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STRUCTURE OF ROTIFER COMMUNITIES OF RESTORED SMALL PEAT-BOG RESEVOIRS OF POLESKI NATIONAL PARK

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Abstract. Artificial small water reservoirs existing over peatbogs of Łeczyńsko-Włodawskie Lakeland have high ecological value. Planktonic rotifer communities of the reservoirs are characterized by high species diversity, presence of rare species as well as high abundance of periphytic and benthic-periphytic forms. Low nutrients concentrations of studied reservoirs confirmed low total rotifers density, presence of indicatory species and high ratio of algaevorous to detritivorous species. The analysis of domination structure of planktonic rotifers showed very low stability of their community and high vulnerability for changes of habitat conditions.

INTRODUCTION

Planktonic rotifers constitute an important link in trophic structure of water ecosystems. On the one hand, these organisms are consumers of bacteria, algae, protozoans and detritus, on the other, they become an important diet component of small invertebrates and juvenile fish [1, 11, 19]. The appearance of rotifer species and community structure depends on many environmental factors, such as temperature, oxygen, toxins, phosphorous concentration and osmotic conditions [24]. Thus the composition and abundance of planktonic rotifers can be used to diagnose the water quality [12, 17, 21].

Small water reservoirs created as a result of human activity differ in relation to trophic conditions, surface area, depth and presence of aquatic vegetation [14, 18]. Specific environmental conditions (nutrients concentrations, pH and water transparency) in such ecosystems strongly influence the presence of invertebrate communities [3, 27].

Artificial water bodies are typical for peat-bogs of Poleski National Park. They were created as a result of intensive meliorations during the 1970s and 1980s. Great trophic diversity of the reservoirs, the presence of basic, humic and eutrophic waters make them rare and valuable habitats to a variety of resident and migratory fish and waterfowl [23]. Some of reservoirs have been studied to recognize physical and chemical water properties, protozoans' fauna and other water zoocenosis [16, 22, 23]. However, there is still lack of comparative studies of water zoocenosis, such as planktonic rotifers in different types of peat-bog reservoirs.

The aim of the study was to determine the characteristic of the Rotifera community structure of seven small restored water bodies (basic, eutrophic and humic) situated on peatbogs on the area of a national park. The results presented in the study constitute a part of the project entitled "Evaluation of the effects of restoration of water-peatbog ecosystems. Part 2.A. Evaluation of ecological status of water ecosystems based on abundance and species structure of zooplankton".

STUDY AREA AND METHODS

The studies were performed on the area of Poleski National Park (the area of 9647.7 ha) created in 1990 [4]. This is the first national park in which peatbog ecosystems are protected [10].

Studies included seven small peat-bog reservoirs differed in surface area, water properties and species structure of vegetation (Tab. 1, Tab. 2).

One reservoir (Moszne) classified as humic is surrounded by high moor; one reservoir (Jagodne) is eutrophic, situated on the area of transitional peat bog. The remaining five reservoirs are basic, located on the area of carbonate peat bog (Bagno Bubnów).

Planktonic rotifers were studied in June and September of 2008. Rotifers were sampled by "Toń II" apparatus from the depth of 0 to 0.5 m. Each sample consisted of 10 cm^3 of water. In both studied months and at each reservoir three samples were taken. Sampled water was sieved through the planktonic net of mesh size 25 μm and condensed to the constant volume of 100 cm^3. The samples were preserved by Lugol's liquid and next by 4% formaldehyde with glycerine. Collected rotifers were counted and identified under inverted microscope. A number of individuals was calculated per 1 dm^3 of water. The normal distribution of collected data was verified using Shapiro-Wilk test. The significance of differences between rotifers densities in particular in peat-bog reservoirs was tested using non-parametric rang test of Kruskal-Wallis. All statistical analyses were made using SAS Programme. The similarity of rotifer communities was determined by calculating Jaccard index using cluster method performed by MVSP-3,1 Programme. The analysis of faunistic similarity of rotifer communities was determined using UPGMA method. Additionally the influence of dominating rotifer species on the similarity of rotifer communities was estimated using PCA analysis of MVSP-3,1 Programme. The analysis included: index of domination, sustainability of domination structure [Bielańska-Grajner 2005], index of Shannon-Wiener and classification of rotifer species into ecological groups [8, 19].

RESULTS AND DISCUSSION

The studied small water reservoirs were inhabited by 40 planktonic rotifer species (Tab. 3).

The highest number of species 11-12 was noted in eutrophic peat bog reservoir Jagodne and one of basic peat bog reservoirs (BB2); the lowest number of species was observed in humic peat bog reservoir Moszne. In the remaining peat bog reservoirs, a total number of rotifer species ranged from 9 to 10 (Tab. 4).

Species richness measured as value of Shannon-Wiener index was high, and showed little differences between basic reservoirs (values of H index = 2.4-2.8). In Moszne peat bog reservoir, the value of H index reached 1.9. The lowest Shannon index (H = 0.6)

Table 1. Morphological, physical and chemical (± SD) characteristic of studied peat-bog reservoirs (mean values for studied months)

Peat-bog reservoir	Surface area (ha)	Max. depth (m)*	pH	Conductivity ($\mu S\ cm^{-1}$)	Dissolved oxygen mg O_2 dm^{-3}	Chlorophyll-a mg dm^{-3}	Total P mg dm^{-3}	$P\text{-}PO_4$ mg dm^{-3}	$N\text{-}NH_4$ mg dm^{-3}	$N\text{-}NO_3$ mg dm^{-3}
Humic Moszne (M)	0.4	0.3-1.0	4.70 ±1.4	88.3 ±9.5	4.9 ±0.9	236.69 ±111.8	0.095 ±0.066	0.006 ±0.008	4.848 ±1.518	0.844 ±0.814
Eutrophic Jagodne (J)	1.6	1.0-2.0	6.50 ±0.93	245.5 ±21.9	-	-	0.684 ±0.592	0.318 ±0.260	2.961 ±2.142	0.487 ±0.028
Basic Bagno Bubnów 1 (BB1)	2.2	1.0-2.0	8.50 ±2.19	176.6 ±21.8	12.1 ±2.1	17.13 ±3.4	0.021 ±0.017	0.015 ±0.018	1.102 ±0.282	0.886 ±0.213
Basic Bagno Bubnów 2 (BB2)	0.5	0.7-1.5	7.69 ±0.48	520.5±26.2	7.4 ±2.1	-	0.034 ±0.011	0.011 ±0.013	0.656 ±0.112	0.488 ±0.213
Basic Bagno Bubnów 3 (BB3)	0.4	0.7-1.5	7.66 ±0.26	488.0 ±111.7	5.9 ±3.3	-	0.015 ±0.006	0.014 ±0.004	0.594 ±0.086	0.528 ±0.318
Basic Bagno Bubnów 4 (BB4)	3.0	0.5-1.5	7.78 ±0.76	390.5 ±38.9	5.9 ±1.3	6.92 ±4.1	0.054 ±0.066	0.013 ±0.013	0.780 ±0.206	0.300 ±0.098
Basic Bagno Bubnów 5 (BB5)	0.7	0.5-1.0	8.34 ±0.03	306.0 ±15.5	9.0 ±1.3	20.85 ±5.3	0.038 ±0.022	0.020 ±0.016	0.684 ±0.240	0.465 ±0.117

* water level depended on precipitation

Table 2. Structure of vegetation of studied peat-bog reservoirs in Poleski National Park in 2008 (peat-bog reservoirs: J - eutrophic Jagodne, M - humic Moszne, BB1 - basic Bagno Bubnów 1, BB2 - basic Bagno Bubnów 2, BB3 - basic Bagno Bubnów 3, BB4 - basic bagno Bubnów 4, BB5 - basic bagno Bubnów 5)

	Peat-bog reservoirs						
	M	J	BB1	BB2	BB3	BB4	BB5
Emergent macrophytes							
Cicuto-Caricetum pseudocyperi de Boer	+						
Hottonia palustris L.		+					
Phragmites australis (Cav.)Trin. ex Steud					+	+	+
Salicetum pentandro-cinerea (Almq.)		+					
Typha latifolia L.	+	+		+			
Floating-leaved macrophytes							
Aldrovanda vesiculosa L.	+						
Nymphaea candida Presl.						+	
Potamogeton natans L.	+		+			+	+
Utricularia vulgaris L.			+				
Submerged macrophytes							
Chara aculeolata Ktitz.				+	+		
Chara hispida L.							+
Myriophyllum spicatum L.			+				

was noted in eutrophic peat bog reservoir Jagodne (Tab. 4). A similar low species diversity was observed in peat bog of Himalaya Mountains [25]. In peat bog reservoirs near Parczew as well as on the area of Wielkopolski National Park, number of rotifer species showed much higher values [13, 20].

Euplanktonic rotifer species, numerously represented in lakes of Łęczyńsko-Włodawskie Lakeland [6, 19] and rivers of Lublin region [5], occurred in a very little number, only 3 species in basic peat bog reservoirs (Tab. 4). Periphytic and benthic-periphytic species (from 6 to 11 dependently on the reservoir) reached higher numbers and constituted from 70% up to 92% of total rotifer species (Tab. 4). Relative abundances of different ecological groups were not a consequence of a type of peat-bog reservoir. Usually the lowest and the highest percentages of ecological groups were observed in basic reservoirs.

In the three of studied peat-bog reservoirs there were noted rare species for Polish fauna: in basic reservoir BB5 – *Lepadella Rottenbergi* (Gosie), in basic reservoir BB1 – *Trichocerca cavia* (Gosse) and in eutrophic reservoir – *Platyias p-atulus* (Müll.).

In the studied peat bog reservoirs indicatory species were presented. Two eutrophobionts were noted in eutrophic reservoir - *Anuraeopsis fissa* Gosse (92% of total rotifers density) and *Keratella cochlearis* f. tecta (Gosse). The group of oligotrophobionts represented one species, *Chromogaster ovalis* (Berg.) in basic reservoir BB1. Two species typical for dystrophic waters, rare for Lubelszczyzna region, *Macrochaetus subquadratus* Perty and *Microcodides chlajna* Gosse were noted in basic peat-bog reservoir BB4 (Tab. 4).

Based on food preferences, rotifer community can be divided into detritivorous, algaevorous, omnivorous and predatory species [9]. Detritivorous species are usually the

Table 3. Species composition of planktonic rotifers of studied peat-bog reservoirs of Poleski National Park in 2008 (peat-bog reservoirs: J - eutrophic Jagodne, M - humic Moszne, BB1 - basic Bagno Bubnów 1, BB2 - basic Bagno Bubnów 2, BB3 - basic Bagno Bubnów 3, BB4 - basic bagno Bubnów 4, BB5 - basic bagno Bubnów 5)

					Peat-bog reservoirs			
		M	J	BB1	BB2	BB3	BB4	BB5
1	*Anuraeopsis fissa* Gosse		+					
2	*Ascomorpha ovalis (*Berg.)					+		
3	*Bdelloidea non. det.*	+			+			
4	*Colurella adriatica* Ehrb.			+	+	+		+
5	*Colurella colurus* (Ehrb.)	+			+			
6	*Colurella uncinata* (Müller)			+				
7	*Chromogaster ovalis* (Berg.)			+				
8	*Elosa spinifera* Wiszn.		+					
9	*Euchlanis dapidula* Parise			+				
10	*Keratella cochlearis* f. *tecta* (Gosse)		+					
11	*Lecane acus* (Harr.)						+	
12	*Lecane bulla* (Gosse)				+	+	+	
13	*Lecane closterocerca* (Schm.)		+			+		+
14	*Lecane crenata* Harr.					+		+
15	*Lecane flexilis* (Gosse)				+			
16	*Lecane hamata* (Stokes)	+						
17	*Lecane ludwigii* (Eckst.)	+	+	+			+	
18	*Lecane luna* (Müll.)				+			
19	*Lecane lunaris* (Ehrb.)				+		+	
20	*Lecane opias* (Herr. & Myers)	+		+		+	+	
21	*Lecane quadridentata* (Ehrb.)					+		
22	*Lecane stichaea* (Harr.)				+			
23	*Lepadella acuminata* (Ehrb.)							+
24	*Lepadella cristata* (Rouss.)			+				
25	*Lepadella ovalis* (Müll.)		+					+
26	*Lepadella rhomboides* (Gosse)			+		+		
27	*Lepadella rottenburgi* (Lucas)							+
28	*Macrochaetus subqudratus* Perty						+	
29	*Microcodides chlaena* Gosse						+	+
30	*Mytilina mucronata* (Müll.)		+					
31	*Mytilina ventralis* (Ehrb.)				+			
32	*Platyias p-atulus* (Müll.)		+					
33	*Polyarthra vulgaris* Carl.	+	+					
34	*Testudinella patina* (And. et Shep.)					+		
35	*Testudinella truncata* (Gosse)					+		
36	*Trichocerca bicrystata* (Gosse)			+				
37	*Trichocerca pusilla* (Laut.)	+			+		+	+
38	*Trichocerca rattus* (Müll.)		+		+			+
39	*Trichocerca similis* (Wierz.)				+		+	+
40	*Trichocerca tigris* (Müll.)		+				+	

Table 4. Ecological characteristic of rotifer communities of studied peat-bog reservoirs of Poleski National Park in 2008 (peat-bog reservoirs: J - eutrophic Jagodne, M - humic Moszne, BB1 - basic Bagno Bubnów 1, BB2 - basic Bagno Bubnów 2, BB3 - basic Bagno Bubnów 3, BB4 - basic bagno Bubnów 4, BB5 - basic bagno Bubnów 5). Densities marked by the same letters don't differ significantly

	Peat-bog reservoirs						
	M	J	BB1	BB2	BB3	BB4	BB5
Number of euplanktonic species	0	1	1	1	3	3	3
Number of benthic-periphytic species	5	5	5	8	6	5	3
Number of periphytic species	1	4	3	3	1	2	4
Number of epibiontic species	1	1	0	0	0	0	0
Number of rare species	0	1	1	0	0	0	1
Number of indicatory species for eutrophic waters	1	2	0	1	0	1	1
Number of indicatory species for oligotrophic waters	0	0	1	0	0	0	0
Number of indicatory species for dystrophic waters	0	0	0	0	0	2	1
Number of predatory species	0	0	0	0	0	0	0
Number of detritivorous species	0	0	1	0	1	1	1
Number of algaevorous species	0	3	1	2	2	3	2
number of omnivorous species	7	8	7	9	7	6	5
Total number of species	7	11	9	12	10	10	10
Shannon index	1,9	0,6	2,4	2,7	2,6	2,6	2,8
Density ind. dm^{-3}	19^a	407^b	18^a	20^a	18^a	18^a	63^c
	± 4.56	± 71.29	± 5.11	± 4.89	± 6.22	± 7.21	± 13.81

most abundant group of planktonic rotifers in freshwater ecosystems [5, 7, 8, 9, 26]. Detritivorous rotifers were presented only in four basic reservoirs (Tab. 4). More numerously were presented algaevorous rotifers while the most abundant were omnivorous species. The dominance of algaevorous species is evidence of low water fertility and low availability of food resources [9]. Gliwicz [9] stated that under low concentrations of nutrients in water, small algae constitute the most available food for rotifers, because of their successful competition with other primary producers. Besides in waters of low nutrients concentration is usually observed little amounts of small detritus, which does not enhance the rapid development of detritivorous or omnivorous species.

Low total densities of planktonic rotifers observed in the studied peat bog reservoirs confirm low fertility of these ecosystems. Its values ranged from 18 -19 ind. dm^{-3} (basic reservoirs BB1, BB3, humic reservoir M) up to 407 ind. dm^{-3} (eutrophic reservoir J) (Tab. 4). Low rotifers densities observed in humic and basic reservoirs showed similar values to those obtained by Sharma and Bhattariai [25] in small acidic peat bogs of Buthan, and by Radwan [20] in peat bog reservoirs near Parczew. Much higher densities (from 250 ind. dm^{-3} up to 400 ind. dm^{-3}), similar to those of studied eutrophic reservoir, were noted in peat bog reservoirs near Turwia in Wielkopolski National Park [15].

The domination structure of planktonic rotifers showed very interesting results (Fig. 1).

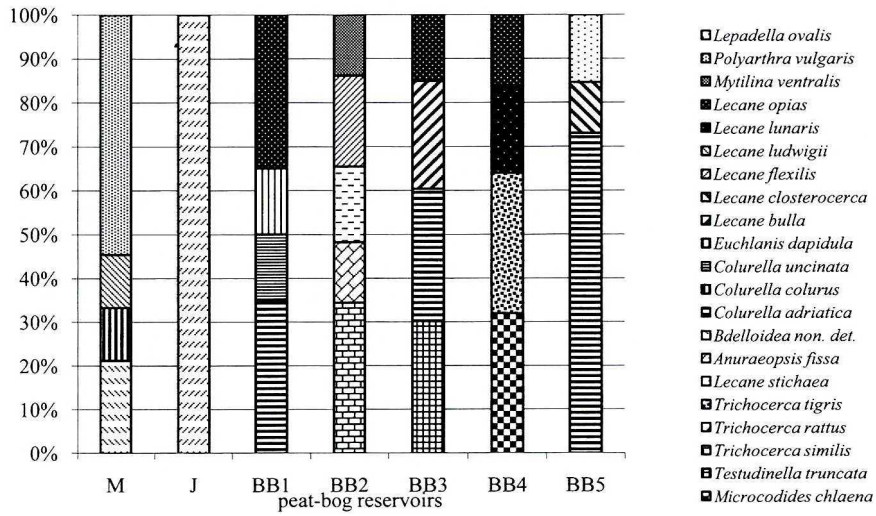

Fig. 1. Relative abundances of particular rotifers species in studied peat-bog reservoirs of Poleski National Park in 2008 (peat-bog reservoirs: J - eutrophic Jagodne, M - humic Moszne, BB1 - basic Bagno Bubnów 1, BB2 - basic Bagno Bubnów 2, BB3 - basic Bagno Bubnów 3, BB4 - basic bagno Bubnów 4, BB5 - basic bagno Bubnów 5)

The group of dominants consisted of 21 rotifer species, which constituted above 50% of all species. The group of dominants was strongly influenced by faunistic differentiation; the group of dominants of each of the studied reservoir was represented by other species (Fig. 1). Bielańska-Grajner [2] classified rotifer communities as sustainable and non-sustainable domination structure. The authors assumed the community as sustainable when: 3 domination classes occurred (dominants, subdominants and recedents), at least 3 species represent dominants and none of them exceeds 45% of total density. Based on those criteria any of the studied peat-bog reservoir did not have a sustainable domination structure. The most non-sustainable domination structure was observed in eutrophic reservoir (J). The dominants were represented by one species – *Anuraeopsis fissa* Gosse, which amounted 92% of total density and recedents were not distinguished (Fig. 1). In the other peat-bog reservoirs, a number of dominants was higher and ranged from 3 to 4; recedents were not presented. In basic peat-bog reservoir (BB5), the share of dominating species (*Colurella adriatica* Ehrb.) exceeded 60% of total rotifer density.

The cluster analysis of planktonic rotifer communities showed small faunistic similarity of studied peat-bog reservoirs. The values of Jaccard`s index ranged from 0.08 to 0.2 (Fig. 2).

Nevertheless, faunistic analysis led to distinguishing three groups of peat-bog reservoirs. First group represented two basic reservoirs (BB2 and BB4) and humic peat-bog reservoir (M). Similarity indices ranged from 0.2 to 0.23 (Fig. 2). The second group included two basic reservoirs (BB1 and BB3) of lower faunistic similarity in comparison to the first group (Fig. 2). The third group represented basic peat-bog reservoir (BB5) and eutrophic reservoir (J). The Jaccard`s index for these reservoirs amounted to 0.15 (Fig. 2).

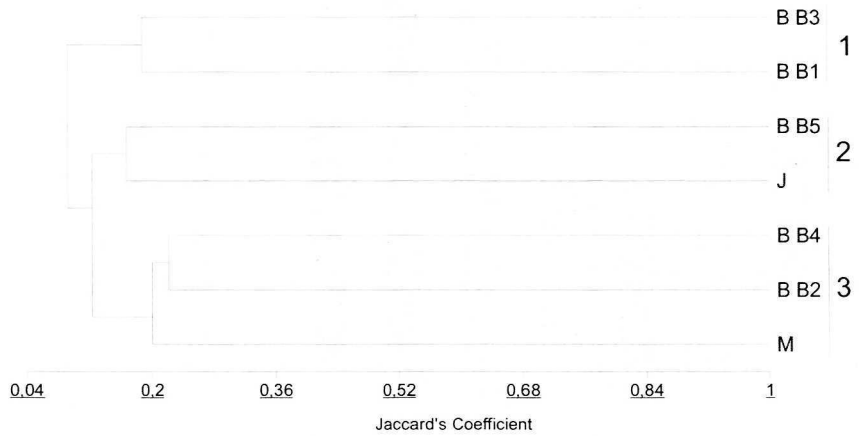

Fig. 2. Structure of similarity of rotifers communities based on rotifers densities in studied peat-bog reservoirs of Poleski National Park in 2008 (peat-bog reservoirs: J - eutrophic Jagodne, M - humic Moszne, BB1 - basic Bagno Bubnów 1, BB2 - basic Bagno Bubnów 2, BB3 - basic Bagno Bubnów 3, BB4 - basic bagno Bubnów 4, BB5 - basic bagno Bubnów 5)

The PCA analysis of similarity of rotifer communities based on their densities confirmed the results obtained in cluster method and showed important faunistic differences among rotifer communities in the studied peat-bog reservoirs (Fig. 3).

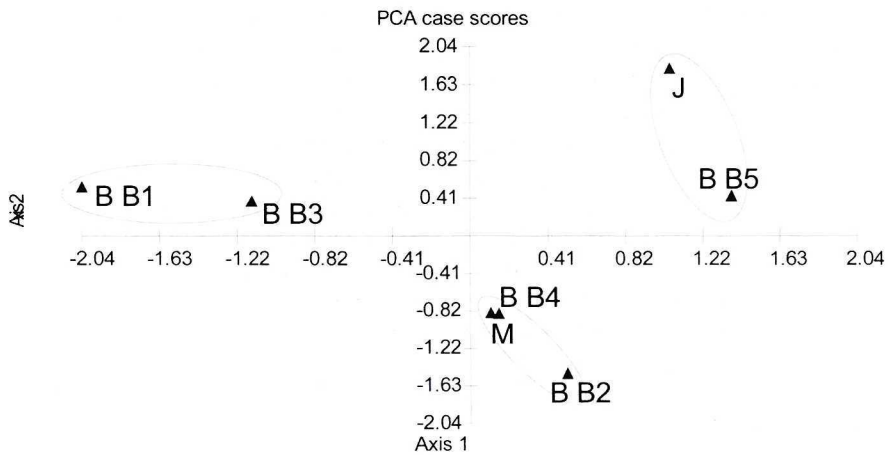

Fig. 3. PCA analysis of rotifers communities based on rotifers densities in studied peat-bog reservoirs of Poleski National Park in 2008 (peat-bog reservoirs: J - eutrophic Jagodne, M - humic Moszne, BB1 - basic Bagno Bubnów 1, BB2 - basic Bagno Bubnów 2, BB3 - basic Bagno Bubnów 3, BB4 - basic bagno Bubnów 4, BB5 - basic bagno Bubnów 5)

Axis 1 explaines rotifers variability in 22%, Axis 2 in 19%. The analysis of similarity of rotifer communities based on domination structure showed approximate results, with an exception of basic reservoir BB4 and humic reservoir (M), where the PCA analysis showed high similarity.

CONCLUSIONS

The most optimal habitat conditions for planktonic rotifers were presented in eutrophic peat bog reservoir; there were noted 11 rotifer species and the highest density of 407 ind dm^{-3}. However, the highest species diversity of rotifers (H index = 2.4-2.8) was observed in basic peat bog reservoirs. High biodiversity of the studied reservoirs has been confirmed by the presence of rare species, domination of periphytic taxa on benthic-periphytic and euplanktonic forms. Low number and densities of indicatory species for eutrophic waters, high ratio of algaevorous to detritivorous species, as well as absence of *Keratella cochlearis* f. tecta (Gosse), confirm low trophy of studied peat bog reservoirs. Such ecosystems, mostly basic and humic, are rarely presented in the area of Łęczyńsko-Włodawskie Lakeland. In the paper, rotifer communities of peat bog reservoirs showed high faunistic differences. The group of dominants included 21 rotifer species, different dependently on a type of reservoir. Domination structure of rotifer communities was non-sustainable, mostly due to the absence of recedents or high domination of one species. All these observations indicate low stability of rotifer communities for changes of environmental conditions of their habitat.

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STRUKTURA ZGRUPOWAŃ WROTKÓW TORFIANEK NA ZRENATURALIZO- WANYM OBSZARZE POLESKIEGO PARKU NARODOWEGO

Jednym z ciekawszych i mniej poznanych ekosystemów wodnych są różnego typu torfianki: węglanowe, humusowe i eutroficzne. Analiza wrotków planktonowych w siedmiu takich zbiornikach Pojezierza Łęczyńsko-Włodawskiego wykazała: dużą różnorodność gatunkową, obecność gatunków rzadkich, znaczny udział form peryfitonowych i bentosowo-peryfitonowych oraz duże różnice faunistyczne między wrotkami różnych torfianek. Mała liczebność wrotków, gatunki wskaźnikowe, znaczny udział gatunków roślinożernych w stosunku do detrytusożernych wskazują na małą żyzności większości torfianek. Mimo tych cech analiza struktury dominacji wykazała brak zrównoważenia zgrupowań wrotków i możliwość ich małej stabilności w przypadku jakichkolwiek zmian środowiskowych.