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The effect of dam reservoirs on oligochaete communities in the River Dunajec (Southern Poland)*

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Abstract — In the studied section of the Dunajec and in two dam reservoirs 47 oligochaete species were found. In the reservoirs and silted river sectors Tubificidae dominated and at the remaining stations Naididae. The structure of dominance depended on the type of bottom, and the trophicity of the water. Hydrotechnical development indirectly affected the structure of the communities, modifying the living conditions of the oligochaetes by changing the velocity of the current and the character of the river bottom below the reservoir.

Key words: regulated streams, water pollution, oligochaete communities.

1. Introduction

As more and more dam reservoirs were constructed, so there was a corresponding increase in the number of papers concerning the formation in them of benthic fauna and its changes as the reservoirs aged (Pataridzhye 1963, Krzyżanek 1970, Ekatyerinskaya 1972, Mordukhayi-Boltovsloyi 1971, Voropayev, Vyendrov 1979). Also the Rożnów reservoir has been studied in this aspect (Olszewski 1953, Grzybowska 1957, 1965, Dumnicka et al. 1986). However, it is only comparatively recently that closer attention has been given to changes in river fauna below a reservoir (Ward, Stanford 1979). Usually, the number of oligochaetes was found to increase below the dam, as for instance in the Rier Svratka (Czechoslovakia) (Peňaz et al. 1978), in the Colorado River (USA) (Ward 1976), or the Tess (England) (Armitage 1978). There is, however, no information on changes in the structure of communities, as oligochaetes were not determined in these studies.

The purpose of the investigations carried out between 1982 and 1983

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was to describe the changes in the numbers and structure of oligochaete communities below various types of reservoirs on the Dunajec (Rożnów — a flood control reservoir, with a power station of the pumped-storage type, Czchów — a storage reservoir). A description of the fauna of the Rożnów reservoir has already been published (Dumnicka et al. 1986), hence in the present paper the oligochaetes of that reservoir are only briefly described.

2. Study area

Samples were taken from 8 stations (fig. 1), a brief description of which is given in Table I. Particular attention was paid to stations lying below the two reservoirs, since they differ considerably. Water is discharged unevenly from the Rożnów reservoir, depending on the functioning of the power station. Diel changes in the water level of the river

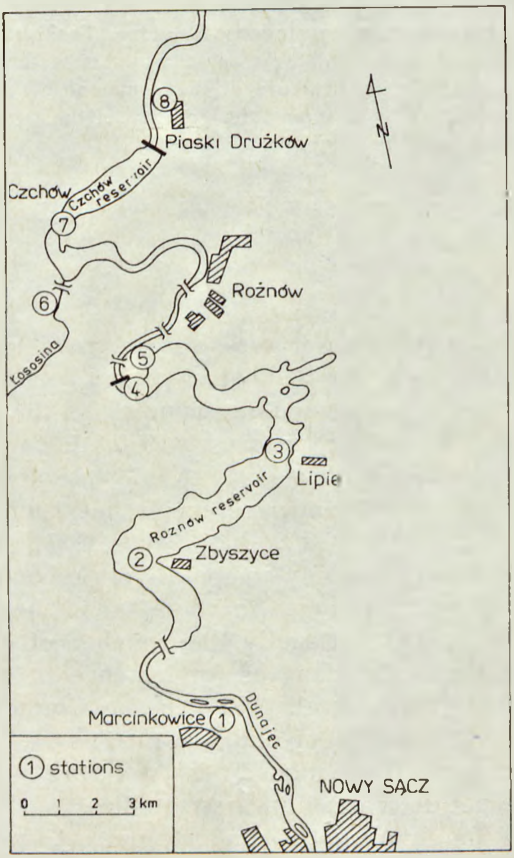

Fig. 1. Map of the investigated area with sampling stations 1—8

Table I. Brief description of the investigated stations

Station / Factor	1	2	3	4	5	6	7	8
Water body	River Dunajec	Rożnów reservoir	Rożnów reservoir	Rożnów reservoir	River Dunajec	River Łososina	Czchów reservoir	River Dunajec
Locality	Marcinkowice, 2 km above the Rożnów reservoir	Zbyszyce, 13 km from the dam	Lipie, 7.5 km from the dam	Rożnów, 500 m from the dam	Rożnów, 600 m below the dam	500 m above the bridge	Czchów, middle part of the reservoir	Piaski-Drużków, 1.5 km below the dam
Depth (m)	0.4 - 1.0	1.5 - 4.5	11 - 14	16.5 - 20	24 hours fluctuations reach 2m	0.2 - 0.8	3.0 - 4.8	0.6 - 1.0
Velocity of current	medium	-	-	-	variable	medium to fast	-	slow to medium
Type of bottom	stones and pebbles	grey mud	grey mud, in summer covered by 0.5 cm layer of yellow sediment	10 cm of grey-yellow mud, below black mud, odourless	big stones with Cladophora	stones, pebbles, partially covered by mud	grey mud, detritus	stones, pebbles, partially covered by mud

below this reservoir reach 2 m, while the velocity of the current also changes, depending on the amount of water discharged. The bottom is covered with large stones on which grow dense thalli of Cladophora. The Czchów reservoir is of the storage type, hence the level of water below it is subject to only slight fluctuations, smaller than in a natural river. Under such conditions, large portions of the bottom are silted over.

3. Material and methods

From the rivers samples were taken using a bottom sampler from an area of 400 cm², and from reservoirs using an Ekman grab from an area of 225 cm². Each time, 3 samples were taken per station. They were then rinsed in an 0.3 mm² mesh net and preserved using 4% formalin. Specimens were picked out using a stereoscopic microscope. Oligochaete density was expressed per m². Dominance was determined from the percentage of a given species in the total oligochaete fauna. The following categories of abundance were adopted: a proportion of 10% or more — dominant species; 1—9.9% — subdominant; under 1% — adominant. In order to compare stations, their similarity was calculated by the Marczewski-Steinhaus method, substituting quantitative data (abundance of species) in the formula and then plotting the dendrogram of similarity of the stations from cluster analysis.

At all the stations material was collected on the following dates: 9 Sept., 12 Oct., 16 Nov., 14 Dec. 1982, 25 Jan., 17 May, 12 Jul., 16 Aug., and 12 Sept. 1983, and on March 1, 1983 at river stations only. In rivers, samples were collected from all the habitats occurring at a station but in the reservoirs from one habitat, since within a station the bottom was uniform.

4. Results

In the material collected, 47 oligochaete species belonging to 5 families (Table II) were found to occur. The family Naididae was the most strongly represented, both in respect to the number of species and abundance.

The number of oligochaete species increased at successive stations, amounting to 22 species at Station 1, 24 at Station 5, and 30 at Station 8. At Station 6 in the River Łososina, running into the Czchów reservoir, 29 species were found. The density of oligochaetes in the Dunajec chang-

Table II. Average number of oligochaetes (per m^2) at the investigated stations in the period 1982 - 1983

Species \ Station	1	2	3	4	5	6	7	8
Naididae								
Amphichaeta leydigii Tauber	3	9			2	7		12
Chaetogaster diaphanus (Gruith.)	1127				20			
- diastrophus (Gruith.)	28				36	191		25
Pristina longiseta Ehr.	50					4		2
bilobata (Bret.)	28					2		
- foreli (Pig.)	400				2	77		
rosea (Pig.)		1			28	31		
- menoni (Aiyer)	102					2		
- idrensis Sperber	65					5		
Haemonais waldvogeli Bret.			13					
Stylaria lacustris (L.)	13		2		437			176
Dero (Dero) digitata (Müll.)		92	374	321		9	31	6
Slavina appendiculata d'Udekem					5			
Vejdovskyella intermedia (Bret.)		189	4		6	28	470	17
Nais barbata Müll.	9223	7			2697	15	11	51
- elinguis Müll.	153				4	31		170
- bretscheri Mich.	613				455	927	16	251
- pseudobtusa Pig.	117				42	35	6	4
- simplex Pig.					2			3
- pardalis Pig.					141	112	10	49
communis Pig.	745	4			64	8		20
variabilis Pig.	33				27	11	27	11
behningi Mich.					9	41		1
alpina Sperber					12	53		2
- christinae Kasp.	502	4			298	16		5
Spocaria josinae (Vejd.)		422	13	13		5	144	299
Uncinais uncinata (Oersted)		88					32	
Ophidonais serpentina (Müll.)					173	3	35	
Tubificidae								
Moraviodrilus pygmaeus (Hr.)							3	
Potamothrix hammoniensis (Mich.)								2
- moldaviensis (V.and M.)		4	35	51		1	22	
Myodrilus templetoni (South.)							64	5
Spirosperma ferox Eisen			2					
Tubifex tubifex (Müll.)		53	59	33			63	34
- ignotus (Stolc.)	10						7	5
Limnodrilus hoffmeisteri Clap.	85	253	174	108		75	193	42
- udekemianus Clap.		46	35	57		1	99	7
- profundicola Verrill	5	20	9	11		6	38	
- claparedeanus Ratz.	2	66	68	51		76	147	7
Aulodrilus limnobius Bret.								3
- pluriseta (Pig.)		229		18		77	112	32
Enchytraeidae								
Propappus volki Mich.					1			
Henlea ventriculosa (d'Udekem)					8			
- spp. Mich.					2			1
Enchytraeus buchholzi Vejd.	2							
Marionina riparia Brets	10	2			16	9		10
Lumbriculidae								
Lumbriculus variegatus (Müll.)								1
Lumbricidae								
Eiseniella tetraedra (Sav.)					34			
Tubificidae gen.spp.juv.	978	1713	2752	2409	24	683	9972	588
Enchytraeidae gen.spp.juv.	17	2		2	99	57	15	46
Lumbricidae + Lumbriculidae					1	1	3	
Total	14347	3204	3540	3074	4648	2608	11520	1817

Table III. Percentage composition of oligochaete communities at the investigated stations in the period 1982-1983

Species \ Stations	Rivers				Reservoirs			
	1	5	8	6	2	3	4	7
Naia barbata	64.3	58.0	2.8	0.6	0.2			0.1
- bretscheri	4.3	9.8	13.8	35.5				0.1
- communis	5.2	1.4	1.0	0.3	0.1			
- christinae	3.5	6.4	0.3	0.6	0.1			
Stylaria lacustris	0.1	9.4	9.6			0.1		
Chaetogaster diastrophus	0.2	0.8	1.4	7.3				
- diaphanus	7.9	0.4						
Limnodrilus hoffmeisteri	0.6		2.3	2.9	7.9	4.9	3.5	1.7
Naia pardalis		3.0	2.6	4.3				0.1
- alpina		0.3	0.1	2.0				
Specaria josinae			12.6	0.2	13.2	0.4	0.4	1.3
Tubificidae gen.spp.juv.	6.8	0.5	32.4	26.2	53.4	77.7	78.4	86.6

ed inversely to the number of species, i.e. numbers were highest at Station 1, lower at Station 5, and lowest at Station 8.

In both reservoirs the number of species determined was lower than in the rivers. The number was lower especially in the deeper regions of the Rożnów reservoir, only 12 species being determined at Station 3, and 9 at Station 4. The density of the oligochaetes differed considerably between the reservoirs: in the Rożnów reservoir (Stations 2, 3 and 4) it was about three times lower than in the Czchów one (Station 7) (Table II).

The structure of the oligochaete communities differed considerably between river stations (Table III). At Stations 1 and 5 the only dominant, with a high coefficient of dominance, was *Nais barbata*, a species characteristic of running waters and occurring in profusion in some mildly polluted rivers. Naididae constituted over 90% of the oligochaete fauna at these stations. Especially at station 5, below the Rożnów reservoir, the share of Tubificidae in the community was small. Species characteristic of mountain rivers were subdominant, i.e. *Nais bretscheri* and *Nais communis*, and also a phytophilous species, *Stylaria lacustris*, as well as *Nais christinae*, not hitherto found in the Dunajec. At Station 8, juvenile forms of Tubificidae were the prime dominant, while *Nais bretscheri* and *Specaria josinae* also dominated. Each of these species prefers a different habitat, and the diversity in the river bottom made it possible for them to occur together. The large share of Tubificidae indicates the existence of well-developed silted zones. In sections with a swift current *Nais bretscheri* dominated while the species *Specaria josinae* occurred in an intermediate habitat. On the River Łososina (Station 6) the prime dominant was *Nais bretscheri*, a species characteristic of mountain waters. Tubificidae gen. spp. juv. were the second dominant, occurring in stagnant pools and places with a poor water flow, these being not uncommon in the mouth section of the river which falls into the Czchów re-

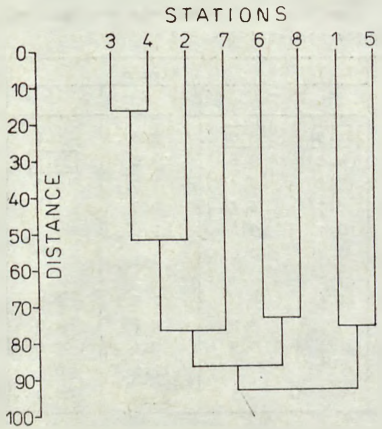

Fig. 2. Dendrogram of the oligochaete communities at the investigated stations

servoir. Among the subdominants there were species from the family Naididae and also Tubificidae.

In both reservoirs Tubificidae were decidedly, dominant, this being typical of stagnant waters. Moreover, in the upper part of the Rożnów reservoir (Station 2) and in the Czchów reservoir (Station 7) there occurred species which had been carried down with the river waters. This was apparent especially in the smallish Czchów reservoir, where the species were brought in by two rivers, the Dunajec and the Łososina. Moreover, in the Rożnów reservoir there also appeared species typical of slow-running and silted lowland rivers, such as *Vejdovskyella intermedia* or *Aulodrilus pluriseta*.

The quantitative similarity of the fauna between stations was not great (fig. 2). Nevertheless, three groups of stations could be distinguished. The first group consisted of all the stations situated on the reservoirs where Tubificidae dominated, the greatest similarity being found between the deep Stations 3 and 4. Stations 6 and 8, which have a similar "mosaic" of habitats on the bottom, constituted the second group and Stations 1 and 5 the third. The patterns of dominance of the oligochaetes were similar at the two last stations, but they differed in the number of oligochaetes.

5. Discussion

The benthos of the Dunajec and of the Rożnów reservoir has already been studied. In the first work on the benthic fauna of the whole Dunajec, the oligochaetes were briefly mentioned (W r ó b e l 1965), only 9 species being determined. Nevertheless, already in the sixties, the present author noted the occurrence of *Nais barbata* at Station 1 in Mar-

cinkowice, where during the most recent investigations it was the dominant species. The oligochaete fauna of the Dunajec was studied in detail (Dratnal et al. 1979) in the sector from Harklova to Sromowce Niżne, where the river is more polluted with communal wastes than on the section studied in the present work, this being evidenced by the great abundance of oligochaetes and the dominance of *Nais elinguis*. The pollution brought about no marked regression in species composition, since the authors reported 42 species from this relatively short stretch of the river.

In piedmont rivers such as the Dunajec or the Łososina, Naididae should be dominant (*Nais bretscheri, N. alpina,* and *N. pardalis* (Kasprzak, Szczęsny 1976, Learner et al. 1978, Dumnicka 1982). Such a pattern was maintained only at Station 6 on the River Łososina and at Station 8 on the River Dunajec, in sections with a swift current. At both these stations Tubificidae were again dominant, this being due to the influence of the Czchów reservoir. In the mouth section of the Łososina, there are large areas of the bottom covered with silted stones, or with fine-grained sediment, where Tubificidae dominated. Below the Czchów reservoir where the flow of water in the Dunajec is relatively even and no sudden upsurges of water occur to wash out the silt, Tubificidae were found most abundantly.

At Stations 1 and 5, the species typical of mountain rivers were substituted by *Nais barbata,* this being the result of a rise in the trophicity of the water below Nowy Sącz. At Station 5 the Rożnów dam has a marked influence on the oligochaeta fauna, consisting mainly in the elimination from this section of the river of species requiring a quiet current and fine-grained bottom. Small Naididae occurring here took refuge among the thalli of Cladophora to prevent being washed away.

In work carried out to date, authors (Peňaz et al. 1968, Ward 1976, Armitage 1978) have found oligochaete numbers to increase below dams. This phenomenon was expiained by the decline in flow, and hence the occurrence of habitat conditions favourable to the oligochaetes. In the Dunajec, a constant decline in the number of oligochaetes was found, irrespective of whether, as compared with the natural one, the current was stronger (Rożnów) or weaker (Czchów). The velocity of the current affected the structure of the community, while in the case of oligochaete numbers it was the trophicity of the water which was the main factor. The greatest numbers were recorded below Nowy Sącz (Station 1) and in the Czchów reservoir (Station 7), where detritus carried down both by the Dunajec and the Łososina accumulated on the bottom.

The investigated section of the Dunajec has a qualitatively rich oligochaete fauna, mostly species already reported from the upper course (Dratnal et al. 1979). The mentioned authors did not record the presence of *Nais christinae* in the Dunajec, while in the section studied it

was one of the subdominants. This species has been described from artificially heated lakes near Konin (K a s p r z a k 1973) (Wielkopolsko-Kujawska Lowland) and has spread rapidly into other waters, mainly rivers (D u m n i c k a unpubl.).

On the basis of the results obtained it may be concluded that the species composition of oligochaetes, the structure of their communities, and the numbers found in the rivers and reservoirs studied are determined by three factors. The character of the bottom is of primary importance, as the oligochaetes exhibit strong species variation depending on the habitat, the second factor is municipal pollution, coming mainly from Nowy Sącz, causing an increase in the trophicity of the water especially at Station 1. Fertilization of the water brings about an increase in oligochaete numbers. Finally, the third factor is the hydrotechnical development of the river, which, by altering the conditions in which these animals live (changes in current velocity, the character of the bottom), indirectly affects their numbers and species composition.

6. Polish summary

Wpływ zbiorników zaporowych na zgrupowania skąposzczetów w Dunajcu (Polska Południowa)

W latach 1982—1983 prowadzono badania nad zgrupowaniami skąposzczetów w rejonie zbiorników Roznów i Czchów. Do badań wytypowano 8 stanowisk (ryc. 1): 4 położone były na rzekach i 4 w zbiornikach (tabela I). Próby pobrano 9-krotnie w okresie od września 1982 do września 1983. Zazwyczaj pobierano 3 próby, starając się uchwycić wszystkie siedliska występujące na danym stanowisku.

W badanym materiale oznaczono 47 gatunków skąposzczetów należących do 5 rodzin (tabela II). W Dunajcu liczba gatunków skąposzczetów wzrastała z biegiem rzeki od 22 gatunków na stanowisku 1 do 30 na stanowisku 8. Zagęszczenie natomiast zmalało od ponad 14 tys. osob. m^{-2} na stanowisku 1 do niecałych 2 tys. osob. m^{-2} na stanowisku 8. W zbiornikach stwierdzono występowanie mniejszej liczby gatunków niż w rzekach.

Struktura zgrupowań skąposzczetów badanych stanowisk nie jest jednakowa. Na stanowiskach 1 i 5 dominuje *Nais barbata*, a na stanowiskach 6 i 8 *Nais bretscheri* i Tubificidae gen. spp. juv. (tabela III). W zbiornikach także dominują Tubificidae.

Ilościowe podobieństwo fauny skąposzczetów badanych stanowisk nie jest duże, niemniej można wyróżnić 3 grupy stanowisk: zbiorniki, rzeka silnie zeutrofizowana, rzeki mniej zeutrofizowane (ryc. 2).

Naturalne dla rzek karpackich zgrupowanie skąposzczetów stwierdzono tylko w siedlisku prądowym na stanowiskach 6 i 8. Na stanowiskach 1 i 5 o strukturze zgrupowania decyduje stopień zanieczyszczenia wody i dodatkowo na stanowisku 5 wpływ zapory. Polega on na wyeliminowaniu gatunków pelo- i psammofilnych, natomiast poniżej zapory w Czchowie, gdzie nie ma dużych wahań poziomu wody w rzece, strefy zamulone zajmują dość dużą powierzchnię. Żyją w nich liczne Tubificidae.

Na podstawie otrzymanych wyników można stwierdzić, że o składzie gatunkowym skąposzczetów, strukturze ich zgrupowań i liczebnościach w Dunajcu powyżej i poniżej zapór decyduje kilka czynników. Na pierwszym miejscu wymienić należy charak-

ter dna, gdyż skąposzczety wykazują silne zróżnicowanie gatunkowe w zależności od siedliska. Drugim czynnikiem są zanieczyszczenia, które wpływają na zmianę gatunków dominujących i na zwiększenie liczebności skąposzczetów. Wreszcie trzecim czynnikiem jest zabudowa hydrotechniczna rzeki, która zmienia charakter dna i szybkość prądu, a tym samym wpływa pośrednio na zmianę składu gatunkowego skąposzczetów oraz na ich liczebność.

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