ACTA HYDROBIOL.	35	4	329—340	KRAKÓW 1993

Profundal macrofauna of the Dobczyce Reservoir (southern Poland) in the fifth year after its filling

Elżbieta Dumnicka

Polish Academy of Sciences, Karol Starmach Institute of Freshwater Biology, ul. Sławkowska 17, 31-016 Kraków, Poland

Manuscript submitted June 7, 1993, accepted October 18, 1993

Abstract - Oligochaetes constituted 91-98% of the numbers and 78-97% of the biomass of the macrofauna, the remaining part were Chironomidae, while Chaoboridae, Sphaeridae, Ephemeroptera, and Coleoptera occurred sporadically. The highest density (14.5 thous. indiv. m^{-2}) and biomass (13 g m^{-2}) were observed near the dam. 14 species of the Oligochaetes (the most numerous being *Potamothrix hammoniensis*, *Limnodrilus claparedeanus*, and *L. hoffmeisteri)* and 5 taxa of Chironomidae were determined in the samples.

Key words: dam reservoirs, Oligochaeta, Chironomidae, density, seasonal changes.

1. Introduction

The dam reservoirs constructed on the Carpathian tributaries of the River Vistula and in its upper course have been studied by hydrobiologists for many years. Particularly interesting are the results of studies on the formation of biocoenoses (Krzyżanek 1971) and on the succession taking place there (Krzyżanek 1986a, b, Grzybowska 1965). The reservoirs on the River Dunajec (Rożnów) (Olszewski 1953), on the Upper Vistula (Wisła Czarne) (Kasza 1986) or on the River San (Solina and Myczkowce) (Płużański 1990) were built at a time when these rivers carried clean water or were only slightly polluted, as, e.g., the River Soła upstream of the reservoir in Tresna

(B o m b ó w n a 1960, P a l u c h et al. 1975). The reservoir in Dobczyce, on the other hand, was built on a river already eutrophicated (M a z u r k i e w i c z 1988).

The Institute of Freshwater Biology already began complex hydrochemical, hydrobiological, and ichthyological investigations of the River Raba before the construction of the reservoir (M a z u r k i e w i c z 1988, A m i r o w i c z 1988, J e l o n e k, S t a r m a c h 1988, F l e i t u c h 1992) and these continue. For a more complete study of the biocoenoses which are being formed in the reservoir annual investigations of the bottom fauna of the profundal of the reservoir are carried out. The profundal, constituting more than 50% of the reservoir bottom, was selected for investigation since its settling is determined mainly by the water trophy whereas in the littoral the composition of the bottom fauna depends on many factors (the presence of submersed and emergent plants, undulation, affluents).

The aim of the study was to test whether the bottom biocoenosis which is being formed under conditions of high water trophy in the Dobczyce Reservoir is similar to those formed in other reservoirs during the first years of their existence. The collected material will also be a basis for study of the progress of succession in this reservoir.

2. Study area

The dam reservoir in Dobczyce was built in 1986 on the River Raba by obstructing it with a 30.3 m earth dam. It is a reservoir of medium size, about 10 km long with a shore line of 43.1 km. The normal damming ordinate (npp) equals 269.9 m; when retaining this ordinate the flooded area is 9.7 km^2, the volume 0.1 km^3, mean depth, 10.25 m, and the greatest depth about 28 m. The frequency of water exchange is about 3.6 times a year. The reservoir is one of the main sources of drinking water supply for Kraków.

The flooded area (fig. 1) comprises the shallow Wolnica bay and two basins - the Dobczyce basin with a depth greater than 20 m and the Myślenice basin, 10-20 m deep, which further turns into backwaters. Stations are situated in the central parts of these basins (Stations 1, 3) and in a slight narrowing between them (Station 2) (fig. 1). The bottom is covered with greyish-black slime with numerous debris of planktonic crustaceans; only at Station 2 is about 10% of the volume taken up by small stones and sand.

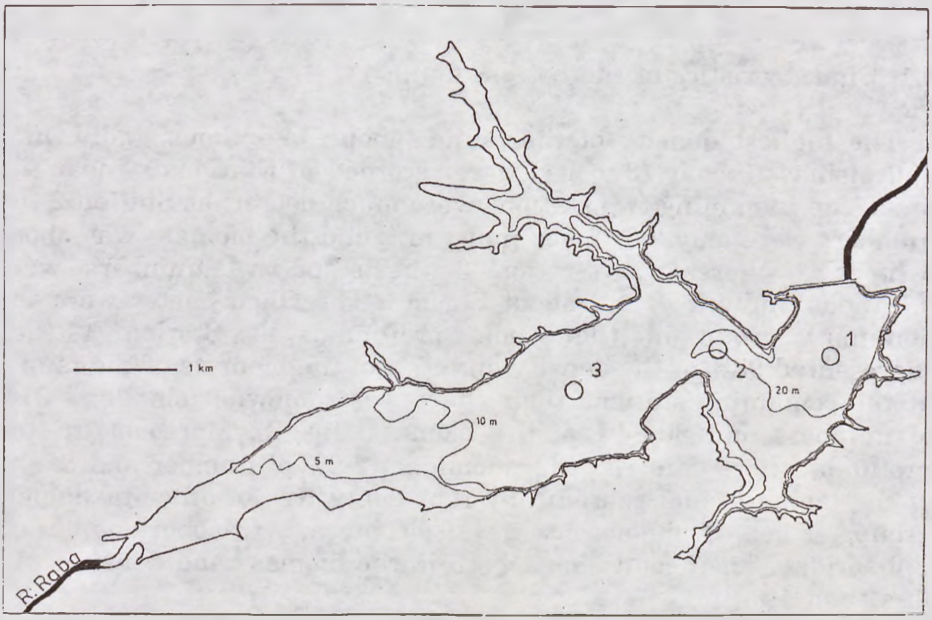

Fig. 1. Sampling stations in the Dobczyce Reservoir

3. Material and methods

Investigations of the macrofauna in 1991 began in March (when the ice cover had melted) and were carried out until the end of the year. The samples were collected 14 times: once a month in the spring (March, April, May) and in late autumn (October, November, December), but in the period from June to September the frequency of sampling was increased to twice a month.

Each time the samples were taken the temperature and oxygen content in the near-bottom layer of water were measured. In spring and autumn the oxygenation of the water was high (over 80%), whereas in the period from June to September, especially at Station 1, a distinct reduction in oxygenation was observed. Biological samples were collected by means of an E k m a n ' s bottom grab, washed on a sieve of about 0.3 mm mesh and sorted in vivo using a binocular magnifying glass, each taxon being weighed separately. The density and biomass (wet mass) were recalculated per 1 m^2 surface area. Statistical calculations were made using the Statgraph program.

4. Results

4.1. Characteristics of the bottom fauna

The highest density of the fauna (about 14.5 thous. indiv. m^{-2}) and biomass (about 13 g m^{-2}) were recorded at Station 1 - near the dam. The remaining two stations were much poorer: at Station 2 the numbers were only 7.5 thous. indiv. m^{-2}, and the biomass was about 6 g m^{-2}, whereas at Station 3 the respective numbers were 9.5 thous. indiv. m^{-2} and about 7 g m^{-2}. The Oligochaetes were the dominant group in the whole profundal: at Station 1 they represented 98% of the density and 97% of the biomass of the fauna; at the remaining stations their share was somewhat smaller - 91% of numbers and 80-84% of the biomass (fig. 2). Moreover, in the profundal there occurred Chironomidae (2-9% of number and 3-20% of the biomass) and sporadically representatives of other taxonomic groups, i.e. Ephemeroptera, Coleoptera, Chaoboridae, and Sphaeridae. Their joint share, both in the biomass and density, was less than 1%.

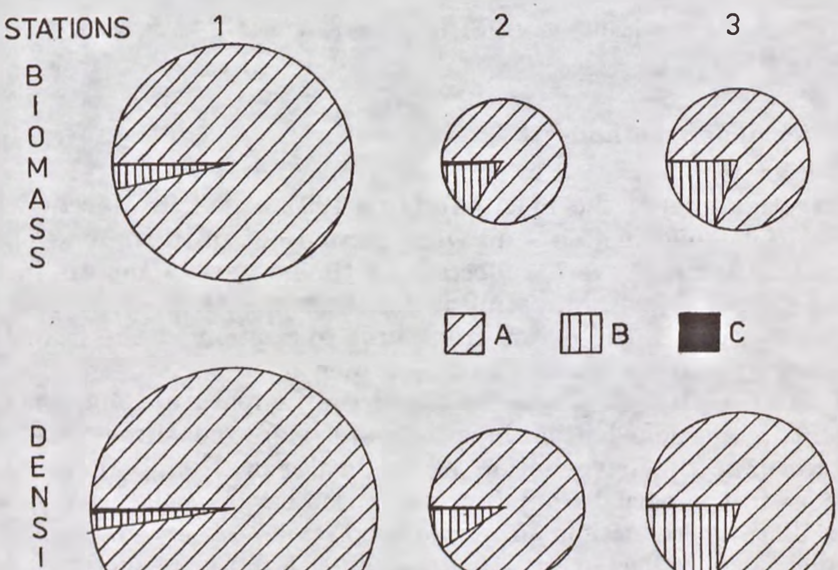

Fig. 2. Percentage of the macrofauna groups in the number and biomass at the stations investigated

Diversity in the species of the bottom fauna was rather small. Oligochaetes were represented by 14 species belonging to 2 families, Naididae and Tubificidae (each representing 7 species) (table I). Besides, juvenile forms of the family Enchytraeidae were found in the samples. Among the species belonging to the family Naididae only one - *Dero digitata* - is a constant inhabitant of deep dam reservoirs. The other species found and belonging to this family are typically riverine forms, which have been brought in with the current. They were found principally at stations situated nearer to the backwaters: at Station 3 - 5 species, at Station 2 - 4 species, and at Station 1, near the dam - only 1 species. The share of the Naididae in the group of oligochaetes was very small - less than 1% at each station. Tubificidae, represented mainly by juvenile specimens, constituted almost the whole of the community. Mature individuals from this family constituted from 12% at Station 2 to 14% at Station 3. Among 7 determined species six occurred at all stations, while *Potamothrix bavaricus* was found only at Station 1. The more frequently occurring species were: *Potamothrix hammoniensis*, *Limnodrilus claparedeanus*, and *L. hoffmeisteri*. *P. hammoniensis* was the most numerous species at all stations, being accompanied at Station 1 by *L. claparedeanus*, and at the shallower Stations 2 and 3 by *L. hoffmeisteri*. *Tubifex tubifex* occurred more frequently only at Station 1, at the others being found sporadically.

Table I. Percentage of oligochaete taxa at the studied stations, + - less than 0.1%

Taxa	Stations		
	1	2	3
Tubificidae gen. spp. juv.	88.5	88.6	87.5
Potamothrix hammoniensis (Mich.)	6.2	6.7	6.0
Limnodrilus claparedeanus Ratz.	3.3	1.1	2.0
– *hoffmeisteri* Clap.	0.9	2.6	3.7
Tubifex tubifex (O. F. Müll.)	0.6	0.2	0.1
Ilyodrilus templetoni (South.)	0.2	0.2	0.1
Nais pseudobtusa Pig.	0.1	0.2	0.1
Limnodrilus profundicola (Ver.)	+	0.2	0.2
Potamothrix bavaricus (Oeschmann)	0.1		
Enchytraeidae gen. spp. juv.	0.1		
Dero digitata (O. F. Müll.)		0.1	0.1
Amphichaeta leydigii Tauber		0.1	0.2
Vejdovskyella comata (Vejd.)		+	
Ophidonais serpentina (O. F. Müll.)		+	
Nais simplex Pig.			+
– *pardalis* Pig.			+

Among the Chironomidae the larvae of *Procladius* spp. S k u z e were the dominant ones. This taxon represented from 23% (Station 1) to 57% (Station 3) of the Chironomidae fauna. At Station 1 the larvae of *Chironomus* spp constituted a great share (26%); at Station 2 they constituted only 4%, and at Station 3, 13% of the Chironomidae fauna. The remaining taxa, among which were determined *Cricotopus* + *Orthocladius* spp., *Tanytarsini* juv., constituted 30-50% of the community.

4.2. Seasonal changes in density and biomass of the fauna

The density of the oligochaetes changed considerably during the investigated period. At Stations 1 and 3 the highest density was recorded in the warm period (fig. 3), though, the correlation between numbers and temperature was not very significant ($p < 0.1$). At Station 2, where the changes in density were equally great but more irregular, no dependence on temperature was observed. Changes in the biomass of the oligochaetes were almost as great as those in density and their progress was similar (fig. 3), but at Stations 1 and 3 the correlation between these two parameters was not significant ($p < 0.2$), while at Station 2 it was highly significant ($p < 0.03$).

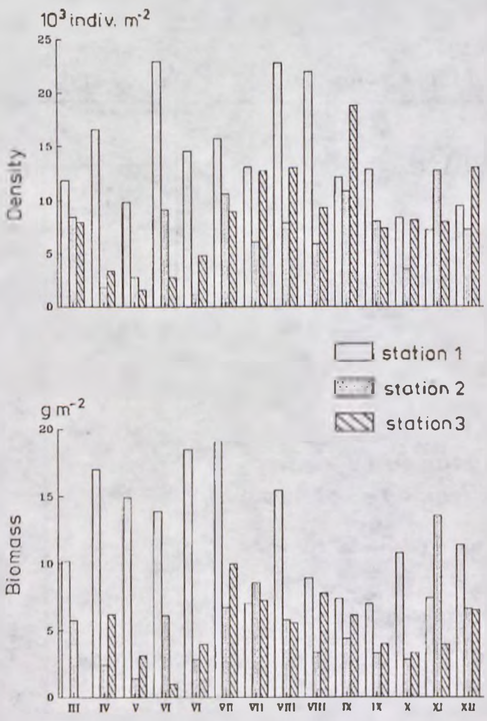

Fig. 3. Changes in density and biomass of Oligochaeta during the period of investigation

The greatest density of Chironomidae was recorded from May to the beginning of July, after which the number of individuals diminished so much that at Stations 1 and 2 in September no live larvae or pupae were observed (fig. 4). Starting from October, at Stations 2 and 3 the density of Chironomidae again increased, while at Station 1 to the end of the investigated period only single individuals of midges were recorded. Changes in the biomass showed a similar tendency as those of density (fig. 4).

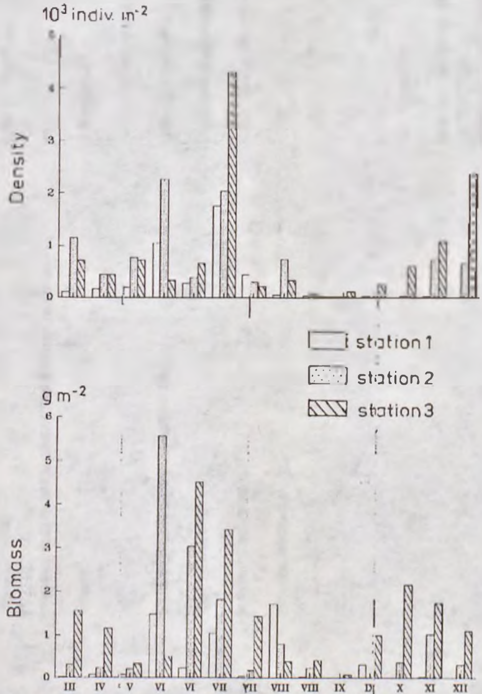

Fig. 4. Changes in density and biomass of Chironomidae during the period of investigation

Changes in the density of mature specimens of the three most frequently occurring species of Tubificidae were also recorded (fig. 5). *Potamothrix hammoniensis* was encountered in the reservoir throughout the whole period of investigation but it appeared in greatest numbers in spring (April, beginning of May) at Station 1 and in August and September at all stations. Also *Limnodrilus hoffmeisteri* with genital organs occurred throughout the whole year, with a maximum from August till October. Many mature specimens were found especially at Station 3. Seasonal changes in the density of *Limnodrilus claparedeanus* were very irregular and differered in their course at the investigated stations. At Station 1 mature

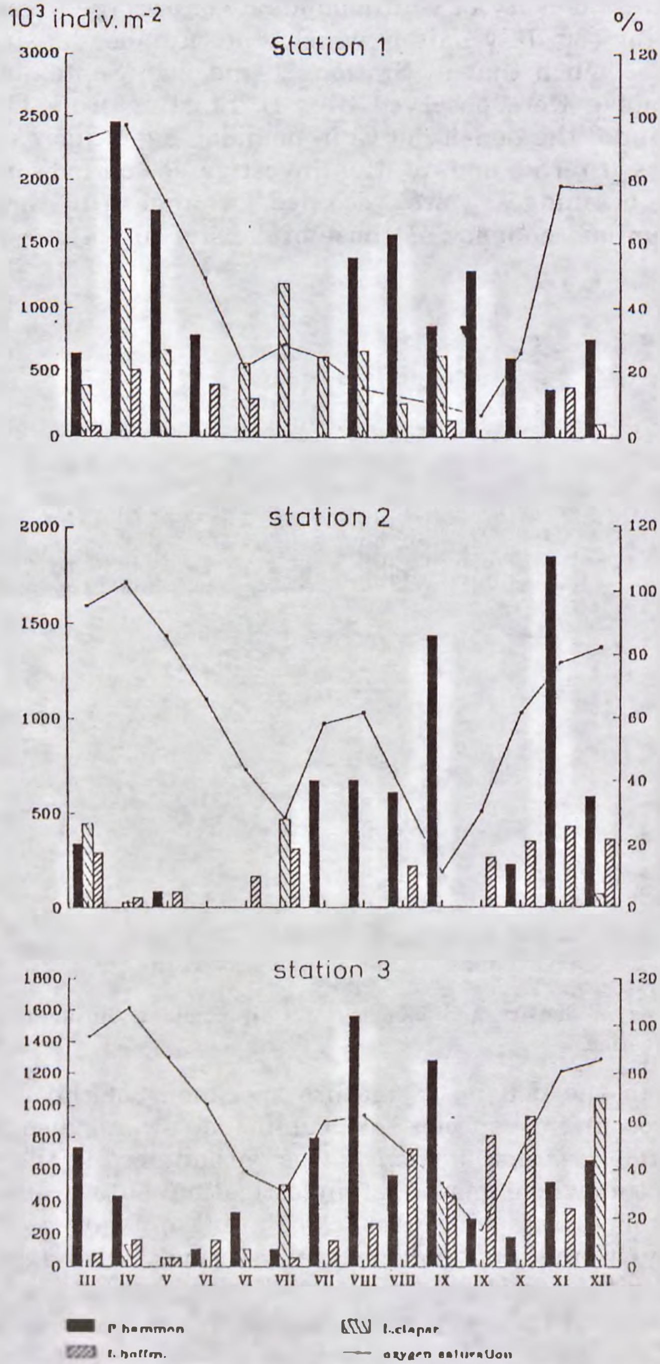

Fig. 5. Changes in density of mature specimens of some Oligochaeta species and oxygen saturation at the stations investigated

specimens occurred from March to September, at Station 2 till July, and at Station 3 from April to September. They appeared again in December at all stations, being especially numerous at Station 3. At Station 1 mature specimens occurred in a greater number in the first half of the year but at the remaining two stations in summer and autumn.

5. Discussion

The bottom fauna of the deeper sections of the dam reservoirs in southern Poland is composed chiefly of the Chironomidae and Oligochaeta (K r z y ż a n e k 1986b, G r z y b o w s k a 1957, D u m n i c k a et al. 1986). Other taxa may also occur in greater numbers, but only exceptionally, e.g., bivalves in the Goczałkowice Reservoir (K r z y ż a n e k 1986a). The mutual relations between the two principal groups vary, depending on the time the area was flooded, as well as on the type of reservoir. In the first period of functioning of the reservoir, when the biocoenoses were forming, in the profundal (especially near the dam) the Oligochaeta prevailed and the density of the fauna exceeded 10 thous. indiv. m^{-2}. Such was the situation in all the reservoirs built on the Carpathian rivers in which investigations were carried out - Rożnów (G r z y b o w s k a 1957), Tresna (K r z y ż a n e k 1971), and Wisła Czarne (K r z y ż a n e k 1986b). The first investigations of the bottom fauna of the reservoir in Dobczyce confirmed this regularity. Only in the Goczałkowice Reservoir, which differs considerably from the other constructed on the Carpathian rivers (smaller depth, wide littoral), at the beginning of its functioning the Chironomidae prevailed (K r z y ż a n e k 1986a).

After a few years of existence of the reservoir its biocoenoses become stabilized: the density of the macrofauna decreases to a level of the order of 2-5 thous. indiv. m^{-2}. In some reservoirs the community structure also undergoes a change, the share of Chironomidae, especially from the genus *Procladius*, increases, as, e.g., in Rożnów (G r z y b o w s k a 1965). In most reservoirs, however, the Oligochaeta are still dominant, as for instance, in Solina (P ł u ż a ń s k i et al. 1990), or Porąbka (K o w n a c k i 1963). This is the so-called oligotrophication period, and its duration depends principally on the amount of biogens flowing into the reservoir (K o w n a c k i, S t a r m a c h 1989). In 1991 the mean content of the biogens in the water of the River Raba flowing into the reservoir, was for PO_4 - 0.565 mg dm^{-3}, NH_4 - 0.63 mg dm^{-3}, and NO_3 - 1.307 mg dm^{-3} (after M a z u r k i e w i c z unpubl. data). With such a high loading of biogens (for P_{min} - about 58 t and N_{min} - about 249 t during the year) this period in the Dobczyce Reservoir may be very brief or may not occur at all.

A significant factor already affecting the composition and structure of the bottom fauna was the small amount of oxygen recorded near the bottom. It may be assumed that this was a limiting factor for Chironomidae and for the more sensitive species of Oligochaeta, especially at Station 1, where this deficiency was the greatest and where it lasted for several months. After a period of poor water oxygenation Chironomidae appeared at this station only as single specimens, and *Dero digitata*, which in the Rożnów Reservoir occurred in greatest numbers precisely at the deepest station (D u m n i c k a et al. 1986), was not found at all. It can be assumed that the oxygen deficiency also induced a change in the reproduction period of the species occurring there. It did not, however, affect the density of the Oligochaeta, which was greatest near the dam. The community occurring at this station comprised several species typical of eutrophic or even polluted waters (M i l b r i n k 1980). Only *Limnodrilus claparedeanus*, according to some authors, requires high concentrations of oxygen in organically polluted waters. On the other hand, P f a n n k u c h e (1977, after M i l b r i n k 1980) observed its very numerous occurrence in the stagnant parts of the Elbe estuary. The species dominating in the Dobczyce Reservoir belong to forms widely distributed in the deeper parts of dam reservoirs in Europe from Spain (M a r t i n e z - A n s e m i l, P r a t 1984) to the reservoirs on the Dnieper (S h c h e r b a k 1989). They form a very simple biocoenosis with only one trophic level (detritiforous) and tolerant of unfavourable environmental conditions.

Further investigations of the bottom fauna in the Dobczyce Reservoir should permit comparison with the trend and rate of succession of this biocoenosis, in a reservoir typical of the Carpathian rivers but of higher trophy.

Acknowledgement - the author wishes to thank her colleagues: Dr A. A m i r o w i c z, T. F l e i t u c h, M.Sc., R. G w i a z d a, M.Sc. for taking samples and Dr G. M a z u r k i e w i c z for making accessible the results of chemical analyses.

6. Polish summary

Makrofauna profundalu zbiornika Dobczyckiego (południowa Polska) w piątym roku po jego powstaniu

Celem pracy było wyjaśnienie, czy biocenoza denna formująca się w warunkach wysokiej trofii wody w zbiorniku Dobczyckim jest podobna do biocenoz powstałych w pierwszych latach istnienia innych zbiorników, zbudowanych na czystych rzekach. W 1991 roku przeprowadzono badania makrofauny na trzech stanowiskach usytuowanych w profundalu zbiornika (ryc. 1).

Najwyższe zagęszczenie fauny (około 14,5 tys. osob. m^{-2}) i biomasę (około 13 g m^{-2}) stwierdzono na stanowisku 1 - przy zaporze. Pozostałe dwa stanowiska były znacznie uboższe (ryc. 2). Skąposzczety były grupą dominującą w całym profundalu: na stanowisku 1 stanowiły 98% zagęszczenia i 97% biomasy fauny, na pozostałych stanowiskach ich udział był nieco mniejszy - 91% liczebności i 80-84% biomasy. Ponadto w profundalu występowały Chironomidae (2-9% liczebności i 3-20% biomasy) oraz sporadycznie Ephemeroptera, Coleoptera, Chaoboridae i Sphaeridae. Skąposzczety reprezentowane były przez 14 gatunków należących do 2 rodzin: Naididae (7 gatunków) i Tubuficidae (7 gatunków). Ponadto w próbach znaleziono juvenilne formy z rodziny Enchytraeidae (tabela I). Zagęszczenie fauny zmieniało się znacznie w okresie badań. Najwyższe zagęszczenia młodocianych form Tubificidae i larw Chironomidae notowano z reguły w okresie ciepłym (ryc. 3, 4), natomiast osobniki dojrzałe występują w różnych porach roku (ryc. 5).

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