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## LONG-TERM CHANGES IN PLANKTONIC ROTIFER ASSEMBLAGES IN THE PONDS OF "LASZ JANOWSKIE" LANDSCAPE PARK

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**Abstract.** One of the most interesting and relatively little-known water ecosystems of "Lasy Janowskie" Natural Landscape Park is its old ponds which have been in most cases excluded from intensive fisheries for many decades. Four of them were studied in 1996, 2005 and 2013, regarding their planktonic rotifer assemblages. The total of 60 rotifer taxa were observed in the plankton. The number of their species in individual reservoirs ranged from 7 to 21, while their density amounted to 33–775 ind. dm<sup>-3</sup>. As many as 21 of the species observed in individual water bodies and study periods belonged to dominants. While watching the changes occurring in the plankton during the period of 17 years, we were trying to determine which of those tiny reservoirs were inhabited by more sustainable rotifer assemblages and which ecological qualities were more closely related to such sustainability: species richness, its diversity, density, bio-mass, composition or domination structure. The results of the studies revealed slight variability of ecological properties in planktonic rotifer assemblages in the ponds composing large reservoir groups, and significantly higher variability of those qualities in "single" ponds, not belonging to large complexes.

**Key words:** ponds, planktonic rotifers, Landscape Park "Lasy Janowskie"

### INTRODUCTION

The Landscape Park of "Lasy Janowskie" is rich in tiny water reservoirs and rivers. They include some clearly diversified ponds: the unique pond of Imielty Lug, which is of high scientific value and is protected as a reservation area, the dystrophic ponds of Wilczow and Witold, not regarded as a protected area, and a large complex of slightly boggy ponds of Momoty Gorne (Fig. 1) remaining under heavy pressure of fisheries.

The rotifers found there provide good research material as they constitute the basic component of small zooplankton [Radwan 1974]. Consuming bacteria,

algae, protozoa and dead organic matter, they play a significant role in the trophodynamics of these ecosystems, and they inhabit them relatively early [Hilbricht-Ilkowska 1964, Radwan 1973, Arndt 1993]. Some of them may become good indicators of water fertility and purity [Karabin 1985, Radwan *et al.* 1988, Paleolog *et al.* 1997].

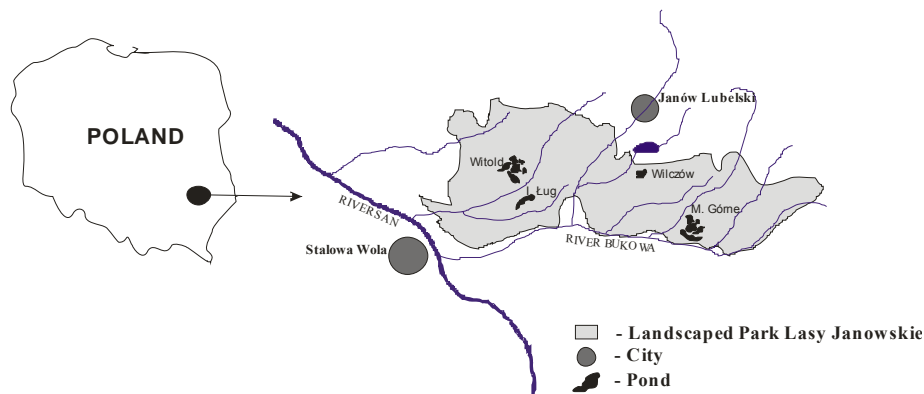


Fig. 1. The map of the study area

Studies were initiated in order to determine the ecological profile of these highly diversified ponds, as well as to describe the dynamics of changes in planktonic rotifer assemblages during the period of 17 years. The work aimed at determining the degree of sustainability among planktonic rotifer assemblages inhabiting the ponds of "Lasy Janowskie" Landscape Park, to see if sustainability was similar in all the analysed reservoirs and whether it referred to all, or only to some of the ecological qualities of rotifer assemblages.

#### STUDY AREA

The Natural Landscape Park of "Lasy Janowskie", situated on Rownina Bilgorajska (Bilgoraj Plain), was founded in 1978. It covers a large woodland area dominated by pine forests (85%) and is abundant in a dense network of rivers, canals and ditches [Paleolog *et al.* 1997]. There are vast swamps and peat-bogs here, as well as groups of morphologically diversified ponds (Fig. 1). Two of the four reservoirs studied, namely the dystrophic pond called Witold and the pond of Momoty Gorne remaining under fisheries pressure, are reservoirs composing large pond complexes covering the areas of 89 ha and 129 ha. On the other hand, the unique pond of Imielty Lug covered by reservation protection law and the pond of Wilczow, not protected, are large, single, dystrophic reservoirs, not included in any complexes, with the area of nearly 50 ha each [Paleolog *et al.* 1997]. For many years the reservoirs have been excluded from

fisheries. Morphologically, they resemble natural reservoirs with well-developed littoral rich in macrophytes. Their dykes are very wide, with gently sloping edges and they are typically covered by shrubs and bushes, sometimes even by woods. It is only at the complex of Momoty Gorne ponds that intensive fisheries had been initiated long before the study started. The catchment areas include dykes, reeds, swamps, peat-bogs, trees, shrubs and the dominating woodland areas.

Table 1. Physical and chemical parameters of the waters in the ponds of the Landscaped Park "Lasy Janowskie" – mean values in the year 1997 [Paleolog *et al.* 1997]

Parameter of water	Ponds			
	Witold	Wilczów	Imielty Ług	Momoty Górne
Temperature °C	21.5 ±1.8	22.3 ±2.1	21.8 ±1.7	20.9 ±1.8
pH	6.88 ±0.11	5.80 ±0.28	6.79 ±0.07	7.05 ±1.10
Conductivity $\mu\text{S cm}^{-2}$	185.0 ±18.1	123.0 ±15.9	126.0 ±22.8	587.0 ±98.2
O <sub>2</sub> mg dm <sup>-3</sup>	8.3 ±2.2	7.6 ±1.8	7.9 ±2.1	9.3 ±3.1
P-PO <sub>4</sub> mg dm <sup>-3</sup>	0.005 ±0.003	0.026 ±0.021	0.026 ±0.019	0.019 ±0.011
Total P mg dm <sup>-3</sup>	0.105 ±0.11	0.055 ±0.28	0.235 ±0.07	0.095 ±1.10
N-NO <sub>3</sub> mg dm <sup>-3</sup>	0.105 ±0.038	0.105 ±0.045	0.282 ±0.089	0.305 ±0.099
N-NH <sub>4</sub> mg dm <sup>-3</sup>	0.326 ±0.120	0.364 ±0.151	0.576 ±0.089	0.185 ±0.023

The waters of the ponds in "Lasy Janowskie" Landscape Park were characterized by low mineralization degree, acidic reaction (with the exception of Momoty Gorne), high level of organic matter concentration, and low oxygenation (Table 1).

#### MATERIALS AND METHODS

The biological material was sampled in the spring and autumn of 1996, 2005 and 2013. The study included four ponds. Two of them, Witold and Momoty Gorne, belonged to large water complexes, while the other two, Imielty Ług and Wilczow, existed individually. At each period the plankton from each reservoir was sieved in three replications. The samples were collected by taking 10 dm<sup>3</sup> of water with the use of "Toń II" sampler at the depth of 0.5 m. The water collected in this way was sieved through a planktonic net no. 25 and condensed to the constant volume of 100 cm<sup>3</sup>. The samples were preserved with Lugol's liquid and 4% formaldehyde and glycerine solution. Planktonic species of rotifers were determined and counted in the preserved samples. In order to verify the regularity of all the variables the Shapiro-Wilk test was used. The significance of differences in the density and biomass of rotifers among individual reservoirs and study periods was studied with the use of Kruskal-Wallis non-parametric rang ANOVA test in SAS. Similarity of rotifer communities studied in the individual ecosystems and study periods was determined by means of the Jaccard index with the cluster method using Multi Variate Statistical Package – MVSP-3.1. The analysis of similarities was performed with the help of Un-

weighted Pair-Group Method Using Arithmetic Averages – UPGMA. To interpret the results, we calculated the index of rotifer domination and determined the sustainability of domination structure [Bielańska-Grajner 2005]. Also, wet biomass of planktonic rotifers was calculated in WW  $\mu\text{g dm}^{-3}$  [Ejsmont-Karabin 1998] and the Shannon index was identified.

## RESULTS AND DISCUSSION

The four ponds studied revealed the presence of 60 rotifer taxa. Their highest abundance was noted at the site belonging to the reservation area, the dystrophic pond of Imielty Lug (51 taxa). Another dystrophic pond of Wilczow revealed only 27 taxa, while the reservoirs forming larger pond complexes, Witold and Momoty Gorne, were inhabited by only 17 taxa each, during the whole study period. To compare, other ponds in Europe and all over the world revealed in most cases similar species abundance [Radwan 1974, Kowalczyk *et al.* 1985, Demetraki-Paleolog 2002, Skowronek *et al.* 2012, Tayade 2013], or lower values [Hilbricht-Ilkowska 1964, Kyselowa 1973, Fereńska 1974, Sulehria *et al.* 2012]. Species abundance of rotifers in the four analyzed ponds was a relatively stable value, as it remained at a similar level in 1996, 2005 and 2013. Its highest values were always recorded in the pond of Imielty Lug (19 to 21 species), while the lowest numbers were noted in Wilczow (7 to 11 species). In the ponds belonging to larger reservoir complexes, namely the ponds of Witold and Momoty Gorne, the differences were even smaller (from 12 to 14 species) (Fig. 2). Species diversity expressed with the Shannon index was slightly different than species abundance. In the pond of Imielty Lug the former reached high values in 2005 and 2013, yet earlier it was lower than in the pond of Momoty Gorne (Fig. 2) In Wilczow the Shannon index and species abundance were initially low, yet in

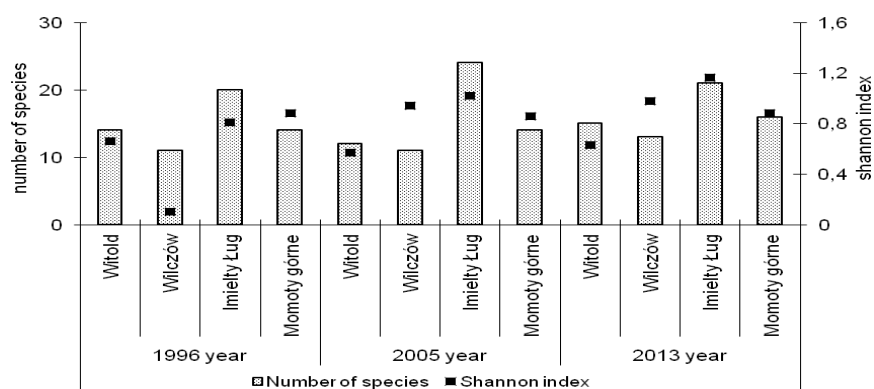


Fig. 2. Number of species and Shannon index for planktonic rotifers in the ponds of the Landscaped Park “Lasy Janowskie” in the years 1996, 2005 and 2013

2005 and 2013 they were at a significantly higher level and reached the values higher than in the remaining ponds analyzed here. It may be thus concluded that, except for the pond of Wilczow, the Shannon index was a stable value, fluctuating within a narrow range in the course of the study (Fig. 2). The literature does not offer many references regarding long-term stability of the Shannon index calculated for rotifers inhabiting the ponds of other regions in Poland and Europe. To compare, three ponds of Poleski National Park, which, unlike the ponds of "Lasy Janowskie" Landscape Park, did not have dystrophic character, revealed much higher differences regarding their species richness [Demetraki-Paleolog 2014].

The density of rotifer plankton was rather low and characteristic of poor and medium-fertile waters. Its highest values of 573 and 775 ind. dm<sup>-3</sup> were recorded in the ponds of Wilczow and Imielty Lug in 1996. Those values were not stable, since in 2005 and 2013 they dropped significantly and ranged from 32 to 82 ind. dm<sup>-3</sup> (Fig. 3). In the ponds composing larger water complexes, namely Witold and Momoty Gorne, the number of planktonic rotifers was much more stable as it ranged from 272 to 374 ind. dm<sup>-3</sup> (Fig. 3). Similarly low density of planktonic rotifers was recorded in other reservoirs of this type [Demetraki-Paleolog 2010, Ortega-Mayagoita and Armengol-Rojo 2000]. Differences in rotifer density observed in ponds in different years of the study are statistically significant, except for the differences in density noted in Momoty Gorne and in Witold between 2005 and 2013. In the majority of other ponds authors observed higher or significantly higher rotifer density [Bielańska-Grajner and Kłos 2002, Skowronek *et al.* 2012, Sulehria *et al.* 2012]. The biomass of planktonic rotifers in the studied ponds of "Lasy Janowskie" Landscape Park was in most cases insignificant and its value was similar, at a comparable level of stability, significance and abundance (Fig. 3). For the sake of comparison, three ponds of Poleski National Park, which, unlike the ponds of "Lasy Janowskie" Landscape Park did not have dystrophic character, revealed lower fluctuations in the abundance of planktonic rotifers in time. The biomass of planktonic rotifers, similarly to that in the ponds of "Lasy Janowskie" Landscape Park, was a value changing more significantly in time [Demetraki-Paleolog 2014]. Numerous authors claim that species composition of plankton may be significantly variable, yet the biomass remains stable. It should be noted, however, that the majority of such opinions is based on studying phytoplankton rather than zooplankton [Howeth and Leibold 2010, Jochimsen and Kümmerlin 2013].

Among the dominants of these small reservoirs, as many as 21 species of rotifers were found (35% of all the species identified). Many of them are common species (Fig. 4). Still, despite such a high number of dominating species, the sustainable domination structure was observed only in the pond of Momoty Gorne. The situation of balanced domination structure was recorded there during all the study periods. In the remaining ponds during all the study periods the domination structure was not balanced (Fig. 4). The criterion of the degree of domination sustainability among rotifers was adopted after Bielańska-Grajner [2005]. The author

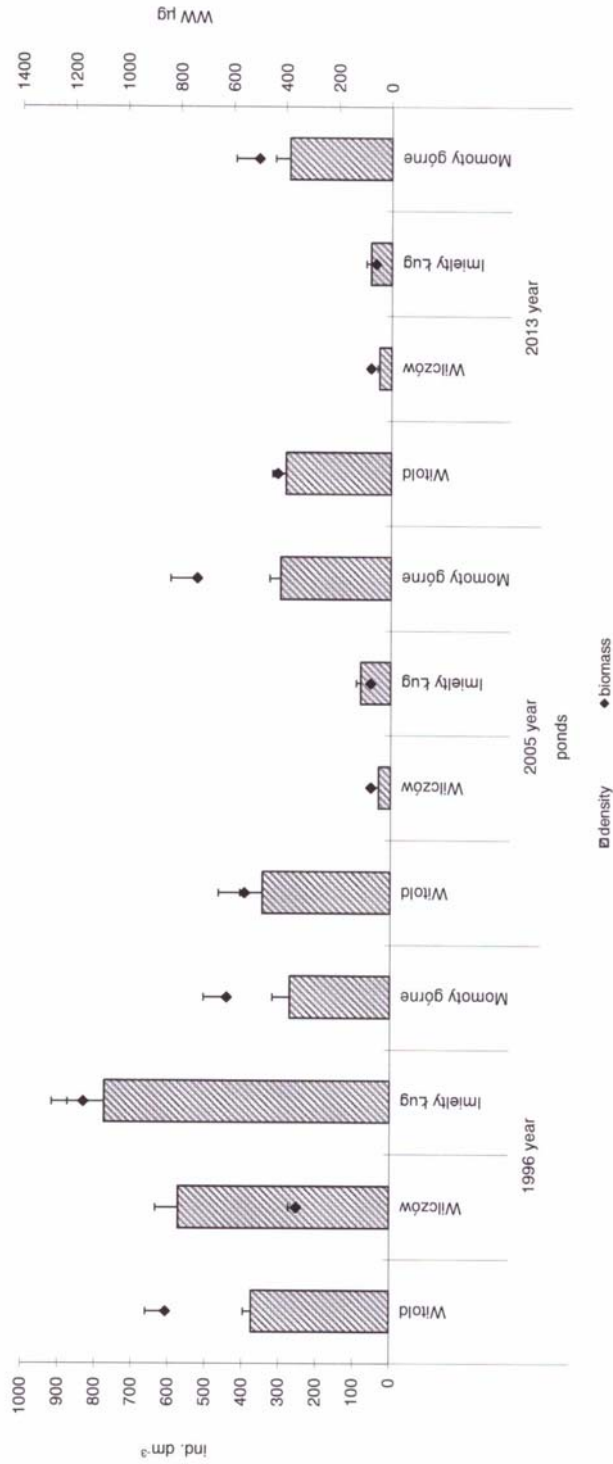


Fig. 3. Planktonic rotifer density and wet biomass (+SD) in the ponds of the Landscaped Park "Łasy Janowskie" in the years 1996, 2005, 2013

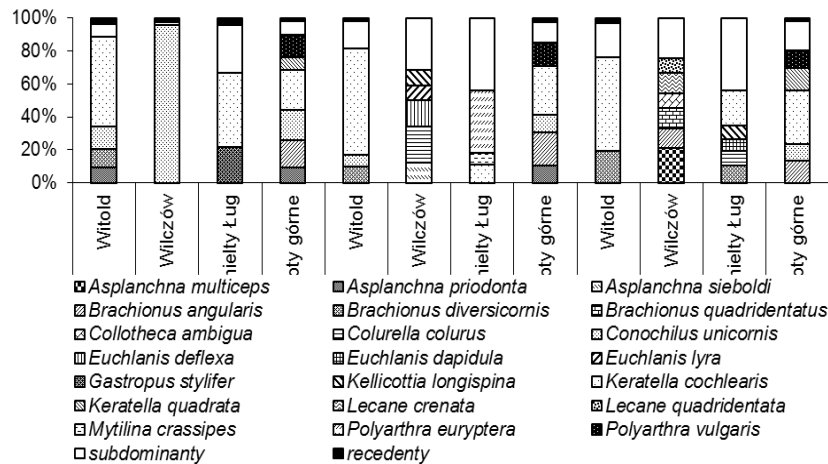


Fig. 4. Domination structure of planktonic rotifers (%) in the ponds of the Landscaped Park “Lasy Janowskie” in the years 1996, 2005 and 2013

treats an assemblage as sustainable when it includes all the three classes of domination (dominants, subdominants and recedents), at least three of the species belong to dominants and none of them exceeds the 45% share of their total abundance.

In order to analyze the degree of modifications occurring in time, regarding the species' composition and domination structure in the particular reservoirs the Serensen index was calculated to show the degree of faunistic similarity of different rotifer communities (Fig. 5). The cluster method revealed very high similarity among rotifer communities inhabiting the pond of Witold. The Serensen index determining similarity of rotifer communities in this particular pond amounted to 0.87 between 1996 and 2013, and between these years and 2005 it reached 0.76. Similarities of rotifer communities inhabiting Momoty Gorne were at an even higher level of 0.91 and 0.74 (Fig. 5). Such low dynamics of changeability within the communities of small plankton may result from the nature of Witold and Momoty Gorne. Both reservoirs, unlike the remaining ones, are situated in larger pond complexes. Similarly low changeability in plankton communities in a long-term period was observed in large water-reservoir complexes of Poleski National Park in south-eastern Poland [Demetraki-Paleolog 2014].

The dynamics of rotifer communities in the two remaining ponds of “Lasy Janowskie” Landscape Park, not belonging to large water complexes, looked different. Rotifer communities observed there were significantly different from groups inhabiting the same reservoirs at a different time. The Serensen index defining similarity between rotifer communities in different years in the pond of Wilczow amounted to 0.18–0.22, while the value for Imielty Ług ranged from 0.18 to 0.19 (Fig. 5).

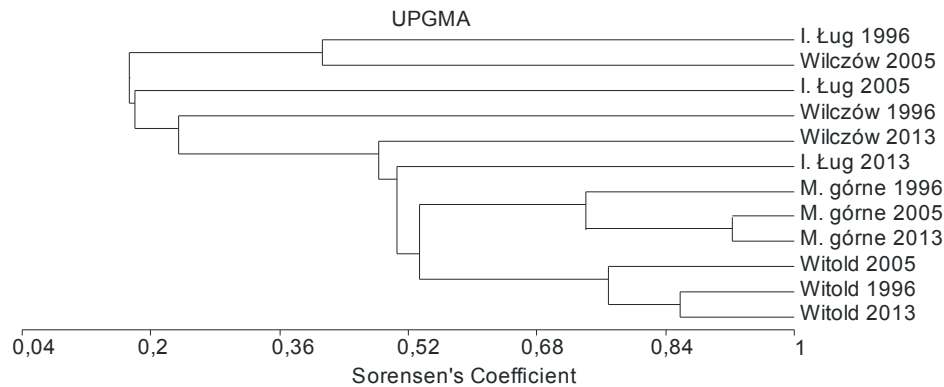


Fig. 5. Similarity structure of planktonic rotifer assemblages, based on their quantity composition in the ponds of the Landscaped Park "Lasy Janowskie" in the years 1996, 2005 and 2013

Many authors claim that lower community sustainability is related to their poor species diversity [Niesler 2001]. The present studies on planktonic rotifers have not confirmed this opinion as the lowest mean values of the Shannon index were recorded in Witold and Wilczow ponds (0.62 and 0.67, respectively), while the highest values were noted in Imielty Lug and Momoty Gorne (1.0 and 0.87, respectively). The highest sustainability of rotifer assemblages in time was observed in Witold and Momoty ponds, while its much lower value was observed in Wilczow and Imielty Lug. Similar studies performed in other Polish ponds and at a different time proved, however, that higher species diversity among rotifers may be related to higher sustainability of their communities [Demetraki-Paleolog 2014]. The reason for high sustainability of rotifer assemblages in Witold and Momoty Gorne ponds could be also their situation in large water complexes. Howeth and Leibold [2010] claims that the degree of sustainability may be determined according to the rate of species spread among local communities. The author quotes the example of a complex of closely situated ponds as the habitat for more stable meta-populations. This suggests that higher sustainability of rotifer communities (and thus preservation of their species diversity and conservation of rare species) is fostered by biocenoses including numerous meta-populations. Such a regularity among other hydrobionts is also mentioned in other studies [Howleth and Leibold 2010, Pinsky 2010].

## CONCLUSIONS

The analyzed ponds of „Lasy Janowskie” Landscape Park are valuable, often dystrophic ecosystems of tiny water reservoirs. They are not typically highly dominated by single species. The dominants include numerous, not necessarily common species. Low density of planktonic rotifers distinguishes these particular reservoirs from the majority of fish-breeding ponds. The studies revealed that:



1. There was little changeability in time regarding both species abundance and species diversity.
2. Sustainability of rotifer assemblages in the ponds of "Łasy Janowskie" Landscape Park is not clearly related to the degree of species diversity.
3. Planktonic rotifer assemblages were definitely more changeable in time in those reservoirs which were not situated within the area of large pond complexes.
4. Modifications regarding the biomass and abundance of planktonic rotifers in time varied, yet they were slightly more stable in the ponds belonging to large water complexes.

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#### WIELOLETNIE ZMIANY ZGRUPOWAŃ PLANKTONU WROTKOWEGO W STAWACH PARKU KRAJOBRAZOWEGO „LASY JANOWSKIE”

**Streszczenie.** Jednym z ciekawszych i mniej poznanych ekosystemów wodnych Parku Krajobrazowego „Lasy Janowskie” są stare stawy, zwykle od wielu dziesięcioleci wyłączone z intensywnej gospodarki rybackiej. W czterech z nich w 1996, 2005 i 2013 roku badano zgrupowania wrotków planktonowych. Łącznie w planktonie stwierdzono 60 taksonów wrotków. W poszczególnych zbiornikach i latach badań liczba ich gatunków wahała się od 7 do 21, a zagęszczenie od 33 do 775 osobn. dm<sup>-3</sup>. Aż 21 spośród stwierdzonych gatunków należało w poszczególnych zbiornikach i okresach badań do dominantów. Obserwując zmiany, jakie zachodziły w planktonie w okresie 17 lat, zastanawiano się, które z tych drobnych zbiorników są zasiedlane przez bardziej ulegające zmianom zgrupowania wrotków i jakich właściwości ekologicznych dotyczy w większym stopniu ta zmienność: bogactwa gatunkowego, różnorodności gatunkowej, zagęszczenia, biomasy, składu gatunkowego czy struktury dominacji. Wyniki badań wykazały niewielką zmienność cech ekologicznych zgrupowań wrotków planktonowych w stawach należących do dużych kompleksów stawowych oraz znacznie większą zmienność tych cech w stawach „samotnie” położonych – nienależących do dużych kompleksów stawowych.

**Słowa kluczowe:** stawy, plankton wrotkowy, Park Krajobrazowy „Lasy Janowskie”