

SEASONAL CHANGES IN THE DIVERSITY AND ABUNDANCE OF GASTROTRICHA IN BOTTOM SEDIMENTS OF THE LITTORAL OF A MESOTROPHIC LAKE

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Summary. Species composition and density of Gastrotricha in bottom sediments were studied, on an annual basis, in the littoral of the mesotrophic Lake Piaseczno (Łęczyńsko-Włodawskie Lakeland). The number of species from spring to autumn remained on the same level (from 24 in spring to 22 in autumn), but in winter in littoral of the lake there were recorded only 8 species. Species diversity expressed by the Shannon index, in spring, summer and autumn was high and amounted 2.86; 2.69 and 2.77 respectively. In winter the value of the index was significantly lower and amounted 1.80.

In individual seasons the mean density of Gastrotricha valued from $50 \cdot 10^3$ indiv. m^{-2} during winter to $1238 \cdot 10^3$ indiv. m^{-2} in spring. The density of Gastrotricha in spring was more than 24 times higher than that winter. There were no significant differences in species diversity Gastrotricha from spring to autumn, although the peak abundance was recorded in the spring. It is necessary to add, that the density of Gastrotricha during the spring peak was one order of magnitude higher from that in summer and autumn. The similarity of the fauna found in winter to the fauna occurring in other seasons, is significantly low, ranging from 24 to 27%. Seasonal changes in amount and diversity of the gastrotrich fauna are probably the result of temperature changes and food availability.

Key words: Gastrotricha, seasonal changes, diversity, density.

INTRODUCTION

In aquatic ecosystems are observed changes in the amount and diversity of fauna on an annual basis. The reasons for these changes have not been established in relation to specific taxonomic groups. Freshwater Gastrotricha occur in all types of standing water. They live in bottom sediments and aquatic vegetation. In both habitats, they achieve high density and high species diversity. In the bottom sediments of aquatic ecosystems Gastrotricha are more numerous than other groups of invertebrates [Nesteruk 1996a, 1996b, 2009, 2010, 2012]. The

aim of this study is to analyze the changes in abundance and diversity of Gastrotricha in mesotrophic lake, on an annual basis.

STUDY AREA, MATERIAL AND METHODS

The studies were carried out in mesotrophic Lake Piaseczno [Radwan *et al.* 2003], situated about 170 km south-east of Warsaw, Poland in the region of Polesie Lubelskie. The area of Lake Piaseczno covers 83.8 ha and its maximum depth reaches up to 38.8 m. The water pH ranged from 5.4 to 8.2, and 5.2 mg⁻¹ of dissolved oxygen was found. The northern part of the lake is narrow and deep, the southern part is wide and shallow. The lake is surrounded by a sandy beach of 20–30 m in width, and only its southern shallow part borders the transitional moor. Samples were collected from January to December 2011 and 2012. At any time of the year, attempts were taken three times (once a month), at two positions. The study area comprised the littoral zone of the lake with its depth from 0.5 to 5.0 m.

Samples from bottom sediments were taken using a tubular bottom sampler with a cross-section area of 10.4 cm². 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]. At any time of the year it was taken altogether 12 samples, in which 1986 individuals of Gastrotricha were identified. All the individuals were identified to species.

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 in different seasons 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 species at the j th stand with a total of s species and k stands.

The significance of differences in mean species diversity indices, densities and biomass of fauna of elodeids and bottom sediments between a mesotrophic and a eutrophic lake were checked using the test of t-Student.

RESULTS AND DISCUSSION

In bottom sediments of littoral of the mesotrophic lake there were recorded 24 gastrotrich species. The species richness was not stable during the individual seasons. The number of species maintained on the same level from spring to autumn (from 24 in spring to 22 in autumn), but in winter there were recorded only 8 species in littoral of the lake.

The definite dominants from spring to autumn were: *Chaetonotus disiunctus*, *Ch. macrochaetus*, *Heterolepidoderma gracile*, *Lepidodermella squamata* and *Aspidiophorus oculifer*. They are typical representatives of the bottom sediments in freshwater ecosystems, they are also present in sand and on aquatic vegetation. Only two species from the mentioned species were recorded in winter. These are: *Ch. disiunctus* and *H. gracile*. Both species belong to common species in all aquatic ecosystems. First of all they live in slime, rarely in sand and on aquatic vegetation, they tolerate big range of pH, from 4.5 to 8.5. The species *Ch. macrochaetus* is worthy of attention, very numerous from spring to autumn, but does not occur during winter. This species is present in lakes with different trophy in all zones including deep profundal. It lives in slime, and also among lake vegetation (Table 1).

Species diversity expressed by the Shannon index was high in spring, summer and autumn and amounted: 2.86; 2.69 and 2.77 respectively. In winter the value of the index was significantly lower ($p < 0.02$) than in other seasons and amounted 1.80 (Table 2).

In individual seasons of a year, the mean density of Gastrotricha varied from $50 \cdot 10^3$ indiv. m^{-2} during winter to $1238 \cdot 10^3$ indiv. m^{-2} in spring. So, the density of Gastrotricha in spring was 24 times higher than that in winter. This difference is statistically significant ($p < 0.02$). In two other seasons of a year (summer and autumn), the density of Gastrotricha was on the same level and amounted $720 \cdot 10^3$ and $980 \cdot 10^3$ indiv. m^{-2} respectively, this difference is not statistically important ($p = 0.05$). There were no significant differences in species diversity Gastrotricha from spring to autumn, although the peak abundance was recorded in the spring. It is necessary to add, that the density of Gastrotricha during the spring peak was one order of magnitude higher from that in summer and autumn, and that difference was statistically significant ($p < 0.02$). The analysis of the similarity of the gastrotrich fauna in individual seasons of a year showed its high resemblance from spring to autumn. The similarity of the fauna found in winter to the fauna occurring in other seasons, is significantly low, ranging from 24 to 27% (Table 3).

Table 1. Species composition and percentage contribution of Gastrotricha in bottom sediments of mesotrophic lake at particular times of the year (average values, n = 12)

Species	Spring		Summer		Autumn		Winter	
	N	D	N	D	N	D	N	D
<i>Chaetonotus</i> sp.	2	0.3	1	0.2				
<i>Ch. acanthodes</i> Stokes, 1887	18	2.5	11	1.8	12	2.1		
<i>Ch. disiunctus</i> Greuter, 1917	56	7.7	30	4.9	60	10.3	18	28.6
<i>Ch. heideri</i> Brehm, 1917	18	2.5	32	5.2	42	7.2		
<i>Ch. heteracanthus</i> Remane, 1927	39	5.3	28	4.6	18	3.1	8	12.7
<i>Ch. hystrix</i> Mechnikow, 1865	5	0.7	28	4.6	20	3.4	4	6.3
<i>Ch. macrochaetus</i> Zelinka, 1889	82	11.2	98	16.1	69	11.8		
<i>Ch. maximus</i> Ehrenberg, 1830	18	2.5	23	3.8	44	7.5	15	23.8
<i>Ch. oculifer</i> Kisielowski, 1981	29	4.0	33	5.4	45	7.7		
<i>Ch. ophiogaster</i> Remane, 1927	11	1.5	3	0.5	8	1.4		
<i>Ch. parafurcatus</i> Nesteruk, 1991	6	0.8	2	0.3	4	0.7		
<i>Ch. polyspinosus</i> Greuter, 1917	31	4.3	11	1.8	25	4.3		
<i>Ch. poznaniensis</i> Kisielowski 1981	5	0.7	2	0.3	1	0.2	2	3.2
<i>Ch. similis</i> Zelnika, 1889	54	7.4	32	5.2	15	2.6		
<i>Ch. sphagnophilus</i> Kisielowski, 1981	28	3.8	19	3.1				
<i>Heterolepidoderma gracile</i> Remane, 1927	98	13.4	80	13.1	68	11.6	10	15.9
<i>H. macrops</i> Kisielowski, 1981	16	2.2	25	4.1	18	3.1		
<i>H. majus</i> Remane, 1927	22	3.0	30	4.9	28	4.8		
<i>L. squamata</i> (Dujardin, 1841).	54	7.4	38	6.2	42	7.2		
<i>Aspidiophorus oculifer</i> Kisielowski, 1981	68	9.3	40	6.6	38	6.5		
<i>A. squamulosus</i> Roszczak, 1936	18	2.5	10	1.6	5	0.8		
<i>Ichthyidium forficula</i> Remane, 1927	28	3.8	10	1.6	14	2.4		
<i>I. palustre</i> Kisielowski, 1981	14	1.9	8	1.3	2	0.3	4	6.3
<i>I. podura</i> (Müller, 1773)	9	1.2	16	2.6	6	1.0	2	3.2
Total	729.0	99.9	610.0	99.8	584.0	100.0	63.0	100.0

Table 2. The number of species, diversity index H' and density for bottom sediments fauna of Gastrotricha in mesotrophic lake at particular times of the year (average values, n = 12)

Parameters	Spring	Summer	Autumn	Winter
Number of species	24	24	22	8
Diversity index (H')	2.86	2.69	2.77	1.82
Density (thousand indiv. m ⁻²)	1238.0	720.0	980.0	50.0

Table 3. The similarity of fauna Gastrotricha in different seasons in bottom sediments in the littoral of mesotrophic lake calculated according to the homogeneity index (%)

Seasons	Spring	Summer	Autumn	Winter
Spring		68	67	24
Summer	68		70	27
Autumn	67	69		27
Winter	24	27	27	

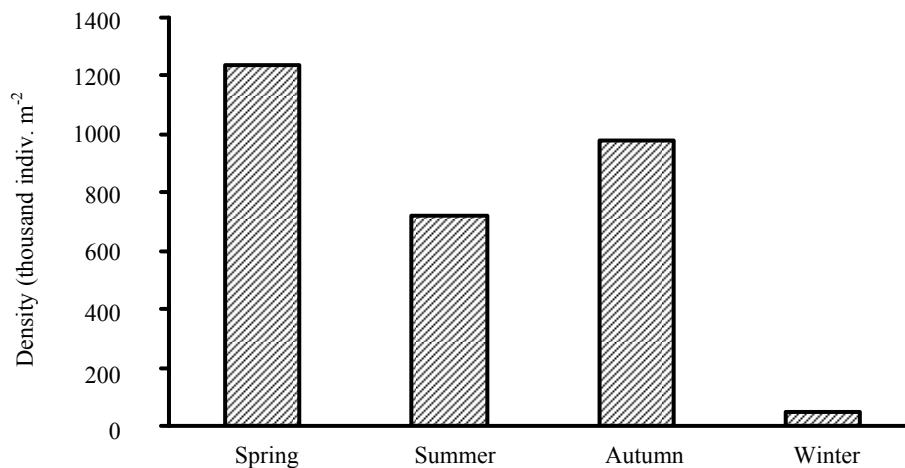


Fig. 1. The density of *Gastrotricha* in bottom sediments in the littoral of mesotrophic lake in different seasons of the year

Gastrotricha represent the important element of aquatic biocenosis, as well structural as functional. 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].

Results of the carried studies make to analyse, which of the factors may have the decisive impact on seasonal occurrence of *Gastrotricha*. Temperature is the important ecological factor, because it conditions life processes and spatial distributions of organisms. In studies on reproduction of freshwater *Gastrotricha*, taken samples were kept during few days in temperature of about 23°C [Weiss 2001]. In studies on storage of samples there was shown the possibility of occurrence of *Gastrotricha* in a wide range of temperatures from 5 to 20°C, but the amount of *Gastrotricha* in temperature of 20°C was definitely higher than in temperature of 5°C [Nesteruk 1998]. Temperature may be one of the factors influencing seasonal changes in density and species diversity of *Gastrotricha*.

Intense processes of the mineralization of organic matter in aquatic ecosystems lead to oxygen consumption in bottom waters, and thereby to oxygen deficit. In small eutrophic reservoirs, where the quantity of oxygen is measured above the sediment, it amounted from 2.0 to 3.2 mg dm⁻³, *Gastrotricha* occurred more numerously than in a mesotrophic lake, where the quantity of oxygen was significantly higher, on average 11 mg dm⁻³ [Nesteruk 1996a]. 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 *et al.* 2007]. Here of the majority of freshwater Gastrotricha is not much sensitive to oxygen deficit indicates the fact of occurrence of these animals in deeper layers of the organic slime, up to 17 cm in depth counting from its surface [Nesteruk 1991]. It may be claimed, that in such deep layers of the sediment exist almost oxygen deprived conditions.

Gastrotricha occur in a wide range of pH, from 4 to 10. The analysis of the values of dominance and number of species showed, that the majority of them prefer moderately acid waters [Nesteruk 1996b, Nesteruk 2005].

Gastrotricha feed on single-celled algae and bacteria, which they catch together with the organic matter. Some species prefer algae over bacterial feed. The important component of aquatic biocenosis are epiphytic algae. Biomass of epiphytic algae occurred on macrophytes is considerably higher in spring and autumn than in summer [Toporowska *et al.* 2008]. So, the amount and accessibility of food in aquatic ecosystems varies in the individual seasons of a year. The results of carried out studies showed, that the peak of the density of Gastrotricha happened in spring, and the density in autumn was higher than that in summer, though this difference is not statistically important. Kazemi-Dinan *et al.* [2014] ascertained positive correlation between the density of periphytic nematode and content of algae, which shows, that the prospective availability of food may foster the nematode abundance.

CONCLUSIONS

1. In aquatic ecosystems Gastrotricha occur all year round.
2. Density and diversity of gastrotrich fauna changes in the annual cycle. The peak abundance of fauna occurs in the spring, and is significantly higher than that in winter.
3. Similarity of the fauna occurring in winter to the fauna occurring in other seasons is significantly low.
4. Seasonal changes in abundance and diversity of the gastrotrich fauna are probably the result of temperature changes and food availability.

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SEZONOWE ZMIANY RÓŻNORODNOŚCI I LICZEBNOŚCI BRZUCHORZĘSKÓW W OSADACH DENNYCH LITORALU MEZOTROFICZNEGO JEZIORA

Streszczenie. Badano skład gatunkowy i zagęszczenie brzuchorzęsków w osadach dennych litoralu mezotroficznego jeziora Piaseczno (Pojezierze Łęczyńsko-Włodawskie) w cyklu rocznym. Liczba gatunków od wiosny do jesieni utrzymywała się na podobnym poziomie (od 24 wiosną do 22 jesienią), natomiast zimą w litoralu jeziora stwierdzono zaledwie 8 gatunków. Różnorodność gatunkowa, wyrażona wskaźnikiem Shannona, wiosną, latem i jesienią była duża i wyniosła odpowiednio: 2,86; 2,69 i 2,77. Zimą wartość wskaźnika była znacząco mniejsza i wyniosła 1,80.

W poszczególnych porach roku średnie zagęszczenie brzuchorzęsków wahało się od $50 \cdot 10^3$ indiv. m^{-2} w okresie zimy do $1238 \cdot 10^3$ indiv. m^{-2} wiosną. Zagęszczenie brzuchorzęsków wiosną było więc ponad 24-krotnie większe niż zimą.

Nie zaobserwowano wyraźnych różnic w zróżnicowaniu gatunkowym brzuchorzęsków od wiosny do jesieni mimo wyraźnego wiosennego szczytu liczebności. Należy jednak dodać, że zagęszczenie brzuchorzęsków podczas wiosennego szczytu było o jeden rząd wielkości większe niż latem i jesienią. Podobieństwo fauny występującej w okresie zimy do fauny występującej w pozostałych sezonach jest znacząco niskie i wynosi od 24 do 27%. Zmiany sezonowe w liczebności i różnorodności fauny Gastrotricha są prawdopodobnie wynikiem zmian temperatury i dostępności pokarmu.

Słowa kluczowe: brzuchorzęski, zmiany sezonowe, różnorodność, gęstość