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STRUCTURE, DYNAMICS AND DISTRIBUTION OF ZOOPLANKTON, AND ITS MANY-YEARS' CHANGES IN THE WIGRY LAKE

ABSTRACT: In connection with setting up of the Wigry Landscape Park, in 1981 the current state of Wigry Lake zooplankton was investigated. Numbers as well as the species and trophic structure of rotifers and crustaceans were analysed. The results were compared with the data obtained in 1922. It was found that the changes in zooplankton structure, having taken place during 60 years, testify to advancing eutrophication of the lake. The progress of this process is not identical in all lake basins. The northern basin seems to be most eutrophicated, because the Czarna Hańcza River which flows into this basin carries large pollution loads.

KEY WORDS: crustaceans, rotifers, eutrophication.

1. INTRODUCTION

The Wigry Lake can be regarded as the cradle of Polish hydrobiology, since the first Polish Hydrobiological Station has been set up there in 1920. This Station has immediately initiated studies of the Suwalskie and Augustowskie lakes, and in the first place – of the Wigry Lake itself. Already in 1922, L i t y ń s k i (1922a, 1922b) has published a paper on the planktonic fauna communities of the Wigry Lake and a list of the Phyllopoda and Copepoda species of the Wigierskie lakes. On the basis of these water bodies, L i t y ń s k i (1925a) and then B o w k i e w i c z (1938) have attempted trophic classification of lakes according to species composition of zooplankton. In the period between World Wars I and II, apart from the above-mentioned papers, more than 10 studies concerning the zooplankton of the

Wigry Lake and of the surrounding lakes have been reported (among others, Adlerówna 1929, Bowkiewicz 1926, 1935, Lityński 1925b, Minkiewicz 1920). In their pioneer investigations, these authors have in the first place concentrated on the basic data: species composition and numbers of zooplankton, and subsequently – on the dynamics of changes in these parameters in the course of the season. World War II has interrupted the extensive activities of the Station; after its finish the Station has not been reactivated, and therefore the studies of the Wigierskie lakes were greatly limited, usually being of an accidental nature.

In the period of studies performed by Lityński and his associates, the Wigry Lake has been a typical mesotrophic reservoir. Since this time, however, there has occurred a slow, but steady increase in chemicalization of agriculture within the lake's watershed and intensification of the agricultural and other activities. This has resulted in e.g. strong pollution (with municipal sewage and waste waters) of the Czarna Hańcza River flowing into the northern basin of the Wigry Lake. These facts exerted a substantial effect on the state of trophy of the reservoir.

At the same time, on account of the high natural qualities and landscape value of the Wigry Lake, for their protection in 1976 the Wigierski Landscape Park has been set up to be transformed in 1988 into the Wigierski National Park. For these reasons it became necessary to evaluate the current state of the flora and fauna (including the zooplankton) of the Wigry Lake as well as to determine the effect of anthropopressure and of eutrophicating factors on the above-mentioned associations of organisms.

2. STUDY AREA, MATERIAL AND METHODS

The Wigry Lake situated in the Suwalskie Lakeland, in the Czarna Hańcza River catchment area, is of post-glacial origin. Its surface area (together with islands) is 2 187 ha; its maximum depth amounts to 73 m, and mean depth – to 15.8 m. The lake's shape resembles the letter S; its length is 17.5 km and maximal width – 3.5 km. The length of the very strongly developed shore-line exceeds 72 km. The reservoir is formed by three basins: northern, central and western, which stand apart distinctly (Fig. 1).

The present complex hydrochemical and biological studies of the Wigry Lake were performed in 1981 by the Hydrobiology Department, Institute of Ecology of the Polish Academy of Sciences, together with the Hydrology Department, Institute of Inland Fisheries. As the Wigry Lake displays greatly differentiated morphometry, zooplankton samples were collected at three sampling stations corresponding to the three basins of the lake (Fig. 1). Samples were taken three times the year: in the period of spring circulation (April), and in the initial (June) and peak (August) period of summer stagnation. Water samples were collected with a 5-l sampler at every 1-m depth, whereupon they were pooled for the layers of the epi-, meta- and hypolimnion. Samples were concentrated with a plankton net (30-μm mesh). They were

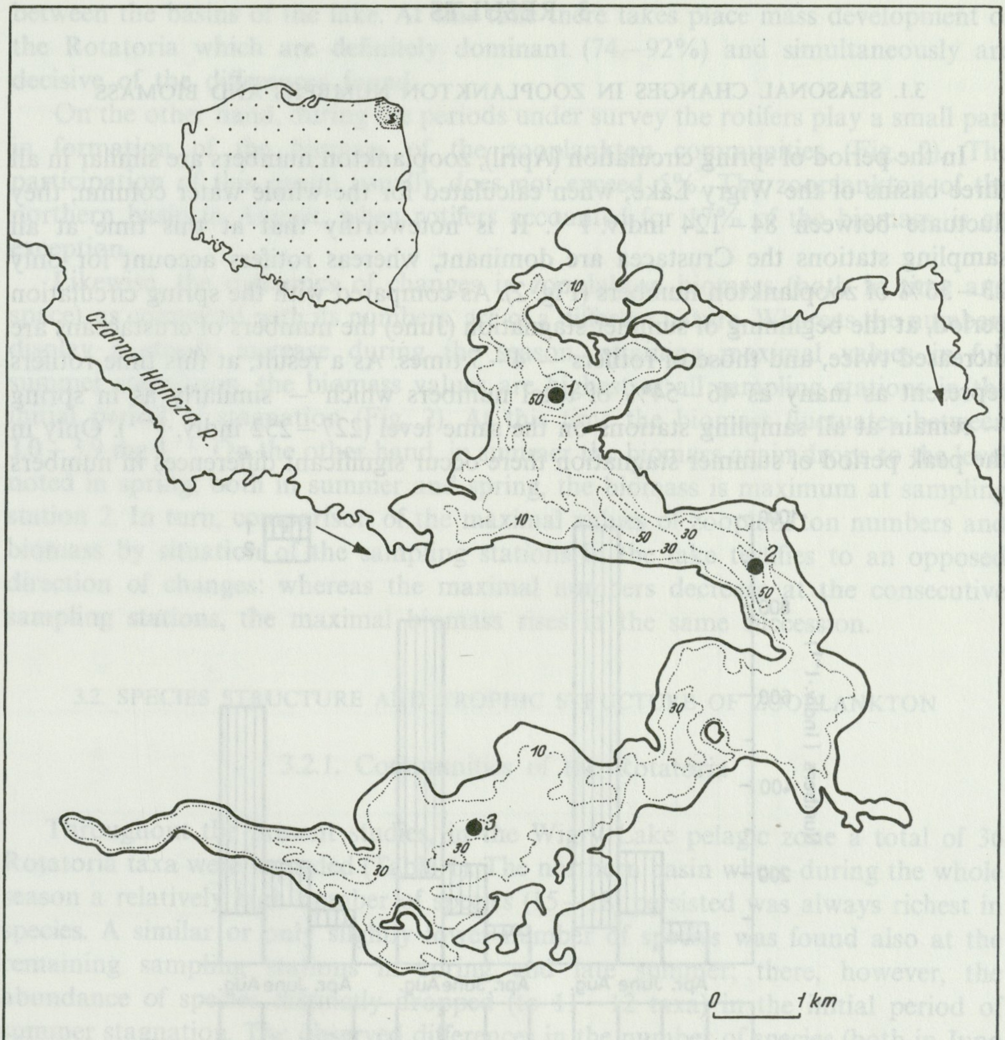

Fig. 1. Wigry Lake
1, 2, 3, — sampling stations

treated according to the methods reported by Hillbricht-Ilkowska and Patalas (1967). For the determination of individual body weight or organisms, the body length:body weight (L:W) relationships were applied (Hillbricht-Ilkowska and Patalas 1967, Ruttner-Kolisko 1977). Numbers, as well as the species and trophic structure of the Rotatoria and Crustacea were analysed.

3. RESULTS

3.1. SEASONAL CHANGES IN ZOOPLANKTON NUMBERS AND BIOMASS

In the period of spring circulation (April), zooplankton numbers are similar in all three basins of the Wigry Lake; when calculated for the whole water column, they fluctuate between 84 – 124 indiv.$\cdot l^{-1}$. It is noteworthy that at this time at all sampling stations the Crustacea are dominant, whereas rotifers account for only 23 – 36% of zooplankton numbers (Fig. 2). As compared with the spring circulation period, at the beginning of summer stagnation (June) the numbers of crustaceans are increased twice, and those of rotifers – 4 – 5 times. As a result, at this time rotifers represent as many as 46 – 54% of total numbers which – similarly as in spring – remain at all sampling stations on the same level (227 – 252 indiv.$\cdot l^{-1}$). Only in the peak period of summer stagnation there occur significant differences in numbers

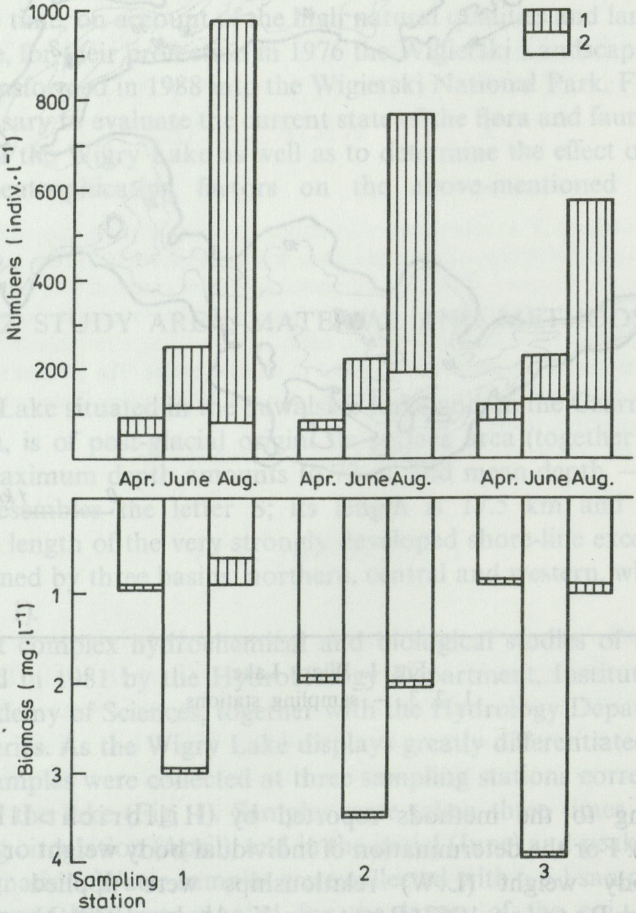

Fig. 2. Changes in zooplankton numbers and biomass in the Wigry Lake during the season
1 – Rotatoria, 2 – Crustacea

between the basins of the lake. At this time there takes place mass development of the Rotatoria which are definitely dominant (74–92%) and simultaneously are decisive of the differences found.

On the other hand, during the periods under survey the rotifers play a small part in formation of the biomass of the zooplankton communities (Fig. 2). The participation of this group usually does not exceed 5%. The zooplankton of the northern basin in August, when rotifers accounted for 17% of the biomass, is an exception.

Likewise, the dynamics of changes in zooplakton biomass (both in time and space), as compared with its numbers, are of a different nature. Whereas the numbers display a steady increase during the season, attaining maximal values in full summer stagnation, the biomass values are highest at all sampling stations in the initial period of stagnation (Fig. 2). At this time the biomass fluctuates between 3.0–3.9 $mg \cdot l^{-1}$. On the other hand, in summer the biomass again drops to the level noted in spring; both in summer and spring, the biomass is maximum at sampling station 2. In turn, comparison of the maximal values of zooplankton numbers and biomass by situation of the sampling stations in the lake testifies to an opposed direction of changes: whereas the maximal numbers decrease at the consecutive sampling stations, the maximal biomass rises in the same succession.

3.2. SPECIES STRUCTURE AND TROPHIC STRUCTURE OF ZOOPLANKTON

3.2.1. Communities of the Rotatoria

Throughout the present studies, in the Wigry Lake pelagic zone a total of 36 Rotatoria taxa were recorded (Table 1). The northern basin where during the whole season a relatively high number of species (15–18) persisted was always richest in species. A similar or only slightly lower number of species was found also at the remaining sampling stations in spring and late summer; there, however, the abundance of species distinctly dropped (to 11–12 taxa) in the initial period of summer stagnation. The observed differences in the number of species (both in June and in the remaining periods) virtually concern only the adominants, while the group of the dominant species is in the different periods of sampling greatly uniform in the whole lake (Table 1).

During spring circulation, *Conochiloides natans*[1] (19–39%) (not encountered in June and August) plays a substantial part in formation of the rotifer community biomass. However, in this period in the whole lake the cryophilic species of the family Synchaetidae are the dominant group; they display directional changes (from sampling station 1 to 3) in the importance of the different species of this group. *Polyarthra dolichoptera* represents in the northern basin (sampling station 1) 37% of the Rotatoria biomass, whereas in the central basin it accounts for 19%, and in the western one (sampling station 3) – for only 9%. At the latter station, *Synchaeta pectinata* representing 44% of rotifer biomass is definitely dominant.

[1] Authors of species are presented in Tables 1 and 2.

Table 1. Seasonal changes in the composition and dominance of different species in the biomass of the Rotatoria community, in the whole water column

Species	Apr.			June			Aug.		
	sampling station								
	1	2	3	1	2	3	1	2	3
Notommatidae									
Cephalodella catellina (Müller)			0.1						
Trichocercidae									
Trichocerca birostris (Wierzejski)							3.5	6.0	7.2
T. pusilla (Lauterborn)							0.1	0.1	
T. capucina (Wierzejski et Zacharias)							0.6		0.8
T. rousseleti (Voigt)							0.9	0.7	0.5
T. porcellus (Gosse)									0.1
Gastropodidae									
Ascomorpha saltans Bartsch							1.5	2.7	0.1
Chromogaster ovalis (Bergendal)							3.8	3.6	13.3
Synchaetidae									
Synchaeta oblonga Ehrenberg	3.2	0.5	3.2						
S. pectinata Ehrenberg	15.3	14.9	44.1						
S. kitina Rousselet	0.9	0.2	1.6	<0.1			18.3	20.1	<0.1
S. tremula (Müller)				<0.1					
Polyarthra vulgaris Carlin				1.9	1.3	2.5	2.6	6.2	8.1
P. dolichoptera Idelson	37.3	19.0	9.2	4.2	3.6	0.5			
P. remata Skorikov							1.2	2.0	1.1
P. major Burskhardt				<0.1			11.4	15.3	15.5

Asplanchnidae									
Asplanchna priodonta Gosse	2.2	3.6	5.4	11.6	2.1	2.7			
Lecanidae									
Lecane (M) *arcuata* (Bryce)				<0.1	0.2				
Colurellidae									
Colurella sp.			<0.1			<0.1	<0.1	<0.1	
Lepadella patella (Müller)						<0.1			
Brachionidae									
Brachionus calyciflorus Pallas	0.4								
B. angularis Gosse				1.6	0.5				
Keratella cochlearis (Gosse)	2.8	3.0	3.3	11.8	11.6	12.8	19.8	14.9	19.6
K. hiemalis Carlin	2.8	5.2	2.3	9.0	6.9	4.4			
K. quadrata (Müller)	10.9	5.8	2.2	37.3	47.9	53.0	6.5	6.4	8.2
Kelliocottia longispina (Kelliocott)	1.5	1.6	0.6	7.9	8.5	13.3	0.7	0.6	0.8
Notholca squamula (Müller)	0.1	<0.1	<0.1						
N. foliacea (Ehrenberg)		<0.1	<0.1						
N. caudata Carlin	0.1	0.3							
N. acuminata (Ehrenberg)	0.1	<0.1							
N. labis Gosse	0.1		0.1						
Conochilidae									
Conochilus unicornis Rousselet	0.9	1.4	3.3	5.7	9.0	1.6	25.3	18.8	20.4
Conochiloides natans (Seligo)	19.4	39.5	19.7						
Testudinellidae									
Pompholyx suculata Hudson				0.3	0.2		1.4	0.9	0.8
Filiniidae									
Filinia terminalis (Plate)	1.7	4.8	4.4	8.2	8.2	9.1	2.0	1.5	3.4
Collothecidae									
Collotheca mutabilis (Hudson)							<0.1		<0.1
Number of species	17	16	17	15	12	11	18	16	17

Also in the case of the family Brachionidae, directional changes are perceptible. Whereas in the northern basin 9 species of this family represent in spring ca. 19% of Rotatoria biomass, in the western basin the Brachionidae (7 species) account for ca. 9% of this biomass. In this group *Keratella quadrata* occurs in greatest numbers; its participation in the biomass does not, however, exceed 11%.

On the other hand, *Keratella quadrata* is definitely dominant in the initial period of summer stagnation. Among the great number of species occurring in this period, only two: *Keratella cochlearis* and *K. quadrata,* account at all sampling stations for more than 10% of biomass of the rotifer community (dominants); *K. quadrata,* by itself, represents 37 – 53% of biomass. As a result, the family Brachionidae is in June the group decisive of rotifer biomass (Table 1).

In the peak period of summer stagnation, the taxonomic differentiation of the rotifer community again increases. In this period the family Brachionidae is represented by only three species whose total percentage in the biomass does not exceed 30%. In the *Keratella cochlearis* population, at sampling stations 1 and 2 the "tecta" form characteristic of lakes undergoing eutrophication was present. On the other hand, the family Syntchetidae becomes dominant, similarly as in spring. At sampling stations 1 and 2 *Synchaeta kitina* occurs fairly abundantly, whereas it is virtually absent from the station 3. Here the family Synchaetidae is represented only by species of the genus Polyarthra. Moreover, at all sampling stations *Conochilus unicornis* occurs in great densitics (19 – 25% of biomass). Furthermore, species of the genus Trichocerca are present.

In the analysis of the structure of the Rotatoria community, also its trophic

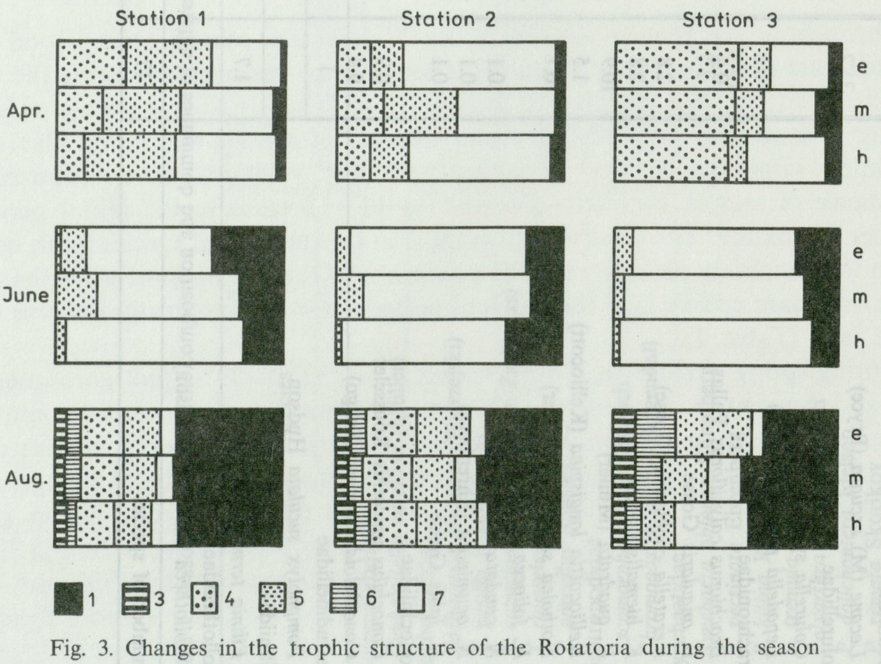

Fig. 3. Changes in the trophic structure of the Rotatoria during the season
e – epilimnion, m – metalimnion, h – hypolimnion; 1 – 7 – trophic groups described in the text

structure was included (Fig. 3). Trophic groups were distinguished according to the classification proposed by K a r a b i n (1985b), without taking predatory *Asplanchna priodonta* into account.

In spring, in the lake organisms of two different trophic groups, feeding on algae, are dominant. Directional (from sampling station 1 to 3) changes in the interrelations of these groups are found. Whereas at sampling station 1 there dominate species feeding only on small algae (maximal diameter 20 – 30 μm, i.e. 5th trophic group), at station 3 there is the greatest abundance of species in whose food an important role (apart from nannophytoplankton) is played by large algae of a size attaining 50 μm (4th trophic group). Apart from the exclusively algivore species, at sampling stations 1 and 2 a considerable part of the biomass of nonpredatory Rotatoria is formed by species with a wide trophic spectrum (nannophytoplankton, bacteria, detritus, i.e. the 7th trophic group). On the other hand, in spring an unimportant role is played by organisms whose principal food consists of fine bacteria-detritus suspension (1st trophic group).

Simplification of the species structure of rotifers in the initial period of summer stagnation (Table 1) corresponds with a drop in the diversity of the trophic structure of the community. At all sampling stations the "nonspecialized" species of the 7th trophic group are definitely dominant. At the same time, as compared with the spring period, the importance of species of the 1st trophic group increases. As a result, the organisms in whose food the bacteria-detritus suspension may be of great importance account in June for 80 – 95% of the biomass of the nonpredatory Rotatoria.

The peak period of summer stagnation is characterized by an increase in the differentiation of the trophic structure. In this period the importance of the "nonspecialized" species abruptly drops, whereas there appear trophic groups absent in the earlier period. They include highly specialized species of the family Gastropodidae, feeding on different species of the Dinoflagellata (6th trophic group), as well as rotifers whose food comprises small and large net algae (3th trophic group). Simultaneously, there continues an increase in the importance of the detritus-feeding species forming at this time 35 – 50% of rotifer biomass. Similarly as in the earlier period, the trophic structure is very similar at all sampling stations. Certain differences were found only for the station 3 where species of the 4th trophic group were replaced by organisms feeding on net phytoplankton.

In the period of full stratification of water masses (August), vertical differentiation of the trophic structure of the Rotatoria was found only at the station 3; it was expressed by directional changes in the importance of trophic groups in parallel with depth (Fig. 3). At sampling stations 1 and 2, the trophic structure of rotifers inhabiting in this period the epi-, meta- and hypolimnion is characterized by considerable similarity, whereas only their numbers change. This may indicate that at these sampling stations the changes in the food base with depth are of a rather quantitative than qualitative nature.

Table 2. Seasonal changes in the composition and dominance of different species in the biomass of the Crustacea community, in the whole water column

Species	Apr.			June			Aug.		
	sampling station								
	1	2	3	1	2	3	1	2	3
Cyclopidae									
Cyclops scutifer Sars				13.3	6.3	27.3	0.7	7.2	16.3
C. kolensis Lilljeborg	45.2	56.1	59.8						
C. abyssorum Sars					5.9				
C. vicinus Uljanine		0.3							
Mesocyclops oithonoides (Sars)	11.3	3.4	15.5	1.3	2.7	0.8	16.8	5.7	11.6
M. leuckarti (Claus)	34.0	27.6		0.3	15.2		18.7	11.8	8.5
M. crassus		1.8				0.4	4.8	4.8	3.4
Calanoidae									
Eudiaptomus gracilis (Sars)	1.5	0.3	11.0	5.3	7.5	8.7			
E. graciloides (Lilljeborg)		2.8		0.8	1.5		1.1	1.2	9.2
Eurythemora acustris (Poppe)	5.8	6.3	7.7	0.3	2.3	0.7	2.1	1.8	1.3
Heterocope appendiculata Sars						0.7			
Cladocera									
Daphnia cucullata Sars	0.4	1.1	5.5	43.7	38.4	27.7	22.9	50.7	13.7
D. cristata Sars				2.0	2.5	1.9	4.2	0.6	2.0
D. longispina hyalina galeata (Leydig)	1.3			0.7	2.6	2.8		0.1	
D. l. h. lacustris Sars				4.1		1.7			3.2
D. l. h. pellucida (Leyding)						0.7			1.3
Bosmina berolinensis Imhof				0.2		0.3	0.1	0.1	
B. crassicornis (P. E. Müller)	0.1	2.8		2.5		1.3	20.5	8.2	13.7
B. longirostris (O. F. Müller)	0.4	0.3	0.4	25.3	19.3	22.1	3.8	5.8	10.6
Diaphanosoma brachyurum (Lievin)							2.2	1.8	4.8
Chydorus sphaericus (O. F. Müller)				0.1			2.0	0.2	0.3
Leptodora kindtii (Focke)					1.8	2.7			
Number of species	9	10	6	14	12	15	13	14	14

3.2.2. The Crustacea community

The total number of the Crustacea taxa found during the present studies is 22 (Table 2), including 7 Cyclopidae species, 4 Calanoidae species and 11 Cladocera taxa (species and subspecies).

In spring, in all basins of the lake the Cyclopidae typical of this period are definitely dominant. Their percentage in the crustacean biomass fluctuates from 90% in the northern and central basin to 75% in the western one; only one Cyclopidae species, i.e. *Cyclops kolensis,* accounts for ca. a half of the biomass of the crustacean community (Table 2).

In the initial period of summer stagnation the number of species definitely increases, mainly owing to a rise of species abundance of the Cladocera. This taxonomic group definitely dominates at that time, representing 60–80% of the biomass. This is mainly due to an increase in the importance of two species occurring already in spring at all sampling stations: *Daphnia cucullata* and *Bosmina longirostris.* On the other hand, the percentage of the remaining cladoceran species does not usually exceed 2–3% of crustacean biomass. The percentage of the Calanoida persists at this time on a level approaching that found in spring. In the Cyclopidae group, being quantitatively poorer, *Cyclops kolensis* is found no more, whereas *Cyclops scutifer* occurs at all stations. Similarly as in spring, the number of the Cyclopidae species is greatest at sampling station 2.

The phenomenon of the species structure of crustaceans becoming similar at all sampling stations is enhanced at the summer stagnation peak (Table 2). There continues the dominance of the Cladocera, among which two species: *Daphnia cucullata* and (instead of *B. longirostris*) *Bosmina coregoni,* play an important role in biomass formation, similarly as in June. The importance of the Cyclopidae again increases; at this time, the biomass of this group depends on three species of the genus Mesocyclops. Only at sampling station 3 *C. scutifer* also occurs in fairly great numbers. The low percentage of the Calanoidae in the biomass of crustaceans, only unfrequently exceeding 10%, seems to be characteristic of the Wigry Lake.

Within the crustacean community four groups of organisms differing in trophic spectrum have been distinguished (Karabin 1985b). The group of microfiltrators is represented by the Cladocera; in the case of "efficient" filtrators, the optimal food particle size is 10–12 μm, whereas for the "inefficient" ones it does not exceed 2–5 μm. Thus, in the food of the latter the bacteria – detritus suspension is dominant, whereas in the food of "efficient" filtrators the participation of nanno-phytoplankton is high. The group of macrofiltrators comprises the Calanoida, nauplii and a half of the population of the *Cyclopidae copepodits;* the predators include *Leptodora kindtii,* adult Cyclopidae and a half of their copepodit population, as well as rotifer *Asplanchna priodonta.* Seasonal changes in the participation of the above-mentioned groups in the biomass of the community are presented in Figure 4. The great similarity of the trophic structure and of its vertical distribution in all three lake basins is noteworthy. This concerns particularly both earlier periods of studies.

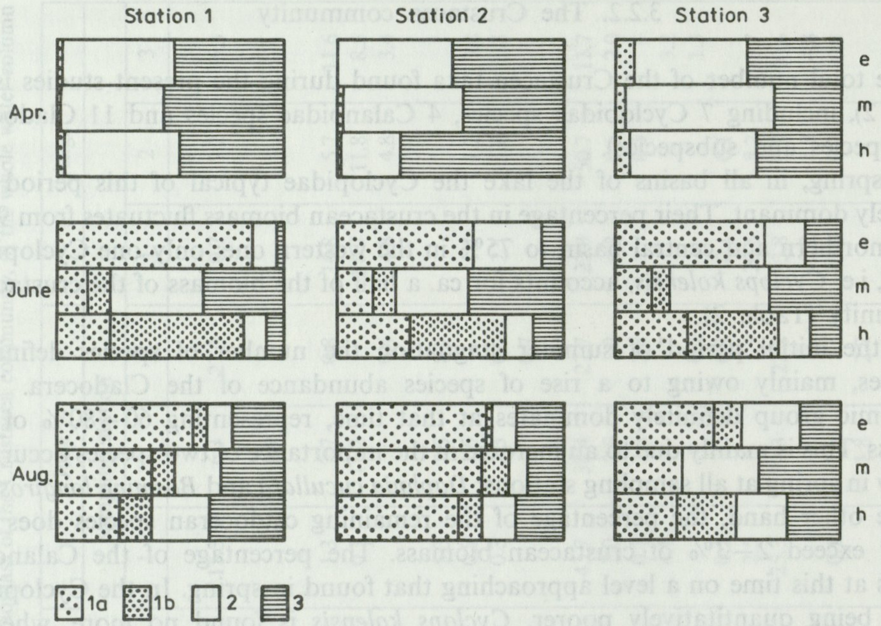

Fig. 4. Changes in the trophic structure of the Crustacea during the season
e — epilimnion, m — metalimnion, h — hypolimnion; 1—3 — trophic groups described in the text

Namely, during spring circulation everywhere the biomass virtually depends on only the macrofiltrators and predators, whose percentage in this biomass is usually similar (45—50%). The sporadically occurring microfiltrators account for no more than 7% (and usually for 1—3%) of the biomass.

The initial period of summer stagnation is characterized by greater differentiation of the trophic structure and by its nearly identical, specific stratification in all three lake basins. In the epilimnion the "efficient" microfiltrators are dominant (the "inefficient" ones are absent). In the metalimnion the percentage of microfiltrators drops to 25%, whereas the "inefficient" ones occur in fairly great numbers; there is dominance of macrofiltrators and predators. In the hypolimnion the microfiltrators are again the dominant group; however, the "inefficient" species account for more than 50% of their biomass.

In the peak period of summer stagnation there continues the dominance of microfiltrators which irrespective of the sampling station and thermal layer represent more than 50% of crustacean biomass. Together with depth, at all sampling stations the importance of the "inefficient" species feeding on the bacteria-detritus suspension is found to increase. Despite the considerable similarity, in this period an increase is observed in the differentiation of crustaceans between the various basins, expressed by the structure of trophic group dominance and by changes in this structure with dept.

3.3. ZOOPLANKTON AS AN INDICATOR OF THE TROPHY STATE OF THE WIGRY LAKE

In the analysis of zooplankton structure, attention was directed to the parameters being indicators of the lake's trophy state. These are epilimnetic indicators concerning the peak period of summer stagnation (Karabin 1985a). For the three Wigry Lake basins, the values of six so-called "basic" indices were calculated and compared with the values characteristic of mesotrophic lakes. The results are recorded in Table 3. Both in the rotifer and crustacean community, two ecological groups characteristic of low and high trophy were singled out. Out of the five rotifer species typical of mesotrophy (Karabin 1985a), at all three sampling stations in the Wigry Lake the same two species: *Chromogaster ovalis* and *Polyarthra major*, were present. On the other hand, out of the 10 species forming the group characteristic of high trophy (eutrophy), in the northern basin there occurred 5 species, and in the western basin – 3 species. As a result, the percentage of species being indicators of high trophy in the total biomass of the indicator species decreases from more than 30% at sampling stations 1 and 2 to 12% of station 3.

Table 3. Values of the epilimnetic indicators of the Wigry Lake trophy state, based on zooplankton structure (Aug. 1981)

Indicator		Sampling station			Values typical of mesotrophy
		1	2	3	
Percentage of species being indicators of high trophy in total biomass of the indicator species	Rotatoria community	34.3%	33.1%	12.2%	<10%
	Crustacea community	50.2%	32.3%	65.9%	<25%
Percentage of the "tecta" form in *Keratella cochlearis* biomass		19.2%	19.4%	2.2%	0–5%
Total numbers of zooplankton (indiv. $\cdot l^{-1}$)		2778	2257	1308	<400
Percentage of Cyclopidae in Crustacea biomass		29.9%	30.5%	27.8%	<15%
Ratio of Cyclopidae/Clodocera biomass		0.53	0.50	0.58	<0.2

Also in the case of the Crustacea the association characteristic of low trophy was scanty. Out of the six species forming this group, only two were present. In contrast, the group of organisms typical of high trophy was almost fully represented, since five of the six species of this community were found. Therefore, their participation in the total biomass of the indicator species is fairly high.

Comparison of the values of all six indices, concerning the three sampling stations, showed that: (1) with the exception of one case, they exceed (sometimes greatly) the values characteristic of mesotrophy; (2) the lowest values (i.e. those closest to mesotrophy) were obtained in the case of four indices at sampling station 3, and for two indices at station 2. Moreover, at station 3 the participation of the "tecta" form in the *K. cochlearis* population still remains within the range of the values typical of mesotrophy, and the percentage of the species being indicators of low trophy in the biomass of the Rotatoria indicator organisms only slightly exceeds these values; (3) the highest values, closest to eutrophy, were found with equal frequency at all three sampling stations.

3.4. MANY-YEARS' CHANGES IN WIGRY LAKE ZOOPLANKTON

Detailed studies of the species structure and numbers of the Crustacea in the western basin of the Wigry Lake (so-called Okuniowa Bay) have been carried out in years 1921 – 1922 (Adlerówna 1929); samples were taken with a plankton net (ca. 0.17-mm mesh) from the 0 – 20 m water layer (i.e. not to the bottom).

Despite the dissimilar method of sample collection, possibly influencing the quantitative (and partly the qualitative) data, it was resolved to compare the present species structure of the Crustacea with that described nearly 60 years ago. For maximal comparability of the results, the data obtained in 1981 were calculated for the 0 – 20 m layer; moreover, it was dispensed with comparison of the absolute numbers, limiting the analysis to the species composition and dominance structure. The only results compared were those concerning the summer stagnation period (28 Aug. 1922 and 18 Aug. 1981).

In both years under study 14 crustacean species (including 11 identical ones) were present in the lake. As compared with year 1922, in 1981 there were three more species: *Daphnia hyalina, Chydorus sphaericus* and *Mesocyclops crassus,* whereas the cladoceran *Bythotrephes longimanus* and two copepod species: *Eudiaptomus gracilis* and *Heterocope appendiculate,* disappeared (Fig. 4). This does not, however, mean that all these species have been eliminated from the environment. Only *B. longimanus* was never found in 1991, whereas both above-mentioned Calanoidae species occurred in the western basin in June. Doubtless, however, these species have been found in 1922 in greater numbers; moreover, according to Lityński (1925a) in summer they were present in all three basins of the lake.

Comparison of the species composition and dominance degree of three taxonomic groups of a higher order: Cladocera, Calanoida and Cyclopidae, showed that the "losses" of the Calanoidae were greatest. The number of their species was reduced by 50%, and the participation in total numbers decreased from more than 17% to less than 2% (Fig. 5). In contrast, during this period the importance of the Cyclopidae definitely increased. While in 1922 three species of this suborder have accounted for ca. 29% of the total numbers, in 1981 four species represented more than 42% of the Crustacea.

The cladoceran community showed the relatively smallest changes. Although the species composition displayed some changes, the importance of two dominant species (*D. cucullata* and *B. coregoni*) and of the whole order for the numbers of the Crustacea remained virtually unchanged. Thus, since this group of organisms was to a great extent decisive of the numbers of crustaceans in both years of studies, the value of the percentage similarity of community ixdex (Whittaker and Fairbanks 1958) (73.5%) was relatively high.

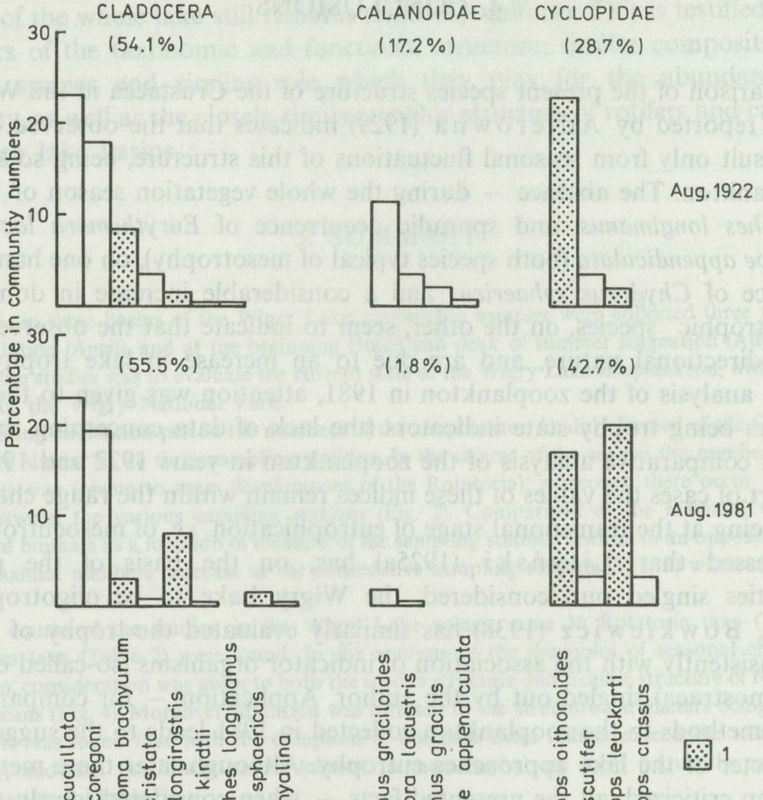

Fig. 5. Comparison of the species structure of the pelagic zone zooplankton (0–20 m) in years 1922 and 1981

1 – species being indicators of high trophy; in brackets – participation of the Cladocera, Calanoida and Cyclopidae in numbers of the community

In the comparison of the crustacean communities between both years of study, attention was directed also to the participation – in these communities – of species characteristic of low and high trophy. The number of species being indicators of mesotrophy decreased from 5 to 3, while the number of species typical of eutrophy rose from 4 to 5 (Fig. 4). There were, however, much greater differences between both these indicator species in their dominance degree in Crustacea numbers. Whereas the participation of the indicator association of low trophy dropped from 30.3% in 1922 to 23.9% in 1981, the participation of the association typical of high trophy increased, respectively, from 35.1% to 49.1%. As a result, the relationship between both these groups (expressed by the ratio of the numbers of the "mesotrophic" to the "eutrophic" group) decreased almost twice: from 0.86 to 0.48.

4. CONCLUSIONS

Comparison of the present species structure of the Crustacea in the Wigry Lake with that reported by Adlerówna (1929) indicates that the observed differences cannot result only from seasonal fluctuations of this structure, being so specific for the zooplankton. The absence – during the whole vegetation season of 1981 – of *Bythotrephes longimanus,* and sporadic occurrence of *Eurythemora lacustris* and *Heterocope appendiculata* (both species typical of mesotrophy), on one hand, and the appearance of *Chydorus sphaericus* and a considerable increase in dominance of other "eutrophic" species, on the other, seem to indicate that the observed changes are of a directional nature, and are due to an increase in lake trophy.

In the analysis of the zooplankton in 1981, attention was given to the structure parameters being trophy state indicators (the lack of data concerning the biomass prevented comparative analysis of the zooplankton in years 1922 and 1981). In the major part of cases the values of these indices remain within the range characteristic of lakes being at the transitional stage of eutrophication, i.e. of mesoeutrophic lakes. It is stressed that Lityński (1925a) has, on the basis of the planktonic communities singled out, considered, the Wigry Lake to be oligotrophic. Subsequently, Bowkiewicz (1938) has similarly evaluated the trophy of the Wigry Lake, consistently with the association of indicator organisms (so-called complex of the Entomostraca) singled out by the author. Application – for comparison – of the same methods to the zooplankton collected in 1981 leads to the suggestion that the character of the lake approaches eutrophy. Although later these methods have partly been criticized, all the presented facts – when considered jointly – confirm that in the Wigry Lake the zooplankton structure is remodelled by eutrophicating factors.

Moreover, it was found that the advancement of the eutrophication process fails to be similar in the three lake basins. According to the zooplankton structure parameters being of the nature of bioindicators, the northern basin (sampling station 1) is most eutrophicated, whereas the western basin (station 3) is still closest to mesotrophy. Zooplankton of the central basin (station 2) exhibits intermediate properties, though its structure is closer to that of the association populating the sampling station 3. Stronger eutrophication of the northern basin is mostly due to the fact that the Czarna Hańcza River flows into this part of the Wigry Lake. Namely, this river receives municipal sewage and waste waters from the city of Suwałki having several tens of thousands inhabitants. Owing to the location of the Czarna Hańcza River inflow and outflow in the same part of the Wigry Lake (in the presence of great differentiation of this lake), the effect of the pollution carried by the river is limited to the northern basin; furthermore, in the case of the northern basin the character of the watershed is mainly agricultural, and touristic traffic is most intensive. The remaining parts of the lake are eutrophicated by relatively slight point pollution from the few surrounding villages and by surface run-off; the watershed is of a predominantly woodland nature.

Finally, it is stressed that despite the earlier mentioned differences the zooplankton of the whole lake still remains relatively uniform. This is testified to by the parameters of the taxonomic and functional structure: similar composition of the dominant species and similar role which they play for the abundance of the community, as well as the closely similar trophic structure of rotifers and crustaceans in all three lake basins.

5. SUMMARY

In 1981, in three basins of the Wigry Lake zooplakton samples were collected three times: during spring circulation (April), and at the beginning (June) and peak of summer stagnation (August) (Fig. 1). The aim of the studies was to evaluate the current state of the Wigry Lake zooplankton, with reference to setting up of the Wigry National Park.

In the spring circulation period the numbers of the zooplankton (mainly formed of the Crustacea) are low and very similar at all three sampling stations. In the course of the season the numbers increase in a continuous way (owing to mass development of the Rotatoria); moreover, there occur differences in numbers between the various sampling stations (Fig. 2). Comparison of the maximal values of the numbers and biomass as a function of location of the sampling stations testifies to an opposed direction of changes: maximal numbers decrease at the consecutive sampling stations (1, 2, 3) whereas the biomass rises.

In the course of the studies, in the Wigry Lake pelagic zone 36 Rotatoria taxa (Table 1) and 22 Crustacea taxa (Table 2) were found. In the analysis of the dynamics of seasonal changes in the zooplankton, consideration was given to both the species structure and trophic structure of rotifers (Fig. 3) and crustaceans (Fig. 4). Moreover, attention was directed to the structure parameters being trophy state indicators. It was found that with the exception of one case these indices exceed the values typical of mesotrophy, and that the lowest values (closest to mesotrophy) are most frequently encountered at sampling station 3 (Table 3).

The present results concerning the Crustacea were compared with the data obtained for the Wigry Lake in 1922. In both years of studies, 14 crustacean species (including 11 identical ones) were found in the lake. The smallest changes were displayed by the Cladocera community for which neither the participation of the dominant species nor the percentage of the whole order in the numbers of the Crustacea underwent significant changes. In contrast, there was a definite increase in the numbers and dominance of the Cyclopidae, with a drop in the importance of the Calanoida (Fig. 5). Comparison of the associations of species characteristic of low and high trophy in both years of studies pointed to a drop in the number of species typical of mesotrophy (from 5 to 3) and to a decrease in the participation of this association in total numbers (from 30.3% to 23.0%), with a simultaneous rise of the number of species typical of eutrophy (from 4 to 5) and of their percentage in the community (from 35.1% to 49.1%).

Comparison of the present species structure with that described 60 years ago testifies to increasing lake trophy. However, the advancement of the eutrophication process is not identical in all three lake basins. The northern basin seems to be most eutrophicated; this is related to the fact that the Czarna Hańcza River, carrying a great amount of municipal sewage and industrial waste waters, flows into this basin.

6. POLISH SUMMARY

W roku 1981 trzykrotnie: w okresie cyrkulacji wiosennej (kwiecień), w początkowym (czerwiec) i szczytowym okresie (sierpień) stagnacji letniej pobrano próby zooplaktonu na trzech plosach jeziora

Wigry (rys. 1). Celem badań była ocena aktualnego stanu zooplanktonu jeziora w związku z utworzeniem Wigierskiego Parku Narodowego.

W okresie cyrkulacji wiosennej liczebność zooplanktonu (który tworzą głównie Crustacea) jest niska i bardzo podobna na wszystkich stanowiskach. W trakcie sezonu liczebność wzrasta w sposób ciągły (spowodowany masowym rozwojem Rotatoria), dochodzi też do zróżnicowania liczebności na poszczególnych stanowiskach (rys. 2). Porównanie maksymalnych wartości liczebności i biomasy w zależności od usytuowania stanowisk wskazuje na przeciwstawny kierunek zmian: maksymalna liczebność zmniejsza się na kolejnych stanowiskach (1, 2, 3), gdy biomasa wzrasta.

W trakcie prowadzonych badań stwierdzono w pelagialu jeziornym obecność 36 taksonów Rotatoria (tab. 1) i 22 taksonów Crustacea (tab. 2). Analizując dynamikę sezonowych zmian zooplanktonu uwzględniono zarówno strukturę gatunkową jak i troficzną wrotków (rys. 3) i skorupiaków (rys. 4). Zwrócono też uwagę na te parametry struktury, które mają charakter indykatorów stanu trofii. Stwierdzono, że za wyjątkiem jednego przypadku, wskaźniki te przekraczają wartości typowe dla mezotrofii oraz, że najniższe wartości (najbliższe mezotrofii) spotykano najczęściej na stanowisku 3 (tab. 3).

Wyniki dotyczące Crustacea porównano z wynikami badań prowadzonych na jeziorze Wigry w 1922 r. W obu latach stwierdzono obecność 14 gatunków, w tym tych samych — 11. Stosunkowo najmniejszym zmianom uległ zespół Cladocera, gdzie nie stwierdzono istotnych zmian zarówno w udziale gatunków dominujących jak i całego rzędu w liczebności Crustacea. Natomiast zdecydowanie wzrosła liczebność i dominacja Cyclopidae, przy spadku znaczenia Calanoida (rys. 5). Porównując zespoły gatunków charakterystycznych dla niskiej i wysokiej trofii w obu latach badań, stwierdzono spadek liczby gatunków typowych dla mezotrofii (z 5 do 3) i udziału tego zespołu w całkowitej liczebności (z 30,3% do 23,9%) przy jednoczesnym wzroście liczby gatunków typowych dla eutrofii (z 4 do 5) i ich udziału w zespole z (35,1% do 49,1%).

Porównanie obecnej struktury gatunkowej z opisaną przed 60-ciu laty wskazuje na wzrastającą trofię jeziora. Jednakże zaawansowanie procesu eutrofizacji nie jest na wszystkich plosach jeziora jednakowe. Najsilniej zeutrofizowane wydaje się być ploso północne, co należy wiązać z uchodzącą do tej części jeziora rzeką Czarna Hańcza, niosącą duże ilości zaniczyszczeń komunalnych i przemysłowych.

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