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**Próba uchwycenia dobowych wędrówek zooplanktonu na podstawie dennego upustu wody w zbiorniku zaporowym w Goczałkowicach\***

**An attempt at determination of the daily migrations of the zooplankton on the basis of daily bottom water discharges in the dam reservoir at Goczałkowice**

Wpłynęło 4 listopada 1975 r.

**Abstract** — In 1972, in connection with the routine repair of damming installations, the water level of the Goczałkowice reservoir was lowered by about 1.5 m below the average exploitation levels. Since the water was discharged through the bottom sluice, an attempt was made on this basis to characterize the daily migrations of plankton animals in the part of the reservoir adjoining the dam.

The lowering of the reservoir level from the ordinate of 254.39 m above sea level was begun on 2nd June 1972 by a bottom discharge with a run-off force of 9.7 m<sup>3</sup>/sec. The lowest water level of 252.98 m above sea level was obtained on 20th August. Then, between 21st and 24th August, a sudden inflow of flood waters with the exceptional discharge force of 627 m<sup>3</sup>/sec resulted in the reservoir being completely filled on 22nd August. At the same time a long period of south-west winds began and this together with the flood made continuation of the investigation impossible.

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\* Praca została wykonana w ramach problemu węzłowego Nr 09.1.7.

## Method

The material was collected from the discharge water in runs of three consecutive days, initially every 3 or 4 hours. The analysis of the first runs collected showed that sampling at intervals of 6 hours was sufficient. Simultaneously with the sampling from the discharge water, on the second day of each run twenty-four hour samples were collected in the vertical in the part of the reservoir adjoining the sluice, in order to compare the vertical distribution of the zooplankton with the composition of animals flowing out of the reservoir at particular times during the day.

The first run of samples was collected on 5th, 6th, and 7th June at a water level of 254.28 m above sea level and run-off force of 12.1 m<sup>3</sup>/sec, the weather being fairly windless. In this period the temperature of the water was between 19.5°C on 5th June and 21.3°C on 7th June. The next run of samples was collected on 7th, 8th, and 9th July in almost windless weather, the level of the reservoir being 254.37 m above sea level, and the run-off increased to 16.4 m<sup>3</sup>/sec. The water was already warmer, its temperature ranging from 22.3—23.2°C. The last run of samples was collected on 1st, 2nd, and 3rd August at the lowest level of the reservoir, 253.72 m above sea level, and the greatest water outflow of 23.8 m<sup>3</sup>/sec. The weather being windless, the water temperature was constant and amounted to 23.2°C.

In the period of investigation (from 5th June to 3rd August) a total amount of 56 132 thousand cubic metres of water was discharged from the reservoir, the maximum daily outflow being 2 056 thousand cubic metres.

In computing the biomass of rotifers the wet weight of particular species was used as quoted by Kosova (1961), while the wet weight of plankton crustaceans was calculated according to the formula of Pečen (1965) and Ščerbakova (1952), which took into account the dependence between the weight and body length, the tables given by Starmach (1955) and Kiselev (1956) also being used.

### Species composition and quantitative relations of zooplankton

In the period of investigation the zooplankton of the dam reservoir in the part near the sluice showed a rather poor faunistic composition. In the material a total number of 24 species were identified (3 of *Protozoa*, 13 of *Rotatoria*, 5 of *Cladocera*, and 3 of *Copepoda*), while in the same period in the whole reservoir over 80 species and forms of animal plankton were reported. In June a mean number of 946 specimens/litre of zooplankton occurred in the outflowing waters. In this period *Rotatoria*

with the species *Polyarthra vulgaris*, *Synchaeta pectinata*, and *Conochilus unicornis* dominated, while *Cladocera* and *Protozoa* appeared in small numbers, not exceeding 100 specimens/l, only the development stages of *Copepoda* being more numerous. Among cladocerans *Daphnia cucullata* and *Bosmina coregoni* and among *Copepoda* *Cyclops strenuus* prevailed.

In July the number of the zooplankton slightly increased to an average of 990 specimens/l. *Rotatoria* with the same dominating species still prevailed, while in the composition of rotifers the summer form of *Brachionus angularis* occurred more numerously. Among *Protozoa* *Tintinnopsis lacustris* and of cladocerans *Daphnia cucullata* appeared in the greatest numbers. In this period *Copepoda* were chiefly represented by the species *Cyclops strenuus*. The less numerous occurrence of their development stages was also noted.

In August the most numerous occurrence of plankton animals (a mean number of 1465 specimens/l) in the whole period of investigation was observed. No changes were noted in the quantitative relations or in the domination of particular groups of zooplankton. *Rotatoria* continued to dominate, the decisive dominant being *Polyarthra vulgaris* before *Synchaeta pectinata* and *Brachionus angularis*. *Conochilus unicornis*, which dominated in previous months, was noted only sporadically, while *Kellicotia longispina* began to appear in greater numbers. Among the other groups of plankton animals the same species continued to dominate.

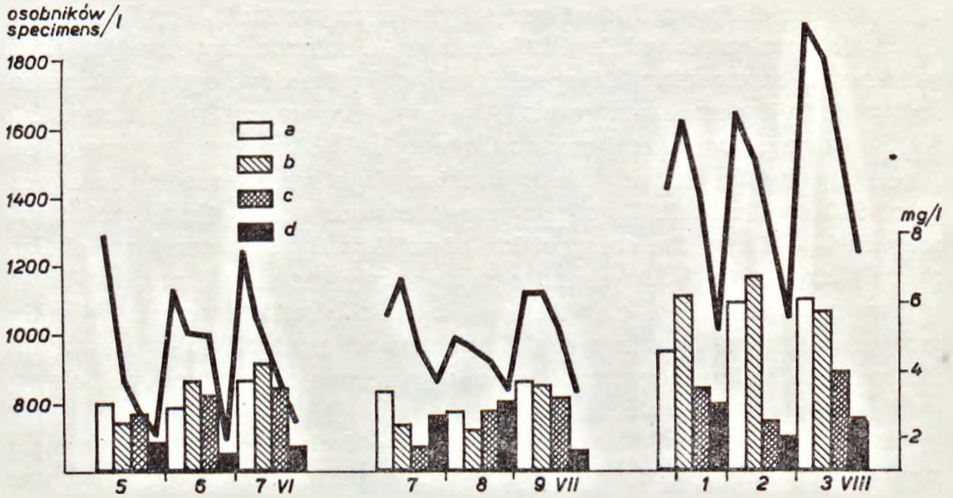
### **The daily dynamics of numbers and biomass of the zooplankton in the outflowing waters and in the part of the reservoir at the dam**

In analysing the samples taken in the vertical of the part of the reservoir near the dam and in comparing them with the discharged waters, one may suppose that these waters come from the middle and lower layers, i.e. from a depth of 2.5 m from the surface to the bottom.

In June (fig. 1) the zooplankton flowing out of the reservoir showed fairly great variations during the 24-hour period. In the early hours (5 a.m.) and average number of 1226 specimens/l of zooplankton, with biomass amounting to 3.177 mg/l, flowed down. At midday the average decreased to 973 specimens/l but the biomass increased slightly to 3.429 mg/l. The afternoon hours were characterized by a further decrease in number (880 specimens/l) and biomass (3.177 mg/l). The lowest values of both number (the mean being 706 specimens/l) and biomass (1.632 mg/l) were noted in the night hours.

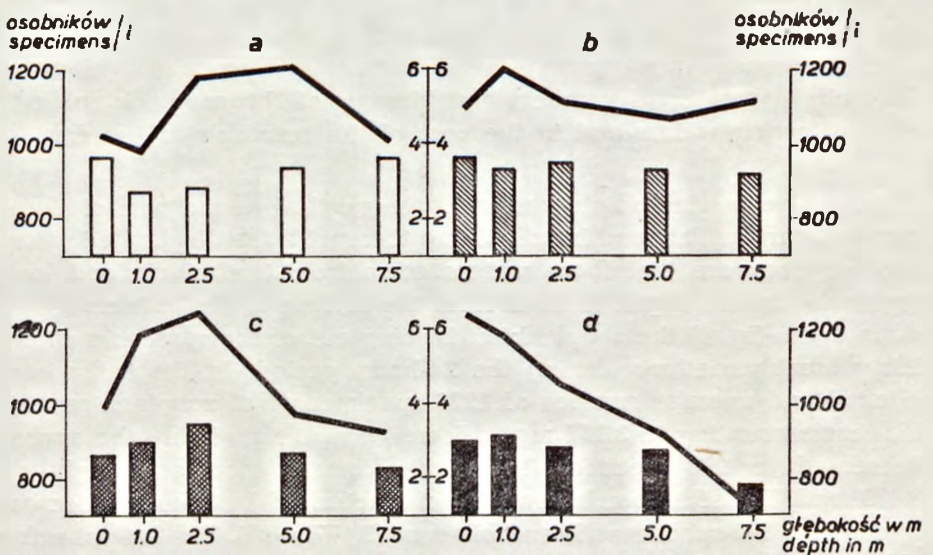
In July with an increased force of water discharge amounting to 16.4 m<sup>3</sup>/sec and mean values of number (990 specimens/l) and biomass (2.777 mg/l) approximating those in June, the following daily dynamics





Ryc. 1. Dynamika liczebności i biomasy zooplanktonu w wodach odpływu w poszczególnych terminach badań. Linia ciągłą oznaczono ilość, a słupkami przedstawiono biomasę zwierząt planktonowych. Godziny: a — 5; b — 11; c — 17; d — 23

Fig. 1. Dynamics of the number and biomass of zooplankton in the outflow waters at particular periods of the investigations. Continuous line denotes the number; columns show the biomass of plankton animals. Hours: a — 5 a. m.; b — 11 a. m.; c — 5 p. m.; d — 11 p. m.



Ryc. 2. Dobowy rozkład średnich ilości (linia ciągła) i biomasy (słupki) zwierząt planktonowych w części przy zaporowej zbiornika. Godziny: a — 5; b — 11; c — 17; d — 23

Fig. 2. Daily distribution of mean numbers (continuous line) and biomass (columns) of plankton animals in the part of the reservoir adjoining the dam. Hours: a — 5 a. m.; b — 11 a. m.; c — 5 p. m.; d — 11 p. m.

of the zooplankton flow was observed: the early morning and morning hours were characterized by a fairly uniform quantity and quality of the zooplankton flowing down. Only in the evening hours was a significant decrease noted in number (to 830 specimens/l) and consequently in biomass (to 1.582 mg/l).

The analysis of materials collected in August (fig. 1) at the greatest water discharge showed the greatest variation in number and biomass of plankton animals during the day. In the early morning hours 1673 specimens/l of 5.538 mg/l on the average flowed down, similar values being noted in the later morning waters. Considerable changes occurred in the evening and night hours when the outflowing water contained the mean number of 1100 specimens/l, the weight being only 2.546 mg/l.

In analysing the daily dynamics of the number and biomass of plankton animals in the part of the reservoir at the dam (fig. 2), the greatest number were found at a depth of 2.5—5.0 m from the surface. The morning hours were characterized by the least variation in number and biomass of plankton animals occurring in the vertical scheme. Already in the afternoon and evening hours a distinct assembly of plankton animals occurred at a depth of 1—2.5 m, the greatest biomass (3.460 mg/l) being noted 2.5 m from the surface. The night hours showed the highest density (1250 specimens/l) in the surface layers of the reservoir and the greatest biomass (3.200 mg/l) at a depth of 1 m from the surface of the water.

### Discussion of results

Analysis of samples collected in the vertical in the part of the reservoir adjoining the dam and in the discharged waters showed an identical quantitative composition.

*Rotatoria*, with the leading species *Polyarthra vulgaris*, *Synchaeta pectinata*, *Conochilus unicornis*, and *Brachionus angularis*, dominated throughout the whole period of investigation. Representatives of other groups of plankton animals were much less numerous. Among *Cladocera* only *Daphnia cucullata* and *Bosmina longirostris* appeared in larger numbers, while *Cyclops strenuus* was the chief representative of *Copepoda*. The least numerous group were *Protozoa*. Among them only *Tintinnopsis lacustris* was encountered in slightly greater numbers.

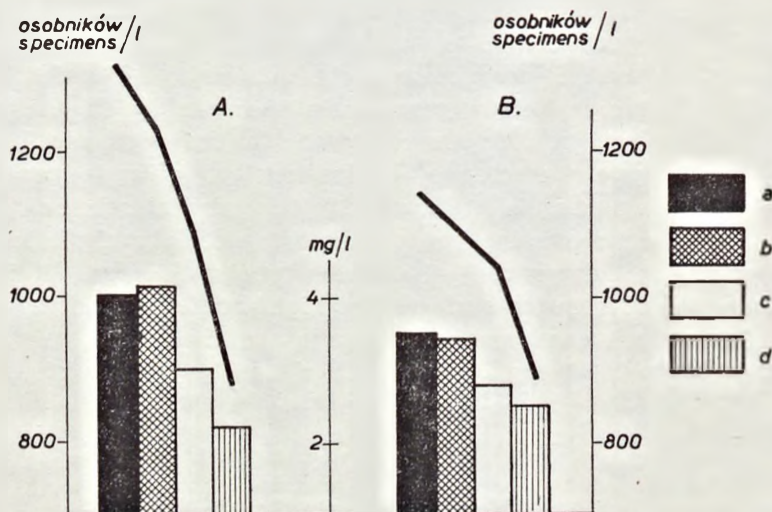
Neither any group of plankton animals nor any species of the given group showed a tendency to flow out more numerously from the reservoir. *Rotatoria* and development stages of *Copepoda* flowed out uniformly throughout the 24-hour cycle while *Cladocera* and mature *Copepoda* were more numerous during the daytime.

In the investigated period in the part of the reservoir adjoining the



dam zooplankton appeared in an average number of 1075 specimens/l with an average weight of 3.096 mg/l, while in the outflowing waters the slightly higher number of 1133 specimens/l with an average weight of 3.351 mg/l was noted. In the outflowing waters these numbers ranged from 680—1930 specimens/l and the biomass from 1.462—6.824 mg/l.

During the investigated period an increase in the number of plankton animals was observed from June (the mean being 946 specimens/l with biomass 2.854 mg/l) to August, when the highest mean density of 1465 specimens/l with a mean weight of 4.424 mg/l was observed.



Ryc. 3. Dobowy rozkład średnich ilości (linia ciągła) i biomasy (słupki) zooplanktonu za badany okres: A — w wodach zrzutowych ze zbiornika; B — w środkowych i dolnych warstwach części przyzaporowej wód zbiornika. Godziny: a — 5; b — 11; c — 17; d — 23

Fig. 3. Daily distribution of mean numbers (continuous line) and biomass (columns) of zooplankton in the investigated period: A — in the waters discharged from the reservoir; B — in the middle and lower layers of the part of the reservoir adjoining the dam.

Hours: a — 5 a. m.; b — 11 a. m.; c — 5 p. m.; d — 11 p. m.

In the investigated period from 5th June to 3rd August 1972 56 132 thousand cubic metres of water was discharged from the reservoir, the weight of plankton animals being about 185 810 kg.

Szla u e r (1960, 1962) considers that, besides oxygen conditions or the force of gravity, the basic reason for the vertical migrations of zooplankton is the intensity of light. Also the influence of these factors is different in particular groups and species or even development stages of plankton animals.

In analysing the daily outflow of plankton animals it should be said that the greatest numbers were noted between 5 a.m. and 5 p.m. (890—

1930 specimens/l), i.e. 62—71% of the total number of the zooplankton flowing down during the 24 hours, while in the evening and night hours there were 680—1240 specimens/l amounting to only 29—30%. The samples collected at the two sampling stations suggest that the discharged waters flow down from the middle and lower layers of the reservoir. This is illustrated by fig. 3 which shows the average number and biomass of the zooplankton flowing down during 24 hours as compared with the number and biomass of plankton animals from the middle and lower layers of the part of the reservoir adjoining the dam. Thus, on the basis of materials collected in the outflow waters, one may suppose that under a continuous bottom outflow and fairly quiet weather conditions (absence of strong waves) plankton animals show a tendency to migrate vertically to deeper water layers during the day and to surface layers at night.

#### STRESZCZENIE

W opracowaniu przedstawiono próbę uchwycenia dobowych wędrówek zooplanktonu na podstawie dennego upustu wody w zbiorniku zaporowym w Goczałkowicach. Materiał pobierano z odpływu w cyklach trzydniowych co 6 godzin przy stałej, ale różnej w poszczególnych cyklach sile odpływu wody ze zbiornika. W drugim dniu każdej serii pobierano równocześnie próby w pionie w części przyzaporowej zbiornika.

Zebrany materiał wykazywał ubogi faunistycznie zooplankton (3 gatunki *Protozoa*, 13 gatunków *Rotatoria*, 5 gatunków *Cladocera* i 3 gatunki *Copepoda*). Przez cały okres badań dominują *Rotatoria* z gatunkami *Polyarthra vulgaris*, *Synchaeta pectinata* i *Conochilus unicornis* oraz w sierpniu *Brachionus angularis*. Na przestrzeni badanego okresu obserwuje się wzrost ilości zwierząt planktonowych od czerwca, gdzie średnia wynosiła 946 osobników/l, a ich biomasa 2,854 mg/l do sierpnia, kiedy notowano najwyższe ich zagęszczenie średnie 1465 osobników/l o wadze średniej 4,424 mg/l.

Od 5 VI do 3 VIII 1972 roku upuszczono ogółem ze zbiornika 56 132 tys. m<sup>3</sup> wody zawierającej około 185 810 kg zwierząt planktonowych.

Analiza materiałów zebranych z odpływu wykazała znaczne wahania sphywającego zooplanktonu w ciągu doby. Najliczniej sphywiał on w godzinach od 5-tej do 17-tej (ryc. 1) średnio od 890 do 1930 osobników/l, co stanowiło od 62 do 71% ogółu sphywającego zooplanktonu w ciągu doby. W godzinach wieczornych i nocnych natomiast ilości te były znacznie mniejsze (680—1240 osobników/l) i wynosiły tylko od 29 do 38%.

W części przyzaporowej zbiornika stwierdzono natomiast najliczniejsze jego występowanie w godzinach porannych na głębokościach od 2,5 do 5,0 m od powierzchni (ryc. 2). Godziny przedpołudniowe charakteryzowały się najmniejszymi wahaniami ilościowymi i biomasy w układzie pionowego występowania zwierząt planktonowych. W godzinach popołudniowych i wieczornych natomiast obserwowano liczniejsze gromadzenie się zwierząt planktonowych na głębokościach od 1 do 2,5 m od powierzchni. Godziny nocne wykazują najwyższe zagęszczenie zooplanktonu w warstwach powierzchniowych zbiornika.

Analizując próby zebrane na obu tych stanowiskach należy sądzić, że wody upuszczane schodzą ze środkowych i dolnych warstw zbiornika (ryc. 3).

Można więc sądzić na podstawie analizy materiałów zebranych z odpływu ze zbior-

nika, że przy stałym dennym odpływie i przy w miarę spokojnych warunkach atmosferycznych zwierzęta planktonowe wykazują tendencje do pionowych wędrówek w dzień w głębsze partie wody, a w godzinach nocnych w przypoверхniowie.

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