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Zooplankton of the Wisła-Czarne dam reservoir before and after experimental alkalisation of its tributaries

Zooplankton zbiornika zaporowego Wisła-Czarne przed i po doświadczalnej alkalizacji jego dopływów

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Abstract: The present study was designed to analyse the species composition and the abundance of zooplankton in the dam reservoir as periodically influenced by strongly acidified waters. An attempt has been made to neutralise the acidic waters in the tributary by depositing dolomite over the stream bed. This procedure did result in an increase in zooplankton abundance (mainly of *Ceriodaphnia quadrangula* and *Bosmina longirostris*), but not before 10 months had passed since application. A relationship between dolomite application and an increase in zooplankton abundance should be considered with caution since an equally high zooplankton abundance was noted once before dolomite use. Further studies should show if this relationship really exists and whether the observed increase is permanent.

In the same period of time, the size structure of *Ceriodaphnia quadrangula*, based on measurements of carapax length, was different at each station in the dam reservoir. Differences in mean dry mass, however, were insignificant.

Key words: zooplankton, dam reservoirs, liming.

Treść: Badania miały na celu analizę składu gatunkowego i liczebności zooplanktonu w zbiorniku zaporowym okresowo poddawanym wpływowi silnie zakwaszonych wód potokowych. W części doświadczalnej podjęto próbę zalkalizowania kwaśnych wód przy pomocy dolomitu rozsypanego w korytach potoków. Działania te spowodowały wzrost ilości zooplanktonu (głównie *Ceriodaphnia quadrangula* i *Bosmina longirostris*) po około 10 miesiącach od zabiegu. Należy jednak ostrożnie interpretować związek między wzrostem ilości zooplanktonu a dolomitowaniem, gdyż przed tym zabiegiem jednorazowo stwierdzono również wysoką liczebność zooplanktonu. Dalsze studia powinny wykazać, czy ten związek rzeczywiście istnieje i czy wzrost ma charakter trwały.

Analizowano także strukturę wielkościową *Ceriodaphnia quadrangula*, w oparciu o długość karapaksu, która była różna na poszczególnych stanowiskach, lecz niezależnie od tego średnia sucha masa populacji z różnych stanowisk nie różniła się w sposób istotny.

1. Introduction

Zooplankton in the Wisła-Czarne dam reservoir has been thoroughly studied in the ten-year period from its construction in 1975 until 1984 by Krzanowski (1987), who observed the highest zooplankton abundance (up to 400 individuals per dm^3) and species diversity in the first four years of reservoir's operation. Later, species composition stabilised at a low level of species variety: 7–9 species of rotifers, 3–4 species of cladocerans and 1 copepod species. No information is available on development of biocenoses in the reservoir in the following 10 years. As a matter of fact, only periodically disadvantageous changes in water quality (strong acidification), which were aggravated in recent years, prompted studies on the present state of the reservoir (1993) and inspired attempts to improve the quality of water flowing into the dam reservoir through dolomite application. The influence of dolomite application on the dam reservoir was studied in 1993 and 1994.

2. Methods and study area

The Wisła-Czarne dam reservoir serves as a drinking water supply for towns and villages situated beneath the dam. It has been constructed at the confluence of the Biała Wisełka and Czarna Wisełka. The catchements of both streams are mainly covered by spruce forest. The height of the surrounding mountains reaches 1220 m a.s.l. (Mt. Barania Góra). At present, the altitude of the water level oscillates around 542 m. Its location is the highest of any dam reservoir in Poland.

The water pH at the mouth of the Czarna Wisełka sometimes even dropped to 3.6 (Wróbel 1998), while the water in the neighbouring Biała Wisełka was nearly neutral.

280 tons of dolomite gravel (40–80 mm in size) was poured into the Czarna Wisełka bed through a period from September until December, 1993.

Zooplankton samples were collected usually every month in the two vegetative seasons. Samples were collected at four stations – near the dam, in the Biała Wisełka bay, in the Czarna Wisełka bay and at reservoir's outlet below the dam (Fig. 1). A sample consisted of a filtrate of 50 dm^3 of water collected from an entire column of water or from a layer extending from the surface to a depth equal to twice the transparency of Secchi's disk. Water was filtered through a plankton net with 50 μm meshes. Samples were fixed with 4% formaline, and their qualitative and quantitative composition was determined upon laboratory conditions. Data was processed using SYSTAT® and Harvard Graphics® software.

3. Results

During a two-year study, the succession of rotifers and cladocerans, expressed in their quantitative proportions, was observed in the dam reservoir. Shifts in favour of rotifers or cladocerans occurred in an approximate two-month cycle. On some occasions (March 31, 1994) cladocerans were replaced by copepods (Fig. 2). At stations located near the mouths of Biała Wisełka and Czarna Wisełka, rotifers prevailed in the spring 1993, while cladocerans of *Bosmina* and *Ceriodaphnia* genera dominated in later dates. Total abundance was low at that time: approximately 40 individuals per dm^3. There were, however,

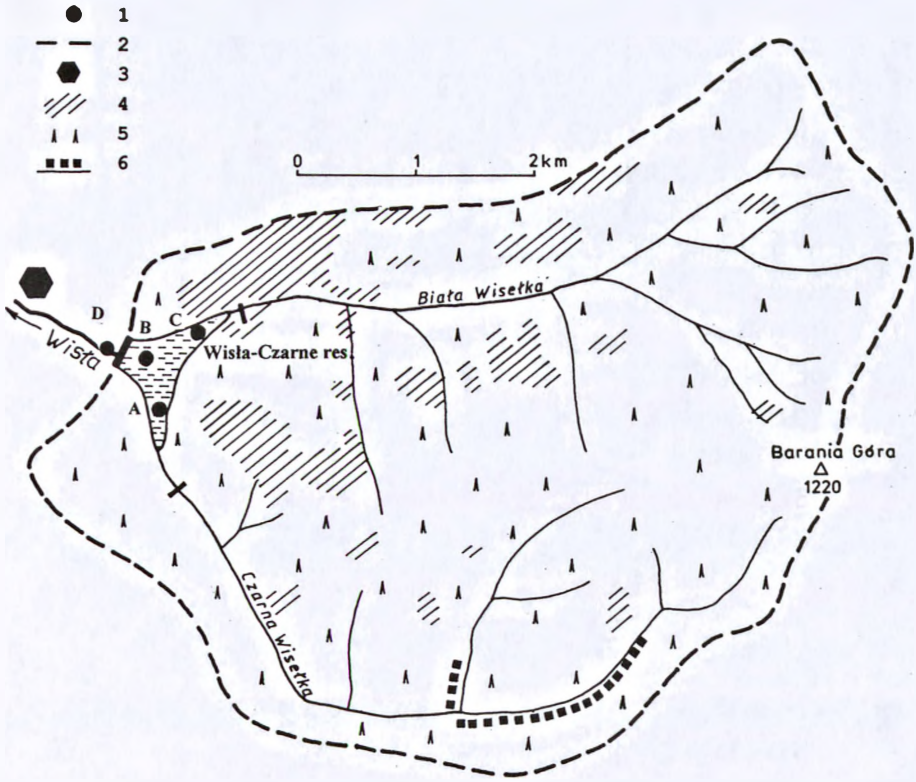

Fig. 1. Catchement area of the Wisła Czarne dam reservoir. 1 – stations: A – Czarna Wisełka bay, B – near the dam, C – Biała Wisełka bay, D – outflow, 2 – borderline of the catchment basin, 3 – hatchery, 4 – meadows and fields, 5 – forests, 6 – dolomiting zone.

Ryc. 1. Zlewnia zbiornika Wisła Czarne. 1 – stanowiska: A – zatoka Czarnej Wisełki, B – przy zaporze, C – zatoka Białej Wisełki, D – odpływ, 2 – granica zlewni, 3 – pstrągarnia, 4 – łąki i pola, 5 – lasy, 6 – strefa dolomitowania.

locations where zooplankton abundance was much higher, e.g. in the Biała Wisełka bay and near the dam. After dolomite application in the Czarna Wisełka, no significant changes in zooplankton composition and abundance were noted until midsummer, 1994. However, in the second half of summer, beginning in August, zooplankton abundance was considerably increased in both branches of the reservoir. At that time, the cladocerans dominated (> 90%), their abundance equalling 120 individuals per dm^3 – 3 times higher value than that noted in the previous period. The central part of the reservoir appeared poorer in zooplankton. In 1994, on average, the percentage share of copepods was nearly the same in both bays (Fig. 3). 10% less rotifers and 12% more cladocerans were observed in the Czarna Wisełka as compared to the Biała Wisełka bay. Abundances of the entire zooplankton population in the Czarna Wisełka bay were usually higher and more stable than in the neighbouring Biała Wisełka bay (Fig. 2).

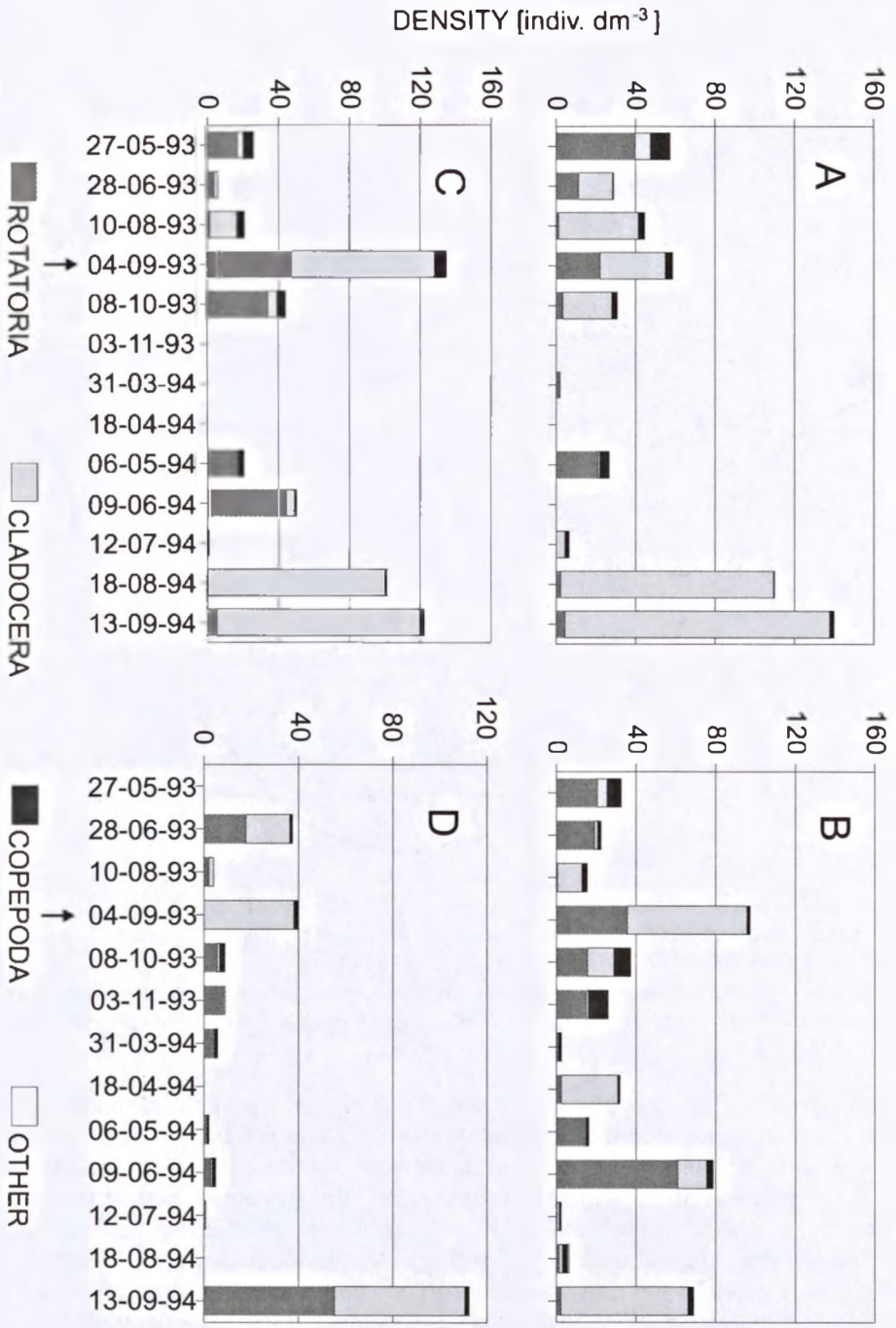

Fig. 2. Densities of rotifers, cladocerans and copepods. A, B, C, D – stations; see Fig. 1. Arrow denotes the date of first dolomite application.

Ryc. 2. Liczebności wrotków, wioślarek i widłonogów. A, B, C, D – stanowiska; por. Ryc. 1. Strzałka wskazuje datę pierwszego zastosowania dolomitu.

Zooplankton observed in the samples collected at the reservoir's outlet constituted only a low percentage of those found in the reservoir. Rotifers displayed a higher tendency towards washing out than cladocerans or copepods (Fig. 3).

In the period of the experiment, an increase in species diversity was noted. The number of species increased from 22 in 1984 and previous years (Krzanowski 1987) to the average of 36 at all stations in 1993/94 (see the list below).

List of planktonic species noted in the Wisła-Czarne dam reservoir

Lista gatunków zooplanktonowych znalezionych w zbiorniku Wisła-Czarne

Rotifera:
Ascomorpha saltans
Asplanchna priodonta
Brachionus angularis
B. calyciflorus
B. falcatus falcatus
B. quadridentatus
B. rubens
B. urceolaris urceolaris
Cephalodella gibba
Conochilus unicornis
Euchlanis sp.
Filinia longiseta
Keratella cochlearis cochlearis
K. cochlearis tecta
K. quadrata
Lecane closterocerca
L. stichaea stichaea
L. luna
L. lunaris
Pompholyx sulcata
Polyarthra vulgaris
P. dolichoptera
Synchaeta pectinata
S. oblonga
S. tremula
Trichocerca capucina

Cladocera:
Alona quadrangularis
A. rectangula
Alonella exigua
Bosmina longirostris
B. coregoni
Ceriodaphnia quadrangula
Daphnia longispina

Cyclopoida:
Cyclops vicinus

Calanoida:
Eudiaptomus gracilis

Harpacticoida:
Elaphoidella bidens

Others:
Hydracarina non det.
Ostracoda non det.

Cladocerans (*Daphnia longispina, Ceriodaphnia rectangula* and *Bosmina longirostris*) quantitatively prevailed in zooplankton. The two stations near the dam and in the Biała Wisełka bay showed the most similar characteristics, their common feature being a low variability of zooplankton abundance through the subsequent dates of sample collections.

The quantitative composition of zooplankton in the stream below the reservoir's outlet was entirely different in comparison with the station located near the dam. While practically no cladocerans were noted in the latter (June 28, 1993), in the former location, 20 individuals were found, constituting 50% of the entire sample. On the other date (September 1993), no rotifers were observed at reservoir's outlet while they were abundantly noted in the reservoir.

In the period of sampling, an appearance of *Planctococcus sphaerocystiformis* was observed in the alimentary canals of *Daphnia longispina* and *Ascomorpha saltans*. This species was probably not digested by daphnia – its colonies were found in the lower part of the intestine just before defecation.

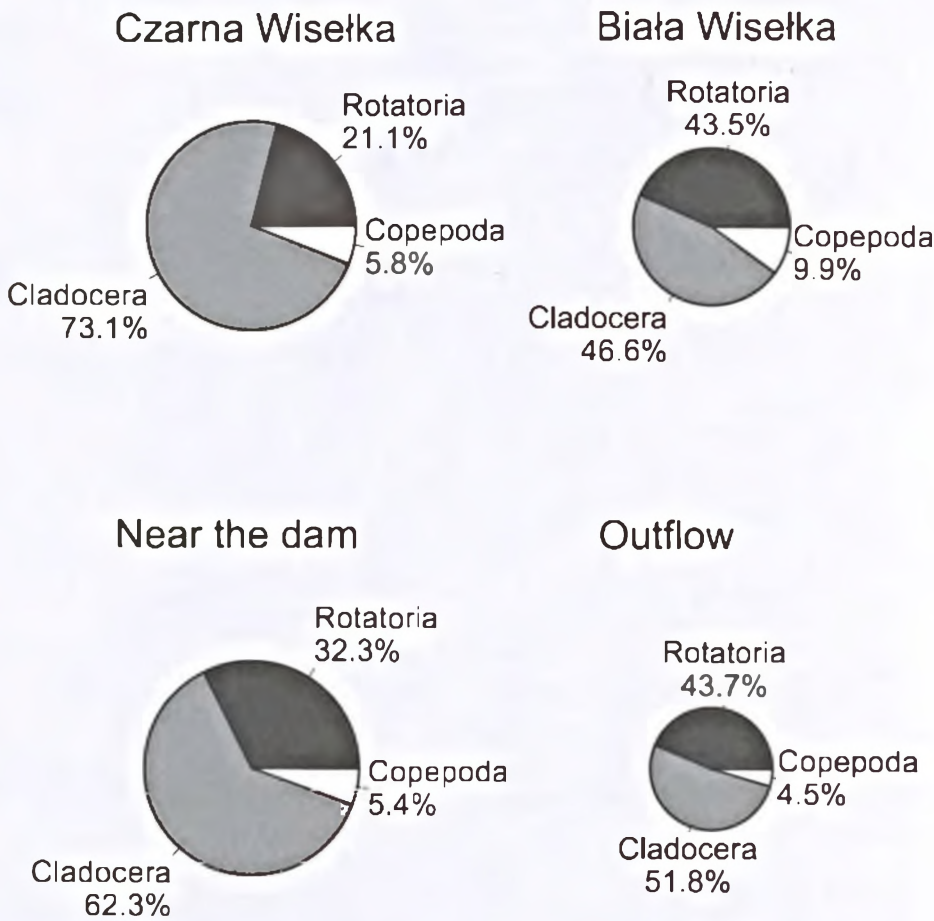

Fig. 3. Proportions between main planktonic groups. Sizes of circles are proportional to the mean densities from all sampling periods.

Ryc. 3. Proporcje między głównymi grupami planktonu. Wielkości kół są proporcjonalne do średnich zagęszczeń z całego okresu poboru prób.

The size structure of the *Ceriodaphnia quadrangula* population was analysed at three stations in the dam reservoir (Fig. 4). The animals' length ranged from 365 to 590 µm. Demographic structure was different in each part of the reservoir. Near the dam, individuals of three generations were considerably more abundant. In the Biała Wisełka bay, a transition of consecutive *Ceriodaphnia* generations to older age classes was accompanied with a low mortality which resulted in difficulties in distinguishing generations. As a consequence, a picture of the senescent population was obtained. In the Czarna Wisełka bay, only one generation prevailed (30%), while the other classes of size were less abundant (5%). Dry mass calculated at the region near the dam averaged 2.2 µg, for the Czarna Wisełka bay – 2.03 µg, and for the Biała Wisełka bay – 2.13 µg. Medians were 2.27, 2.14 and 2.20 µg, while the standard deviations were 0.56, 0.5 and 0.6, respectively.

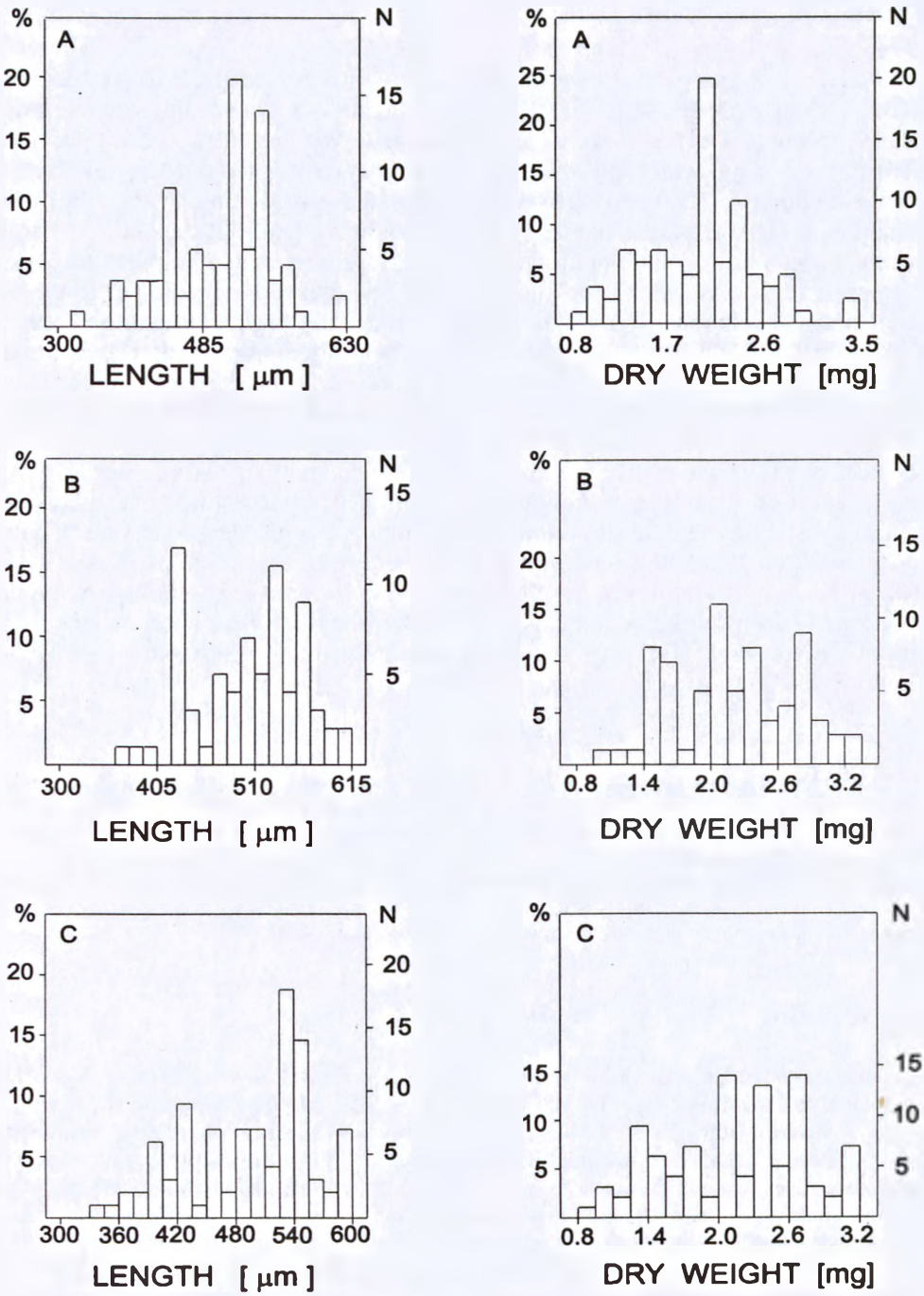

Fig. 4. Size structure and dry weight distribution of *Ceriodaphnia quadrangula* population in different parts of the reservoir. A, B, C – stations; see Fig 1.

Ryc. 4. Struktura rozmiarów i rozkład suchej masy populacji *Ceriodaphnia quadrangula* w różnych częściach zbiornika. A, B, C – stanowiska; por. Ryc. 1.

4. Discussion

Usually, the water pH value in the dam reservoir was beneficial for zooplankton, i.e. weakly basic. Only during the time of strong photosynthesis did it increase up to about 9. Decreases below 7 were rarely observed (Wróbel 1998). Periodically (i.e. after rainfalls or snow melting) the influx of acid water exerted only a slight influence on zooplankton. This may be explained by the observation that acidic inflow water runs under the water masses of the reservoir to its outlet located close to the bottom. An increase in zooplankton abundance approximately 10 months after dolomite application may be cautiously ascribed to the delayed influence of this procedure. Caution is also justified by the fact that an equally high zooplankton abundance was previously observed in a period before dolomite application. The evaluation as to whether an increase in zooplankton abundance in the dam will be permanent would be possible only after a continued monitoring in the future.

The analysis of the size structure of *Ceriodaphnia quadrangula* population showed that each part of the reservoir has an independent size structure of this species, in addition to a unique biomass distribution. It appears, however, that mean biomass, based on the determination of specimens' magnitude at one station can be used in ecological calculations. In the dam reservoir, the average masses of *Ceriodaphnia* at various stations were almost the same in a range of about 1/5 standard deviation. Therefore, they can be assumed to be identical. Size and dry weight distribution histograms (Fig. 4) showed the existence of a few separate cohorts (5–6) belonging to different generations.

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Streszczenie

W ciągu dwuletnich badań obserwowano zmiany udziału ilościowego wrotków i wioślarek w zooplanktonie zbiornika (Ryc. 1). Mniej więcej w rytmie 2 miesięcy następowały przesunięcia na korzyść wrotków lub wioślarek. Niekiedy (31 marzec 1994) wioślarki były zastępowane przez widłonogi (Ryc. 2). Stanowiska w pobliżu ujść Wiselek miały na wiosnę 1993 r. przewagę wrotków, potem zdecydowanie dominowały wioślarki z rodzaju *Bosmina* i *Ceriodaphnia*. Całkowita liczebność była wtedy niewielka: około 40 osobników na 1 dm^3, jakkolwiek zdarzały się miejsca, w których zooplanktonu było znacznie więcej. Po dolomitowaniu koryta Czarnej Wiselki, do połowy lata 1994 nie zauważono istotniejszych zmian w składzie zooplanktonu ani w jego liczebności. Dopiero w drugiej połowie lata, od sierpnia, zdecydowanie wzrosła liczebność zooplanktonu w obu ramionach zbiornika. Dominowały wioślarki (>90%). Liczebność wynosiła około 120 osobników w 1 dm^3, co było wartością około 3-krotnie wyższą niż w okresie poprzednim.

Porównanie z danymi wcześniejszymi wykazało wzrost różnorodności gatunkowej. Liczba gatunków wzrosła z 22 w roku 1984 i w latach poprzednich (Krzanowski 1987) do 36 w latach

1993–1994 na wszystkich stanowiskach zbiornikowych. W zooplanktonie występowała liczebnościowa przewaga wioślarek: *Daphnia longispina*, *Ceriodaphnia rectangula* i *Bosmina longirostris*.

Udział głównych taksonów zooplanktonu w zatoce Białej Wiselki, plosie zbiornika i w odpływie był bardzo podobny (Fig. 3). W zatoce Czarnej Wiselki największy udział miały wioślarki.

Struktura wielkości i suchej masy *Ceriodaphnia quadrangula* (Fig. 4) wskazuje, że lokalne populacje znajdowały się w różnej sytuacji demograficznej. Najmłodsza była populacja na stanowisku A, pozostałe stanowiska miały populacje o większym udziale osobników starszych.

W okresie licznego występowania zielenicy *Planctococcus sphaerocystiphormis*, obserwowano ją w przewodzie pokarmowym *Daphnia longispina* i *Ascomorpha saltans*. Prawdopodobnie gatunek ten nie był trawiony przez dafnie. Jego kolonie znajdowano w tylnej części jelita dafni, tuż przed defekacją.

Środowisko zbiornika ma zwykle korzystny odczyn wody, słabo alkaliczny. Niekiedy, w okresie silnej fotosyntezy, pH podnosi się do około 9. Bardzo rzadko spada też poniżej 7. Okresowe (po deszczach lub podczas tajania śniegu) dopływy kwaśnej wody miały niewielki wpływ na zooplankton. Kwaśna chłodna woda wślizguje się pod masy wody jeziora i przemieszcza się do dopływu znajdującego się przy dnie. Wzrost liczebności zooplanktonu po około 10 miesiącach od rozsypania dolomitu w korycie Czarnej Wiselki może być przypisany wpływowi dolomitowania.