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Diversity of flora and fauna in running waters of the Province of Cracow (southern Poland) in relation to water quality. 4. Zooseston

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Abstract – 119 animal species belonging to 8 higher taxonomic units were identified. Rotifera were the most numerous animals in zooseston (95 species). Cladocera (15 species) and Copepoda (4 species) were less numerous. According to the results of similarity analysis the examined stations were divided into five groups. Three kinds of river environment distortion were distinguished: trophic, chemical, and hydrological.

Key words: zooplankton, biodiversity, rivers, streams.

1. Introduction

Investigations of rivers in the Cracow region have a long, 120-year, tradition. Most of them were devoted to the Rivers Vistula and Raba. Zooseston, however, contrary to other communities, was not investigated in the Vistula habitats. Only the zooseston of that river was examined relatively well. The first investigations by Starmach (1938) gave a small collection of data concerning zooseston. Later, investigations of the zooseston were carried out by Turoboyski (1956, 1962), Kyselowa and Kysela (1966), Starzykowa (1972), Hanak-Schmager (1974), Turoboyski and Pudo (1979), Bednarz and Żurek (1988). Until now the rivers and streams of the Province of Cracow had not been investigated simultaneously.

The main task of this work was to investigate the species composition of zooseston in all the main rivers and streams in the neighbourhood of Cracow, and to test the usefulness of this community for water quality assessment in rivers.

2. Study area

Zooseston samples were collected at 38 sites out of 41 chosen for the complex investigation of rivers and streams of the province (Fig. 1). Left-side tributaries of the Vistula flow through Jurassic limestone formations and, in their low reaches, Quaternary alluvia. These streams have considerably harder water than the

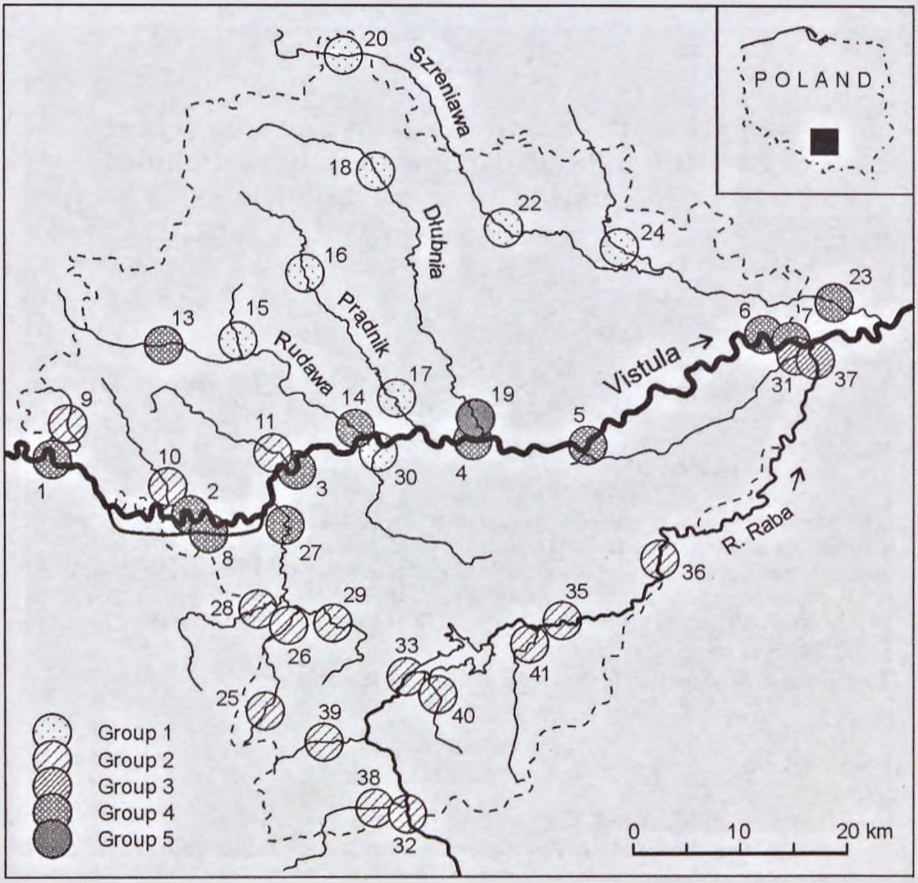

Fig. 1. Location of the studied stations in the Cracow Province and their classification according to similarities between zooseston communities: 1–7 – the Vistula (1– Okleśna, 2 – Czernichów, 3 – Tyniec, 4 – Cracow, 5 – Niepołomice, 6 – Sierosławice, 7 – Uście Solne), 8 – the Łączany Canal, 9 – the Regulanka stream at Regulice, 10 – the Rudno stream at Przeginia, 11 – the Sanka stream above the water intake, 13, 14 – the River Rudawa (13 – Krzeszowice, 14 – Cracow), 15 – the Rudawka stream at Rudawa, 16, 17 – the Prądnik stream (16 – Ojców, 17 – Zielonki), 18, 19 – the Dłubnia stream (18 – Grzegorzowice, 19 – Zesławice), 20–23 – the River Szreniawa (20 – Przybysławice, 22 – Kacice, 23 – Biskupice), 24 – the Ścieklec stream at Mokocice, 25 – the Harbutówka stream at Biertowice, 26, 27 – the River Skawinka (26 – Radziszów, 27 – below the heated water discharge at Skawina), 28 – the Cedron stream at Wola Radziszowska, 29 – the Głogoczówka stream at Jaworzna, 30 – the Wilga stream at Swoszowice, 31 – the Drwinka stream at Świniary, 32–37 – the River Raba (32 – Lubień, 33 – Myślenice-Zarabie, 35 – Gdów, 36 – Książnice, 37 – Uście Solne), 38 – the Krzczonówka stream 1 km above its outflow into the Raba, 39 – the Trzebuńka stream at Stróża, 40 – the Trzemeśnianka stream at Łęki, 41 – the Krzyworzeka stream at Czasław.

right-bank tributaries (also the Vistula water is relatively hard). Farther to the east from Cracow, left-side tributaries flow on loess formations. Right-side tributaries flow on Tertiary sandstones of Carpathian flysch. These streams usually have soft weakly buffered water. Drainage basins are mostly more forested than those of left-bank tributaries. Water chemistry and trophic state in the Vistula basin is greatly affected (Wojtan et al. 2000). Discharge of saline waters from the Silesian coal mines and domestic wastes strongly affect the habitat conditions in the Vistula. Average chloride concentration in that river in 1994 was 1536 mg L^{-1} (max. 1802, min. 823 mg L^{-1}), while the mean amount of soluble substances was 2387 mg L^{-1} (Krokowski et al. 1994, Kułakowski 1994). Olszewski (1871), noted in the Vistula 5.7 mg Cl^{-} L^{-1} 123 years ago.

3. Material and methods

Zooplankton samples were collected from 10 to 30 October 1994 using a calibrated bucket. A hundred litres of water was filtered through a 50 µm mesh plankton net. Samples were preserved with 4% formalin. At the laboratory, the samples were concentrated and zooplankton was identified and counted under the microscope. For identification the keys of Koste (1978), Flössner (1972), and Dussart (1969) were used.

The matrix of similarity indices of the sites was calculated by the INDEX programme written for this purpose. As a measure of the site similarity, the SIMI index was applied (Stander 1970). It was calculated according to the formula:

$$\mathrm{SIMI} = \left(\sum^{S} P_{iA} P_{iB}\right) / \left(\sum^{S} P_{iA}^{2} \sum^{S} P_{iB}^{2}\right)^{1/2}$$

where: P_{iA} and P_{iB} are average relative abundance expressed as a proportion for the collection data of i-th species in the compared communities A and B, and S is the number of species. SIMI values ranged from 0 to 1, and the value 1 indicated identical communities. The matrix of indices was entered to the SYSTAT program for making the cluster analysis. Clustering by the average linkage method was used.

4. Results and discussion

In the seston of the investigated streams and rivers altogether 119 animal species belonging to eight systematic groups were identified (Table I). Most numerous were rotifers (95 taxa). Cladocerans and copepods were less numerous with only 15 and 4 species, respectively. Early development stages of copepods, nauplii, and copepodites were sometimes recorded in great numbers.

According to zooseston density, streams were divided into three groups (Fig. 2). In the first one were included those streams poor in seston, up to 2 individuals per litre. These streams flow in the Cracow-Częstochowa Jurassic region (9 – Regulanka, 10 – Rudno, 11 – Sanka, 18 – Dłubnia) and in the south of the Cracow Province (39 – Trzebuńka, 41 – Krzyworzeka). Chiefly sessile species, sometimes rare (*Dipleuchlanis propatula, Lecane flexilis*), were found there.

To the second group of sites with a greater amount of seston (2–20 ind. L^{-1}) belonged those on slightly polluted rivers, frequently flowing through agricultural or relatively little urbanised regions (13 – Rudawa, 16 – Prądnik, 22 – Szreniawa, 24 – Ścieklec, 25 – Harbutówka, 26 – Skawinka, 28 – Cedron, 29 – Głogoczówka, 32, 33 – Raba, and 40 – Trzemeśnianka) (Fig. 2). Along the course of the River Raba, the amount of zooseston slightly increased. In this group of sites the *Lecane-Cephalodella-Euchlanis* set is characteristic. The third group comprised sites with densities above 20 individuals per litre which were located in strongly eutrophicated rivers. Large towns here play a peculiar role, since below them the

Table I. List of zooseston species recorded in the rivers and streams of the Cracow Province in October 1994 (numbers of stations explained in Fig. 1, groups of stations separated according to clustering presented in Fig. 3): ● – dominant species.

	Taxa	Groups of stations																						
		1								2														
		17	16	24	22	20	18	30	15	41	35	26	39	32	25	9	29	28	38	11	10	33	36	40
	ROTATORIA																							
1	*Anureopsis fissa fissa* (Gosse)																							
2	*Asplanchna priodonta* Gosse																			+				
3	- *sieboldi* (Leydig)																							
4	*Brachionus angularis* Gosse																							
5	- *bidentata inermis* (Rousselet)																							
6	- *calyciflorus* Pallas				+		+					+					+							
7	- *dimidiatus* (Bryce)						+	+																
8	- *diversicornis* (Daday)																							
9	- *leydigi tridentatus* (Sernov)																							
10	- *plicatilis* (O.F.M.)																							
11	- *quadridentatus ancylognatus* (Schmarda)																							
12	- *quadridentatus brevispinus* (Ehrb.)									+		+						+				+		
13	- *quadridentatus quadridentatus* (Hermanns)									●														+
14	- *quadridentatus rhenanus* (Lauterborn)																							
15	- *urceolaris cluniorbicularis* (Skorikov)														+									
16	*urceolaris nilsoni* (Ahlstrom)											+						+						
17	- *urceolaris rubens* (Ehrb.)																							
18	- *urceolaris urceolaris* (O.F.M.)																							
19	*Cephalodella* sp.													+		+								
20	- *elegans* Myers														+				+					
21	- *gibba gibba* (Ehrb.)							+	+	+		●	+	●	●	+	●	●	●	●	●		+	+
22	- *labiosa* Wulf.	+	+														+							
23	- *macrodactyla* (Stenroos)		+																					
24	- *sterea sterea* Gosse																						+	
25	*Colurella geophila* Donner																							
26	- *obtusa obtusa* (Gosse)										+												+	
27	- *uncinata* O.F.M.							+	+		+	+			+			+			+	●	+	
28	*Conochilus unicornis* Rousselet																							

29	*Dipleuchlanis propatula* (Gosse)																		
30	*Diplois deflexa deflexa* (Gosse)					+						+							
31	*Euchlanis dilatata dilatata* Ehrb.		●	+			+	+	+		+		+	+	+		+	+	
32	- *lyra* Hudson		+																
33	- *triquetra* Ehrb.		+																
34	*Filinia limnetica* (Zacharias)																		
35	- *longiseta* (Ehrb.)		+																
36	*Keratella cochlearis cochlearis* Gosse		+			●				+	+							+	
37	- *irregularis* (Lauterborn)																		
38	- *tecta* (Lauterborn)																		
39	- *quadrata* (O.F.M.)	+																	
40	*Lecane aculeata aculeata* (Jakubski)		+																
41	- *bulla bulla* (Gosse)				+		+	+	+	+							●	+	+
42	- *closterocerca* (Schmarda)		●	●	+	+	+	+	●	+			+	●			●	+	+
43	- *cornuta oidipus* (Hauer)																		
44	- *flexilis* (Gosse)														+				
45	- *furcata furcata* (Murray)														+				
46	- *luna* (O.F.M)				+	+									●		+	+	+
47	- *lunaris* (Ehrb.)		+		+	+		+	●	+	+	●	+	●	●	●	●	●	+
48	- *obtusa* (Murray)													+					
49	- *stenroosi californica* (Wulf)																		
50	*Lepadella ovalis* (O.F.M.)		+		+	●	●	●	●	●	●		+	●	+	●	●	●	+
51	- *patella* (O.F.M.)															+			
52	*Lophocharis* sp. Ehrb.		+																
53	*Monommata* sp. Bartsch					+													
54	*Mytilina bicarinata* (Perty)				+									+			+		+
55	- *ventralis brevispina* (Ehrb.)		+																
56	*Notholca* sp.																		
57	- *acuminata* (Ehrb.)		+																
58	- *labis* Gosse			+															+
59	- *squamula* (O.F.M.)								+										
60	- *striata* (O.F.M.)																		
61	*Paracolurella logima logima* (Myers)																+		
62	*Philodina* sp.			●						+		●	●						
63	*Platyias quadricornis* (Ehrb.)		+										●						
64	*Polyarthra euryptera* (Wierzejski)					+													
65	- *major* Buckhardt																		

Table I. *continued*

	Taxa	Groups of stations																						
		1								2														
		17	16	24	22	20	18	30	15	41	35	26	39	32	25	9	29	28	38	11	10	33	36	40
66	- *minor* Voigt																							
67	- *vulgaris* Carlin							+																
68	- *vulgaris longiremis* Carlin			+																				
69	*Pompholyx sulcata* (Hudson)																							
70	*Proales* sp. Gosse																		+					
71	- *similis* De Beauchamp																							+
72	*Rotaria neptunia*							+															●	
73	*Scardium longicaudum* O.F.M.																							
74	*Synchaeta kitina* Rousselet																					+		
75	- *tremula* (O.F.M.)																							
76	*Testudinella caeca* (Parsons)																							
77	- *mucronata hauerensis* (Gillard)							+											+					
78	- *patella* (Hermann)							+				+	+	+					+				+	+
79	*Trichotria curta* Skorikov																							
80	- *pocillum* (O.F.M.)													+				+						
81	- *tetractis tetractis* Ehrb.									+									+			+	+	+
82	- *tetractis similis* (Stenroos)																							+
83	*Trichocera* sp.											+		+										
84	- *bicristata* (Gosse)																							
85	- *capucina* (Wierzejski et Zacharias)														+									
86	- *cylindrica* (Imhof)																	+			●			
87	- *rattus* (O.F.M.)																							+
88	- *similis similis* (Wierzejski)		+					+																
	CLADOCERA																							
89	*Alona costata* Sars										+	+												
90	- *guttata* Sars									+									+					+
91	- *quadrangula*									+														
92	- *quadrangularis* (O.F.M.)								+	+														+
93	- *rectangula* Sars							+		+	+				+	+			+					
94	- *rustica* Scott																							

95	*Bosmina coregoni* Baird																		+						
96	- *longirostris* (O.F.M.)																				●				
97	*Ceriodaphnia quadrangula* (O.F.M.)																								
98	*Chydorus sphaericus* (O.F.M.)							+			●	+		+										+	●
99	*Daphnia longispina* (O.F.M.)																								
100	*Eurycercus lamellatus* (O.F.M.)																								
101	*Liocryptus sordidus* (Lievin)															+		+							
102	*Peracantha truncata* (O.F.M.)							+											+						
103	*Simocephalus vetulus* (O.F.M.)																								
	COPEPODA																								
104	*Acanthocyclops robustus* (Sars)																								
105	*Eucyclops serrulatus* (Fischer)					+																			
106	*Mesocyclops leuckarti* (Claus)							+																	
107	*Thermocyclops crassus* (Fischer)																								
108	Copepodites							+				+				+		+		+				+	+
109	Nauplii					+	+	●	+			+	●	+	+		+	●	+	●	+	+		+	+
110	*Hydra* sp.								+																+
111	Nematoda	●	●		●	●	●	●	●			+	+	+	+	●	●	●	+	+					+
112	Oligochaeta		+						+		+	+	●	●	+		+	+	●	+				●	●
113	*Mideopsis orbicularis* (Mull.)							+				+		+		+				+					
114	Chironomidae							+	●		●	●	●	●	+	+	+	+	+	+	●	+	+	●	+

Table I. *continued*

	Taxa	Groups of stations														
		3		4												5
		37	31	13	7	6	5	4	2	1	27	8	3	14	23	19
	ROTATORIA															
1	*Anureopsis fissa fissa* (Gosse)														●	
2	*Asplanchna priodonta* Gosse			+	+									+	+	+
3	- *sieboldi* (Leydig)				+											
4	*Brachionus angularis* Gosse				+	+	+	●	●	●	●	+	●	+	+	+
5	- *bidentata inermis* (Rousselet)				+											
6	- *calyciflorus* Pallas				●	+	●	+	+				+			
7	- *dimidiatus* (Bryce)				+	+			+				+			
8	- *diversicornis* (Daday)				+										+	
9	- *leydigi tridentatus* (Sernov)							+								
10	- *plicatilis* (O.F.M.)				+	+	+	+	+	+		+	+			
11	- *quadridentatus ancylognatus* (Schmarda)				●	●	+	+			+		+			
12	- *quadridentatus brevispinus* (Ehrb.)	+	+		●	●	●	●	●	+	+	+	+	●		
13	- *quadridentatus quadridentatus* (Hermanns)	+							+							
14	- *quadridentatus rhenanus* (Lauterborn)	+			●	+										
15	- *urceolaris cluniorbicularis* (Skorikov)					+	+									
16	*urceolaris nilsoni* (Ahlstrom)	+	+		●	●	●	●	+			●	●	+		
17	- *urceolaris rubens* (Ehrb.)					+					●					
18	- *urceolaris urceolaris* (O.F.M.)	+			●	●	●	●	●	●	●	●	●			
19	*Cephalodella* sp.															
20	- *elegans* Myers															
21	- *gibba gibba* (Ehrb.)	●	●	+				+	+		+					
22	- *labiosa* Wulf.															
23	- *macrodactyla* (Stenroos)															
24	- *sterea sterea* Gosse															
25	*Colurella geophila* Donner		+													
26	- *obtusa obtusa* (Gosse)	+														
27	- *uncinata* O.F.M.	+	+		+	+	+		+	+	+	+	+		+	
28	*Conochilus unicornis* Rousselet							+								

29	*Dipleuchlanis propatula* (Gosse)															
30	*Diplois deflexa deflexa* (Gosse)	+														
31	*Euchlanis dilatata dilatata* Ehrb.	●	●	+			+	+	+		+	+	+	+	+	
32	- *lyra* Hudson															
33	- *triquetra* Ehrb.															
34	*Filinia limnetica* (Zacharias)															+
35	- *longiseta* (Ehrb.)				+				+	+	+				+	+
36	*Keratella cochlearis cochlearis* Gosse						+	+	+	+	+		+	●	●	●
37	- *irregularis* (Lauterborn)				+											
38	- *tecta* (Lauterborn)						+	+		+	+			●	●	●
39	- *quadrata* (O.F.M.)				+		+	+	+	+	+	+	+			●
40	*Lecane aculeata aculeata* (Jakubski)															
41	- *bulla bulla* (Gosse)	+			+		+		+	+	+		+			
42	- *closterocerca* (Schmarda)	+														
43	- *cornuta oidipus* (Hauer)												+			
44	- *flexilis* (Gosse)															
45	- *furcata furcata* (Murray)															
46	- *luna* (O.F.M)	+	+									+				
47	- *lunaris* (Ehrb.)	+	+	+				+		+	+	+	+	+		
48	- *obtusa* (Murray)													+		
49	- *stenroosi californica* (Wulf)	+														
50	*Lepadella ovalis* (O.F.M.)	+	+	+				+			+		+	+		
51	- *patella* (O.F.M.)															
52	*Lophocharis* sp. Ehrb.															
53	*Monommata* sp. Bartsch															
54	*Mytilina bicarinata* (Perty)									+						
55	- *ventralis brevispina* (Ehrb.)															
56	*Notholca* sp.									+						
57	- *acuminata* (Ehrb.)	+														
58	- *labis* Gosse															
59	- *squamula* (O.F.M.)												+			
60	- *striata* (O.F.M.)															
61	*Paracolurella logima logima* (Myers)		+											+		
62	*Philodina* sp.		+	●	●	+	●	+	+	+	●	+	+	+		
63	*Platyias quadricornis* (Ehrb.)															
64	*Polyarthra euryptera* (Wierzejski)										+					●
65	- *major* Buckhardt													+		

Table I. *continued*

	Taxa	Groups of stations 3		4												5
		37	31	13	7	6	5	4	2	1	27	8	3	14	23	19
66	- *minor* Voigt								+							
67	- *vulgaris* Carlin				+	+	+	+	+	+	+	+	+	+		●
68	- *vulgaris longiremis* Carlin				+										●	+
69	*Pompholyx sulcata* (Hudson)								+	+						+
70	*Proales* sp. Gosse															
71	- *similis* De Beauchamp															
72	*Rotaria neptunia*				+			+	+		+	+	+			+
73	*Scardium longicaudum* O.F.M.															
74	*Synchaeta kitina* Rousselet									+		+	+			
75	- *tremula* (O.F.M.)															+
76	*Testudinella caeca* (Parsons)									+						
77	- *mucronata hauerensis* (Gillard)															
78	- *patella* (Hermann)	+										+	+	+		
79	*Trichotria curta* Skorikov															
80	- *pocillum* (O.F.M.)															
81	- *tetractis tetractis* Ehrb.	+														
82	- *tetractis similis* (Stenroos)															
83	*Trichocera* sp.		+													
84	- *bicristata* (Gosse)							+			+					
85	- *capucina* (Wierzejski et Zacharias)															
86	- *cylindrica* (Imhof)															
87	- *rattus* (O.F.M.)															
88	- *similis similis* (Wierzejski)	+														
	CLADOCERA															
89	*Alona costata* Sars															
90	- *guttata* Sars															
91	- *quadrangula*															
92	- *quadrangularis* (O.F.M.)															
93	- *rectangula* Sars															
94	- *rustica* Scott															

95	*Bosmina coregoni* Baird															+
96	- *longirostris* (O.F.M.)				+		+				+			●	+	+
97	*Ceriodaphnia quadrangula* (O.F.M.)	+												+		
98	*Chydorus sphaericus* (O.F.M.)							+		+			+			
99	*Daphnia longispina* (O.F.M.)											+		+		+
100	*Eurycercus lamellatus* (O.F.M.)		+													
101	*Liocryptus sordidus* (Lievin)			+												
102	*Peracantha truncata* (O.F.M.)															
103	*Simocephalus vetulus* (O.F.M.)								+		+	+				
	COPEPODA															
104	*Acanthocyclops robustus* (Sars)											+				
105	*Eucyclops serrulatus* (Fischer)		+							+		+				
106	*Mesocyclops leuckarti* (Claus)										+					
107	*Thermocyclops crassus* (Fischer)					+										
108	Copepodites	+		+	+	+	+	+	+	+	+	+		+		+
109	Nauplii	●	+	+	+	+	+	+	●	●	●	●	●	●	+	
110	*Hydra* sp.															
111	Nematoda	+		●	+	+	+		+	+	+			●		
112	Oligochaeta	●		●	+	+	+		+	+	+			+		+
113	*Mideopsis orbicularis* (Mull.)															
114	Chironomidae	+	+	+					+	+	+	+	+	+	+	

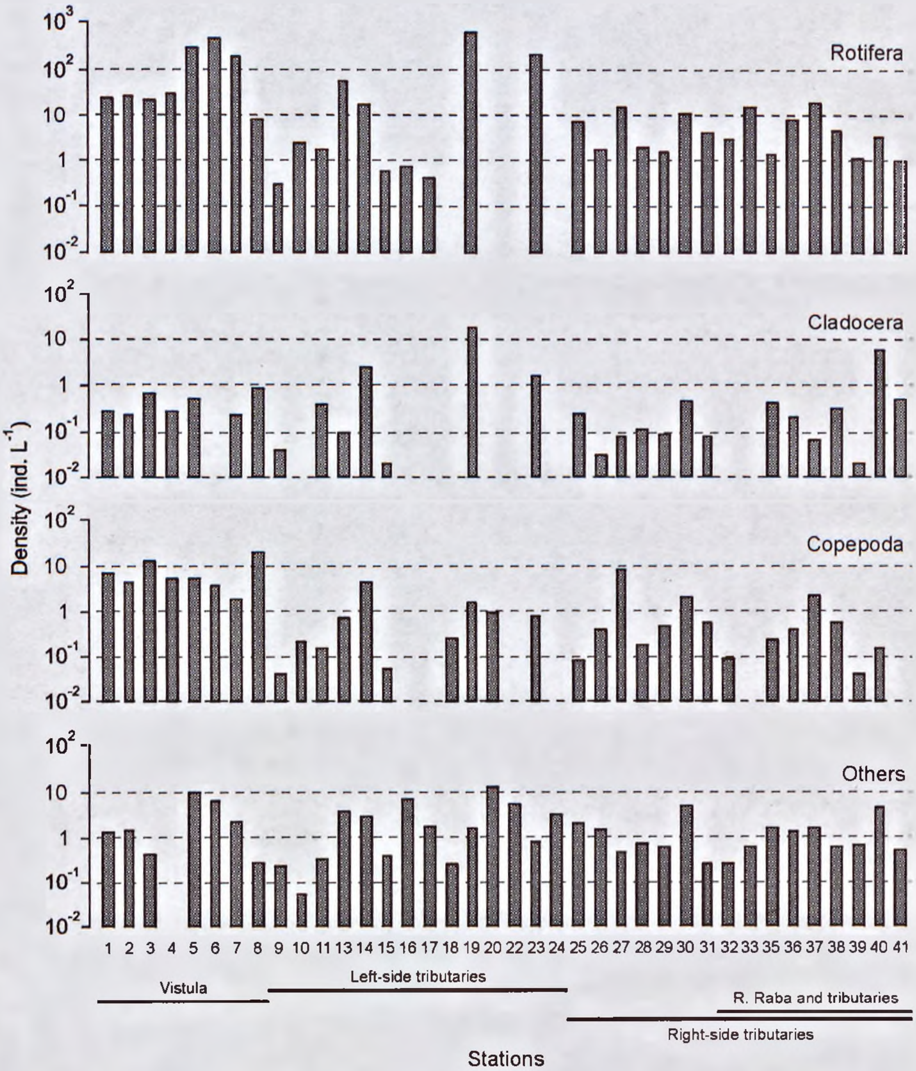

Fig. 2. Mean density of zooseston in the rivers and streams of the Cracow Province in October 1994 (numbers of stations explained in Fig. 1).

zooseston numbers increased 10–20 times. This group of sites is characterized by the *Brachionus-Keratella-Philodina-Polyarthra vulgaris* community.

The sites on the Vistula below Cracow (5), the Rudawa below Krzeszowice (13), and the Dłubnia below the dam reservoir at Zesławice and Szreniawa in its lower course (19 and 23), had species well-known from ponds and lakes: *Keratella cochlearis, K. quadrata, Brachionus angularis, Asplanchna priodonta, Daphnia longispina*, and *Bosmina longirostris*. Undoubtedly, these species originated from fish ponds, a small reservoir, or water stages. This is an undesirable, eutrophicating effect on the rivers of those stagnant water habitats. A very interesting habitat for zooplankton are the beds of the Łączany Canal (8). In thick as well as loose thalli of *Enteromorpha*, there live in large quantities *Simocephalus vetulus* and predaceous copepods *Acathocyclops robustus* and *Eucyclops serrulatus*. The Vistula has a unique set of 15 *Brachionus* species, among them also *Brachionus plicatilis* which prefers brackish waters. All the seston assemblages occurring at the stations on the Vistula are typical of strongly eutrophicated habitats (Table I).

Clustering of similarity indices allows the separation of five groups of sites at a 0.20–0.25 similarity level (Fig. 3; summary of this classification in Fig. 1). Three groups of stations are numerous while the remaining two have only one and two sites. Each of these groups has a few subgroups; however their consideration is of no significance for practical purposes. The first group comprises stations relatively

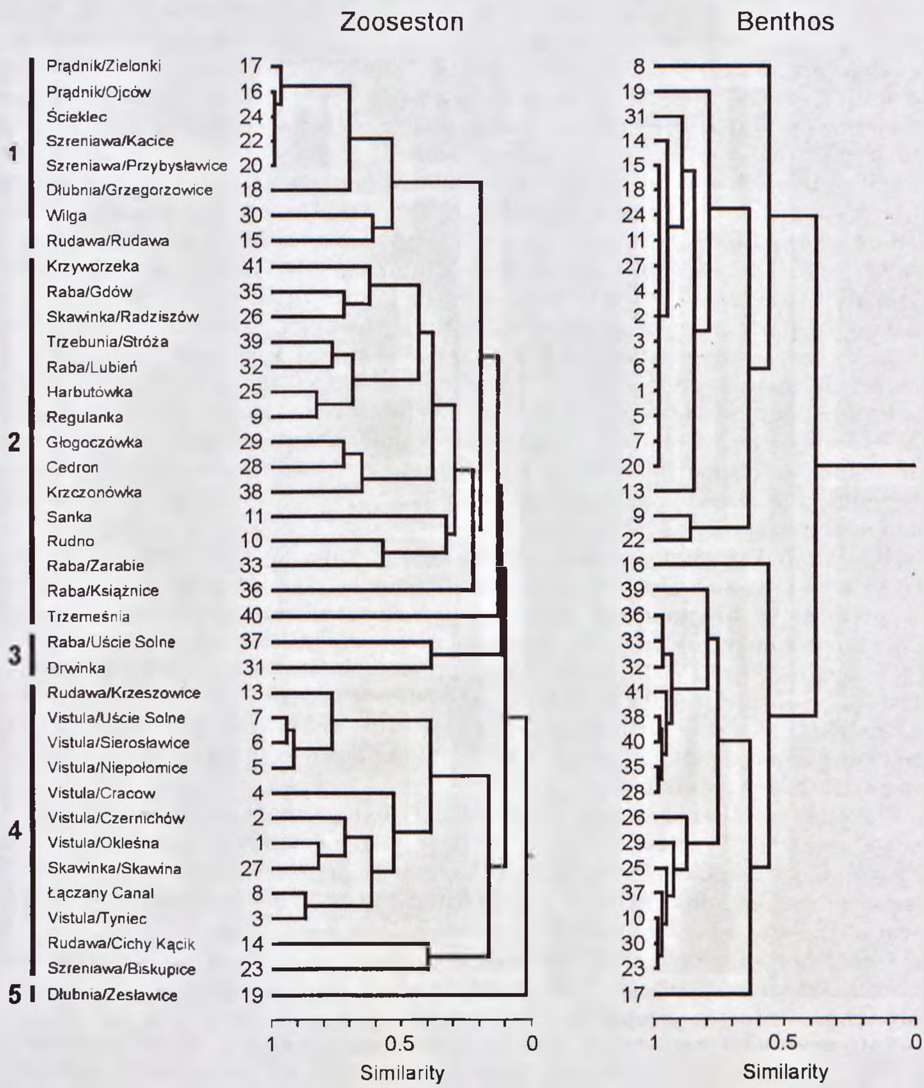

Fig. 3. Similarity of the zooseston and benthic macrofauna (after Dumnicka 1994) assemblages in rivers and streams of the Cracow Province in October 1994.

poor in species. Here belong Prądnik (16) and Szreniawa from Przybysławice to Proszowice (20–22), together with its tributary, the stream Ścieklec (24). A common feature here is the almost absence of zooseston. For the Szreniawa and Ścieklec this is caused by a large amount of mineral suspension and bad water quality, whereas for the Prądnik it is a result of natural biofiltration by benthic communities. To the second group belong many stations located on the tributaries of the Raba, as well as on the River Raba itself. Its seston is poor, and the waters are poor in dissolved substances. The third group of sites has only two: on the Drwinka stream (31) with humic water and on the low part of the Raba (37), which also receives humic waters from the Puszcza Niepołomicka Forest. In the fourth group, belong sites on the Vistula and lower parts of some its tributaries: the Rudawa in Cracow (14), Skawinka at Skawina (27), and Szreniawa at Biskupice (23). These sites are rich in indicators of eutrophy (*Brachionus* sp., *Keratella* sp., *Philodina* sp., *Polyarthra vulgaris*). The fifth group differs from the others. Here the station on the Dłubnia River at Zesławice (19) is included. This site receives the outflowing water from a small dam reservoir with the zooplankton assemblage occurring in that habitat.

The values of station similarity calculated for zooseston communities gave worse results than for benthic assemblages (Fig. 3). The comparison of these two clusters shows that the similarity of zooplankton mostly varied in the range 0.3–0.7; whereas benthic communities (Dumnicka 1994) usually had higher similarity in the range 0.7–0.9. Moreover, the groups of stations in the cluster of benthos similarities were more concise than those of zooseston. A very high similarity of zooseston (close to 1) was found for sites very poor in species (the streams Szreniawa and Ścieklec). The explanation of these low values of the similarity index is relatively simple: each of the examined streams flow through a different region. They are affected by runoffs from agricultural and forest catchments, municipal or industrial pollution, and modified by ponds and dam reservoirs. The plankton assemblages therefore have very different sets of species, this resulting in small similarities.

High similarity values may have two causes. Sites may be damaged without fauna as well as those rich in fauna, but of similar species composition. For the interpretation of site groups obtained by clustering, the data concerning the quality of the environment are required. Taking into account the chemical characteristics of the rivers (Wojtan et al. 2000), three different types of distortion of examined sites are possible – trophic, chemical, and hydrological. All these changes are more or less local. Some of them do not damage the typical assemblages of riverine organisms. For example, phyto- and zooplankton outflowing from ponds is quickly eliminated by bottom fauna.

The effect of altered trophic relations is visible at the sites on the Vistula. In the zooseston the *Brachionus-Polyarthra* assemblage dominates. It is characteristic of eutrophic waters. Well marked is the impact of Cracow. Below the city, the density of zooplankton increased 10–20 times (Fig. 2). This was caused by slowing down of the water current owing to the cascade of water stages. Longer retention time, together with high concentrations of nutrients and organic matter stimulate reproduction of zooplankton. Distortions in chemical characteristics of the water cause changes in the composition of biocenoses. Some of the species drifting into a local assemblage are able to survive in changed conditions. A good example is the Vistula. Increased salinity caused the development of *Brachionus plicatilis*, characteristic of brackish waters. The effect of this kind of distortion overlays effects of trophic changes. There were extremely altered sites on the Szreniawa and

Ścieklec streams, where high concentrations of sewage and suspension reduced plankton and benthic fauna. The hydrological alteration of river habitats, e.g. turbulent zones below the weirs and slow water movement before them, had a serious impact on the river fauna. Also a serious threat are changes caused by hydrotechnical regulations or the use of the river waters for cooling in power stations. Heated water discharged into the river causes impairment in the ontogenetic development of animals, as was observed below the Skawina power plant.

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