Phytoplankton of the Yasna Polyana Reservoir (Southeast Bulgaria)

Michaela Beshkova & Daniela Saiz†

Department of Hydrobiology, Institute of Zoology, Bulgarian Academy of Sciences,
1, Tsar Osvoboditel Blvd., 1000 Sofia, Bulgaria, e-mail: mbeshkova@zoology.bas.bg

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Abstract. Temporal changes in phytoplankton quality composition, structure, numbers and biomass were investigated at the warm monomictic Yasna Polyana Reservoir over a period of ten years (1979–1989). A total of 108 taxa were encountered. Green algae, followed by diatoms, were the richest in species, while in respect to biomass the main algal groups were diatoms and dinoflagellates. Community structure and dominant composition were low changeable throughout the period of study, with *Cyclotella* sp., *Peridinea* sp. and *Ceratium hirundinella* as the leading taxa. Phytoplankton numerical abundance ranged from 11.10^3 to 4296.10^3 ind. l^{-1} and biomass from 0.05–16.5 mg l^{-1}, respectively. In terms of the phytoplankton biomass, the reservoir was determined as oligomesotrophic and the phytoplankton was found to be phosphorus-limited. Certain differences have been observed in the structure of phytoplankton between the studied reservoir and the dimictic Bulgarian reservoirs.

Key words: diatoms, dinoflagellates, monomictic reservoir, phytoplankton

Introduction

The so far published data on the phytoplankton in the reservoirs in Bulgaria relate to different but mainly dimictic water basins with different altitude, morphometry, hydrology, and trophic state (Naidenow & Saiz 1977, 1987; Saiz 1977, 1981, 1987; Beshkova 1995, 1996; Beshkova & Botev 1994). However, there have been no detailed data on the phytoplankton in monomictic reservoirs in Bulgaria.

The Yasna Polyana Reservoir is a warm monomictic reservoir (winter holomixis) built for drinking water supply of the Bulgarian Black Sea Coast. Prior to its construction, Angelov (1968) published a forecast on hypothetical self-purification and its effect on water quality. The zooplankton and the physical and chemical conditions of the reservoir were investigated by Naidenow (1993). Some questions relating to the reservoir's self-purifying capacities were studied out by Kalchev & al. (2001) and Kalchev & Botev (2005). However, data on the phytoplankton, which is an important component of the reservoir ecosystem and contributor to its biotic processes, are very scanty and relate only to the dominant species during the period 1980–1981 (Naidenow & Saiz 1987).

The present work is the first detailed investigation into the phytoplankton community structure of a warm monomictic reservoir in Bulgaria. The aim of the paper is to study the composition, structure, numerical abundance and biomass of the phytoplankton in the Yasna Polyana Reservoir over a ten-year period (1979–1989) and to examine the relationship between the phytoplankton biomass and some major environmental factors (water temperature, ionic forms of nitrogen and phosphorus, N:P ratio and zooplankton biomass), as well as to compare the phytoplankton structure and dynamics with those of the dimictic Bulgarian reservoirs.

Material and methods

Table 1. Characteristics of Yasna Polyana Reservoir: *data from Naidenow 1993); **data from Kalchev & al. 2001; * data from Kalchev & Botev 2005.**

Characteristic	Value
Location	Southeast Bulgaria
Geographic position	43°16′ N, 27°40′ E
Elevation, m a.s.l**	93
Mixing, season**	Winter-Spring
Maximal thermal stratification period**	September–October
Purpose	drinking water supply
Maximum volume, m^{3*}	42.693.10^6
Surface area, km^{2*}	2,618.10^6
Maximum depth, m**	43
Water catchment area, km^{2**}	50,8. 10^6
Temperature, °C, mean, (max.value, month)*	26,5, (July 1982)
Secchi disc, m (monts with max.value)*	0,5–5,2 (June, July)
pH, range*	7,2–8,4
Alkalinity, mg equv., month average *	2,05–3,09
PO_4 -P mgl^{-1}, weighted average***	0,019
N inorganic, mgl^{-1}, weighted average***	0,302
N.P^{-1} , rel.units, weighted average***	35

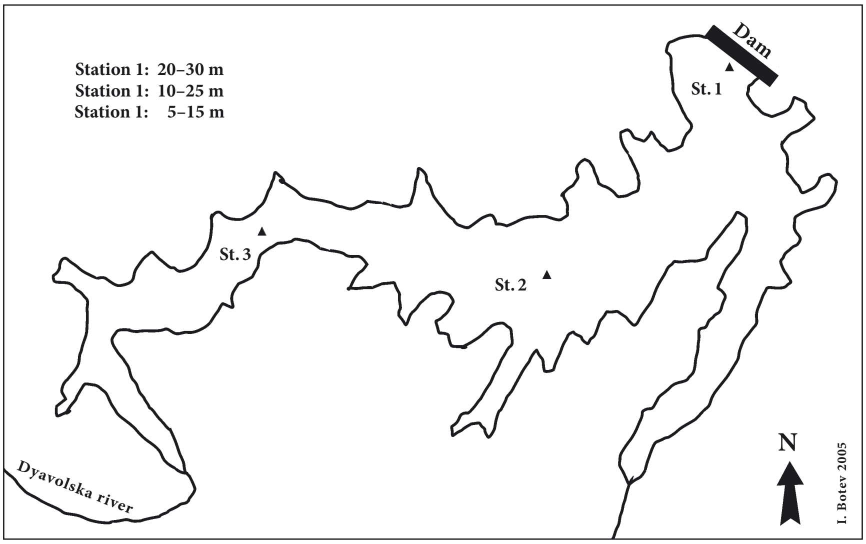

Fig. 1. Scheme of the reservoir with location of the sampling sites.

The main characteristics of the reservoir are given in Table 1. The scheme of the reservoir with location of the sampling sites (stations) is presented in Fig.1. Samples were taken on the following dates: 09.08.1979, 15.10.1979, 22.04.1980, from station 1 and on 25.06.1980, 17.03.1981, 16.06.1981, 05.09.1981, 06.05.1982, 06.07.1982, 08.10.1982, 11.06.1983, 23.09.1983, 05.07.1984, 05.05.1985, 25.06.1987, 05.09.1988, and 24.04.1989 from all three stations. The qualitative samples were taken with plankton net from the surface, while the quantitative ones (0.5 l in volume) were collected by bathometer, at in-depth intervals of 5 m from surface to bottom. The samples were preserved in formaldehyde to 4 % final concentration. They were identified on a normal light microscope and the algae were counted on an inverted microscope, in a hemocyitometer type of chamber. The numerical abundance was expressed in individuals (cells, colonies, filaments) per litre. The biovolume was calculated by formulas of corresponding geometric shapes (Rott, 1981), after measuring the individual dimensions and converting them into weight units, at assumed specific gravity of 1.00 g cm^{-1}. The biomass was obtained from individual numerical abundance and biovolume. The pattern of phytoplankton structure was evaluated on the basis of the percentage share of distinct algal groups in the total biomass. Dominants were the species whose share of the total biomass was distinctly higher than that of the remaining species and which formed together over 80 % of the biomass were accepted as dominants. The threshold was about 10 %. Frequency of occurrence (pF) was calculated after De Vries (1937), as a percentage share of the samples in which a given species was identified from the total number of samples taken from a given habitat. The degree of dominance (Dt) was estimated after Kozhova (1970). It presented the percentage share of samples where a given species is dominant from the total number of samples in which this species occurs. The species with high values in both indices were accepted as characteristic for the phytoplankton community. This means that they occurred often and mostly dominated. Using Spearman's rank correlation test, the phytoplankton biomass was correlated with water temperature, the ionic forms of nitrogen (NH_4-N, NO_3-N, TN) and phosphorous (PO_4-P), the ratio between them (N:P ratio), and the zooplankton biomass. The values of chemical variables were obtained from the original data by averaging the data from 0 m, 5 m and 10 m in the three sampling sites at each sampling visit (a total of 41 values). The data on zooplankton biomass (averaged from all stations and depths at each sampling date) were taken from the publication of Naidenow (1993).

Results

Phytoplankton quality composition and dominant structure

A total of 1 08 taxa were encountered during the period of study, of which *Cyanoprokaryota* with 12, *Euglenophyta* – 11, *Pyrrhophyta* – 4, *Chrysophyta* – 5, *Bacillariophyta* – 36, *Cryptophyta* – 1, and *Chlorophyta* – 39 (Table 2). The taxa found in the quantitative samples (marked with asterisk) accounted for 65 % of all taxa listed in the Table. The number of species observed during a single sampling visit counted 23 on the average (minimum 10 in April 1980, maximum 43 in July 1982). Of these, *Bacillariophyta* held the first place, followed by *Chlorophyta*. The other algal groups were usually presented by only 1 to 3 species in the samples.

As it is shown in Table 2, there were few perennial taxa (almost throughout the entire period of study). However, many of them (in bold) were among the dominants (during distinct months, sampling stations or depths).

From all taxa, we have separated only those combining a high degree of occurrence and dominance (high values of pF and Dt). Thus we discovered *Cyclotella* sp. (pF = 79, Dt = 47), *Fragilaria ulna* var. *acus* (pF = 62, Dt = 66), *Peridinea* sp (pF = 63, Dt = 14), *Ceratium hirundinella* (pF = 25, Dt = 80), *Dinobryon sociale* (pF = 23, Dt = 30), *Aulacoseira granulata* (pF = 24,Dt = 42), *Asterionella formosa* (pF = 70, Dt = 10), and *Trachelomonas volvocina* (pF = 66, Dt = 11) as most significant in the phytoplankton community. Of these, *Cyclotella* sp. (34), *Peridinea* sp. (22) and *Ceratium hirundinella* (20) usually held the lead in biomass (in percentage), thus qualifying as most characteristic for the phytoplankton community.

Table 2. List of taxa and their temporal distribution (*quantitatively significant taxa, bold – dominants).

Taxa	Spring					Summer								Autumn		
	1980	1981	1982	1985	1989	1979	1980	1981	1982	1983	1984	1987	1988	1979	1982	1983
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Cyanoprokaryota																
Anabaena affinis Lemmerm.													+			
A. sheremetievi Elenkin*		+					+	+	+	+	+	+			+	+
Anabaena sp.			+						+				+			
Aphanizomenon elenkinii Kisselev*								+					+		+	
Aph. flos-aquae (L.) Ralfs*			+			+			+				+			+
Merismopedia tennuissima Lemmerm.			+						+							
Microcystis aeruginosa Kütz. emend. Elenkin*			+		+				+		+					
Oscillatoria limosa C. Agardh*								+	+							+
Oscillatoria sp.*								+								
Phormidium ambiguum Gomont*								+	+							
Ph.naveanum Grunov*								+								
Phormidium sp.								+								
Euglenophyta																
Colacium vesiculosum Ehrenb.								+								
Euglena acus Ehrenb.										+					+	
E. polymorpha P.A. Dang.					+											
E. spirogyra Ehrenb.														+		
Euglena sp.*			+						+				+			
Phacus acuminatus Stokes*							+	+	+			+				
Ph. caudatus Huebner								+								
Trachelomonas armata (Ehrenb.) Stein*									+							
T. hispida (Perty) Stein*			+					+	+			+	+		+	+
T. hispida var. *coronata* Lemmerm.									+							

Table 2. Continuation.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
T. volvocina Ehrenb.*	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+
Pyrrhophyta																
Ceratium hirundinella (O.F. Müller) Bergh*			+			+	+	+	+	+	+	+	+		+	+
Glenodinium quadriens (Stein) Schill.																
Gymnodinium paradoxum Schill.*										+						
Peridinea sp.*	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+
Chrysophyta																
Chromulina sp.*									+							
Dinobryon divergens Imhof*			+			+		+	+		+	+	+	+		+
D. sertularia Ehrenb.*								+						+		
D. sociale Ehrenb.*			+		+	+	+	+	+	+			+			+
Mallomonas sp.*								+	+		+				+	
Bacillariophyta																
Achnanthes lanceolata (Bréb.) Grunov*								+								+
Amphora ovalis Kütz.*				+				+	+	+		+			+	
Asterionella formosa Hassall*	+	+	+	+	+		+	+	+	+	+	+		+	+	
Aulacoseira granulata (Ehrenb.) Simonsen*	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+
A. granulata var. *angustissima* (O. Müller)* Simonsen				+				+			+	+			+	
A. islandica (O. Müller) Simonsen*	+	+				+	+	+	+			+	+	+	+	
A. italica (Ehrenb. Simonsen																
Cocconeis placentula Ehrenb.*			+					+	+							
*Cyclotella radiosa** (Grunov) Lemmerm.					+								+			
Cyclotella sp.*	+	+	+	+		+	+	+	+	+	+	+			+	+
Cymatopleura solea (Bréb.) W. Smith*			+					+			+					
Cymbella sp.*		+						+								+
Diatoma vulgaris Bory*		+	+					+	+	+	+		+			
Epithemia zebra (Ehrenb.) Kütz.	+	+														
Fragilaria arcus var. *arcus* (Ehrenb.) Cleve*	+	+	+		+		+	+	+	+	+	+		+		+
F. crotonensis Kitton*				+				+			+	+	+			+
F. pinnata Ehrenb.*									+							
F. ulna (Nitzsch) Lange-Bert.*	+	+	+	+	+			+	+		+		+			+
F. ulna* var. *acus (Kütz.) Lange-Bert.*	+	+	+	+	+			+		+	+	+	+	+	+	
Gomphonema acuminatum Ehrenb.*		+		+			+	+	+	+	+	+			+	+
G. constrictum Ehrenb.*								+								+
G. olivaceum (Lyngb.) Kütz.*								+					+			
Gyrosigma acuminatum (Kütz.) Rabenh.*		+	+					+								
Melosira varians C. Agardh*						+				+						
Meridion circulare (Grev.) C. Agardh			+					+								
Navicula sp.*		+	+	+		+	+	+	+		+	+	+			
Nitzshia acicularis W. Smith							+			+	+				+	+
N. sigmoidea (Nizsch) W. Smith*								+		+		+	+			+
Nitzshia sp.*								+								
Pinnularia sp.*			+	+												
Rhizosolenia eriensis H. L. Smith													+			
Rhoicosphenia curvata (Kütz.) Grunov*		+							+							
Rhopalodia gibba (Ehrenb.) O. Müller*								+	+	+						
Stephanodiscus hanthshii Grunov*							+							+	+	
Surirella elegans Ehrenb.*			+					+								
Tabellaria floculosa (Roth) Kütz.*									+		+	+				
Cryptophyta																
Cryptomonas sp.*		+		+	+					+	+					+

Table 2. Continuation.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Chlorophyta																
Actinastrum hantzshii Lagerh.*								+			+					
Ankistrodesmus longissimus (Lemmerm.) Wille													+	+		
Botriococcus braunii Kütz.	+															
Carteria globosa Korschik.										+						
Chlorococcales														+		
Closterium acerosum (Schrank) Ehrenb.								+								
Closterium aciculare T. West								+					+			
C. moniliferum (Bory) Ehrenb. ex Ralfs								+								
Closterium venus Kütz. ex Ralfs	+															
Coelastrum microporum Nägeli*										+					+	
Cosmarium sp.													+			
Crucigenia quadrata Morren								+	+						+	
C.tetrapedia (Kirchn.) W. & G.S. West*		+														
Dictyospaerium pulhellum Wood*			+										+			
Eudorina elegans Ehrenb.*										+	+					
Gloeotila sp.*					+								+			
Golenkinia radiata Chodat									+							
Gonatozygon monotaenium de Bary								+								
Gonium pectorale O.F. Müller*													+			
*Lambertia judayi** (G.M. Smith) Korschik.								+	+					+		
Monoraphidium arcuatum (Korschik.) Hindák								+								
Mougeotia sp. **st***.	+						+	+						+		
Pandorina morum (O.F. Müller) Bory*			+	+				+	+	+	+				+	
Pediastrum boryanum (Turpin) Menegh.*			+	+				+							+	
P. duplex Meyen*				+												
Phacotus lenticularis (Ehrenb.) Stein*											+		+			
Scenedesmus acuminatus (Lagerh.) Chodat*		+						+				+				
S. acuminatus var. *biseriatus* Reinsch			+													
S. acutiformis Schröder*		+							+							
S. arcuatus var. *platydiscus* G.M. Smith				+												
S. bijugatus Kütz.*	+														+	
S. communis E.H. Hegew.		+	+	+	+		+		+			+			+	
S. opoliensis P.G. Richt.															+	
Spirogyra sp. st*.								+	+		+					
Staurastrum gracile Ralfs*			+		+			+				+				
Tetraedron minimum (A. Braun) Hansg.*			+				+	+	+	+		+	+	+	+	
Treubaria schmidlei (Schröd.) Fott & Kováčik								+								
Zygnema sp.									+							

Numbers and biomass

The dynamics of phytoplankton numerical abundance and biomass is shown in Figs 2, 3. The numbers ranged from 11.10^3 to $4296.10^3 l^{-1}$ throughout the period of study (geometrical mean = 119.10^3 ind. l^{-1}). The biomass range was 0.05–16.5 mg l^{-1} (geometrical mean = 0.69 mg l^{-1}). The highest values of the phytoplankton numerical abundance were registered in May 1985 and in September 1988 (Fig. 2). Comparing only the summer months of different years, a tendency of certain rise in phytoplankton numbers from 1980 to 1988 was discovered. No such tendency was registered in respect to the biomass (Fig. 3). The phytoplankton biomass showed two significant correlations: a negative, with NH_4-N (Rs = -0,44, P = 0,004, n = 41), and a positive, with PO_4-P (Rs = -0,34, P = 0,03, n = 41).

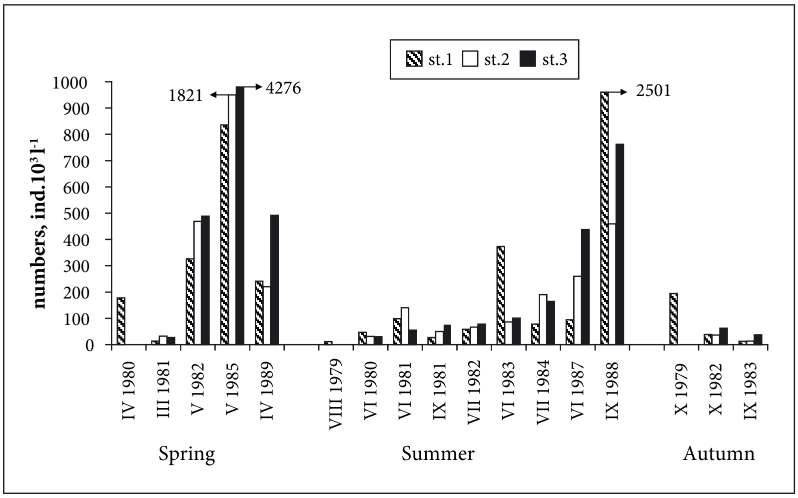

Fig. 2. Seasonal and annual changes of the phytoplankton numerical abundance during the study period.

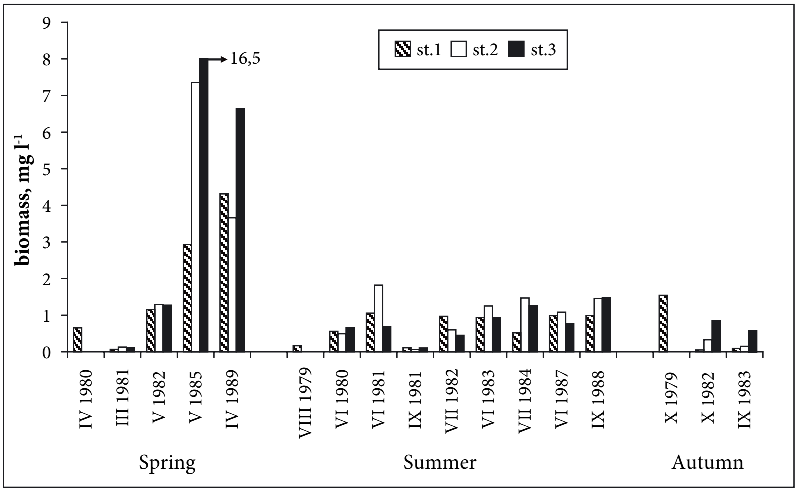

Fig. 3. Seasonal and annual changes of the total phytoplankton biomass during the study period.

Dynamics of the phytoplankton structure and the dominant species

The pattern of the phytoplankton temporal and spatial distribution is shown in Fig 4. In spring, phytoplankton was dominated mainly by diatoms. In 1980 and 1981, *Cyclotella* sp. claimed the greatest share of the total biomass and co-dominated with *Mougeotia* sp. (Station 1, 25 m) and *Peridinea* sp., respectively. *Anabaena* sp. also appeared at a depth of 10 m, with 23.5 % share of the total biomass. In May 1982, *Cyclotella* sp. again dominated the phytoplankton community but other diatoms, namely *Asterionella formosa, F. ulna* var *acus, Gyrosigma acuminatum* and *Surirella elegans*, also contributed to the dominant complex at different depths. *Peridinea* sp. and *Microcystis aeruginosa* (station 1, 5 m) were also abundant in the upper layers. In May 1985, at surface water temperature of 15 °C, *Fragilaria ulna* var. *acus* replaced *Cyclotella* sp. as the leading dominant, but *Cyclotella* sp. remained as a co-dominant, mainly in the deeper layers, together with *Aulacoseira granulata*. In April 1989, at surface water temperature of 17 °C, the dominant assemblage consisted of *Peridinea* sp. (dominant), *Dinobryon sociale* (codominant) in the surface layer and *Asterionella formosa,* whose share increased below a depth of 15 m. *Microcystis aeruginosa* appeared again (with 23 % share of the total biomass) only at 5 m to 10 m at Station 1.

The summer phytoplankton assemblages were composed mostly of dinoflagellates (*Peridinea* sp. and/or *Ceratium hirundinella*) in the epilimnion and of diatoms in the deeper layers. Other taxonomical groups were more poorly represented (Fig. 4). *Chlorophyta* was represented by *Mougeotia* sp., which developed in June 1980 at the deepest station; *Tetraedron minimum* emerged in September 1981 (and was better developed in the shallower stations); and *Gleotila* sp. dominated the phytoplankton in September 1988 and was not encountered before. Obviously, this was a new species for the phytoplankton community. *Chrysophyta* were represented mostly by *Dinobryon sociale* (June 1981 and 1983) and *Mallomonas* sp. (September 1981). *Trachelomonas volvocina* represented *Euglenophyta* and dominated in July 1982 and June 1983, mainly at the shallower part of the reservoir (Stations 2 and 3). *Cyanoprokaryota* were better represented in September (1981, 1988) by *Anabaena sheremetievi*. This species also preferred the shallower part of the reservoir. The diatoms represented in the summer phytoplankton were: *Cyclotella* sp. (occurred during all studied summer months), *Asterionella formosa* (mainly in June 1981), *Aulacoseira granulata* (predominantly in July 1984 and June 1987), *Aulacoseira islandica* (only in June 1980 at Station 1), *Fragilaria ulna* var. *acus*, and *Gyrosigma acuminatus* (July 1982).

In September the phytoplankton community contained more algal groups (Fig. 4) and the dominant complex changed from monodominant in the upper layers to polydominant, with contribution of different diatom species in-depth.

In autumn (September 1983, October 1982) phytoplankton was more heterogeneous. The horizontal heterogeneity was better expressed in October, when phytoplankton was completely dominated by dinoflagellates at Stations 2 and 3, and by diatoms (*Cyclotella* sp., *Fragilaria ulna* var. *acus* and *Aulacoseira granulata*) at Station 1. At that station *Tetraedron minimum* also contributed significantly to the biomass within the 0–10 m water column.

Discussion

The warm monomictic Yasna Polyana Reservoir differs from the dimictic Bulgarian reservoirs by only one complete mixing of the water column in winter and, respectively, by longer thermal stratification (nine months). This hydrological characteristic is coupled with very poor nutrient contents (Naidenow 1993). Phytoplankton reaches the maximum biomass in spring, in contrast to most dimictic lowland reservoirs, which exhibit one summer maximum, regardless of their trophic state. The long period of stratification additionally enhances the effect of low nutrients and the total biomass does not exceed $2\,mg\,l^{-1}$ (except in May 1982 and 1989). This usually indicates an oligomesotrophic state by Likens (1975). Under such conditions the phytoplankton is phosphorous-limited, which is confirmed by the positive correlation between the phytoplankton biomass and PO_4-P. The negative correlation found between the phytoplankton biomass and ammonium nitrogen can be attributed to the consumption of nitrogen by the phytoplankton.

In the Yasna Polyana Reservoir, as in most reservoirs, the major groups relat-

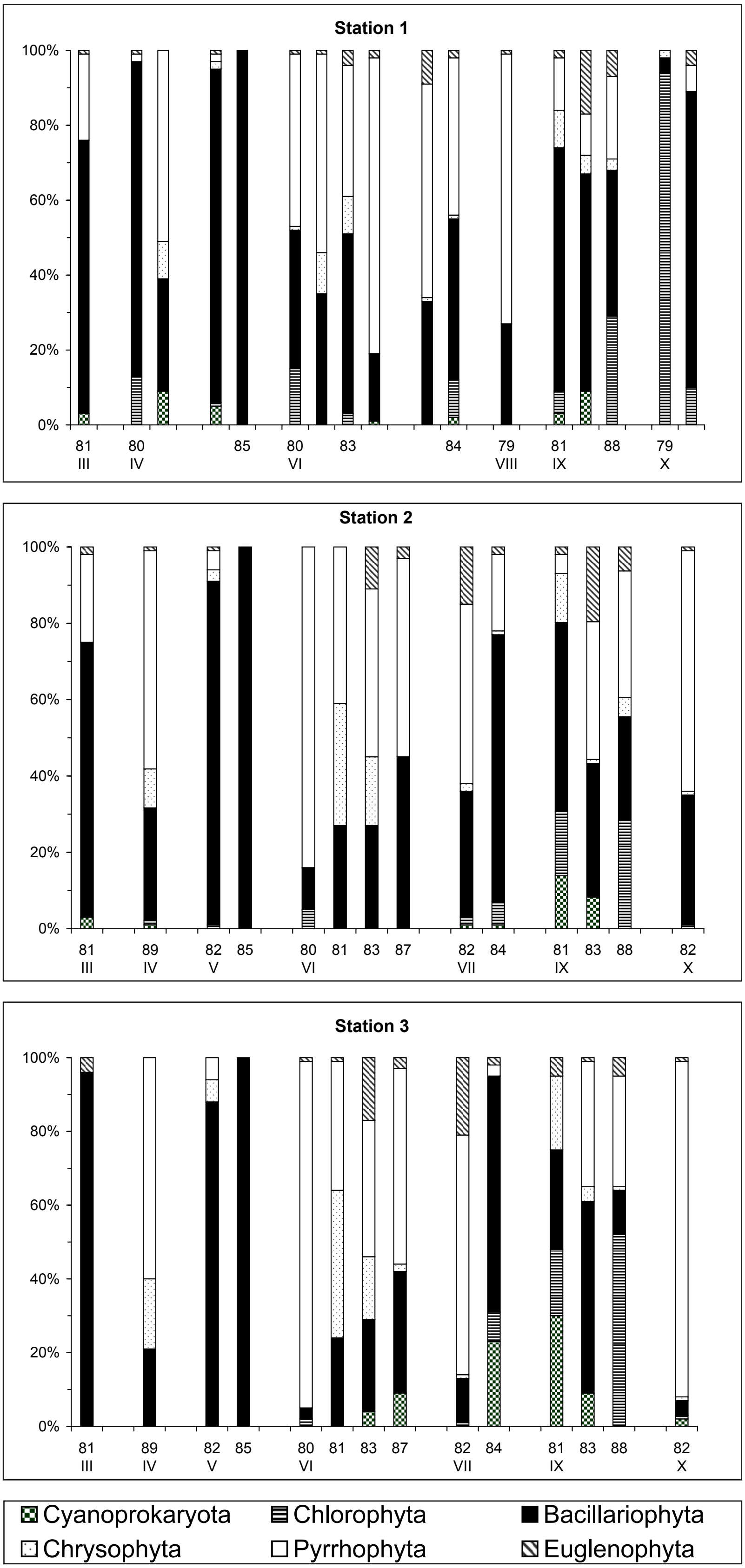

Fig. 4. Proportions of different taxonomic groups in the total biomass during different sampling months and years.

ed to species richness are diatoms and green algae (Table 2). However, the situation differs on the level of phytoplankton quantitative structure. Generally, the seasonal character of phytoplankton in the dimictic Bulgarian reservoirs depends to a great extent on their altitude. Thus, phytoplankton in the reservoirs at medium mountain altitudes is dominated by diatoms and shows two maxima of the biomass: the first in spring and the second in autumn (Kozuharov & Naidenow 1979). In most lowland reservoirs the phytoplankton maximum is in summer, when most of the biomass is formed by green algae (Saiz 1981, 1987; Beshkova 1995), although occasionally blue-greens and dinoflagellates also reach significant amounts in summer (Kozuharov & Naidenow 1979). In these reservoirs the abundance of diatoms is usually related mainly to summer and autumn water mixing, because these algae are better adapted to a combination of mixing, low temperature and little light (Willén 1991). Cyanoprokaryotes are another important group and often develop in great numbers late in summer and early in autumn, mainly in the eutrophic reservoirs. The contribution of other algal divisions to the total biomass is usually small. The seasonal pattern of phytoplankton in the Yasna Polyana Reservoir differs considerably from this scheme. During the entire period of study the phytoplankton biomass has been formed mainly by diatoms and dinoflagellates, and the differences between the various sampling visits mainly relate to their proportions (Fig. 4). Diatoms contributed considerably to the biomass long after the onset of stratification had reached its maximum in May. Their relative biomass correlated negatively with water temperature (Rs = -0,31, P = 0,04, n = 42) and temperature is the key factor for a switch from diatoms to dinoflagellates. At a temperature over 15 °C (April 1989), the relative biomass of diatoms decreases as, respectively, the ratio of dinoflagellates increase. In summer (June – early September), the surface water temperature varies between 21 °C and 25.5 °C and thermal stratification is well developed. Green algae, which usually dominate the phytoplankton in summer in the dimictic reservoirs, have a negligible quantitative contribution here (with only two cases of domination, Fig. 4). Thus, dinoflagellates (*Peridinea* sp., *Ceratium hirundinella*), together with diatoms, form most of the biomass almost during the entire period of thermal stratification. The reason for prevalent development of dinoflagellates instead of green algae is still unclear. It is known that dinoflagellates are well adapted to stratified conditions by their slow growing rate (k-strategies) and aptitude to overcome sedimentation (Rojo & Alverez-Cobelas 2001). Therefore, the transition from r-selected species in spring (*Cyclotella*) to large k-selected dinoflagellates in summer is a confirmation of autogenic succession described by Sommer & al. (1986). Their ability for mixotrophy (Popovský & Pfister 1990) seems to give them advantage over the green algae under nutrient-limited conditions (respectively phosphorus limitation). On the other hand, despite the fact that no correlation has been found between phytoplankton and zooplankton biomass, the zooplankton possibly has influenced the level of phytoplankton structure by selective grazing. The motile dinoflagellates with their large dimensions, hard theca and diverse spines are better protected against zooplankton grazing.

The Yasna Polyana Reservoir also differs from the dimictic reservoirs in the development and dynamics of *Cyanoprokaryota*. In dimictic reservoirs these algae are common in late summer or early autumn. In the Yasna Polyana Reservoir they appear first in spring, with slight abundance and sparse distribution (usually at deep stations, in the 5 m to 10 m depth column), and in most instances are represented by the chroococcal species *Microcystis aeruginosa*. They nearly disappear in June and July and reappear in September, but already represented by filamentous, heterocyst-forming and nitrogen fixing species (*Anabaena*), developing mainly in the shallower part of the reservoir. *Cyanoprokaryota* blooms, common in the summer-autumn period in most other lowland reservoirs (mainly in the eutrophic), are missing here. Probably, the reason is the relatively high N:P ratio in the Yasna Polyana Reservoir (an average of 34 after Kalchev & al. 2001 and Kalchev & Botev 2005) which suggests phosphorus limitation, as the blue green algae are presumably better competitors under nitrogen limitation and, respectively, a low N:P ratio (Smith 1983; Sommer 1986; Tilman & al. 1986; 1988; Jarvis 1988; Varis 1991). The phytoplankton in the Yasna Polyana Reservoir is found to be more stable in comparison to the dimictic lowland Bulgarian reservoirs. This is expressed by the dominant complex composition of perennial taxa, i.e. of the same taxa almost throughout the investigated period (namely *Cyclotella* sp., *Peridinea* sp. and *Ceratium hirundinella*). A similar phenomenon was also established by Naidenow (1993) in relation to the zooplankton community. Such persistency of the dominant assemblage could be regarded as an indication that the phytoplankton community in the reservoir maintains equilibrium with the environment and has arguably reached a climax state (Townsend 2001). One possible reason for the higher stability of the phytoplankton in the Yasna Polyana Reservoir, except for the lower trophic state, may be the presence of two principal hydrological events: namely, one long period of thermally stratified waters and one short period of complete mixing in the studied reservoir, instead of four alternating periods of two mixes and two periods of stratified waters which is the case in the dimictic reservoirs.

Conclusions

Regarding the average value of the phytoplankton biomass (geometrical mean = $0.69\,\mathrm{mg\,l^{-1}}$), the Yasna Polyana Reservoir was found to be oligomesotrophic. The phytoplankton was probably phosphorus-limited, taking into account respectively the high N:P ratio and the positive correlation between phytoplankton biomass and phosphorus. Diatoms and dinoflagellates were the main groups forming the phytoplankton biomass. The phytoplankton community structure differed from the structure in the dimictic Bulgarian reservoirs mainly by: 1) dominant complex formation by the perennial taxa; 2) higher contribution of the diatoms throughout the entire period of investigation; 3) prevalence of dinoflagellates instead of the green algae during the period of thermal stratification; and 4) minor contribution of *Cyanoprokaryota*. Phosphorus limitation could be regarded as an acceptable reason for the significant role of diatoms and poor development of *Cyanoprokaryota,* but it could not serve as a plausible explanation of the prevalence of dinoflagellates instead of the green algae. The reason probably lies in the joint effect of a long duration of thermal stratification, phosphorus limitation and selective zooplankton grazing. However, the solving of these questions would need further profound investigations.

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