o dobrze rozwiniętej roślinności zanurzonej. W strukturze dominacji największy udział miały Gastropoda (23–100%) oraz Chironomidae (8–87%). Analiza ordynacyjna wykazała istotność czterech parametrów środowiskowych jako limitujących występowanie fauny naroślinnej w starorzeczach; należą do nich temperatura, tlen rozpuszczony, P ogólny oraz P-PO_4.

Słowa kluczowe: starorzecza, parametry środowiskowe, makrofity, fauna naroślinna