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FAUNISTIC SIMILARITY IN PLANKTONIC ROTIFER ASSEMBLAGES FOUND IN SIX EUTROPHIC LAKES SITUATED WITHIN OR BEYOND THE WATER SYSTEM OF WIEPRZ-KRZNA CANAL (EASTERN POLAND)

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Abstract. Dratów, Krzcień and Tomaszne lakes are linked by means of Wieprz-Krzna Canal. On the other hand, Bikcze, Mytycze and Plotycze lakes are not included in the water system of Wieprz-Krzna Canal. However, all these lakes are regarded as biologically valuable water reservoirs forming Łęczyńsko-Włodawskie Lakeland. They are shallow eutrophic lakes with varied water surface, different catchment area and diversified structure of catchment management. The qualitative and quantitative composition of planktonic rotifers was studied in spring, summer and autumn of 2012 and 2013. The studies revealed the presence of 67 *Rotifera* species with their mean density ranging from 119 ind. dm⁻³ in Tomaszne lake to 1441 ind. dm⁻³ in Bikcze lake. Dominants included few very common species of *Brachionus angularis*, *Keratella cochlearis*, *Keratella cochlearis tecta*, *Keratella quadrata*, *Polyartchra vulgaris*. Dominance structure and species diversity suggest a slightly higher ecological status of Mytycze lake, as compared to the remaining eutrophic reservoirs. Faunistic differences observed among rotifer assemblages inhabiting individual lakes were significantly bigger than those registered in the successive study years within the area of individual lakes. This property referred to all the reservoirs, both the ones linked with the water system of the canal and the lakes not included in the canal system. Bigger faunistic differences occurred among rotifer assemblages inhabiting the lakes of Wieprz-Krzna Canal system, as compared with the assemblages found in the lakes not included in the system.

Key words: Dratów lake, Krzcień lake, Tomaszne lake, Bikcze lake, Mytycze lake, Plotycze lake, planktonic rotifers, faunistic similarity

INTRODUCTION

A significant element of the water network of Polesie Lubelskie region is the system of Wieprz-Krzna Canal, which was built in the 60s of the 20th century

and comprises the area of nearly 530.000 ha. The canal was constructed in order to intensify the agricultural produce due to amelioration or drainage of the arable area. The system of the canal included some of the lakes. Surrounding them completely or partially with a dike resulted in separating those lakes from the catchment area and combining their waters, as well as the water of the rivers [Wojciechowski 1991]. These changes intensified the proces of eutrophication and led to transforming the structure of water biocenoses [Radwan and Kornijów 1994]. Those lakes included, among others, Dratów lake, Krzceń lake and Tomaszne lake. On the other hand, there are also numerous, equally shallow and eutrophic lakes in Łęczyńsko-Włodawskie Lakeland, which are not linked by the water system of Wieprz-Krzna Canal. These include the lakes considered in the present study, namely Bikcze, Mytycze and Płotycze. Rotifers inhabiting them provide good reserach material since they make the basic component of minute zooplankton [Radwan 1973]. Feeding on bacteria, algae, protozoa and dead organic matter, they play an important role in the trophodynamics of water reservoirs and inhabit them relatively early [Hilbricht-Ilkowska 1964, Radwan 1973]. Some of them can also become good indicators of land ferility and water purity [Karabin 1985, Radwan *et al.* 1988, Paleolog *et al.* 1997].

Studies of these lakes were initiated in order to determine the degree of faunistic similarity among rotifer assemblages inhabiting them. The authors were particularly interested in determining if and to what degree linking these lakes by means of Wieprz-Krzna Canal might affect the difference between rotifer assemblages found in these lakes and those inhabiting the reservoirs beyond the canal system.

STUDY AREA

The lakes of Dratów, Krzceń and Tomaszne are linked by means of the waters of Wieprz-Krzna Canal, while the lakes of Bikcze, Mytycze and Płotycze do not have any common water connection (Fig. 1). The lakes selected for the study are situated in Łęczyńsko-Włodawskie Lakeland, which is a unique and valuable natural region of Poland [Chmielewski (ed.) 2006]. The area is characterized by a high degree of unchanged nature. It comprises the Poleski National Park, three landscape parks, seven areas included in Natura 2000 programme and twelve reserves. The whole region has been granted the status of UNESCO Biosphere Reserve. The reservoirs listed above belong to shallow polymictic and eutrophic lakes which are common in this area. They are used, at least periodically, for fishing and are classified as tench-and-pike lakes [Harasimiuk (ed.) 1998]. A significant element of water balance for Dratów, Krzceń and Tomaszne lakes is their water supply coming from the Canal, which occurs every year mainly in autumn and winter when there is no ice cap, and in early spring,

immediately after the ice has melted. Water flows in through sluices directly from Wieprz-Krzna Canal, while Mytycze is supplied directly from Dratów, by means of a culvert. It is only in the recent twenty years that less intense water management, including introducing a lower amount of water into the reservoirs, has been implemented [Chmielewski (ed.) 2006].

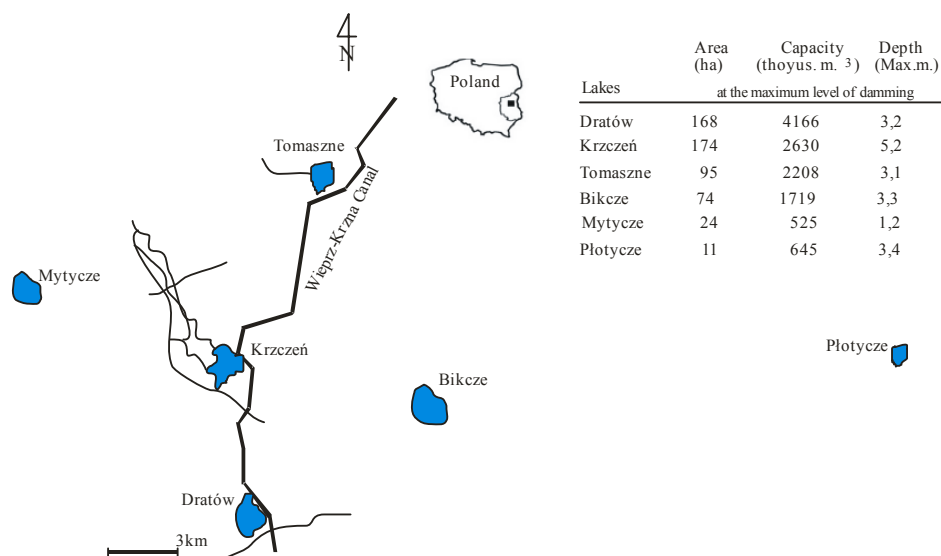


Fig. 1. Situation of the lakes within or beyond the system of Wieprz-Krzna Canal and their morphometric qualities

With the maximum water accumulation level, the highest capacity has been recorded for Dratów, while the capacity of Krzceń and Tomaszne is nearly twice lower. The remaining lakes, Bikcze, Mytycze and Płotycze do not have the function of accumulating water and are characterized by lower estimated water capacity (Fig. 1). The catchment structure in the individual lakes is dominated, to a different degree, by meadows, pastures, arable areas and forests.

MATERIAL AND METHODS

The material for the studies was taken in the summer and autumn of 2012 and 2013 from six lakes of Łęczyńsko-Włodawskie Lakeland (eastern Poland), namely Dratów, Krzceń, Tomaszne, Bikcze, Mytycze and Płotycze lakes. In each study period, the plankton was sieved in three replications from the pelagic zone. Samples were collected by taking each time 10 dm³ of water with the use of „Toń II” sampler at the depth of 0 to 1 m. Next, the water was sieved through

a planktonic net no. 25 and condensed to the fixed volume of 100 cm³. The samples were preserved in Lugol's liquid and after a few hours they were put into a 4% formaldehyde solution with an addition of glycerine. The samples preserved in this way were used to identify the species and the number of rotifers, with the help of a reversed microscope. The number of individuals in the sample was calculated per 1 dm³ of water in the reservoir. Normal distribution of all the variables was verified with the help of Shapiro-Wilk test. The significance of differences in rotifer density among the individual lakes was checked using the ANOVA non-parametric rang test (Kruskal-Wallis) in the SAS software [SAS Institute Inc. 2001]. Similarity of rotifer assemblages in individual lakes and their zones was determined by means of Sørensen index and cluster analysis was performed with the use of Multi Variate Statistical Package – MVSP-3.1. The similarity analysis was performed by means of the Unweighted Pair-Group Method Using Arithmetic Averages – UPGMA. Additionally, to determine the degree to which dominating species affect similarity between different rotifer assemblages the PCA (Principal Components Analysis) was performed in the MVSP-3.1. software. The calculations included the index of rotifer domination, estimation of sustainability in the domination structure [Bielańska-Grajner 2005] and Shannon-Wiener index [Shannon and Wiener 1963].

RESULTS AND DISCUSSION

1. Qualitative structure

In the six lakes studied during three years the total number of 67 planktonic rotifer species was recorded. Their number was slightly higher in the lakes included in the Wieprz-Krzna Canal system and it ranged from 18 in Dratów in 2012 to 24 in Tomaszne in 2013. Their number in the eutrophic lakes not included in the canal system was low and it ranged from 10 species in Płotycze in 2013 to 15 species in Mytycze. Only Bikcze revealed a higher number of 21 rotifer species in 2012 (Fig. 2). The shallow lakes situated beyond Wieprz-Krzna Canal, namely Bikcze, Mytycze and Płotycze, where a significant area of the water surface was formed by litoral, the majority of the species were benthos-periphytome and periphytome forms. The lakes linked by the canal, where the litoral was usually poorer, revealed a higher share of euplanktonic species. Clear preferences for benthos-periphytome and periphytome species to the environment rich in plants were frequently observed in other reservoirs [Bielańska-Grajner 1987, Paleolog *et al.* 1997, Radwan *et al.* 1988, Demetraki-Paleolog 2007, Demetraki-Paleolog and Sender 2013].

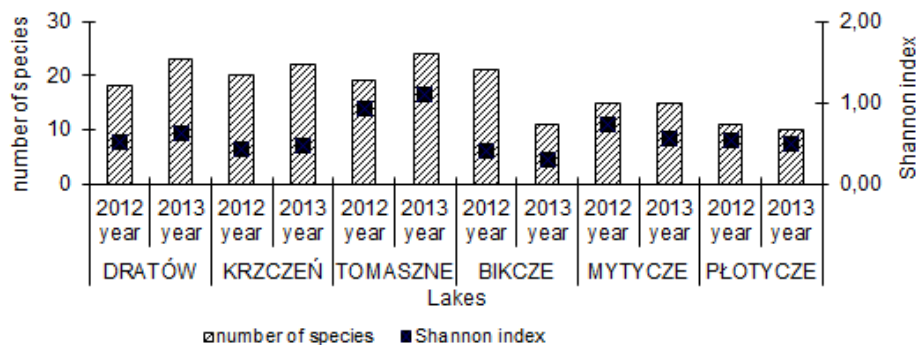


Fig. 2. Species richness and species diversity among planktonic rotifer assemblages in the selected lakes of Łęczyńsko-Włodawskie Lakeland, within and beyond the system of Wieprz-Krzna Canal, 2012 and 2013

Species diversity of planktonic rotifers in the analyzed lakes was slightly different, in relation to species richness. Shannon-Wiener index revealed its highest values in Tomaszne lake belonging to the water system of Wieprz-Krzna Canal – from 0.93 to 1.1 (Fig. 2). The lowest species diversity was recorded in the waters of the big Bikcze lake, not linked with Wieprz-Krzna Canal. In the remaining lakes, both those linked with the canal and the ones not belonging to the system, species diversity throughout two years of studies ranged from 0.42 in Krzcień to 0.72 in Mytycze. The differences in species diversity between the lakes of the canal system and those situated beyond that system were not statistically significant.

2. Quantitative structure

The highest mean rotifer density was recorded in the big, eutrophic lake of Bikcze. In 2012 it amounted to 1344 ind. dm⁻³, while in 2013 it was 1441 ind. dm⁻³. A slightly lower density was observed in Krzcień and Plotycze, ranging from 804 ind. dm⁻³ to 933 ind. dm⁻³. Density values in Dratów and Mytycze were on the average half the value recorded in Bikcze, and the lowest mean density was observed in Tomaszne – 119 ind. dm⁻³ (Fig. 3). In all the lakes situated beyond the canal mean rotifer density value was higher by 357 ind. dm⁻³, as compared with the lakes of Wieprz-Krzna Canal system, and the difference was statistically significant. All differences regarding rotifer density between individual lakes, except the difference between Plotycze and Krzcień, were statistically significant.

The dominating species were very common rotifers. The dominants in all the lakes included *Keratella cochlearis*. Another species, *Keratella cochlearis tecta*, dominated only in Mytycze and Plotycze. *Brachionus angularis* was dominating in Dratów, *Polyartchra vulgaris* was a dominating rotifer species in all the lakes,

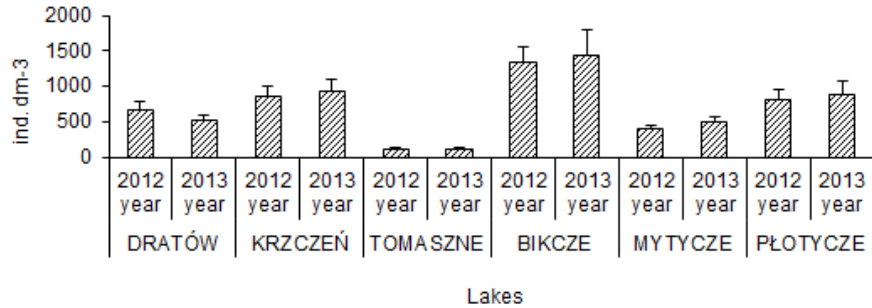


Fig. 3. Density of planktonic rotifer assemblages in the selected lakes of Łęczyńsko-Włodawskie Lakeland, within and beyond the system of Wieprz-Krzna Canal, 2012 and 2013

except for Krzceń and Dratów which were dominated by another species, namely *Keratella quadrata* (Fig. 4). To make the domination structure analysis more transparent, rotifer assemblages were categorized according to Łuczak and Wierzbowska [1981], Müller [1984], and Bielańska-Grajner [2005] into those having sustainable or non-sustainable domination structure. According to the authors, an assemblage is sustainable if it contains all the three domination classes (dominants, sub-dominants and recedents), at least three of the species represent

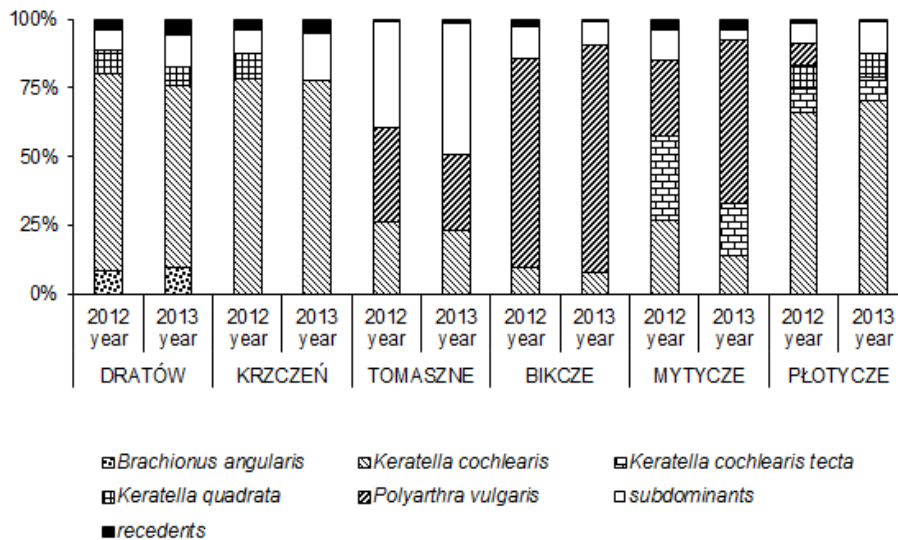


Fig. 4. Domination structure among planktonic rotifer assemblages in the selected lakes of Łęczyńsko-Włodawskie Lakeland, within and beyond the system of Wieprz-Krzna Canal, 2012 and 2013

dominants and none of them exceeds a 45% share of their total number. Following this criterion, the domination structure of planktonic rotifers was sustainable only in Mytycze lake in 2012 (Fig. 4). It may be concluded that domination structure among rotifer assemblages in the lakes situated beyond the canal system was closer to sustainability, as the only case of sustainability was recorded here, while in the remaining lakes of this group, except for Bikcze lake, only one criterion was not fulfilled, namely that of 45% domination of a single species. Sustainable domination structure may suggest a higher ecological status of the reservoir and the trophy of its waters that is not very high [Bielańska-Grajner 2005]. However, in Mytycze lake low trophy and a high ecological status are doubtful due to a high share of *Keratella cochlearis tecta* in its waters. This species was also observed among the dominants in Płotycze lake. *Keratella cochlearis tecta*, and especially its high share in the population of *Keratella cochlearis*, is regarded as an important indicator of high water fertility [Radwan *et al.* 2004, Karabin and Ejsmont-Karabin 1996].

3. Classification of rotifer assemblages

A cluster analysis of planktonic rotifer assemblages performed on the basis of their quantitative composition suggests a significant faunistic stability of rotifer groups in particular lakes. In each of the six lakes rotifer assemblages observed in 2012 were most similar to the assemblages inhabiting that lake in 2013 (Fig. 5). The similarity reached the highest level in the small lakes not linked

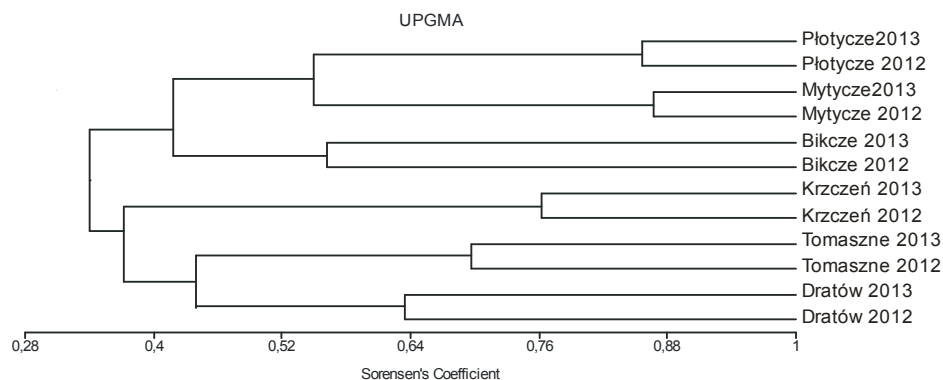


Fig. 5. Faunistic similarity among planktonic rotifer assemblages in the selected lakes of Łęczyńsko-Włodawskie Lakeland, within and beyond the system of Wieprz-Krzna Canal, 2012 and 2013

by the canal, with Sorensen's coefficient from 0.85 to 0.6. In the lakes belonging to Wieprz-Krzna Canal, namely Krzceń, Tomaszne and Dratów, lower values were recorded, from 0.63 to 0.76. The lowest faunistic similarity within a single lake in different years of studies occurred in the big eutrophic lake of Bikcze,

with Sorensen's coefficient at 0.55 (Fig. 5). This particular lake did not belong to the canal system, yet it was linked with Nadrybie lake by means of a system of ditches. A comparative analysis of rotifer assemblages found in different lakes revealed the presence of two groups of lakes which were faunistically similar. The first group, consisting of more faunistically similar reservoirs, included the lakes lying beyond Wieprz-Krzna Canal, namely Płotycze, Mytycze and Bikcze, with Sorensen's coefficient from 0.42 to 0.55 (Fig. 5). The other group included the lakes of Wieprz-Krzna Canal system, Krzceń, Tomaszne and Dratów. A lower faunistic similarity was observed here, with Sorensen's coefficient from 0.37 to 0.45. The whole group of the lakes belonging to Wieprz-Krzna Canal was faunistically different, as compared to the group of lakes situated beyond the canal system, with Sorensen's index at 0.34 (Fig. 5). The analysis of similarities among rotifer assemblages conducted on the basis of

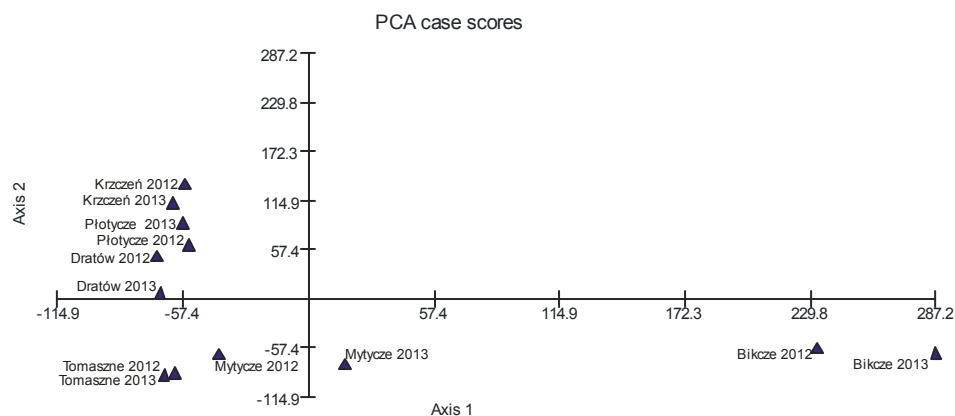


Fig. 6. Principal component analysis (PCA) of planktonic rotifer assemblages in the selected lakes of Łęczyńsko-Włodawskie Lakeland, within and beyond the system of Wieprz-Krzna Canal, 2012 and 2013

their quantitative structure by means of the Principle Component Analysis, PCA, actually confirms the results of the cluster analysis and suggests a significant similarity among rotifer assemblages inhabiting a particular lake in the years 2012 and 2013 (Fig. 6). Grouping rotifer assemblages in the studied lakes according to the main components (Fig. 6), it may be observed that the lakes of Wieprz-Krzna Canal system were inhabited by faunistically similar rotifer assemblages. However, this group was joined by a small lake of Płotycze, not linked by the canal (Fig. 6). Also, rotifer assemblages found in Tomaszne, a lake belonging to the canal system, and Mytycze, a lake situated beyond the system. Bikcze lake, similarly like in the cluster analysis, was more faunistically specific and it varied significantly from the remaining lakes in this respect. The first main

component expressed on the abscissa (Fig. 6), Axis 1, accounts for variability among rotifer assemblages in 68.68%, while the other one, expressed on the ordinate, Axis 2, accounts for rotifer assemblage variability in 29.48%

CONCLUSIONS

1. Sixty-seven species of planktonic rotifers were found in the six lakes studied.

2. Species richness and variety were typically higher in the lakes belonging to Wieprz-Krzna Canal system, as compared to the remaining eutrophic shallow lakes situated beyond the canal system.

3. The lakes not linked by the canal revealed a statistically significantly higher rotifer density.

4. Dominants included few very common species of *Keratella cochlearis*, *Keratella cochlearis tecta*, *Keratella quadrata*, *Polyartchra vulgaris*, *Brachionus angularis*.

5. Rotifer dominance structure remained sustainable only in one year studied in Mytycze. Rotifer assemblages in the lakes not linked by the canal were slightly closer to sustainability.

6. The highest faunistic similarity was observed among rotifer assemblages inhabiting a particular lake in two comparable years of study. The highest values regarding such similarity were recorded in the lakes situated separately, not linked with any other reservoir.

7. The lakes linked by the water system with Wieprz-Krzna Canal formed a separate group regarding faunistic similarity among rotifers, as compared to the lakes lying beyond this system. The faunistic similarities of the lakes were slightly higher in the reservoirs linked by means of the canal.

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PODOBIENSTWA FAUNISTYCZNE ZGRUPOWAŃ WROTKÓW PLANKTONOWYCH
SZEŚCIU JEZIOR EUTROFICZNYCH NALEŻĄCYCH I NIENALEŻĄCYCH
DO SYSTEMU WODNEGO KANAŁU WIEPRZ-KRZNA (WSCHODNIA POLSKA)

Streszczenie. Jeziora Dratów, Krzceń i Tomaszne są połączone ze sobą Kanałem Wieprz-Krzna. Z kolei jeziora Błocze, Mytycze i Płotycze nie należą do systemu wodnego Kanału Wieprz-Krzna. Wszystkie należą do cennych przyrodniczo zbiorników wodnych Pojezierza Łęczyńsko-Włodawskiego. Są płytkimi jeziorami eutroficznymi o różnej powierzchni lustra wody, różnej powierzchni zlewni i różnej strukturze użytkowania zlewni. Wiosną, latem i jesienią 2012 i 2013 roku przeprowadzono w nich badania nad składem jakościowym i ilościowym wrotków planktonowych. Te badania pozwoliły na stwierdzenie 67 gatunków *Rotifera* o średnim zagęszczeniu wahającym się od

119 ind. dm^{-3} w jeziorze Tomaszne do 1441 ind. dm^{-3} w jeziorze Bikcze. Wśród dominantów znalazło się niewiele bardzo pospolitych gatunków: *Brachionus angularis*, *Keratella cochlearis*, *Keratella cochlearis tecta*, *Keratella quadrata*, *Polyartchra vulgaris*. Struktura dominacji oraz różnorodność gatunkowa wskazują na nieco wyższy status ekologiczny jeziora Mytycze niż pozostałych jezior eutroficznych. Różnice faunistyczne pomiędzy zgrupowaniami wrotków zasiedlającymi różne jeziora były znacznie większe niż obserwowane pomiędzy kolejnymi latami badań w obrębie poszczególnych jezior. Właściwość ta dotyczyła wszystkich jezior – i tych związanych z systemem wodnym kanału i tych niepołączonych kanałem. Większe różnice faunistyczne wystąpiły pomiędzy zgrupowaniami wrotków zasiedlającymi jeziora systemu Kanału Wieprz-Krzna niż tymi, które zasiedlały jeziora niezwiązane z systemem kanału.

Słowa kluczowe: jezioro Dratów, jezioro Krzczeń, jezioro Tomaszne, jezioro Bikcze, Jezioro Mytycze, jezioro Płotycze, wrotki planktonowe, podobieństwo faunistyczne