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Summer phytoplankton composition in 26 lakes of Łęczna-Włodawa Lakeland

Struktura letniego fitoplanktonu w 26 jeziorach Pojezierza Łęczyńsko-Włodawskiego

SUMMARY

Studies of summer phytoplankton composition were done in 26 deep and shallow, meso-, eu- and dystrophic lakes of Łęczna-Włodawa Lakeland. Studies were carried out in the 10-year period (1990–2000). The four lakes' groups were distinguished: group I dominated by *Cyanophyta* (mainly filamentous blue-green algae: *Limnothrix*, *Spirulina*), group II dominated by *Cryptophyceae* (dominant species *Cryptomonas* sp.), group IV with different composition of algal flora. The phytoplankton composition of lakes confirms their trophic character.

STRESZCZENIE

Badania nad strukturą letniego fitoplanktonu przeprowadzono w 26 płytkich i głębokich, mezo-, eu- i dystroficznych jeziorach Pojezierza Łęczyńsko-Włodawskiego. Badania prowadzono w latach 1990–2000. Wyróżniono cztery grupy jezior: grupa z dominującymi *Cyanophyta* (głównie sinice nitkowate: *Limnothrix*, *Spirulina*), grupa II z dominującymi *Cryptophyceae* (gatunki dominujące *Cryptomonas* sp.), grupa III z dominującymi *Chlorophyta* (gatunki z rzędu *Tetrasporales*), grupa IV o zróżnicowanej strukturze fitoplanktonu. Struktura fitoplanktonu na ogół potwierdzała typ troficzny jezior.

K e y w o r d s: lakes, summer phytoplankton, trophic status, lakes of Łęczna--Włodawa Lakeland.

INTRODUCTION

Phytoplankton plays an important role as a producer of organic matter in the natural lake systems. The quality and quantity of algal flora during vegetation season depends mainly on nutrients.

An assessment of lake's trophic status often takes into consideration summer phytoplankton and especially its structure of domination (dominant species and domination of higher taxa) (3, 14).

The first investigations of lake's phytoplankton in Łęczna-Włodawa Lakeland were conducted in the 1960s (16). In the beginning of the 1970s studies were extended and included quantity analyses (biomass, total number, concentration of chlorophyll-a and primary production of littoral) (1, 12, 13, 17).

The aim of the work described in this paper was presentation of the composition (quantitative and qualitative) of summer phytoplankton communities in 26 lakes situated in Łęczna-Włodawa Lakeland. Results are referred to phytoplankton in the shallow and deep lakes with different trophic status.

STUDY AREA AND METHODS

Quantitative and qualitative studies of phytoplankton were carried out in 26 lakes situated within Łęczna-Włodawa Lakeland (Fig. 1). Additionally basic physico-chemical parameters were determined (SD, conductivity, pH) for characteristic of phytoplankton life conditions (Table 1). The subject of investigations was phytoplankton of lakes in Polesie National Park (lakes: Moszne, Długie, Łukie) and their buffer zone (lakes: Zagłębocze, Rogóźno, Piaseczno, Bikcze, Uściwierz, Sumin, Nadrybie, Ciesacin).

The studies concerned also forest lakes located in Sobibór Landscape Park within the eastern part of Lakeland (lakes: Wspólne, Pereszpa, Koseniec, Brudno, Brudzieniec, Płotycze, Orchowe).

In north-western and western part of the Lakeland planktonic algal community were studied in lakes: Krasne, Czarne near Sosnowica, Głębokie near Uścimów, Kleszczów, Miejskie and Czarne Gościnieckie. The investigations took into account also one lake (Głębokie near Cyców) situated in the southern part of Lakeland.

The above-mentioned lakes belong to deep stratified water body as well as shallow nonstratified (Table 1). There were also different their trophic status. The part of lakes was characterized by mesoeutrophic and another by eutrophic. The lakes surrounding by peat bog were described as dystrophic or eutrophic-dystrophic (Table 1). Many of the studied lakes are natural reserves.

Sampling of phytoplankton was carried out in the summer (June-July) in the 10-year period (1990–2000).

Water samples were collected by the Ruttner-type water-sampler (2 dm^3 capacity). In deep stratified lakes water was taken from two zones (epilimnion, metalimnion) and poured into collective analysis. Phytoplankton of shallow lakes was sampled at 1 m depth. The subsample (200 ml) was taken for quantitative and qualitative analyses of phytoplankton.

The number of phytoplankton was determined with inverted microscope by the Utermöhl method (11).

Characterization of the phytoplankton took into account of its total abundance and structure in terms of the percentage shares of taxonomic groups and the dominant species. The domination was calculated both in the taxonomic group to which this dominant species belongs and in the total phytoplankton.

In statistical analysis cluster method were used (4) in which every lakes is individual object. Typical features for these objects are percentage shares of phytoplankton taxonomic groups. Based

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Tab. 1. Depth, trophy, physical and chemical parameters of the studied lakes. Own data and after Radwan and Kornijów (5, 6)

Lake	Depth max. [m][(6)]	Sd max. [m]	Conductivity [μS/cm]	pH	Trophy[(6)]
Piaseczno	38.8	2.5	202	7.8	mesotrophic
Krasne	34.0	2.0	253	8.9	mesotrophic
Rogóźno	25.4	4.3	250	8.5	mesotrophic
Zagłębocze	25.0	3.2	206	8.5	mesotrophic
Bialskie	18.2	1.8	333	8.8	mesotrophic
Czarne near Sosnowica	15.6	0.5	467	9.1	eutrophic-dystrophic
Brudno	2.0	0.25	256	9.7	eutrophic
Głębokie near Cyców	5.7	0.9[(5)]	–	6.6[(5)]	eutrophic
Pereszpa	6.2	1.4	154	7.4	eutrophic
Głębokie near Uścimów	7.1	0.8	192	8.6	eutrophic
Brudzieniec	6.2	0.5	177	7.5	eutrophic-dystrophic
Moszne	1.1	1 (to bottom)	180	8.5	dystrophic
Łukie	6.5	3 (to bottom)	210	8.5	eutrophic
Długie	1.3	1	464	8.3	dystrophic
Nadrybie	1.95	0.5 (to bottom)	120	8.6	eutrophic
Czarne Gościnieckie	3.25	0.9[(6)]	80[(6)]	–	dystrophic
Płotycze	7.8	1 (to bottom)	105	6.8	dystrophic
Orchowe	1.25	0.75	168	8.4	eutrophic
Miejskie	2.2	0.5	120[(6)]	–	eutrophic
Koseniec	4.2	1.1	264	7.9	eutrophic
Sumin	6.5	0.9	399	8.5	eutrophic
Uściwierz	6.6	1.5	289	8.2	eutrophic
Ciesacin	1.8	0.5 (to bottom)	150	8.2	eutrophic
Wspólne	2.25	0.6	284	8.0	eutrophic
Bikcze	3.3	1.7 (to bottom)	266	8.2	eutrophic
Kleszczów	2.35	2[(6)]	80[(6)]	–	eutrophic

on these features the most similar two objects were connected in one group (cluster). The same procedure were used in groups connections to higher complexes. Euclidean Distance as resemblance measure is the difference between percentage shares of one taxonomic group for two various objects. Because every object is characterized by some taxonomic groups euclidean distances were averaged (UPGMA). Classified groups are showed on dendrogram (Fig. 2).

RESULTS AND DISCUSSION

A. Quantitative and qualitative differentiation of summer phytoplankton

Phytoplankton of studied lakes was characterized by a high quantitative and qualitative differentiation (Table 2).

Tab. 2. Abundance of phytoplankton and percentage shares of dominant species in the studied lakes of Łęczna-Włodawa Lakeland

Lake	Total numbers of phytoplankton ($N \cdot 10^6$ dm^3)	Dominant species	Percentage shares of dominant species	
			in taxonomic group*	in total phytoplankton
1	2	3	4	5
		Group I		
Czarne near Sosnowica	11.0	*Limnothrix redekei*	100	99
Brudno	13.1	*Limnothrix redekei*	100	90
Krasne	8.1	*Limnothrix redekei*	72	71
Rogóźno	0.2	*Limnothrix limnetica*	83	68
Głębokie near Cyców	15.5	*Limnothrix limnetica*	100	64
		Cryptomonas sp.	100	23
Pereszpa	2.1	*Spirulina* sp.	63	37
		Lyngbya sp.	21	12
		Naviculaceae	100	24
Bialskie	0.8	*Aphanothece clathrata*	60	39
		Coenococcus planctonicus	37	11
Zagłębocze	1.2	*Aphanothece clathrata*	64	33
		Group II		
Głębokie near Uścimów	6.7	*Cryptomonas* sp.	100	63
		Scenedesmus quadricauda	34	11
Brudzieniec	11.1	*Cryptomonas* sp.	100	61
		Scenedesmus quadricauda	22	8
Moszne	0.4	*Cryptomonas* sp.	100	60
		Aphanothece clathrata	97	9
		Scenedesmus quadricauda	69	14
Łukie	1.0	*Cryptomonas* sp.	100	50
		Koliella sp.	81	33
Długie	0.7	*Cryptomonas* sp.	100	43
		Gymnodinium sp.	54	11
		Ceratium hirundinella	46	10
Nadrybie	0.2	*Cryptomonas* sp.	100	41
		Aphanothece clathrata	99	11
		Scenedesmus quadricauda	68	30
		Group III		
Czarne Gościnieckie	199.9	*Cosmarium succisum*	100	99
Płotycze	1.6	*Staurastrum gracile*	47	41
		Closterium acutum	44	38
		Aphanothece clathrata	84	10

Table 2 continued

1	2	3	4	5
Orchowe	1.1	*Tetraëdron minimum*	37	31
		Chlorococcum sp.	27	23
		Scenedesmus quadricauda	17	14
Miejskie	15.8	*Scenedesmus quadricauda*	34	26
		Aphanothece clathrata	38	8
Koseniec	2.2	*Scenedesmus disciformis*	19	11
		Dictyosphaerium pulchellum	17	9
		Scenedesmus quadricauda	14	8
		Crucigenia apiculata	14	8
Sumin	5.8	*Scenedesmus quadricauda*	24	13
		Tetraëdron minimum	23	12
		Cryptomonas sp.	100	24
Piaseczno	0.5	*Tetraëdron minimum*	30	15
		Chlorella vulgaris	22	11
		Chroococcus limneticus	73	14
		Cryptomonas sp.	100	26
		Group IV		
Uściwierz	1.1	*Aphanothece clathrata*	71	20
		Cryptomonas sp.	100	21
		Scenedesmus quadricauda	24	9
Ciesacin	3.8	*Microcystis incerta*	41	15
		Scenedesmus quadricauda	29	11
Wspólne	3.2	*Microcystis incerta*	75	25
		Cryptomonas sp.	100	26
		Cyclotella comta	100	21
		Pediastrum sp.	75	13
Bikcze	10.0	*Lyngbya* sp.	72	28
		Scenedesmus quadricauda	27	10
Kleszczów	12.8	*Ceratium hirundinella*	90	41
		Mallomonas sp.	100	21

* In taxonomic group to which this dominant species belongs.

Fifteen among twenty-six lakes have eutrophic character and considering summer phytoplankton abundance they can be divided into two groups:

— shallow, eutrophic lakes: Bikcze, Kleszczów, Miejskie, Brudno, Głębokie near Cyców with phytoplankton abundance usually $>10 \cdot 10^6$ indiv. per dm^3;

— shallow, eutrophic lakes with phytoplankton abundance from 1 to $7 \cdot 10^6$ indiv. per dm^3, e.g. Uściwierz, Głębokie near Uścimów, Koseniec, Sumin, Pereszpa, Ciesacin, Wspólne, Łukie and Orchowe.

The five lakes are deep, stratified reservoirs and characterized as mesotrophic. Total phytoplankton number of these lakes (except of Krasne) had low values ($0.2 \cdot 10^6$–$1.0 \cdot 10^6$ indiv. per dm^3).

Fig. 2. Dendrogram of the 26 studied lakes obtained with agglomerative hierarchical clustering procedure (with Euclidean Distance as a resemblance measure)

Eutrophic-dystrophic lakes (Brudzieniec and Czarne near Sosnowica) had phytoplankton abundance $1.1 \cdot 10^6$ indiv. per dm^3.

Phytoplankton of dystrophic lakes had the greatest quantitative differentiation (Moszne — $0.4 \cdot 10^6$ indiv/dm^3, Płotycze — $1.6 \cdot 10^6$ indiv/dm^3 and Czarne Gościnieckie — $200 \cdot 10^6$ indiv/dm^3). During single sampling in June of 1990 year the bloom of *Cosmarium succisum* was found in lake Czarne Gościnieckie.

In all lakes during vegetation season 165 species of planktonic algae were determined. In comparison with 60- and 70s (250 species) it can indicate that phytoplankton species diversity decreased (7). The highest phytoplankton richness was found in Ciesacin, Płotycze and Piaseczno lakes (62, 53 and 51 species respectively). The least species were in Czarne near Sosnowica — 6 and Krasne — 7. In the rest of the studied lakes the number of species were ranged from 15 to 38.

Fig. 3. Percentage shares of taxonomic groups in the total numbers of phytoplankton in the studied lakes of Łęczna-Włodawa Lakeland.

Group I — phytoplankton dominated by *Cyanophyta*, Group II — phytoplankton dominated by *Cryptophyceae*, Group III — phytoplankton dominated by *Chlorophyta*, Group IV — with different composition of phytoplankton

Summer phytoplankton of the studied lakes was dominated by species belonging to three systematic taxa: *Cyanophyta*, *Cryptophyceae* and *Chlorophyta* (Fig. 3). The others groups as *Dinophyceae*, *Euglenophyta*, *Chrysophyta* and *Bacillariophyceae* were represented usually by 2–3 species.

Green algae were in all lakes represented by the greatest number of species. The highest *Chlorophyta* phytoplankton richness (20–35 species) was found in Piaseczno, Płotycze, Ciesacin lakes and the most poor (about 5 species) in Czarne near Sosnowica, Krasne, Brudno. The next group considering species richness was *Cyanophyta* with 5–10 species in most of the studied lakes. The highest species richness in *Chlorophyta* and *Cyanophyta* groups was also observed at the beginning of 70s (7).

Dendrogram (Fig. 2) presents the division of lakes into four groups where similarities in phytoplankton composition were considered. The phytoplankton of the distinguished lakes was dominated by blue-green algae (group I), cryptophytes (group II), green algae (group III) or was composed of nondominated different taxonomic groups of algal flora (group IV).

Phytoplankton of the first group (within the 8 lakes) was constituted by blue-green algae between 51 and 99% (Fig. 3). The *Cyanophyta* domination occurred both in deep and shallow lakes, which had a meso- as well as eutrophic and eutrophic-dystrophic status. The dominant species were *Limnothrix redekei*, *L. limnetica*, *Spirulina* sp., *Lyngbya* sp., *Aphanothece clathrata* (Table 2).

In the group of six shallow lakes (mean depth does not exceed 3.5 meters) great percentage share (often above 50%) of the phytoplankton was taken by *Cryptophyceae* (group II, Fig. 3) with the *Cryptomonas* sp. as dominant. In these lakes very often also *Chlorophyta* (Fig. 3) had a high value of abundance (10–45%) with the dominant species *Scenedesmus quadricauda*.

Group III was made up of seven lakes in which significant share (50–99%) of the phytoplankton was taken by chlorophytes (Fig. 3). In the majority of the lakes, where a dominant role played *Chlorophyta*, the most frequent species were the small green algae such as: *Scenedesmus quadricauda*, *Tetraëdron minimum*, *Crucigenia apiculata*, *Dictyosphaerium pulchellum,* and also *Staurastrum gracile* and *Closterium acutum*. In the case of lake Czarne Gościnieckie the bloom of *Cosmarium succisum* have been appeared (Table 2). In this group there were also the deepest, mesotrophic Piaseczno Lake. In this lake green algae reached 50% of phytoplankton number. Only in Piaseczno Lake phytoplankton has been studied systematically from 1970s. Quantitative and qualitative structure of algae assemblage has remarkable changed over the past 30 years, taking into account also short periods of blue-green algae bloom (e.g. in 1989) (14).

Phytoplankton of five lakes was characterized by greatest diversity (group IV). In these water bodies 3–4 taxonomic groups codominated (Fig. 3). The most

frequent species were: *Microcystis incerta, Ceratium hirundinella*, *Cryptomonas* sp. and *Scenedesmus quadricauda* (Table 2).

Besides species belonging to three distinguished taxonomic groups, in phytoplankton of some lakes numerous species occurred, e.g.: in Długie lake *Gymnodinium* sp. — with 11% share in total phytoplankton, 21 % of the phytoplankton was taken by *Cyclotella comta* in Wspólne lake, in Kleszczów lake *Mallomonas* sp. dominated (21%), and small diatoms of *Naviculaceae* family in Pereszpa (Table 2).

B. Phytoplankton as lakes trophy indicator

One of the important and almost always taken into consideration parameter in lake ecosystems characterization, is abundance of phytoplankton and its structure mainly expressed in species domination. An assessment of the trophy level very often includes summer phytoplankton (3, 8).

The lakes of Łęczna-Włodawa Lakeland, in which phytoplankton were studied, are characterized as eutrophic (6) but the composition of algal flora indicates different level of eutrophication.

Fifteen among twenty-six lakes are shallow and eutrophic. Their high fertility confirmed quantity and quality of phytoplankton and low water transparency (most often <1 m) and high pH (>8).

The planktonic algae assemblage of these lakes were dominated by filamentous blue-green algae of *Limnothrix* and *Spirulina* genera, or chlorophytes from *Tetrasporales* ordo.

Filamentous cyanophytes (*Limnothrix redekei*, *L. limnetica*, *Spirulina* sp.) as well as chlorophytes (*Scenedesmus* sp., *Tetraëdron* sp., *Crucigenia* sp. and others) are described by many authors as typical of advanced eutrophy (8, 9, 10).

The five lakes are deep, stratified reservoirs and characterized as mesotrophic. For the last few years in Rogóźno and Krasne lakes during all vegetation season cyanophyte *Limnothrix limnetica* dominated and reached a great phytoplankton abundance, as early as from March (15). Long-term cyanophytes domination remaining may indicate the increasing fertility of mesotrophic lakes.

Quantity and quality of summer phytoplankton confirmed mesotrophic character of Piaseczno, Zagłębocze and Bialskie lakes.

Based on phytoplankton composition, pH and conductivity measurements explicit classification of Moszne, Długie, Płotycze and Czarne near Sosnowica lakes to dystrophic or eutrophic-dystrophic is controversial. The problems connected with classification of this trophic status lakes is handled by other authors (2). Physico-chemical features of water, phytoplankton composition and macrophytes seems to be asses these lakes as humic and eutrophic.

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