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PHYTOPLANKTON FLUCTUATIONS IN POND TYPE LAKE BIKCZE

ABSTRACT: The studies were conducted in 1974 from April to November. Phytoplankton fluctuations in numbers and seasonal fluctuations of five taxonomic groups were investigated. Attention was paid to seasonal changes in phytoplankton species composition. The numbers of *Scenedesmus quadricauda* (Turp.) Bréb. increased rapidly from day to day from 6 to 170 thous. ind. · dm^{-3}.

KEY WORDS: Lake, phytoplankton, numbers, dominant species, water blooms.

1. INTRODUCTION

Lake Bikcze is a polymictic water body of a surface area 85 ha and maximal depth 3.3 m (W i l g a t 1953). Although it has been defined as a eutrophic water body (B r z ę k et al. 1975) it has underwent since 1969 a gradual diseutrophication under the influence of neighbouring and gradually developing ombrophilous peat-bogs (W o j c i e c h o w s k i 1976).

Changes in the lake are always reflected by quantitative and structural changes of phytoplankton. According to many authors (M u n a w a r and M u n a w a r 1975, W o j c i e c h o w s k a 1976a, S p o d n i e w s k a 1978) contribution of nannoplankton to phytoplankton biomass is an important factor indicating the trophic character of the lake. Another important factor, frequently analysed, is the seasonal phytoplankton fluctuations in the lake. In many publications (W o j c i e c h o w s k a 1976b, S a d č i k o v et al. 1983, Š k u n d i n a 1983) seasonal phytoplankton fluctuations are examined in two or more years, but samples are usually taken once or twice a month.

Here, fluctuations in phytoplankton numbers during one season are examined, on the basis of frequently taken samples in research series. Fluctuations in phytoplankton numbers, percentage of nannoplankton and fluctuations of taxonomic groups are given. Phytoplankton changes have been often analysed from day to day.

2. METHODS

Because of the little differentiated, rather circular shape of lake the research site (permenent) was chosen in the middle of the water level at the depth of about 3 m. Studies were conducted in 1974 from April 1 to November 6 at 47 dates in 6 series. In four series samples were taken three times in three consecutive days with four day intervals between particular cycles. In the first and last series samples were taken twice in three consecutive days, because of atmospheric conditions. On August 12 samples were not taken because of the storm and on the curves only two consecutive days instead of three are marked.

Water samples were taken using a sampler of Patalas (1954) type of a volume 2 dm^3, from three water layers, every 0.5 m (down to 1.5 m as below this depth sediments were floating in the water), poured together as one sample. After mixing, a final 0.25 dm^3 sample was fixed in Lugol solution and afterwards in formalin with glycerin.

Phytoplankton numbers were estimated by means of inverted microscope by Utermohl's method (after Vollenweider 1969). In each sample numbers of all algal species were estimated, counting colonies or cells, according to the form occurring in the lake. In the case of *Dinobryon divergens* the cells were counted. During its mass growth in Utermohl's sedimentation chambers colonies and single cells (single loricas containing the protoplast) were equally abundant. As this species occurs basically in the form of colonies and probably occurred mainly in that form in the lake, it was considered as microplankton.

Phytoplankton numbers were calculated per water volume unit (dm^3).

3. RESULTS

3.1. SEASONAL CHANGES IN TOTAL PHYTOPLANKTON NUMBERS AND PERCENTAGE OF NANNOPLANKTON

Changes in total phytoplankton numbers are shown in Figure 1. Phytoplankton numbers were the highest in May 6 – 22 due to mass growth od *Dinobryon divergens.* The development of this species had two peaks. First, beginning on May 6 with about 10 mlln. $\cdot dm^{-3}$ of *Dinobryon divergens* cells increasing to 12 mlln. $\cdot dm^{-3}$ on May 7 and decreasing to 7 mlln. $\cdot dm^{-3}$ on May 8. The second distinct peak was on May 13 – 15. Abundant development of *Dinobryon divergens* was followed by a decrease in

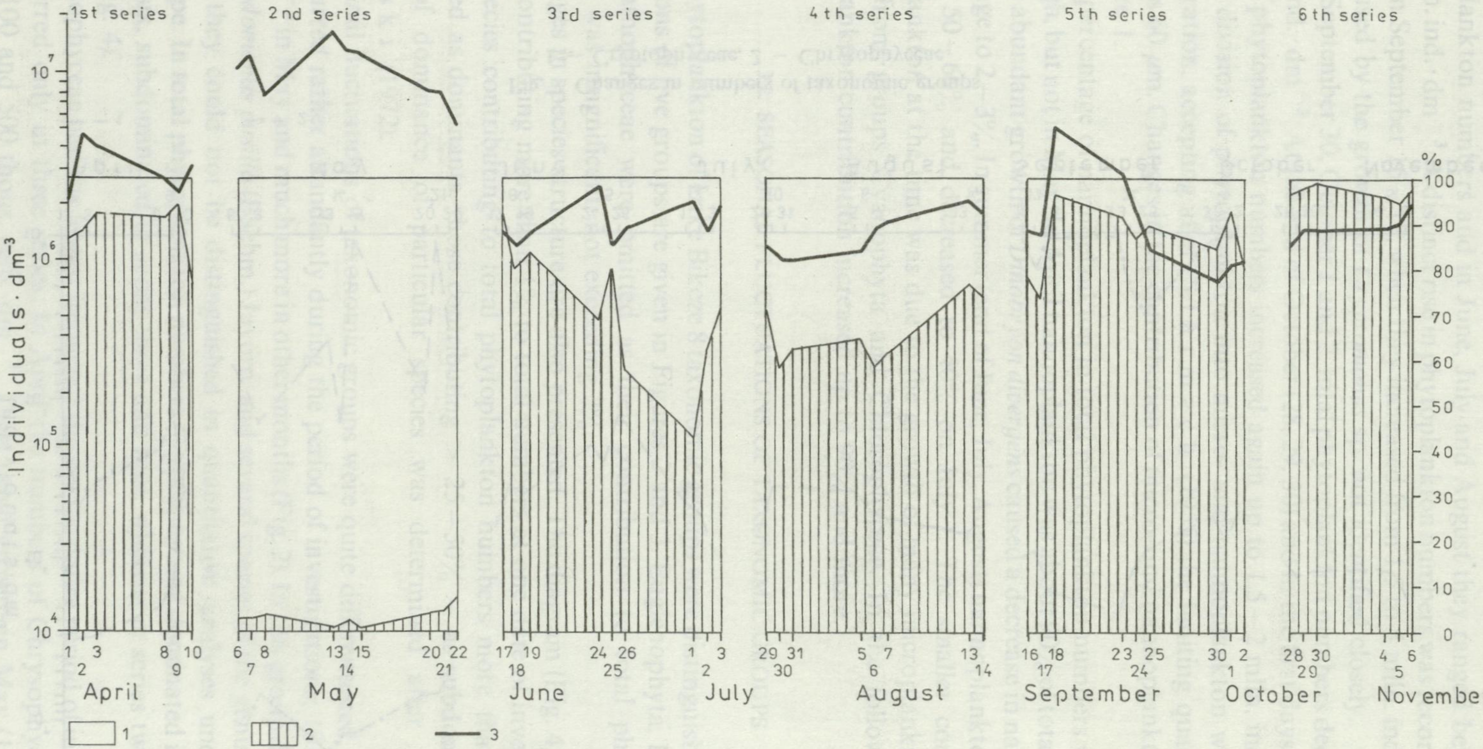

Fig. 1. Changes in percentage of micro- and nannoplankton and total phytoplankton numbers
1 – percentage of microplankton, 2 – percentage of nannoplankton, 3 – total numbers of phytoplankton

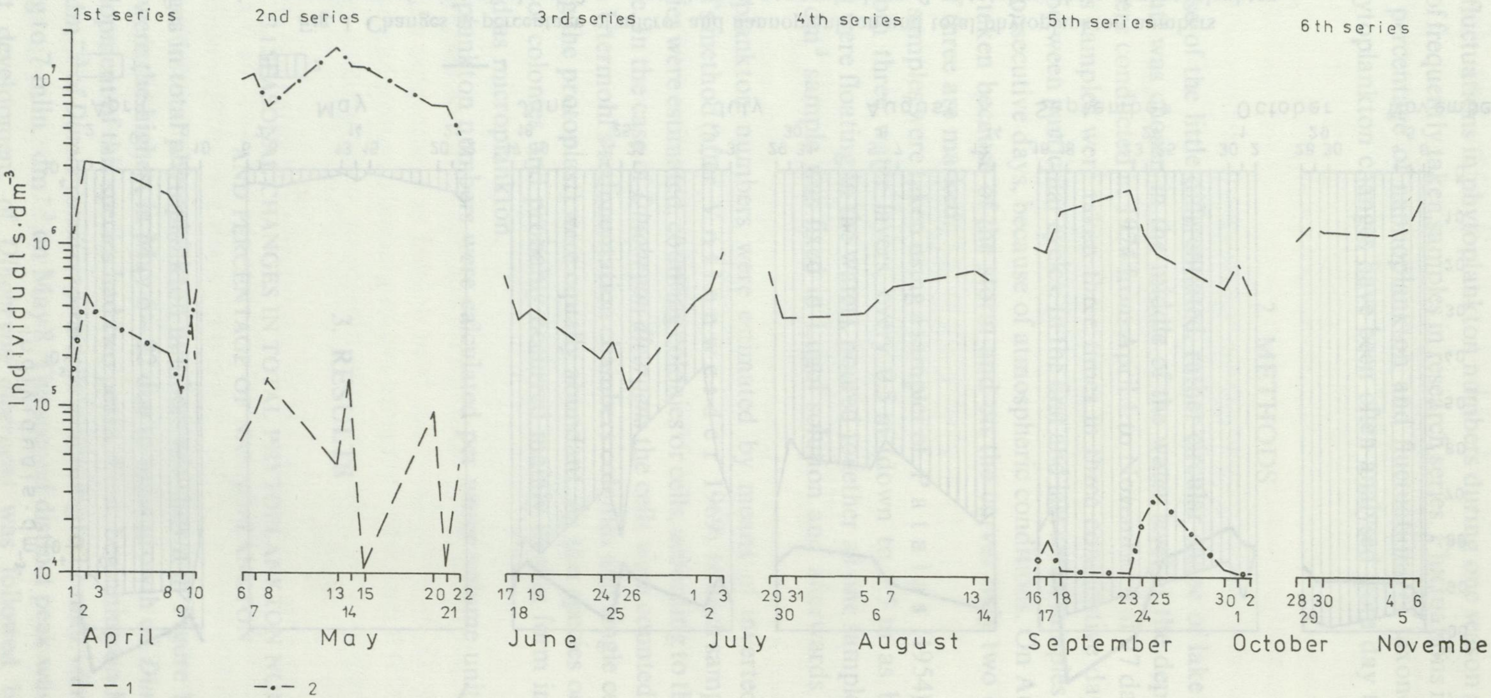

Fig. 2. Changes in numbers of taxonomic groups
1 – Cryptophyceae, 2 – Chrysophyceae

phytoplankton numbers and in June, July and August they ranged between 1.5 and 2.5 mlln. ind. · dm^{-3}. A distinct rise in phytoplankton numbers was recorded in a 3-day series on September 16 – 18, when they increased from 1.5 to 5 mlln. ind. · dm^{-3}. This was caused by the growth of *Cryptomonas* sp. not identified closely.

On September 30, October 1 and 2, total phytoplankton numbers decreased to 900 thous. ind. · dm^{-3}. At the end of October (28, 29, 30) and in the first days of November (4, 5, 6) phytoplankton numbers increased again up to 1.5 – 2 mlln. ind. · dm^{-3}.

The division of phytoplankton into micro- and nannoplankton was taken into consideration, accepting after Starmach (1955) the limiting quantity between fractions 60 μm. Changes in the contribution of micro- and nannoplankton are shown in Figure 1.

The percentage of nannoplankton in total phytoplankton numbers was exceptionally high, but not in May. In April nannoplankton was about 90% of total numbers. In May the abundant growth of *Dinobryon divergens* caused a decrease in nannoplankton percentage to 2 – 3%. In summer (end of June, July, August) nannoplankton was on the average 50 – 60% and decreased to 40% on July 1. The smaller contribution of nannoplankton at the time was due to the growth of many microplanktonic species, mainly from groups Cyanophyta and Chlorophyceae. In the following months nannoplankton contribution increased up to 90% and more.

3.2. SEASONAL FLUCTUATIONS OF TAXONOMIC GROUPS

In phytoplankton of Lake Bikcze 8 taxonomic groups were distinguished. Seasonal fluctuations of five groups are given in Figures 2 and 3. Euglenophyta, Dinophyceae and Xanthophyceae were omitted as their contribution to total phytoplankton numbers was insignificant, not exceeding 2%.

Changes in species structure are also presented. The diagram (Fig. 4) includes all species contributing more than 1% to total numbers at one date of investigations at least. Species contributing to total phytoplankton numbers more than 50% were considered as dominants, those contributing > 25 – 50% – as subdominants. The degree of dominance of particular species was determined after Wojciechowski (1972).

Seasonal fluctuations of taxonomic groups were quite differentiated. Cryptophyceae occurred rather abundantly during the period of investigations; 10 – 100 thous. ind. · dm^{-3} in May and much more in other months (Fig. 2). In this group distinguished were *Rhodomonas pusilla* (Bachm.) Javorn. and several species of the genus *Cryptomonas*, but they could not be distinguished in quantitative analyses under inverted microscope. In total phytoplankton numbers Cryptophyceae dominated in series one, five and six, subdominated in series three and four, whereas in series two they were < 1% (Fig. 4).

Chrysophyceae had the lowest frequency during the entire period of investigations and occurred only in three series. In April the numbers of Chrysophyceae ranged between 100 and 500 thous. cells · dm^{-3}. Their rapid growth in May (10 – 17 mlln.

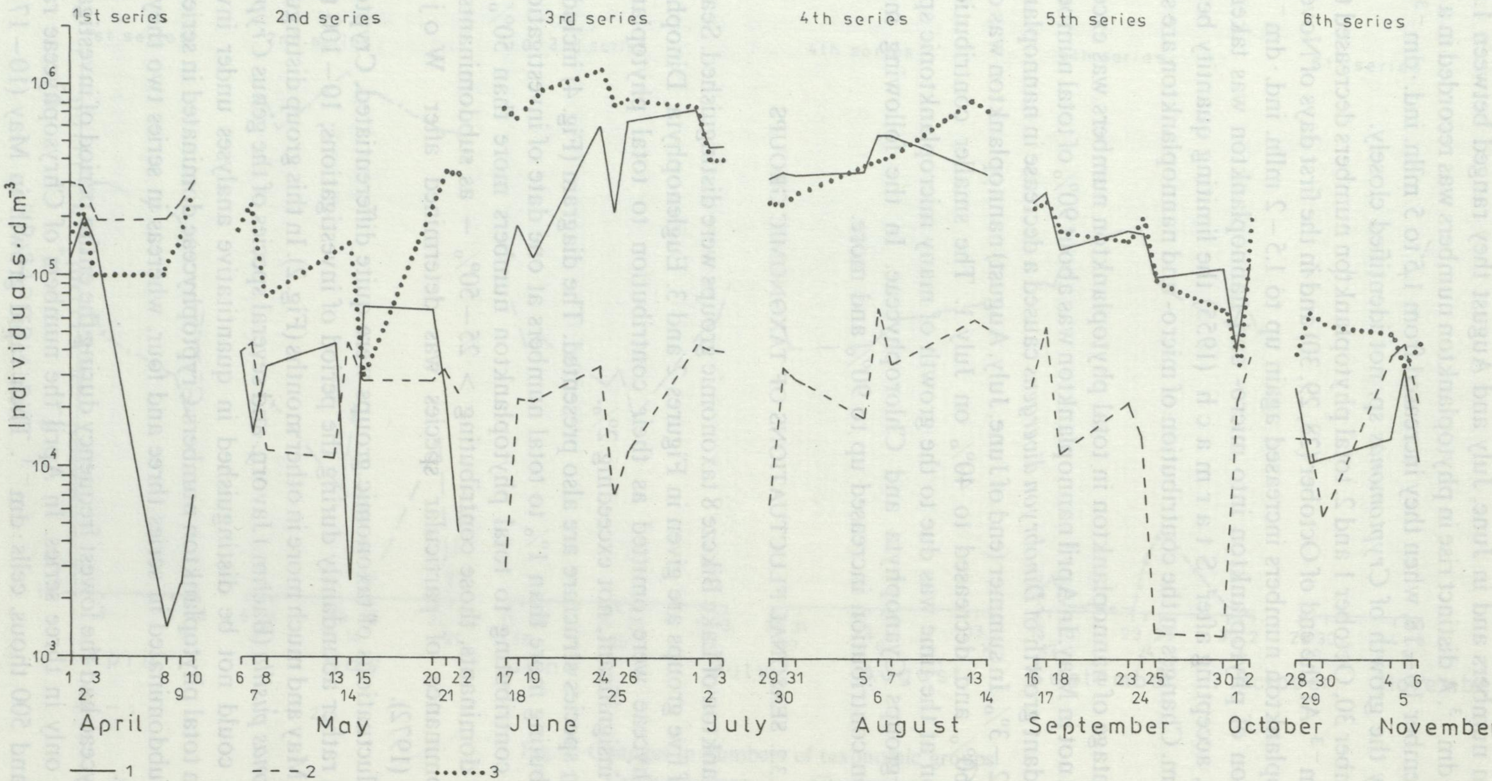

Fig. 3. Changes in numbers of taxonomic groups
1 – Cyanophyta, 2 – Bacillariophyceae, 3 – Chlorophyceae

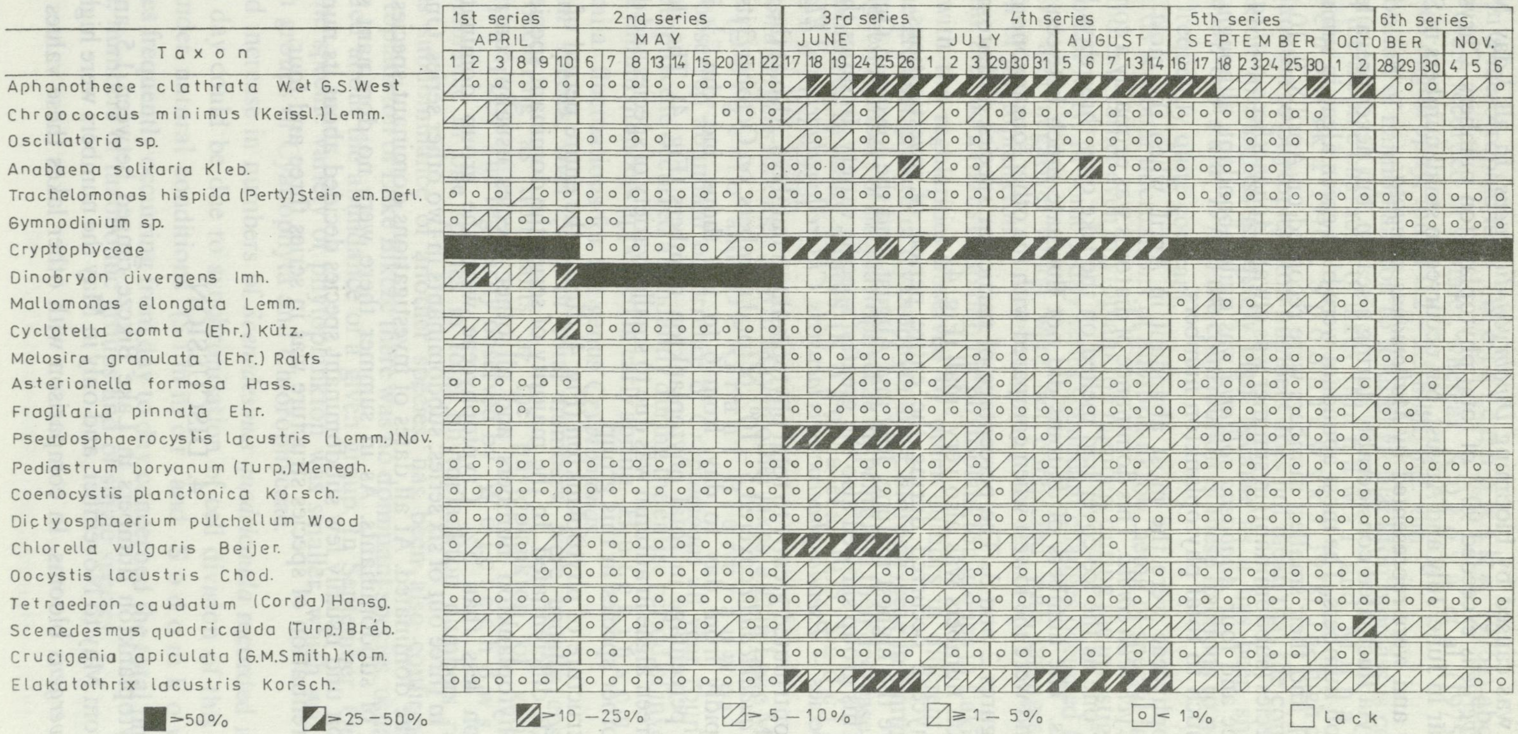

Fig. 4. Changes in relative numbers of phytoplankton taxa

cells · dm^{-3}) was caused by blooming *Dinobryon divergens*. In all 3-day May series *Dinobryon divergens* exceeded 90% of total phytoplankton numbers. Chrysophyceae did not appear in June, July and August, but occurred in small numbers in September and October and were represented by *Mallomonas elongata*.

Cyanophyta fluctuated considerably during a season, but never prevailed in total phytoplankton numbers. The most abundant were blue-green algae in summer (June, July, August), and their smallest numbers were recorded on April 8, 9, 10. The most abundant species (subdominant) in summer was always *Aphanothece clathrata* (Fig. 4). In series three and four *Anabaena solitaria* was quite abundant, although it did not contribute much to total phytoplankton numbers.

Bacillariophyceae were the most abundant in April, when the most abundant species was *Cyclotella comta*. This dominance of diatoms was probably a continuation of the winter one as the ice-cover had melted on the lake only three days before the investigations. The numbers of diatoms did not fluctuate much between May and November and were the lowest when compared with the other four taxonomic groups shown in Figures 2 and 3. The percentage of particular species of diatoms in total phytoplankton numbers was also very small (Fig. 4).

Chlorophyceae occurred during the entire period of investigations and their numbers were the highest in June, July and August, and the lowest in October and November. This group showed also the greatest specific variety. In series three (June, July) three species – *Pseudosphaerocystis lacustris*, *Chlorella vulgaris* and *Elakatothrix lacustris* – contributed greatly to total phytoplankton numbers. Also at the same time *Scenedesmus quadricauda* covered 5 – 10% of total numbers; on October 2 its numbers increased rapidly from day to day, from 6 to 170 thous. ind. · dm^{-3}, increasing distinctly its percentage in total phytoplankton numbers (Fig. 4). The decrease in numbers of green algae in autumn was due to smaller variety of species and decreasing numbers of other species in this group.

Species structure of phytoplankton (Fig. 4) during the entire period of investigations was little differentiated. In the majority of series the dominant species decided about the phytoplankton numbers and all other species usually contributed to phytoplankton less than 5%. Cryptophyceae were the group dominating most frequently – in three out of six series; subdominants in two other series. Only in May Chrysophyceae dominated. At all dates of investigations dominant species excluded the presence of subdominants. As in summer there were no dominant species in phytoplankton und usually few subdominant species decided about its numbers, the greatest differentiation of species structure was in series three and four.

4. DISCUSSION

Total phytoplankton numbers in Lake Bikcze ranged between 1.5 and 2 mlln. ind. · dm^{-3} from May to November, and only in May the numbers were higher due to *Dinobryon divergens* blooms. In comparison with other lakes these values were not high, e.g., in a-mesotrophic lake (W o j c i e c h o w s k a 1976a) about 1.5 mlln. ind. $\cdot dm^{-3}$ were recorded in summer, whereas K o ž o v a et al. (1975) in another lake, close to oligotrophy, found 0.2 – 2.5 mlln. ind. $\cdot dm^{-3}$.

Contribution of nannoplankton to total phytoplankton biomass is considered as an index of the trophic character of lakes (M u n a w a r and M u n a w a r 1975, W o j c i e c h o w s k a 1976b, S p o d n i e w s k a 1978). The high contribution of nannoplankton to phytoplankton numbers does not mean that the contribution of nannoplankton to biomass is equally high, because as it has been shown earlier (W o j c i e c h o w s k a 1976a) the contribution of these fractions to numbers and biomass is frequently quite contrary.

As regards seasonal fluctuations of phytoplankton, being of special interest here, the results indicate rather even phytoplankton numbers during the investigations, with the exception of May. In some 3-day series significant changes occurred from day to day (positive and negative) which were not connected with changes in species composition of phytoplankton.

In general, the fluctuations of taxonomic phytoplankton groups in Lake Bikcze are consistent with the regularities observed by other authors in different lakes. For example, the greatest growth of Cyanophyta and Chlorophyceae in summer and the relatively highest numbers of Bacillariophyceae in spring and their decrease in summer, have been confirmed by many authors (K o ž o v a et al. 1975, S a d č i k o v et al. 1983, Š k u n d i n a 1983).

Dinobryon divergens bloomed also in May in other lakes, e.g., in Lake Maarsseveen in Holland (D o r g e l l o and D e G r a a f B i e r b r a u w e r 1981). The latter have observed abundant occurrence of *Cryptomonas* all year round. In Lake Bikcze Cryptophyceae occurred abundantly during the entire period of investigations, and their maximum numbers appeared in early spring. H u t c h i n s o n (1967) has observed similar fluctuations for the genus *Cryptomonas*.

Dominant species, over 50% of total numbers, were usually cosmopolites, frequently occurring as dominants in the phytoplankton of various lakes (Š k u n d i n a 1983). The regularity observed by W o j c i e c h o w s k i (1972) that the dominance of one species in total phytoplankton numbers rules out a simultaneous subdominance of another species, has been also confirmed. In the summer phytoplankton of Lake Bikcze there was no dominant species, usually several species decided about the abundance of a given group. In September, October and November the specific variety of phytoplankton was smaller, which was especially noticeable in groups of Cyanophyta and Chlorophyceae.

The rapid increase in numbers of *Scenedesmus quadricauda* recorded in October from day to day could be due to synchronization of cell division of this species as confirmed under natural conditions (S i m m e r and S o d o m k o v a 1968). These changes frequently occurring from day to day concerned the total phytoplankton numbers, numbers of taxonomic groups and of single species.

5. SUMMARY

The object of the study was a detailed presentation of seasonal fluctuations of phytoplankton, frequently from day to day. The studies were conducted from April to November in pond type polymictic Lake Bikcze, 3 m deep.

Changes of phytoplankton were shown by changes in numbers determined by Utermohl's method (after V o l l e n w e i d e r 1969). Numbers of phytoplankton were the highest on May 6 – 21 (Fig. 1), when *Dinobryon divergens* bloomed, whereas the lowest ones were recorded on October 1 and 2. Simultaneously total phytoplankton numbers varied from day to day (positively and negatively).

The percentage of nannoplankton in total phytoplankton numbers was very high (> 60%) during the entire period of investigations (Fig. 1) and decreased to 2 – 3% when *Dinobryon divergens* bloomed.

Cyanophyta and Chlorophyceae were most abundant in summer (Fig. 3) and the most numerous species at the time were: *Aphanothece clathrata, Anabaena solitaria, Pseudosphaerocystis lacustris, Chlorella vulgaris* and others (Fig. 4). Cryptophyceae, represented by *Rhodomonas pusilla* and *Cryptomonas* sp., occurred abundantly all the time. Bacillariophyceae were the most numerous in April, when *Cyclotella comta* dominated. In other months the number of diatoms remained more or less on an equal level.

The numbers of *Scenedesmus quadricauda* increased from day to day in October from 6 to 170 thous. ind. $\cdot$ dm^{-3} Such a great increase could be due to synchronized division of this species.

6. POLISH SUMMARY

Celem pracy było przedstawienie dynamiki sezonowej fitoplanktonu możliwie szczegółowo, często nawet z dnia na dzień. Badania prowadzono od kwietnia do listopada w stawowym Jeziorze Bikcze, polimiktycznym o głębokości 3 m.

Zmiany fitoplanktonu przedstawiono zmianami liczebności, którą określono metodą Utermohla (wg V o l l e n w e i d e r a 1969). Liczebność fitoplanktonu miała najwyższe wartości od 6 do 21 maja (rys. 1), kiedy to natrafiono na zakwit *Dinobryon divergens*, a najniższe 1 i 2 października. Równocześnie stwierdzono zmienność ogólnej liczebności fitoplanktonu z dnia na dzień (dodatnią i ujemną).

Udział procentowy nannoplanktonu w ogólnej liczebności fitoplanktonu był bardzo duży (> 60%) w całym okresie badań (rys. 1), malał tylko do ok. 2 – 3% w okresie zakwitu *Dinobryon divergens*.

W miesiącach letnich największą liczebność miały *Cyanophyta* i *Chlorophyceae* (rys. 3), a najliczniejszymi gatunkami w tym okresie były: *Aphanothece clathrata, Anabaena solitaria, Pseudosphaerocystis lacustris, Chlorella vulgaris* i inne (rys. 4). Licznie w całym okresie występowały *Cryptophyceae* reprezentowane przez *Rhodomonas pusilla* i *Cryptomonas* sp. *Bacillariophyceae* największą liczebność osiągnęły w kwietniu, a dominującym gatunkiem w tym okresie była *Cyclotella comta*. W pozostałych miesiącach liczba okrzemek utrzymywała się mniej więcej na równym poziomie.

W październiku zanotowano z dnia na dzień wzrost liczebności *Scenedesmus quadricauda* z wartości 6 do 170 tys. osobników $\cdot$ dm^{-3}. Tak duży wzrost mógł być spowodowany synchronicznym podziałem tego gatunku.

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