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INFLUENCE OF HUMIFICATION ON BIODIVERSITY OF LAKE BENTHIC MACROINVERTEBRATES[*] [**]

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A b s t r a c t. The work present the taxonomic composition and abundance of macrozoobenthos in three humic lakes, each undergoing different stages in the process of humification. The potential influence of habitat conditions was defined, modified under the influence of the humic substances, on biodiversity and the number of benthic invertebrates. Fish were also researched in an attempt to define the possibility of their influence on the benthic fauna.

K e y w o r d s**:** humic lake, benthic macroinvertebrate, fish, biodiversity, nutrients

INTRODUCTION

The process of lake humification is connected with the inflow of organic substances of humic character that cause significant changes in the water environment as well as the formation of a specific association of hydrobionts. The universally well-known features of humic lakes are, besides high concentrations of dissolved organic carbon: darkness of the water, low transparency, and poor oxygen conditions [1]. The lakes are surrounded by raised bogs, approximating to the moss peat bog type with many rare and relic plant species [5]. The allochtonic load of biogenic substances is assimilated by dissolved humic substances (DHS), high concentrations of which result in low pH as well as cause a deficiency of mineral nutrient substances.

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The object of the research was the estimation of macrozoobenthos changes against the background of the physicochemical proprieties of water in three humic lakes of Drawieński National Park. The lakes differed mainly in the content of humic substances, thanks to which it was possible to define a clear gradient of this factor – from the oligohumic Piaseczno Małe Lake, to the mesohumic Głodne Lake IV, after the polyhumic Głodne Lake III. The taxonomic composition and number of benthic invertebrates were examined. The aim of the study was to determine the influence of abiotic features of biotopes on the benthic biodiversity.

MATERIAL AND METHODS

The subject of the investigation were three small, postglacial mid-forest lakes Głodne Lake III (GL III), Głodne Lake IV (GL IV), and Piaseczno Małe Lake (PML) in the area of the Drawieński National Park. The Głodne Lakes are surrounded by ring of ombrotrophic peat bogs from *Oxycocco-Sphagnetea* class with a predominant proportion of *Sphagnum magellanicum* and *Sph. rubellum*. Around Piaseczno Małe Lake there extends a narrow strand of peat moss and a near transitional minerotrophic moor is situated under its northern bank [4].

The qualitative and quantitative composition of the macrozoobenthos was investigated in the spring and autumn, 1999-2000, in samples of bottom sediment taken from the deepest place the profundal (with the use of the Kajak sampler) and in the littoral (with the use of the Czapla sampler). The samples were sieved through a net with 250 µm mesh size, sorted and preserved in 70% ethyl alcohol or in 4% formaldehyde. The density of organisms was counted (ind. m^{-2}).

Water transparency was measured *in situ*, and water temperature, pH, oxygen saturation, dissolved oxygen and conductivity were measured in the whole water column, at 1 m intervals, with the use of the YSI 600R multi-parameter probe. The water samples for chemical analyses were taken from May 1999 to July 2001, at 3-month intervals. The total phosphorus, total nitrogen, colour, hardness, dissolved organic carbon [3] and extinction coefficient of green (530 nm) and red (630 nm) light [1] were analysed in the laboratory.

RESULTS

The lakes are located in a natural depression of terrain, which is why from early spring through most of the year they are provided with sharp thermal and oxygenic stratification. The functioning of the lakes is dependent on the qualitative composition and quantity of inflow of organic substances, especially humic acids. The value of physicochemical parameters of water (water colour, Secchi disc visibility and A_{530}/A_{630} ratio) suggested the furthest process of humification advance in GL III,

and less advanced in GL IV and PML (Tab. 1). The lakes represented a state of low abundance of bio-availability of mineral substances. The oxic epilimnion is on average 1 m thick in polyhumic, 3 m in mesohumic, and 4-5 m in oligohumic lakes.

Table 1. Morphometric and physicochemical factors of the studied lakes (physicochemical data represent average annual values)

Lake	Głodne III	Głodne IV	Piaseczno Małe
Water surface area (ha)	0.65	0.42	8
Max. depth (m)	8.5	7.2	8.4
Mean depth (m)	3.1	3.2	3
Basin area (ha)	91	7.32	21.6
Transparency (m)	1.3	2.3	3.6
pH	4.5	4.6	7.1
Water colour (mg Pt dm^{-3})	112	40	30
A_{530}/A_{630} (5 cm^{-1})	2.5	1.5	1
Conductivity (μS cm^{-1})	29	24	69
Hardness (mg $CaCO_3$ dm^{-3})	6.5	3.7	18.8
Total nitrogen (mg N dm^{-3})	1.5	1.5	1.9
Total phosphorus (mg P dm^{-3})	0.075	0.078	0.077
DOC (mg C dm^{-3})	17.6	9	15.8

In the composition of benthos 28 taxa belonging to 10 systematic groups were found. Greater qualitative wealth was noted in the oligo- and mesohumic lakes – 19 and 18 species, respectively, than in the polyhumic lake – 12 species (Tab. 2). In all the lakes *Diptera* dominated, their quantitative share decreasing with growing humic gradient of the waters – from 80% in the oligohumic, through 54% in the mesohumic, to 37% in the polyhumic lake. Representatives of *Diptera* included *Chaoborus* obscuripes and *Chironominae* in GL III and the two remaining lakes, appearing only in the profundal – *Chaoborus flavicans* (Tab. 2). Besides *Diptera* in the polyhumic lake, *Ephemeroptera* and *Trichoptera* occurred in larger number, in the mesohumic *Hydracarina,* and in the oligohumic – besides *Ephemeroptera – Megaloptera* and *Oligochaeta*.

In the polyhumic lake in the profundal macrozoobenthos did not appear, and in the remaining lakes only *Diptera* was affirmed. In the littoral of GL IV there was noted a 61% totality of organisms, while in PML only 33%.

Fish populations in the lakes were poor – in GL IV only perch were found and in PML perch, pike, roach, rudd, tench and ruff.

Table 2. Composition and abundance (ind. m^{-2}) of benthic macroinvertebrate in the littoral and profundal zones of the lakes (S – spring, A – autumn, * – only in the profundal)

Lake / Group / Species	Głodne III		Głodne IV		Piaseczno Małe	
	S	A	S	A	S	A
	W	J	W	J	W	J
Oligochaeta						
Tubifex tubifex	46	46		46	230	
Hirudinea						
Erpobdella complanata (L.)						23
Erpobdella testacea (Savigny)					23	
Ephemeroptera						
Caenis horaria (L.)					46	414
Caenis luctuosa (Burm.)						23
Leptophlebia vespertina (L.)	230	644	276		276	
Paraleptophlebia submarginata (Steph.)				322		414
Odonata						
Cordulia aenea (L.)		138	46	46		23
Enallagma cyathigerum (Charp.)				46		
Ischnura elegans (Vand. Lind.)				92		46
Leucorrhinia sp.				92		
Pyrrhosoma nymphula (Sulz.)				46		
Somatochlora metallica (Vand. Lind.)					46	
Heteroptera						
Plea minutissima Leach			46	46		
Coleoptera						
Hyphydrus ovatus (L.)		46				
Noterus crassicornis (O.F. Müller)	46					
Megaloptera						
Sialis lutaria (L.)		46		46	46	299
Trichoptera	46	276	368	230	138	207
Diptera						
Chaoboridae						
Chaoborus flavicans (Meig.)			1400*	1610*	1050*	6790*
Chaoborus obscuripes (V.D. Wulp)		460				
Chaoborus pallidus (Fabr.)				46		
Chironomidae						
Chironominae		230	644	184	277	851
Diamesinae				92		
Orthocladinae				92	23	
Tanypodinae	184	46	92	92	322	368
N.det.					23	23
Ceratopogonidae	46				70*	
Hydracarina	46		598	1150	46	23

DISCUSSION

Humic lakes are natural habitats which create difficult conditions of development for hydrobionts. This is mainly caused by dissolved humic substances which, due to its chemical proprieties, modifies the abiotic environment as well as the structure and metabolic processes of organisms [7]. The consequence of physicochemical transformations of water in humic lakes is a decrease in biodiversity and the number of hydrobiont assemblages, in the macrozoobenthos [4]. The results of this study show that increasing gradient of dissolved humic substances concentrations causes the retreat of some groups of organisms – for example *Hirudinea*, and a decline in the number of others – for example *Ephemeroptera*, *Diptera* and *Odonata* [2]. Representatives of some groups of benthos are completely absent, for example *Gastropoda*, while others – e.g. *Bivalvia* – occur only sporadically [6]. High concentration of DHS in the polyhumic lake and the high gradient of oxygen concentrations in the water column affect selectively water organisms, causing not only the atrophy of benthos in the profundal but also the elimination of ichthyofauna.

In lakes with a lower content of dissolved humic substances the differentiation of qualitative and quantitative benthos is considerably greater (Tab. 2). The large number of the population of predatory dipterans larvae rewards the attention of *Chaoborus flavicans* in the profundal in situations were fish occur. In humic lakes congeneric populations of ichthyofauna, mainly perch, are frequent [8]. The mass occurrence of *Diptera* may be connected with the larger accessibility of food, since larval stages feed on *Rotifera*, and later on *Cladocera* [6]. Together with the growth of dissolved humic substances content in water, unfavourable transformations of water environment, including a fall of pH and insignificant hypolimnion oxygenation, diminish the population of predatory fish, as may be confirmed by data regarding pike in the oligohumic lake Piaseczno Małe. The result of oxygen reduction in bottom waters is the retreat of "calm feed" fish – roach, tench, rudd and ruff.

CONCLUSION

Increase in the concentration of humic substances in lake waters leads to changes in the abiotic features of the environment, such as high water colour, decline in the thickness of the trophogenic zone, pH decrease, limitation of the bioavailability of biogenic compounds. In these conditions some groups of benthic fauna are not found (for example *Gastropoda*), and species diversity and number are reduced. Food pressure from the ichthyofauna exists, but its scale is difficult to qualify.

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WPŁYW HUMIFIKACJI NA RÓŻNORODNOŚĆ GATUNKOWĄ ZOOBENTOSU W JEZIORACH

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S t r e s z c z e n i e. Przedstawiono skład gatunkowy i zagęszczenie makrozoobentosu w strefie litoralu i profundalu trzech jezior humusowych znajdujących się w różnych stadiach zaawansowania procesu humifikacji. Określono potencjalny wpływ warunków siedliskowych modyfikowanych pod wpływem substancji humusowych na różnorodność gatunkową i liczebność bezkręgowców bentosowych. Zbadano też ichtiofaunę celem określenia możliwości jej wpływu na faunę bentosową.

S ł o w a k l u c z o w e: jeziora humusowe, makrozoobentos, ryby, różnorodność gatunkowa, biogeny