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A regulated river ecosystem in a polluted section of the Upper Vistula*

7. Bottom Ciliata

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Abstract — The species composition of Ciliata in mud indicates a considerable pollution of the water. The water stage deteriorates the conditions for development of microfauna. A considerable decrease in numbers and diversity of the Ciliata species in the area of the reservoir at Łączany, especially in the deepest places close to the dam, was found. A few kilometres below the reservoir, owing to an improvement of the hydrological conditions of the river, a qualitatively richer microfauna of Ciliata developed and algivorous species appeared.

Key words: regulated river, pollution, bottom Ciliata, shallows near the bank.

1. Introduction

The considerable pollution of the River Vistula has brought about a change of its biocenosis. A study of the effect of pollution on the microfauna of protozoans in this river (mainly those from the Ciliata) was carried out by Turoboyski (1953, 1956, 1970, 1976) over many years.

The purpose of the present work was to make a qualitative and quantitative investigation of the Ciliata in bottom sediments of a shallow zone near the river bank and to analyse the effect of the water stage at Łączany on the Ciliata communities in connection with the proposed building of cascades on the River Vistula.

2. Study area, material, and methods

The investigations were carried out at the six stations shown on the map (fig. 1). Their detailed description and some hydrological data are

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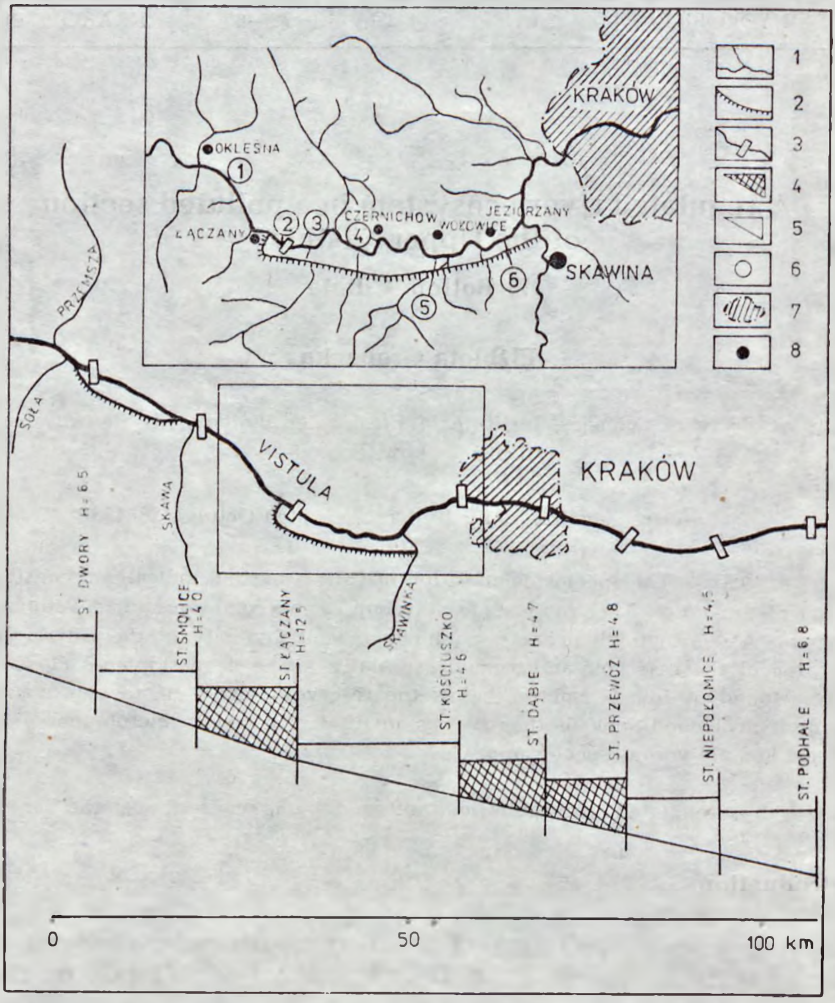

Fig. 1. The Upper Vistula, showing cascade building and stations on the investigated river section. 1 — rivers; 2 — canal; 3 — water stages, dams; 4 — water stages built; 5 — water stages under construction and planned; 6 — stations; 7 — cities; 8 — towns and villages

given by Dumnicka, Kownacki (1988a) and hydrochemical characteristics by Kasza (1988).

The materials for examination of the microfauna were collected only from a shallow zone of the river, at a distance of 20—30 cm from the bank and from a depth of 25 cm. A small spoon was used to collect the surface layer of the mud accumulated between the stones and on the bottom. Only in the reservoir at Łączany, in a deeper place near the dam (Station 2) was a Starmach's mud sucker used (unpublished data). The samples were collected for one year from December 1982 to

December 1983, usually once a month. Altogether 60 samples were taken. The material was always analysed *in vivo*. The microscopic analysis was carried out on the basis of Kahl's (1935), Liebmann's (1962), and Wu, Curds (1979) keys. The number of Ciliata was estimated by calculating the number of specimens in a microscopic preparation made from a drop of mud mixed with 0.02 ml of bottom water.

Table I. The species composition of Ciliata and their division into Groups I-III at Stations 1-6

Group	Species	Stations					
		1	2	3	4	5	6
I - dominants	Aspidisca cicada Clap. et L.	+	+	+	+	+	+
	Chilodonella uncinata Ehrb.	+	+	+	+	+	+
	Chilodonella sp.	+	+	+	+	+	+
	Cinetochilum margaritaceum Perty	+	+	+	+	+	+
	Cyclidium glaucoma O.F.M.	+	+	+	+	+	+
	Oxytricha fallax Stein	+	+	+	+	+	+
	Paramecium caudatum Ehrb.	+	+	+	+	+	+
	Spirostomum minus Roux	+	+	+	+	+	+
	Vorticella sp.	+	+	+	+	+	+
II - subdominants	Aspidisca herbicola Kahl	+	+			+	
	Aspidisca lynceus	+		+	+	+	+
	Chilodonella cucullulus O.F.M.	+	+		+	+	+
	Coleps hirtus Nitzsch				+	+	+
	Colpidium colpoda Stein	+		+	+		+
	Cyclidium sp.	+		+	+		+
	Euplotes patella fo. latus Kahl		+		+	+	+
	Euplotes patella fo. typicus Kahl	+	+	+			
	Frontonia acuminata		+		+		+
	Glaucoma scintillans (Ehrb.) Schew.			+	+	+	+
	Litonotus fasciola (Ehrb.) Wrzesniowski	+	+	+		+	
	Litonotus sp.	+		+	+	+	+
	Loxodes striatus Engelmann	+	+	+	+		+
	Metopus es O.F.M.	+	+		+		+
	Metopus sp.	+	+		+		
	Paramecium bursaria (Ehrb.) Focke	+	+	+		+	
	Prorodon sp.	+	+	+	+		+
	Stentor coeruleus Ehrb.	+	+	+	+	+	
	Stentor polymorphus (Ehrb.) Stein	+	+			+	+
	Trachelophyllum sp.	+	+	+			
	Urostyla sp.	+		+			+
	Vorticella campanula Ehrb.			+		+	+
III - sporadic species	Aspidisca sp.						+
	Chilodonella labiata Stokes	+					
	Didinium nasutum O.F.M.		+				+
	Epalxis sp.	+					
	Halteria grandinella O.F.M.			+			
	Paramecium trichium Stokes, Wenrich				+		
	Plagiopyla nasuta Stein		+				
	Prorodon teres Ehrb.	+	+				
	Saprocinium sp.	+					
	Spathidium sp.		+				
	Spirostomum teres Clap. et L.						+
	Stentor roeseli Ehrb.	+					+
	Stentor sp.			+			
	Strobilidium gyrans					+	
	Stylonychia sp.					+	
	Vorticella convallaria L.				+		
	Vorticella microstoma Ehrb.					+	+
	Zoothamnium sp.					+	

Besides, the frequency of occurrence of the given species of Ciliata at particular stations was calculated, the criterion being the percentage of their occurrence in the total number of samples. On the basis of the frequency and numbers, the Ciliata species were divided into three groups: I — dominants, i.e. species found in more than 20% of samples, II — subdominants, i.e. species found in 5—20% of samples, III — sporadic species, found in less than 5% of samples.

3. Results

3.1. Species composition

Altogether 49 species of Ciliata were determined. The species composition of the respective groups and their distribution at the stations are given in Table I. Group I comprised the 9 species of most constant occurrence. Their presence was noted at all stations. Moreover, nearly all of these species occurred periodically in much larger quantities.

Group II included 22 species which appeared at least half the stations. These species not only decreased in frequency but also appeared in small numbers. A periodic increase in numbers was noted only with respect to *Aspidisca lynceus, Glaucoma scintillans, Euplotes patella, Metopus es,* and *Stentor polymorphus.*

Group III, comprising sporadically occurring species contained 18 species of Ciliata. They usually appeared at only one station (exceptionally at two) and most often on one date. Moreover, all of them occurred in very small quantities. At most stations (1, 2, 5, and 6) the greatest diversity of species and their greatest numbers were evident in summer. Only at Stations 3 and 4 did more species appear in winter. On one sampling date a maximum of only 20—30% of the species were found (fig. 2), the majority of which usually belonged to Group I.

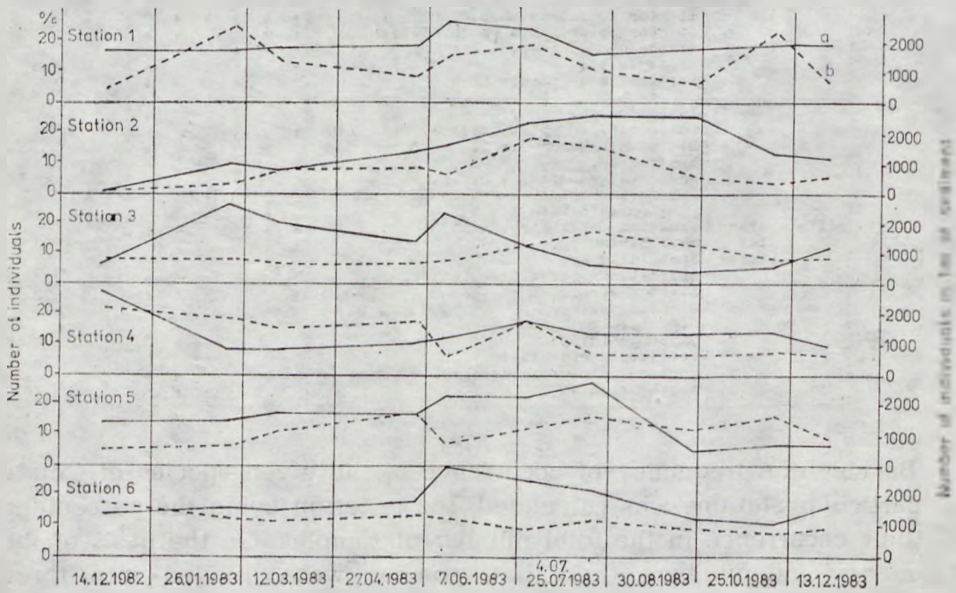

Fig. 2. Number of Ciliata occurring at Stations 1—6 expressed as percentage in relation to the total number of 49 species (a) and in 1 ml of bottom sediment (b)

3.2. Quantitative changes

The numbers of Ciliata varied at particular stations and showed great changes in time. As can be seen in fig. 2, seasonal changes in numbers were irregular, greater quantities appearing at individual stations in different seasons of the year. In most cases it was spring, summer, or autumn, although a small increase in numbers was also noted at Stations 4 and 5 in winter 1982. The poorest microfauna of Ciliata with respect to numbers was noted at the reservoir at Łączany (Station 2) in winter, while and at the beginning of winter 1982 protozoans were altogether absent. A slightly larger number of Ciliata in this reservoir was recorded in summer, the maximum being observed at the end of this season. On the other hand, a comparison of the shallow Station 2 near to bank of the reservoir with the deeper, very slimed Station 3 near the dam pointed always out the worse state of the latter station both in regard to the number of species and to their variety. However, just bejond the dam (station 3) where as the result of the rapid current the mud near the bank was washed out, the community of microfauna was as a rule poor. The greatest seasonal fluctuations in numbers occurred at Station 1 above the reservoir.

3.3. Food requirements

In the Ciliata community there occurred species with differing food requirements. Among the 9 dominants (Group I) were found exclusively polyphagous species, whose major food consists of bacteria. The Ciliata species feeding on algae, especially diatoms and flagellates, appear only in Groups II and III, this also applies to predatory forms (Table I).

With regard to the distribution of the representatives of particular groups along the river course, it may be stated that the initial section (Station 1, 2, and 3) was characterized by a prevalence of bacteriophagous microfauna. The algivorous Ciliata appeared more often, though always in small numbers, at the stations below the reservoir.

4. Discussion

The River Vistula, one of the most polluted rivers in Poland, carries on the investigated section a heavy load of industrial wastes from the Upper Silesia. This high pollution is confirmed by physico-chemical studies carried out by Kasza (1988). On the basis of microbiological analyses of the water, the Vistula has been assigned to purity class III (Starzecka 1988). The results of the investigations concerning the microfauna of Ciliata also show a considerable degree of pollution of the water (predominance of species characteristic for α- and β-mesosaprobic

zones). Similarly, Turoboyski (1953, 1956), while studying the microfauna of Ciliata of the Upper Vistula almost 20 years ago, classified its waters as strongly polluted.

Many years' constant pollution of the Vistula brought about considerable changes in its biocenosis, one of its manifestations being a reduction in the number of species of Ciliata. Turoboyski (1953) noted the presence of 64 species of Ciliata in this river, whereas in the present study the number had fallen to 49. A similar impoverishment of species composition in polluted rivers in southern Poland is indicated by the work of Czapik (1975, 1982), Narloch (1975), Wiąckowski (1981) and Grabacka (1985).

Certain groups of organisms are connected with a certain degree of pollution. Nevertheless, the lists of indicator species distinguishing saprobic zones differ greatly from each other (Starmach 1960, Liebmann 1962, Fjerdingstad 1964, Sladeček 1966, Turoboyski 1970, 1976, Foissner 1979). In the literature the usefulness of protozoans in evaluation of the degree of water pollution is a subject of discussion. The present investigation confirms the opinion that there are not many species which can be regarded as very sensitive and reliable indicators of pollution. At particular stations Ciliata belonging to different zones usually appeared side by side. It would seem that the degree of pollution should be assessed not only on the basis of the presence of individual species, but that the community of Ciliata should also be considered as a whole, taking into account the quantitative dominance of species. The occurrence of Ciliata with differing food requirements (Bick, Kunze 1971) is also an indication of the differentiation of environmental conditions. It was noted that the occurrence of algivorous Ciliata was correlated with an improvement in the conditions in the river, especially with an increase in oxygen saturation Kasza (1988). An increase in number of the algivorous species was usually accompanied by a decrease in that of the bacteriophagous ones. The linear differentiation of the fauna of Ciliata along the pollution gradient was also described by Wiąckowski (1981) and Czapik (1982).

The water stage at Łączany has had a negative effect on the biocenosis of Ciliata. This is confirmed by the distinct decrease in their numbers in the reservoir and also by the development of the bacteriophagous species. The low oxygenation of the surface water of the reservoir (Kasza 1988) allows the assumption that there are still worse oxygen conditions at the bottom in the deeper parts by the dam. The zone of the river near the bank, with small depth and a rapid flow created much more favourable conditions for the development of bottom microfauna. Nevertheless, in the zone near the bank just below the dam, the development of Ciliata communities was slightly poorer owing to the strong current, which scoured out the mud.

On the basis of the investigations carried out, it should be stated that the pollution of the River Vistula on the examined section has had a negative effect on the variety and numbers of Ciliata. The water stage at Łączany deteriorates the conditions for the development of microfauna. More favourable changes in the environment, especially in the conditions of oxygenation, appeared gradually in the water at a certain distance from the reservoir, this being manifested by the development of more diversified species of the microfauna of Ciliata and an increase in their numbers.

5. Polish summary

Ekosystem uregulowanego i zanieczyszczonego odcinka Górnej Wisły

7. Orzęski denne

Prowadzono badania nad orzęskami zanieczyszczonego odcinka górnej Wisły, w rejonie progu wodnego w Łączanach (od 33 km do 55 km), na 6 stanowiskach (ryc. 1). Celem niniejszej pracy było zbadanie oraz przeanalizowanie wpływu stopnia wodnego na zbiorowiska orzęsków w osadach dennych przybrzeżnych płycizn rzeki. W badaniach stwierdzono zubożenie jakościowe orzęsków — znaleziono tylko 49 gatunków (tabela I). Zmiany liczebności orzęsków są raczej nieregularne (ryc. 2) z tendencją do jej wzrostu, w większości przypadków w czasie lata lub jesieni.

Grupa dominantów (I) była bardzo nieliczna (9 gatunków) i tworzyły ją wyłącznie gatunki bakteriożerne. Pewne polepszenie warunków środowiskowych wzdłuż biegu rzeki, zwłaszcza w zakresie nasycenia wody tlenem poza progiem wodnym w Łączanach, sprzyjało pojawieniu się w dnie orzęsków glonożernych (tabela I).

Próg wodny w Łączanach pogarszał warunki środowiskowe rozwoju mikrofauny, zwłaszcza w głębszych partiach zbiornika, co przejawiało się tak jakościowym, jak i ilościowym zubożeniem mikrofauny orzęsków (ryc. 2).

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