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ZOOPLANKTON COMMUNITIES VERSUS LAKE TROPHY IN SUWAŁKI LANDSCAPE PARK (NORTH-EASTERN POLAND)

ABSTRACT: Quantitative, qualitative and functional parameters of summer zooplankton of 25 lakes of Suwałki Landscape Park and its nearest neihgbourhood have been analysed. Many characters of this zooplankton were different from those in Masurian lakes. Using zooplankton indices of lake trophy it has been revealed that only shallow water bodies underwent eutrophication whereas all stratified ones (morphometrically mesotrophic) maintained their specific trophic character.

KEY WORDS: zooplankton, lake trophy, Suwałki Landscape Park.

1. INTRODUCTION

Hydrobiological studies of Suwałki region lakes were conducted mostly in the nineteen-twenties and thirties, when at Lake Wigry the hydrobiological station was functioning. However, hydrobiologists' attention was then paid mostly to the Wigry lake and to the surrounding lakes. The basic data, concerning the species composition of Crustacea communities in lakes Hańcza, Szelment and Perty were given by Lityński (1925), who indicated that the crustacean community of these lakes is typical of lakes of a low trophy settled by salmonids.

The aim of investigations presented here was to estimate the present ecological state of zooplankton communities of Suwałki Landscape Park (SLP) lakes and its protection zone, and to determine the effect of anthropogenous factors on these communities. Taking into account that for the majority of lakes under study these are the first data on zooplankton, it has been considered worthwhile to conduct a detailed analysis of composition and structure of these communities, including quantitative and qualitative parameters.

2. AREA AND METHODS

In the years 1983–1985 (summer) pelagic zooplankton was studied in 19 lakes of the Suwałki Landscape Park or its protective zone and in 6 lakes in the vicinity of the Park (Fig. 1). Among SLP lakes, 13 were in the direct Szeszupa watershed (lakes nos: I–XIII), whereas three water bodies (nos: XVI–XVIII) – in the Czarna Hańcza watershed. The four lakes eastwards from SLP (nos: XX–XXIII) are joined

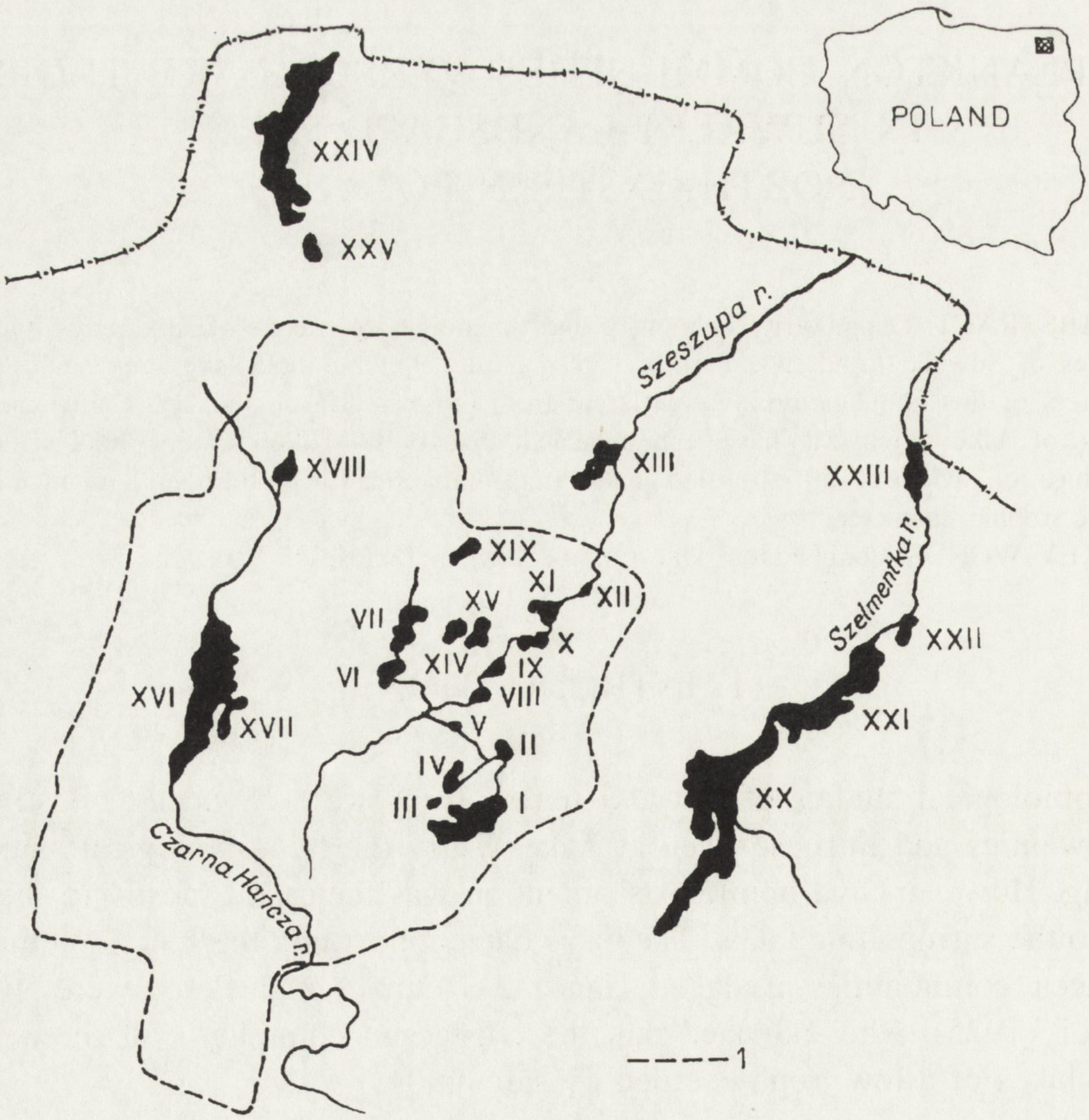

Fig. 1. Locality of lakes examined
Names of lakes acc. to numeration applied are given in Table 1. 1 – outline of Suwałki Landscape Park with the protective zone

by the Szelmentka, which is a tributary of the Szeszupa. Three SLP lakes (nos: XIV, XV and XIX) and two lakes (nos: XXIV–XXV) northwards from SLP have no outflow. Detailed physiographic and hydrographic description of the study area is given in Bajkiewicz-Grabowska (1993).

Zooplankton samples were taken at the deepest place in a lake. Samples were collected with a 5-litre sampler of Bernatowicz type at every 1 m depth, pooled for epi-, meta- and hypolimnion and concentrated with a plankton net of 30 μm mesh. Zooplankters were determined to the species, and measured, and then the relationship "length/weight" was used to determine the mean body weight of individuals of particular species. The measurements were made separately for material from each lake.

3. RESULTS

3.1. ZOOPLANKTON NUMBERS AND BIOMASS

Total numbers of pelagic zooplankton (Rotifera + Crustacea) in surface water layers[1] broadly fluctuate, between 117 and 26 420 ind. · dm^{-3} (Table 1). The group of organisms decisive of zooplankton numbers are Rotifera, accounting in the majority of lakes for 75–90% of zooplankton numbers. An exception are two lakes Hańcza and Szelment Wlk., where rotifers account for less than 50% of the numbers (35–48%). In both these lakes at the same time there were extremely low numbers of rotifers: 56–57 ind. · dm^{-3} (whereas in the majority of lakes discussed they remain within 500–3000 ind. · dm^{-3}). On the other hand, in lake Wistuć abundance of Rotifera reached 26 thous. ind. · dm^{-3}, which was over 98% of all zooplankton numbers in these lake. These are already values typical of polytrophic lakes. The differentiation was much smaller between particular lakes as regards Crustacea (Table 1), but here also the lowest numbers were recorded in lake Hańcza.

Similarly as in case of zooplankton numbers, also total biomass was characterized by a great differentiation. This concerned both the absolute biomass value (0.4–8.6 mg · dm^{-3}) and the contribution of particular organisms (Fig. 2).

Usually Crustacea decide about the zooplankton biomass; rotifers are of small significance. However, two lakes seem to be an interesting exception: Boczniel and Jegliniszki (XVII and XVIII), where as a result of quantitative and qualitative scarcity of crustaceans (nauplii of Cyclopoidae dominate among them), zooplankton biomass is very low and is dominated in over 70% by small non-predatory rotifers. Furthermore, in four lakes of the lower Szeszupa reach a relatively high biomass of species of the genus Asplanchna (0.74–2.52 mg · dm^{-3}) was observed. Thus, in seven from 25 lakes examined, rotifers accounting for over 30% of the zooplankton

[1] "Surface waters" should be understood as the epilimnion of stratified lakes and the whole water column of shallow non-stratified water bodies.

Table 1. Zooplankton numbers in surface water layers of the lakes under study during summer stagnation

No*	Lake	Numbers (ind. · dm^{-3})			%
		Rotifera	Crustacea	Σ	Rotifera
I	Szurpiły	972	78	1050	92.6
II	Kopane	1092	336	1365	75.4
III	Kluczysko	1961	553	2514	78.0
IV	Jeglówek	852	175	1027	83.0
V	Udziejek	1674	482	2156	77.6
VI	Jaczno	206	115	32	64.2
VII	Kamenduł	451	250	70	64.3
VIII	Gulbin	2047	482	2529	80.9
IX	Okrągłe	1450	330	1780	81.4
X	Krajwelek	3894	441	4335	89.9
XI	Przechodnie	1641	373	2014	81.4
XII	Podstawelek	2803	477	3280	85.4
XIII	Pobondzie	1837	308	2145	85.6
XIV	Kojle	268	67	335	80.0
XV	Perty	224	129	353	63.5
XVI	Hańcza	56	61	117	47.9
XVII	Boczniel	2746	192	2938	93.5
XVIII	Jegliniszki	2112	227	2333	90.3
XIX	Czarne	1948	304	2252	86.5
XX	Szelment Wielki	57	104	161	35.4
XXI	Szelment Mały	446	121	567	78.6
XXII	Iłgieł	1726	194	1920	90.0
XXIII	Kupowo	2041	401	2442	83.6
XXIV	Wiżajny	520	507	1027	50.6
XXV	Wistuć	25980	440	26420	98.3

*See Figure 1.

contribute significantly to community biomass. In the remaining lakes the percentage of this group of organisms in biomass ranged between 1.4 and 15.5%.

Cladocera dominate most frequently in these lakes; in 13 water bodies they represent more than half of the total zooplankton biomass (Fig. 2). In many lakes, especially those in the middle and lower reaches of the Szeszupa and Szelmentka, also high biomass of Cyclopidae were recorded. Still, a characteristic feature of Suwałki lakes seem to be low biomass and small significance of Calanoida in the community of crustaceans in surface water layers. In three lakes only, their percentage did not exceed 20% of biomass, whereas in four lakes this group was not recorded.

3.2. THE STRUCTURE OF COMMUNITIES OF ROTIFERA

3.2.1. Taxonomic structure

In the lakes under study 51 species of rotifers were found (data for the entire water column) (Table 2). The most common species were *Keratella cochlearis* (found in all lakes), *Polyarthra vulgaris* (not found in lake Wistuć) and *Trichocerca* (D.) *rousseleti* and *Synchaeta kitina* (not found in two lakes). Furthermore, 14 other species can be considered as "very constant", i.e., occurring on more than 60% of stations. This group of species covered 35% of all Rotifera taxons found.

There is also a great number of "accidental" species (39% of all taxons) and as a rule the numbers did not exceed several individuals per liter. The majority of them were the littoral species (genera Lecane, Testudinella, Colurella, Lepadella, Scaridium and species: *Trichocerca porcellus, Lophocharis salpina*).

The constancy of species occurrence on the whole area examined was compared with values obtained for the group of lakes of the Szeszupa watershed. Rotifer communities in these lakes were undoubtedly more uniform as regards species. Among 41 taxons occurring there, almost half (46%) were the "very constant" species, and 7 of them were found in all lakes. Small (11. i.e., 27%) however, is the number of "accidental" species.

As shown in Table 2, frequent co-occurrence of species of the genera Trichocerca and Polyarthra is characteristic of the lakes under study. Frequently 4–5 species of each of these genera have been found i one lake. but their role in rotifer community biomass was entirely different (Fig. 3). Although Trichocerca contribution to the biomass of nonpredatory rotifers was small (only in the three lakes it exceeded 15%), species of Polyarthra genus dominated and practically decided about the biomass of this community. In as much as 21 lakes they represent over 50%, whereas in lakes Jeglówek, Boczniel, Jegliniszki and Szelment Wlk. even over 85% of rotifer biomass.

Only two lakes have a specific and different from other lakes species composition of rotifer community. These are Hańcza and Wistuć, which in the discussed group of lakes represent extreme trophy types. Trophy State Index TSI_{SD}

Table 2. Species composition and frequency of Rotifera in lakes examined (summer stagnation)
Numbers of lakes (I–XXV) see Figure 1, FA – frequency (%) of lakes for the Szeszupa watershed, FB – as above, for all lakes

Species	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Cephalodella catellina (Müller)											
Scaridium longicaudatum (Müller)											
Trichocerca (D) *rousseleti* (Voigt)	*	*	*	*	*	*	*	*	*	*	*
T. (D) *porcellus* (Gosse)											
T. (D) *similis* (Wierzejski)	*	*	*	*		*	*				
Trichocerca pusilla (Lauterborn)	*	*	*		*		*	*	*	*	
T. cylindrica (Imhof)		*	*						*	*	*
T. capucina (Wierzejski et Zacharias)	*	*	*	*	*	*	*	*	*	*	*
Gastropus stylifer Imhof	*	*	*	*	*	*	*	*	*	*	*
G. hyptopus (Ehrenberg)		*			*			*	*	*	*
Ascomorpha saltans Bartsch	*	*	*		*	*	*	*	*	*	*
A. ecaudis Perty	*			*							
Chromogaster ovalis (Bergendal)	*	*		*	*	*	*	*	*	*	*
Synchaeta grandis Zacharias											
S. pectinata Ehrenberg											
S. kitina Rousselet	*	*		*	*	*	*	*	*	*	*
Polyarthra vulgaris Carlin	*	*	*	*	*	*	*	*	*	*	*
P. dolichoptera Idelson	*	*	*	*		*	*				
P. remata Skorikov	*	*	*	*	*	*	*	*	*	*	*
P. major Burchhardt	*	*	*	*			*	*	*	*	*
P. euryptera Wierzejski	*	*					*		*	*	
Bipalpus hudsoni (Imhof)	*										
Asplanchna priodonta Gosse		*	*	*	*		*	*	*	*	*
A. girodi Guerne				*							
Lecane (M) *arcuata* (Bryce)								*			
L. (M) *lunaris* (Ehrenberg)											
L. (M) *bulla* (Gosse)											
Proalides tentaculatus Beauchamp											
Lophocharis salpina (Ehrenberg)				*					*		
Colurella obtusa (Gosse)										*	
C. adriatica Ehrenberg					*					*	
Lepadella patella (Müller)										*	
Euchlanis dilatata Ehrenberg	*										
Brachionus calyciflorus Pallas	*										
B. angularis Gosse								*		*	
Platyias patulus (Müller)											
Keratella cochlearis (Gosse)	*	*	*	*	*	*	*	*	*	*	*
K. irregularis (Lauterborn)	*	*	*	*	*			*	*	*	*
K. hiemalis Carlin						*	*				
K. quadrata (Müller)	*	*	*	*	*	*	*	*	*	*	*
Kellicottia longispina (Kellicott)	*	*	*	*		*	*		*		
Anuraeopsis fissa (Gosse)		*	*		*		*	*	*	*	*
Conochilus hippocrepis (Schrank)					*						
C. unicornis Rousselet	*	*		*		*	*				*
Conochiloides coenobasis Skorikov											
Testudinella patina (Herman)										*	
Pompholyx sulcata (Hudson)	*	*	*		*	*	*	*	*	*	*
Filinia terminalis (Plate)	*			*		*	*				
F. longiseta (Ehrenberg)	*	*	*		*		*	*	*	*	*
Collotheca pelagica (Rousselet)	*	*	*	*		*					
C. mutabilis (Hudson)	*	*	*	*	*	*	*	*	*	*	
Number of species	27	26	21	22	21	19	24	21	23	27	19

XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	FA	FB
							*							–	4
*														8	4
*	*	*	*	*	*		*	*	*	*	*	*		100	92
												*		–	4
					*		*				*	*		46	40
*	*									*	*	*	*	77	56
	*						*							46	28
*	*	*	*		*		*			*	*	*		100	80
*	*	*	*		*		*	*	*	*	*			100	84
*							*			*				54	36
*	*	*	*		*		*		*	*	*		*	92	80
		*			*		*	*						15	24
*	*	*	*		*		*			*	*			92	72
					*									–	4
					*	*								–	8
*	*	*	*			*	*	*	*	*	*	*		92	92
*	*	*	*	*	*	*	*	*	*	*	*	*		100	96
*			*	*		*	*	*						54	48
*	*	*	*		*	*	*		*	*	*			100	84
*	*	*	*		*		*	*	*	*	*	*		92	84
			*				*							39	28
														8	4
*	*	*	*		*		*	*			*		*	85	68
*														15	8
														8	4
						*	*							–	8
						*								–	4
													*	–	4
														15	8
										*				8	8
														15	8
											*			15	12
*														8	4
														8	4
											*		*	23	20
*					*									–	4
*	*	*	*	*	*	*	*	*	*	*	*	*	*	100	100
*														85	44
														15	8
*	*	*	*				*	*	*	*	*			100	80
*	*	*	*	*			*	*	*	*	*			69	68
*	*				*	*	*		*	*	*		*	77	72
				*					*					8	12
	*	*	*	*	*		*	*	*		*	*		54	64
							*							–	4
														–	4
*		*	*							*	*	*		85	64
		*	*					*	*					31	32
*	*	*			*		*			*			*	85	64
		*	*					*			*	*		46	44
*	*	*	*				*	*	*	*	*	*	*	92	84
25	20	20	20	7	18	9	26	15	15	19	22	13	10	40	51

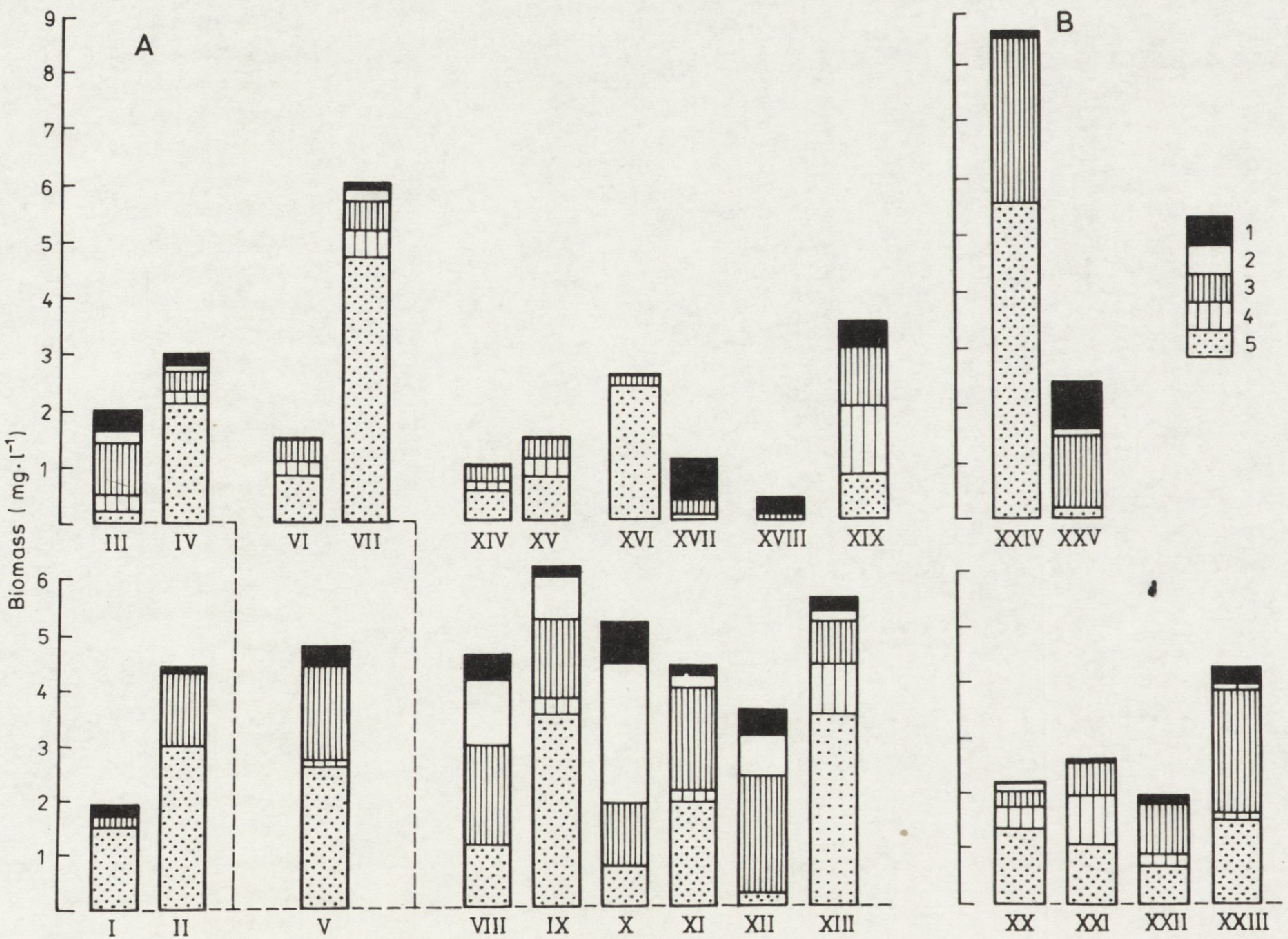

Fig. 2. Biomass of zooplankton in SLP lakes (A) and beyond the Park area (B)
Dotted line gives a schematic presentation of the Szeszupa and Szelmentka watershed lakes combined
1 – Rotifera, 2 – *Asplanchna* sp., 3 – Cyclopoida, 4 – Calanoida, 5 – Cladocera, I–XXV – lake determinations, c.f. Table 1

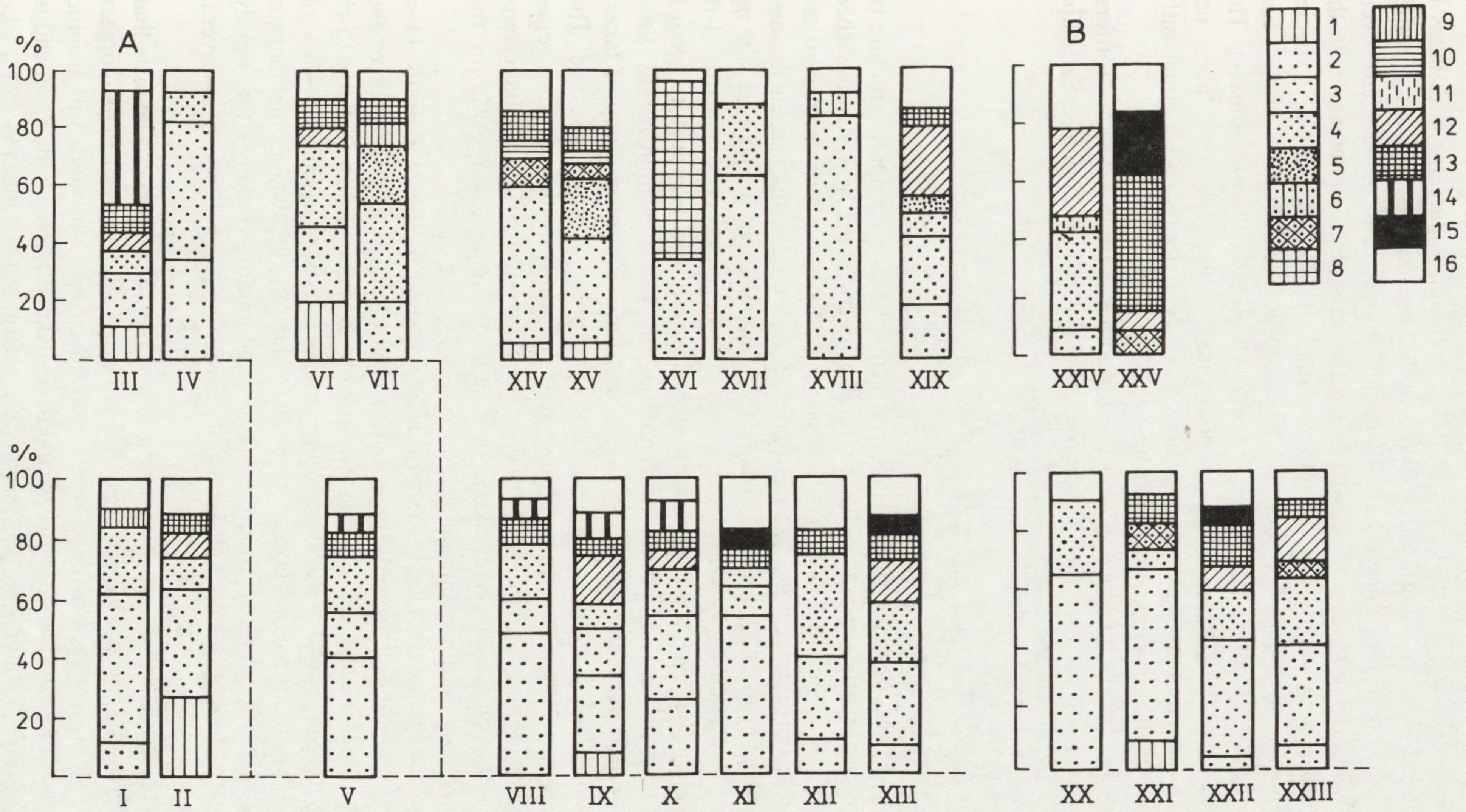

Fig. 3. Species percentage in non-predatory Rotifera biomass in SLP lakes (A) and beyond the Park area (B)
Dotted line indicates diagrammatic connections of lakes of the Szeszupa and Szelmentka watersheds. 1 – *Gastropus stylifer*, 2 – *Polyarthra major*, 3 – *P. remata*, 4 – *P. vulgaris*, 5 – *P. euryptera*, 6 – *P. dolichoptera*, 7 – *Synchaeta kitina*, 8 – *Conochilus hippocrepis*, 9 – *C. unicornis*, 10 – *Collotheca mutabilis*, 11 – *Pompholyx sulcata*, 12 – *Trichocerca* sp., 13 – *Keratella cochlearis*, 14 – *Filinia longiseta*, 15 – *Anuraeopsis fissa*, 16 – others, I–XXV – lake determinations see Table 1

equals 28.3 and 66.0, respectively – Table 3. The common feature for both lakes is the poor Rotifera species composition. Whereas in the majority of lakes rotifer communities are composed of more than 20 species, in lake Hańcza there are seven, and in lake Wistuć – ten taxons. However, they differ in species composition. In the first, besides *Polyarthra vulgaris*, dominates one of the "accidental" species *Conochilus hippocrepis* (62% of community biomass), whereas in the second – two species: *Keratella cochlearis* (49%) and *Anuraeopsis fissa* (22% of biomass). The commonly occurring *K. cochlearis* is a subdominant in the remaining lakes, not exceeding 10% of community biomass, whereas *A. fissa* occurs more abundantly mostly in lakes of the Szeszupa lower reach.

Among other species contributing over 5% to biomass of non-predatory rotifers, the most frequently occurring were: *Filinia longiseta* (lakes of the middle Szeszupa reach) and *Gastropus stylifer* and *Synchaeta kitina.*

3.2.2. Trophic structure

On the basis of earlier investigations (Karabin 1985b) the trophic structure of communities of non-predatory rotifers has been determined. There were distinguished 6 trophic groups, for which the basic kind of food is (1) bacteria-detritus suspension, of a particle size up to several μm (1-st group); (2) bacteria-detritus suspension and nanoplankton smaller than 20 μm (2-d group); (3) nanoplankton of maximal size up to 20–30 μm (3-rd group); (4) nanoplankton and fine net algae up to 50 μm (4-th group); (5) net algae (5-th group); (6) Dinoflagellata, mainly Peridinium (6-th group).

As shown in Figure 4, rotifer communities in lakes examined are little differentiated within particular lakes and have a uniform (within the group of lakes) trophic structure. Usually a strong dominance of one trophic group is observed. The earlier discussion on species structure has indicated that species of the genus Polyarthra are the dominant group. Because these species form the 3-rd trophic group, organisms feeding on nanophytoplankton distinctly dominate (over 50%) in the biomass of almost all rotifer communities.

Also species feeding on suspension of bacteria and small-size detritus (1-st group) occur commonly and greatly contribute to the biomass, and in lakes of the lower reaches of both rivers – also species feeding on net algae of different size (5-th group). Total contribution of these two groups does not exceed usually 35–40% of the biomass. An exception are lakes: Kluczysko and Wistuć, where the detritus suspension is a main kind of food of rotifer community. Finally, the family Gastropodidae feeding on dinoflagellates is of considerable significance in several lakes (6-th group).

Another characteristic feature of species structure of rotifers of these lakes is that only species having a precise, narrow food specialization decide about their biomass (over 90% of biomass). Species of a broad food spectrum (2-nd and 3-rd trophic group) are of little significance. An exception is lake Hańcza with Conochilus hippocrepis – species belonging to the 2-nd trophic group. Lake Hańcza is still a lake

Table 3. Zooplankton indices of lake trophy

A – range of values for specific trophy, d – dimictic, p – polymictic, II Ecol gr. – contribution of II ecological group to the total biomass of ecological groups in percent, TECTA – percentage of *tecta* forms in *Keratella cochlearis* population, CYCLOP – contribution of Cyclopoida to Crustacea biomass, TSI – mean trophy state index estimated according to while disc transparency and chlorophyll concentration

Lake	Mictic types	TSI	II Ecol. gr.		TECTA	CYCLOP
			Rotifera	Crustacea		
Szurpiły	d	39.0	3.1	16.0	2.1	7.5
Kopane	p	45.0	3.8	44.7	6.3	26.9
Kluczysko	d	50.7	74.8	95.2	1.6	66.9
Jeglówek	d	32.7	–	35.4	–	15.0
Udziejek	p	58.7	17.1	49.1	27.6	38.7
Jaczno	d	40.6	21.8	27.0	–	22.0
Kamenduł	d	45.7	26.9	14.0	9.5	9.6
Gulbin	p	54.4	13.0	65.0	40.9	61.7
Okrągłe	p	56.0	29.2	47.9	21.6	26.2
Krajwelek	p	60.3	51.1	75.9	26.3	50.1
Przechodnie	p	57.9	14.2	68.2	24.2	46.9
Podstawelek	p	54.9	63.8	94.0	40.0	89.6
Pobondzie	p	55.7	51.7	30.1	13.3	15.8
Kojle	d	38.4	–	34.0	–	26.8
Perty	d	33.3	–	32.9	–	25.1
Hańcza	d	25.5	–	5.6	–	4.8
Boczniel	p	?	24.0	100.0	–	66.8
Jegliniszki	p	?	100.0	100.0	–	89.1
Czarne	d	54.3	1.4	84.1	1.0	32.6
Szelment Wielki	d	38.1	–	26.3	–	15.4
Szelment Mały	d	45.6	0.1	37.9	0.7	21.9
Iłgieł	p	51.1	70.1	52.4	21.5	50.2
Kupowo	d	55.0	26.7	68.6	36.3	57.9
Wiżajny	p	62.1	58.6	55.1	41.0	33.5
Wistuć	p	66.0	100.0	91.8	100.0	85.1
A						
Mesotrophy		45	10	25	5	15
Meso-eutrophy		45–55	10–90	25–60	5–20	15–30
Eutrophy		55	90	60	20	30

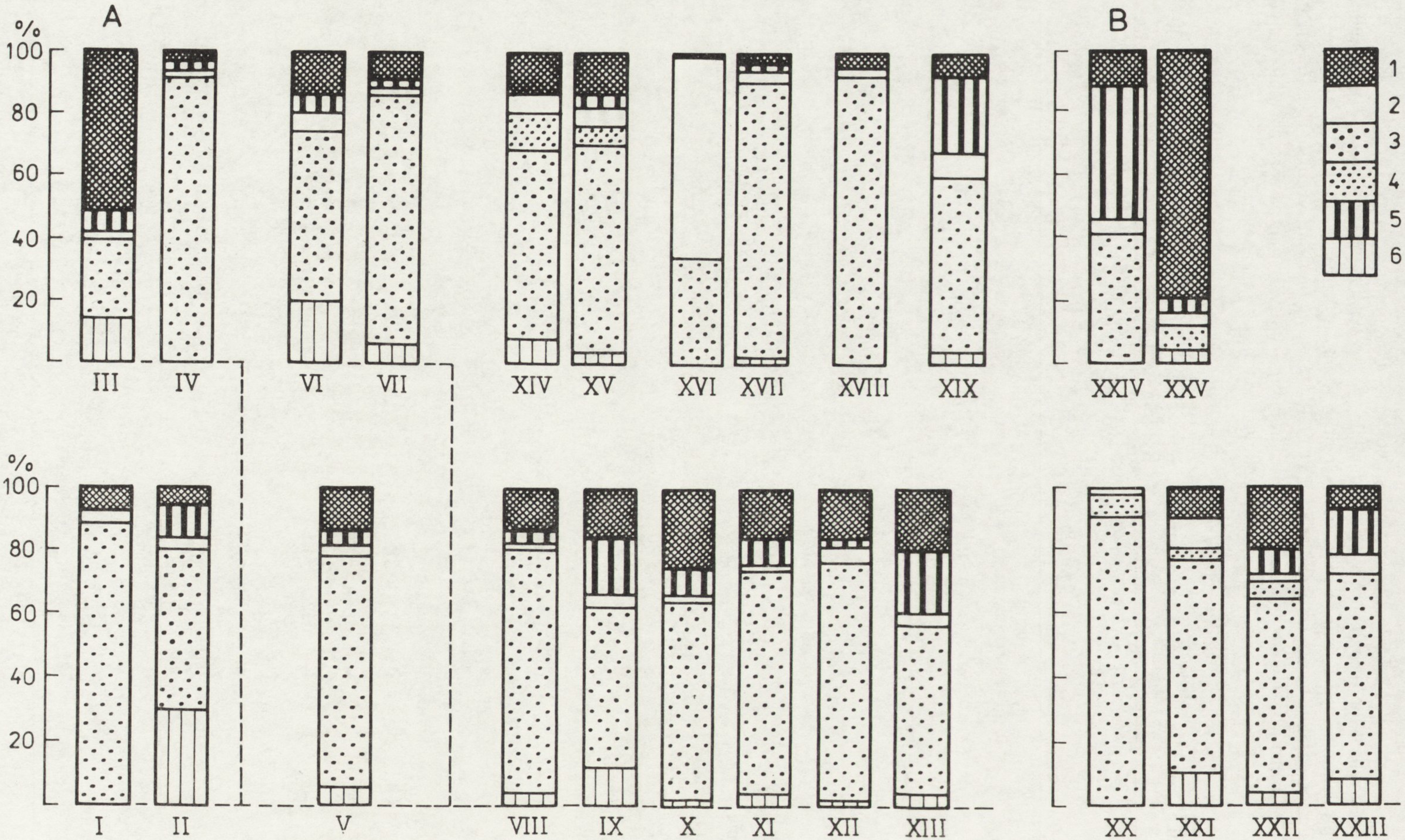

Fig. 4. Comparison of percentage of trophic groups in biomass of nonpredatory Rotifera in SLP lakes (A) and beyond The Park area (B) Dotted line indicates diagrammatic lake connections of the Szeszupa and Szelmentka watersheds. 1–6 trophic groups, detailed description in the paper, I–XXV – lake determinations see Table 1

of a low trophy (TSI_{SD} = 28.3) (Table 3) and thus of low productivity. Under conditions of low food concentration a species with a broad food spectrum has to be a competitively stronger one. Perhaps this explains why in this lake the 2-nd group dominates.

3.3. STRUCTURE OF CRUSTACEA COMMUNITIES

3.3.1. Taxonomic structure

The Crustacea community in lakes examined was represented by 26 species, including 7 Cyclopoida species, 4 Calanoida species, and 14 Cladocera species (Table 4). Among the latter, striking is the great abundance of species of the Bosmina (6 species) and Daphnia (4 species) genera.

However only 6 (24%) among the taxons found can be considered as "very constant". These are: *Mesocyclops leuckarti, M. oithonoides, Daphnia cucullata, Eudiaptomus graciloides, Bosmina longirostris* and *Diaphanosoma brachyurum*. Still, none of these taxons occurred in all lakes. But there is a numerous (44% of taxons) group of "accidental" species, the majority of which are "cold-stenotherm", littoral or characteristic of extreme trophic types of lakes ones. Thus, crustacean communities are more differentiated in species than rotifer communities of these lakes.

The most frequent were lakes with crustacean communities of 9 to 11 species, none of them representing more than 50% of the biomass, and the "very constant" species dominating (Fig. 5). Among them *Daphnia cucullata* or *Mesocyclops oithonoides* contributed the most to the the biomass formation. The prevalence of the latter over another also frequently occurring species of the genus *M. leuckarti,* seemed to be characteristic of the examined group of Suwałki lakes. In the majority of the Szeszupa watershed lakes, *Diaphanosoma brachyurum* also contributed considerably to the biomass. Other common Cladocera species were found in greater quantities only in single lakes.

Still, many lakes deviate from the above presented rule. This concerns first of all lakes: Boczniel (XVII) and Jegliniszki (XVIII). Their crustacean communities are characterized by: 1) scarcity of species (5 and 3 species, respectively); 2) lack of *Daphnia cucullata*, which is rare; 3) very high contribution of *Mesocyclops leuckarti*, in lake Jegliniszki exceeding 90% of crustacean biomass. as shown in Figure 2 the qualitative poverty of Crustacea low abundance in these lakes goes together with the low number of co-occurring species. Only in these lakes biomass of non-predatory rotifers exceeds that of crustaceans.

A similar structure has been observed in two other shallow lakes: Postawelek;(XII) and Wistuć (XXV). In communities poor in species (4 and 5) 90% of biomass was formed by one species – *Mesocyclops leuckarti* or *M. oithonoides,* whereas the significance of *Daphnia cucullata* was marginal. A specific but totally different structure was that of Crustacea community from lake Hańcza. Here *D.*

Table 4. Species composition and frequency of Crustacea of lakes examined (summer stagnation)

Species	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Mesocyclops leukarti (Claus)	*	*	*	*	*	*	*	*		*	*
M. oithonoides (Sars)	*	*	*	*	*	*	*	*	*	*	*
M. crassus (Rehberg)	*	*			*			*			*
Cyclops scutifer Sars											
C. abbysorum Sars						*					
C. lacustris Sars											
Acanthocyclops sp.	*						*		*		
Eudiaptomus gracilis (Sars)						*	*		*		
E. graciloides (Lilijeborg)	*	*	*	*	*			*		*	*
Eurytemora lacustris (Poppe)	*			*							
Heterocope appendiculata Sars	*			*							
Daphnia cucullata Sars	*	*	*	*	*	*	*	*	*	*	*
D. cristata Sars	*			*			*	*			
D. hyalina (Leydig)		*	*		*	*	*		*		*
D. longiremis Sars											
Bosmina berolinensis Imhof							*				
B. kessleri Uljanin						*	*				
B. coregoni Baird											
B. longirostris (O. F. Müller)	*	*	*	*	*			*	*	*	*
B. obtusirostris Sars											
B. crassicornis (P. E. Müller)	*			*							*
Diaphanosoma brachyurum (Levin)	*	*	*	*	*	*	*	*	*	*	*
Chydorus sphaericus (O. F. Müller)											*
Ceriodaphnia quadrangula (O. F. M.)	*		*	*			*	*			*
Leptodora kindtii (Focke)	*	*			*	*				*	*
Number of species	14	9	8	11	9	9	11	9	7	7	12

Numbers of lakes (I–XXV) see Fig. 1, FA – frequency (% of lakes) for the Szeszupa watershed, FB – as above, for all lakes

XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	FA	FB
	*	*	*	*	*	*	*	*	*	*	*	*	*	85	92
*	*	*	*	*	*		*	*	*	*	*			100	88
	*	*	*							*	*			46	40
								*						–	4
				*										8	8
		*	*											–	8
														31	16
	*	*	*	*								*		23	32
		*	*	*	*		*	*	*	*	*			62	68
				*				*	*					15	20
				*				*						15	16
*	*	*	*	*			*	*	*	*	*	*	*	100	92
				*				*	*					31	28
	*	*	*				*				*			62	48
								*						–	4
														8	4
		*	*				*			*				15	24
											*	*		–	8
*		*			*	*	*	*	*		*			77	68
				*										–	4
	*							*	*					31	24
	*	*	*				*		*		*			92	68
	*									*		*	*	15	20
*			*		*	*	*						*	54	48
	*												*	54	32
4	10	11	11	10	5	3	9	11	9	7	9	5	5	20	25

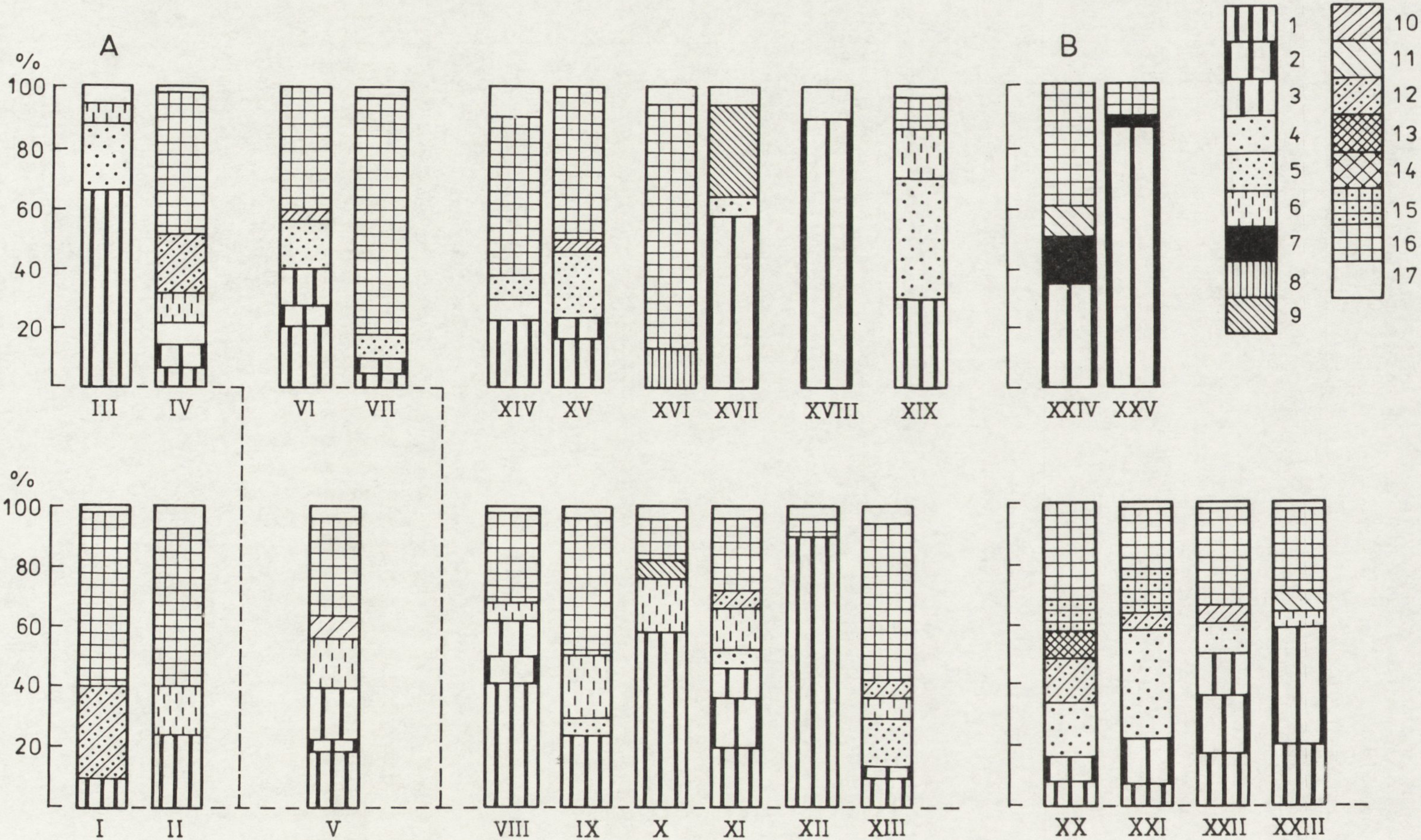

Fig. 5. Species percentage in Crustacea biomass in SLP lakes (A) and beyond the Park area (B)
Dotted line indicates diagrammatic connections of lakes in the Szeszupa and Szelmentka watersheds. 1 – *Mesocyclops oithonoides*, 2 – *M. leuckarti*, 3 – *M. crassus*, 4 – *Eudiaptomus graciloides*, 5 – *E. gracilis*, 6 – *Diaphanosoma brachyurum*, 7 – *Chydorus sphaericus*, 8 – *Bosmina obtusirostris*, 9 – *B. longirostris*, 10 – B. *kessleri*, 11– *B. crassicornis*, 12 – *B. coregoni*, 13 – *Daphnia longiremis*, 14 – *D. hyalina*, 15 – *D. cristata*, 16 – *D. cucullata*, 17 – other, I–XXV – lake determinations see Table 1

cucullata represented over 80% of the biomass, whereas the contribution of Cyclopoida did not exceed 5%.

Besides the common and abundantly occurring species, the significance of which has been above discussed, rarely occurring and not abundant species also decide about the character of crustacean communities in Suwałki lakes. There are communities occurring mainly in deeper water layers: meta- and hypolimnion. And thus, in four lakes: Szurpiły (I), Jeglówek (IV), Hańcza (XVI) and Szelment Wlk. (XX) the presence of *Eurytemora lacustris* and *Heterocope appendiculata* – "cold-stenotherm" species, was observed, the occurrence of which is connected with mesotrophic lakes (Patalas and Patalas 1966). Furthermore, in lake Hańcza, *Bosmina obtusirostris* was recorded and – in lake Szelment Wielki – *Daphnia longiremis*, species rarely occurring in Poland, but quite common northwards from Poland.

3.3.2. Trophic structure

Similarly as in case of rotifers, the trophic structure of Crustacea communities was determined. The following trophic groups of crustaceans were distinguished (Karabin 1985b): (1) microfiltrators and within them (Gliwicz 1974, 1977); (2) "inefficient" microfiltrators (*Chydorus sphaericus, Bosmina longirostris, Diaphanosoma brachyurum*), optimum size of food particles 2–5 μm and thus mostly the bacterial-detritus suspension; (3) "efficient" microfiltrators (the remaining Cladocera), optimum size of food particles 10–12 μm, nanophytoplankton prevails in the food; (4) macrofiltrators (Calanoida and young copepodite stages of Cyclopoida), nanophytoplankton is the main food; (5) predatory (Leptodora, older copepodite stages and adult Cyclopoida, Asplanchna), except Leptodora these are facultative predators.

Results are given in Figure 6. Crustacean communities of the lakes under study can be divided into several groups of different type of trophic structure: (1) "efficient" microfiltrators represent over 90% of Crustacea biomass (lake Hańcza, Szurpiły); (2) "efficient" microfiltrators still dominate (over 50% of the biomass), but a significant role play also "inefficient" macrofiltrators and microfiltrators, predators do not exceed 25% of crustacean biomass (deep lakes of the upper reaches of rivers Szeszupa and Szurpiłówka and lakes Kojle and Perty); (3) microfiltrators, among which "inefficient" species dominate,represent less than 30% of the biomass. Still, dominant are predators or macrofiltrators (majority of shallow, polymictic lakes).

In several other lakes the trophic structure is not so distinct as there is no distinct dominance of a specific trophic group.

3.4. STATE OF LAKE EUTROPHICATION AND ZOOPLANKTON STRUCTURE

In order to determine the effect of eutrophication factors on pelagic zooplankton on the basis of earlier investigations (Karabin 1985a), ecological groups

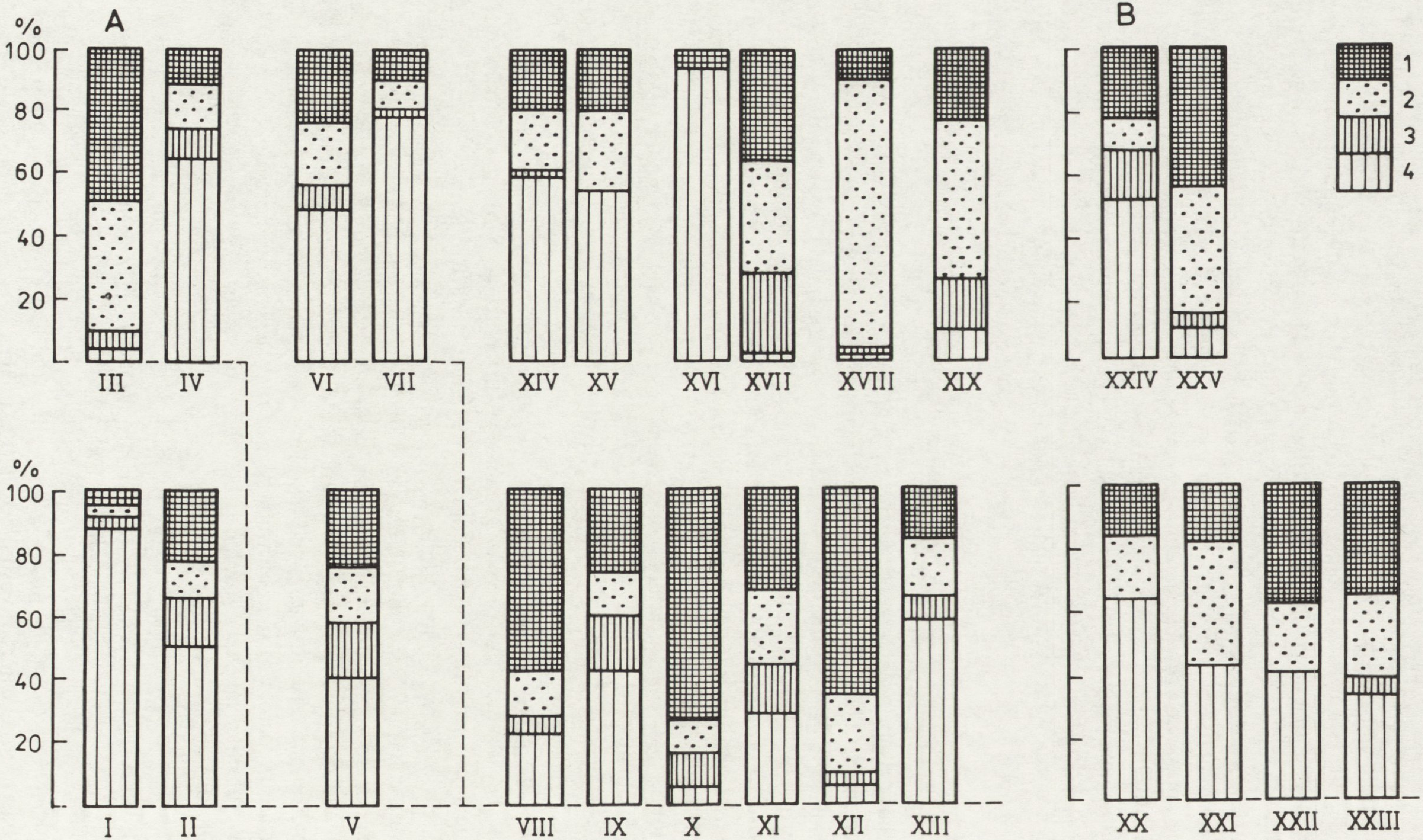

Fig. 6. Comparison of percentage of trophic groups in Crustacea biomass in SLP lakes (A) and beyond the Park (B)
Dotted line indicates the diagrammatic connection of lakes of the Szeszupa and Szelmentka watershed. 1 – predatory, 2 – macrofiltrators, 3 – "inefficient" microfiltrators 4 – "efficient" microfiltrators. I–XXV – lake determinations see Table 1

characteristics of low (I-st group and high (II-nd group) trophy were distinguished within rotifer and crustacean communities, and their contribution to biomass was determined (Table 3).

Within the Rotifera I ecological group is formed by: *Chromogaster ovalis, Conochilus hippocrepis, Ascomorpha ecaudis, Gastropus stylifer* and *Polyarthra major*, and group II: *Keratella quadrata, Pompholyx sulcata, Filinia longiseta, Anuraeopsis fissa, Trichocerca pusilla, Brachionus* sp. and Bdelloidae.

All, except one lakes situated in the direct Szeszupa watershed are characterized by co-occurrence of indicatory forms of low and high trophy, but usually with the greater percentage of species characteristic of low trophy. This is mostly caused by a relatively abundant occurrence of a big rotifer *Polyarthra major.*

More abundant in species and spatially more differentiated in these lakes is a community typical of eutrophy. Whereas in lake Kluczysko (III), in the upper river reach, this community accounted for 44% of the biomass of non-predatory Rotifera, in the next water body, lake Jeglówek (IV) no species typical of eutrophy were found. Also, in the remaining lakes of the watershed Szurpiły (I), Kopane (II), Jaczno (IV), the community of eutrophy indicators is not abundant in species and of a low relative biomass (below 2%). However, in lake Udziejek and the remaining lakes of Szeszupa watershed the number and significance of species typical of eutrophy increase (8–12%) (Table 3).

In the remaining lakes of the Suwałki Landscape Park indicatory forms of low and high trophy do not occur. In three lakes Kojle (XIV), Perty (XV), Hańcza (XVI) only a community indicating low trophy was observed. In the last lake,poor in species, there was only one species of I group noted. Nevertheless, it formed 62% of rotifer biomass. Also in lake Czarne (XIX), I ecological group distinctly dominates, whereas two species of II group represent only 0.7% of the biomass. One of the remaining two lakes – lake Jegliniszki (XVIII) was practically devoid of indicatory species, whereas in the lake Boczniel (XVII) both these groups are present but their role in the Rotifera community is insignificant.

In the Szelmentka watershed lakes situated beyond the Suwałki Landscape Park, similarly as in the case of Szeszupa watershed, directional changes in the significance of groups discussed above were observed. In the first of these lakes, Szelment Wlk. (XX), no species from the II ecological group were found. In this lake also the community typical of low trophy, is poor in species but because of the great abundance of *Polyarthra major* this community distinctly dominates in the biomass. Also in the next lake of the watershed, Szelment Mały (XXI), species typical of low trophy form over 50% of the biomass of Rotifera. However in this lake some organisms indicatory of eutrophy are already present, although they form less than 1% of the biomass.

The significance of these two groups changes distinctly in two successive lakes of the watershed. First of all the significance of species from I group decreases as they form less than 15% of the community biomass. At the same time both the species abundance and the contribution of II ecological group increase, especially in lake Iłgieł (XXII) (Table 3).

In two shallow lakes situated to the north of SLP, species typical of eutrophy prevail. And although in lake Wiżajny (XXIV) *Polyarthra major* still occurs but not abundantly (8% of biomass), then in the other lake Wistuć (XXV) there are no representatives of the ecological group, whereas species typical of high trophy form over 85% of Rotifera biomass, *Keratella cochlearis* f. *tecta* itself – accounting for 49%.

Within the Crustacea community the I ecological group in lakes examined is formed by: *Bosmina berolinensis, Daphnia hyalina galeata, D. cristata* and *D. cucullata*. More abundant in species is the II ecological group including: *Mesocyclops leuckarti, M. oithonoides, Diaphanosoma brachyurum, Chydorus sphaericus, Bosmina coregoni thersites* and *B. longirostris*.

Among lakes of the Szeszupa watershed all species typical of low trophy have been found only in lake Kamenduł (VII). In the remaining lakes (an exception being lake Szurpiły (I) and Jeglówek (IV), where *Daphnia cucullata* also occurs) this community is represented only by *Daphnia cucullata*, the significance of which, and thus of the whole community decreases consistently with lake locality in the drainage basin. The only exception is the last lake in the river reach (Pobondzie (XIII)) where *D. cucullata* percentage is high, and also lake Kluczysko (III), where this community forms only 4% of crustacean biomass.

At the same time in lake Kamenduł II ecological group plays the least important role (10% of the biomass). This group is also qualitatively and quantitatively poor in lakes: Szurpiły, Jeglówek, Jaczno and Pobondzie, where 2–3 species form 11–26% of Crustacean biomass whereas in the remaining lakes of this watershed – they account for as much as 40 to 94%.

Greatly differentiated is the significance of mentioned groups in other SLP lakes (Table 3). In lake Hańcza (XVI) the I ecological group represented by *Daphnia cucullata* only form 80% of Crustacea biomass, whereas the contribution of two species of II ecological group does not exceed 5%. On the other hand, in lakes Boczniel (XVII) and Jegliniszki (XVIII) species typical of low trophy do not occur at all, whereas 90% of the biomass of crustacean zooplankton is formed by the group indicatory of high trophy. This community, besides Cyclopoida, consist *Bosmina longirostris* – a species typical of eutrophic water bodies of pond type.

Similarly as in the case of Rotifera, also in Crustacea communities of the Szelmentka watershed there is a tendency of directional changes in the significance of ecological groups. In the lakes Szelment Wielki (XX) and Szelment Mały (XXI), the I ecological group, formed by *Daphnia cucullata* and *D. cristata* account for 44 and 36% of Crustacea biomass, respectively. Simultaneously lake Szelment Wielki is characterized by the lowest contribution to biomass of species typical of high trophy (15%). The significance of these species increases consistently with the locality of lakes in the watershed and attains the highest values in lake Kupowo (66%).

The last two lakes: Wiżajny (XXIV) and Wistuć (XXV) vary from the majority of lakes in species composition of the II ecological group. The place of *Mesocyclops leuckarti* (as in lakes Boczniel and Jegliniszki), *Chydorus sphaericus* and *Bosmina coregoni thersites*. The participation of this ecological group in crustacean biomass, is relatively low in lake Wiżajny, but achieves (90%) in lake Wistuć.

The discussed above ecological groups of Rotifera and Crustacea, as well as other chosen parameters of zooplankton structure, have been used for a biological estimation of trophic state of the lakes under study. As both ecological groups are affected by fluctuation in abundance of species not connected with trophy, the index of trophic state is assumed as mutual relations of biomass of both groups expressed by contribution of IInd ecological group to total biomass of both groups. The results obtained are presented in Table 3, and the range of used indices characteristics of distinguished types of trophic lakes – in Table 3B. This allows to divide the lakes examined into 5 groups varying as to trophy:

– I group comprises two deep, dimictic lakes: Hańcza (XVI) and Szurpiły (I). These lakes have all indices within range characteristic of mesotrophy;

– II group is also found only in stratified lakes: Jeglówek (IV), Jaczno (VII), Kojle (XIV), Perty (XV) and Szelment Wlk (XX). In a few cases values typical of meso-eutrophy were obtained, but most of indices indicated the mesotrophic character of these lakes;

– III group of lakes are systems that can be stated as transitorial between meso- and eutrophic ones. This group comprises lakes having distinct – Kamenduł (VII) and Szelment Mały (XXI) and weak stratification – Kopane (II), and also polymictic lakes – Okrągłe (IX) and Pobondzie (XIII). The latter have values of a range typical of eutrophy;

– IV group consists of small shallow lakes of the Szeszupa lower reach: Udziejek (V), Gulbin (VIII), Krajwelek, Przechodnie and Postawelek (X–XIII) and the lower Szelmentka reach: Iłgieł (XXII) and Kupowo (XXIII), and also shallow lakes Wiżajny (XXIV) and Wistuć (XXV). According to the values obtained these lakes should be considered as eutrophic. In the case of the lake Wistuć, very high numbers of rotifers (26 thous. ind $\cdot$ l^{-1}) and lack of f. "typica" in the population of *Keratella cochlearis* may indicate the hypertrophic character of this lake. Finally, according to zooplankton trophy indicators, lakes Kluczysko (III) and Czarne (XIX) with weak stratification were also included to this group;

– V group consists of two lakes: Boczniel (XVII) and Jegliniszki (XVIII), both of specific character differing them from all the remaining water bodies. These lakes are very shallow (maximal depth – 1.5 m) and have the bottom overgrown totally by the water soldier – *Stratiotes aloides* L.. Chemical indices indicate high trophy, whereas the low phytoplankton concentration and relatively high water transparency – a low one. A similar lack of "consistency" is displayed by the zooplankton structure. Lack or sporadic occurrence of species from the I ecological group and high contribution of rotifers not only to the numbers but also to biomass, indicate the polytrophic character of these lakes. On the other hand, the trophic structure of

Rotifera (high contribution of the 3-rd trophic group practically, no detritus-feeders), lack of f. *tecta* in *Keratella cochlearis* population are characteristic of low trophy.

3.5. COMPARISON OF ZOOPLANKTON OF SUWAŁKI AND MASURIAN LAKES

In order to indicate specific zooplankton characters of Suwałki lakes examined, communities of these lakes were compared with zooplankton of well known lakes of the Masurian Lakeland. As lake trophy has a significant influence on zooplankton structure this comparison should be made for lakes of a similar trophic state. Thus, according to trophic state index TSI_{SD} based on water transparency (Carlson 1977), lakes of both lakelands were divided into 5 groups, each covering 5 successive TSI_{SD} units.

When comparing the corresponding groups of Suwałki and Masurian lakes, attention should be paid first of all to much higher zooplankton abundance in the former (Fig. 7). Zooplankton numbers in these lakes exceed 2–4 times mean values recorded in Masurian lakes. This is caused mostly by greater abundance of Rotifera, which were much more important in Suwałki lakes: rotifers in Masurian lakes accounted for from 40% (4th group) to 77% (5th group), whereas in Suwałki lakes their average percentage in zooplankton numbers did not decrease below 72% (1st group), in three groups exceeding 80%. Crustacean numbers in water bodies of both lakelands are similar and fluctuate on the average between 150 and 400 ind. $\cdot$ dm^{-3}. Differences are noted in the contribution of distinguished taxonomic groups (Cladocera, Calanoida and Cyclopoida). Taking into account mutual relation among these three groups, one should pay attention first of all to the small role of Calanoida in zooplankton of the Suwałki lakes. In distinguished groups of Masurian lakes they form ca 20% of Crustacea numbers, but in similar Suwałki lakes hardly achieve 3–9%, and only in 3rd group the contribution of Calanoida reaches 17%. Of two Eudiaptomus species deciding about the abundance of Calanoida, *E. gracilis* has a greater frequency in Suwałki lakes than in Masurian ones.

The dominant, as regards numbers, crustacean group of both lakelands are Cyclopoida, and about their abundance species of the genus Mesocyclops decide. However, dominance of *M. oithonoides* over another species of this genus – *M. leuckarti* differentiates distinctly the Suwałki lake group from Masurian (Karabin 1985a) and Suwałki (Patalas 1954) lakes, where reverse relation between these species have been observed.

In the latter group of crustaceans – Cladocera – no special differences are observed in the numbers and contribution of this group to crustacean communities of both lakelands.

Still, some differences have been observed in the species composition of Cladocera, which are distinctly more abundant in species in Suwałki lakes. This concerns especially genera Daphnia and Bosmina. Besides species found in both groups of lakes, in Suwałki lakes there are species occurring probably sporadically in

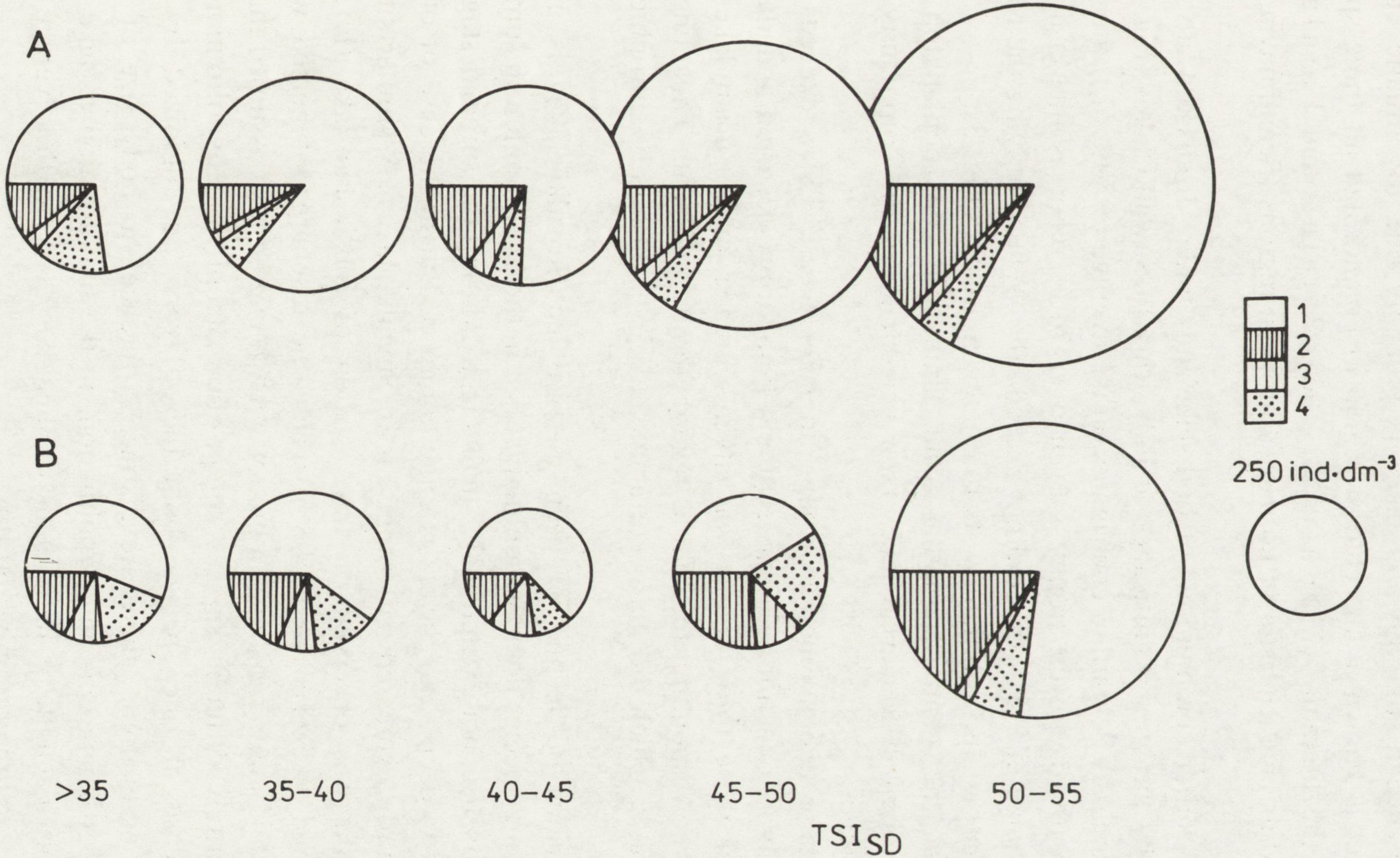

Fig. 7. Comparison of the numbers of Rotifera (1), Cyclopoida (2), Calanoida (3) and Cladocera (4) in groups of lakes of different trophy from Suwałki (A) and Masurian Lakelands (B)

the Masurian Lakeland. These are: *Daphnia longiremis, Bosmina obtusirostris* and *B. kessleri.* In previously examined over 60 Masurian lakes of a different morphometry and trophy, no any of these species were observed.

Their presence in the Suwałki lakes is probably due to climatic conditions. Suwałki district is known as the coldest region in Poland. and all three species are mentioned in the literature (Manuilova 1964, Patalas and Patalas 1966) and considered as characteristic of northern European regions (Scandinavia, northern Russia).

However, rotifer communities of both lakelands under discussion are distinctly differentiated by the great significance of Polyarthra in Suwałki lakes (Fig. 8). In all groups of these lakes Polyarthra contributes on the average to 30% of rotifer numbers and in lakes with the lowest trophy – even over 70%. Whereas in Masurian lakes average percentage of Polyarthra did not exceed 30%. When studying the role of this group in biomass of the community its role is even greater (Fig. 3).

Species of the genus Keratella occur abundantly in zooplankton of both lakelands, although in Masurian lakes their percentage in the community numbers was usually higher.

Besides these two taxonomic groups, in lakes where TSI_{SD} exceeds 40, also rotifers of genera Conochilus, Trichocerca and Pompholyx occurred abundantly. The significance of these three taxons was always greater in Masurian lakes than in Suwałki lakes corresponding to them as regards the trophic state. This concerns first of all Pompholyx, which did not occur abundantly even in highly eutrophic Suwałki lakes (Fig. 8).

The characteristic feature of deep mesotrophic Suwałki lakes is an almost unchanged spring species composition maintained in the hypolimnion in summer. The phenomenon itself is not exceptional – maintenance during the summer stagnation of spring species in deep water layers is quite common. But in the case of other lakes it is not generally expressed so strongly as in Suwałki lakes. A similar situation to that in Suwałki was observed on three station of Ślesińskie lake (Ejsmont-Karabin and Węgleńska 1988), where the discharge of heated water was followed by rapid cutting of hypolimnion waters. It can be also assumed that besides the almost entirely different species composition of epi- and hypolimnion rotifers, also in the case of one species, both these layers are colonized by different populations. For example, there are distinct differences in body size of *Keratella cochlearis* occurring in epi- and hypolimnion. In the hypolimnion of lake Szelment Wielki, the lorica length of individuals of this species is on the average 217 μm, whereas in the epilimnion only 160 μm.

Similarly, as in the case of crustaceans, rotifer communities of Suwałki lakes are characterized by the co-occurrence of a great number of species of the same genus. This concerns first of all Polyarthra, but also Trichocerca or family of Gastropodidae. In the case of the latter, in many Suwałki lakes *Gastropus hyptopus* was found – a species very rare in Masurian lakes.

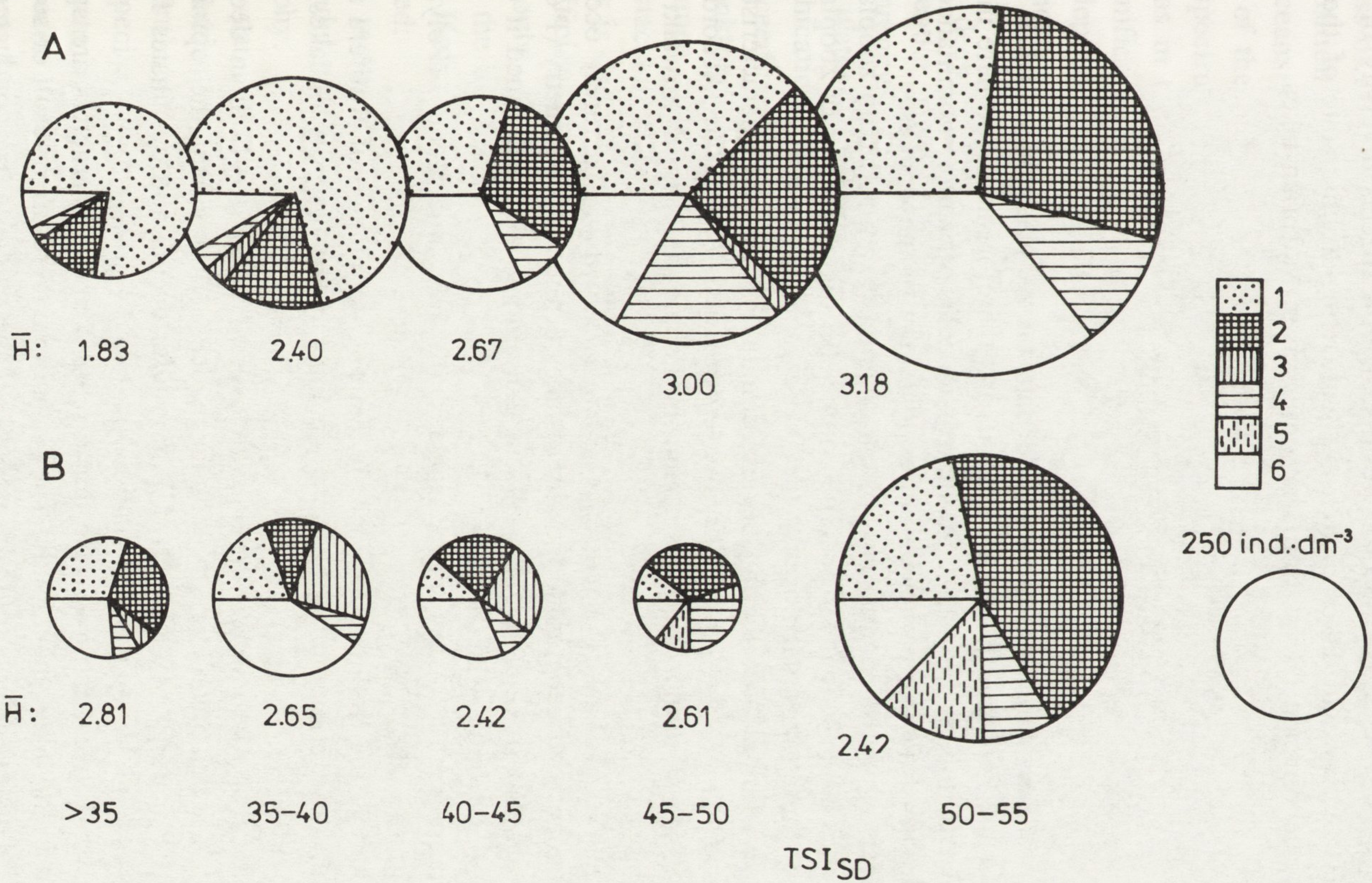

Fig. 8. Comparison of numbers of the most common Rotifera taxons and species diversity (H) in groups of lakes of different trophy of Suwałki (A) and Masurian Lakelands (B)
1 – Polyarthra sp., 2 – Keratella sp., 3 – Conochilus sp., 4 – Trichocerca sp., 5 – *Pompholyx sulcata*, 6 – other

Furthermore, in Suwałki lakes as compared with Masurian lakes there is a strong dominance of one species, exceeding 50% of rotifer community. This as well as the occurrence of many species of one genus, and first of all increasing significance of not numerous species in eutrophic lakes results in high species diversity of rotifer community (H) of Suwałki lakes, increasing with rising trophic state of the lakes (Fig. 8). This phenomenon differs from that observed in Masurian lakes.

4. CONCLUSIONS

Limnological literature does not provide data on zooplankton of lakes in the Suwałki Landscape Park and its neighbourhood, and therefore analysed here in detail are quantitative (numbers, biomass), qualitative (species structure, dominance) and functional (trophic structure) parameters of zooplankton of these lakes.

This analysis as well as comparison of communities examined with zooplankton of Masurian lakes have made possible to determine specific characters of zooplankton communities of these lakes, such as:

1. presence of cold stenotherm species, rare in Poland and characteristic for northern areas: *Daphnia longiremis, Bosmina obtusirostris, B. kessleri*. According to Patalas (1954), *D. longiremis* was found in Poland only in 8 Suwałki lakes (Hańcza and lakes of Wigry surroundings);

2. frequent (36% of lakes) occurrence *Gastropus hyptopus*, a rarely occurring species independently of geographic locality of lakes or their morphometry (Pejler 1965, Radwan 1973). One should point out that among lakes examined it occurs only in shallow, eutrophic water bodies;

3. co-occurrence of many rotifer species of the same genus (Polyarthra, Trichocerca) in one lake;

4. regardless of the trophic state there is a strong dominance of Rotifera and of Polyarthra within this community, the genus deciding in the majority of lakes about the rotifer biomass;

5. dominance of *Mesocyclops oithonoides* over *M. leuckarti,* both in deep and shallow lakes. Such a character of dominance does not confirm the opinion of Patalas and Patalas (1966) that *M. oithonoides* occurs and dominates first of all in deep lakes, and *M. leuckarti* in shallow ones.

Three years of investigations prove that discussed above characters are specific and permanent in the lakes under study. They cannot be therefore a result of seasonal succession of plankton, which could be possible if the studies were conducted only during one vegetation season.

The analysis of zooplankton indices of trophy allowed to distinguish groups of lakes of a different degree of eutrophication. However, not only trophy indices, but also other parameters of zooplankton structure divide lakes into groups characterised by different quantitative, qualitative and functional structure of zooplankton:

1. Lake Hańcza. Very deep water body, its TSI_{SD} differs greatly from that for other lakes, and indicates the α-mesotrophic character of this water body. This is fully confirmed by all parameters of zooplankton structure: very low numbers and biomass of rotifers and crustaceans, and thus of the whole zooplankton, poor species composition of rotifers, very high dominance of one species *D. cucullata* among crustaceans and of *Conochilus hippocrepis* among rotifers. Comparison of trophic status of these species shows that these are organisms of a quite broad and similar food spectrum. The majority of available food particles fluctuate within 2–20 μm, whereas in the food, besides nanophytoplankton, bacterial-detritus suspension may be significant (Pejler 1965, Gliwicz 1974, 1977). Thus, the food composition may depend on the existing food base. As it has been already mentioned, under conditions of low productivity of this lake, both species have to be competitive in relation to the more specialized ones;

2. deep stratified lakes, mostly in the upper reaches of rivers: Szeszupa and Szelmentka (Szurpiły, Jeglówek, Jaczno, Kojle, Perty, Szelment Wielki). The disc transparency, chlorophyll concentration and zooplankton indices of trophy show that these water bodies are still mesotrophic (although with weak symptoms of eutrophication). Furthermore, zooplankton numbers and biomass are relatively low, not exceeding 1000 ind. $\cdot$ dm^{-3} and 3.0 mg $\cdot$ dm^{-3}. Another characteristic feature of zooplankton in these lakes is the homogeneous taxonomic structure with distinct dominance of species of Polyarthra genus in communities of rotifers and of Daphnia in crustacean communities. Thus, in surface layers of water the 60–90% biomass of rotifers is due to 3 trophic groups, whereas 55–90% biomass of crustaceans – due to the "efficient" filtrators. In both cases these are organisms, for which nanoplankton is the only or main source of food.

In the hypolimnion of lakes: Szurpiły, Jeglówek and Szelment Wielki, similarly as in Hańcza, *Heterocope appendiculata* and *Eurytemona lacustris* have been recorded;

3. morphometrically and mictically differentiated group of lakes (Kopane, Kamenduł, Okrągłe, Pobondzie, Szelment Mały) of a transitory, meso- eutrophic type of trophy. Zooplankton of these lakes is greatly differentiated both spatially and within particular lakes. This may be considered as a symptom of zooplankton restructurisation following the changing trophy. Still a significant (sometimes dominant) role is that of Polyarthra and *Daphnia cucullata* species, but besides them other species also contribute significantly to the biomass (Trichocerca, Gastropodidae, *Synchaeta kitina* among rotifers and *Diaphanosoma brachyurum, Eudiaptomus graciloides* and *Mesocyclops oithonoides* in crustacean communities). As these organisms belong to different trophic groups, in the majority of lakes trophic structure of zooplankton is greatly differentiated. Simultaneously the zooplankton abundance increases. In this group of lake biomass attains the highest average values: 4.5–6.5 mg $\cdot$ dm^{-3} (an exception is Szelment Mały), mainly by increasing numbers of large crustaceans. Such character of zooplankton changes is probably due to an increase in abundance and differentiation of food base;

4. shallow, polymictic lakes situated in the lower Szeszupa reach (Udziejek, Gulbin, Krajwelek, Przechodnie and Postawelek), Szelmentka (Iłgieł and Kupowo), lake Wiżajny and two small lakes with a weak stratification (Kluczysko and Czarne). On the basis of trophy indices these lakes have to be considered as eutrophic. Characteristic for this group are the high zooplankton numbers (1 000–4 300 ind. $\cdot$ dm^{-3}) at a relatively low biomass (2.0–5.5 mg $\cdot$ dm^{-3}). This is due to a significant change of taxonomic structure of Crustacea as compared with other lakes. In the majority of lakes the place of first dominant (*Daphnia cucullata*) is taken by relatively small species of the genus Mesocyclops, mainly *Mesocyclops oithonoides*, covering 40–90% of the biomass. Also the significance of *Diaphanosoma brachyurum, Bosmina* sp. increases and in lake Wiżajny – *Chydorus sphaericus*. Thus the trophic structure of crustaceans changes. The significance of "efficient" filtrators feeding mostly on nanoplankton decreases, whereas that of species in the food of which detritus prevail ("inefficient" filtrators) increases. But first of all facultative predators dominate – Mesocyclops, Asplanchna, organisms having a broad food spectrum. There is, however, a lack of such significant changes in rotifer communities, where Polyarthra still dominates. The significance of Trichocerca increases and species of little significance such as *Filinia longiseta* and *Anuraeopsis fissa* occur more abundantly. This causes a slightly increasing significance of detritus feeders and those feeding on net algae. They exceed 40% only in lakes Kluczysko and Wiżajny.

5. in lake Wistuć. TSI_{SD} values indicate the polytrophic character of this lake. This is confirmed by structure parameters, distinctly differing the community of this lake from zooplankton in the remaining lakes: great zooplankton numbers (26000 ind. $\cdot$ dm^{-3}) in over 98% consisting of rotifers, relatively low biomass, poor composition and different species structure. Such common species as Polyarthra have not been recorded in this lake only and only in this lake *Keratella cochlearis* and *Anuraeopsis fissa* decide about the rotifer biomass. Particular is also the structure of crustacean community, in which *Mesocyclops leuckarti* forms 90% of the biomass. Although trophic structure of this community does not differ from that recorded in eutrophic lakes, in the case of rotifers this is the only reservoir with distinct dominance of species feeding on bacterial-detritus suspension (80% of biomass).

6. two other shallow lakes differ also from the remaining lakes – Boczniel and Jegliniszki whereas the composition and structure of rotifer community displays many characters typical of low trophy (practically no detritophages, very high dominance of species feeding on nanoplankton, lack of f. *tecta* in the *Keratella cochlearis* population), still the structure of crustacean communities is typical of eutrophic lakes (lack of *Daphnia cucullata*, great dominance of *Mesocyclops leuckarti*). However, the most characteristic feature of these lakes is the low abundance and poor species composition of crustacean communities. Their relatively great abundance is caused by the abundant occurrence of *M. leuckarti* nauplii. The numbers of the remaining (4) 2 species is 0.6 and 15.2 ind. $\cdot$ dm^{-3}, respectively (Table 4) as a result the biomass of crustaceans is very low, 4 times lower than that of rotifers. When trying to explain

this phenomenon, attention has been drawn to the fact that the bottoms of these two shallow lakes are entirely overgrown with submerged higher vegetation, mainly by water soldier. Brammer (oral inf.) has found that in the presence of this plant, phytoplankton and also crustaceans are inhibited in their development. On the other hand, a qualitative and quantitative zooplankton poverty has been observed in abundant in nutrients shallow lake Łuknajno (Biosphere Reserve) of Masurian Lakeland – unpubl. material. In this lake also, most of the bottom is covered by macrophytes, although a much more differentiated as regards species than in the lakes examined. Considering all this, one should find reasons for the specific structure of zooplankton in the direct influence of water soldier on phytoplankton (and perhaps on zooplankton), or in an another type of nutrient cycling in these ecosystems by higher vegetation and not the phytoplankton. This would in both cases limit the phytoplankton development and thus the food base of zooplankton.

Analysis of taxonomic and trophic structure shows that the factor affecting directly the species composition and abundance of zooplankton is its food base (phytoplankton) changing in a process of lake eutrophication.

On the basis of zooplanktonic and other trophic indices (disc transparency, chlorophyll concentration), 7 lakes have been determined as mesotrophic (including lake Hańcza – close to oligotrophy), 5 as meso-eutrophic, 10 as eutrophic and 1 as polytrophic. Thus almost half of lakes are eutrophic water bodies. Nevertheless, a thesis may be presented that on the area examined the effect of eutrophic factors is moderate. This is indicated by comparison of lake morphometry and trophy (Fig. 9).

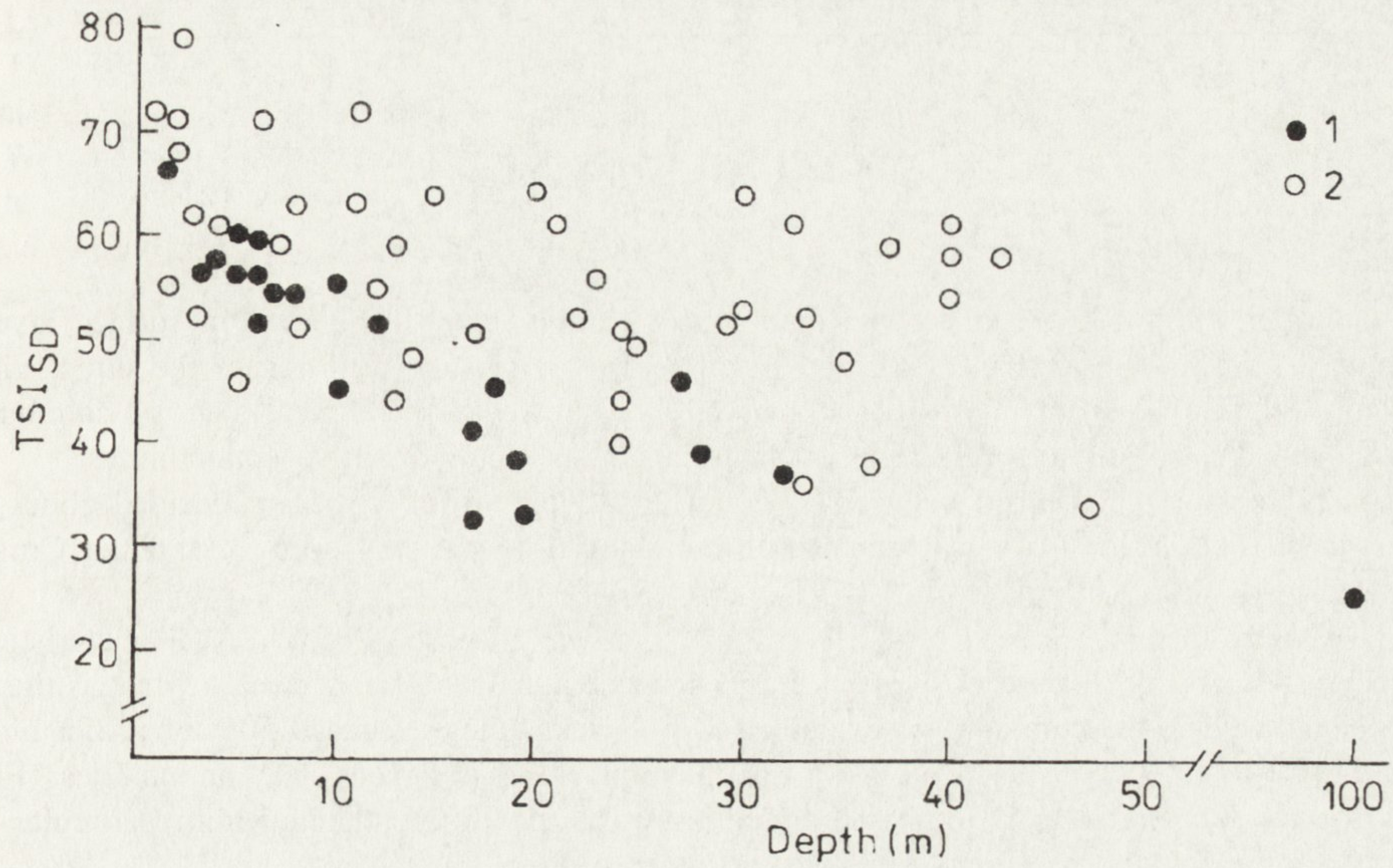

Fig. 9. Comparison of relations between the maximal depth and TSI_{SD} values in Suwałki (1) and Masurian (2) lakes

In the case of Suwałki lakes there is a distinct relation between maximal depth and TSI_{SD} values. Only shallow polymictic i.e., morphometrically eutrophic lakes undergo eutrophication. Whereas all deep distinctly stratified lakes (morphometrically mesotrophic) retain their right trophic character. As these lakes usually have high shores, their direct watershed is relatively small, which is additional protection against eutrophication caused by surface runoff. Thus, on the area examined, the intensity of eutrophic factors is so weak that it can not "break" natural barriers protecting these lakes against eutrophication.

Different situation was observed on the Masurian Lakeland (including Masurian Landscape Park). A lack of relation between the depth and trophy was observed there, and TSI_{SD} in many deep stratified lakes indicate a strong eutrophication (Fig. 9). In the case of these reservoirs the most frequent and significant eutrophying factor are the point sources of pollution (municipal and industrial sewage discharge).

The point sources of pollution are much less frequent on the SLP. It seems, that staying at the present industrialization level and installing local sewage treatment plants will be a sufficient protection against further eutrophication of the lakes under study. This treatment is necessary to retain the great biological, landscape and touristic values of lakes of the Suwałki Landscape Park and its protection zone.

Comparison of zooplankton structure in lakes along the rivers Szelmentka and Szeszupa shows that changes in parameters of this structure frequently have a directional character, indicating an increase in lake trophy with the distance from the river source. Comparison of trophy and morphometry (depth, surface) indicates that this is only due to the fact that in the upper reaches of both rivers there are relatively big, stratified lakes, and in the lower reach – small polytrophic ones.

5. SUMMARY

In the years 1983–1985, studies on summer zooplankton were conducted in surface layers of 25 lakes of the Suwałki Landscape Park and its protective zone as well as in the direct vicinity of the Park (Fig. 1). The aim of investigations was to estimate the ecological state of communities of rotifers and crustaceans and the effect of anthropogenous factor on these communities.

Zooplankton numbers ranged between 117 and 26420 ind. $\cdot$ dm^{-3}, rotifers decided about these numbers (Table 1). The biomass was equally differentiated (0.4–8.6 mg $\cdot$ dm^{-3}), and the Crustacea mostly affected its values. (Fig. 2).

In lakes examined, the presence of 51 rotifer taxons was recorded (Table 2). Characteristic was the co-occurrence of a great number of species of Trichocerca and Polyarthra genera whereas the latter distinctly dominated in the communities examined – in 21 lakes they exceeded 50% of rotifer biomass (Fig. 3). Furthermore, organisms feeding on nanophytoplankton dominated in communities (Fig. 4) and thus the trophic structure of rotifer communities was little differentiated within particular lakes but greatly similar within the groups of the lakes under study.

The Crustacea community considered of 25 species (Table 4). In the majority of lakes crustacean communities were formed by 9–11 species, but they did not contribute to more than 50% of the biomass,and "very constant" species dominated (Fig. 5). An exception were 4 shallow lakes (nos XII, XVII, XVIII, XXV), where the genus Mesocyclops formed over 90% of the biomass of qualitatively poor communities (3–5 species). The community from lake Hańcza had an entirely different structure,

Daphnia cucullata accounted for 90% of biomass and the structure made possible the division of crustacean communities of lakes examined into several groups of a different type of trophic structure (Fig. 6).

In order to determine specific characters of zooplankton of Suwałki lakes, rotifer and crustacean communities of these lakes were compared with zooplankton of analogous as regards trophy reservoirs of Masurian Lakeland. Suwałki lakes are characterized by: high dominance of Rotifera regardless of the trophic state (Fig. 7), co-occurrence of many species of the same genus (Polyarthra, Trichocerca) and a relatively high index of species diversity of rotifers (Fig. 8), the presence of species rare in Poland: *Daphnia longiremis, Bosmina obtusirostris, B. kessleri, Gastropus hyptopus.*

Relations of ecological groups' biomass characteristic of low and high trophy, and also other indicatory zooplankton characters were used for biological estimation of trophic state of lakes (Table 3). There were distinguished 5 groups of water bodies being at a different stage of eutrophication process: from mesotrophy to high eutrophy. Almost half of the lakes under study were eutrophic. But the comparison of morphometry and trophy of lakes (Fig. 9) indicated that only shallow water bodies underwent eutrophication. However, the stratified, deep (morphometrically mesotrophic) lakes retained their specific trophic character. Thus, a thesis can be presented that the intensity of eutrophying eutrophication factors on the area discussed is not powerful enough to break natural protection barriers.

6. POLISH SUMMARY

W latach 1983–1985 badano letni zooplankton występujący w powierzchniowych warstwach wody 25 jezior leżących na terenie Suwalskiego Parku Krajobrazowego i jego otuliny oraz w bezpośrednim sąsiedztwie Parku (rys. 1). Celem badań była ocena stanu ekologicznego zespołów wrotków i skorupiaków oraz wpływu czynników antropogennych na te zespoły.

Liczebność zooplanktonu wahała się od 117 do 26420 osobn. · dm^{-3}, decydowały o niej wrotki. (tab. 1). Biomasa była równie silnie zróżnicowana (0,4–8,6 mg · dm^{-3}), a na jej wartości wpływały głównie Crustacea (rys. 2).

W badanych jeziorach stwierdzono obecność 51 taksonów wrotków (tab. 2). Charakterystyczne było tu współwystępowanie dużej liczby gatunków z rodzaju Trichocerca i Polyarthra, przy czym te ostatnie zdecydowanie dominowały w badanych zespołach – w 21 jeziorach stanowiły ponad 50% biomasy wrotków (rys. 3). Co za tym idzie, w zespołach dominowały organizmy odżywiające się nanofitoplanktonem (rys. 4) powodując, iż struktura troficzna zespołów wrotków odznaczała się małym zróżnicowaniem w obrębie poszczególnych jezior, a dużym podobieństwem w obrębie rozpatrywanych grup jezior.

Zespół Crustacea obejmował 25 gatunków (tab. 1). W większości jezior zespoły skorupiakowe tworzone były przez 9–11 gatunków, przy czym udział każdego z nich nie przekraczał 50% biomasy, a dominowały gatunki "bardzo stałe" (rys. 5). Wyjątek stanowiły 4 płytkie jeziora (nr XII, XVII, XVIII, XXV), gdzie na biomasę ubogich jakościowo zespołów (3–5 gatunków) składał się w ponad 90% rodzaj Mesocyclops. Całkowicie odmienną stukturą odznaczał się zespół jeziora Hańcza, gdzie *Daphnia cucullata* stanowiła 90% biomasy, a udział Cyclopoida nie przekraczał 5%. Ta zróżnicowana struktura gatunkowa umożliwiła podzielenie zespołów skorupiakowych badanych jezior na kilka grup o odmiennym struktury troficznej (rys. 6).

W celu określenia specyficznych cech zooplanktonu jezior suwalskich porównano zespoły wrotków i skorupiaków tych jezior z zooplanktonem analogicznych pod wzgędem trofii zbiorników Pojezierza Mazurskiego. Specyfika jezior suwalskich, to m.in.: silna dominacja Rotifera bez względu na stan trofii (rys. 7), współwystępowaniae wielu gatunów tego samego rodzaju (Polyarthra, Trichocerca) i stosunkowo wysoki wskaźnik różnorodności gatunkowej wrotków (rys. 8), obecność rzadkich dla Polski gatunków: *Daphnia longiremis, Bosmina obtusirostris, B. kessleri, Gastropus hyptopus.*

Relacje biomas grup ekologicznych charakterystycznych dla niskiej i wysokiej trofii, jak też inne, mające chrakter wskaźnikowy, cechy zooplanktonu posłużyły do biologicznej oceny stanu trofii jezior (tab. 3). Wyróżniono 5 grup zbiorników znajdujących się na różnych etapach eutrofizacji: od mezotrofii do silnej eutrofii. Prawie połowa badanych jezior jest zeutrofizowana. Jednak porównanie morfometrii i trofii jezior (rys. 9) wskazuje, że eutrofizacji uległy jedynie zbiorniki płytkie. Natomiast stratyfikowane, głębokie (morfometrycznie mezotroficzne) jeziora zachowały właściwy sobie charakter trofii. Można zatem wysunąć tezę, że na omawianym terenie natężenie czynników eutrofizacyjnych jest jeszcze na tyle stałe, że nie jest w stanie przełamać naturalnych barier ochronnych.

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