Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2017, 14, 64–76

THE ASSESSMENT OF SIMILARITY, SPECIES DIVERSITY AND ABUNDANCE OF BENTHIC AND EPIPHYTIC FAUNAE OF GASTROTRICHA IN FARM PONDS

Teresa Nesteruk

Faculty of Natural Science, Department of Zoology, Siedlce University of Natural Sciences and Humanities, B. Prusa str. 12, 08-110 Siedlce, Poland, e-mail: teresa.nesteruk@uph.edu.pl

Abstract. The species diversity, density and similarity of Gastrotrich fauna of bottom sediments to epiphytic fauna in three farm ponds were investigated. In the studied habitats 31 species of *Gastrotricha* belonging to the family of *Chaetonotidae* were found altogether. In bottom sediments of the ponds there were 29 and on plants 17 species of *Gastrotricha*. Three species (*Heterolepidoderma gracile* Rmane, 1927, *Chaetonotus disjunctus* Greuter, 1917 and *Ch. oculifer* Kisielewski, 1981) were found to be dominants in bottom sediments with the dominance over 10.0%. *H. gracile* and *Ch. oculifer* also occur on vegetation, but their dominance is significantly lower. In turn three species (*H. macrops* Kisielewski, 1981*, H. ocellatum* (Mečnikow, 1865) and *Lepidodermella squamata* (Dujardin, 1841) proved to be dominant on water vegetation, with the dominance over 10.0% in all studied ponds. The value of species diversity index H' including the number of species and uniformity of their dominance is from 2.76 to 2.93 for bottom sediments and from 2.60 to 2.72 for plants.

The total density of gastrotrich fauna in bottom sediments fluctuated from 350.0 to 920.0 10^3 indiv. m^{-2} and on elodeids from 520 to 1110 10^3 indiv. m^{-2}. The density of gastrotrich fauna of elodeids was higher than in bottom sediments in all the studied ponds. In each of the ponds examined, the differences are statistically significant.

The similarity between bottom sediment fauna and epiphytic fauna in each of the studied ponds, calculated according to the homogeneity index, was very low and ranged from 44% to 48%.

Key words: Gastrotricha, epiphytic fauna, bottom sediment fauna, farm ponds

INTRODUCTION

Gastrotricha are a type of monophyletic, microscopic, acoelomate metazoans [Hochberg and Litvaitis 2000, Todaro *et. al* 2006]. Freshwater Gastrotricha belong to the smallest metazoans; body length of an average freshwater Gastrotricha is about 150 microns [Kisielewski 1998]. The gastrotrichs are a regular component of ponds, lake, streams and rivers. Gastrotrichs constitute a significant part of benthic, psammic and epiphytic ecosystems [Nesteruk 1996, 2000, 2004, 2007, 2011, 2012, 2016, Ricci and Balsamo 2000, Balsamo and Todaro 2002, Balsamo *et al*. 2008].

Gastrotrichs represent an important element of aquatic biocenosis, as well structural as functional. The diversity of the phylum Gastrotricha is not very high, but these animals, as a part of the microphagous benthic community, play a significant ecological role in aquatic environments, linking the microbial loop to the higher trophic levels [Balsamo *et al*. 2014].

The occurrence of the gastrotrich fauna is determined by many biotic factors (vegetation, competition, and predatory) and abiotic (physical and chemical parameters of water and bottom sediments), which influence ecosystems and change their level of organisation. Fluctuation of these factors impacts the density, species composition and structure of the whole gastrotrich assembly. Physical and chemical properties of water have the vital influence on life conditions of each population. Water buffers activity of the environmental factors and stabilizes the range of their effect on organisms [Lampert and Sommer 2003].

Ponds are artificial water reservoirs dedicated 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 do not have seasonal stratification, typical for 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. The occurrence of any zoocenosis depends on the environmental factors that cause seasonal changes in its abundance. In the case of ponds, seasonal changes are caused by their cyclical drying and freezing, which results in a loss of habitats and loss of biodiversity. The aim of the study is to evaluate the similarity, species diversity and abundance of benthic and epiphytic fauna of Gastrotricha in the farm ponds.

STUDY AREA, MATERIAL AND METHODS

The study was carried out in three farm ponds located in a village Golice (52°02'N and 22°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 [Nesteruk 2012]. Currently, all the three ponds are reservoirs of high fertility.

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 7.2 to 8.9, and 6.4 to 7.6 mg cm^{-3} of dissolved oxygen was found. The bottom is slimy with clay bedding.

In the eastern part of the reservoir there are present: *T. angustifolia* L., *Carex* sp. and *Sparganium erectum* L. Emend. Rchb. s. str. Submerged plants consist of *C. demersum* L. and *E. canadensis* Michx., and *Hydrocharis morsus-ranae* L.

Pond P2 with the surface of 50 m^2 originated in 1960s and hasn't been cleaned nor deepened. The water pH ranged within 7.2 to 8.6, and 4.8 to 7.3 mg cm^{-3} 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* L., *T. angustifolia* L., *Hydrocharis morsus-ranae* L., *P. natans* L., *C. demersum* L., *E. canadensis* Michx. 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 7.2 to 8.6, and 8.2 to 8.6 mg cm^{-3} of dissolved oxygen was found. It has a high shore; its bottom is sandy with clay bedding with a rather thick layer of organic sediment. In the eastern part of the reservoir there are present: *T. angustifolia* L., *Carex* sp. and *Sparganium erectum* L. Emend. Rchb. s. str. Submerged plants consist of *C. demersum* L. and *E. canadensis* Michx., and *Hydrocharis morsus-ranae* L.

Samples from two sites in each ponds were collected four times for twice consecutive vegetative seasons (April, June, August and October) in the years 2014 and 2015. During the whole study period 16 samples from plants and 16 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 Gastrotricha. The plants from which the fauna was collected included: *C. demersum* L. and *E. canadensis* Michx. in each reservoir.

A square metal frame with half meter-long sides was placed at the bottom of the reservoir. All the plants were thus collected from an area restricted to 0.25 m^2 and put with water into a 10 l container. The water was then squeezed out from the plants. The whole material collected in that way was mixed. Five containers were then taken from that (each of 200 cm^3 volume) and used to determine of Gastrotricha density and percentage share.

The density was investigated in each container. A mixed portion of 2 cm^3 was taken from each container. The number of specimens in 2 cm^3 was calculated in the whole volume (200 cm^3) of each of the five containers, and then in the whole volume of the collected sample. With the known surface area of a square metal frame (0.25 m^2) and the number of individuals in the whole volume of the collected sample, the number of individuals per m2 of bottom area could be calculated.

Samples from bottom sediments were taken using a tubular bottom sampler with a cross-section area of 10.4 cm^2. 10 cm of the upper layer of the sediment in the sampler was divided into successive fractions and collected into 2–4 separate containers. These subsamples were considered as one sample. In the layer of that thickness there are 89.3–96.5% of the total *Gastrotricha*, average 92.7% [Nesteruk 1991].

Species dominance was calculated as $D = 100 \cdot n/N$, where n – number of specimens of a given species, and N – total number of specimens.

Shannon-Wiener index of general diversity (H') was determined according to Shannon and Weaver [1963]:

$$H' = - \sum p_i \ln p_i$$

where: $p_i = n_i/n$,

n_i – number of i-species,

n – total density of individuals in the zoocenosis.

Similarity of the gastrotrich fauna occurring in particular seasons of the year 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 ith species at the jth stand with a total of s species an k stands.

The material for characterization of physico-chemical water parameters was collected. For each sample, the pH and oxygen content were determined. Water parameters were analyzed using an oxygen meter (Oxi 340i WTW GmbH & Co.KG) and a digital pH meter (CP-215 Elmetron). Material for identification of other physicochemical parameters of water was collected every two months in each season. BZT_5 and ion concentration: orthophosphate and nitrate were determined in these samples. Parameters analyzes were performed according to standard methods [Hermanowicz *et al*. 1976].

To compare the density of bottom sediments fauna and epiphytic fauna between studied ponds one –way analysis of variance (ANOVA) was used. The post-hoc Tukey's test was applied to evaluate differences between particular ponds. T-test was used for comparison of density between epiphytic fauna and bottom sediments fauna in particular ponds.

RESUTS AND DSCUSSION

The species diversity, density and similarity of Gastrotrich fauna of bottom sediments to epiphytic fauna in three farm ponds were investigated. These ponds originated on the area of farms and they differ in age. 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 (Table 1).

Table 1. Physico-chemical factors of near-bottom water layers in three farm ponds (average values for the period April-October in 2014 and 2015)

Parameter	Pond P1				Pond P2				Pond P3			
	April	June	August	October	April	June	August	October	April	June	August	October
pH	8.9	7.2	7.6	8.2	8.4	7.2	7.4	8.6	8.2	7.4	7.2	8.6
Dissolved oxygen mg · dm^{-3}	7.2	6.4	7.4	7.6	7.3	4.8	6.8	7.2	8.4	8.6	8.2	8.6
$N\text{-}NO_3$ mg N dm^{-3}	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.5	1.0	0.6	0.5
$P\text{-}PO_4$ mg PO_4 dm^{-3}	2.0	0.8	0.1	0.2	0.2	0.1	0.3	0.2	2.0	0.1	0.1	0.1
BZT_5 mg O_2dm^{-3}	4.8	4.1	3.9	4.1	4.9	4.6	4.2	4.2	4.2	2.8	3.4	2.8

Benthic and epiphytic gastrotrich faunae in the studied ponds show distinct differentiation in respect of dominance structure. In the studied habitats 31 species of *Gastrotricha* belonging to the family of *Chaetonotidae* were found altogether. In bottom sediments of the ponds there were 29 and on plants 17 species of *Gastrotricha*. In the studied habitats *Gastrotricha* fauna differs in species composition and shows different dominance structure (Table 2).

Three species (*Heterolepidoderma gracile* Rmane, 1927, *Chaetonotus disjunctus* Greuter, 1917 and *Ch. oculifer* Kisielewski, 1981) were found to be dominants in bottom sediments with the dominance over 10.0%. *H. gracile* and *Ch. oculifer* also occur on vegetation, but their dominance is significantly lower. In turn, three species – *H. macrops* Kisielewski, 1981, *H. ocellatum* (Mečnikow, 1865) and *Lepidodermella squamata* (Dujardin, 1841) – proved to be dominant on water vegetation, with the dominance over 10.0% in all studied ponds.

The value of species diversity index H' including the number of species and uniformity of their dominance is from 2.76 (pond P3) to 2.93 (pond P2) for bottom sediments and from 2.60 (pond P3) to 2.72 (pond P1) for plants (Table 3).

The total density of gastrotrich fauna in bottom sediments fluctuated from 350.0 (pond P3) to 920.0 10^3 indiv. m^{-2} (pond P2) and on elodeids from 520 (pond P3) to 1110 10^3 indiv. m^{-2} (pond P2). Thus, in bottom sediments the density in pond P3 was about 2.6 times lower than in pond P2 (Table 3 and Fig. 1). The density of fauna in bottom sediments of the studied ponds was significantly different – one-way ANOVA $F2,45 = 137.79$ $p < 0.001$. Tukey's post hoc test indicated that each pond was different from the others (in all cases $p < 0.001$). The density on elodeids was more than two times lower in pond P3 than in pond P2. The concentration of epiphytic fauna is significant – one-way ANOVA $F2,45 = 88.43$ $p < 0.001$. Tukey's post hoc test indicated that each pond was different from the others (in all cases $p < 0.002$).

Table 2. Species composition and percentage contribution of gastrotrich species in their total number in bottom sediments and on aquatic vegetation in the studied ponds

Species	Bottom sediment fauna						Epiphytic fauna					
	Pond P1		Pond P2		Pond P3		Pond P1		Pond P2		Pond P3	
	N	D	N	D	N	D	N	D	N	D	N	D
Chaetonotus acanthodes Stokes,1887	4	1.2	6	1.5	2	1.0	18	3.9	5	1.0	4	1.4
Ch. heideri Brehm, 1917	2	0.6	4	1.0	2	1.0						
Ch. heteracanthus Remane, 1927	2	0.6	4	1.0								
Ch. m. macrolepidotus Greuter, 1917	1	0.3	2	0.5								
Ch. rectaculeatus Kisielewska, 1981			2	0.5	1	0.5						
Ch. simrothi Voigt, 1909	2	0.6	3	0.7	1	0.5	4	0.9	2	0.4		
Ch. disiunctus Greuter, 917	32	10.0	48	11.8	20	10.3						
Ch. greuteri Remane, 1927	1	0.3	1	0.2								
Ch. maximus Ehrenberg, 1830	6	1.9	14	3.4	6	3.1	28	6.1	28	5.5	12	4.2
Ch. oculifer Kisielewski, 1981	32	10.0	41	10.0	20	10.2	18	3.9	26	5.1	8	2.8
Ch. parafurcatus Nesteruk, 1991	2	0.6			1	0.5						
Ch polyspinosus Greuter, 1917	16	5.0	20	4.9	8	4.1	30	6.5	34	6.7	10	3.5
Ch. similis Zelinka, 1889	24	7.5	20	4.9	10	5.1	28	6.0	28	5.5	14	4.9
Ch. sphagnophilus Kisielewski, 1981	12	3.8	13	3.2								
Ch. succinctus Voigt, 1904	2	0.6	1	0.2								
Ch. hystrix Mećnikow, 1865	14	4.4	16	3.9	11	5.6	26	5.6	36	7.1	16	5.6
Ch. macrochaetus Zelinka, 1889	22	6.9	35	8.6	18	9.2	38	8.3	42	8.3	26	9.1
Ch. persetosus Zelinka, 1889	4	1.2	6	1.5	8	4.1	12	2.6	10	2.0	18	6.3
Ch. rafalski Kisielewski, 1979	1	0.3	2	0.5								
Lepidodermella squamata (Dujardin, 1841)	10	3.1	8	2.0	6	3.1	48	10.4	52	10.3	30	10.5
Heterolepidoderma gracile Rmane, 1927	40	12.5	50	12.2	28	14.4	8	1.7	12	2.4	8	2.8
H. macrops Kisielewski, 1981							54	11.7	60	11.8	38	13.3
H. ocellatum (Mečnikow, 1865)							56	12.2	54	10.7	46	16.1
Aspidiophorus paradoxus (Voigt, 1902)	3	0.9	6	1.5	4	2.0	18	3.9	26	5.1	15	5.3
A. oculifer Kisielewski, 1981	12	3.8	18	4.4	12	6.2						
A. squamulosus Roszczak, 1936	24	7.5	28	6.9	15	7.7	30	6.5	40	7.9	22	7.7
Ichthydium forficula Remane, 1927	12	3.8	10	2.4	6	3.1	22	4.8	24	4.7	10	3.5
I. palustre Kisielewski, 1981	14	4.4	12	2.9	6	3.1						
I. podura (Müller, 1773)	14	4.4	18	4.4	8	4.1	22	4.8	28	5.5	8	2.8
Polymerurus rhomboides (Stokes, 1887)	8	2.5	12	2.9	2	1.0						
P. nodicaudus (Voigt, 1901)	4	1.2	8	2.0								
Total	320	99.9	408	99.9	195	100.0	460	99.8	507	100.0	285	99.8

N – number of individuals of a given species, D – percentage share (%). Mean values (n = 16) for each pond

Table 3. The number of species, diversity index H', and density for bottom sediment and epiphytic faunae of Gastrotricha in the studied ponds (average values, n = 16)

Parameters	Bottom sediment fauna			Epiphytic fauna		
	Pond P1	Pond P2	Pond P3	Pond P1	Pond P2	Pond P3
Number of species	28	28	22	17	17	16
Diversity index (H')	2.92	2.93	2.76	2.72	2.70	2.60
Density (thousand indiv. m^{-1})	780.0	920.0	350.0	945.0	1110.0	520.0

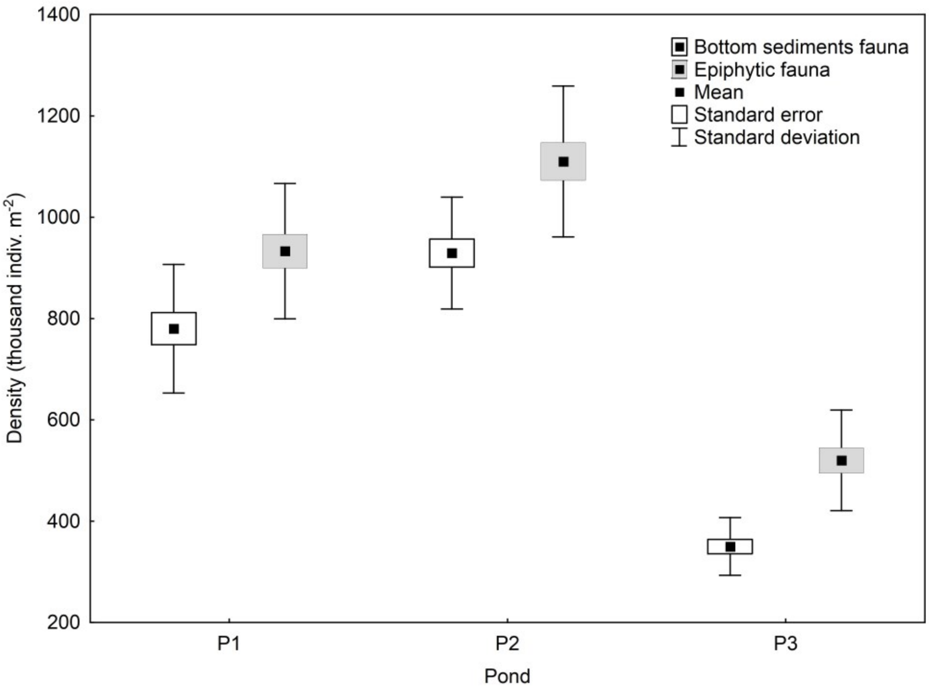

Fig. 1. Density of benthic and epiphytic fauna in the studied ponds

The density of gastrotrich fauna of elodeids was higher than that in bottom sediments in all the studied ponds. T-test was used for comparison of density between epiphytic fauna and bottom sediments fauna in particular ponds. In each of the ponds examined, the differences are statistically significant (Table 4).

The similarity of fauna of the bottom sediments in studied ponds, assessed on the basis of the homogeneity index, was very high and amounted from 78.0% (pond

P2 to pond P3) to 85.0% (pond P1 to pond P2), and of epiphytic fauna amounted from 76.0% (pond P1 to pond P3) to 84.0% (Pond P1 to pond P2) (Table 5).

The similarity between bottom sediment fauna and epiphytic fauna in each of the studied ponds, calculated according to the homogeneity index, was very low and ranged from 44% in pond P1 to 48% in pond P3 (Fig. 2).

Table 4. Comparison between density of bottom sediment and epiphytic faunae of Gastrotricha in each studied pond

Reservoir	N	t	p
Pond P1	16	-3.33	0.002
Pond P2	16	-3.39	< 0.001
Pond P3	16	-5.94	< 0.001

N – number of samples, t – value of the test function, and p – probability of the t-test

Table 5. Similarity of benthic and epiphytic faunae in the studied ponds, calculated according to the homogeneity coefficient (%)

Ponds	Ponds P2	Ponds P3
Pond P1	$85.0^{b}; 84.0^{p}$	$80.0^{b}; 76.0^{p}$
Pond P2		$78.0^{b}; 80.0^{p}$

b – similarity of benthic fauna, p – similarity of epiphytic fauna

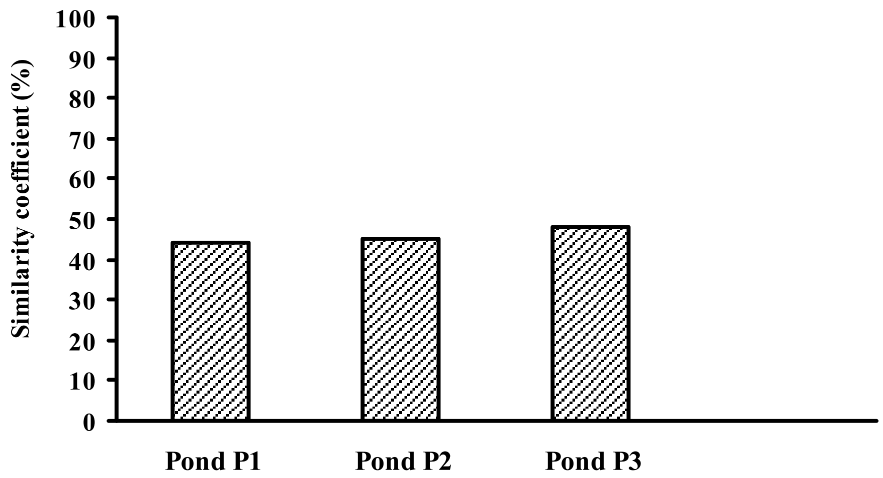

Fig. 2. Similarity between bottom sediment and epiphytic faunae of Gastrotricha in the particular ponds calculated according to the homogeneity index (%)

For gastrotrichs, ponds are one of the most preferable habitats. In the organic bottom sediment they even reach a number of 2.6 mln individuals m^{-2} [Nesteruk 1996]. Gastrotrichs reach such high numbers due to a 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. Oxygen requirements probably differ for individual species. Studies carried in eutrophic Lake Yaonude Municipal in Kamerun (central Africa) showed that Gastrotricha belonging to gender *Polymerurus* Remane were especially numerous in almost oxygen deprived bottom sediment [Zèbazè Togouet *at al*. 2007]. The analysis of the values of dominance and number of species showed, that the majority of them prefer moderately acid waters [Nesteruk 2005].

Epiphytic fauna of Gastrotricha in water bodies is composed of the same systematic groups as zoobenthos. Species composition, percentage, and seasonal dynamics, however, differ significantly between the two communities [Kornijów *et al*. 1990, Nesteruk 2011]. Obviously, also the role of both communities in the functioning of aquatic ecosystems is different, particularly in the context of verified significance of herbivore invertebrates as important macrophyte consumers [Lodge 1991, Kornijów 1996, Tarkowska-Kukuryk and Kornijów 2008]. One of important elements of water biocenoses are gastrotrichs.

Studies on the elodeid fauna of Gastrotricha indicate that the species composition and their percentage in this community differ significantly from the fauna of the bottom sediments. Three species that dominate in the community of elodeids (*H. macrops*, *H. ocellatum* and *L. squamata*) are eurytopic species. In the bottom sediments of the ponds, they were not found. *H. macrops* occurs mainly in shallow, fertile ponds, in peat-hags, and alder woods. It is mainly found among vegetation, often being abundant there. *H. macrops* is known as a species associated with vegetation. *H. ocellatum* lives in peat-bogs, lakes of various trophy, ponds, and peat-hags. The contribution of *H. ocellatum* to the whole elodeid fauna in the studied ponds was found to be 10.1–16.7%. *L. squamata* is a typical lacustrine species, which is present not only in the lakes of different trophy, but also in the mountains and sea-shore lakes. This species can also be found in all types of substrates: in the mud, among vegetation and in the sand. The percentage of this species in the elodeid fauna of the three studied ponds was about two to five times higher than in the bottom sediments of these ponds.

In the bottom sediments of the studied ponds, the dominant group consisted of three species (*Ch. disiunctus, Ch. oculifer* and *H. gracile*). The first is a species common in peat-bogs, in bottom sediments of highly eutrophic water bodies and in bottom sediments of lakes of various trophic status. It lives mainly in the mud, less frequently among decaying leaves and in sand, and it does not occur among vegetation. *Ch. oculifer* is one of the most common species in the country. It can also be found in sphagnum peat- hags, alder woods, rush communities and in ponds. It lives in the mud and among aquatic vegetation [Nesteruk 2000, 2004]. In the studied ponds, percentage of this species on elodeids is even 3.7 times lower than in the bottom sediments. Worth noting is the species *H. gracile*, whose percentage in the fauna of bottom sediments of the three eutrophic ponds ranged from 12.5 to 14.4%, while the elodeid was 5 to 7 times lower.

The high percentage of *H. ocellatum* and *H. macrops* in the ponds tested and the results of previous studies confirm that their classification for species strongly associated with vegetation is correct. Species, *L. squamata* has a strong relationship to vegetation, but it should be emphasized that it is also abundant in bottom sediments.

Particular species prefer a specific type of substrate (sandy, muddy, stony), where they can find the optimal life conditions [Kajak 1988, Kornijów 1989]. It seems that the exchange of representatives of sediment and vegetation may concern only a few eurytopic species, but the typical representatives of bottom fauna (*Ch. disiunctus*, *Ch. heteracanthus*, *Ch. macrolepidotus*, *Ch. macrolepidotus ophiogaster*, *Ch. rafalski*, *Ch. parafurcatus*, *Ichthydium palustre,* and *Polymerurus serraticaudus*) never been found on aquatic vegetation.

The results of studies conducted in the farm ponds demonstrate that some species of Gastrotricha finds the optimal life conditions in bottom sediments, as well as on elodeids. It is plausible that they can migrate between both habitats. These are: *Aspidiophorus squamulosus*, *Ch. acanthodes*, *Ch. heideri*, *Ch. oculifer*, *Ch. polyspin*osus, *Ch. similis*, *Ch. sphagnophilus*, *Ch. hystrix*, *Ch. macrochaetus*, *H. majus*, *H. gracile*, and *L. squamata.*

In each of the studied ponds, a low similarity was found between bottom sediment and elodeid faunae. The similarity between the fauna of bottom sediments and that of elodeids in the particular ponds, measured with the Riedl's [1963] homogeneity index, ranged from 44 to 48%. It can be assumed that the low similarity between the faunae is due to the species' preference of the appropriate type of substrate.

So far, research carried out on bottom and epiphytic fauna shows that the density and biomass of elodeid fauna are equal or even higher than those of bottom sediments [Kornijów and Kairesalo 1994, Nesteruk 2012]. The density of gastrotrich fauna of elodeids in the studied ponds has been found to be from 1.2 to 1.4 times higher than in bottom sediments of the ponds. The differences in density in these three ponds are statistically significant.

High density 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 *E. canadensis* [Kornijów and Kairesalo 1994]. Water plants represent food base for the majority of epiphytic fauna. Gastrotrichs feed on unicellular algae and bacteria. Some species prefer algae to bacteria. Macrophytes are densely colonized by peryphyton. Epiphytic algae, mostly diatoms, consist important component of gastrotrich food. Amount and availability of food in water ecosystems is changeable in particular seasons of a year. A positive correlation between the density of peryphytic nematodes and content of algae was found. It shows that potential availability of food advantages fauna abundance [Kazemi--Dinan *et al*. 2014].

The studies, conducted in small mid-forest water bodies located in the region of Greater Poland (in west central Poland), showed that in the reservoir zones dominated by elodeids, rotifers are of the highest diversity and abundance [Basińska and Kuczyńska-Kippen 2009]. In such zones, the high density of epiphytic fauna may be due to the fact that complex structured aquatic plants provide them effective shelter [Iglesias *et al*. 2007]. Furthermore, in the reservoir zones dominated by elodeids , the high density of epiphytic fauna may be a result of favorable physico-chemical properties of the substrate, among which are the oxygen concentration and availability of food [Kuczyńska-Kippen 2007].

CONCLUSIONS

1. The density of gastrotrich fauna of elodeids was higher than in bottom sediments in all the studied ponds. In each of the ponds examined, the differences are statistically significant.

2. The similarity between bottom sediment fauna and epiphytic fauna in each of the studied ponds, calculated according to the homogeneity index, was very low and ranged from 44 to 48%. It can be assumed that the low similarity between the faunae is due to the species' preference of the appropriate type of substrate.

3. The high percentage of *Heterolepidoderma ocellatum* (Mečnikow, 1865) and *H. macrops* Kisielewski, 1981 in the ponds studied and the results of previous research confirm that their classification for species strongly associated with vegetation is correct.

4. The species *Lepidodermella squamata* (Dujardin, 1841) is strongly related to vegetation, but it should be emphasized that it is also abundant in bottom sediments.

REFERENCES

Bajkiewicz-Grabowska E., Mikulski Z., 1999. General hydrology (in Polish). PWN, Warszawa.

Balsamo M., Todaro M. A., 2002. Gastrotricha. Freshwater Meiofauna Biology and Ecology (ed. by S.D. Rundle A.I. Robertson A.I., Schmid-Araya J.M.). Backhuys Publisher, Leiden, 45–61.

Balsamo M., d'Hondt J.L., Kisielewski J., Pierboni L., 2008. Global diversity of gastrotrichs (Gastrotricha) in fresh waters. Hydrobiologia 595, 85–91.

Balsamo M., Grilli P., Guidi L., d'Hondt J. L., 2014. Gastrotricha. Biology, ecology and systematics. Families Dasydytidae, Dichaeturidae, Neogosseidae, Proichthydiidae. Identification guides to the plankton and benthos of inland waters 24, H. Dumont (ed.). Backuys Publ., Margraf Publ. GmbH, Weikersheim.

Basińska A., Kuczyńska-Kippen N., 2009. Differentiated macrophyte types as a habitat for rotifers in small mid-forest water bodies. Biologia 64(6), 1100–1107.

Hermanowicz W., Dożańska W., Dojlido J., Koziorowski B., 1976. Physical and chemical investigation methods of water and sewage (in Polish). Arkady, Warszawa.

Hochberg R., Litvaitis M. K., 2000. Phylogeny of Gastrotricha: a Morphology-Based Framework of Gastrotricha Reletionschips. Biol. Bull. 198, 299–305.

Iglesias C. N., Goyenela G., Mazzeo N., 2007. Horizontal dynamics of zooplankton in subtropical lake blanca (Uruguay) hosting multiple zooplankton predators and aquatic plant refuges. Hydrobiologia 584, (1) 179–189.

Kajak Z., 1988. Considerations on benthos abundance in freshwaters, its factors and mechanisms. Int. Rev. Ges. Hydrobiol. 73, 5–19.

Kazemi-Dinan A., Schroeder F., Peters L., Majdi N., Traunspurger W., 2014. The effect of trophic state and depth on periphytic nematode communities in lakes. Limnologica 44, 49–57.

Kisielewski J.,1998. Gastrotricha (in Polish). Freshwater fauna of Poland 31. Łódź.

Kornijów R., 1989. Seasonal changes in the macrofauna living on submerges plants in the two lakes of different trophy. Arch. Hydrobiol. 117, 49–60.

Kornijów R., 1996. Cumulative consumption of the lake macrophyte Elodea by abundant generalist invertebrate herbivores. Hydrobiologia 319, 185–190.

Kornijów R., Kairesalo T., 1994. Elodea Canadensis sustains rich environment for macroinvertebrates. Verh. Int. Verein. Limnol. 25, 2270–2275.

Kornijów R., Gulati R.D., van Donk E., 1990. Hydrophyte-macroinvertebrate interactions in Zwemlust, a lake undergoing biomanipulation. Hydrobiologia 200/201, 467–474.

Kuczyńska-Kippen N., 2007. Habitat choice in rotifera communities of three shallow lakes: impact of macrophyte substratum and season. Hydrobiologia 593, 27–37.

Lampert W., Sommer U., 2001. Ecology of inland waters (in Polish). Wyd. Nauk. PWN, Warszawa.

Lodge D.M., 1991. Herbivory on freshwater macrophytes. Aquat. Bot. 41, 195–224.

Nesteruk T., 1991. Vertical distribution of Gastrotricha in organic bottom sediment of inland water bodies. Acta Hydrobiol. 33, 253–264.

Nesteruk T., 1996. Density and biomass of Gastrotricha in sediments of different types of standing waters. Hydrobiologia 324, 205–208.

Nesteruk T., 2000. Epiphytic Gastrotricha – species composition and dominance. Acta Hydrobiol. 42, 53–57.

Nesteruk T., 2004. Benthic and epiphytic fauna of Gastrotricha in littoral of mesotrophic lake in Łęczna Włodawa Lakeland, Poland. Fragm. Faun. 47(1), 1–6.

Nesteruk T., 2005. Ecotone zone as a form of protection and enrichment of biological diversity. Teka Kom. Ochr. Kszt. Środ. Przyr. 2, 108–114.

Nesteruk T., 2007. Diversity and abundance of Gastrotricha in the psammon mesotrophic lake. Pol. J. Ecol. 4, 833–839.

Nesteruk T., 2011. Comparison of gastrotrich fauna of elodeids and in bottom sediments of lakes of different trophic statuss (the region Polesie Lubelskie. Eastern Poland). Oceanol. Hydrobiol. Stud. 40(2), 13–21.

Nesteruk T., 2012. Quantitative assessments of benthic and epiphytic fauna of meioinvertebrates of small water bodies of anthropogenic origin. Teka Kom. Ochr. Kszt. Środ. Przyr. 9, 134–142.

Nesteruk T., 2016. Quantitative assessment of epiphytic and benthic meioinvertebrate fauna in various types of standing water. Polish Journal of Environmental Studies 25(4), 1661–1668. DOI: 10.15244/pjoes/62490.

Ricci C., Balsamo M., 2000. The biology and ecology of lotic rotifers and gastrotrichs. Freshw. Biol. 44, 15–28. DOI:10.1046/j.1365-2427.2000.00584.

Riedl R., 1963. Probleme und Methoden der Erforschung des litoralen Benthos. Verh. Dtsch. Zool., Suppl. 26, 505–567.

Shannon C. E., Weaver W., 1963. The mathematical theory of communication. University of Illinois Press, Urbana.

Tarkowska-Kukuryk M., Kornijów R., 2008. Influence of spatial distribution of submerged macrophytes on chironomids assemblages in shallow lakes. Pol. J. Ecol. 56, 569–579.

Todaro M.A.J., Telford J., Lockyer A.E., Littlewood D.T.J., 2006. Interrelationship of the Gastrotricha and their place among the metazoan inferred from 18Sr RNA genes. Zool. Scripta 35, 251–259.

Zèbazè Togouet S.H., Njine T., Kemka N., Nola M., Menbohan S.F., Koste W., Boutin C., Hochberg R., 2007. Spatio – temporal changes In the abundance of the Populations gastrotrich community in a shallow lake of tropical Africa. Limnologica 37, 311–322.

OCENA PODOBIEŃSTWA, RÓŻNORODNOŚCI GATUNKOWEJ I OBFITOŚCI FAUNY OSADÓW DENNYCH I FAUNY EPIFITYCZNEJ GASTROTRICHA W STAWACH GOSPODARCZYCH

Streszczenie. Badano różnorodność gatunkową, gęstość i podobieństwo fauny Gastrotricha osadów dennych do fauny epifitycznej w trzech stawach gospodarczych. W badanych siedliskach stwierdzono łącznie 31 gatunków brzuchorzęsków należących do rodziny Chaetonotidae. W osadach dennych stawów stwierdzono 29 gatunków, a na roślinności wodnej 17 gatunków brzuchorzęsków. W osadach dennych dominowały trzy gatunki: *Heterolepidoderma gracile* Rmane, 1927, *Chaetonotus disjunctus* Greuter, 1917 i *Ch. oculifer* Kisielewski, 1981, *H. gracile* i *Ch. oculifer* występowały również na roślinności, ale ich dominacja była znacznie mniejsza. Na roślinności wodnej dominantami były: *H. macrops* Kisielewski, 1981, *H. ocellatum* (Mečnikow, 1865) i *Lepidodermella squamata* (Dujardin, 1841). Wartość wskaźnika różnorodności gatunków H', uwzględniająca liczbę gatunków i ich strukturę dominacji wynosiła od 2,76 do 2,93 dla osadów dennych i od 2,60 do 2,72 dla roślinności wodnej.

Zagęszczenie Gastrotricha w osadach dennych wahało się od 350,0 do 920,0 10^3 osobn. m^{-2} i na roślinności od 520 do 1110 10^3 osobn. m^{-2}. Gęstość fauny brzuchorzęsków na elodeidach była znacząco większa niż w osadach dennych we wszystkich badanych stawach.

Podobieństwo fauny osadów dennych do fauny epifitycznej w badanych stawach, obliczone według wskaźnika jednorodności, było bardzo małe i wynosiło od 44 do 48%.

Słowa kluczowe: brzuchorzęski, fauna epifityczna, fauna osadów dennych, stawy gospodarskie