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# THE DEGREE OF SIMILARITY IN FAUNISTIC PLANKTONIC ROTIFER ASSEMBLAGES IN THREE LAKES LINKED BY WIEPRZ-KRZNA CANAL (EASTERN POLAND)

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**Abstract.** Dratów, Krzczeń and Tomaszne lakes are among environmentally valuable reservoirs in Poland and Łęczyńsko-Włodawskie Lakeland. These are shallow eutrophic reservoirs of varied water surface. What they have in common is the fact that they are linked by Wieprz-Krzna Canal. The main aim of the present study was to determine the degree of faunistic similarity between planktonic rorifer assemblages inhabiting these particular lakes. The authors were interested to find out whether linking the lakes with the canal, as well as currently applied water exchange could affect the degree of faunistic similarity occurring between these lakes. Physical and chemical analyses, as well as the studies of planktonic rotifers were carried out in the spring, summer and autumn of 2012 and 2013. They included determining the qualitative composition and the density of planktonic rotifers. The studies resulted in finding 50 species of *Rotifera*, with mean density ranging from 75 to 855 ind. $dm^{-3}$. The dominants included the common species of *Keratella cochlearis, Keratella cochlearis tecta, Keratella quadrata, Polyarthra vulgaris, Kellicottia longispina, Brachionus angularis, Ascomorpha odalis* and *Synchaeta pectinata.* The results revealed high faunistic similarity among rotifer assemblages inhabiting a particular lake in different years, and high diversification occurring between the lakes compared in the work. The analyses showed that linking the lakes by Wieprz-Krzna Canal did not significantly affect the faunistic similarity of these particular lakes.

**Key words:** Dratów lake, Krzczeń lake, Tomaszne lake, biological diversity, 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]. Such lakes included, among others, the reservoirs studied in the present work, namely Dratów lake, Krzczeń lake and Tomaszne lake. 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, Paleolog *et al*. 1997, Radwan *et al*. 1988].

The studies of these lakes were undertaken in order to determine the degree of faunistic similarity among rotifer assemblages inhabiting them and to assess, if possible, the effect of linking these lakes with Wieprz-Krzna Canal on such similarity.

## STUDY AREA

The lakes of Dratów, Krzczeń and Tomaszne are situated in the area of Łęczyńsko-Włodawskie Lakeland, eastern Poland. The morphometric features characterizing these reservoirs are their insignificant depth and relatively large area (Fig. 1). At the maximum level of buildup, the largest volume is that of Dratów, while Krzczeń and Tomaszne are twice smaller.

The lakes mentioned here belong to shallow polymictic and eutrophic lakes which are common in this area. They are used, at least periodically, for fishing [Harasimiuk (ed.) 1998]. The structure of the catchment is dominated to a different degree by meadows, pastures, arable area and forests. The physical and chemical properties of the water in these lakes are presented in Table 1.

A significant element of water balance in the reservoirs is their supply 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 [Solis 2012]. Water flows in through sluices directly from Wieprz-Krzna Canal. The lakes receive from the canal some amount of water from the rivers. The most significant exchange of lake water with the water from the canal occurs apparently in case of Dratów lake [Solis 2012]. Linking the studied lakes by means of a canal also affects mutual mixing of the waters in those lakes. It is significant, regarding the results of the present work, that the waters of Dratów lake and Tomaszne lake are linked by a very long section of the canal, while the waters of Dratów and Krzczeń lakes and those of Krzczeń and Tomaszne lakes are connected by signifi-

| Lakes | Area (ha) | Capacity (thyous. m. $^3$) | Depth (Max.m.) |
|---|---|---|---|
| | at the maximum level of damming | | |
| Dratów | 168 | 4166 | 3,2 |
| Krzczeń | 174 | 2630 | 5,2 |
| Tomaszne | 95 | 2208 | 3,1 |

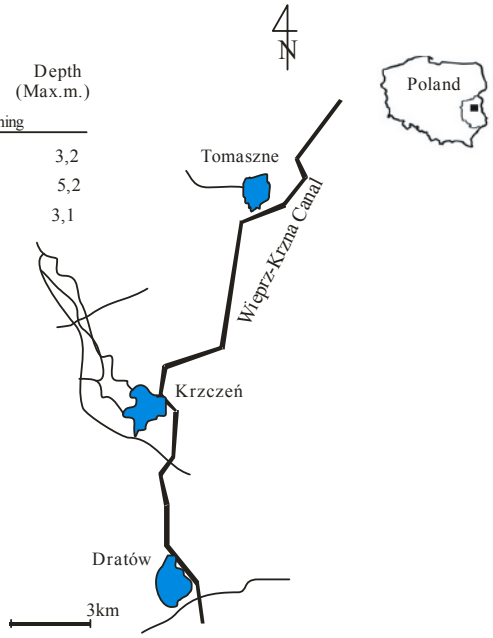


Fig. 1. The map of the study area

Table 1. Physical and chemical parameters of the waters in the lakes: Dratów, Krzczeń, Tomaszne in the 2012 year

| Parameter of water | Lakes | | |
|---|---|---|---|
| | Dratów | Krzczeń | Tomaszne |
| Temperature, $^oC$ | 14.4 ±4.2 | 14.5 ±3.8 | 14.9 ±4.4 |
| pH | 8.53 ±0.33 | 8.42 ±0.42 | 8.51 ±0.22 |
| Conductivity, µS cm$^{-2}$ | 305.83 ±48.8 | 271.1 ±50.2 | 350.6 ±4.8 |
| $O_2$, mg dm$^{-3}$ | 10.56 ±2.4 | 10.56 ±2.8 | 11.51 ±3.1 |
| N-$NH_4$, mg dm$^{-3}$ | 0.135 ±0.0315 | 0.106 ±0.0317 | 0.078 ±0.0177 |
| N-$NO_3$, mg dm$^{-3}$ | 0.122 ±0.0862 | 0.126 ±0.0667 | 0.149 ±0.0733 |
| P-$PO_4$, mg dm$^{-3}$ | 0.0575 ±0.038 | 0.038 ±0.016 | 0.029 ±0.024 |
| Total P, mg dm$^{-3}$ | 0.137 ±0.074 | 0.229 ±0.077 | 0.077 ±0.049 |
| Chlorophyll, mg dm$^{-3}$ | 65.39 ±40.78 | 146.44 ±68.73 | 46.83 ±24.05 |

cantly shorter sections of the canal. It is only in the recent twenty years that less intense watner management, including introducing a lower amount of water into the reservoirs, has been implemented [Chmielewski (ed.) 2006].

## MATERIAL AND METHODS

The material for the studies was taken in the summer and autumn of 2012 and 2013 from three lakes of Łęczyńsko-Włodawskie Lakeland (eastern Poland), namely Dratów, Krzczeń and Tomaszne lakes. In each study period, the plankton was sieved in three replications from the litoral zone and in three replications from the pelagic zone, Since the study aimed at comparing the whole lakes, rather than their particular zones, the three replications from the litoral zone and the three replications from the pelagial zone were treated as six replications of the samples taken at a particular time from a particular lake. The samples were collected by taking each time 10 $dm^3$ 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 $cm^3$. The samples were preserved in Lugol's liquid and after a few hours they were put in formaldehyde 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 numer of individuals in the sample was calculated per 1 $dm^3$ of water in the reservoir.

The 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 programme [SAS Institute Inc. 2001]. The similarity of rotifer assemblages in individual lakes and their zones was determined by means of Sörensen index and cluster analysis with the use of *Multi Variate Statistical Package* – MVSP-3.1. The similarity analysis was performer by means of the *Unweighted Pair-Group Method Using Arithmetic Avarages* – UPGMA. Additionally, to determine the degree to which dominating species affect the similarity between different rotifer assemblages the PCA (*Principal Components Analysis*) was performed in the MVSP-3.1. programme. The calculations included the index of domination, estimation of sustainability in the domination structure [Bielańska-Grajner 2005] and the Shannon – Wiener index [Shannon and Wiener 1963]. Water for analyses and physical and chemical measurements was taken only in 2012. This was done in the same periods, replications and lake zones, as in the case of planktonic samples. Physical and chemical parameters were determined according to Hermanowicz *et al*. [1976] and PN-ISO 10260 [2002].

## RESULTS AND DISCUSSION

### 1. Qualitative structure

In the three studied lakes during three years the total numer of 50 planktonic rotifer species was recorded. Their numer ranged in a very small area and in 2012 it amounted from 18 in Dratów lake to 20 in Krzczeń lake. In 2013 the numer was

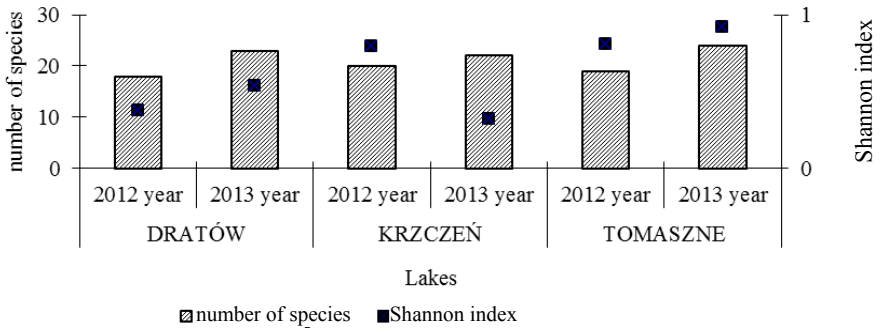


Fig. 2. Number of species and Shannon index for planktonic rotifers in the lakes: Dratów, Krzczeń, Tomaszne in the years 2012 and 2013

was slightly higher, since it ranged from 22 in Krzczeń lake to 24 in Tomaszne lake (Fig. 2).

Species diversity of planktonic rotifers in the analyzed lakes was slightly different, regarding species richness. The Shannon-Wiener index revealed its highest values in Tomaszne lake, where it amounted to 0.81 in 2012, while in 2013 its value was at the level of 0.92. In Krzczeń lake it was 0.79 in 2012, yet a year later species diversity was twice lower, 0.32. The lowest values of species richness were noted in the biggest lake, Dratów, from 0.37 to 0.53 (Fig. 2). According to the previous studies, this particular lake has been characterized by low species diversity of planktonic rotifers since the time of its becoming a part of the water system of Wieprz-Krzna Canal [Radwan 1973]. Such regularity has been related by many researchers with improved fertility of the water in the lake, following its connection with river waters [Bielańska-Grajner 1987, Radwan *et al.* 1988, Paleolog *et al*. 1997, Imai Akio *et al*. 2001, Demetraki-Paleolog 2007]. In case of Dratów lake, river waters are delivered to it by menas of Wieprz--Krzna Canal at the amount higher than to the remaining lakes [Solis 2012].

No species that would be uncommon in the fauna of Poland were noted in the studied lakes. However, some indicatory species were observed. The most abundant group was eutrophobionts. There were 5 of them in Dratów lake and 3–4 in the remaining lakes. Indicatory species of oligotrophy were scarce. They were found only in Krzczeń and Tomaszne lakes, at the amount of 1–2.

## 2. Quantitative structure

The highest rotifer density was recorded in the big, shallow, eutrophic lake of Krzczeń and in the most abundant in water, also eutrophic lake of Dratów. In Krzczeń the rotifer density ranged from 233 ind. $dm^{-3}$ in 2012 roku to 854 ind. $dm^{-3}$

in 2013, while in Dratów it was from 494 ind. $dm^{-3}$ in 2013 to 627 ind. $dm^{-3}$ in 2012. The much smaller lake of Tomaszne revealed the lowest rotifer density ranging from 75 to 93 ind. $dm^{-3}$ (Fig. 3). All the differences in rotifer density between particular lakes were statistically significant. Similarly, the differences in rotifer density between particular study years were statistically significant, except for the difference between 2012 and 2013 in Tomaszne lake.

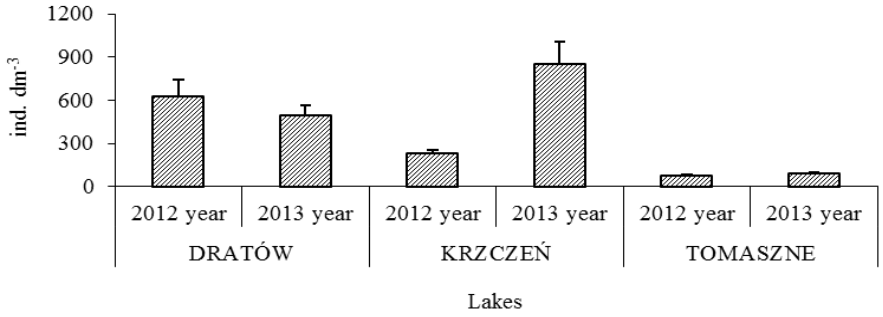


Fig. 3. Planktonic rotifer density (+SD) in the lakes: Dratów, Krzczeń, Tomaszne in the years 2012 and 2013

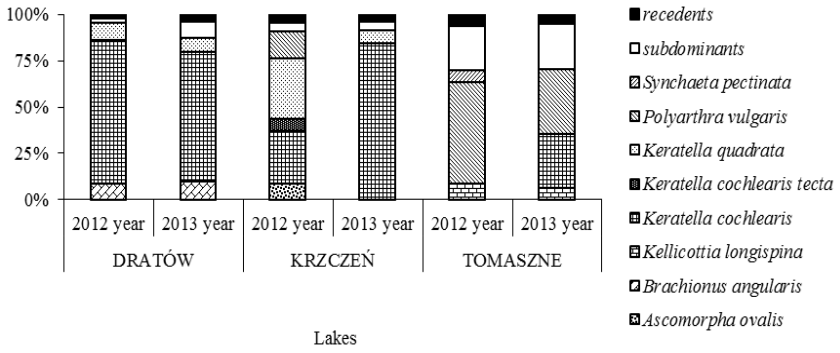


Fig. 4. Domination structure of planktonic rotifers (%) in the lakes: Dratów, Krzczeń, Tomaszne in the years 2012 and 2013

The dominating species were common rotifers. The dominants included *Keratella cochlearis. Keratella quadrata* and *Brachionus angulasria* in Dratów lake, *Keratella quadrata Keratella cochlearis, Keratella cochlearis tecta, Polyarthra vulgaris* and *Ascomorpha ovalis* in Krzczeń lake, *Kellicottia longispina, Keratella cochlearis, Polyarthra vulgaris* and *Synchaeta pectinata* in Tomaszne lake (Fig 4). 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 recendts), at least three of the species represent dominants and none of them exceeds a 45% share of their total numer. Following such a criterion, the domination structure of planktonic rotifers was sustainable only in Krzczeń lake in 2012 and in Tomaszne lake in 2013. In the remaining cases one of the criteria determining sustainability was not fulfilled, namely the main dominant exceeded the 45% share in the total numer of rotifers (Fig. 4). A sustainable domination structure may indicate a higher ecological status of the reservoir and a relatively low trophy of its waters [Bielańska-Grajner 2005]. Despite frequently noted non-sustainable domination structure of planktonic rotifers, inflowing river waters and the eutrophic character of these lakes [Radwan 1973, Pawlik-Skowrońska *et al*. 2014] the populations of *Keratelli cochlearis* in these lakes did not reveal a high share of the *tecta* form. Such a high share of the *tecta* is often considered as an important key indicator of high fertility of water [Karabin and Ejsmont-Karabin 1996, Radwan *et al.* 2004].

## 3. Classification of rotifer assemblages

A cluster analysis of planktonic rotifer assemblages in the three lakes, performed on the basis of their quntitative composition suggests that planktonic rotifer assemblages occurring in different periods in a particular lake are much more similar to one another than planktonic rotifer assemblages inhabiting different lakes (Fig. 5). The highest degree of similarity was observed in rotifer

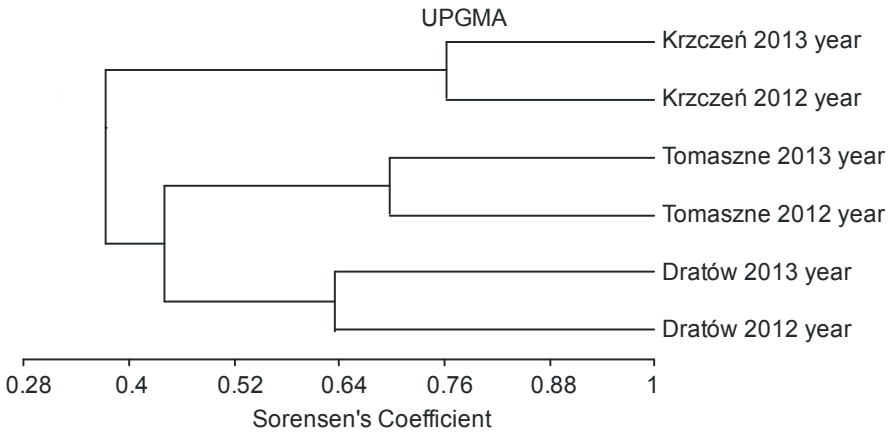


Fig. 5. Similarity structure of planktonic rotifer assemblages, based on their quantity composition in the lakes: Dratów, Krzczeń, Tomaszne in the years 2012 and 2013

assemblages inhabiting Krzczeń lake in different years, with Sorensen's coefficient of 0.78. In case of Dratów and Tomaszne lakes the values were 0.70 and 0.64, respectively. Significantly higher faunistic differences were observed between planktonic rotifer assemblages inhabiting different lakes. Sorensen's coefficient for rotifer assemblages in Dratów and Krzczeń lakes was 0.44, whereas for Tomaszne and Krzczeń lakes it was as low as 0.36. The analysis suggests that linking the studied lakes by means of a canal did not have a significant effect on the similarity regarding the species composition of planktonic rotifers in these lakes. Such reasoning results from the fact that the lakes connected with the longest section of the canal (Tomaszne and Dratów) are inhabited by rotifer assemblages which are more similar to each other than those found in the lakes linked by a much shorter fragment of the canal (Krzczeń and Dratów). Apparently, geological environment, the type of the nearest catchment area and some other factors have a bigger effect on the species composition and domination structure of rotifers than connecting the lakes with the canal. Numerous works point at the dominating effect of the catchment area and the ground in shaping the qualitative and quantitative structure of the plankton [Radwan 1973, Żurek 1982, Walsh *et al*. 2005, Van Egeren *et al*. 2011]. The faunistic similarities between rotifer assemblages inhabiting a particular lake at different periods (from 0.64 to 0.74), which are listed here, were not very significant when compared with similarities observed in other lakes and ponds of Łęczyńsko-Włodawskie Lakeland [Demetraki-Paleolog and Sender 2013, Demetraki-Paleolog 2013, Demetraki-Paleolog *at al*. 2014, Demetraki-Paleolog and Kolejko 2014].

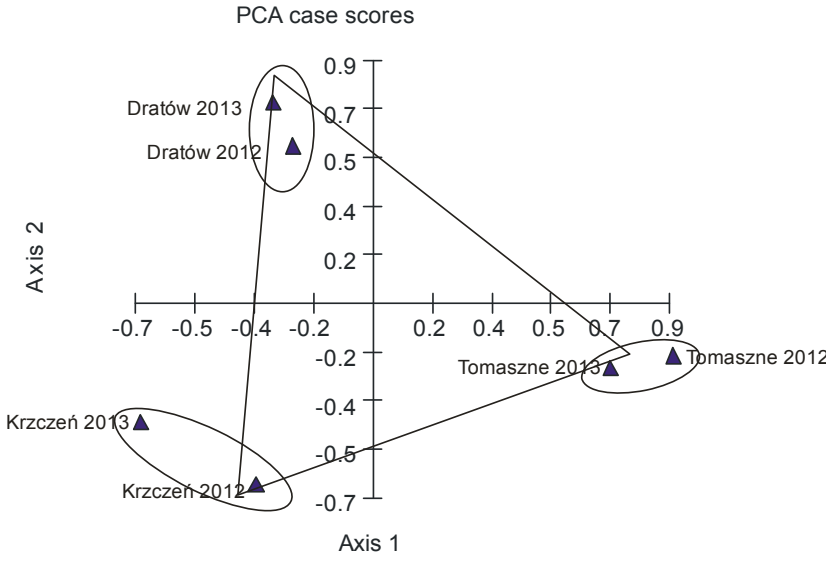


Fig. 6. Principal Components Analysis of planktonic rotifers in the lakes: Dratów, Krzczeń, Tomaszne in the years 2012 and 2013

In order to eliminate the influence of some chance species on the picture of faunistic similarities between the assemblages of planktonic rotifers, the Principle Components Analysis, PCA, was performed, additionally. The analysis showed that axis 1 accounts for the changing diversity of rotifer assemblages in 46.7%, while axis 2 does this in 34.9%. Both axes therefore explain the variability to a very high degree, namely 81.6%. The obtained results are very coherent with the cluster analysis presented above (Fig. 5 and 6). It can be clearly noticed that the highest similarity occurred between rotifer assemblages inhabiting the same lake in different years. Rotifer assemblages inhabiting different eutrophic lakes, even if the latter were linked by the canal, revealed significant differences. The degree of faunistic diversification calculated on the basis of PCA is presented graphically in Fig. 6. Similarity of rotifer assemblages on the graph seems to be almost in conformity with the angles of a large equilateral triangle, which means that faunistic diversification of these lakes was quite significant and it was similarly significant for all the lakes compared. In other words, lakes connected by a short or a long section of the canal were faunistically diversified to a similar degree. This confirms the fact that geological environment , type of the nearest catchment and the type of its management, as well as other similar factors, have a bigger effect on the species composition and domination structure of rotifers than the fact of linking the lakes with the canal.

## CONCLUSIONS

1. Fifty species of planktonic rotifers were found in the three lakes, including 5 species of indicatory autrophs and 2 indicatory species of oligotrophs.
2. Species richness was at a similar level in in all the three lakes, while species diversity was much higher in Tomaszne lake, as compared with the remaining ones.
3. The dominants included common common species of *Keratella cochlearis, Keratella cochlearis tecta, Keratella quadrata, Polyartchra vulgaris, Kellicottia longispina, Brachionus angularis, Ascomorpha ovalis, Synchaeta pectinata.* Only in Krzczeń in 2012 and in Tomaszne in 2013 the domination structure of rotifers was sustainable.
4. The character of rotifer assemblages suggests a high faunistic similarity of the rotifers inhabiting a particular lake in different years, as well as a significant faunistic diversification occurring between the lakes compared in the study.
5. The cluster analysis and PCA showed that linking the lakes by means of Wieprz-Krzna canal and the scale of water exchange between these lakes does not significantly affect faunistic similarity of these reservoirs.

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## STOPIEŃ PODOBIEŃSTWA FAUNISTYCZNEGO ZGRUPOWAŃ WROTKÓW PLANKTONOWYCH W TRZECH JEZIORACH POŁĄCZONYCH KANAŁEM WIEPRZ-KRZNA (WSCHODNIA POLSKA)

**Streszczenie.** Dratów, Krzczeń i Tomaszne należą do bardzo cennych przyrodniczo jezior Polski i Pojezierza Łęczyńsko-Włodawskiego. Są one płytkimi zbiornikami eutroficznymi o różnej powierzchni lustra wody. Ich cechą wspólną jest połączenie kanałem Wieprz-Krzna. Głównym celem badań było określenie stopnia podobieństwa faunistycznego wrotków planktonowych zasiedlających te jeziora. Autorów ciekawiło, czy połączenie kanałem i aktualnie stosowana wymiana wody może mieć wpływ na stopień podobieństwa faunistycznego występujący między tymi jeziorami. Badania fizyko-chemiczne i badania wrotków planktonowych prowadzono wiosną, latem i jesienią 2012 i 2013 roku. Przeprowadzono w nich badania nad składem jakościowym i zagęszczeniem wrotków planktonowych. Badania te pozwoliły na stwierdzenie 50 gatunków *Rotifera* o zagęszczeniu wahającym się w szerokim zakresie od 75 do 855 ind. $dm^{-3}$. Wśród dominantów znalazły się pospolite gatunki: *Keratella cochlearis, Keratella cochlearis tecta, Keratella*

*quadrata, Polyarthra vulgaris, Kellicottia longispina, Brachionus angularis, Ascomorpha odalis* i *Synchaeta pectinata.* Badania wykazały duże podobieństwo faunistyczne zgrupowań wrotków zasiedlających dane jezioro w różnych latach i znaczne zróżnicowanie występujące pomiędzy porównywanymi jeziorami. Przeprowadzone analizy wykazały, że połączenie jezior kanałem Wieprz-Krzna nie wpływa w znaczący sposób na upodobnienie się faunistyczne tych zbiorników do siebie.

**Słowa kluczowe:** jezioro Dratów, jezioro Krzczeń, jezioro Tomaszne, różnorodność biologiczna, wrotki planktonowe, podobieństwo faunistyczne