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DISTRIBUTION OF ZOOBENTHOS BETWEEN LITTORAL AND MIDDLE LAKE ZONE IN TWO SHALLOW LAKES OF DIFFERENT TROPHIC STATUS

Monika Tarkowska-Kukuryk, Tomasz Mieczan, Jacek Rechulicz, Wojciech Pęczuła

Department of Hydrobiology, University of Life Sciences in Lublin
Dobrzańskiego str. 37, 20-262 Lublin, monika.kukuryk@up.lublin.pl

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Summary. Zonal distribution, taxonomic richness and densities of zoobenthos were studied in two shallow lakes of Polesie Lubelskie; eutrophic Lake Sumin and hypertrophic Lake Syczyńskie. Bottom fauna was collected in May, July and October of 2010 from littoral and middle lake zones. Taxonomic composition and abundance of bottom fauna were significantly affected by lake zone and trophic status of lake. The highest taxonomic diversity of zoobenthos, in both studied lakes was observed in littoral zone. Density of bottom fauna showed the highest values in middle lake (profundal) zone of hypertrophic lake. In the littoral zone, zoobenthos was represented mostly by larvae of Chironomidae, in middle lake zone high abundances showed larvae of Chaoboridae. Taxonomic composition and abundances of bottom fauna indicate a visible distinction between littoral and middle lake zone in lakes of different trophic status.

Key words: benthic invertebrates, chironomids, lake, habitat

INTRODUCTION

The distribution of macroinvertebrates in lakes is regulated by many physical and biological factors, such as depth, food quality and availability, particle size and content of organic matter, type of substrate, water temperature and dissolved oxygen content [Merritt and Cummins 1996, James *et al*. 1998, Weather-

head and James 2001]. Habitat conditions change along horizontal gradient and may influence the distribution and structure of bottom fauna between littoral and profundal (middle lake) zones. Usually higher habitat diversity (presence of macrophytes) and good oxygen conditions in littoral area contribute to high abundance, species richness and productivity of benthic invertebrates [Pieczyńska *et al.* 1999]. Conversely, the profundal zone is rather homogenous habitat with frequent oxygen deficits, intensive heterotrophic production and low diversity of bottom fauna with dominance of a few species resistant to unfavorable habitat conditions [Hamburger *et al.* 2000].

The presence of macrophytes has been known to have a significant influence on the diversity of invertebrates communities [Tessier *et al.* 2004, Bogut *et al.* 2007]. Particular macrophyte species due to their architecture and ability to create patches of different sizes presenting different scales of habitat to invertebrates. Higher diversity of benthic invertebrates is often observed among macrophytes than outside vegetation stands [Beckett *et al.* 1992, Tarkowska-Kukuryk and Kornijów 2008].

The study aims at evaluation of the distribution, taxonomic structure, richness and abundance of bottom macroinvertebrates between littoral and middle lake zone.

STUDY AREA, MATERIAL AND METHODS

Studies were conducted in two shallow lakes of Polesie Lubelskie differed in trophic status; eutrophic Lake Sumin (surface area 91.5 ha, max. depth 6.5 m) and hypertrophic Lake Syczyńskie (surface area 6 ha, max. depth 2.9) (Tab. 1). Benthic invertebrates were collected in May, July and October of 2010 from littoral and middle lake zone.

Table 1. Physical, chemical and biological characteristic of studied lakes (mean values for summer period)

Parameters	Sumin		Syczyńskie	
	littoral	middle lake	littoral	middle lake
Temperature, ^{o}C	17.4	17.7	15.8	16.1
Secchi disc depth, m	0.8	0.9	0.6	0.3
pH	7.6	7.2	6.9	7.4
Disssolved oxygen, $mg \cdot L^{-1}$	10.41	9.34	11.09	10.65
Conductivity, $\mu S \cdot cm^{-1}$	414	410	575	574
Total suspension, $mg \cdot L^{-1}$	4.08	6.31	14.16	13.02
$N\text{-}NH_4$, $mg \cdot L^{-1}$	0.351	0.387	0.213	0.201
$N\text{-}NO_3$, $mg \cdot L^{-1}$	0.394	0.374	0.292	0.329
TP, $mg \cdot L^{-1}$	0.042	0.053	0.466	0.464
$P\text{-}PO_4$, $mg \cdot L^{-1}$	0.011	0.023	0.271	0.202
Chlorophyll *a*, $\mu g \cdot L^{-1}$	10.48	9.87	74.72	70–27
TOC, $mg \cdot L^{-1}$	14.96	14.7	6.7	6.9

The samples of bottom fauna (10 cores of the bottom sediments per 1 sample) were taken from 3 sites, using a tube apparatus (surface area 15.2 cm^2). The sediments collected were sieved through the 250 μm mesh size, put into the plastic bags and transported to the laboratory.

At the laboratory macroinvertebrates were selected from sediment samples and preserved in 4% formaldehyde solution. Next collected fauna were counted and identified under dissected microscope; the nomenclature of taxa was accepted after Wiederholm [1983] and Kołodziejczyk and Koperski [2000]. Densities were calculated per m^2 of bottom surface.

Taxonomic diversity of bottom fauna was estimated by calculating Shannon-Wiener index according to the formula:

$$H' = -\Sigma (p_i \log p_i^2)$$

were: H' – index of taxonomic diversity

p_i – abundance of *i* species in total abundance of fauna.

The influence of trophic status, season and lake zone on mean densities and taxonomic richness of bottom fauna was verified using main effect analysis of variance (ANOVA). The test of Kołmogorow-Smirnow was used to verify the normal distribution of collected data. Statistical analysis were performed by means of STATISTICA 7.0 Software.

RESULTS

Densities of bottom fauna were significantly affected by trophic status of lake (ANOVA; $F = 28.67$; $P < 0.001$) and lake zone (ANOVA, $F = 16.97$; $P < 0.001$) (Fig. 1). In eutrophic Lake Sumin mean abundances of zoobenthos in littoral (range from 1056 to 1782 ind. · m^{-2}) were higher than in middle lake (from 354 to 783 ind. · m^{-2}); in hypertrophic Lake Syczyńskie was observed the opposite pattern, significantly higher densities of bottom fauna were noted in middle lake zone (from 4284 to 5814 ind. · m^{-2}). In the littoral zone higher densities of zoobenthos were observed in eutrophic Lake Sumin, while in the middle lake zone mean abundances of bottom fauna were significantly higher in hypertrophic Lake Syczyńskie. Density of bottom fauna showed seasonal variability (Fig. 1). In eutrophic Lake Sumin the lowest densities of bottom fauna were noted in May (littoral zone; 306 ind. · m^{-2}) and the highest in October (littoral zone; 1782 ind. · m^{-2}). In hypertrophic Lake Syczyńskie the lowest (littoral zone, 528 ind. · m^{-2}) and the highest (middle lake zone, 5814 ind. · m^{-2}) abundances of zoobenthos were recorded in October.

The domination structure of bottom fauna depended on trophic status of lake and lake zone (Fig. 2). In eutrophic Lake Sumin in both studied zones, dominated larvae of Chironomidae amounted from 34% (May, middle lake zone) up to 86% (May, littoral) of total zoobenthos density. In littoral zone were observed

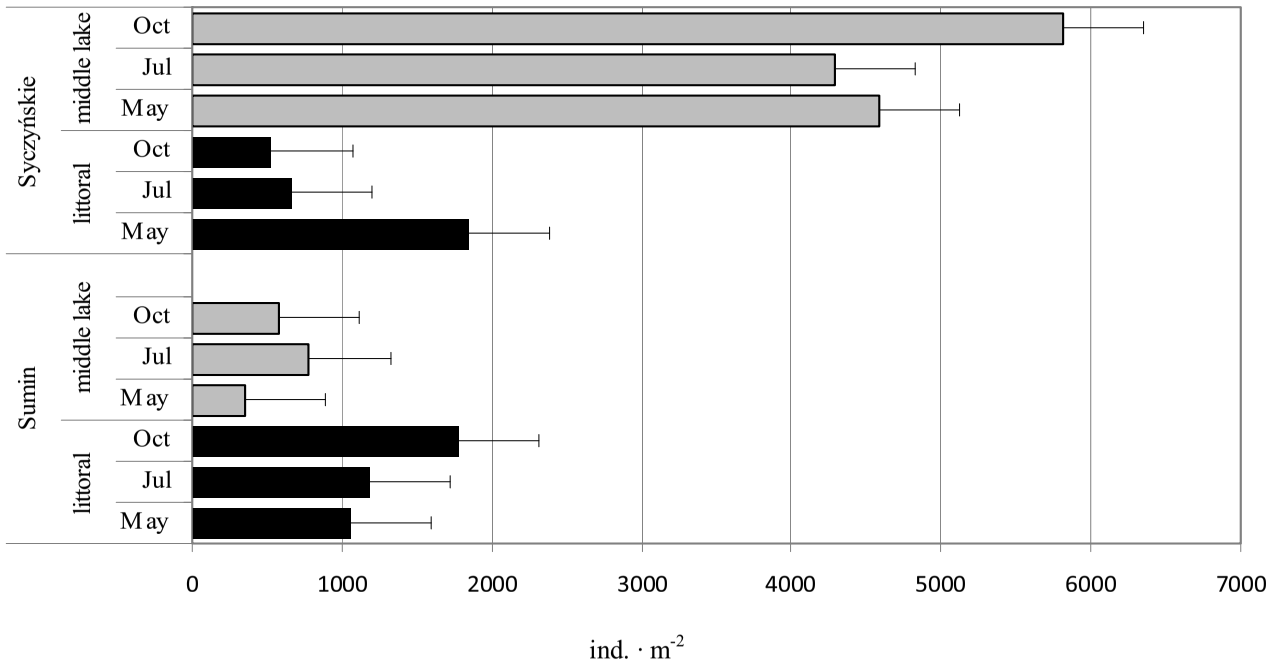

Fig. 1. Mean denisties (+SD) of bottom fauna in litoral and middle lake zones in studies seasons in lakes Sumin and Syczyńskie in 2010

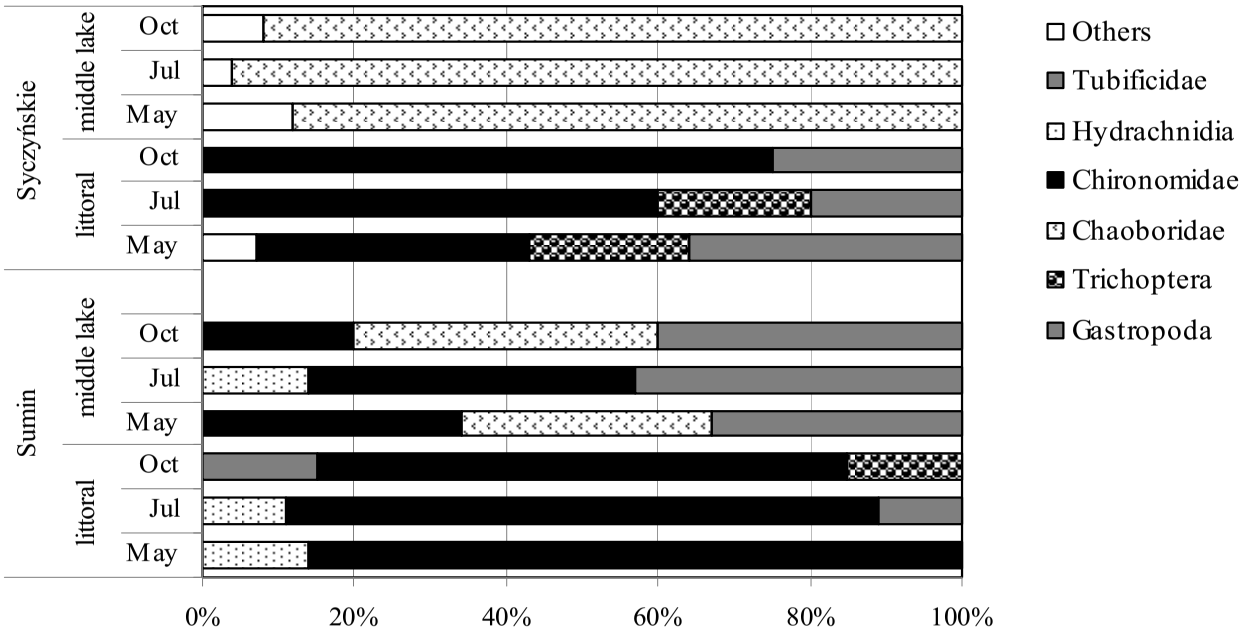

Fig. 2. Relative abudances of bottom fauna in littoral and middle lake zones in studied seasons in lakes Sumin and Syczyński in 2010

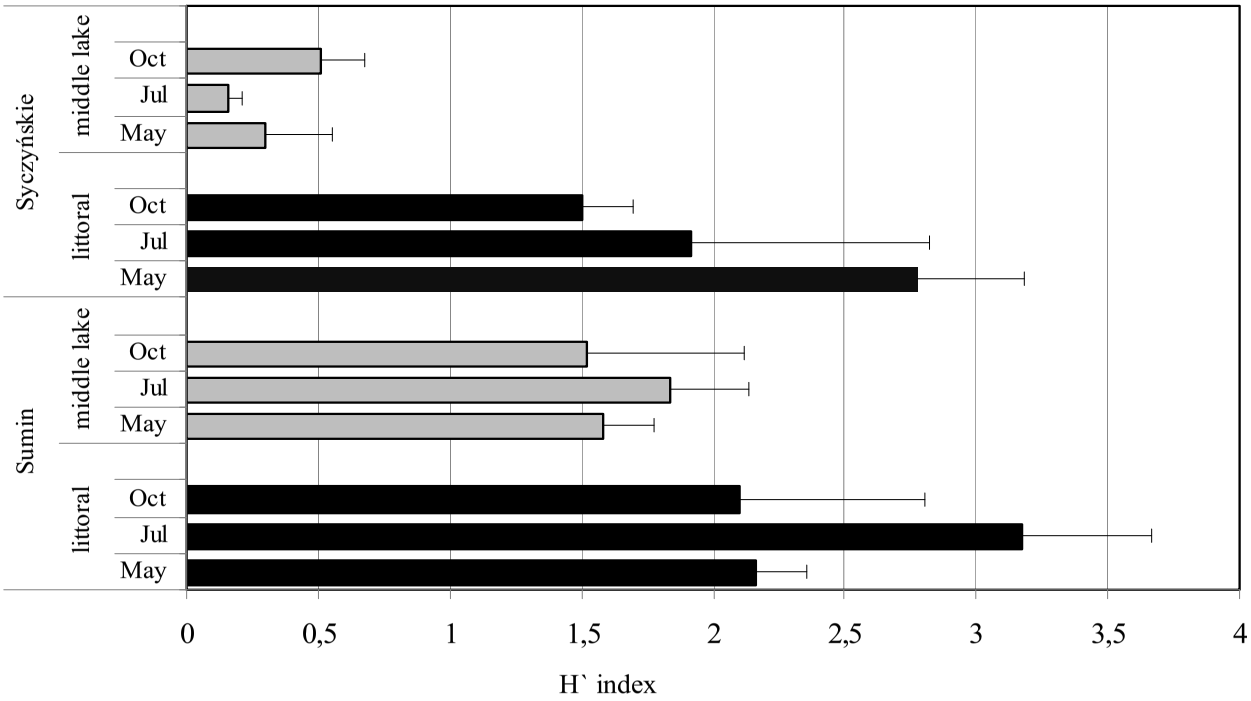

Fig. 3. Values of Shannon-Wiener index (+SD) for bottom fauna in littoral and middle lake zones in studied seasons in lakes Sumin and Syczyńskie in 2010

mostly phytophilous chironomids taxa *Endochironomus albipennis* (Meigen) and *Polypedilum sordens* (v.d. Vulp) and larvae of pelophilous *Einfeldia* sp. In middle lake zone midges community represented eurytopic larvae of *Cladota-nytarsus mancus* and pelophilous *Chironomus* sp. and *Einfeldia* sp. Only in Octo-ber in middle lake zone the highest amounts reached larvae of Chaoboridae (*Chaoborus flavicans* L.) (41%) and Gastropoda (*Planorbarius corneus* L.) (39%). In hypertrophic Lake Syczyńskie, in littoral zone dominated chironomids, mostly pelophilous taxa *Chironomus* sp. and *Einfeldia* sp., reached from 36% (May) to 75% (October). In the middle lake zone prevailed larvae of Chaoboridae, amounted from 88% (May) to 96% (July) of total density of bottom fauna.

Trophic status and lake zone affected the taxonomic diversity of bottom fauna (Fig. 3). In both lakes the highest values of Shannon-Wiener index was observed in littoral zone, mean H` = 2.2 (L. Sumin) and H` = 2.1 (L. Syczyńskie). Values of Shannon index showed seasonal variability. In eutrophic Lake Sumin, in both studied zones, the highest values of H index was noted in July, 3.2 (littoral) and 1.8 (middle lake), and the lowest in October, 2.1 and 1.5 respectively. In hypertrophic Lake Syczyńskie, in littoral, values of H index ranged from 1.5 (October) to 2.8 (May). In middle lake zone, diversity index reached very low values and varied from to 0.2 (July) to 0.5 (October).

DISCUSSION

The results confirmed the distribution of zoobenthos between littoral and middle lake zone. In both studied lakes, in littoral, zoobenthos showed higher taxonomic diversity than in middle lake zone. The highest diversity of bottom fauna is usually observed in littoral zone. In the zone due to the presence of macrophytes water transparency increases, sediments resuspension is reduced, creating good oxygen conditions for benthic taxa [van den Berg *et al.* 1997, Blindow *et al.* 2002]. Dense stands of submerged vegetation affect positively the number of available niches and abundance of potential food for benthic invertebrates. The presence of vegetation diminishes the predation efficiency, making invertebrates less vulnerable for fish predation [Diehl 1992].

The density of bottom fauna didn't show the similar pattern. In eutrophic Lake Sumin the abundances of bottom fauna in the middle lake zone were lower than in littoral, but in hypertrophic Lake Syczyńskie was observed the opposite relation. Mean densities of bottom fauna were few times higher than in littoral and were closely related to very high numbers of Chaoboridae larvae. These organisms constitute an important component of zoobenthos in profundal zone of highly eutrophic lakes [Henrikson and Oscarson 1984, Yan *et al.* 1984]. Under hypertrophic conditions larvae of Chaoboridae may prevail community of bottom fauna and become the only taxa inhabited profundal zone under oxygen deficits. Their density may exceed a number of few thousand individuals per m^2 of bottom surface [Rieradevall and Prat 1991].

In the littoral zone bottom fauna was represented by larvae of Chironomidae. These larvae constitute the most important group of zoobenthos in different types of water ecosystems [Pinder 1986, Dermott 1988, Real *et al.* 2000]. Larvae of chironomids showed high resistance for oxygen depletion and water pollution and are frequently used as indicators of trophic status of lakes [Kansanen *et al.* 1984, Lindegaard 1995].

Shannon-Wiener index of species diversity calculated for bottom fauna confirmed its distinction between littoral and middle lake zone. Values of diversity index reflected habitat conditions for bottom fauna. As it was reported by Kajak [1988] and Jonasson [1996] the most important determinants of zoobenthos distribution are food availability, oxygen content and water temperature. Based on the results littoral zones of both lakes seem to present favourable conditions for development of bottom fauna. Littoral zone is usually abundant in food (algae and detritus) for benthic grazers. Macrophytes can enhance sedimentation, contribute directly to the particulate organic matter used by invertebrates as food source [Bowen 1987, James *et al*. 1998]. Littoral vegetation provides a large surface for colonization of algae which represent an important food source for the majority of benthic taxa [Pinowska 2002, Tessier *et al.* 2004]. In both lakes bottom fauna in littoral zones was represented mostly by algivorous (Chironomidae) and detritivorous taxa (Chironomidae, Gastropoda) [Holopainen and Jonasson 1983, Yeager *et al.* 2001]. The worst habitat conditions and extremely low values of Shannon-Wiener index were observed in middle lake zone of hypertrophic Lake Syczyńskie. In the lake are frequently observed oxygen deficits and long lasting blooms of cyanophyte [Toporowska *et al.* 2010].

CONCLUSIONS

Littoral and middle lake zone create different habitats for benthic invertebrates. The more favourable environmental conditions (high oxygen content and food availability, presence of macrophytes) are observed in littoral zone. Thus the zone is intensively colonized by benthic taxa, what is reflected in higher species diversity and domination structure of zoobenthos in comparison to the middle lake zone. Clear differentiation of benthic fauna between littoral and middle lake zone is observed in lakes regardless of their trophic status.

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ROZMIESZCZENIE ZOOBENTOSU W STREFIE LITORALU I ŚRÓDJEZIERZA W DWÓCH PŁYTKICH JEZIORACH O RÓŻNYM STATUSIE TROFICZNYM

Streszczenie. W dwóch płytkich jeziorach Polesia Lubelskiego, eutroficznym jeziorze Sumin oraz hipertroficznym jeziorze Syczyńskie analizowano strefowe rozmieszczenie, bogactwo gatunkowe oraz zagęszczenie zoobentosu. Próby fauny dennej pobierano w maju, lipcu oraz październiku 2010 roku ze strefy litoralu i śródjezierza. Struktura taksonomiczna oraz zagęszczenie fauny dennej były istotnie zależne od strefy jeziora i jego stanu troficznego. Największe zróżnicowanie taksonomiczne zoobentosu w obu badanych jeziorach obserwowano w strefie litoralu. Zagęszczenie fauny dennej osiągało najwyższe wartości w strefie śródjezierza hipertroficznego jeziora. W strefie litoralu zoobentos reprezentowany był przede wszystkim przez larwy Chironomidae; w strefie śródjezierza największą liczebność osiągały larwy Chaoboridae. Obserwowany skład taksonomiczny oraz liczebność fauny dennej wskazują na wyraźną odrębność stref litoralu i śródjezierza w jeziorach o różnym statusie troficznym.

Słowa kluczowe: makrofauna bentosowa, ochotkowate, jezioro, siedlisko