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Factors influencing the microspatial zooplankton and oxygen heterogeneity in Włocławek dam reservoir

By RYSZARD WIŚNIEWSKI and LESZEK ANDRZEJ BŁĘDZKI, Toruń

With 2 figures and 2 tables in the text

Abstract

During the investigations conducted in Włocławek Reservoir in the years 1980–85 considerable horizontal and vertical differentiation of physico-chemical and biological parameters were found. The highest variability was observed in zooplankton and dissolved oxygen concentration. Close connection of zooplankton and oxygen heterogeneity with the hydrological and meteorological factors – water discharge and wind – was shown.

Wind influenced heavy waving affects resuspension of fine deposits rich in organic matter, and subsequent rise of BOD rate in the water by one order. Its connection with the heterogeneity of biological events is discussed.

Introduction

During the five-year research on Włocławek dam reservoir there have been found remarkable horizontal and vertical differentiation of physico-chemical parameters in the aquatic environment and related to that differentiation of biotic elements (GIZIŃSKI et al., in press). Some elements, like zooplankton and dissolved oxygen displayed a particularly great variability, which stood in opposition to the homogeneity of the environment typically related to dam reservoir hydrological characteristics.

On the basis of the obtained data it was hypothesized that the flow of the reservoir water is of a more complex nature than could be inferred from watermass dynamics. Under certain meteorological conditions, the water in some parts seems to flow in an irregular manner or forms two separate streams – one in the area of water current and a different one over the littoral terrace.

An attempt to explain this phenomenon formed the basis for the detailed research programme carried out in the central, limnetic part of the reservoir in the years 1983–84 (BŁĘDZKI 1986, WIŚNIEWSKI 1986, WIŚNIEWSKI et al., in press).

The purpose of the present work has been an analysis of factors responsible for zooplankton distribution variability in the central part of the Włocławek Reservoir.

Research area

Detailed characteristics of the reservoir have been presented in the works by GRZEŚ (1983), BŁĘDZKI (1987) and GIZIŃSKI et al., (in press). Its most important parameters are: length – 57 km, width – 0.5–

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2.5 km (average 1.2 km), area – 75 km square; capacity 408 million cubic metres, average multi-year inflow (May-October) 953 $m^3 \cdot s^{-1}$.

In the research area (Fig. 1) there can be distinguished a river current part and shallow overflow part. In the current part (max. depth 11 m) water flow speed is higher (1–10 cm $\cdot$ s^{-1}) than in the shallower part.

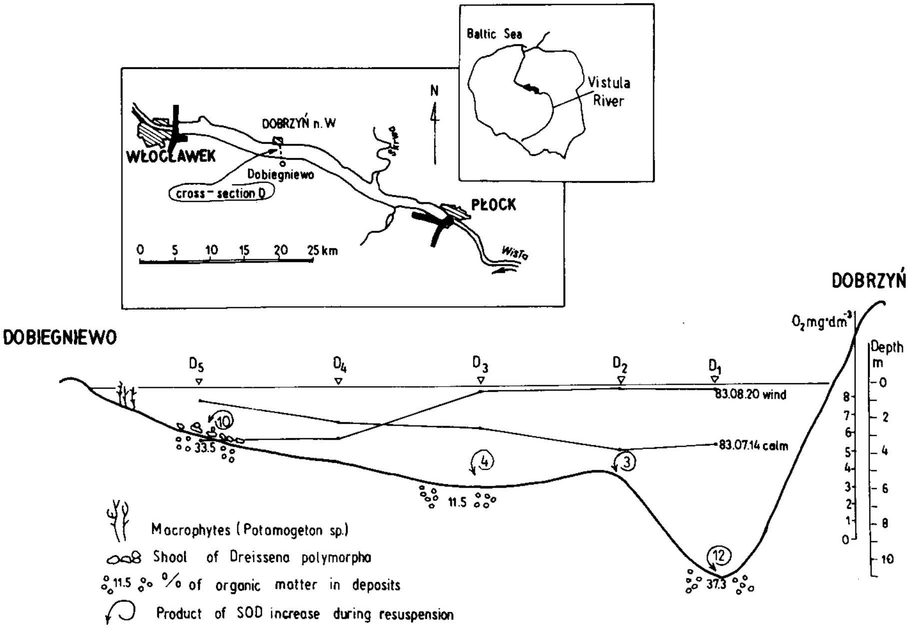

Fig. 1. Włocławek Reservoir. Sampling stations and oxygen differentiation.

The bottom in the littoral area (depth 4–5 m) is rough due to its origin. Such elements as tree stumps, roadside ditches and other structural elements from flooded villages affect the water flow and increase the "mosaic"-like characteristics of the environment. The reservoir is exposed to winds especially western ones. Strong waves caused by winds cause resuspension of bottom deposits in the littoral platform (Grześ 1983, Wiśniewski 1986).

Methods

Water for analysis of oxygen content was collected with a 150 cm^3 sampler from precisely 1 cm water layer (Giziński & Wiśniewski, in prep.). Zooplankton samples were collected with a Patalas sampler from a full water column. Biomass (dry) was determined according to Bottrell et al. (1976). A detailed description of methods is included in a work by Wiśniewski et al. (in press).

Results

Horizontal zooplankton distribution in the study section is presented in Fig. 2. It shows quite clearly that the variability of the number of collected species characterizes mainly the overflow area, the species composition in the current area displaying more stability.

The same phenomenon, i.e. horizontal diversity as well as the great temporal variability is manifested in the abundance and biomass results with regard to both particular zooplankton groups and zooplankton in general (Table 1). For the investigated crossection, the abundance and biomass differences were noted frequently at extreme sampling stations.

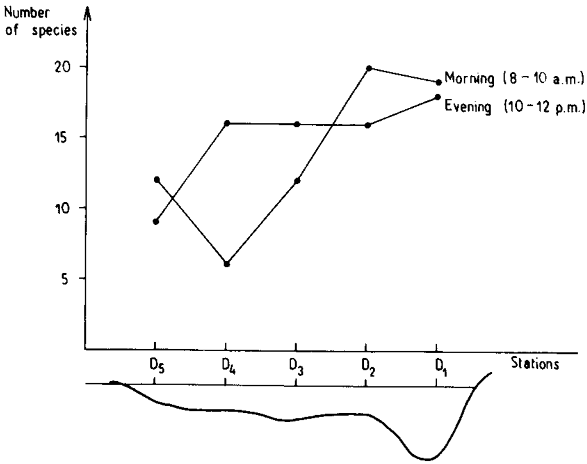

Fig. 2. Horizontal differentiation of zooplankton species in cross-section D.

Table 1. Numbers – N and dry biomass – B of zooplankton in cross-section D. (N – ind · dm^{-3}, B – µg · dm^{-3}). E – evening (10–12 p.m.), M – morning (8–10 a.m.).

Stations / Taxons		D_5 N	D_5 B	D_4 N	D_4 B	D_3 N	D_3 B	D_2 N	D_2 B	D_1 N	D_1 B
Rotatoria	E	10	0.55	1	0.01	10	0.90	2077	290	1508	165
	M	1	0.03	127	4.25	520	47	997	200	858	134
Cladocera	E	55	1476	13	338	48	856	478	1582	173	535
	M	6	18	97	628	253	932	109	747	170	644
Copepoda	E	617	2256	2129	4419	1586	2497	462	606	154	89
	M	2007	5588	620	819	262	218	400	499	133	57
Total Crustacea	E	673	3732	2142	4757	1636	3353	940	2183	326	624
	M	2013	5607	717	1447	515	1150	509	1246	303	701
Total Zooplankton	E	683	3733	2143	4757	1647	3354	3018	2477	1834	789
	M	2015	5607	845	1452	1121	1197	1507	1446	1161	835

Temporal variability in samples collected every 12 hours is best seen at the stations situated in the shallower and more variable part of section. There is also an observable horizontal division in the reservoir between Rotatoria prevailing in the current part and Copepoda dominating in the overflow area.

The clearly marked difference between the two sections is further confirmed by horizontal distribution of herbivorous and carnivorous zooplankton species; these latter prevail at shallow stations (Table 2).

Oxygen concentrations in water sampled at the same stations and times as zooplankton displayed a similar variability as observed in the case of zooplankton. There are quite remarkable differences in oxygen concentrations in the surface water at the extreme stations which reach up to 3.7 mg · dm^{-3} according to earlier studies (WIŚNIEWSKI et al., in press).

There is a clear effect of wind mixing causing higher oxidation of surface water in the current area and oxygen drop in the overflow area.

Analysis of vertical oxygen distribution (WIŚNIEWSKI et al., in press) shows that the bottom water generally contains far less oxygen than the surface water, especially in the shallower part. There were frequent oxygen deficits due to resuspension of bottom deposits on the shore platform, particularly frequent in the sections of high accumulation of sediments with high organic matter concentrations. In such places, as determined from previous studies (WIŚNIEWSKI 1986) sediment oxygen demand rate may increase even up to 10 times when the sediments are subject to intensive mixing (Fig. 1).

Table 2. Ratio of numbers (N) and biomass (B) of carnivorous (C) and herbivorous (H) zooplankton in cross-section D. E – evening (10–12 p.m.), M – morning (8–10 a.m.).

$N^{C}/_{H}$	E	10.83	177	29.78	0.18	0.09	Dominant forms:
							carnivorous –
	M	251.0	4.83	0.31	0.37	0.13	*Asplanchna* sp.
$B^{C}/_{H}$	E	25.15	112	28.1	0.38	0.13	*Leptodora kindti*
							herbivorous –
	M	266.0	3.34	0.44	1.52	0.07	*Brachionus calycyflorus*
Stations		D_5	D_4	D_3	D_2	D_1	*Moina micrura*

Discussion

Studies conducted on the central, limnetic part of the reservoir confirm there exist factors bringing about microscale changes of the water's physico-chemical properties. The result of these changes is diversification of biotic elements, especially zooplankton.

BŁĘDZKI (1987) found that the spatial (especially horizontal) element of zooplankton variability was usually higher than the temporal one, in which seasonality was more distinctive than longterm variability. It is also shown there that hydrological factors related to the flow rate of water through the reservoir have very little influence upon zooplankton variability. Waterflow – related variability index for the current part of the area in question is: for species 9–18 %, abundance 15–20 % and biomass 22–29 %.

Therefore, the observed zooplankton diversity is the effect of intensive local factors appearing under certain ecological and hydro-meteorological situations.

One of the important factors limiting zooplankton is the suspended matter carried off the bottom by water current and having a mechanical influence (ZUREK 1980, 1982) or limiting the pressure of fish on invertebrate predators.

The portion of the reservoir studied, due to its vast and shallow area of overflow and organic sediments accumulated therein, is greatly susceptible to resuspension of bottom sediments. During an intensive wind-effected wave period there were observed in the area intensive resuspension processes causing the oxygen demand rate to increase ten times (WIŚNIEWSKI 1986).

Oxygen deficits observed in the overflow area may be a restricting factor for fish whose oxygen optimum is 5 mg · dm^{-3} (COBLE 1983) and whose pressure on zooplankton may be high (PIJANOWSKA 1985).

Great and rapid de-oxygenation of water may result in zooplankton mortality increase (DUNCAN 1983, TINSON & LAYBOURN-PARRY 1985). Critical oxygen concentrations for zooplankton may be very low, e. g. for *Daphnia magna* it is 0.3 mg · dm^{-3} (KOBAYASHI 1982). However according to findings by BŁĘDZKI (in prep.) an oxygen concentration of about 1 mg · dm^{-3} causes elimination of 1/3 zooplankton population after 36 hours exposure.

Undoubtedly, release of biogens from bottom sediments during resuspension process is also an important factor in zooplankton distribution (POLTZ 1980, NEUHUBER et al. 1980). Especially important may be the release of toxic substances, e. g. aromatic carbohydrates found in the sediments in the Włocławek Reservoir (GIZIŃSKI et al., in press).

Another group of factors influencing the occurrence and distribution of zooplankton are the zooplankton's nutritional demand and survival strategies. High C/H ratio create an unbalanced trophic structure of zooplankton population. Probably, typical predators have switched to alternative food – further studies will give information on that.

Brachionus calyciflorus dominating in the examined material may, as proved by studies by GILBERT (1967), produce long spines protecting it against predators. GILBERT (1980) also proved that *Polyarthra vulgaris* has three times the chance of survival than, e. g. *Keratella kochlearis* due to its effective escape mechanism.

The above picture of diversified zooplankton distribution and environmental factors influencing it, is an attempt to look in microscale at the temporal-spatial organization of the examined eco-system. It certainly seems to be the result of a more complex mechanism, or several mechanisms, and to learn about them requires further research.

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Authors' address:

RYSZARD WIŚNIEWSKI and LESZEK ANDRZEJ BŁĘDZKI, Institute of Biology, N. Copernicus University, ul. Gagarina 9, 87–100 Toruń, Poland.