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Fertility of *Eudiaptomus*, *Bosmina* and *Daphnia* (Crustacea) Representatives in Lakes of Varied Trophic States in the Suwałki District

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Abstract

In the years 1996-1999 the authors studied fertility of females of seven zooplankton crustacean species of the genus *Eudiaptomus* (2 species), *Bosmina* (4) and *Daphnia* (1) in six lakes of various trophic states from oligotrophic (Lake Białe) to distrophic (Lake Konopniak and Lake Suchar Zachodni) in the Suwałki District. Water samples were collected every three months at the same sites to analyse 20 physico-chemical parameters. Chlorophyll *a* and *b* and carotenoids were evaluated as the food content indices in phytoplankton as a whole and separately in cells smaller than 50 μm.

The study has revealed that the highest female fertility in Copepoda representatives (genus *Eudiaptomus)* occurs in spring, while in Cladocera individuals (genus *Bosmina* and *Daphnia*) – in summer. Generally, both in Copepoda and Cladocera representatives the number of laid eggs increases and their size decreases with the rise in lake trophic state.

Keywords: zooplankton crustacean, fertility, chlorophyll, carotenoids, lake, hydrochemistry, trophic state.

Introduction

Plankton organisms constitute an unusually dynamic system, immediately reacting to the changes of short and long duration that occur in the aquatic environment [1]. Consequently, the occurrence of zooplankton groups and their fertility vary depending on the state of trophicity and pollution of a particular water reservoir [2]. Zooplankton representatives in reaction to environmental conditions and food abundance lay smaller or greater numbers of eggs.

The fertility of Calanoida representatives in natural conditions was described by [3-6], the fertility of Cyclopoida representatives by [7-10], and that of Cladocera representatives by [11-18].

We decided to investigate the fertility of zooplankton representatives in the lakes of basic limnologic types in the Suwałki District differing in a number of features, particularly in physico-chemical properties of water and in the content of phytoplankton, i.e. trophicity.

Material and Methods

The study was conducted in the years 1996-1999 using such plankton crustacean species as *Eudiaptomus gracilis* (G.O. Sars), *Eudiaptomus graciloides* (Lilleborg), *Bosmina berolinensis* (O.F. Müller), *Bosmina coregoni* (Baird), *Bosmina crassicornis* (O.F. Müller), *Bosmina longirostris* (O.F. Müller) and *Daphnia cucullata* (G.O. Sars), which turned out to be typical of the investigated lakes. The study included 6 lakes in the Suwałki District, with Lake Hańcza lying within the Suwałki Landscape

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Park, the remaining lakes being situated in Wigry National Park.

– Lake Białe called Wigierskie – about 300 years ago was part of Lake Wigry [19,20]. It covers an area of 100.2 ha; length 1,875 m and mean width 750 m. Maximum depth 34.0 m, mean depth 13.2 m. Like Lake Hańcza it resembles the oligotrophic type [21].
– Lake Hańcza – covers an area of 314.4 ha; Maximum depth 108.7 m; length 4,535 m and width 1,175 m; stony bed and poor lakeside flora. This reservoir approximates the oligotrophic type [22].
– Lake Wigry covers an area of 2,118 ha, has a well-developed coastal line of 72 km with numerous bays. Maximum length is 17.5 km, width 3.5 km; maximum depth 73.0 m (mean 15.8 m). Bottom relief is irregular, with a number of deep and shallow waters forming the so-called subaqueous mounds. Investigations were carried out in Słupiańska Bay, the largest bay of this lake, situated in its western part (48 ha, maximum depth 25 m). Wigry is a mesotrophic lake [23].
– Lake Leszczewek, like Lake Białe, used to be a bay in Lake Wigry [19]. Cultivated fields are its direct catchment, the lake being eutrophic. It covers an area of 21.0 ha, and is 1,000 long and 325.0 m wide, with maximum depth of 6.5 m (mean 3.6 m). There is an abundance of rushy plants which cover an area of 1.8 ha.
– Lake Konopniak – a typically distrophic lake, according to [24] included in the group of mid-forest, interior, mostly oval-shaped lakes called suchary. It covers an area of 21.0 ha; length – 230 m, width – 100.0 m, maximum depth 6.7 m (mean 3.1 m). It is surrounded by a floating layer of peat.
– Suchar Zachodni – like Lake Konopniak, is a distrophic type of reservoir of suchar nature. It covers an area of 1.2 ha; length – 195.0 m, width – 80.0 m, maximum depth – 2.3 m. (mean 1.1 m). It is surrounded by a floating layer of peat. Both in Lake Konopniak and in Suchar Zachodni the water is of tea-coloured due to the presence of humus substances [25].

Physico-chemical parameters of the water were assayed using the methods recommended by Greenberg *et al.* [26]. Water samples were collected from the epilimnion of the pelagic zone at a depth of about 0.5 m at the same site and time as the rest of the research material. Chlorophyll *a, b* and carotenoid contents as trophic state [27-29] were estimated in the whole seston and in the seston smaller than 50 µm. Six litres of water were collected from Lake Hańcza, 6 l from Lake Białe, 3 l from the Słupiańska Bay of lake Wigry, 2.5 l from Lake Leszczewek, 1 l from Lake Konopniak and 1 l from Suchar Zachodni. The water was filtered using Whatman GF/C filters, and the seston deposit was then placed in a mortar

Table 1. Range of data of physico-chemical factors of the water of the investigated lakes – in each lake samples were lokated at one site close to lake shore, distance 10-50 m, depth 0.5-1.0 m (range at values for all sampling terms).

Parameters	Lake					
	Białe	Hańcza	Wigry	Leszczewek	Konopniak	Suchar Zachodni
Temperature (^oC)	12.0-23.0	9.0-22.5	1.5-22.0	0.5-24.0	10.5-24.7	11.0-24.0
Transparency (m)	4.05-9.05	3.8-8.5	0.50-5.30	0.50-1.90	0.85-1.60	0.45-1.10
pH	6.96-8.09	6.97-8.30	7.04-8.48	7.0-8.21	4.5-5.8	5.2-6.9
O_2 (mg L^{-1})	6.8-12.2	7.6-12.6	7.2-12.6	7.2-12.2	4.4-11.6	7.6-14.4
BOD_5 (mg L^{-1})	1.2-5.2	1.2-5.0	1.2-5.0	3.8-7.4	1.0-4.8	2.0-6.8
COD (mg L^{-1})	4.20-6.80	4.0-7.0	4.20-13.20	5.10-17.82	10.1-21.3	22.57-29.70
CO_2 (mg L^{-1})	2.2-15.4	0.0-11.0	0.0-8.8	4.4-11.0	2.2-11.0	4.4-6.6
Alkalinity in $CaCO_3$ (mval L^{-1})	1.8-3.4	2.4-3.0	2.3-4.3	2.8-4.8	0.5-1.6	0.6-1.1
$N-NH_3$ (mg L^{-1})	0.050-0.280	0.100-0.310	0.007-0.470	0.100-0.890	0.44-1.27	1.05-1.78
$N-NO_2$ (mg L^{-1})	0.0-0.004	0.001-0.008	0.001-0.008	0.001-0.008	0.0-0.010	0.002-0.018
$N-NO_3$ (mg L^{-1})	0.010-0.035	0.0-0.105	0.0-0.045	0.025-0.150	0.010-0.160	0.030-0.240
$P-PO_4$ (mg L^{-1})	0.010-0.210	0.011-0.295	0.010-0.445	0.060-0.460	0.0-0.320	0.002-0.052
Sulphates (mg L^{-1})	7.40-41.96	5.00-51.02	13.03-29.00	14.81-24.27	4.94-53.90	6.99-16.96
Chlorides (mg L^{-1})	10.0-20.0	12.0-24.0	14.0-25.0	10.0-59.0	14.0-87.0	80.0-170.0
Total hardness (mg Ca L^{-1})	23.76-41.76	34.56-54.0	27.36-59.04	41.04-77.04	2.88-10.01	6.48-15.20
Total hardness (mg Mg L^{-1})	6.02-17.63	3.44-30.53	12.09-35.54	10.75-21.93	0.0-0.86	0.0-0.44
Fe (mg L^{-1})	0.0-0.25	0.0-0.42	0.0-0.30	0.01-0.60	0.01-0.52	0.05-0.11
Dry residue (mg L^{-1})	36.0-152.0	31.0-212.0	88.0-294.0	104.0-398.0	21.0-88.0	80.0-199.0
Dissolved solids (mg L^{-1})	32.0-127.0	29.0-164.0	59.0-260.0	66.0-336.0	2.0-82.0	8.0-81.0
Suspended solids (mg L^{-1})	7.0-179.0	4.0-69.0	25.0-60.0	5.0-62.0	1.0-37.0	12.0-169.0

Table 2. Chlorophyll *a* content in phytoplankton of the investigated lakes (in mg m^{-3}).

Lake	'96		'97			'98			'99		
	summer	autumn	spring	summer	autumn	spring	summer	autumn	winter	spring	summer
Białe	0.573	0.330	0.242 (0.103)*	0.741 (0.220)	0.160 (0.045)	0.034 (0.480)	0.243 (0.301)	0.133 (0.107)		0.105 (0.100)	0.404 (0.222)
Hańcza	0.688	0.585	0.415 (0.103)	0.968 (0.202)	0.795 (0.450)	1.802 (0.498)	2.690 (0.6030)	0.900 (0.150)		0.762 (0.132)	2.990 (0.770)
Wigry	1.187	1.029	6.660 (5.298)	7.652 (6.620)	1.736 (0.570)	5.183 (3.304)	2.890 (2.600)	2.800 (0.430)	1.930 (1.930)	0.750 (0.500)	2.372 (1.810)
Leszczewek	19.720	11.072	16.280 (9.370)	73.500 (51.500)	45.146 (24.088)	15.140 (10.900)	59.900 (28.890)	24.000 (5.100)	5.084 (0.096)	13.651 (6.799)	26.570 (11.657)
Konopniak	10.820	20.301	8.039 (2.410)	14.360 (5.100)	4.130 (13.127)	5.221 (4.574)	7.200 (6.260)	19.000 (3.200)		4.742 (0.684)	9.089 (5.296)
Suchar Zachodni	41.800	12.492	19.700	54.520 (1.670)	6.441 (3.505)	16.703 (9.652)	39.680 (3.530)	21.700 (8.000)		15.269 (0.458)	87.270 (7.103)

* in cells < 50 µm.

to be ground in 22.0 ml of cooled 80% acetone. Next, extinction was measured on a spectrophotometer three times in each sample at a wavelength of 665 nm (chlorophyll *a*), 649 nm (chlorophyll *b*) and 440 nm (carotenoids). Appropriate formulas [30] were used to calculate the concentration of these pigments expressed in mg m^{-3}.

Analysis of the crustacean fertility included the number of eggs, their size and the number of eggs per one fertile female (the smallest female with eggs was considered fertile). Therefore, 30-50 females of each crustacean species were studied. A commonly used method was applied to collect zooplankton from the pelagic zone at each site in the spring (May), summer (August) and in autumn (October) every year.

The data obtained were subjected to statistical analysis using the methods described in the monograph of [31].

Results

Results of hydrochemical analysis of the waters included in the study have been presented in Table 1. According to them Lake Białe and Lake Hańcza are the most deficient in biogenes and the most transparent. These and other hydrochemical parameters determine their oligotrophic nature. Lake Wigry can be classified as mesotrophic and Lake Leszczewek as eutrophic. Lake Konopniak and Suchar Zachodni are typically distrophic and show a low content of calcium and magnesium and great amounts of humus compounds.

The lowest values of chlorophyll and carotenoids, which are phytoplankton growth indices, were noted in Lake Białe and Lake Hańcza, the highest in the remaining three lakes (Table 2-4). Of the zooplankton species examined *Eudiaptomus graciloides* was observed in all the lakes except Lake Konopniak and Suchar Zachodni, and *Eudiaptomus gracilis* in all the lakes except Lake Białe and Leszczewek (Table 5). *Bosmina berolinensis* and *Bosmina crassicornis* were found in Lake Białe, Lake Hańcza and Lake Wigry and *Bosmina longirostris* in all the lakes included in the study except Suchar Zachodni. *Daphnia cucullata* was observed in all the lakes except Lake Konopniak. Data concerning fertility of particular zooplankton species in the lakes have been presented in Tables 6-9. The data reveal that Calanoidea females lay the largest number of eggs in the spring and the smallest number in the autumn. The higher trophicity of the harmonic-type lake, the larger numbers of eggs are laid every season of the year. Cladocera females lay the largest number of eggs in the summer and like in Calanoidea representatives, the higher trophicity of the harmonic lake is, the more eggs are laid. As shown in Table 10 in *Eudiaptomus graciloides, Bosmina longirostris* and *Daphnia cucullata* females, the more eggs are laid, the smaller size they are.

Discussion

The analysis of physico-chemical parameters of water, chlorophyll and carotenoid contents indicates that the lakes included in the study represent basic limnologic types: oligotrophic-like (Lake Białe and Hańcza), mesotrophic (lake Wigry), eutrophic (Lake Leszczewek) and distrophic (Lake Konopniak and Suchar Zachodni). The latter two belong to the so-called disharmonic lakes, the remaining being harmonic. The crustacean species studied can be divided into three groups according to the type of food they feed on [32].

Worthy of consideration is the fact revealed in the previous [6, 12] and in the present study that Copepoda females lay the maximum number of eggs in the spring, while Cladocera representatives in the summer. This may result from differences in the Copepoda and Cladocera species biology. In winter Copepoda representatives can be found in lakes mainly as copepoidal forms which feed

Table 3. Chlorophyll *b* content in phytoplankton of the investigated lakes (in mg m^{-3}).

Lake	’96		’97			’98			’99		
	summer	autumn	spring	summer	autumn	spring	summer	autumn	winter	spring	summer
Białe	0.474	0.307	0.228 (0.106)*	0.662 (0.460)	0.095 (0.071)	0.579 (0.086)	0.530 (0.430)	0.140 (0.022)		1.162 (0.105)	0.211 (0.106)
Hańcza	0.712	0.808	0.587 (0.061)	1.382 (0.238)	0.312 (0.103)	0.796 (0.179)	1.800 (0.260)	0.650 (0.095)		0.483 (0.109)	1.760 (0.560)
Wigry	1.050	0.973	3.465 (3.230)	7.640 (3.984)	0.857 (0.400)	2.015 (1.513)	1.980 (1.360)	1.500 (0.210)	1.830 (1.813)	0.430 (0.390)	1.678 (2.770)
Leszczewek	10.504	10.106	8.560 (5.240)	40.380 (6.290)	4.686 (2.501)	7.338 (3.595)	4.000 (3.980)	16.000 (3.800)	2.239 (1.830)	8.182 (3.447)	8.100 (6.007)
Konopniak	14.360	28.710	33.176 (2.920)	6.983 (4.524)	11.714 (2.388)	3.026 (2.538)	3.200 (3.000)	7.000 (1.200)		3.632 (0.714)	6.059 (4.480)
Suchar Zachodni	21.707	26.080	31.420	32.920 (2.824)	4.686 (0.189)	8.177 (4.019)	35.300 (2.730)	9.500 (4.400)		10.470 (0.338)	6.888 (1.678)

* in cells < 50 µm

Table 5. List of crustacean species found in investigated lakes.

Species	Lake					
	Białe	Hańcza	Wigry	Leszczewek	Konopniak	Suchar Zachodni
Cyclopoida						
Cyclops abbysorum (G.O. Sars)	x	x				
Cyclops scutifer (G.O. Sars)	x					
Cyclops strenuus (Fisher)			x			
Cyclops vicinus (Uljanin)		x				
Mesocyclops leuckarti (Claus)	x	x	x	x	x	
Mesocyclops oithonoides (G.O. Sars)	x	x	x			
Calanoida						
Eudiaptomus gracilis (G.O. Sars)		x	x		x	x
Eudiaptomus graciloides (Lillieborg)	x	x	x	x		
Eurytemora lacustris (Poppe)	x	x	x			
Heterocope appendiculata (G.O. Sars)	x		x			
Cladocera						
Daphnia cristata (G.O. Sars)	x	x	x			
Daphnia cucullata (G.O. Sars)	x	x	x	x		x
Daphnia hyalina (Leydig)		x	x			
Daphnia longiremis (G.O. Sars)	x	x	x			
Bosmina berolinensis (Imhof)	x	x	x			
Bosmina coregoni (Baird)	x	x				
Bosmina crassicornis (O.F. Müller)	x	x	x			
Bosmina longirostris (O.F. Müller)	x	x	x	x	x	
Bosmina obtusirostris (G.O. Sars)		x				
Diaphanosoma brachyurum (Liévin)			x	x		
Simocephalus vetulus (O.F. Müller)		x	x		x	
Scapholeberis mucronata (O.F. Müller)					x	x
Chydorus sphaericus (O.F. Müller)	x	x	x	x	x	x
Ceriodaphnia quadrangula (O.F. Müller)	x	x	x	x	x	
Alona quadrangularis (O.F. Müller)	x	x	x	x		
Alonella nana (Baird)					x	
Holopedium gibberum (Zaddachi)					x	
Graptoleberis testundinaria (G.O. Sars)					x	
Peracantha truncata (Baird)					x	
Leptodora kindtii (Focke)	x		x	x		
Polyphemus pediculus L.				x	x	
Number of species	18	20	20	10	12	4

Table 4. Carotenoids content in phytoplankton of the investigated lakes (in mg m^{-3}).

Lake	’96		’97			’98			’99		
	summer	autumn	spring	summer	autumn	spring	summer	autumn	winter	spring	summer
Białe	0.170	0.354	0.115 (0.096)*	0.267 (0.053)	0.041 (0.006)	0.194 (0.035)	0.490 (0.246)	0.007 (0.006)		0.617 (0.004)	0.187 (0.110)
Hańcza	0.755	0.340	0.006 (0.005)	0.880 (0.872)	0.444 (0.199)	1.039 (0.078)	0.770 (0.240)	1.017 (0.160)		0.283 (0.011)	0.930 (0.140)
Wigry	0.312	0.347	4.380 (1.030)	3.244 (0.184)	0.400 (0.045)	3.525 (1.398)	1.550 (0.530)	1.990 (0.570)	2.709 (0.770)	0.780 (0.330)	0.685 (0.270)
Leszczewek	5.721	10.118	9.910 (3.684)	34.980 (6.260)	4.857 (2.110)	3.857 (3.631)	3.960 (3.550)	13.000 (1.700)	2.405 (0.021)	3.891 (2.681)	10.500 (6.646)
Konopniak	12.711	10.301	3.520 (0.450)	13.930 (1.395)	5.199 (1.188)	2.135 (2.149)	3.890 (3.300)	14.000 (1.800)		1.391 (0.064)	4.847 (0.187)
Suchar Zachodni	9.617	8.220	4.500	9.280 (0.182)	4.857 (0.454)	7.085 (6.269)	1.190 (0.016)	3.400 (1.140)		5.523 (0.159)	2.867 (1.097)

* in cells < 50 µm

Table 6. Number of eggs in *Eudiaptomus graciloides* female from various lakes (mean per one fertile female).

Lake	’96		’97			’98			’99	
	summer	autumn	spring	summer	autumn	spring	summer	autumn	spring	summer
Białe	7.900	5.500	8.000	8.000	0.0	11.200	8.800	8.000	11.330	8.000
Hańcza	7.750	6.000	11.600	6.500	6.000	6.933	6.667	5.000	8.000	6.000
Wigry	12.000	6.670	13.500	9.617	8.250	13.670	12.000	10.000	13.140	10.000
Leszczewek				10.660	11.420	15.160	12.000	12.400	14.500	13.400

Table 7. Number of eggs in *Bosmina longirostris* female from various lakes (mean per one fertile female).

Lake	’96		’97			’98			’99	
	summer	autumn	spring	summer	autumn	spring	summer	autumn	spring	summer
Hańcza	2.700	1.000	2.000	2.904	1.070	1.000	2.710	1.500	1.666	2.686
Leszczewek	3.169	2.444	2.643	3.284	1.250	1.330	2.857	2.840	1.700	3.365
Konopniak	1.365	1.000	0.0	1.083	1.000	0.0	2.000	1.000	0.0	1.250

Table 8. Number of eggs in some species of crustacean from various lakes (mean per one fertile female).

Lake	’96		’97			’98			’99	
	summer	autumn	spring	summer	autumn	spring	summer	autumn	spring	summer
Bosmina berolinensis Lake Białe	1.460	1.000	1.000	1.330	1.000	1.000	1.250	1.000	0.0	1.330
Bosmina crassicornis Lake Hańcza	2.000	1.000	0.0	2.300	1.000	1.000	2.000	1.000	1.000	2.143
Bosmina crassicornis Lake Białe	1.460	1.000	1.000	1.330	1.000	1.000	1.250	1.000	0.0	1.335
Eudiaptomus gracilis Lake Suchar Zachodni			26.667	18.000	0.0	25.667	24.333	24.000	27.500	18.000

Table 9. Number of eggs in *Daphnia cucullata* female from various lakes (mean per one fertile female).

Lake	'96		'97			'98			'99	
	summer	autumn	spring	summer	autumn	spring	summer	autumn	spring	summer
Białe	1.500	1.000	1.000	1.375	1.000	1.000	1.500	1.000	0.0	1.400
Hańcza	1.285	1.000	1.000	1.364	1.300	1.000	1.125	1.333	1.000	1.273
Wigry	2.400	1.000	1.000	2.370	0.0	1.000	1.600	1.000	1.000	2.080
Leszczewek	2.095	1.000	1.000	3.110	1.000	1.000	2.619	1.000	1.000	2.500

Table 10. Body size (in mm), number (per one fertile female) and size eggs (in μm) in some species of crustacean from various lakes.

Specification	Lake					
	Białe	Hańcza	Wigry	Leszczewek	Konopniak	Suchar Zachodni
	Eudiaptomus graciloides					
Mean lenght of female Mean number of eggs Mean size of eggs	1.400 7.670 0.104	1.320 7.045 0.102	1.285 11.060 0.099	1.026 14.005 0.097		1.400* 16.517 0.098
	Bosmina longirostris					
Mean lenght of female Mean number of eggs Mean size of eggs	0.518** 1.370 0.170	0.510*** 1.340 0.159	0.490 1.926 0.140	0.391 2.488 0.116	0.450 0.870 0.130	
	Daphnia cucullata					
Mean lenght of female Mean number of eggs Mean size of eggs	1.360 1.111 0.205	1.408 1.168 0.210	1.210 1.445 0.189	1.150 2.940 0.168		

* *Eudiaptomus gracilis,* ** *Bosmina berolinensis,* *** *Bosmina crassicornis*

on diatoms found in abundance in lakes in the winter. Diatoms are rich in fat produced in the process of photosynthesis as a reserve substance and contain a relatively large number of carotenoids [33]. Therefore, winter plankton in lakes contains mainly Copepoda species which under a microscope show little reddish globules of fat with dissolved carotenoids [34]. In the spring, when Copepoda individuals become perfect and energetically rich, they are able to lay large amounts of eggs. The present study has revealed that the fertility of *Eudiaptomus graciloides* is largely conditioned by the seston content of carotenoids (Fig. 1), which indirectly reflects fat concentration. Cladocera representatives, however, are very rare in the winter plankton; due to phytoplankton green alga deficiency, food conditions are rather poor and thus after winter the energetic state of Cladocera species is less satisfactory than of Copepoda representatives. It is in the spring that the growth of green alga-rich phytoplankton [35] creates an appropriate food base for active filtrators, thus increasing fertility in the summer months. Cladocera representatives as filtrators prefer green algae of the so-called nanoplankton [36-37]. Moreover, copepoidal forms can feed on *Daphnia* representatives in the early spring [39].

Worth noting is the presence of *Eudiaptomus gracilis* (85.2-100% of the whole zooplankton; 2.79-76.0 specimens /l) in distrophic, disharmonic, mid-forest lake Suchar Zachodni. Its fertility was the highest of all the plankton crustaceans in this lake, reaching even 27 eggs per one female. During the whole period of the experi-

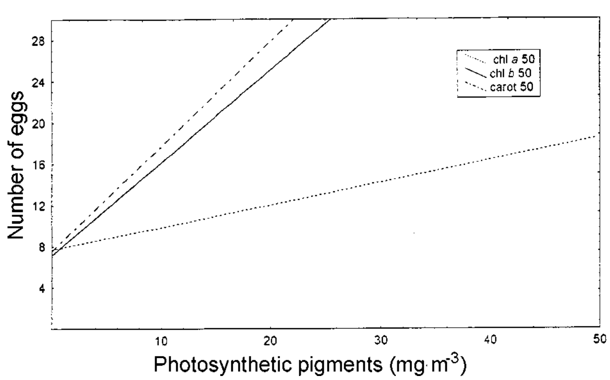

Fig. 1. Content of photosyntesising pigments (mg m^{-3}) in phytoplankton (< 50 μm) and the number of eggs (mean per one fertile female) in *Eudiaptomus* females (*gracilis* and *graciloides*).

ment the water was of acid nature, transparence seldom exceeded 1 m, there were high contents of humus compounds and ammonium nitrogen, high oxidability, and a low content of calcium and hardly detectable content of magnesium.

Chlorophyll and carotenoid contents in the water of Suchar Zachodni were similar to that of eutrophic Lake Leszczewek, indicating an intensive growth of phytoplankton as a substantial part of food for the species of the genus *Eudiaptomus* [40-42]. Being practically the only species forming zooplankton in this lake, with no food rivals, *Eudiaptomus gracilis* specimens have almost ideal food conditions; hence, high fertility of the females (Fig. 2). It should be noted that a small number of *Daphnia cucullata* specimens were observed in Suchar Zachodni, but no eggs were found. *Eudiaptomus gracilis* is an eurytopic species frequently encountered in clean Alpine lakes [43] and in polyhumus reservoirs of Lapland [44]. First of all, the food is to ensure the growth of a particular individual, and next egg laying. That was the case of *Daphnia cucullata* in Suchar Zachodni where females were sporadically observed during our four-year study, but none of them laid eggs. Probably, the phytoplankton there can only ensure the growth of the species individuals. It has been known [45] that *Dictyosphaerium pullhellum* is the predominant cryptomonad alga in the water of Suchar Zachodni. According to recent studies [46] Dinoflagellata, less available for the Cladocera than Calanoida representatives [47], predominate in disharmonic lakes. Moreover, representatives of the genus *Eudiaptomus* can break too long alga chains into smaller fragments [41, 48] and feed on them.

According to their development, the lakes included in this study belong to two groups : harmonic and disharmonic. The former includes Lakes Białe, Hańcza, Wigry and Leszczewek, the latter Lakes Konopniak and Suchar Zachodni. Chlorophyll content is lowest in Lake Białe, reaching maximum values in Lake Leszczewek and in the two disharmonic lakes. In harmonic lakes, crustacean

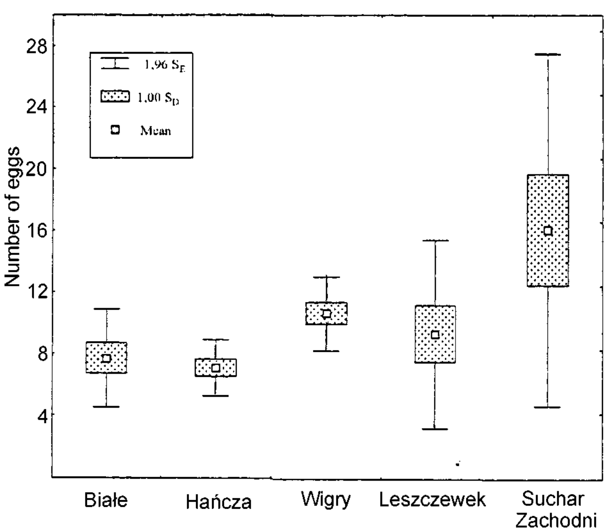

Fig. 2. The number of eggs (mean per one fertile female) in *Eudiaptomus* females (*gracilis* and *graciloides*) in lakes of various trophic state.

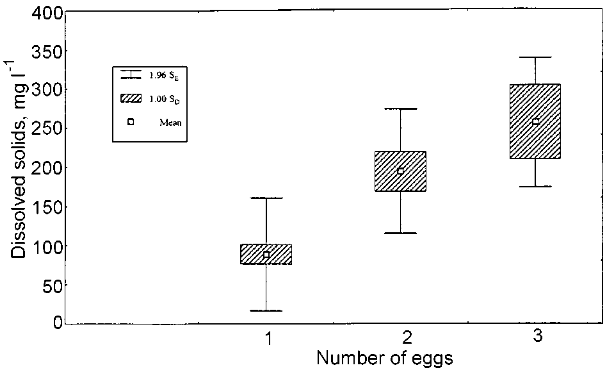

Fig. 3. The content of substance dissolved in water and the number of eggs (mean per one fertile female) in *Bosmina* females (*berolinensis, coregoni, crassicornis* and *longirostris*).

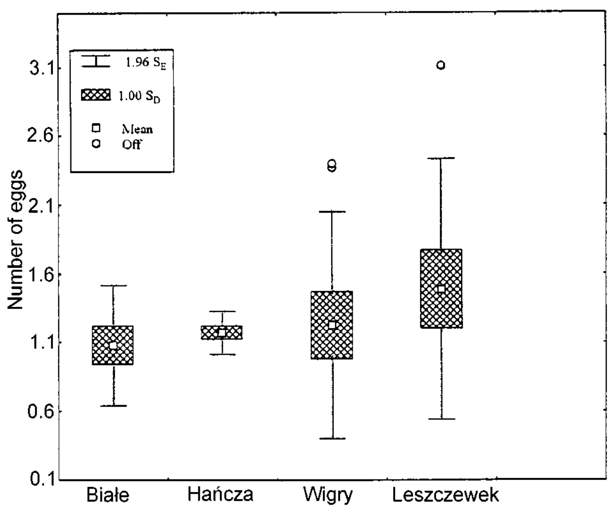

Fig. 4. The number of eggs (mean per one fertile female) in *Daphnia cucullata* females in lakes of various trophic states.

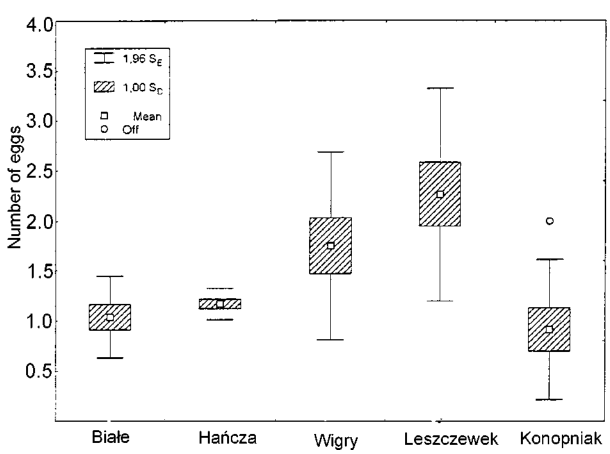

Fig. 5. The number of eggs in (mean per one fertile female) *Bosmina* females (*berolinensis, coregoni, crassicornis* and *longirostris*) in lakes of various trophic states.

species fertility increases with the increase in trophy (Fig. 3, 4). In disharmonic lakes, however, zooplankton fertility is different. In zooplankton the number of species is considerably reduced – only single *Daphnia cucullata* specimens were observed in Suchar Zachodni and females had no eggs. In Konopniak, *Bosmina longirostris* females laid the smallest number of eggs (Fig. 5). Of the Calanoida representatives *Eudiaptomus gracilis* was found to grow only in Suchar Zachodni.

The present study has revealed that the water of Suchar Zachodni and Konopniak is of acid nature, which badly affects the growth of bacterio- [49-51], phyto- [52] and zooplankton [44, 53, 54]. In acidified humus lakes, plankton populations usually contain one, two, and seldom a few species [55-58].

As shown in the present study, the fertility of plankton crustaceans of the genus *Eudiaptomus, Bosmina* and *Daphnia* depends on a number of environmental factors typical of particular water bodies, with the most significant role of the available food.

Using the method of similarities of the parameters examined (Fig. 6) we can see that the mean number of eggs in plankton crustacean females always approximates to one of a few indices of trophic states of particular water bodies.

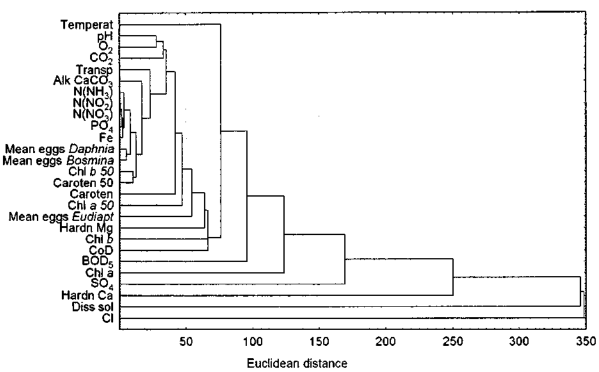

Fig. 6. Clustering according of water chemistry data and to number of eggs in investigated species.

This study has revealed that the highest female fertility in Copepoda representatives (genus *Eudiaptomus*) occurs in spring, while in Cladocera individuals (genus *Bosmina* and *Daphnia*) – in summer. Generally, both in Copepoda and Cladocera representatives the number of laid eggs increases and their size decreases with the rise in lake trophic state.

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