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STRUCTURE OF FAUNA ASSOCIATED WITH FLOATING-LEAVED AND SUBMERGED MACROPHYTES IN A SMALL DEPRESSION RESERVOIR (EASTERN POLAND)

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Summary. The taxonomic structure and abundance of invertebrates associated with floating-leaved and submerged macrophytes were studied in a small depression reservoir Nadrybie created as a result of ground subsidence in hard-coal mine. Number of epiphytic taxa were low (range 5–9 taxa dependently on macrophyte type and season) typical for highly eutrophic shallow lakes with permanent blooms of cyanobacteria. Whereas the densities of epiphytic fauna were high (mean 59–103 ind. 100 g WW^{-1}), similar to values reported on submerged macrophytes in lakes of clear water state. Invertebrates associated with both, floating-leaved and submerged macrophytes were dominated by larvae of Chironomidae. The relative abundances of chironomids depended on season and type of macrophytes and ranged from 56 up to 98% of total density of epiphytic fauna.

Key words: epiphytic fauna, depression reservoir, small water bodies

INTRODUCTION

Submerged macrophytes play important roles in aquatic ecosystems by producing organic matter [Hemminga and Duarte 2000, Caffrey 2004], modulating the physical environment [Petticrew and Kalff 1992, Madsen *et al.* 2001], participating in biogeochemical cycles [Wetzel 2001, Caraco *et al*. 2006] and supporting dense and distinctive communities of macroinvertebrates [Cogerino *et al.* 1995, Tolonen *et al.* 2001]. Although studies on the relations between submerged macrophytes and associated fauna are common, they are mostly conducted in shallow

lakes, river estuaries or ponds. Up to know the information about the epiphytic fauna in small water bodies is scarce. Similarly, it is known that floating-leaved macrophytes are suitable potential substratum for epiphytic fauna [Kornijów and Ścibior 1999], although the relatively low structural heterogeneity of nymphaeid aboveground parts and the increased underlying shading create conditions that are unfavourable to epiphytic fauna [McAbendroth *et al.* 2005]. Moreover, the structure of epiphytic fauna in small water bodies created as a result of human activity, such as exploitation of mineral resources is still not well recognized. The present paper shows the results of preliminary studies on the structure of invertebrate fauna associated with floating-leaved and submerged macrophytes in a small, shallow depression reservoir.

STUDY AREA, MATERIAL AND METHODS

Depression reservoir Nadrybie was created in 1984 as a consequence of ground subsidence on the area of „Bogdanka" hard-coal mine (eastern Poland). Physical and chemical conditions of water allow to classify the reservoir as highly eutrophic (Tab. 1). The reservoir is relatively small (surface area 30 ha) and shallow (max. depth 1.5 m). The total area overgrown by vegetation exceeds 50% of its surface. Dense, well developed stands of emergent vegetation are dominated by bullrush (*Typha latifolia* L.) and common reed (*Phragmites australis* (Cav.) Trin. ex Steud). Floating-leaved macrophytes are represented by broad-leaved pondweed (*Potamogeton natans* L.), water knotweed (*Polygonum amphibium* L.) and pleuston plant, common duckweed (*Lemna minor* L.). Submerged vegetation is dominated by rigid hornwort (*Ceratophyllum demersum* L.) with small patches of Eurasian watermilfoil (*Myriophyllum spicatum* L.) and single shoots of sago pondweed (*Potamogeton pectinatus* L.).

Table 1. Physical and chemical characteristic of Nadrybie Reservoir (mean values for summer period)

Secchi disc visibility, m	pH	Conductivity, $\mu S \cdot cm^{-1}$	Dissolved oxygen, $mg \cdot L^{-1}$	P_{tot}, $mg \cdot L^{-1}$)	$P\text{-}PO_4$, $mg \cdot L^{-1}$	$N\text{-}NH_4$, $mg \cdot L^{-1}$	$N\text{-}NO_3$, $mg \cdot L^{-1}$	Total suspension, $mg \cdot L^{-1}$	Chlorophyll *a*, $\mu g \cdot L^{-1}$
0.36 (±0.05)	8.2 (±0.7)	477 (±91)	9.8 (±1.1)	0.47 (±0.18)	0.31 (±0.09)	0.61 (±0.12)	0.12 (±0.03)	65.2 (±18.4)	192.6 (±57.8)

P_{tot} – total phosphorous; $P\text{-}PO_4$ – dissolved orthophosphates; $N\text{-}NH_4$ – ammonium nitrate; $N\text{-}NO_3$ – nitrate nitrogen

For the studies, samples were collected at dominant soft macrophyte species, *Potamogeton natans* (floating-leaved macrophytes – FLM) and *Ceratophyllum demersum* (submerged macrophytes – SUM). Fauna was collected in May, July and October 2007. Samples were taken by means of cylindrical apparatus, with openings covered by net of mesh size 250 µm [Kornijów 1998]. The plants were at first sampled by floristic anchor and then 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. Then collected invertebrates were counted and identified; nomenclature of taxa was accepted after Wiederholm [1983] and Kołodziejczyk and Koperski [2000]. Densities were calculated per 100 g of wt weight (WW) of plant.

The influence of macrophyte type and season on species diversity and abundance of epiphytic invertebrates was verified by means of two way ANOVA. Data were logarithmically transformed to normalize the distribution and stabilize heterogeneous variances. Pearson's correlation coefficients were calculated between environmental variables and density of epiphytic fauna to recognize the relations between macrophyte type and associated fauna. The analysis were performed by means of SAS Programme [2001].

RESULTS AND DISCUSSION

The total number of epiphytic taxa was low and amounted to 10 (floating--leaved macrophytes) and 12 taxa (submerged macrophytes) and showed seasonal variability. On floating-leaved macrophytes number of taxa ranged from 5 (October) to 8 (July); on submerged macrophytes from 6 (October) to 9 taxa (July). Such a low taxonomic diversity is typical for highly eutrophic lakes with permanent blooms of cyanobacteria [Brodersen *et al.* 2001, Tarkowska-Kukuryk 2010]. Cyanobacteria were dominant in phytoplankton in the Nadrybie Reservoir during the study period and show the highest relative abundance in summer (July).

The density of epiphytic fauna also showed seasonal variability; observed differences were significant for fauna associated with both, floating-leaved (ANOVA; $F = 676$; $p < 0.001$) and submerged macrophytes (ANOVA; $F = 1008$; $p < 0.001$) (Fig. 1). Studied macrophyte types, however, did not differ significantly in terms of abundance of epiphytic fauna. On floating-leaved macrophytes

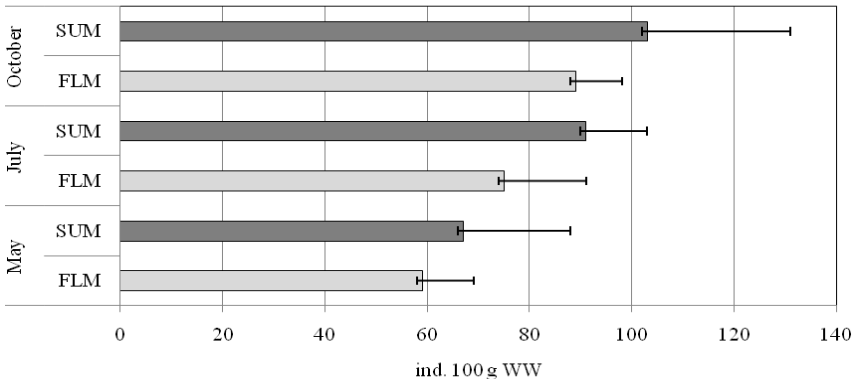

Fig. 1. Seasonal variation of mean density (+SD) of fauna associated with floating-leaved and submerged macrophytes in Nadrybie Reservoir in 2007

number of individuals ranged from 59 ind. 100 g WW^{-1} (May) to 89 ind. 100 g WW^{-1} (October); on submerged macrophytes, density of fauna varied between 67 ind. 100 g WW^{-1} (May) and 103 ind. 100 g WW^{-1} (October). Observed densities of epiphytic fauna were high, similar to values reported on submerged macrophytes in shallow lakes [Cheruvelil *et al.* 2002, Tarkowska-Kukuryk and Kornijów 2008]. On both types of vegetation, density of fauna showed the rising tendency from spring to autumn. This phenomenon may be related to „dilution effect", the rapid growth of macrophytes stems and leaves during vegetation period which causes the increase of colonization area for invertebrates [Kornijów and Ścibior 1999].

Density of fauna associated with floating-leaved macrophyte negatively correlated with conductivity ($r = -0.92$; $p = 0.021$), dissolved oxygen ($r = -0.89$; $p = 0.028$) and positively related to $P\text{-}PO_4$, ($r = 0.71$; $p = 0.024$), $N\text{-}NH_4$ ($r = 0.88$; $p = 0.032$), and $N\text{-}NO_3$ ($r = 0.85$; $p = 0.029$). Abundance of fauna associated with submerged macrophytes showed positive relation with P_{tot} ($r = 0.42$; $p = 0.044$) and total suspension ($r = 0.73$; $p = 0.049$). The effect of conductivity and dissolved oxygen on macroinvertebrates should be considered with regard to nympheids and their relations with environmental conditions. High biomass and cover of nympheids (potential colonization area) is usually observed under low conductivity (80–150 $\mu S \cdot cm^{-1}$), [Makela *et al*. 2004], in the studied reservoir its value exceeded 400 $\mu S \cdot cm^{-1}$. Dense cover of floating-leaved macrophytes, such as *Trapa natans* may negatively affect the content of dissolved oxygen in water column [Takamura *et al*. 2003]. Under low oxygen conditions, fauna associated with macrophytes is limited to taxa which are able to live under unfavorable habitat conditions. Dominant chironomid taxa, observed on floating-leaved macrophytes in the studied reservoir are typical for highly eutrophic lakes. The concentration of nutrients ($N\text{-}NH_4$, $N\text{-}NO_3$, $P_{tot.}$, $P\text{-}PO_4$) significantly affects the biomass and structure of planktonic and periphytic algae. Many invertebrate taxa (such as larvae of Chironomidae, Gastropoda) are important consumers of algae and their presence is restricted to food availability [Pinowska 2002, Tarkowska-Kukuryk 2013].

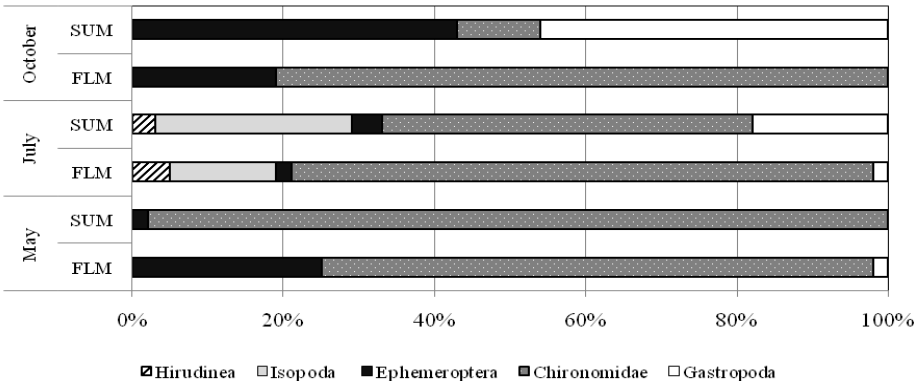

Fig. 2. Relative abudances of taxa of fauna associated with floating-leaved and submerged macrophytes in Nadrybie Reservoir in 2007

The fauna associated with floating-leaved and submerged macrophytes was dominated by chironomids. The larvae constituted the major component of epiphytic fauna in freshwater ecosystems [Lawrence and Gresens 2004, Maasri *et al.* 2008, Tarkowska-Kukuryk 2011]. The percentage of chironomids ranged from 73 to 81% on floating-leaved macrophytes and from 56 up to 98% on submerged macrophytes (Fig. 2). The chironomid assemblages were represented mostly by phytophilous taxa, such as *Cricotopus* sp. (gr. *sylvestris*), *Endochironomus albipennis*, *Paratanytarsus austriacus,* which are known to favour densely vegetated littoral areas [Berg 1995].

The results of the study have shown that floating-leaved and submerged macrophytes should be considered as suitable habitats for invertebrate fauna in small anthropogenic water bodies, such as depression reservoirs. Moreover, high abundance of epiphytic fauna on nymphaeids suggests that, floating-leaved plants, despite their structural distinctiveness, can positively affect epiphytic fauna, providing substratum, food resources and shelter, similarly to other morphological groups of plants.

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STRUKTURA FAUNY ZASIEDLAJĄCEJ MAKROFITY ZANURZONE I O LIŚCIACH PŁYWAJĄCYCH W DROBNYM ZBIORNIKU ZAPADLISKOWYM (WSCHODNIA POLSKA)

Streszczenie. Badania obfitości i składu taksonomicznego fauny naroślinnej na makrofitach o liściach pływających i zanurzonych prowadzono w zapadliskowym zbiorniku Nadrybie, który powstał w wyniku wydobycia węgla kamiennego. Liczba taksonów fauny bezkręgowej na obu typach roślinno-

ści była niska (zakres 5–9 taksonów), typowa dla silnie zeutrofizowanych, płytkich jezior, w których obserwowane są zakwity sinic. Natomiast zagęszczenie fauny bezkręgowej było wysokie (zakres 59–103 osobn. 100 g m.m. roślin), zbliżone do wartości uzyskiwanych na makrofitach zanurzonych w płytkich jeziorach, o dobrej jakości wody. Głównym komponentem fauny bezkręgowej zasiedlającej makrofity o liściach pływających i zanurzonych były larwy Chironomidae, których udział w zależności od sezonu i typu roślinności wahał się od 56 aż do 98% ogólnej liczebności fauny.

Słowa kluczowe: fauna naroślinna, zbiorniki zapadliskowe, drobne zbiorniki wodne