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EFFECT OF BIOTIC ZONES ON SPECIES DISTRIBUTION OF *CLADOCERA* IN MESOTROPHIC LAKE PIASECZNO[*]

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A b s t r a c t. Species distribution of *Cladocera* was studied in deep, mesotrophic Lake Piaseczno (Łęczna-Włodawa Lakeland). There was a strong impact of biotic zones on quality of cladocerans as their species richness dropped towards the deepest part of the lake. There were great differences in seasonal changes of species diversity in particular biotic zones, which suggests an important role of macrophytes in forming habitat conditions.

K e y w o r d s: mesotrophic lake, *Cladocera*, spatial distribution, species diversity

INTRODUCTION

Spatial partitioning of resources is believed to involve trade-offs in the ability of different species to perform under different environmental conditions. Many abiotic and biotic factors have been implicated in determining the boundaries of species distribution. These factors change horizontally relative to depth and macrophyte coverage, forming biotic zones with various habitat and nourishing conditions: littoral, sublittoral, and pelagic zone. Planktonic crustaceans, especially cladocerans, are expected to prefer or avoid habitats on the basis of their complexity [4], physical and chemical properties of water [16], and food resources [21]. The aim of the study was to recognize the horizontal species distribution of *Cladocera* in a deep, mesotrophic lake, and to determine habitat preferences of particular cladocerans.

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STUDY SITE, MATERIAL AND METHOD

The study was carried out in 2002-2003 in deep mesotrophic lake Piaseczno located in Łęczna-Włodawa Lakeland. Samples were collected once a month, from April to November, from two stations in littoral: emergent macrophytes (max. depth 0.5 m) with dominating *Phragmites australis* and submerged macrophytes (max. depth 3 m) with dominating *Myriophyllum alterniflorum*, and from one station in sublittoral (max. depth 6 m). In pelagic zone samples were taken three times a year (May, July and September) from a station located in the deepest part of the lake (max. depth 38 m). In each of the distinguished stations samples were taken every 1-2 meters of depth from surface to the bottom of lake using "Toń" sampler, sieved through a 50-µm plankton net, and preserved with formalin and glycerin solution. In the laboratory, species composition was examined and the obtained results were averaged for each of the distinguished stations.

In the analysis of the collected material the following coefficients were considered: species diversity index (H) according to the formula of Shannon-Wiener, stability of occurrence (Fr) as a percentage share of samples containing particular species, and ecological importance (Q) as a square root of stability of occurrence and domination of species.

RESULTS

In the research 39 species were collected. They belonged to the following families of *Cladocera*: *Chydoridae* (24 species), *Daphnidae* (5 species), *Macrothricidae* (4 species), *Bosminidae* (2 species), *Sididae* (2 species), *Leptodoridae* (1 species) and *Polyphemidae* (1 species).

There were 38 species in littoral, including 35 species found amid emerged macrophytes and 33 species obtained amid submerged macrophytes. In sublittoral 28 species and in pelagial 8 species occurred (Fig. 1). Most of the species caught in littoral and sublittoral (21 and 17 species, respectively) belonged to the family *Chydoridae*, whereas in pelagial the greatest number – 3 species – represented the family *Daphnidae*. Cladocerans occurring in the stations within littoral and sublittoral zones represented 6-7 families, while cladocerans caught in the pelagial belonged to 5 families. Species diversity index took different values in biotic zones of the examined lake. The highest values were noted in littoral – $H=3.6$ for the station of emerged macrophytes and $H=3.4$ for the station of submerged macrophytes. A lower value of Shannon-Wiener index was in sublittoral ($H=2.6$), and the lowest, only $H=0.3$, in pelagial (Fig. 2).

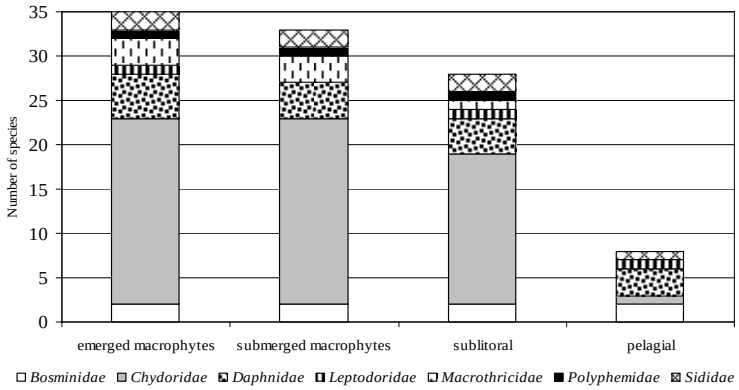

Fig. 1. Number of species and their participation to families of *Cladocera* in particular stations of examined lake

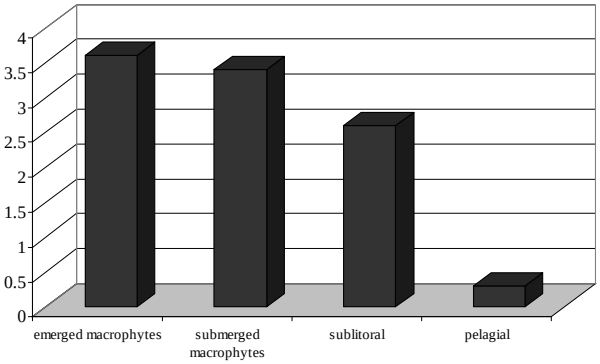

Fig. 2. Species diversity index in examined stations of lake Piaseczno

There was a strong seasonal differentiation in the quality of *Cladocera*. The highest number of species – 33, was found in July and September, whereas the lowest species richness – 20, was in April and November. Among families living in the examined lake *Chydoridae* showed the greatest seasonal changes in species abundance as the number of cladocerns belonging to that family ranged from 10 in April and November to 20 in July. Other families underwent smaller changes in species diversity. Seasonal changes in the number of species were different in the particular biotic zones. In each of the distinguished stations the lowest species richness (8-11) was found in April and November. In littoral zone, amid emerged macrophytes there was a quality peak in July when 27 species of *Cladocera* occurred; amid submerged macrophytes quality abundance was high from May to September, reaching 21-24 species. In sublittoral the highest number of species – 21, was found in September. In pelagic zone 7-8 species of cladocerans were occurring during the entire run of research (Fig. 3).

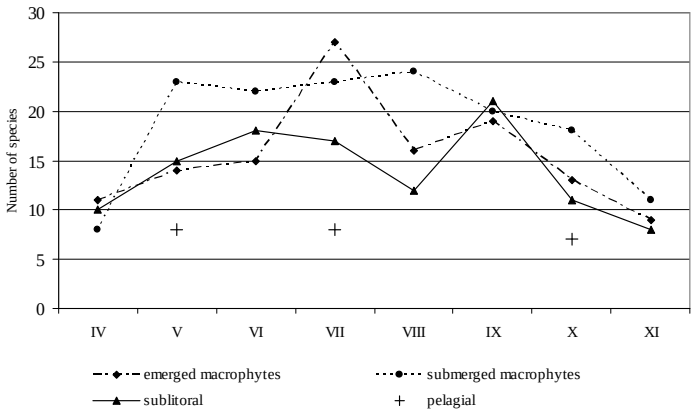

Fig. 3. Seasonal changes in number of cladoceran species in examined stations of lake Piaseczno

There were great differences in the stability of occurrence of cladocerans in biotic zones of the investigated lake. Amid emerged macrophytes *Acroperus harpae, Acroperus elongatus, Ceriodaphnia quadrangula, Chydorus sphaericus* belonged to euconstants, while *Sida crystallina, Bosmina longirostris, Diaphanosoma brachyurum* and *Alonella excisa* appeared as constants. There were also 9 accessory species and 18 accidentals in that station. Within submerged macrophytes to the euconstants belonged *Ceriodaphnia quadrangula, Diaphanosoma brachyurum, Bosmina coregoni, Acroperus harpae* and *Chydorus sphaericus*, whereas *Bosmina longirostris* and *Daphnia longispina* were constants. Additionally, 10 accessory species and 16 accidentals lived there. In sublittoral a group of euconstants was formed by: *Bosmina coregoni, Daphnia longispina, Diaphanosoma brachyurum, Ceriodaphnia quadrangula* and *Bosmina longirostris*. *Daphnia cucullata* and *Chydorus sphaericus* were constants. There were also 21 accidentals, no accessory species were found. In pelagic zone *Diaphanosoma brachyurum, Daphnia longispina* and *Daphnia cucullata* belonged to euconstants, while *Bosmina coregoni, Bosmina longirostris* and *Chydorus sphaericus* formed a group of constants. *Ceriodaphnia quadrangula* was accessory and *Leptodora kindtii* – accidental species.

In each biotic zone of Lake Piaseczno *Diaphanosoma brachyurum* had high ecological importance. Value of the ratio for that species rose toward pelagic zone and reached from Q = 16% amid emerged macrophytes to Q = 71% within pelagial. *Bosmina coregoni, Bosmina longirostris* and *Chydorus sphaericus* were also of great ecological importance, gaining the highest values of Q ratio in sublittoral. *Ceriodaphnia quadrangula* obtained the highest ecological importance amid emerged macrophytes (Q = 47%) and the lowest in pelagial (Q = 4%). *Daphnia longispina* and *Daphnia cucullata* showed the greatest ecological importance in pelagic zone (*D. cucullata* – 31.9%, *D. longispina* – 23.9%) and a bit lower in sublittoral,

whereas values of Q ratio for those species in littoral were smaller than 10%. Amid emerged macrophytes to the species of high ecological importance belonged also *Acroperus harpae* (Q = 36%), *Acroperus elongatus* (Q = 18%), *Alonella excisa* (Q = 15%) and *Macrothrix rosea* (Q = 13%).

DISCUSSION

Zooplankton, including microcrustaceans, exhibit characteristic vertical and horizontal distribution in lakes. The type and abundance of macrophytes changes with increasing depth and can build habitats favouring temporal and spatial coexistence of cladocerans. Lake Piaseczno, with its well formed littoral (down to 5 meters of depth) and strongly separated sublittoral, provides food and habitat conditions convenient for different species of *Cladocera*. As a result a great number of cladoceran species occurred in those zones. Typical filtrators coexisted there with species related with vegetation and feeding periphyton, as well as species showing different behavioural strategies, for instance predatory *Polyphemus pediculus, Anchistropus emarginatus* feeding on soft tissues of invertebrates, or *Leydygia acanthocercoides* living in upper layers of sediments. Pelagic zone in contrary to littoral and sublittoral where cladocerans can exist in 3 distinct habitats: open water, submerged vegetation and sediments, seems to be rather homogenous, so lower species diversity occurred there, mostly filtrators and predatory *Leptodora kindtii*. Other European lakes show similar species richness in pelagic zone [12,13,23,24].

There was a strong effect of biotic zone on the seasonal composition of *Cladocera*. Amid emerged macrophytes the greatest species diversity occurred in July, which may be connected with food availability. High water temperature favoured peryphiton to develop on reed steams, therefore not only filtrators but also scrapers could find suitable feeding source. Predatory pressure of fry might also affect species richness within emerged macrophytes, since Gliwicz *et al*. [6] and Hobæk *et al*. [11] suggest that temperate fish predation may enhance species richness in zooplankton through mitigating competitive exclusion by dominant members of the plankton communities. Amid submerged macrophytes the number of species was high and its temporal changes were unimportant. It shows a great role of vegetation in creating conditions to fulfil requirements of different species of *Cladocera* and is compatible with results obtained by other authors [1,3,5,7,8,10,17-20]. Vegetation in lakes may function as a refuge from planktivores by hindering predator foraging activity [14,22] and the effectiveness of the refuge increases with its complexity [15]. *Myriophyllum alterniflorum* has a complex structure with many finely divided leaves, so it can offer better protection against fish predation than *Phragmites australis*.

Among the families of *Cladocera* occurring in Lake Piaseczno, *Chydoridae* showed the greatest seasonal shifts in species richness. They existed mostly in

littoral and sublittoral, and their presence or absence might result from the physical conditions in particular season's i.e. low habitat complexity in spring and autumn and high habitat complexity in summer months. Most *Chydoridae* are efficient grazers on periphyton involving submerged macrophytes to develop, therefore the occurrence of *Chydoridae* may be related with food availability.

Cladocera displayed a different extent of association to biotic zones as demonstrated by ratios of stability of occurrence and ecological importance. *Diaphanosoma brachyurum* was characterised by high stability of occurrence and ecological importance in each of biotic zones, nevertheless it had the highest values of mentioned ratios in pelagic zone. According to Korovhinsky [12], representatives of *Diaphanosoma* have been recorded in pelagial of most European lakes of low nutrient state. Likewise, *Bosmina coregoni* was mostly attached to sublittoral in spite of appearing in all the biotic zones. *Bosmina longirostris* and *Chydorus sphaericus* were characterized by the highest stability of occurrence in sublittoral and the highest ecological importance in sublittoral and within station of emerged macrophytes, which can be an evidence of their preferences to moderate habitat complexity. In sublittoral vegetation covers the bottom in scattered clumps. Also *Phragmites australis* does not form as dense assemblages as *Myriophylum alterniflorum*. Thus, *B. longirostris* and *C. sphaericus* may avoid too homogenous pelagic zone and too complex station of submerged macrophytes in the lake. Interestingly, values of stability for *Ceriodaphnia quadrangula* increased from pelagic zone towards shores of lake, but its ecological importance rose with increasing habitat complexity. Also Bergstrőm *et al*. [2] showed that *C. quadrangula* was biased to use *Myriophyllum* clumps as a refuge.

Amid emerged macrophytes some species were characterized by considerable values of ecological importance and stability of occurrence, although they were unimportant in other zones. Some of them are considered to be typical for locations covered with reed. It is an evidence for distinction of this habitat and supports the hypothesis that different species of macrophytes may have different effect on zooplankton distribution.

Species distribution of cladocerans in biotic zones cannot be explained by phylogenetic similarity. The *Chydoridae* were represented by 24 species: 23 of them occupied littoral and/or sublittoral, while 1 species was present in all biotic zones. *Sida crystallina* existed in littoral, and *Diaphanosoma brachyurum* – common in all biotic zones – belongs to the *Sididae*. Likewise, *Simocephalus vetulus* and *Ceriodaphnia quadrangula* – with the highest stability of occurrence and ecological importance within submerged macrophytes, as well as *Daphnia cucullata* and *Daphnia longispina* – with the highest Fr ratios and Q ratios in pelagic zone, although members of the family *Daphnidae*, yet differed in their response to the habitat type. So, while species of cladocerans appeared to have

specific habitat choices, higher taxonomic status was not a good predictor of horizontal distribution.

CONCLUSION

Biotic zones with different habitat conditions, clearly distinguished in the examined lake, have strong impact on species distribution of *Cladocera*. Nevertheless, while species of cladocerans appeared to have specific habitat choices, higher taxonomic status was not a good predictor of horizontal distribution.

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WPŁYW STREF BIOTYCZNYCH NA KSZTAŁTOWANIE SIĘ STRUKTURY JAKOŚCIOWEJ WIOŚLAREK (*CLADOCERA*) W MEZOTROFICZNYM JEZIORZE PIASECZNO

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S t r e s z c z e n i e. Badania prowadzono w latach 2002-2003 w głębokim, mezotroficznym jeziorze Piaseczno na Pojezierzu Łęczyńsko-Włodawskim. Próby planktonowe pobierano w odstępach czterotygodniowych, od kwietnia do listopada na dwóch stanowiskach w litoralu: w strefie roślin wynurzonych z dominującym *Phragmites australis* oraz w strefie roślin zanurzonych z dominującym *Myriophyllum alterniflorum* oraz w sublitoralu. Dodatkowo wyznaczono stanowisko w pelagialu, położone w najgłębszej części jeziora (głębokość maksymalna 38 m), z którego próby pobierano w maju, lipcu i wrześniu. W badanym jeziorze zaznaczyło się wyraźne strefowe zróżnicowanie jakościowe wioślarek, gdyż przestrzenne rozmieszczenie i liczba gatunków w jeziorze zmieniały się wraz z głębokością: w litoralu występowało 35 gatunków wioślarek w strefie roślin wynurzonych i 33 gatunki wioślarek w strefie roślin zanurzonych, w sublitoralu 28 gatunków, zaś w pelagialu 8 gatunków. Na poszczególnych stanowiskach w strefie litoralu oraz w sublitoralu pod względem bogactwa gatunkowego dominowały *Chydoridae*, w pelagialu zaś najliczniej reprezentowane były *Daphnidae*. Grupą wykazującą najwyższą dynamikę sezonowych zmian w tych strefach były *Chydoridae*

S ł o w a k l u c z o w e: mezotroficzne jezioro, *Cladocera*, różnorodność gatunkowa, przestrzenne rozmieszczenie