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QUANTITATIVE ASSESSMENTS OF BENTHIC AND EPIPHYTIC FAUNA OF MEIOINVERTEBRATES OF SMALL WATER BODIES OF ANTHROPOGENIC ORIGIN

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Summary. In this work there has been taken a trial to quantitative assessments of benthic and epiphytic fauna of chosen groups of meioinvertebrates of three ponds of anthropogenic origin. These ponds originated on the area of farms and they differ in age. The plants from which the fauna was collected included: *Elodea canadensis*, *Ceratophyllum demersum* and *Potamogeton natans***.** In the taken material there was estimated the density and dominance structure of benthic and epiphytic fauna of the following taxa: Turbellaria, Gastrotricha, Rotifera and Nematoda.

Total density of the studied phyla in bottom sediments fluctuated from 875.0 to 2246 10^3 indiv. m^{-2} and on elodeids from 1540.0 to 3302.0 10^3 indiv. m^{-2}. Mean density of meioinvertebrates per 100 g dry weight of plants in studied ponds amounted from 135.0 to 265.7 10^3 indiv. 100 g^{-1} d.w. Density of meioinvertebrate fauna of elodeids in the studied ponds has been proved to be from 1.4 to 1.7 times higher than in bottom sediments of the ponds. The differences in density in these three habitats are statistically significant.

Epiphytic meioinvertebrate fauna in ponds of high trophic level shows low similarity to oligotrophic one. The development of meioinvertebrate community on elodeids is mainly affected by trophic status of reservoir and not by character of vegetation.

Key words: meioinvertebrates, ponds, density, bottom sediment, elodeids

INTRODUCTION

Small water bodies (ponds, clay pits, peat-hags) are the optimum habitats for many organisms. They are important for preservation and enrichment of landscape and determine biocoenotic equilibrium of natural systems.

Habitat diversity ensures species diversity in communities [Hawksworth 1996]. This in turn affects productivity of the whole community and cycles of matter in a landscape [Harper and Hawksworth 1996].

The occurrence of any zoocoenosis is determined by environmental factors which result in seasonal changes of population density. Seasonal changes are caused by cyclic drying and freezing of water bodies which results in the loss of shallow water habitats and consequently in losses of biological diversity. Churski [1993] reported the loss of 1/3 of shallow water areas in the last decade in Europe. The same losses are also noted in Poland.

Ponds are artificial water reservoirs originated for rearing purposes. They are adapted to seasonal emptying and bottom desiccation to quicken the rate of sediment mineralization [Bajkiewicz-Grabowska and Mikulski 1999]. They regulate the level of ground waters on the adjacent areas and collect water in thaw periods. They don't have seasonal stratification typical of lakes. Lighting and thermal conditions resemble these, which are present in the margin of a lake in its littoral. They represent a variable environment containing a varied world of animals and plants. In this work there has been taken a trial to quantitative assessments of benthic and epiphytic fauna of chosen groups of meioinvertebrates of three ponds of anthropogenic origin.

STUDY AREA, MATERIAL AND METHODS

The study was carried out in three ponds located in a village Golice (52^o 02' N and 22^o 35' E), which is situated 6 km from Siedlce in eastern Poland, 100 km east of Warsaw. These ponds originated on the area of farms and they differ in age. In this work ponds were marked as reservoirs P1, P2 and P3. The ponds P1 and P2 were situated a short distance of each other, about 300 m, and pond P3 less than 1 km.

Pond P1 with the surface of 50 m^2 originated in 1960s and in 1991 was deepened and newly managed. The water pH ranged within 6.8 to 8.9, and 6.3 to 7.4 mg l^{-1} of dissolved oxygen was found. The bottom is slimy with clay bedding. In the south-eastern part of the reservoir in the rushes area there is present *Typha angustifolia* and *Carex sp.*. Submerged plants consist of: *Hydrocharis morsus-ranae, Potamogeton natans and Elodea canadensis.* Northern shore is overgrown with *Salix sp.*

Pond P2 with the surface of 50 m^2 originated in 1960s and hasn't been cleaned nor deepened. The water pH ranged within 6.7 to 8.4, and 4.0 to 7.3 mg l^{-1} of dissolved oxygen was found.

The bottom is slimy with clay bedding. In the rushes area along the whole shoreline there are present: *Carex sp., Typha latifolia, Typha angustifolia, Ceratophyllum demersum, Potamogeton natans, Elodea Canadensis, Hydroharis morsus-ranae* and a lot of *Lemna sp.*

Pond P3 with the surface of 60 m^2 is the youngest of the studied ponds, it originated in 1998. The water pH ranged within 6.4 to 8.4, and 6.3 to 8.1 mg l^{-1} of dissolved oxygen was found. It has a high shore; its bottom is sandy with clay bedding with not very thick layer of the organic sediment. In the eastern part of the reservoir there are present: *Typha angustifolia, Carex sp.* and *Sparaganium efectum.* Submerged plants consist of *Elodea canadensis.*

Water in the three studied ponds was well oxygenated, and the highest values of dissolved oxygen were recorded in pond P3. Water reaction in the studied reservoirs was neutral during summer, but in spring and autumn was alkaline.

Samples from three sites in each ponds were collected four times for twice consecutive vegetative seasons (April, June, August and October) in the years 2008 and 2009. During the whole study period 24 samples from plants and 24 samples in bottom sediments were collected from each pond.

In the taken material there was estimated the density and dominance structure of benthic and epiphytic fauna of the following taxa: Turbellaria, Gastrotricha, Rotifera and Nematoda.

The plants from which the fauna was collected included: *Potamogeton natans* and *Elodea canadensis* in reservoir P1; *Potamogeton natans*, *Ceratophyllum demersum* and *Elodea canadensis* in reservoir P2; *Elodea canadensis* in reservoir P3.

A square metal frame with half a meter long sides was placed at the bottom of the reservoir. Thus all the plants were collected from the area restricted to 0.25 m^2. The water was squeezed out from the plants into a five containers of the volume 200 cm^3; the surfaces of *Potamogeton natans* were scraped with a scalpel and rinsed with distilled water. Material collected in that way was mixed and used to determine invertebrates density and percentage share of particular taxa in the total fauna of invertebrates. In order to compare density of epiphytic fauna with that of bottom sediments, the latter should be related not only to the unit of weight, but also to the area of the bottom overgrown by elodeids.

The density was investigated in each container. From each container 5--thoroughly mixed portions of 2 cm^3 were taken. The number of individuals in 10 cm^3 was calculated in the whole volume of each of the five containers. With the known surface area of a square metal frame (0.25 m^2) and the number of individuals in five containers, the number of individuals per m^2 of bottom surface could be calculated. The plants which the fauna was selected from were weighed, dried and then weighed again in the laboratory. Then density of fauna living on elodeids per 100 g dry weight of plants was calculated.

Samples from bottom sediments were taken with the use of a tubular bottom corer [Kajak *et al.* 1965] with cross-section surface area of 10.4 cm^2. The upper 10 cm sediment layer containing approximately 96.5% of all Gastrotricha [Nesteruk 1991] was examined. The density of each taxa per m^2 of the bottom was defined using the method described by Nesteruk [1996].

Percentage contribution invertebrates groups in the studied reservoirs was counted from the formula $D = 100n/N$, where n – is the number of individuals of a given taxa, and N – is the number of all individuals of the ascertained taxa.

Similarity of the fauna in three ponds was assessed from the index of homogeneity [Riedl 1963].

$$HD = \sum_{i=1}^{s} \left(\sum_{j=1}^{k} \frac{D_{ij}}{k} \right) \frac{D_{\min_i}}{D_{\max_i}}$$

where D_{ij} is the dominance index of the *i*th individual of taxa at the *j*th stand with a total of *s* individuals of all taxa.

The significance of differences between mean densities of epiphytic and benthic fauna were verified using the test of t-Student.

RESULTS AND DISCUSSION

Benthic and epiphytic meioinvertebrate fauna in the studied ponds shows distinct differentiation in respect of density and dominance structure (Tab. 1). Total density of the studied phyla in bottom sediments fluctuated from 875.0 (pond P3)

Table 1. Density and percentage contribution of particular taxa of meioinvertebrates in their total abundance in three ponds (mean values, n = 24)

Ponds	Taxa	Bottom sediments		Aquatic plants			
		A	D	A	D	E	D
Pond P1	Turbellaria	25.0	1.3	30.0	1.0	2.0	1.0
	Gastrotricha	892.0	45.3	1447.0	50.6	94.0	47.5
	Rotifera	712.0	36.2	880.0	30.8	55.0	27.8
	Nematoda	338.0	17.2	502.0	17.6	47.0	23.7
Total		1967.0	100.0	2859.0	100.0	198.0	100.0
Pond P2	Turbellaria	24.0	1.0	35.0	1.1	2.7	1.1
	Gastrotricha	857.0	37.5	1560.0	47.2	152.0	57.2
	Rotifera	824.0	36.0	906.0	27.4	40.0	15.0
	Nematoda	541.0	23.7	801.0	24.3	71.0	26.7
Total		2246.0	100.0	3302.0	100.0	265.7	100.0
Pond P3	Turbellaria	48.0	4.5	20.0	1.3	5.0	3.7
	Gastrotricha	243.0	22.6	360.0	23.4	35.0	25.9
	Rotifera	220.0	20.5	180.0	11.7	15.0	11.1
	Nematoda	64.0	33.9	980.0	63.6	82.0	59.3
Total		875.0	100.0	1540.0	100.0	145.0	100.0

The density is given in: A – thousand indiv.m^{-2} and E – thousand indiv. 100 g^{-1} d.w. of plants; D – percentage contribution (%)

Table 2. Similarity of benthic (B) and epiphytic (E) fauna between the studied ponds, calculated according to the homogeneity coefficient, %

Characteristics		Pond P2		Pond P3	
		B	E	B	E
Pond P1	B	86.0		47.0	
	E		76.0		45.0
Pond P2	B			55.0	
	E				47.0

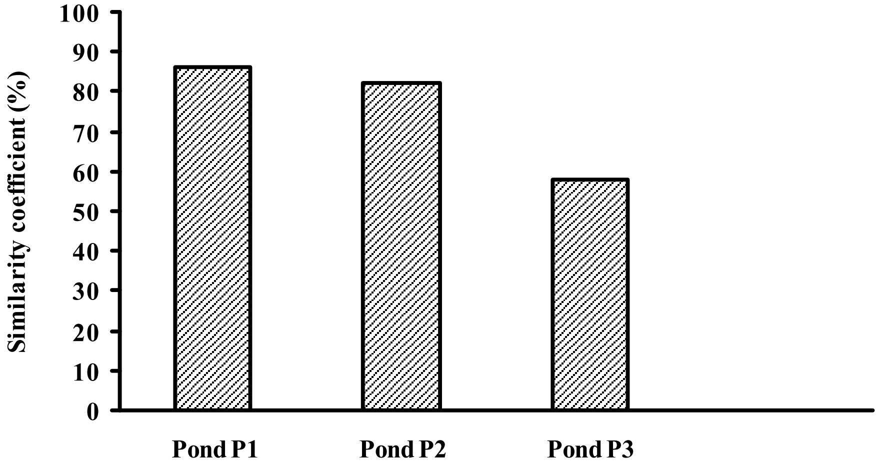

Fig. 1. Similarity between bottom sediments fauna and epiphytic fauna in the studied ponds, calculated according to the homogeneity index, %

to 2246.0 10^3 indiv. m^{-2} (pond P2) and on elodeids from 1540 (pond P3) to 3302 10^3 indiv.m^{-2} (pond P2). Thus, in bottom sediments the density in pond P3 was about 2.5 times lower ($p < 0.02$) than in pond P2, whereas the density on elodeids was more than two times lower ($p < 0.02$) in pond P3 than in pond P2.

Mean density of meioinvertebrates per 100 g dry weight of plants in studied ponds amounted to 265.7 10^3 indiv. 100 g^{-1} d.w. in pond P2 and was 1.8 times higher ($p < 0.05$) than in the pond P3 (135.0 10^3 indiv.). The highest density of the benthic and epiphytic fauna was recorded in ponds P1 and P2 located near each other; in the youngest studied pond P3 it was nearly twice lower ($p < 0.02$). In ponds P1 and P2 the most numerous were Gastrotricha and Rotifera. Percentage contribution of Gastrotricha in bottom sediments to the whole studied fauna in ponds P1 and P2 was from 37.5 to 45.3% and on plants slightly fluctuated and was about 50.0%. Among the studied taxa the least numerous were Turbellaria. Their percentage share in the whole studied benthic and epiphytic fauna in all the reservoirs was from 1.0 to 4.5%.

Similarity of fauna of the bottom sediments in ponds P1 and P2, assessed on the basis of the homogeneity index, was high and amounted to 86.0%, and of epiphytic fauna amounted to 76.0% (Tab. 2). Both ponds were characterized by similar values of physicochemical parameters of water, similar structure of sediments and similar age. Similarity of the studied fauna of the bottom sediments in pond P3 to ponds P1 and P2 was distinctly lower and amounted to 47.0 and 55.0 %, respectively. The similarity of epiphytic fauna in pond P3 to ponds P1 and P2 was from 45.0 to 47.0%. Benthic meioinvertebrate fauna in pond P3 was similar in 58% to epiphytic fauna (Fig. 1).

Epiphytic fauna consists of the same systematic groups as bottom fauna, but the species composition and dominance structure of both assemblages differ from each other [Kornijów 1988, 1989a, b]. This applies to the studied meioinvertebrate fauna in three ponds. So far, few researches carried on bottom and epiphytic fauna show that density and biomass of elodeid fauna are equal or even higher than fauna of bottom sediments [Kajak 1988, Kornijów and Kairesalo 1994]. Density of meioinvertebrate fauna of elodeids in the studied ponds has been proved to be from 1.4 to 1.7 times higher than in bottom sediments of the ponds. The differences in density in these three habitats are statistically significant.

The obtained results show that organic bottom sediments are settled by numerous of meioinvertebrate fauna. The quantity of water organisms is influenced by the chemical composition of water and its physical properties, because they create animal and plant assemblages typical for different types of trophic waters. In ponds P1 and P2 the density of fauna was higher than in pond P3. The similarity of these two reservoirs is also expressed in similar values of the physicochemical parameters and their age. In both ponds, during the whole study period, the most numerous were Gastrotricha and Rotifera. For Gastrotricha, ponds are the most fundamental habitat. In the organic bottom sediment they even reach the number of 2.6 mln individuals m^{-2} [Nesteruk 1996].

Gastrotricha reach such high numbers due to small sensibility to oxygen deficiency. Nesteruk [1991] ascertained that in the organic bottom slime they are abundant up to 17 cm in depth, so it can be thought that the conditions existing so deep in the slime are almost anoxic. Moreover, Gastrotricha tolerate waters with a wide pH spectrum. They are abundant in waters from slightly acidic up to alkaline with pH = 10.0 [Roszczak 1969].

High gastrotrich density in the studied ponds P1 and P2, higher than the rest of the taxa, shows that they constitute an essential element of water biocenosis. Moreover, shorter succession of generations of Gastrotricha than in other meioinvertebrate groups makes for greater annual output in comparison with other animal groups with longer life cycles.

In both reservoirs (P1 and P2) rotifers were as numerous as Gastrotricha. Data connected with the density of meioinvertebrates in freshwaters are scarce, and so there is only a limited range of conclusion. The only data of meiobenthos density in bottom sediments counted per m^2 are those given by Strayer [1985] for the oligotrophic lake Mirror in the USA. Densities of the same level referred to Gastrotricha, Rotifera and Nematoda, but for Turbellaria, were usually one order of magnitude lower.

In the youngest reservoir P3 with the highest water oxygenation, the dominant group of bottom sediments and of elodeids was Nematoda. Studies carried out in an inner-lake region of 17 reservoirs with different trophy showed that the highest density, biomass and number of species of nematodes were recorded in two oligotrophic reservoirs. In highly eutrophic reservoirs the values of these parameters were distinctly lower [Prejs 1977].

In the studied ponds there was recorded small density of Turbellaria, in spite of the fact that they belong to typical representatives of freshwater fauna. The amount of oxygen dissolved in water decides on their presence in a reservoir, so they are most numerous in oligotrophic waters [Strayer 1985].

High densities of epiphytic taxa should be considered a result of abundant and available food. Research carried out in oligotrophic Lake Pääjärvi (southern Finland) revealed that both the total density and biomass of all the animal communities (zoobenthos, epiphytic fauna and nekton) were positively related to the biomass of *Elodea canadensis* [Kornijów and Kairesalo 1994]. Water plants represent food base for the majority epiphytic fauna. Tissues of the plants contain bacteria which get into a diet of the majority of gastrotrichs and nematodes.

Abundance of bacteria, root secretions and decaying plant tissue make good food conditions also for nematodes [Prejs 1988]. The author concluded significant correlation between density and the level of destruction of the rhizones of pondweed. Usually density of nematodes living in rhizones of decaying pondweeds is many times higher than in rhizones of healthy plants.

The similarity of elodeid meioinvertebrate fauna in oligotrophic pond P3 to eutrophic ponds P1 and P2 was amounted to 45 and 47%, respectively. Low values of similarity of epiphytic fauna in reservoirs of different trophic status and similar vegetation structure allow one to conclude that trophic status of reservoir exerts an important effect on the development of a given community of epiphytic meioinvertebrates. The character of vegetation is, however, not the main factor determining the settlement and diversity of meioinvertebrates which was shown for gastrotrich communities for peat-bogs and lakes [Kisielewski 1981, Nesteruk 2007, 2009, 2010, 2011].

CONCLUSIONS

1. The density of meioinvertebrate fauna is from 1.4 to 2.7 times greater on elodeids than in bottom sediments of the studied ponds.

2. The highest density of the benthic and epiphytic meioinvertebrate fauna was recorded in two eutrophic ponds.

3. Epiphytic meioinvertebrate fauna in ponds of high trophic level shows low similarity to oligotrophic one. The development of meioinvertebrate community on elodeids is mainly affected by trophic status of reservoir and not by character of vegetation.

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OCENA ILOŚCIOWA FAUNY NAROŚLINNEJ I FAUNY OSADÓW DENNYCH MEIOBEZKRĘGOWCÓW W MAŁYCH ZBIORNIKACH WODNYCH POCHODZENIA ANTROPOGENICZNEGO

Streszczenie. Podjęto próbę ilościowej oceny wybranych grup meiobezkręgowców żyjących w osadach dennych i na roślinności wodnej w trzech stawach pochodzenia antropogenicznego. Stawy różniły się powierzchnią i wiekiem. Roślinność wodną, z których fauna była pozyskiwana, stanowiły: moczarka kanadyjska, rogatek sztywny i rdestnica pływająca. W pobranym materiale

badano zagęszczenie i strukturę dominacji fauny żyjącej w osadach dennych i na roślinności wodnej następujących meiobezkręgowców: Turbellaria, Gastrotricha, Rotifera i Nematoda.
Całkowite zagęszczenie badanych grup meiobezkręgowców w osadach dennych wahało się od 875.0 do 2246.0 · 10^3 osobn. m^{-2} , a na elodeidach od 1540,0 do 3302,0 · 10^3 osobn. m^{-2}. Średnie zagęszczenie meiobezkręgowców na 100 g suchej masy roślin w badanych stawach wynosiło od 135,0 do 265,7 · 10^3 indiv. 100 g^{-1} d.w. Zagęszczenie fauny meiobezkregowców żyjącej na elodeidach było od 1,4 do 1,7 razy większe niż w osadach dennych badanych stawów. Różnice zagęszczenia fauny w badanych środowiskach są istotne statystycznie.
Fauna epifityczna meiobezkręgowców w eutroficznych stawach wykazuje niskie podobieństwo do fauny w stawach oligotroficznych. Decydujący wpływ na wykształcanie się określonego zgrupowania fauny meiobezkręgowców na elodeidach ma głównie trofia zbiornika, a nie charakter roślinności.

Słowa kluczowe: meiobezkręgowce, stawy, zagęszczenie, osady denne, elodeidy