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Biodiversity and species composition of phytoplankton in the ponds of Lednice Park

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RAMEZANPOOR Z. & MARŠÁLEK B. 2004: Biodiversity and species composition of phytoplankton in the ponds of Lednice Park. *Acta Musei Moraviae, Scientiae biologicae* (Brno) **89:** 175–192. – Phytoplankton was studied in two shallow ponds (the "Zámecký" and "Růžový") situated in the Lednice Park in the course of 2002 and 2003. The main water source for both ponds is the River Dyje that flows through the park. The area itself is the most temperate area in the Czech Republic. The current condition of the phytoplankton communities, together with the physical and chemical factors prevalent in these ponds and the River Dyje were investigated. Quantitative samples were taken every two weeks during spring and summer. The relative toxicity of microcystin resulting from algal bloom, the richness of species, the diversity of species and the equitability indices, which displayed considerable fluctuation within the period of investigation, are all discussed. Diversity indices decreased in correlation with an increasing abundance of *Microcystis*. Minimum diversity was recorded during algal bloom. The same was true for most of the correlation between the number of species and the equitability index. For most of the parameters measured and correlations examined, there were no differences between localities except in the case of Růžový Pond, where the relationships within the phytoplankton community and all the parameters measured with respect to equitability showed significant differences. The main conclusions that may be drawn from the results obtained are: 1) The bodies of water in the Lednice Park are tending towards low diversity and eutrophication. 2) The different community of phytoplankton in Růžový Pond may be due to some interaction between water body nutrients and their combination with materials originating either from the decomposition of tree leaves (*Ailanthus glandulosa, Salix* sp. and *Acer campestre)* or ion exchange with roots, or both.

Key words. Phytoplankton, biodiversity, southern Moravia, Czech Republic

Introduction

Phytoplankton blooms are unique events in nature. Plant biomass may increase by up to 3 orders of magnitude over a period of only days. The species composition of these blooms has an important role to play. In particular, toxic Cyanophyta may accumulate into harmful algal blooms.

The River Dyje is subject to nutrient inputs, including nitrogen and phosphorous, as a result of human activity along the river (LUCKÝ 1997, VÁCLAVÍK 1927, LUSK 1977, LUSK 1970, LUSK 1975, LUSK 1984). These nutrients stimulate the growth of phytoplankton, and blooms (periods of very high growth by a single species) may occur.

It is important to survey the diversity of species in this group for several reasons. First, previously undiscovered species may well be identified by such work. Second, it is important for scientists and managers to understand the composition of the species for a particular ecosystem in order to have an indicator of the state of biodiversity. If we do not

know which organisms live in the river, we cannot recognize invasive and autochthonous species. This is especially important with respect to the study of phytoplankton, since certain species are often used as indicators that give a rough assessment of the state of an ecosystem (an indication of human-mediated nutrient inputs, for example). Thus the phytoplankton can yield valuable information about changes in an ecosystem, and biodiversity surveys are the most thorough means of recording these changes. Some ecologists argue that low diversity communities may be more susceptible to biological invasion, so the significance of the diversity issue is clear.

Here we present biodiversity and species composition data for phytoplankton assemblages from three sites in the Lednice Park.

Material and Method

Site description

Lednice Park is located in the city of Lednice (southern Moravia, Czech Republic). There are two ponds in this park at an elevation of about 160 m above sea level. The areas of the Zámecký and Růžový ponds are 30.12 ha and 1.57 ha respectively. The Dyje River flowing through the park is the main water source for both of them. The area itself is the most temperate in the Czech Republic (Bana & Sukop 1999). It lies on the lowest layer of sedimentary rock. Jurassic limestone and dolomite, influencing the environmental condition of the region, occur above this layer (Bayer & Bajkov 1929). The three sampling sites selected in Lednice Park are shown in Fig. 1.

Chemistry

In order to analyse chemical parameters, water samples were collected every two weeks 20 cm below the surface during the vegetation seasons of the year 2002 and 2003. An adapted type of Ruthner sampler was employed. Water samples were taken into glass bottles in such a way that no air remained in the bottle. Secchi disc depth was determined at each sampling site. Concentrations of dissolved oxygen (DO) were measured in the field using a Hanna H1 9145 digital oxygen meter. Air and water temperature and pH were determined using a Hanna H1 9025C digital instrument. BOD and COD were measured in the laboratory following standard procedures (ASTM 1996).

Phytoplankton

For phytoplankton survey purposes, 500 ml of water was taken from each site (20 cm below the surface). Phytoplankton samples were fixed in Lugol and formalin (4%) solution separately. Algal cells were counted with an inverted Meopta microscope at ×675 magnification with 2-ml sediment chambers. Linear dimensions were measured using 20 specimens of each species (except for rare species, which were present in lower numbers). Measurements were done with an ocular scale, calibrated to an object micrometer.

The species were identified alive during the first day after sampling with a Zeiss/Jena compound microscope. Additionally, diatoms were analysed on permanent

slides. For these purposes, a subsample was washed with distilled water, and subsequently oxidized in 30% H_2O_2 for 3–5 days. An aliquot was dropped onto a slide and the liquid was vaporized by heating. Samples were then mounted in Naphrax (Biological Supplies Ltd.).

Analysis of microcystins

Extraction of microcystins from lyophilised biomass was performed by ultrasonication of 10 mg biomass in 1ml of 50% methanol (v/v). The extraction was repeated twice and both fractions were pooled and analysed by HPLC. Solid phase extraction (SPE C-18 Waters Sep-Pac Vac35cc, 10-g cartridges) of microcystins from water was performed after MOOLLAN et al. (1996). A 500-ml water sample was applied to an appropriately conditioned column and eluted with 100 ml of methanol. Methanolic extracts were dried by rotary evaporation, redissolved in 200 ml of methanol, filtered and analysed by HPLC, including a Waters 600E HPLC solvent delivery system equipped with a Waters 717 plus autosampler. Analysis took place on a Supelcosil ABZ+Plus column (150´–4.6mm–5 mm, Supelco) with a water/acetonitrile gradient (+0.05% trifluoroacetic acid). Purified microcystin-LR (Calbiochem-Novabiochem Corp.) was employed as an external standard. Photodiode array detection (Waters PDA 996, wavelength 200–300 nm) was used for the detection of microcystins, and variants including microcystin-LR were identified according to their characteristic UV-absorbance spectra with a maximum at 238 nm, and quantified as "microcystin-LR equivalents" (FALCONER et al. 1999). The detection limit was 4–6 mg/g d.w. for the analysis of biomass and 100–250 ng/l for water samples (BLÁHA & MARŠÁLEK 2003).

Analysis of diversity

Diversity comprises the number of taxa present and the distribution of abundances among the different taxa. Diversity indices are proposed as univariate measures composed of both characteristics. The statistical behaviour and ecological significance of several diversity indices has been widely discussed and the controversy is far from being resolved (HURLBERT 1971, PIELOU 1977, ROBINSON & SANDGREN 1984, KREBS 1989, VALIELA 1995). We therefore employed two unrelated indices to demonstrate the robustness of our results. Since any two diversity indices are differently weighted regarding their sensitivity to species richness or equitability, they often show discrepancies in their responses to changes in community composition (HURLBERT 1971). We adopted two statistics in common use: the Shannon-Weaver index H´ with the species richness S and the evenness index J´.

- Shannon-Weaver information theory index H´:

$$H' = -\sum_{i=1}^{i=S} P_i \ln P_i$$

P_i – contribution of the each species to the total abundance of the community
S – number of species

• Evenness J' (Pielou 1977):

$$J' = H' / H_{max} = H' / \ln S$$

The exact species numbers in a community cannot be estimated from samples. However, S can easily be compared if it is based on a standardised sample size, which was the case since we counted equal numbers of cells in the experiments of each series.

Diversity indices, H', depend on contributions pi of the each species to the community or sample. This can be expressed either in terms of contribution to the total number of organisms or to total biomass.

We conducted separate analyses on the chemical and physical parameters measured. The ANOVA comparison of analyses of variances was used for evenness and index of diversity, classified by year and locality. A pooled variance t-test was also used for pH, BOD and COD. The relationship between measures of diversity was analysed with Pearson's correlation coefficient. Canoco and Microsoft Excel software were used for data analysis. In Canoco, unimodal ordination methods, canonical correspondence analysis (CCA) and detrended correspondence analysis for indirect gradient analysis were used.

Results and Discussion

A characteristic feature of Lednice Park is the eutrophicated water of the Zámecký Pond. Its physical and chemical parameters are shown in Tab. 1. Algal bloom was observed from June and continued up to the end of September. The main phytoplankton species (Plates 1–5) involved in algal bloom were *Anabaena flos-aquae*, *Microcystis aeruginosa*, *M. ichtyoblabe*, *M. wesenbergii*, *M. flos-aquae* and *Aphanocapsa incerta.* The average concentration of microcystin was 964.8 (µg/g DW) during the bloom. Values for microcystin grew continuously from a minimum of 207.8 (µg/g DW) at the beginning of the experiment (Jul. 2003) to a maximum of 1348.1 (µg/g DW) at the end (Sep. 2003).

Lemna gibba is a floating plant that was observed on the River Dyje at the beginning of summer. It covered a considerable part of surface of the Dyje by midsummer. The density of *Lemna gibba* fell with decreasing temperature but it remained on the surface of the Dyje throughout the summer. The submerged plants *Ceratophyllum demersum* and *Potamogeton crispus* also occurred in the Dyje River during the vegetation season.

Seasonal cycles showed a regular pattern common to each station. Increasing phytoplankton abundance was observed from May to September and exhibited a greater or lesser degree of variability of abundance, duration and timing of peaks. As a result of analysis of the phytoplankton community, a complex of five divisions were distinguished with respect to selected species of Cyanophyta, Chlorophyta, Chrysophyta, Cryptophyta and Euglenophyta (Tab. 2).

Cyanophyta, with an annual average abundance of 45%, constituted the most widely distributed division of phytoplankton in comparison with other divisions in Zámecký Pond during the survey (Fig. 2). The Chlorophyta (annual average 30%) and

Bacillariophyceae (annual average 21%) were the second and third most abundant divisions in Zámecký Pond.

The algal flora of Růžový Pond showed a very different developmental pattern in comparison to those of Zamecky Pond and the River Dyje. Chlorophyta (annual average 52%) and Bacillariophyta (mainly centrals, with a 35% annual average) were dominant phytoplankton representatives of the Růžový Pond.

The main phytoplankton species, based on abundance, occurred in the following order: *Stephanodiscus hantzschii, Cyclotella meneghiniana, Cyclostephanos invisitatus, Aulacoseira granulate, Aulacoseira ambigua* (all Centrales) with 16.1%; *Coelastrum microporum, Coelastrum astroideum* with 14.6% and *Scenedesmus* spp. with 14.1%.

Although there was no regular dominance pattern of phytoplankton groups from the River Dyje, the Cyanophyta with 37%, Chlorophyta with 27% and Bacillariophyceae with 29% made up the most abundant types. The main community of phytoplankton in the River Dyje included *Microsystis aeruginosa* with 13.3%, *Aphanizomenon klebahnii* with 4.8% and *Microcystis ichtyoblabe* with 4.4% from the Cyanophyta, *Nitzschia acicularis* with 14%, *Stephanodiscus hantzschii* with 6.2% and some small centrals with 4.6% from Bacillariophyceae.

DCA analysis has shown a marked similarity of species present in different localities, and in the succession of phytoplankton communities of the Lednice park waters (Fig. 3). The relationships between phytoplankton communities and environmental factors highlighted significant differences between phytoplankton species in the Růžový Pond with those occurring in the Zámecký Pond and the Dyje River (Fig. 4).

Analyses of variance (ANOVA) of chemical and physical factors including pH and COD showed no significant differences between data collected over two years and at different sites. There was a significant difference in BOD values between Zámecký Pond and the River Dyje and Růžový Pond and the Dyje River. The index of equitability or evenness did not show any significant difference but the Shannon index of diversity varied significantly over the two years.

The seasonal variation of phytoplankton diversity showed oscillation within a short time scale around a mean. It can be seen that the phase of lower diversity coincided with the period of algal bloom. It may be emphasized that the minimum diversities occurred during the algal blooms characterized by the highest densities.

The relationship between measures of diversity with Pearson's correlation coefficient showed a negative correlation in each station (Fig. 5). There is a significant difference among the results of diversity indices in the years 2002 and 2003. The community has shifted toward heavy eutrophication and an unstable structure. This is confirmed by the very high values of microcystin during algal bloom in Zámecký Pond. Correlations among diversity indices in both Zámecký and Růžový ponds and the Dyje River [Růžový-Dyje (r^2=0.056), Dyje-Zámecký (r^2=0.543), Zámecký-Růžový (r^2=0.307)] were positive. All of them showed low diversity at the time. However, this variance was generally low in Růžový Pond and no algal bloom was seen. In the case of Růžový Pond

it seems some different combination of factors is involved. We therefore tried to survey the differences from another point of view (Tab. 3). The dominant tree species around Růžový Pond are deciduous trees, *Ailanthus glandulosa, Salix* sp. and *Acer campestre.* On draining the pond in autumn, the bottom is covered in leaf litter. Růžový Pond is also surrounded by a thick network of roots (although 1.35 ha in area) and there is also a considerable development of roots into the pond. The influence of decomposing leaves or ion exchange with intrusive roots may well bear further investigation.

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Appendix 1
Figures and Tables

Factors/Date	Dyje			Růžový			Zámecký		
	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Temp. c	5.4	25.2	17.7	5.1	25.2	18.4	5.3	25.2	18.4
Depth cm	70	110	90	75	85	80	50	110	83
Transparency cm (2002)	35	65	53	15	45	29	0	65	39
Transparency cm (2003)	35	95	58	10	65	28	20	80	49
Oxygen sat. %(2002)	40	108	68	62	188	114	41	145	84
Oxygen sat. %(2003)	35	265	84	45	234	119	37	112	73
DO mg/l(2002)	3.4	12.6	6.8	6.3	19.5	10.2	3.6	15.9	7.8
DO mg/l(2003)	2.9	30.9	8.6	4.0	25.9	11.4	3.2	11.9	6.7
pH (2002)	7.6	9.2	8.1	7.9	9.4	8.5	7.6	9.7	8.5
pH (2003)	7.9	9.6	8.6	8.1	10	8.8	8.1	9.6	8.7
COD (2003)	8	130	41	15	137	69	13	170	61
BOD (2003)	4	20	10	6	72	24	3	37	16
Diversity index [H'] (2002)	0.62	3.19	1.75	1.84	2.86	2.26	0.23	3.01	1.87
Diversity index [H'] (2003)	0.41	2.42	1.55	0.75	2.39	1.53	0.20	2.53	1.22
Equitability (2002)	0.23	0.84	0.59	0.51	0.84	0.73	0.09	0.91	0.60
Equitability (2003)	0.28	0.92	0.66	0.29	0.84	0.58	0.08	0.96	0.48

Tab. 1. Values of chemical and physical factors measured in 3 sampling localities during the growth season 2002–2003.

Tab. 2. List of observed phytoplankton in the Zámecký, Růžový ponds and the Dyje River.

CHROMOPHYTA

Chrysophyceae

Bicosoeca planctonica
Chrysococcus biporus
Chrysococcus punctiformis
Chrysococcus rufescens
Chrysococcus triporus
Kephyrion tubiforme

Bacillariophyceae

Centrales

Actinocyclus normanii
Aulacoseira ambigua
Aulacoseira granulata
Aulacoseira italica
Cyclostephanos dubius
Cyclostephanos invisitatus

Cyclotella meneghiniana
Melosira varians
Skeletonema potamos
Stephanodiscus hantzschii
Thalassiosira weissflogi

Pennales

Achnanthes hungarica
Achnanthes lanceolata
Amphora ovalis
Amphora veneta
Asterionella formosa
Caloneis silicula
Cocconeis placentula
Cymatopleura librilis
Cymbella ehrenbergii
Cymbella minuta
Cymbella tumida
Diatoma tenuis
Diatoma vulgaris
Fragilaria construens
Fragilaria sp.
Gomphonema truncatum
Gyrosigma acuminatum
Navicula avenacea
Navicula capitata
Navicula citrus
Navicula cryptocephala
Navicula cuspidata
Navicula gregaria
Navicula menisculus
Navicula tripunctata
Navicula sp.
Nitzschia acicularis
Nitzschia fonticola
Nitzschia hungarica
Nitzschia linearis
Nitzschia cf. palea
Nitzschia sp.
Nitzschia tryblionella
Pinnularia gibba
Pinnularia microstauron
Pinnularia sp.
Surirella brebissoni
Surirella minuta
Surirella ovata
Synedra acus
Synedra ulna

XANTHOPHYTA

Goniochloris mutica
Goniochloris sculpta

EUGLENOPHYTA

Euglena acus
Euglena acus v. *angularis*
Euglena ehrenbergii
Euglena hemichromata
Euglena pisciformis
Euglena sp.
Euglena tripteris
Euglena viridis
Lepocinclis texta
Phacusacuminatus
Phacus cf. *clavata*
Phacus curvicauda
Phacus longicauda
Phacus sp.
Phacus tortus
Trachelomonas sp.

CHLOROPHYTA

Chlorophyceae

Actinastrum aciculare
Actinastrum hantzschi
Ankyra ancora
Botryococcus braunii
Catenococcus minutus
Chlamydomonas sp.
Chlorogonium fusiforme
Chodatella citriformis
Closteriopsis sp.
Coelastrum astroideum
Coelastrum microporum
Crucigenia rectangularis
Crucigenia tetrapedia
Crucigeniella apiculata

Crucigeniella neglecta
Desmodesmus bicaudatus
Desmodesmus intermedius
Desmodesmus quadricauda
Desmodesmus opoliensis
Desmodesmus pannonicus
Desmodesmus praetervisus
Desmodesmus pulloideus
Desmodesmus semperviens
Desmodesmus smithii
Desmodesmus sp.
Desmodesmus spinosus
Dictyosphaerium ehrenbergianum
Dictyosphaerium sp.
Dictyosphaerium subsolitarium
Dictyosphaerium tetrachotomum
Didymocystis inconspicua
Didymocystis planctonica
Eudorina elegans
Golenkinia radiate
Gonium sociale
Granulocystis helenae
Hyaloraphidium contortum
Kirchneriella irregularis
Koliella longiseta
Lagerheimia chodatii
Lagerheimia genevensis
Lagerheimia subsalsa
Micractinium pusillum
Micractinium sp.
Monoraphidium arcuatum
Monoraphidium circinale
Monoraphidium contortum
Monoraphidium fontinale
Monoraphidium griffithi
Monoraphidium komarkovae
Monoraphidium minutum
Monoraphidium nanum
Monoraphidium tortile
Nephrochlamys rotunda
Nephrochlamys subsolitaria
Nephrochlamys willeana
Nephroselmis angulata
Oocystis borgeii
Oocystis lacustris
Oocystis marssonii
Oocystis parva
Pandorina elegans
Pandorina morum
Pediastrum boryanum
Pediastrum duplex
Pediastrum tetras
Pedinomonas rotunda
Phacotus lenticularis
Platymonas cordiformis
Polyedriopsis spinulosa
Pteromonas aculeata
Pteromonas cordiformis
Pteromonas golenkiniana
Scenedesmus acuminatus
Scenedesmus disiformis
Scenedesmus linearis
Scenedesmus obliquus
Schroederia robusta
Schroederia setigera
Selenastrum bibraianus
Stylosphaeridium stipitatum
Tetraedron caudatum
Tetraedron minimum
Tetradesmus wisconsinensis
Tetraedron triangulare
Tetrastrum elegans
Tetrastrum glabrum
Tetrastrum staurogeniaeforme
Tetrastrum triangulare

Conjugatophyceae

Closterium limneticum
Cosmarium homavanense
Staurastrum pingue

CRYPTOPHYTA

Chroomonas caudata
Chroomonas nordstedtii
Cryptomonas curvata
Cryptomonas erosa

Cryptomonas marssonii
Cryptomonas ovata
Cryptomonas sp.
Rhodomonas lacustris
Plagioselmis nannoplanktonica

PYROPHYTA

Ceratium furcoides
Gymnodinium sp.
Peridinium aciculiferum
Peridinium sp.

CYANOPHYTA

Anabaena flos-aquae
Aphanizomenon klbahnii
Aphanizomenon gracile
Aphanizomenon issatschenkoi
Aphanocapsa incerta
Aphanocapsa sp.
Chroococcus limneticus
Chroococcus minutus
Limnothrix redekii
Merismopedia tenuissima
Microcystis aeruginosa
Microcystis flos-aquae
Microcystis viridis
Microcystis wesenbergii
Oscillatoria limosa
Phormidium tenue
Planktolyngbia sp.
Planktothrix agardhii
Pseudanabaena limnetica
Pseudanabaena mucicola
Woronichinia naegeliana

Study area	**Ružový**	**Zámecký**	**Dyje**
Type of study area	Fish pond	Fish pond	Running water
Area (ha)	1.57	30.12	-
Ecological status	Protected area	Protected area	-
Water depth	80 cm	83 cm	90 cm
Sediment depth	50-60 cm	80-90	-
Sediment TOM	3.8%	4.7%	-
Water velocity	Standing Water	Very slow	>40 $m.s^{-1}$
Fish abundance	Very dense	Very low	
Fish species	*Cyprinus carpa* *Carasius alotus*	*Cyprinus carpa* *Carasius alotus*	
Dominant plants around of ponds	*1-Pterocarya fraxinifolia* *2-Salix sp.*	1-Taxus baccata 2-Quercus sp	

Tab. 3. List of the examined localities and basic environmental characteristics.

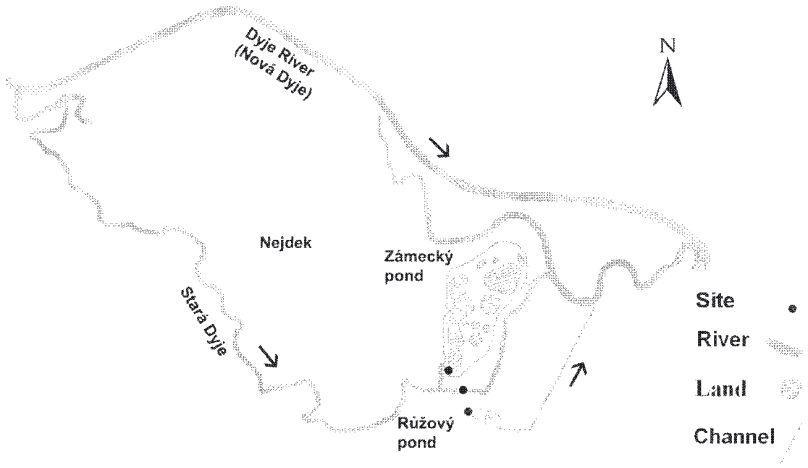


Fig. 1. Map of the study areas and sampling sites.

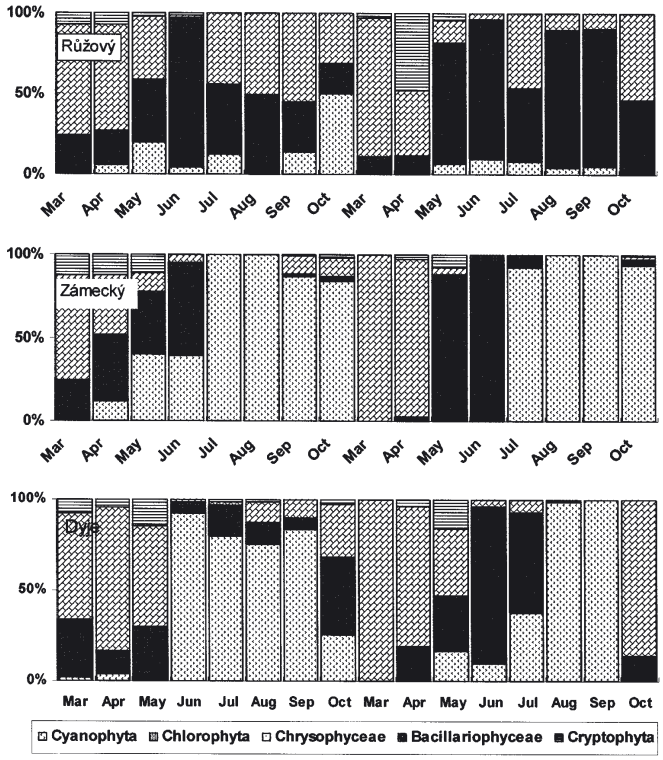


Fig. 2. Phytoplankton composition: bars represent the relative abundance computed from the monthly mean of five groups.

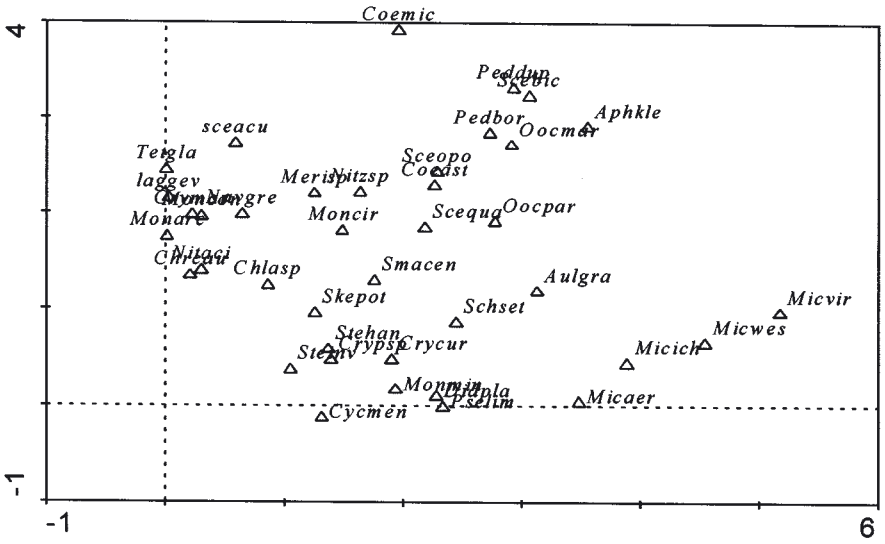


Fig. 3. Species distribution at different localities along the linear transects by DCA ordination. Species acronyms: *Anabaena flos-aquae* (Anaflo), *Aphanizomenon klebahnii* (Aphkle), *Aphanocapsa incerta* (Apains), *Merismopedia tenuissima* (Merten), *Botrycoccus brownii* (Botbro), *Microcystis aeruginosa* (Micaer), *M.viridis* (Micvir), *M. flos-aquae* (Micflo), *M. Wesenbergii* (Micwes), *Woronichinia naegeliana* (Wornae), *M.ichtyoblabe* (Micich), *Coelastrum microporum* (Coemic), *Koliella longiseta* (Kollon), *Synedra acus* (Synacu), *Surirella minuta* (Surmin), *Navicula tripunctata* (Navtri), *Euglena* sp. (Euglsp), *Euglena pisciformis* (Eugpis), *Dictyosphaerium subsolitarium* (Dicsub), *Gyrosigma acuminatum* (Gyracu), *Nitzschia gracilis* (Nitgrac), *Skeletonema potamos* (Skepot), *Cyclotella meneghiniana* (Cycmen), small centrales (Smacen), *Chroomonas caudata* (Chrcau), *Cymbella minuta* (Cymmin), *Coelastrum microporum* (Coemic), *Monoraphidium arcuatum* (Monarc), *Scenedesmus opoliensis* (Sceopo), *Scenedesmus quadricauda* (Scequa), *Tetrastrum glabrum* (Tetgla).

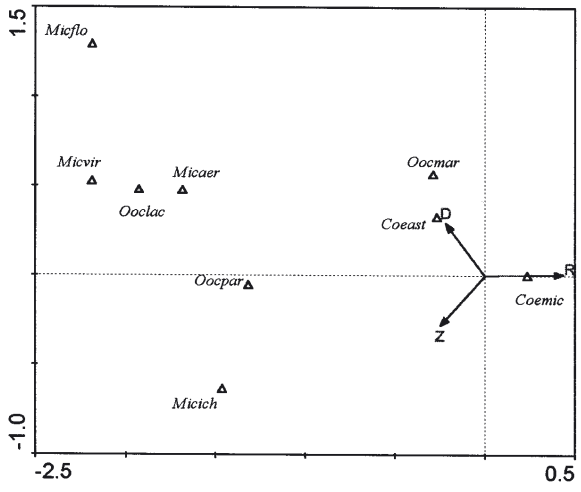


Fig. 4. CCA analysis of species found in different localities. (For the species acronomy see Fig. 3).

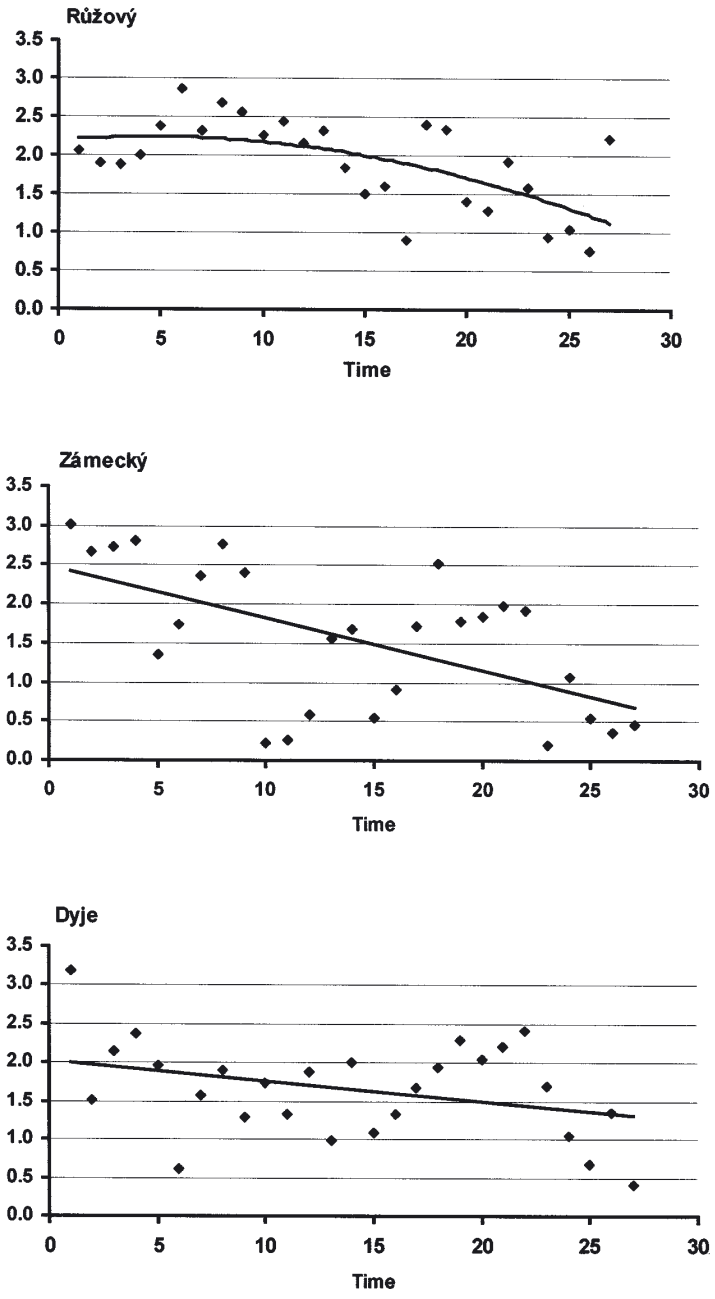


Fig. 5. Relationships of diversity with Pearson's correlation coefficient during vegetation season at study sites: time interval is two weeks, numbers 1–14 for year 2002 and 15–28 for year 2003. Results of significant estimates for linear regression are given in the text.

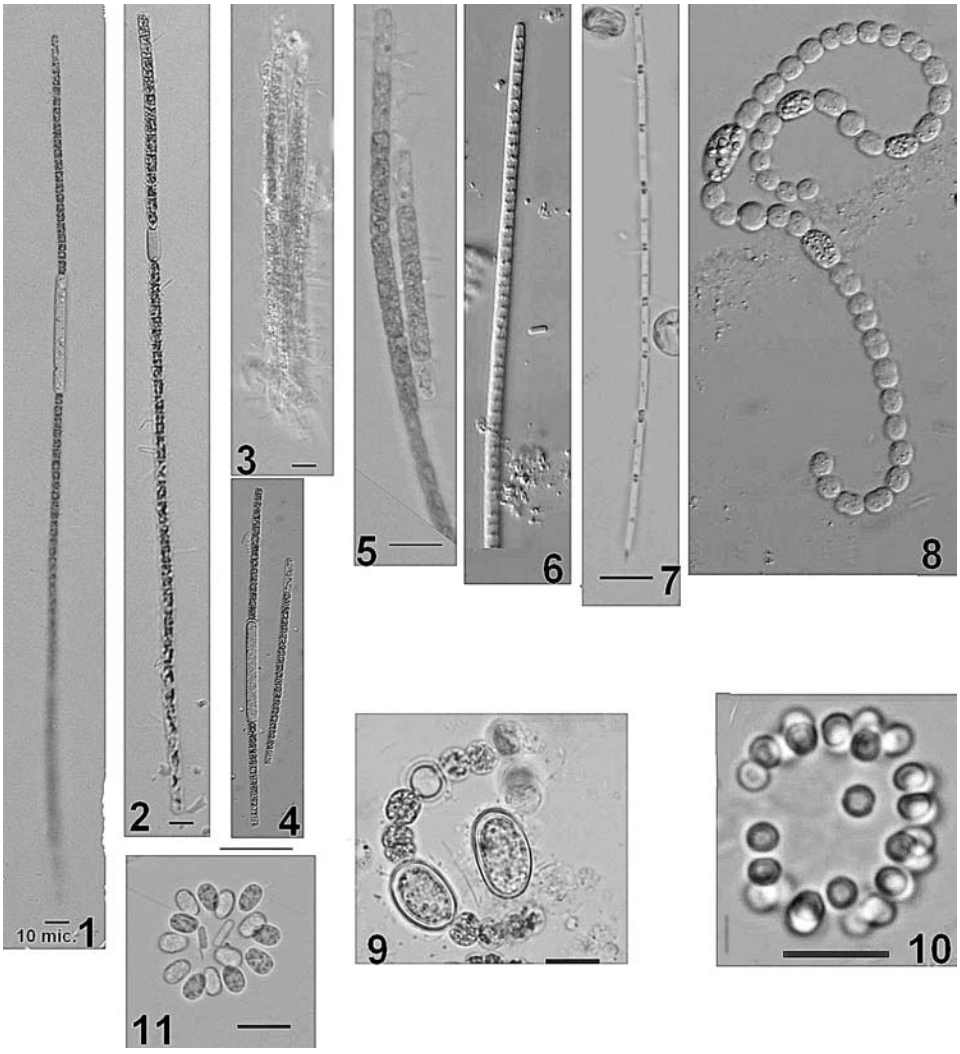


Plate 1. 1–4, *Aphanizomenon klebahnii*. 5, *Aphanizomenon* sp. 6, *Phormidium* sp. 7, *Limnothrix redekei*. 8–9, *Anabaena flos-aquae*, 400×. 10, *Snowella lacustris*. 11, Young coloni of *Woronichinia naegeliana*, *Synechococcum endogloeicus*.

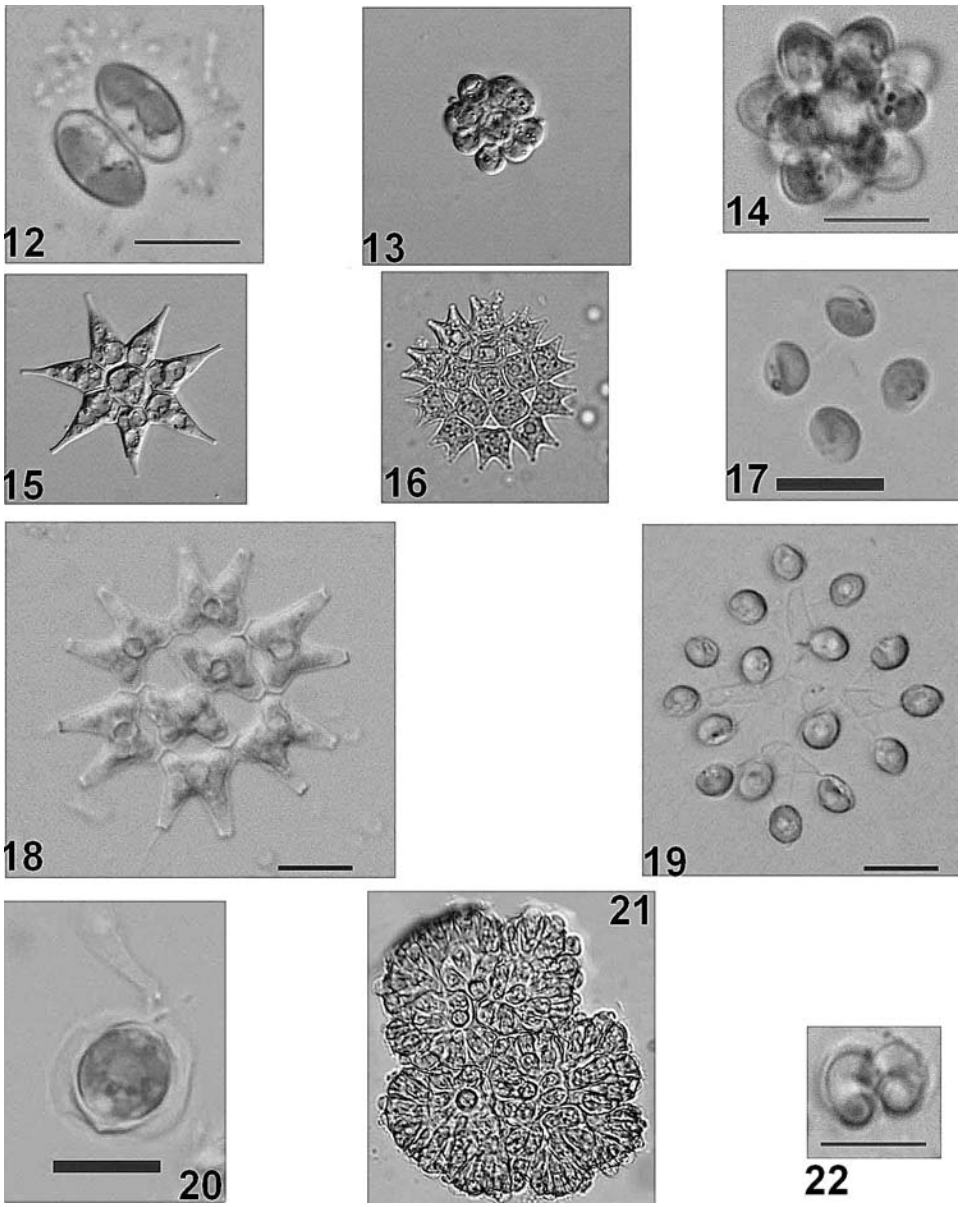


Plate 2. 12, *Dicellula* sp. according to the cell content and protoplasm it correspond the genus *Oocystis* because of join cells but without spines. Similar to cenobia cell from the genus *Tetrachlorella* which belong also probably to Oocystaceae type. 13, *Coelastrum microporum*. 14, *C. astroideum*. 15, *Pediastrum simplex*. 16, 18, *Pediastrum duplex*. 17, *Dictyosphaerium ehrenbergianum* 19, *Dictyosphaerium tetrachotomum*. 20, *Pteromonas* sp. 21, *Botryococcus braunii*. 22, *Kirchneriella obesa*.

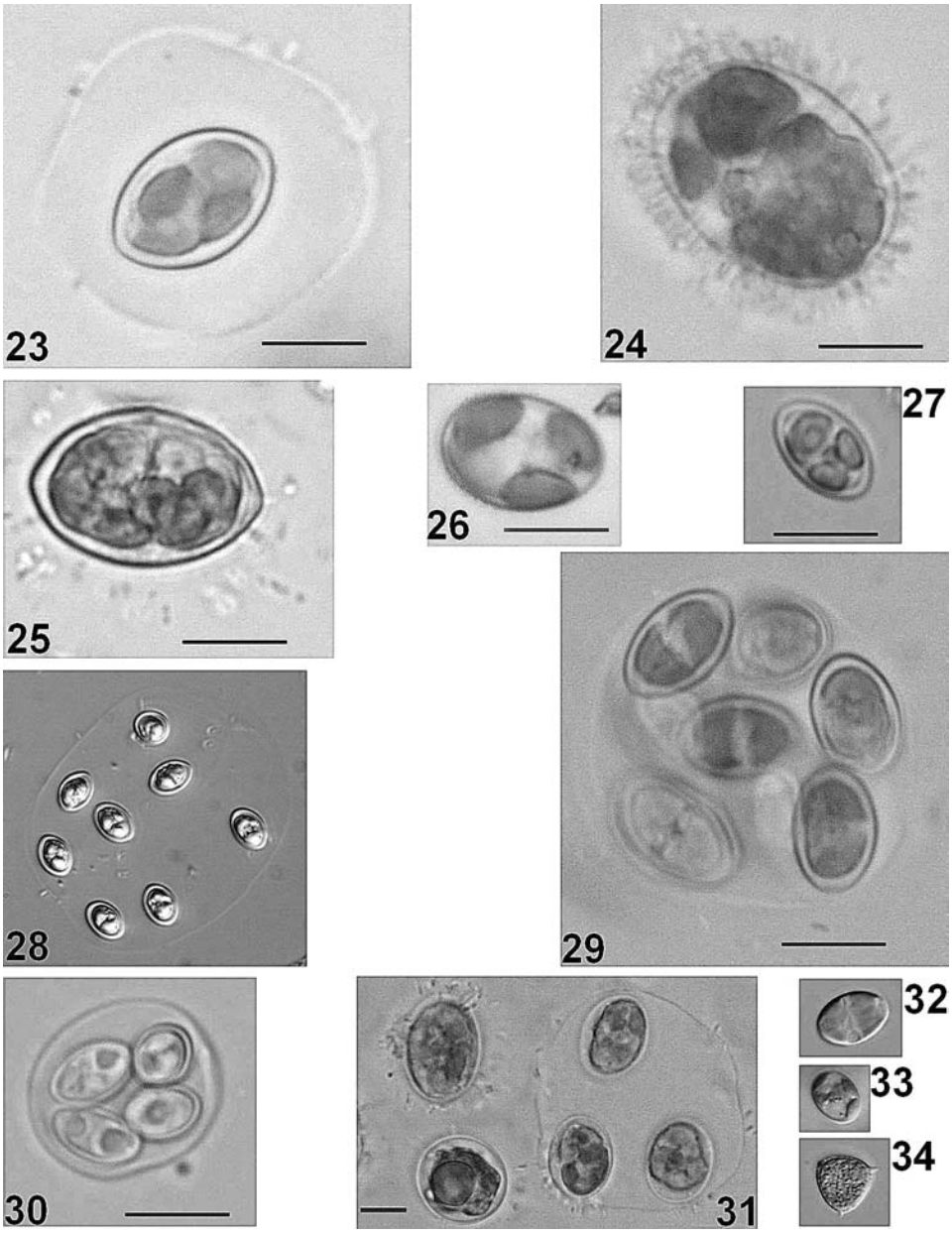


Plate 3. 23, 25, 26, 29, *Oocystis marssonii*. 27, 30, 32, *Oocystis parva*. 24, 31, *Oocystis borgeii*. 28, *Oocystis lacustris*. 33, *Oocystis* sp. 34, *Goniochloris* sp.

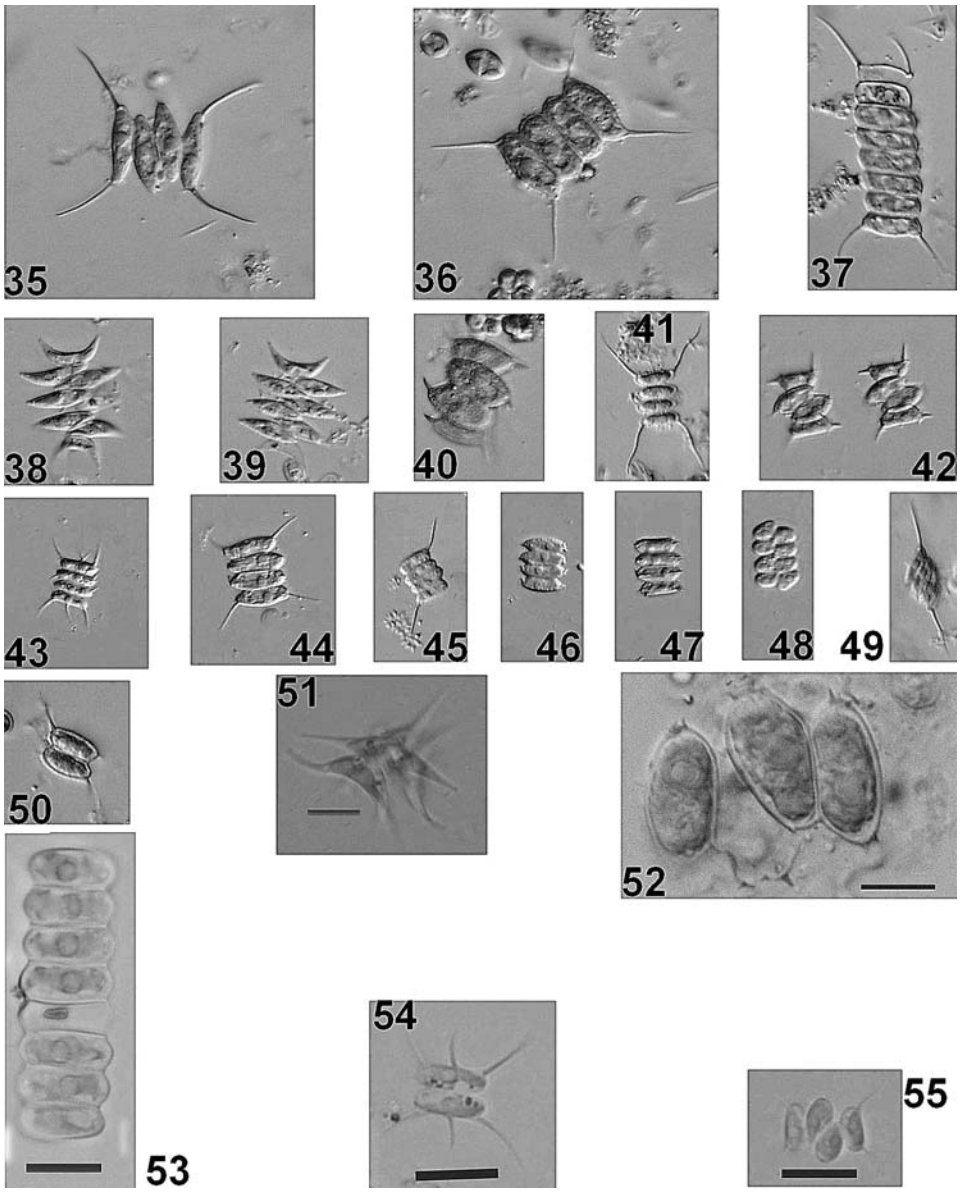


Plate 4. 35, *Desmodesmus opoliensis*. 36, 37, *Desmodesmus quadricauda*. 37, 38, *Scenedesmus acuminatus*. 40, *Desmodesmus pannonicus*. 41, *Desmodesmus* sp. 42, *Desmodesmus sp.* 43, *Desmodesmus semperviens.* 44, *Desmodesmus* sp. 45, 50, *Desmodesmus bicaudatus*. 46, *Desmodesmus pulloideus*. 47, *Desmodesmus praetervisus*. 48, *Scenedesmus disiformis.* 49, *Desmodesmus sp.* 51, *Tetradesmus wisconsinensis*. 52, *Desmodesmus smithii*. 53, *Scenedesmus linearis*. 54, *Desmodesmus spinosus.* 55, *Desmodesmus intermedius.*

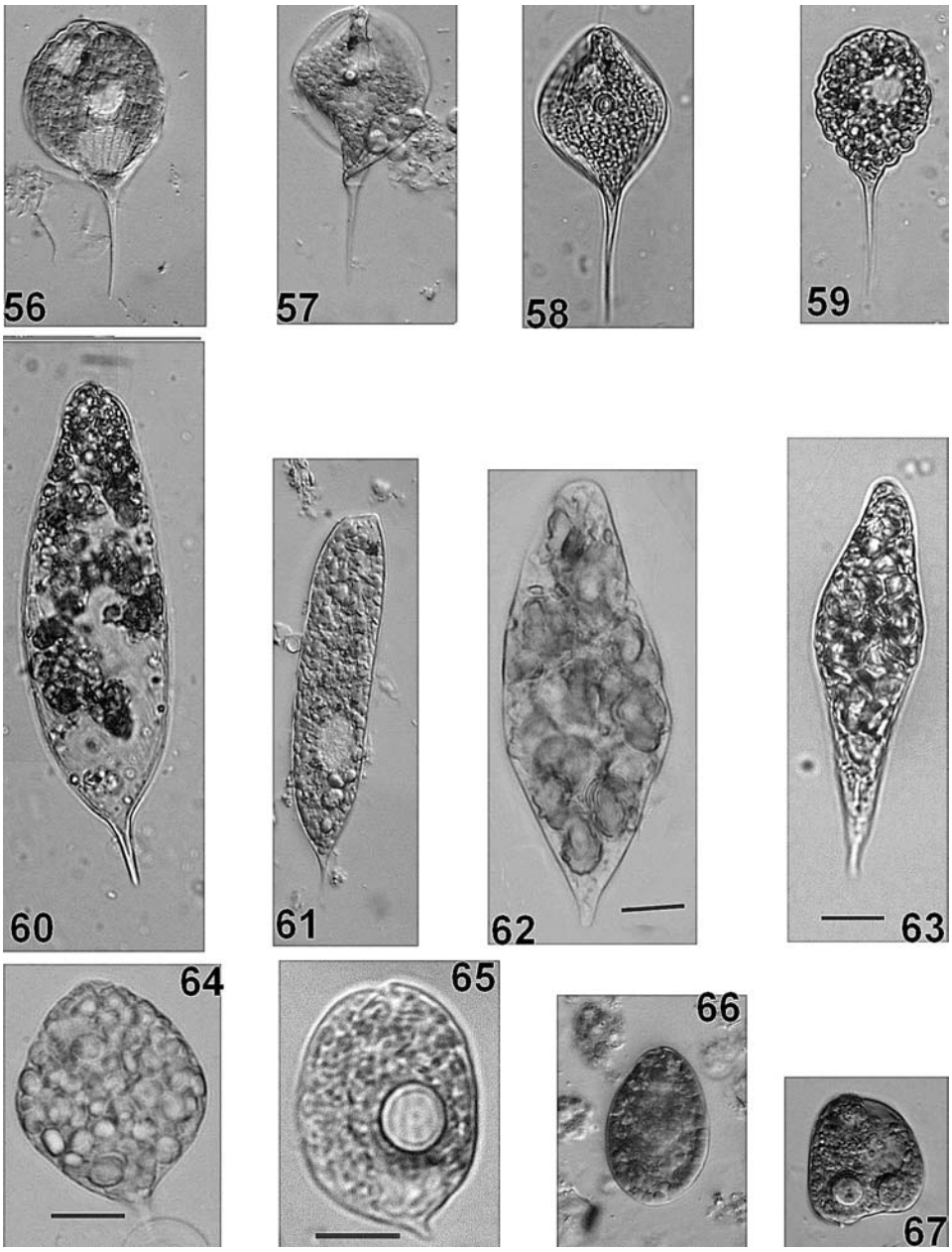


Plate 5. 56, 59, *Phacus longicauda*. 57, 58, *Phacus. tortus*. 60, *Euglena* sp. 61, *Euglena. tripteris*. 62, *Euglena viridis*. 63, *Euglena hemichromata*. 64, *Phacus cf. clavata.* 65, *Phacus acuminatus*. 66, *Lepocinclis texta*. 67, *Lepocinclis texta* (during reproduction).