

STRUCTURE OF THE BIOCEANOSIS IN THREE POLESIE LUBELSKIE  
REGION (EASTERN POLAND) SHALLOW LAKES  
OF DIFFERENT TROPHY

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**Summary.** The structure of phytoplankton, emergent macrophytes, zooplankton (*Rotifera*, *Cladocera*, *Copepoda*) and zoobenthos was studied in three trophically different shallow lakes: slightly eutrophic Lake Uściwierz, eutrophic Lake Rotcze, dystrophic Lake Moszne, located in the Polesie Lubelskie Region (eastern Poland). The samples were collected in 2000 and 2001. 69 species of algae were found in the investigated lakes. The highest number of species – 38 occurred in the eutrophic lake, while the lowest – 22 species in the dystrophic lake. However, in the dystrophic lake the density of phytoplankton was the highest (1485 ind. ml<sup>-1</sup>) and the lowest in the eutrophic lake (208 ind. ml<sup>-1</sup>). The largest number of species of emergent macrophytes was found in the slightly eutrophic lake – 6, and the lowest in the eutrophic lake – 2. *Phragmitetum* was a dominant plant community in every lake. Zooplankton and zoobenthos reached the highest diversity in the eutrophic lake – 46 species of zooplankton and 30 taxa of zoobenthos, and the lowest in the dystrophic lake – 24 species of zooplankton and 6 taxa of zoobenthos. The highest density of zoobenthos was found in the slightly eutrophic lake and achieved 1786 ind. m<sup>-2</sup>, and the lowest in the dystrophic lake (467 ind. m<sup>-2</sup>). Zooplankton density was clearly differentiated in investigated lakes. The highest density of *Rotatoria* (1279 ind. l<sup>-1</sup>) was found in the dystrophic lake, and *Cladocera* and *Copepoda* in the eutrophic lake (398 ind. l<sup>-1</sup>). The lowest density of *Rotatoria* occurred in the slightly eutrophic lake (53 ind. l<sup>-1</sup>) and crustacean plankton in the dystrophic lake (41 ind. l<sup>-1</sup>).

**Key words:** shallow lakes, emergent macrophytes, phytoplankton, zooplankton, zoobenthos

## INTRODUCTION

Shallow lakes of Polesie Lubelskie Region (Eastern Poland) show a great morphological and trophic differentiation [16, 17, 27]. Lake trophic status is one of the main factors affecting qualitative and quantitative structure of biocenosis [19]. The investigated lakes represent three types of trophy: slightly eutrophic Lake Uściwierz, eutrophic Lake Rotcze and dystrophic Lake Moszne [17]. According to Górniak [1] Lake Moszne belongs to polyhumic lakes. Their surface area varied between 17.6 ha and 256.3 ha, and their depths - ranged from 1.0 m to 6.6 m (Tab. 1).

**Table 1.** Limnological characteristics of investigated lakes in Polesie Lubelskie Region (years 2000, 2001)

Feature	Area	SD	Max. depth	pH	N-NH <sub>4</sub>	P <sub>tot.</sub>	P-PO <sub>4</sub>	Mixing	Littoral type	Trophy state
Lake	(ha)	(m)	(m)							
Uściwierz	256.3	1.2	6.6	7.9	0.48	0.16	0.19	polymictic	small lake phyto-littoral with elements of psammolittoral	slightly eutrophic
Rotcze	45.8	2.5	4.3	8.7	0.06	0.2	0.16	polymictic	small lake phytolittoral	eutrophic
Moszne	17.6	1.0	1.0	7.6	0.37	0.15	0.01	polymictic	marsh phytolittoral	dystrophic

The aim of this paper is to examine the effect of lake trophic status on the structure of phytoplankton, macrophytes, zooplankton and zoobenthos, and the relations between them.

## MATERIAL AND METHODS

The samples were collected twice a year in spring and autumn 2000 and 2001. The floristic composition of emergent plants and their density were analyzed [2, 4]. The samples of zooplankton and zoobenthos were taken in littoral and pelagic zones with standard limnological methods [7, 10].

The correlation among elements of water biocenosis was estimated using Statistica 3.0 programme [12].

## RESULTS

All ecological communities differed in qualitative and quantitative structure in the investigated lakes.

### Phytoplankton

The highest number of species – 38 occurred in slightly eutrophic Lake Uściwierz, and the lowest in dystrophic Lake Moszne – 22 species (Fig. 1). Species diversity of phytoplankton was higher in littoral than in pelagial zone. However, in the dystrophic lake the diversity was similar in both zones. Density of phytoplankton was the highest in the dystrophic lake (1485 ind. ml<sup>-1</sup>), and the lowest in the eutrophic lake (208 ind. ml<sup>-1</sup>).

Phytoplankton consisted of three systematic groups: *Cyanophyta*, *Cryptophyceae* and *Chlorophyta*. *Cyanophyta* predominated among all the groups of phytoplankton in the slightly eutrophic lake, and among them *Aphanothece clathrata*, an indicator of eutrophy was dominant [20, 25]. In the eutrophic lake *Cryptophyceae*, especially *Closterium diana* dominated, while in the dystrophic lake it was *Chlorophyceae*, particularly *Tetraedron minimum*.

### Emergent macrophytes

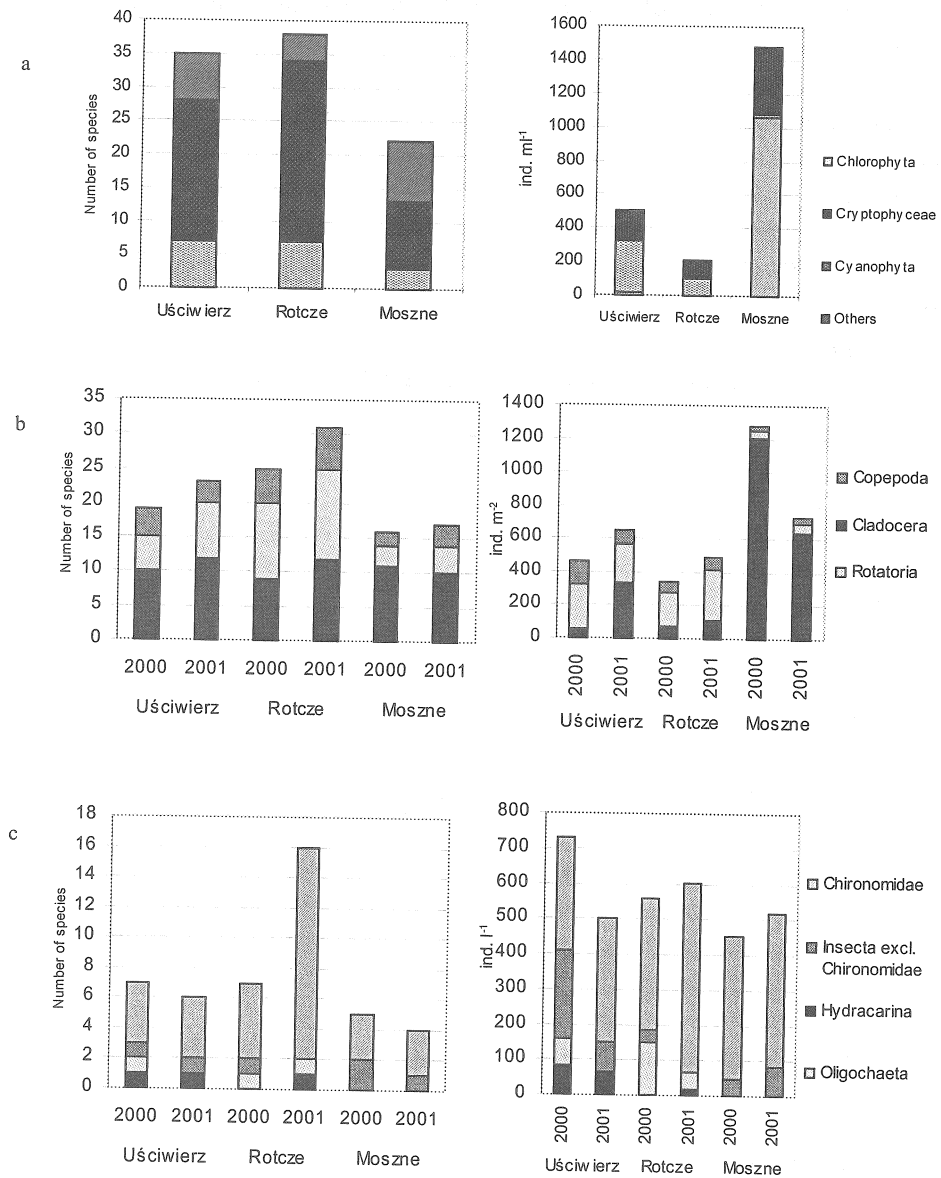
The emergent macrophytes were represented by 7 species. The highest species richness occurred in the slightly eutrophic lake, while the lowest in the eutrophic lake (Fig. 2).

*Phragmitetum* (Gams 1927) Schmale 1939 occurred in all investigated lakes. *Phragmitetum* was the most common association in lakes irrespectively of a lake's trophic status [6, 24]. *Equisetetum limosi* Steffen 1931 and *Eleocharitetum palustris* Sennikov 1919 completed the plant communities in the slightly eutrophic lake. *Scirpetum lacustris* (Allorge 1922) Chouard 1924 and *Thelypteridi-Phragmitetum* Kuiper 1957 dominated in the dystrophic lake (Tab. 2). The presence of *Thelypteridi-Phragmitetum* association indicates high fertility of lake [13].

The highest density of emergent macrophytes was achieved in the slightly eutrophic lake. *Eleocharis palustris* was the most numerous species there. The lowest density of emergent macrophytes was found in the eutrophic lake, and *Phragmites australis* predominated among them. As a rule, these two species have a wide habitat tolerance [24].

### Zooplankton

Zooplankton of investigated lakes was relatively abundant. The total number of 61 species comprised three taxonomic groups: *Rotatoria*, *Cladocera*, *Copepoda*. The highest number – 30 of species was achieved by rotifers, a little less – 21 by *Cladocera* and the lowest – 10 by copepods (Figs 1, 2).



**Fig. 1.** Number of species and density of water biocenosis in pelagic and profundal zone in investigated lakes (a - phytoplankton, b - zooplankton, c - zoobenthos)

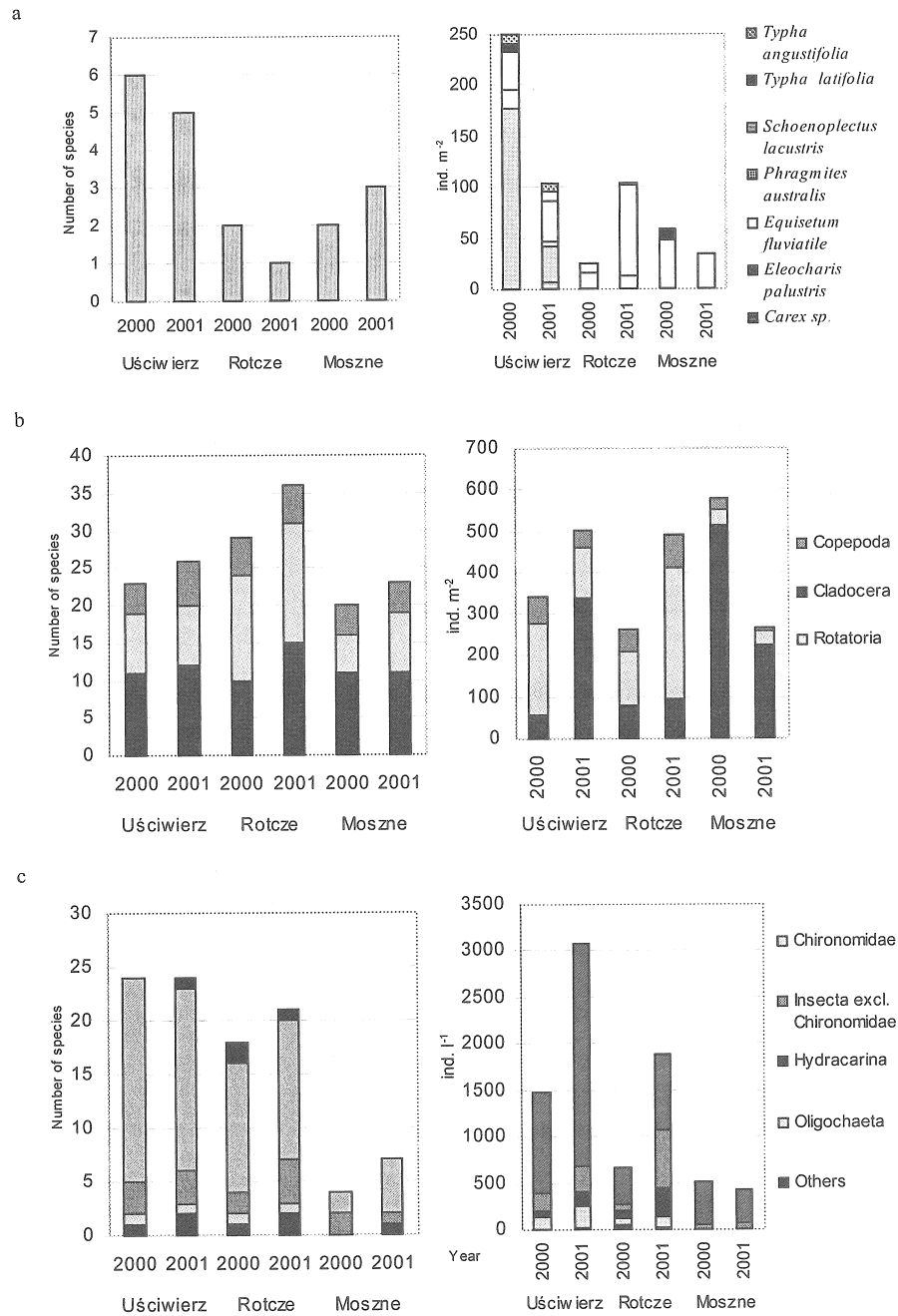


Fig. 2. Number of species and density of water biocenosis in littoral zone in investigated lakes (a) - emergent macrophytes, b- zooplankton, c- zoobenthos)

**Table 2.** Plant communities and species composition of emergent macrophytes in lakes of Polesie Lubelskie Region

	Lake	Uściwierz	Rotcze	Moszne
<b>Species</b>				
<i>Typha latifolia</i>		+		+
<i>Typha angustifolia</i>		+	+	
<i>Schoenoplectus lacustris</i>		+		+
<i>Phragmites australis</i>		+	+	+
<i>Equisetum fluviatile</i>		+		
<i>Eleocharis palustris</i>		+		
<i>Carex</i> sp.				+
<b>Plant communities</b>				
<i>Phragmitetum</i>		+	+	+
<i>Equisetetum limosi</i>		+		
<i>Eleocharitetum palustris</i>		+		
<i>Scirpetum lacustris</i>				+
<i>Thelypteridi-Phragmitetum</i>				+

+ – presence

Quantitative structure of zooplankton in investigated lakes was distinctly differentiated. It ranged from 24 species in the dystrophic lake to 46 species in the eutrophic lake. As a rule, a little higher species diversity of zooplankton was observed in the littoral with well developed macrophytes. The rare rotifer *Lecane subtilis*, the species typical for near shore zone and peatbog – pools, was found in the littoral of the dystrophic lake [15].

Qualitative structure of zooplankton in Polesie Lubelskie Region was of higher biodiversity than in the lakes of similar trophic status in Florida [3]. In the lakes studied, 24-45 species occurred, while in Conway lakes in Florida only 1-3 species were found. Higher diversity of zooplankton in Polish lakes is probably connected with well developed macrophytes and ecotonal zones [26]. In Polish and Florida lakes the rotifers achieved the highest biodiversity among zooplankton community.

The quantitative structure of zooplankton in the lakes investigated was similar. The highest density was achieved by *Rotatoria*. It ranged from 53 ind. l<sup>-1</sup> in pelagial zone of the slightly eutrophic lake to 1204 ind. l<sup>-1</sup> in pelagial zone of the dystrophic lake. The lowest density was found among *Copepoda*. They ranged from 9 ind. l<sup>-1</sup> in littoral zone of the dystrophic lake to 140 ind. l<sup>-1</sup> in pelagial zone of the slightly eutrophic lake. Density of *Cladocera* equaled 32 ind. l<sup>-1</sup> in littoral of Lake Moszne and 315 ind. l<sup>-1</sup> in littoral zone of Lake Rotcze. A little higher diversity of all taxo-

nomic groups occurred in pelagial zone and the lowest in littoral. The total diversity of zooplankton ranged from 261 ind. l<sup>-1</sup> in littoral zone of the eutrophic lake to 1279 ind. l<sup>-1</sup> in pelagial of the dystrophic lake (Fig. 1). Rotifers were predominated by 6 taxa: *Asplanchna priodonta*, *Keratella cochlearis*, *Keratella cochlearis f. tecta*, *Filinia longiseta*, *Polyartra vulgaris* and *Trichocerca similis* (Tab. 3). They belong to eutrophy indicators. The similar composition of dominating species occurred in other Polish [8] and foreign lakes [3].

Crustacean plankton achieved the highest diversity in both zones in the dystrophic lake. Diversity ranged from 41 ind. l<sup>-1</sup> in littoral of the dystrophic lake to 398 ind. l<sup>-1</sup> in littoral of the eutrophic lake (Fig. 2). As a rule, higher diversity was found in pelagial zone irrespectively of lake's trophic status. *Cladocera* dominated in the eutrophic lakes, while *Copepoda* in the dystrophic lake. Among crustacean plankton 8 species dominated. There were 4 species indicating of mesotrophy: *Bosmina coregoni*, *Daphnia cucullata*, *Eucyclops macruioides* and *Mesocyclops leucarti*, and one eutrophobiont *Diaphanosoma brachyrum* (Tab. 3). There were no clear differences in the dominance structure of crustacean plankton between littoral and pelagial zone. The number of trophic status indicators depended on degree of fertility of lakes. The group of eutrophy indicators comprised 12 species and that of meso and dystrophy indicators – 4-5 species. This kind of structure of zooplankton can probably reflect the “unstable balance” in water biocenosis of lakes [9, 19].

### Zoobenthos

43 taxa were found in the benthic fauna. Among them there were 31 *Chironomidae* species and 12 other taxa of different systematic rank (*Oligochaeta*, *Chaoborus flavicans*, *Hydracarina*, *Heleidae*). *Chironomidae* was clearly predominant. Majority of these species were typical of eutrophy: *Einfeldia* gr. *carbonaria*, *Chironomus* f. l. *plumosus*, *Glyptotendipes* gr. *gripekoveni* [19]. Some of them had been found for the first time in the lakes of Polesie Lubelskie Region: *Ablablesmyia phatta*, *Micropectra apposita* (Tab. 3). The highest species richness was encountered in the eutrophic lake – 30 species including 22 species of chironomids. In the slightly eutrophic lake 26 taxa (18 species of chironomids) occurred. The highest density of zoobenthos (1786 ind. m<sup>-2</sup> in 2001) was found in Lake Uściwierz, and a little less in Lake Rotcze (1462 ind. m<sup>-2</sup>). In both lakes the qualitative and quantitative structure of zoobenthos was higher in littoral zone. Various taxa predominated in Lake Rotcze and Lake Uściwierz. In the dystrophic lake the quantitative (6 species) and qualitative (467 ind. m<sup>-2</sup>) structure of bottom fauna was extremely poor (Figs 1, 2). *Einfeldia* f. l. *carbonaria* and *Heleidae* predominated in this lake.

**Table 3.** Indicator species of planktic and benthic invertebrates occurring in the investigated lakes of Polesie Lubelskie Region

Taxa/indicator of trophic	Lake	Uściwierz	Rotcze	Moszne
Zooplankton				
<b>Mesotrophy</b>				
<i>Bosmina coregoni</i>		+	+	
<i>Daphnia cuculata</i>		+	+	+
<i>Eucyclops macruroides</i>		+	+	
<i>Mesocyclops leuckarti</i>		+	+	+
<b>Eutrophy</b>				
<i>Anuraeopsis fissa</i>		+	+	+
<i>Keratella cochlearis</i>		+	+	+
<i>Keratella cochlearis f. tecta</i>		+	+	+
<i>Brachionus angularis</i>			+	+
<i>Brachionus diversicornis</i>		+	+	
<i>Trichocerca capucina</i>		+	+	+
<i>Filinia longiseta</i>		+		+
<i>Alona affinis</i>		+	+	+
<i>Alona guttata</i>			+	+
<i>Diaphanosoma brachyurum</i>		+	+	
<i>Polyphemus pediculus</i>			+	
<i>Sida crystallina</i>				+
<b>Dystrophy</b>				
<i>Asplanchna priodonta</i>		+	+	+
<i>Colurella adriatica</i>			+	+
<i>Colurella colurus</i>			+	
<i>Gastropus stylifer</i>				+
<i>Kellicotia longispina</i>		+	+	
<i>Trichocerca similis</i>			+	+
Zoobenthos				
<b>Eutrophy</b>				
<i>Chironomus f.l. plumosus</i>		+	+	
<i>Einfeldia carbonaria</i>		+	+	+
<i>Einfeldia pagana</i>			+	

+ - presence



## DISCOUSSION

There were clear relationships between ecological communities in investigated lakes. The results of correlation show that the diversity of emergent macrophytes in all investigated lakes had the highest influence on diversity and number of zooplankton species. In the eutrophic lakes there was a positive correlation between diversity of emergent macrophytes (*Phragmitetum*) and a numbers of rotifer species ( $r = 0.86$ ) but in the dystrophic lake the negative correlation ( $r = -0.81$ ) was found (Fig. 3).

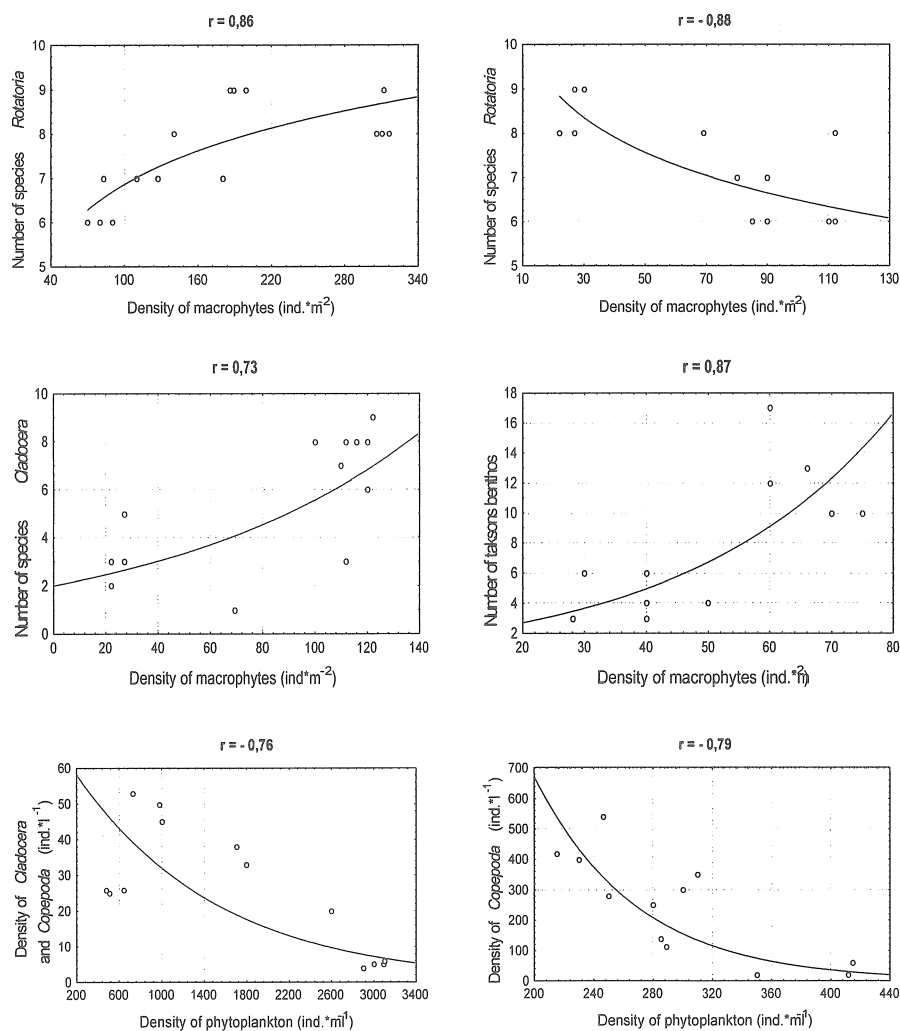


Fig. 3. Correlation between ecological communities in investigated lakes

Correlation between density of emergent macrophytes and density of rotifers was negative ( $r = -0.82$ ) (Fig. 3) [22].

The clear negative correlation was found between the density of phytoplankton and density of crustacean plankton in the dystrophic lake ( $r = -0.76$ ) and between density of phytoplankton and copepods in the eutrophic lakes ( $r = -0.79$ ) (Fig. 3).

These relationships point to the effective grazing of phytoplankton by zooplankton [21]. However, the positive correlation in the dystrophic lakes was found between the density of emergent macrophytes and number of *Cladocera* species ( $r = 0.73$ ). Probably this relationship was connected with the usage of plant beds as refuges from fish predators by crustaceans [5, 14]. High correlation ( $r = 0.87$ ) occurred between density of cladocerans and copepods in the dystrophic lakes. It may suggest the high food abundance for crustaceans and low competition for food in the lake (Fig. 3).

Statistic analysis show the positive correlation ( $r = 0.87$ ) between density of emergent macrophytes (*Phragmitetum*) and the number of zoobenthos species in the eutrophic lake (Fig. 3). High number of zoobenthos species observed among emergent macrophytes could have been connected with high diversity of microhabitats. Some species occurring there belong to epiphytic fauna and find proper habitats in well developed emergent macrophytes [11].

#### CONCLUSIONS

1. The highest biodiversity and density of water invertebrates occurred in the eutrophic lakes.
2. The highest density of phytoplankton and zooplankton was found in pelagic zone and the highest species diversity in littoral zone. However, the highest density of zoobenthos occurred in littoral zone.
3. In all investigated lakes, irrespective of trophic status, the highest number of species typical of eutrophic water bodies was found.
4. The significant positive correlation occurred between number of zoobenthos species and density of emergent macrophytes and negative correlation was found between density of zooplankton and phytoplankton.

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## STRUKTURA BIOCENOZ WODNYCH TRZECH PŁYTKICH JEZIOR POLESIA LUBELSKIEGO (WSCHODNIA POLSKA) O RÓŻNEJ TROFII

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**Streszczenie.** Struktura fitoplanktonu, makrofitów wynurzonych, zooplanktonu (*Rotifera*, *Cladocera*, *Copepoda*) oraz zoobentosu była badana w trzech płytkich jeziorach Polesia Lubelskiego: lekko eutroficznym jeziorze Uściwierz, eutroficznym jeziorze Rotcze i dystroficznym jeziorze Moszne. Próby pobierano w 2000 i 2001 roku. W badanych jeziorach występowało 69 gatunków glonów. Najwięcej gatunków – 53 występowało w eutroficznym jeziorze, zaś najmniej – 22 gatunki w jeziorze dystroficznym. Natomiast liczebność fitoplanktonu była najwyższa w dystroficznym jeziorze, osiągając 1660 osobn.·ml<sup>-1</sup>, zaś najniższa, wynosząca 159,4 osobn.·ml<sup>-1</sup> w jeziorze eutroficznym. Największa liczba gatunków makrofitów wynurzonych, bo wynosząca 6 gatunków występowała w lekko eutroficznym jeziorze Uściwierz, zaś najniższa, osiągająca zaledwie 2 gatunki w eutroficznym jeziorze Rotcze. We wszystkich jeziorach dominował zespół *Phragmitetum*. Zooplankton i zoobentos osiągał największą różnorodność w eutroficznym jeziorze Rotcze zaś najmniejszą w dystroficznym jeziorze Moszne. Natomiast największa liczebność zoobentosu kształtowała się w lekko eutroficznym jeziorze Uściwierz, osiągając 1786 osobn.·m<sup>-2</sup>, a najmniejsza, wynosząca 467 osobn.·m<sup>-2</sup> w dystroficznym jeziorze Moszne. Liczebność zooplanktonu była wyraźnie zróżnicowana w badanych jeziorach. Najwyższe liczebności *Rotatoria*, wynoszące 1279 osobn.·l<sup>-1</sup> występowały w dystroficznym jeziorze, a najniższe w lekko eutroficznym jeziorze, osiągając 53 osobn.·l<sup>-1</sup>. *Cladocera* i *Copepoda* największe liczebności osiągały w eutroficznym jeziorze (398 osobn.·l<sup>-1</sup>), najniższe zaś w jeziorze dystroficznym (41 osobn.·l<sup>-1</sup>).

**Słowa kluczowe:** płytkie jeziora, makrofity wynurzone, fitoplankton, zooplankton, zoobentos