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A hundred years of phycological research in the Lednice Ponds – the impact of environmental conditions on the development of cyanobacteria and algae

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KOPP R., SKÁCELOVÁ O., HETEŠA J., MARVAN P., BEŠTA T., ZAPOMĚLOVÁ E., STRAKOVÁ L. & BOHUNICKÁ M. 2012: A hundred years of phycological research in the Lednice Ponds – the impact of environmental conditions on the development of cyanobacteria and algae. *Acta Musei Moraviae, Scientiae Biologicae* (Brno) **97(1): 3–87**. – This study provides an overview of a long-term historical survey of the phytoplankton and phytobenthos in the Lednice Ponds, a National Nature Reserve. Historical work has been added to data collected by the authors. Previous to this work, information dating from the 1960s was collated only in the form of the final manuscripts of research reports. This study describes the dynamics of the algae and cyanobacteria within the context of the mode of management. The first records, from the 19th century, concern the occurrence of halophilous species and aquatic cyanobacteria blooms. In the period between the 20th century's two world wars, the ponds, being eutrophic, experienced regular blooms. In years of lower fish stocks, the massive occurrence of water macrophytes in the ponds facilitated a mass development of filamentous algae, including halophilous taxa. From the 1950s to the 1990s, fish stocks rose and massive eutrophication of the pond system took place, in which nanoplanktonic species became dominant. Starting in the 1990s, stocking of commercial-sized fish was gradually reduced and small, invasive fishes exploited the vacant niche, leading to reduction of the zooplankton. This tendency was especially marked after 2008. Cyanobacteria blooms occurred regularly once more, but their composition altered. The phytobenthos became less diversified than before, while increasing biodiversity was observed only in years with partial summer drying, or in the year after such drying. Microbiotopes have an important role to play in the conservation of biodiversity: microbiotopes with a phytobenthos or a metaphyton corresponding to lower fish stocks can still continue exist in ponds that otherwise feature high fish stocks, rich phytoplankton and blooms.

Keywords: algae, cyanobacteria, Lednice Ponds National Nature Reserve, Czech Republic

Characteristics of the area and its natural conditions

The Lednice Ponds are located in southern Moravia, east of Pálava and near the border with Austria in the land-registry area of Sedlec, Hlohovec, Lednice, Valtice, and Břeclav municipality. A system of four large ponds, named Nesyt (the largest of its kind in Moravia), Hlohovecký, Prostřední and Mlýnský, was built in what was originally a swampy area, in the early 15th century. Zámecký, a fifth big pond, is much more recent (its construction began in 1805) and is located in the gardens of the local stately home. In addition to these large bodies of water, the area is rich in smaller ponds, such as Výtopa, Podzámecký, and the Alachy system of forest pools located south of Prostřední Pond. In the 1950s, a complex of eight fish nurseries ponds was added, below Nesyt Pond.

Geologically, the area is made up of sandy-loamy fluvial sediments with occasional pebbles (flood clay) and the sediments of man-made water reservoirs. Soluble salts are washed out of a Tertiary marine sediment and affect the surface layers of soil and water in the ponds they contain. The Lednice Ponds have a specific chemistry arising out of salinisation, consisting of a high concentration of dissolved substances and high initial natural production. The presence of saline soils allows the occurrence of halophytic vegetation on the western banks of Nesyt Pond. Geomorphologically, the area lies in the western part of the Dolnomoravský úval graben and is located in the downlands known as the Valtická pahorkatina, in the Nesytská lowland part, which is characterized by elongated depressions in neogene sediments.

The area investigated is part of the basin of the River Dyje. The system of ponds is located on a right-hand tributary of the Dyje, a stream called the Včelínek (Mikulovská

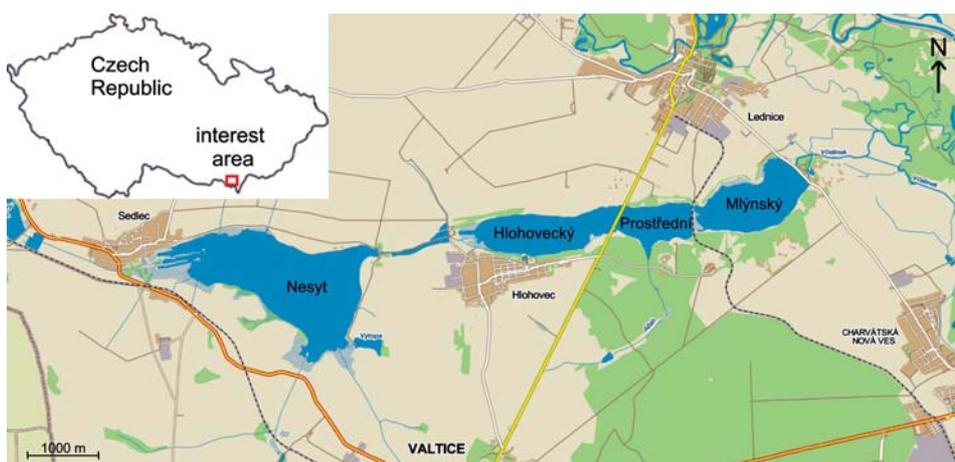


Fig. 1. Map of the area studied.

strouha). One part of this area falls within a zone of protection for natural water accumulation associated with the River Morava. The ponds lie at an altitude of around 160 metres above sea level. The system consists of four large ponds occupying a total area of 552 ha, located in a natural basin that falls away from west to east (Fig. 1). The basic parameters of the ponds are summarized in Table 1. The main feeder stream is about 15 km long, under occasional regulation and connecting all major ponds, so the system is endowed with a certain flow. However, the low rate of this flow means that the water level is largely dependent on rainfall. For this reason, BAYER & BAJKOV (1929) coined the epithet “heaven ponds” for the system.

This area has a warm climate, with a long, warm, dry summer, swift transitional periods and a short, mild, very dry winter during which the snow cover does not last long (QUITT 1971). The vegetation period covers 175 days, with an overall sum of rainfall during the growing period of 342.2 mm, and an average annual rainfall of 516.6 mm. The sum of active temperature is 2800°C.

The Lednice Ponds lie in a first-grade oak vegetation zone. In terms of phytogeographical distribution they are part of the thermophyticum, Pannonian phytogeographical area (Pannonicum), phytochorion no. 18: the southern Moravian graben. The wider surroundings of the pond system are made up of extensive agrocoenoses with only minor representation of permanent vegetation formations. To the south of the ponds lies a large forest complex on sandy subsoil. All the ponds are usually lined with continuous belts of willow and other species, which occasionally descend into the shallows, especially in the tributary parts of the ponds.

The area of the Lednice Ponds is a varied mosaic of phytocoenoses, divided among several unions: *Salicion albae* (Oberdor.) Th. Müll. et Görs, *Phragmition communis* Koch, coastal *Humulo-Polygonion dumetorum* Pass vegetation, communities of high sedges (especially the *Caricion gracilis* Neuh. union), communities of floating plants (*Lemnion minoris* de Bolós et Masclans union), submerged plants (*Potamion* Miljan), exposed pond-bed vegetation (*Nanocyperion* Koch ex Malcuit), communities of annual weed species (*Bidention tripartiti* Nord. em. R. Tx. in Poli et J. Tx and *Agropyro-Rumicion* Nord.), communities inhabiting the area of low coastline towards the water (*Scirpion maritimi* Dahl et Hadač) and communities associated with deeper water (*Oenanthion aquaticae* Hejný ex Neuh.).

Tab. 1. Main characteristics of the Lednice ponds.

Pond	Cadastral area (ha)	Water area (ha)	Average depth (m)	Maximum depth (m)
Nesyt	289	250	1.50	4.18
Hlohovecký	104	94	1.15	3.00
Prostřední	52	45	1.00	2.71
Mlýnský	107	100	1.02	2.95

The major representatives of the aquatic macrophytes in Nesyt Pond are *Batrachium baudotii* (Godr.) F.W. Schultz and *Batrachium rionii* (Lagger) Nyman. Exposed bottom hosts, for example, *Samolus valerandii* L. and *Chenopodium chenopodioides* (L.) Aellen. In the area of saline soils, in the western part of Nesyt (a substantial part of the area is declared a nature reserve, as NNR Slanisko u Nesytu), *Juncus gerardii* Loisel., *Scorzonera parviflora* Jacq., and *Taraxacum bessarabicum* (Hornem.) Hand.-Mazz. have been found (FORMÁNEK *et al.* 2005).

The area is a unique ornithological locality of international importance. For many bird species, it is an important nesting and sanctuary area (especially the stands of reeds), and a stopover on major migratory routes. The ponds were already partially protected at the time of aristocratic Lichtenstein ownership. Birds were hunted only rarely and the owners were probably preserving the area as a “hunting reserve” as early as the 17th century. In the 1920s, a biological station was established in Rybniční zámeček [“Castle Pond”] to study its biota. The area was declared a State Nature Reserve in 1953. Since 1990, the Lednice Ponds have been recognized as wetlands of international importance, known as the Ramsar site. In 1992, the area was re-categorized from “State Nature Reserve” to “National Natural Reserve”. In 1996, the area known as the “Lednicko-Valtický areál”, which includes the Lednice NNR Ponds was listed as part of the UNESCO World Cultural and Natural Heritage and since 2003 it has been a part of the Lower Moravia Biosphere Reserve. Government regulation No 601/2004 Coll., 27.10.2004, brought the Lednice Ponds Bird Sanctuary into existence. Regulation No 301/2007 Coll. established an “Important European Locality” in the area of the Nesyt, Hlohovecký, Prostřední and Mlýnský Ponds.

Fishery management

The landlocked areas now covered by the Czech Republic have long relied on the *rybník* for the production of freshwater fish for the table. A constant feature of the Czech countryside, a *rybník* is a man-made and closely-managed stewpond that may occupy an area from that of a village pond to that of a substantial lake. For the remainder of this article, the term “pond” should be understood in this context. The first of these ponds appeared in historical records, at quite a high level of sophistication, in the 15th century, although an exact time for the establishment of Nesyt Pond remains to be found. It first appears in formal records in 1418, already under the administration of the Lichtenstein estate (Hurt 1960). The three other major ponds at Lednice were created later. From the very beginning, the fishponds were used for breeding and raising carp (*Cyprinus carpio* L.), predatory fish such as pike (*Esox lucius* L.) for the table and other species, such as crucian carp (*Carassius carassius* L.), which served as prey (SCHILLER 1924).

In the 15th century, the fishponds were closely maintained, without assisted fertilization or extra feeding, and harvested largely at intervals of once every 3–4 years. We can only guess at the size of the fish stock, since the harvest was counted by the heap, but at the end of the 17th century annual production was about 100 kg of fish per surface

hectare. Historical sources indicate that the water-masters had regularly to deal with quite strong inflows of mud (VÁCLAVÍK 1924). In the 19th century, fish species preference turned to the production of zander (*Sander lucioperca* L., also known as pike-perch) and tench (*Tinca tinca* L.), since the markets of nearby Vienna favoured them.

In this period, a three-year harvest cycle was introduced and annual production reached 65 to 100 kg per surface hectare. In 1896, the three-year cycle gave way to a two-year cycle and production increased significantly. SCHILLER (1924) records that the average annual production of the ponds in the 1920s and 1930s was 140–190 kg per surface hectare and that the ponds were drained and summer-dried every seven years. The Liechtenstein estates were confiscated by the state in 1945. Pond management was passed to the “State Fisheries Enterprise”, which administered them until the early 1990s.

State enterprise squeezed even more out of the waters, reducing the two-year cycle to a single year. At the end of the 1950s, annual production ranged between 200 kg and 340 kg per surface hectare (LOSOS & HETEŠA 1971). Winter draining and summer drying of the ponds ceased and was replaced by the addition of mineral fertilizers. A further increase in fish stocks occurred during the 1970s and 1980s, with the breeding of introduced species of herbivorous fish such as grass carp (*Ctenopharyngodon idella* Val.), silver carp (*Hypophthalmichthys molitrix* Val.) and bighead carp (*H. nobilis* Rich.); feeding was intensified still further. More nutrients were also supplied by waste water from the surrounding municipality and running off from carp-duck farming in Nesyt (until 1994). At the end of the nineties, annual production was around 750–1150 kg per surface hectare (HETEŠA *et al.* 1994). During the 1990s, fish farming became the responsibility of the nature protection authorities. Administration of the Protected Landscape Area (PLA) tightened the supervision of the area of the Lednice Ponds and set new conditions for their management, with sweeping changes of approach intended to restore the species diversity of the reservation. Since the early nineties, summer drying (lowering of the water level) has returned to some of the ponds, while the breeding and raising of herbivorous grass carp have been prohibited, at the same time as reducing supplementary feeding and limiting the number of fish. The production of the ponds fell away steadily, and in 2004–2008 annual totals were only around 20–650 kg per surface hectare. Sharp limitation of carp stocking led to an increase in unwanted species of fish, such as the goldfish, or Prussian carp (*Carassius gibelio* Bloch), also known as the silver crucian carp, which is undesirable in the ecosystem of the Lednice Ponds.

In general terms, the Lednice Ponds may be considered as very productive, although the average increment of carp decreases from the Nesyt to the Mlýnský Ponds. It has been confirmed that Nesyt is the most fertile pond in the system and Mlýnský the least. This state was first published by BAYER & BAJKOV (1929) and confirmed by LOSOS & HETEŠA (1971). Supplementary feeding and intensive fertilizer use increase fish production and lead to a levelling-off in production capacity. These attempts at optimizing production, together with various approaches to the numbers and ages of fish stock, have a significant impact on the biological and physico-chemical characteristics of the pond water.

The physico-chemical characteristics of the Lednice Ponds

The average values of the physico-chemical parameters for the Lednice Ponds monitored to date are shown in Tables 2–9. The first to address the water chemistry of the ponds were Rzehak and Kornhaut, whose data were first quoted by ZIMMERMANN (1923). These authors found high levels of sulphates and chlorides in the system. The first comprehensive account of the water chemistry was published by JIROVEC (1936), who also confirmed a high content of salts. He characterized the ponds as highly eutrophic, rich in organic matter and with a high calcium content. The observed sulphate content increased

Tab. 2. Physical parameters of the outflow from Nesyt Pond (average vegetation season).

Source	Date	Oxygen (%)	pH	Conductivity (mS/m)	Transparency (cm)
JIROVEC (1936)	1933-1935	-	8.45	-	-
LOSOS AND HETEŠA (1971)	1957-1959	-	8.40	-	-
VOLFOVÁ (1960)	1959	-	8.47	-	90
ÚLEHLOVÁ & REJTHAR (1973)	1969-1970	-	7.32	-	-
LUKEŠ (1988)	1986-1987	49.6	8.29	-	-
HETEŠA <i>et al.</i> (1994)	1992-1994	66.1	8.39	108.3	21
SUKOP & KOPP (2001)	2001	105.6	8.73	130.5	21
SUKOP & KOPP (2002a,b)	2002	115.8	8.68	127.8	34
Kopp (unpublished)	2005	72.0	8.72	131.7	35
Kopp (unpublished)	2006	93.1	8.61	125.5	25
Kopp (unpublished)	2007	66.3	8.42	163.1	35
Kopp (unpublished)	2008	63.0	8.31	153.1	73
Kopp (unpublished)	2009	96.7	8.57	114.9	57
Kopp (unpublished)	2010	82.2	8.68	127.0	73
Kopp (unpublished)	2011	95.6	8.54	134.8	57

Tab. 3. Physical parameters of the outflow from Hlohovecký Pond (average vegetation season).

Source	Date	Oxygen (%)	pH	Conductivity (mS/m)	Transparency (cm)
JIROVEC (1936)	1933-1935		8.70		
HETEŠA (1962)	1954-1955	103.0	7.38		
LOSOS & HETEŠA (1971)	1957-1959		8.30		
VOLFOVÁ (1960)	1959		8.49		> 100
URBÁNKOVÁ (1987)	1986-1987	> 100	8.40		
HETEŠA <i>et al.</i> (1994)	1992-1994	88.4	8.75	109.0	22
SUKOP & KOPP (2001)	2001	114.4	8.65	126.7	103
SUKOP & KOPP (2002b)	2002	105.6	8.47	134.2	145
Kopp (unpublished)	2005	75.8	8.67	143.8	67
Kopp (unpublished)	2006	89.3	8.48	128.4	37
Kopp (unpublished)	2007	82.1	8.82	140.2	42
Kopp (unpublished)	2008	74.0	8.62	156.3	54
Kopp (unpublished)	2009	106.6	8.57	133.2	46
Kopp (unpublished)	2010	70.5	8.54	127.6	136
Kopp (unpublished)	2011	83.9	8.32	134.7	97

steadily from Nesyt to Mlýnský while, in contrast, the highest amount of organic matter was established in Nesyt, a result of its receiving a greater influx of waste waters.

LOSOS & HETEŠA (1971) monitored the physico-chemical parameters of the Lednice ponds in 1957–1959. They found no significant differences between the ponds and, compared to the previous results (JÍROVEC 1936), the alkalinity of all the ponds had increased. Further, due to a higher buffering capacity, the average pH values had dropped. Between 1970 and 1972 MARVAN & SLÁDEČEK (1974) investigated sources of water pollution in Nesyt Pond and described its water quality as β -mesosaprobic. However, in

Tab. 4. Physical parameters of the outflow from Prostřední Pond (average vegetation season).

Source	Date	Oxygen (%)	pH	Conductivity (mS/m)	Transparency (cm)
JÍROVEC (1936)	1933-1935		8.75		
HETEŠA & LOSOS (1962)	1957	90.2	7.43		55
LOSOS & HETEŠA (1971)	1957-1959		8.40		
VOLFOVÁ (1960)	1959		8.48		>100
URBÁNKOVÁ (1987)	1986-1987	>100	8.80		
HETEŠA <i>et al.</i> (1994)	1992-1994	84.6	8.50	107.0	23
SUKOP & KOPP (2001)	2001	85.0	8.41	123.8	150
SUKOP & KOPP (2002b)	2002	148.9	8.75	128.5	77
Kopp (unpublished)	2005	77.2	8.66	139.5	65
Kopp (unpublished)	2006	104.5	8.70	122.3	47
Kopp (unpublished)	2007	65.0	8.93	130.4	50
Kopp (unpublished)	2008	77.2	8.86	132.4	58
Kopp (unpublished)	2009	86.9	8.47	126.3	135
Kopp (unpublished)	2010	90.7	8.61	125.6	74
Kopp (unpublished)	2011	85.1	8.49	133.9	90

Tab. 5. Physical parameters of the outflow from Mlýnský Pond (average vegetation season).

Source	Date	Oxygen (%)	pH	Conductivity (mS/m)	Transparency (cm)
JÍROVEC (1936)	1933-1935		8.55		
LOSOS & HETEŠA (1971)	1957-1959		8.30		
VOLFOVÁ (1960)	1959		8.51		>100
URBÁNKOVÁ (1987)	1986-1987	>100	8.85		
HETEŠA <i>et al.</i> (1994)	1992-1994	94.2	8.48	90.0	39
SUKOP & KOPP (2001)	2001	110.0	8.70	122.6	84
SUKOP & KOPP (2002b)	2002	109.3	8.67	130.6	95
Kopp (unpublished)	2005	83.1	8.67	135.7	25
Kopp (unpublished)	2006	103.8	8.66	116.6	42
Kopp (unpublished)	2007	65.1	8.65	134.1	60
Kopp (unpublished)	2008	80.4	8.68	132.1	85
Kopp (unpublished)	2009	91.3	8.51	131.8	144
Kopp (unpublished)	2010	95.5	8.79	117.0	126
Kopp (unpublished)	2011	82.5	8.54	132.1	113

1971 the values of nitrogen and phosphorus became very high in the littoral during the vegetation season. They reached more than 2 mg/l for total phosphorus and 3 mg/l for total nitrogen at the end of the vegetation season (DVOŘÁK 1973). In the following years, the physico-chemical parameters of the Lednice Ponds were monitored, largely by students working on diploma theses. Pollution and eutrophication of Nesyt in 1986 and 1987 were examined by LUKEŠ (1988) and the other three ponds were described by

Tab. 6. Chemical parameters of the outflow from Nesyt Pond (average vegetation season, by various authors, edited).

Nesyt Pond parameter	unit	Date					
		1923–1935	1957–1959	1969–1975	1986–1987	1992–1994	2005–2007
N-NH ₄	mg/l		0.19	0.88	2.42	0.41	0.98
N-NO ₂	mg/l				0.090	0.020	0.007
N-NO ₃	mg/l	0.01	0.02	0.24	1.07	1.51	1.56
P-PO ₄	mg/l		0.29	1.24	0.94	0.81	0.25
N _T	mg/l		0.5	1.45	6.0		4.2
P _T	mg/l				1.46		0.91
COD _{Mn}	mg/l	28.5	16.2	12.5	14.6	33.1	26.4
COD _{Cr}	mg/l				67.4		82.7
ANC	mmol/l	4.98	7.36	7.11	6.44	8.50	4.05
Ca	mg/l		66	73	104	110	121
Mg	mg/l		85	49	68	76	108
Cl ⁻	mg/l	44.0	50.4	57.9	70.0	145.0	127.9
SO ₄	mg/l	299	291	215		370	534
Fe	mg/l	0.11	0.08		0.26	0.90	> 0.04
K	mg/l		34.6	30.6			25.0

Tab. 7. Chemical parameters of the outflow from Hlohovecký Pond (average vegetation season; various authors, edited).

Hlohovecký Pond parameter	unit	Date				
		1923-1935	1954-1959	1986-1987	1992-1994	2005-2007
N-NH ₄	mg/l		0.12	0.54	0.45	0.43
N-NO ₂	mg/l			0.070	0.020	0.006
N-NO ₃	mg/l	0.00	0.10	1.46	1.33	1.64
P-PO ₄	mg/l		0.48	0.34	0.77	0.25
N _T	mg/l		0.4	5.3		2.2
P _T	mg/l					0.55
COD _{Mn}	mg/l	15.1	34.6	20.0	37.7	16.4
COD _{Cr}	mg/l					52.7
ANC	mmol/l	5.80	6.37	6.20	8.00	5.78
Ca	mg/l		60	44	125	103
Mg	mg/l		91	130	48	95
Cl ⁻	mg/l	40.1	49.9	75.0	115.0	102.9
SO ₄	mg/l	465	271		245	391
Fe	mg/l	0	0.01		0.75	> 0.04
K	mg/l		31.6			20.0

URBÁNKOVÁ (1987). Nesyt Pond was heavily polluted by untreated sewage from the surrounding municipalities and by fertilizer runoff. A duck farm also had a considerable negative impact on water quality. LUKEŠ (1988) characterized the water in Nesyt as heavily contaminated, often reaching an α -mesosaprobic level. The values of the chemical parameters were qualitatively worse, the figures for phosphorus and nitrogen increased, partly due to connection of the pond to an irrigation system (after 1974), and

Tab. 8. Chemical parameters of the outflow from Prostřední Pond (average vegetation season; various authors, edited).

Prostřední Pond parameter	unit	Date				
		1923-1935	1957-1959	1986-1987	1992-1994	2005-2007
N-NH ₄	mg/l		0.16	0.42	0.51	0.71
N-NO ₂	mg/l			0.020	0.020	0.018
N-NO ₃	mg/l	0.00	0.20	0.18	1.91	1.53
P-PO ₄	mg/l		0.31	0.33	0.89	0.19
N _T	mg/l		1.7	3.6		2.2
P _T	mg/l					0.45
COD _{Mn}	mg/l	27.6	15.7	17.7	43.0	15.7
COD _{Cr}	mg/l					52.3
ANC	mmol/l	3.95	6.26	6.20	7.70	5.75
Ca	mg/l		59	56	110	84
Mg	mg/l		90	105	64	93
Cl ⁻	mg/l	39.6	45.4	70.0	115.0	98.6
SO ₄	mg/l	364	266		245	353
Fe	mg/l	0	0.07		1.70	> 0.04
K	mg/l		28.9			20.0

Tab. 9. Chemical parameters of the outflow from Mlýnský Pond (average vegetation season; various authors, edited).

Mlýnský Pond parameter	unit	Date				
		1933-1935	1957-1959	1986-1987	1992-1994	2005-2007
N-NH ₄	mg/l			0.46	0.36	1.01
N-NO ₂	mg/l			0.010	0.020	0.010
N-NO ₃	mg/l	0.01	0.17	0.10	1.87	1.58
P-PO ₄	mg/l		0.18	0.29	1.02	0.11
N _T	mg/l		1.0	4.2		2.2
P _T	mg/l					0.30
COD _{Mn}	mg/l	20.2	17.4		49.4	15.3
COD _{Cr}	mg/l					62.0
ANC	mmol/l	3.45	6.21	5.55	6.90	5.58
Ca	mg/l		59	54	110	75
Mg	mg/l		87	96	70	99
Cl ⁻	mg/l	45.3	46.6	69.0	115.0	102.3
SO ₄	mg/l	474	257		245	344
Fe	mg/l	0.03	0.07		0.75	> 0.04
K	mg/l		25.9			20.0

to drainage of water rich in nutrients from river Dyje. The increase in nutrient content and lowering of the water quality were reported in three other low-lying ponds (URBANKOVÁ 1987).

In 1992, the prices of irrigation water increased sharply and consequently pumping from the River Dyje ceased. In the same year, a waste-water treatment plant for town of Mikulov came into commission and the quality of the inflow water to Nesyt Pond improved. There was a marked intensification of fish farming and the water chemistry of the Lednice Ponds changed. The total salinity increased significantly, especially the calcium and chloride content. The number of organic compounds and biogenic elements rose as well, while high fish stocks kept water transparency permanently low (HETEŠA *et al.* 1994).

In the last fifteen years, fish stocks have been lowered and the water transparency has increased. The levels of dissolved oxygen and pH have been unstable due to rapid trophic changes and high primary production. Nutrient content has also remained high. The values of phosphorus have clearly shown that, despite a decline, it is not a limiting factor for production in the Lednice Ponds. In comparison with the previous detailed monitoring of the Lednice Ponds, in 1992–1994 (HETEŠA *et al.* 1994), the water quality has largely improved in recent years. The quantity of organic substances in the ponds has fallen significantly, as have as the amounts of phosphorus, calcium, magnesium, potassium, and chlorides, as well as water alkalinity. These changes can largely be attributed to improvements in the treatment of waste water from surrounding villages, reductions in agricultural and fisheries production, and cessation of artificial fertilization and supplementary fish feeding in the ponds.

Basic chemical characteristics of the sediments in the Lednice Ponds

The sediments in the Lednice Ponds were analyzed in 2007 and 2008 to check the availability of essential biogenic elements (C, N, P). The measurements centred exclusively on the content of those elements that can be released into the aquatic environment under routine living conditions, not on the gross content of the individual components of the sediment. The total content of each element in dry sediment is much higher.

A mixed sediment sample (0–10 cm) was taken from three different parts of each pond three times during each vegetation season. Based on the standard ČSN EN 12457-4 procedure, an aqueous extract was prepared at a liquid:solid ratio of 10:1 (the solid sample was converted to dry weight at 105°C). Extraction was made by smoothly rotating the bottles (“head-over-heels rotation”) at a rate of 10 rpm at 23°C for 24 hours. The subsequent separation of liquid and solid parts employed membrane filters with a pore size 0.45 µm. The calculations were converted to dry weight of sediment and the results are listed in Table 10. Quite marked differences in the content of extractable substances were disclosed, with significantly higher values from Nesyt and Mlýnský compared to Hlohovecký and Prostřední Ponds.

Significant differences also emerged at the various sampling dates during the vegetation season. Phosphorus, which is usually a limiting factor for production

processes in aquatic ecosystems, was excessive in the sediments of Nesyt and Mlýnský and the limiting factor in them was therefore more probably nitrogen or carbon. However, chemical analysis and the ratios of biogenic elements in water are decisive. The results for chemical oxygen consumption (CODCr) and organic carbon (TOC) indicated high levels of organic matter in the sediments. Calcium levels were also higher, which corresponds with the properties of the geological subsoil of the Lednice Ponds. Similar results were acquired by LOSOS & HETEŠA (1971) in their analysis of the sediments of Prostřední Pond. REJTHAR & ÚLEHLOVÁ (1973) reported an analysis of sediments from Nesyt Pond. They cited no exact methodology for the analysis, but it may be inferred that a procedure for the determination of total content of all substances, rather than one examining only the extractible part, was employed. The figures for mineral content were significantly higher, while the values for dry matter, ammonium nitrate and phosphates were consistent with our values. However, their nitrogen and calcium values were approximately 10 times higher than those disclosed by our work. High levels of

Tab. 10. Physico-chemical characteristics of the sediments in the Lednice ponds, 2007–2008 (Mean \pm SD, in mg/kg of dry weight of sediment).

Pond		Nesyt	Hlohovecký	Prostřední	Mlýnský
dry matter	%	42.2 \pm 17.7	67.7 \pm 9.3	67.1 \pm 14.1	36.5 \pm 8.3
pH		8.10 \pm 0.32	8.07 \pm 0.47	8.26 \pm 0.40	8.32 \pm 0.42
TOC	mg/kg	479 \pm 225	148 \pm 58	207 \pm 46	337 \pm 79
N-NH ₄	mg/kg	84.1 \pm 73.9	9.1 \pm 3.9	5.4 \pm 3.5	30.8 \pm 25.0
N-NO ₂	mg/kg	0.13 \pm 0.09	0.74 \pm 0.82	1.03 \pm 0.75	0.11 \pm 0.07
N-NO ₃	mg/kg	1.8 \pm 0.9	10.6 \pm 10.4	18.6 \pm 11.3	2.6 \pm 1.5
P-PO ₄	mg/kg	30.2 \pm 21.2	0.8 \pm 0.7	1.3 \pm 0.3	8.1 \pm 5.2
CODCr	mg/kg	513 \pm 142	213 \pm 67	336 \pm 157	524 \pm 72
N _T	mg/kg	113 \pm 89	20 \pm 6	18 \pm 5	53 \pm 28
P _T	mg/kg	35.4 \pm 24.6	1.6 \pm 0.3	2.2 \pm 0.6	10.5 \pm 5.1
Ca	mg/kg	238 \pm 18	475 \pm 36	328 \pm 47	275 \pm 6

ammonium nitrate and low levels of nitrite and nitrate are typical of eutrophic waters. Generally, in terms of basic nutrients, the sediments of the Lednice Ponds may be categorized as nutrient-rich.

The composition and dynamics of the Lednice Ponds (phytoplankton and phytobenthos)

Phycologists first turned their attention to the Lednice Pond system in the late 19th century. The earliest data on the microscopic cyanobacteria and algae of the locality were published by KALMUS (1863) and NAVE (1864); LEONHARDI (1864) concentrated on the charophytes.

Among the cyanobacteria, the observers noticed conspicuous, slimy, macroscopic epiphytic colonies of *Gloeotrichia salina* (Kütz.) Rabenh. (KALMUS 1863, NAVE 1863), syn. *Gloeotrichia natans* Rabenh. (FISCHER 1920), covering the submerged plants of oligotrophic waters. This cyanobacterium is no longer found at the locality; nor are several previously-reported charophyte species: *Chara aspera* Willd., *Ch. contraria* A. Braun ex Kütz., and *Tolypella glomerata* (Desv.) Leonh. (LEONHARDI 1863, data appearing in a collation by ČELAKOVSKÝ 1883). The occurrence of both *Gloeotrichia* and charophytes indicate a lower trophic level for the Lednice Ponds in the distant past.

On the other hand, species common in mesotrophic and eutrophic waters, and also quite common at present, were also recorded, e.g. the planktonic coccoid cyanobacterium *Microcystis aeruginosa* (Kütz.) Kütz., the benthic filamentous *Oscillatoria limosa* Ag. ex Gom., the diatoms *Cymbella prostrata* (Berk.) Cl. (syn. *Encyonema prostratum* (Berk.) Kütz.) and *Synedra tabulata* (C.Agardh) Kütz. (the authors probably meant today's *Tabularia fasciculata* (C.Agardh) D.M.Williams et Round or *T. fasciculata* spec. agg.). Apart from the cyanobacteria and charophytes, the macroscopic green thalli of some *Enteromorpha* (ZAPLETÁLEK, 1932, referred them as *E. tubulosa* J.Agardh, *E. interstitialis* (L.) Grev. and *E. prolifera* J.G.Ag., but, the species is probably identical with *Ulva flexuosa* ssp. *pilifera* (Kütz.) as today referred), while burgeoning microscopic research at the time led to the largest group of brown algae, the diatoms. Floristic research into the diatoms not only provided insight into the spectacular world of microstructures, it also provided information on the trophic state of the waters at that time. The earliest records from the Lednice Ponds include *Gyrosigma spenceri* (W.Sm.) Cleve, *Neidium dubium* (Ehrenb.) Cleve and *Rhopalodia gibba* (Ehrenb.) O.Müll., all species recognized as indicators of unpolluted waters.

In contrast, floristic research from the 19th century (KALMUS 1863, NAVE 1864), surprisingly enough, contains no reference to diatoms of the genus *Epithemia*, which are quite large, of characteristic shape, and are common in non-polluted waters with abundant macrophytes. *Epithemia* was first mentioned by FISCHER (1920), whose data were then included in a collation by PROCHÁZKA (1924). By 1929, BÍLÝ (1929) had described individual species of the genus *Epithemia* as “abundant” or “common” in southern Moravia.

In the early 20th century, the algal communities of the Lednice Ponds attracted quite a lot of attention, but published works were of a purely floristic character and tended to focus on diatom communities. A number of halophilic species were reported (e.g. *Anomoeoneis sphaerophora* (Ehenb.) Pfitzer, *Caloneis permagna* (J.W.Bailey) Cleve, *Pinnularia brebissonii* (Kütz.) Rabenh., *Navicula salinarum* Grunow, *Craticula halophila* (Grunow) D.G.Mann, and *Nitzschia tryblionella* Hantzsch), which may be attributed to the high salt content of the Lednice Ponds at that time.

The diatoms typical of clean waters were present in the epiphyton and epilithon. Today, these species are not found in the Lednice Ponds, or only rarely. For example *Cymbella aspera* (Ehrenb.) Cleve was classified as common in 1932 (ZAPLETÁLEK 1932b), but has not been reported since. Another species, *Eunotia bilunaris* (Ehrenb.) Mills (syn: *E. curvata* (Kütz.) Lagerst.), was also common (PROCHÁZKA 1924), but since

the 1970s has occurred only among sedges (MARVAN & KOMÁREK 1978). All of these species are still found in outer littoral zone of the Lednice Ponds, but only when the water quality temporarily improves, for example during the “summering” drainage, or when fish stocks are lowered.

Blooming cyanobacteria made up a common part of the plankton, especially filamentous species such as *Dolichospermum flos-aquae* (Lyngb.) Wackl., Hoffm. et Kom. (basionym: *Anabaena flos-aquae*), and *Aphanizomenon flos-aquae* (L.) Ralfs ex Born. et Flah. Other cyanobacteria reported included further species of the genus *Dolichospermum*: *D. crassum* (Lemm.) Wackl., Hoffm. et Kom. (basionym: *Anabaena crassa*), *D. spiroides* (Kleb.) Wackl., Hoffm. et Kom. (basionym: *Anabaena spiroides*), *D. lemmermannii* (Richt.) Wackl., Hoffm. et Kom. (basionym: *Anabaena lemmermannii*), and the coccoid species *Microcystis aeruginosa*, *M. flos-aquae* (Wittr.) Kirchn., and *Merismopedia glauca* (Ehrenb.) Näg. (FISCHER 1920). The green algae were especially represented in the plankton of the Lednice Ponds by the genera *Ankistrodesmus*, *Pediastrum*, and *Tetraedron* (FISCHER 1920).

Due to the absence of data on algal and cyanobacterial abundance and frequency, no conclusions about the the progression of dynamics can be drawn for this time period. However, based on the presence of a number of species indicating low organic impact, it may be assumed that the water quality of the Lednice Ponds was very good at the beginning of the 20th century.

The first ecologically focused hydrobiological study of the Lednice Ponds was published by BAYER & BAJKOV (1929). The establishment of a biological station by České vysoké školy Brněnské [“Czech Colleges of Higher Education, Brno”] near Prostřední Pond in 1922 enabled regular qualified monitoring of the ponds, determination of their microflora and calculation of biomass. In 1923–24, all four of the ponds were monitored in detail. Although research tended to prioritize the zooplankton, a certain amount of attention was also dedicated to the phytoplankton. The phyto-benthos was not studied at all.

Nesyt Pond was described as extremely eutrophic, with large numbers of small plankton but without the cyanobacterial blooms that are usually common. It was dominated by the dinoflagellate *Ceratium hirundinella* (Müll.) Dujard., in contrast to the other Lednice Ponds, where the cyanobacterium *Aphanizomenon flos-aquae* was dominant (with the exception of Prostřední Pond, where *C. hirundinella* predominated in July or August). Of the other taxa, diatoms, green algae and euglenophytes were especially prevalent. In the autumn of 1924, the Nesyt Pond plankton was relatively poor, with indicators of eutrophic waters such as *Phacus longicauda* (Ehrenb.) Dujard., *Trachelomonas volvocina* (Ehrenb.) Ehrenb., *Pediastrum duplex* Meyen, and species of the genus *Navicula* dominant.

The phytoplankton of Hlohovecký Pond was characterized by rich development of planktonic cyanobacteria, in particular of *Aphanizomenon flos-aquae*, whereas the dinoflagellate *Ceratium hirundinella*, predominant in Nesyt Pond, was rare there. The most common species were *Pediastrum duplex*, *Phacus longicauda*, the benthic *Craticula cuspidata* (Kütz.) D.G. Mann (syn. *Navicula cuspidata* (Kütz.) Kütz.), and

Lepocinclis acus (O.F.Müll.) Marin et Melkonian (syn. *Euglena acus* (O.F.Müll.) Ehrenb.). As the season advanced in Hlohovecký Pond, the vegetation changed. In May 1924, the phytoplankton was made up especially of the diatoms *Fragilaria crotonensis* Kitton, *Aulacoseira granulata* (Ehrenb.) Simons. (syn. *Melosira granulata* (Ehrenb.) Ralfs), *Craticula cuspidata*, *Gomphonema* spp., the green alga *Pediastrum duplex*, and the conjugatophycean *Closterium parvulum* Näg. In the course of June and July, the cyanobacterium *Aphanizomenon flos-aquae* predominated, accompanied by *Euglena viridis* (O.F.Müll.) Ehrenb., *Fragilaria acus* Kütz., *Craticula cuspidata*, *Trachelomonas volvocina* and others. From August to October, the phytoplankton was again dominated by green algae such as *Pediastrum duplex* and *Pediastrum boryanum* (Turp.) Menegh. and the euglenophytes *Phacus longicauda*, *Lepocinclis acus*, and *Trachelomonas volvocina*. BAYER & BAJKOV (1929) recorded acute pollution of Hlohovecký Pond with waste waters from the village of Hlohovec and a considerable proportion of organic compounds in the water. This corresponded with the development of *Euglena viridis*, an indicator typical of polluted waters.

Prostřední Pond, just like Nesyt, was characterized by a predominance of the dinophyte *Ceratium hirundinella*, although there were also cyanobacterial blooms of *Aphanizomenon flos-aquae* and *Microcystis aeruginosa*. Other microflora in the pond included, in particular, the diatoms *Fragilaria crotonensis*, *Aulacoseira granulata*, *Melosira varians* C. Agardh, and *Craticula cuspidata*, the green alga *Pediastrum duplex*, and the euglenophytes *Trachelomonas volvocina*, *Lepocinclis acus*, and *E. viridis*. In the course of the vegetation season, in May 1924, the diatoms *Fragilaria crotonensis*, *Aulacoseira* sp., the green alga *Pediastrum duplex*, the dinoflagellate *Ceratium hirundinella*, and the cyanobacterium *Microcystis aeruginosa* were observed. In June, the filamentous *Aphanizomenon flos-aquae* replaced the coccoid *Microcystis aeruginosa*, while species of the genus *Navicula* and the euglenophytes *Lepocinclis acus* and *Phacus longicauda* were also common in the phytoplankton. The dinoflagellate *Ceratium hirundinella* was the dominant organism in the phytoplankton during July and August. Apart from the above species of euglenophytes and green algae, the cyanobacteria *Aphanizomenon flos-aquae*, *Nostoc* sp., and *Dolichospermum spiroides* were also present in the pond. In the autumn months, the abundance of the dinoflagellate *Ceratium hirundinella* declined and the plankton become dominated by euglenophytes, diatoms and green algae.

Mlýnský had the lowest productivity of all of the large Lednice Ponds. This was primarily due to a lower organic matter content, arising out of the absence of inflow of polluted waste water. The composition of the phytoplankton was very similar to that in the other ponds, although Mlýnský suffered from heavy cyanobacterial blooms, largely made up of *Aphanizomenon flos-aquae*. The spring phytoplankton was mainly composed of the diatoms *Fragilaria crotonensis*, species of the genus *Navicula*, and the green alga *Pediastrum duplex*. The cyanobacterium *Aphanizomenon flos-aquae* started to appear from June onwards, and it became a clear dominant during the summer. The phytoplankton community was also supplemented with other species of cyanobacteria, such as *Microcystis aeruginosa* and *Dolichospermum spiroides*, the dinoflagellate *Ceratium*

hirundinella, and the green alga *Pediastrum duplex*. In the autumn plankton, representatives of the euglenophyta began to appear.

In general terms, BAYER & BAJKOV (1929) characterized the phytoplankton of Lednice Ponds as rich, with frequent changes in the quantities of individual organisms in particular ponds. However, the ponds are connected by a common flow, so carriage of organisms from the higher ponds to the lower ones is natural. The situation in which species common higher up are not present lower down arises out of the different physico-chemical conditions in the individual ponds, waste water inflow, composition of fish stocks, and other factors. Special attention should be paid to significant blooms of cyanobacteria, which occur regularly in the Lednice Ponds at the hottest time of year.

The occurrence of a strong cyanobacterial bloom made up of the species *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* in 1925 and 1927 in Prostřední Pond was observed by SOUDEK (1929). He referred to a rapid development and subsequent sudden disappearance of the flagellated green algae *Volvox* in the Lednice ponds. He also summed up the characteristics of the Lednice Ponds succinctly, noting that they consist of areas and quantities of water appropriate to lakes but, if judged by the substances contained in their waters, are more reminiscent of puddles and ditches.

Detailed ecology and floristics, 1920–1930

Thanks to two Moravian diatomologists, FISCHER (1922, 1926–1927) and in particular BÍLÝ (1925, 1926, 1927, 1929), the 1920s were a golden age for diatomological floristic surveys in Moravia (Figs 32, 33). Their work concentrated largely on saline habitats and, in addition to extensive floristic data, they detailed the characteristics of the Lednice Ponds and pointed out the higher content of salts in comparison with ponds in other areas.

In the genus *Epithemia*, three species were recorded: *E. adnata* (Kütz.) Bréb. (syn. *E. zebra* (Ehrenb.) Kütz.) in Hlohovecký Pond (FISCHER 1920), *E. sorex* Kütz. as a common species in the River Dyje and *E. turgida* (Ehrenb.) Kütz. as abundant (BÍLÝ 1929). Among other oligotrophic species, *Rhopalodia gibberula* var. *producta* (Grunow) O.Müll. was found in Mlýnský Pond (FISCHER 1920), while *Cymbella aspera* was widespread in southern Moravia (FISCHER 1920, BÍLÝ 1929).

In their studies of the southern Moravian saline habitats, both FISCHER (1920) and BÍLÝ (1929), found many typical mesohalic taxa in the Lednice Ponds: *Bacillaria paradoxa* Gmelin (or *B. paxillifer* (O. F. Müll.) Hend.), especially in the “Střední” Pond (today known as Prostřední), as well as in Mlýnský and on the weir of Hlohovecký Pond (BÍLÝ 1929); *Nitzschia tryblionella* in Hlohovecký (FISCHER 1920), and *Nitzschia levidensis* (W. Smith) Grunow (syn. *N. tryblionella* var. *levidensis* (W. Smith) Grunow in Cleve et Grunow in Nesyt (FISCHER 1920). *Nitzschia calida* Grunow (syn. *N. tryblionella* var. *calida* (Grunow) Van Heurck was recorded by FISCHER (1920) in Hlohovecký, but BÍLÝ indicated that its occurrence in Moravia is suspect (1929, p. 21). *Nitzschia vitrea* G. Norman was found in the Mlýnský and Hlohovecký Ponds, (FISCHER 1920), *Nitzschia heufleriana* Grunow (BÍLÝ 1926), *Cylindrotheca gracilis* (Bréb.) Grunow (BÍLÝ 1929),

and *Caloneis permagna* (syn. *Navicula permagna* (Bailey) A. M. Edwards) occurred in Lednice Ponds in general (BÍLÝ 1929). *Navicula oblonga* (Kütz.) Kütz. was reported from the Hlohovecký (FISCHER 1920) and Mlýnský Ponds (BÍLÝ 1926), *Navicula salinarum* from Hlohovecký (FISCHER 1920) and from the Lednice Ponds overall (BÍLÝ 1929), *Hippodonta hungarica* (Grunow) Lange-Bert., Metzeltin et Witkowski (syn. *Navicula hungarica* Grunow) from the Hlohovecký and Mlýnský Ponds (FISCHER 1920) and according to BÍLÝ (1929) as an abundant species of the Lednice Ponds in general. *Pinnularia brebissonii* was found in Nesyt (FISCHER 1920), *Caloneis amphisbaena* (Bory) Cleve (syn. *Nitzschia amphisbaena* Bory) in Hlohovecký (FISCHER 1920) and in “South Moravia”, without specific location, according to BÍLÝ (1927).

In addition to mesohalic, halophilous and phytophilous species, common species of wider ecological amplitude were also recorded: *Cocconeis pediculus* Ehrenb. and *C. placentula* Ehrenb. in Hlohovecký Pond (FISCHER 1920), *Ctenophora pulchella* (Ralfs ex Kütz.) Williams et Round (syn. *Synedra pulchella* Kütz.) in the Mlýnský and Hlohovecký Ponds (FISCHER 1920), and *Tabularia affinis* (Kütz.) Snoeijs (syn. *Synedra affinis* Kütz.) in Mlýnský Pond (FISCHER 1920). These species were to predominate several decades later, when intensive fishery management increased the supply of nutrients in the system.

The phytoplankton, and especially blooms, in the Lednice Ponds were studied in the 1930s by ZAPLETÁLEK (1932a, 1932b). He was also interested in mats and macroscopic clusters of algae and their development and he included data on diatoms previously reported by R. Fischer and J. Bílý in his study. He thus provided a fairly complete phycological characterization of the Lednice Ponds for that time.

In 1930, Nesyt Pond was partly drained and much of its bed became covered in a dense growth of the pondweed *Potamogeton pectinatus* L. A massive development of submerged macrophytes led to only limited growth of phytoplankton and no bloom was observed that year. The transition of the microflora was reported by ZAPLETÁLEK 1932 (“Character of the vegetation”, p.5). He described the situation in the summer of 1930, when the Nesyt water level was low, reporting that the salty water was heavily populated with both halophilous forms of zooplankton and halophilous diatom species (*Nitzschia* Hass.) and, from the cyanobacteria group, *Nodularia spumigena* Mert. (recently *N. moravica* Hind., Šmarda et Kom. 2003) (ZAPLETÁLEK 1932a, p.7). At the outlet of Hlohovecký Pond, chains of *Melosira varians* colonies along with halophilous *Bacillaria paradoxa* occurred in notable abundance. The stones of the retaining wall were covered with a “bark” made up of *Calothrix braunii* Born. et Flah., which indicated that the chemical composition of water was rich in dissolved calcium carbonate (ZAPLETÁLEK 1932a, p.8). The same species formed an epilithon on the retaining wall of Mlýnský Pond and its occurrence as a base layer on the epilithon has remained more or less continuous to this day. The cyanobacterium *Gloeotrichia pisum* (C. Agardh) Thur. ex Born. et Flah. was very abundant in Mlýnský, as Zapletálek noted: “In 1930 [*G. pisum*] covered the submerged parts of aquatic plants to the extent that they looked like rosaries” (ZAPLETÁLEK 1932a, p. 9). *Gloeotrichia pisum* has not been observed in Lednice Ponds since then. Zapletálek’s hydrobiological observations are the last published records of a rich past epiphyton including species sensible to the pollution in the Lednice Ponds.

A massive expansion of submerged macrophytes led to very restricted development in the phytoplankton, and no bloom was observed in 1930. The plankton was largely made up of the green algae *Actinastrum hantzschii* Lagerh. and *Scenedesmus*, sporadically also by *Euglena* spp., and the dinoflagellate *Ceratium hirundinella*. In 1931, Nesyt Pond was at its maximum water level and in the springtime diatoms predominated in the phytoplankton. In June, green algae such as *Pandorina morum* (Müll.) Bory, *Pediastrum duplex* and others took over, whereas in July pride of place went to the cyanobacterium *Aulacoseira granulata*. At the end of the month, *Microcystis aeruginosa* bloomed, if weakly, then no bloom was observed in August. *Aulacoseira granulata* predominated again, accompanied by the green alga *Pediastrum duplex* and the euglenophytes *Phacus longicauda* and *Colacium vesiculosum* Ehrenb.

The physico-chemical characteristics of Hlohovecký Pond, with its high content of organic matter, supported the development of a dense bloom of cyanobacteria, which in June 1930 consisted of *Aphanizomenon flos-aquae*, while at the end of August planktonic *Botryococcus braunii* Kütz. predominated. To a lesser extent, *Microcystis aeruginosa* and common representatives of green algae belonging to the genera *Pediastrum* and *Scenedesmus* were also present. In 1931, no cyanobacterial bloom developed, mainly in reaction to nutrient removal by a considerable expansion of *Potamogeton pectinatus*, which densely covered the pond bottom. Phytoplankton was more strongly represented at the end of August by *Dictyosphaerium ehrenbergianum* Näg., *Pediastrum duplex*, *Aulacoseira granulata*, *Acanthoceras zachariasii* (Brun) Simons. (syn. *Attheya zachariasii* Brun), *Staurastrum paradoxum* Meyen ex Ralfs, and *Coelosphaerium kuetzingianum* Näg.

The phytoplankton gradually disappeared during autumn. Prostřední Pond sustained a very strong bloom in 1930. In June and July, this was composed of *Dolichospermum spiroides*, *Microcystis aeruginosa*, and *M. ochracea* (Brand) Lemmerm. (according to KOMÁREK & ANAGNOSTIDIS 1998, *M. ochracea* is a synonym of *M. aeruginosa*). Further to the cyanobacteria, the phytoplankton contained various species of the genera *Pediastrum* and *Scenedesmus*, as well as *Botryococcus braunii*, *Coelastrum microporum* Näg., *Sphaerocystis schroeteri* Chod. (syn. *Gloeococcus schroeteri*), *Ceratium hirundinella* and others. In 1931, the pond was drained in summer, to be refilled in October.

In 1930, no bloom was observed in Mlýnský Pond. The cyanobacterium *Gloetrichia pisum* was notable, covering the submerged parts of plants. The phytoplankton was made up of *Acanthoceras zachariasii*, *Ceratium hirundinella*, *Pediastrum tetras* (Ehrenb.) Ralfs, *Crucigenia rectangularis* (Näg.) Gay, *Botryococcus braunii*, *Sphaerocystis schroeteri*, *Oocystis lacustris* Chod., *Cyclotella meneghiniana* Kütz., and *Coelosphaerium kuetzingianum*. In 1931, the pond was half-drained. In late July and early August, a bloom of *Dolichospermum spiroides*, and also sporadically *Microcystis aeruginosa*, appeared. The green alga *Pediastrum duplex* was also present. In the autumn, the phytoplankton was composed of common species.

Monitoring by ZAPLETÁLEK (1932, 1932b) confirmed previous observations of strong eutrophy, while the occurrence of cyanobacterial blooms in the Lednice Ponds was

published by BAYER & BAJKOV (1929). Certain differences were also recorded for the Hlohovecký and Nesyt Ponds, largely concerning the absence of cyanobacterial blooms whenever submerged macrophytes surged. The species composition of the phytoplankton of all four ponds was otherwise very similar and coincided with the findings of previous authors.

The phytoplankton of the Lednice Ponds, 1940–1990

Somewhat random data for the next 25 years (BÍLÝ 1932, 1944–45; FOTT 1941, 1959, 1961; MARVAN 1957) are consistent with the findings of previous authors and essentially confirm the unchanged character of the Lednice Ponds until the mid-fifties. After this long break, a comprehensive survey of the Lednice Ponds was undertaken that covered the years 1954–1962 (HETEŠA 1962, LOSOS & HETEŠA 1971). In addition to investigating the composition and development the planktonic biota, the authors also looked into the chemical composition of the water. Particular attention was paid to differences in species structure and the dynamics of the plankton among the individual ponds and different years, and to the development and composition of cyanobacterial blooms.

HETEŠA (1962) monitored phytoplankton development in Hlohovecký Pond between 1954 and 1955 (Fig. 2). The spring of 1954 was unusually cold and phytoplankton development therefore delayed. The pond was at half-water and in July the water temperature was still relatively low, around 20°C. The cyanobacteria were therefore restrained and the dominant position was held by representatives of Cryptophyceae, especially by *Chroomonas caudata* Geitl. Diatoms were present in minute quantities, with *Nitzschia palea* (Kütz.) W.Smith the most common. Green algae also thin, largely *Desmodesmus communis* (Hegew.) Hegew. (syn. *Scenedesmus quadricauda*), *Micractinium pusillum* Fres. (syn. *Richteriella botryoides*), and *Ankistrodesmus falcatus* (Corda) Ralfs. A total of 34 species were found in the phytoplankton. In late July and early August, the water finally warmed up, bringing about a more pronounced development of phytoplankton. A bloom of the cyanobacterial genus *Dolichospermum* emerged and filaments of the genus *Oscillatoria* were found. An abundance of diatoms, still represented mainly by *Nitzschia palea*, appeared, and the green algae were also richly represented by *Monoraphidium minutum* (Näg.) Kom.-Legn. (syn. *Selenastrum minutum*), *Desmodesmus communis*, *Desmodesmus denticulatus* (Lagerh.) An *et al.* (syn. *Scenedesmus denticulatus*), and *Ankistrodesmus falcatus*.

In September, the phytoplankton was richer and 48 species were encountered. A weak bloom was formed by *Microcystis aeruginosa*, *Oscillatoria* spp. released from the benthos, and *Dolichospermum* spp. A higher incidence was observed in the diatoms, represented especially by *Cyclotella meneghiniana*, *Melosira varians*, *Ulnaria ulna* (Nitzsch) Compère (syn. *Synedra ulna* (Nitzsch) Ehrenb.), and *Nitzschia*. Euglenophytes were also present in significant numbers, mainly *Lepocinclis oxyuris* (Schmarda) Marin et Melkonian (syn. *Euglena oxyuris* Schmarda), *Lepocinclis spirogyroides* Marin et Melkonian (syn. *E. spirogyra* Ehrenb.), *L. acus*, and *Trachelomonas volvocina*. From the

green algae, flagellates of the genera *Chlamydomonas* Ehrenb., *Scenedesmus* and *Tetraedron* were observed, as well as newly-emerged *Oocystis lacustris*, *Actinastrum hantzschii*, *Kirchneriella lunaris* (Kirchn.) Möb. and *Monoraphidium minutum*.

In October, the species range within the phytoplankton dropped to 30 species, with maximum development reached by green algae, primarily composed of *Monoraphidium minutum*, *Desmodesmus communis* and *Chlamydomonas* spp. No bloom of the cyanobacterium *Microcystis aeruginosa* was observed; only heterocytes of the genus *Dolichospermum* occurred. A very small number of diatoms appeared, as did small quantities of euglenophytes, represented by *Trachelomonas volvocina*.

In mid-November, the phytoplankton of Hlohovecký Pond totalled 25 species. Despite the relatively low water temperature (6.7°C), the cyanobacterium *Microcystis aeruginosa* formed a bloom again. Stronger development was also recorded among the diatoms, especially *Fragilaria capucina* Desm. released from the benthos. Other groups were represented largely by *Chroomonas acuta* Uterm., *Ch. caudata* Geitl., and *Chlamydomonas*. The euglenophytes and green chroococcal algae retreated. In January 1955, the phytoplankton was sampled from holes cut in the ice. Biomass and abundance in the phytoplankton communities were low. In addition to diatoms, represented primarily by benthic types such as *Fragilaria capucina* and *Melosira varians*, higher incidence was observed for *Chroomonas caudata* and *Chlamydomonas*. The cyanobacteria vanished completely and the golden alga *Dinobryon sertularia* Ehrenb. was recorded sporadically.

The following sampling was conducted in April, when the phytoplankton had already had three months for extensive development. Diatoms were the predominant group with absolute pride of place going to a centric species, *Stephanodiscus hantzschii* Grunow. Higher abundance was observed for the cryptophytes, represented by *Chroomonas* spp. and *Cryptomonas erosa* Ehrenb. Of the green algae, the most common was *Chlamydomonas* spp. Cyanobacteria were not recorded. In early June, the pond was limed which, hardly surprisingly, had a profound influence on the development of the phytoplankton. Predominance was retained by the diatom *Fragilaria capucina* and to a lesser extent by *Stephanodiscus hantzschii*. Other groups were represented in very low numbers, although a cyanobacterial bloom made up of *Aphanizomenon flos-aquae* and *Dolichospermum* spp. began to emerge. At the end of July, the *Aphanizomenon flos-aquae* bloom intensified, and the diatoms, represented by *Stephanodiscus hantzschii*, *Cyclotella meneghiniana*, and *Nitzschia palea* lost their dominant role. Green algae, especially *Chlamydomonas* spp., *Pediastrum duplex* and *Coelastrum microporum* started to appear. The cryptophycean species *Chroomonas caudata* and *Cryptomonas erosa* were also relatively numerous.

Taken together, the data disclosed a high degree of dynamism in the development of most species and groups of the phytoplankton in Hlohovecký Pond. In autumn and winter, a large proportion of the phytoplankton was made up of the secondary planktonic diatoms *Fragilaria capucina* and *Melosira varians*. It was observed that the replacement of planktonic organisms as the seasons turned was usually of a standard character and the development of the individual plankton species and groups was profoundly influenced by commercially-based interventions in the biology of the pond.

Detailed research on the Lednice Ponds was conducted in 1957–1959 by LOSOS & HETEŠA (1971, 1973). In particular, they monitored the development of qualitative and quantitative ratios among the phytoplankton with respect to the water chemistry. They confirmed what previous authors had recorded of various species compositions and quantitative ratios of the plankton in the individual ponds. They also included a special chapter on the cyanobacterial blooms in the Lednice Ponds, which became very dense in the period monitored: the number of cells often exceeded half a million/ml. LOSOS & HETEŠA (1971) suggested that the principal cause of such an intensive development of the bloom lay mainly in active superphosphate fertilization of the ponds, in liming, and also in the warm prevailing climate of the area. Another specific feature was the interchange of various types of cyanobacterial bloom in the course of one growing season. The most common species to occur in the Lednice Ponds during the period monitored were filamentous *Aphanizomenon flos-aquae*, *Dolichospermum flos-aquae* and the coccoid *Microcystis aeruginosa*.

The phytoplankton of Nesyt Pond in 1957 consisted primarily of representatives of bloom-forming cyanobacteria. At first, the most common was *Aphanizomenon flos-aquae*, at its maximum in July. In September, the lake was occupied by *Microcystis aeruginosa*. Other groups occurred at low abundance; only in September did larger numbers of representatives of the genus *Chlamydomonas* appear. The summer months of 1958 were again characterized by a heavy bloom of blue-green algae. In June and July, the pond was dominated by *Aphanizomenon flos-aquae*, while at the end of July the prevailing species was *Dolichospermum flos-aquae*. *Microcystis aeruginosa* started to appear in August and became dominant at the end of the month. In early summer the diatoms were more significantly represented, and their development peaked in July, in particular the genus *Fragilaria* Lyngbye and *Stephanodiscus hantzschii*. Green chlorococcal algae showed up in the course of June and occurred in increased quantity in the pond until the fish-harvesting period. The highest abundance was observed for the genera *Actinastrum*, *Scenedesmus*, and *Oocystis*.

In January 1959, when the pond was refilled, the phytoplankton was quick to develop under the ice. This process was enabled by favorable light conditions under the ice, not covered with snow that year, so that the daylight could penetrate the entire water column down to the bottom of the pond. The main development was seen in green flagellates of the genus *Chlamydomonas*, and a greater abundance was also noted in a golden alga of the genus *Chrysococcus*, and the green alga *Ankistrodesmus falcatus*. High phytoplankton biomass persisted even into February, then a rapid decline in the quantity of all groups was observed. The phytoplankton revived in June with an incoming bloom of cyanobacteria, formed throughout the growing season by *Aphanizomenon flos-aquae*. Other groups occurred only at low abundances during the remainder of the year.

Hlohovecký Pond was deliberately drained in both summer and winter in 1957, and not refilled until April 1958. The initial phytoplankton biomass was made up of diatoms, in particular *Ulnaria ulna*. Diatoms occurred as the predominant organisms during the summer as well, with the genus *Fragilaria* and later also *Stephanodiscus hantzschii* achieving their highest abundances. In 1958, bloom cyanobacteria occurred in negligible

amounts in Hlohovecký Pond. In August and September, representatives of the green algal genera *Pediastrum* and *Scenedesmus* appeared. In the autumn, species of the genus *Chrysococcus* were present in higher numbers, with other groups of algae occurring only sporadically. At the end of September, the pond was fished out and immediately filled with water to a high level. As elsewhere in the Lednice system, winter development of phytoplankton under the ice was observed in Hlohovecký Pond. The biomass was made up of golden algae of the genera *Ochromonas*, *Chrysococcus* and *Chromulina*, and the green algae *Chlamydomonas* spp. and *Ankistrodesmus falcatus*. In March, while the ice was thawing, a significant reduction in the phytoplankton biomass occurred. In the spring months, only the sporadic presence of diatoms and green alga of the genus *Ankyra* was noted. In June, bloom of cyanobacteria appeared and the quantity of other species of algae decreased to a minimum. A first weak peak was reached by the cyanobacteria *Dolichospermum flos-aquae* and *Aphanizomenon flos-aquae*. At the end of July, a short but massive development of *Microcystis aeruginosa* occurred, while *Aphanizomenon flos-aquae* was present in approximately the same abundance, whereas *Dolichospermum flos-aquae* retreated significantly. In September, *Aphanizomenon flos-aquae* formed a clear dominant. At the end of the growing season, green algae and diatoms, mostly the genera *Pediastrum* and *Nitzschia*, began to emerge.

In 1957, the phytoplankton of Prostřední Pond was almost entirely composed of two species of blue-green algae: *Microcystis aeruginosa* and *Dolichospermum flos-aquae*. In early August, the sudden death and decomposition of the bloom led to a fish-kill and loss of zooplankton (HETEŠA & LOSOS 1962). The reason for the mishap lay in more than simply the heaviness of the bloom. An unfortunate combination of circumstances also contributed significantly to such an abrupt decline: high water temperature (up to 29.5°C), no wind, and a substantial quantity of zooplankton placing great demands on the oxygen for the entire pond biota. The cyanobacterial bloom peaked in July, died off and started to decay in late July and the beginning of August. The amount of dissolved oxygen began to decrease markedly and the first fish deaths were recorded on 7 August 1957. Hlohovecký Pond was drained for the summer and the water level of Nesyt Pond was low, so it was not possible to ensure an inflow of oxygen-rich water. Between August 7 and 13, the whole fish stock was lost and the zooplankton died off. The increased quantity of organic matter in the pond led to a considerable development of colourless saprophytic flagellates and the genus *Cryptomonas* was observed. The photosynthetic activity of *Cryptomonas* raised the oxygen concentration in the water and oxygen saturation was 100% on 17 August. A more pronounced revival of the pond began in late August, when it was partially drained and refilled with water from Nesyt Pond. The quantity of organic matter led to the development of the filamentous cyanobacterium *Oscillatoria fragilis* Böcher (according to KOMÁREK & ANAGNOSTIDIS 2005, *O. fragilis* is an unrevised species, described from the benthos), which enriched the primarily planktonic community by detaching from the substrate. Green algae of the genera *Oocystis*, *Kirchneriella*, *Ankistrodesmus*, and *Scenedesmus* were also found. Later, the abundance of diatoms, especially of the genera *Nitzschia* and *Cyclotella* increased as well. Clear ice in the winter allowed the development of green flagellates of the genus

Chlamydomonas. After the ice melted, the phytoplankton was very poor, a situation that lasted until June. In July, a cyanobacterial bloom of *Microcystis* and *Aphanizomenon* appeared and dominated until the fish harvest at the end of September. Other groups of algae occurred only in lower quantities.

In winter 1958–59, representatives of the genus *Chlamydomonas* and golden algae, mostly of the genus *Ochromonas*, again occupied the pond. In March and April, the quantity of phytoplankton was very low. A slight increase in the phytoplankton biomass, consisting largely of the green alga *Botryococcus braunii* and diatoms of the genus *Fragilaria*, was observed in May and June. A cyanobacterial bloom developed in June and persisted until the fish-harvesting period in October. First to bloom was *Dolichospermum flos-aquae*, peaking in July. A parallel development was reported for *Microcystis aeruginosa*, which predominated until mid-September, when it started to decline in abundance. At the end of September, *Aphanizomenon flos-aquae* took advantage of the diminishing quantities of other species of cyanobacteria, and a massive development of it culminated at the end of September. The numbers of other groups of algae were negligible.

The phytoplankton of Mlýnský Pond was characterized by a highly diverse composition, largely due to the development of chlorococcal algae. At the beginning of 1957, only small amounts of cyanobacteria were present. In June, the pond was dominated by green algae, of which the most abundant was *Coelastrum microporum*, and diatoms with *Nitzschia palea* predominating. In July, the phytoplankton biomass decreased and, in addition to the above taxa, a weak cyanobacterial bloom also occurred. Other reported taxa included the filamentous cyanobacterium *Oscillatoria* and the dinoflagellate *Ceratium hirundinella*. In August and September, the composition of phytoplankton came under the influence of a strong inflow from Prostřední Pond. Cyanobacterial biomass increased significantly and an uncommon filamentous cyanobacterium, *Dolichospermum tenericaule* (Nyg.) Zapomělová *et al.* (syn. *Anabaena tenericaulis* Nyg.), became dominant. *Oscillatoria fragilis* was also present and, among other groups, the highest abundance was achieved by green algae and diatoms, which dominated the phytoplankton in September. The cyanobacteria retreated, *Dolichospermum tenericaule* vanished, and the quantity of *Oscillatoria fragilis* increased slightly. In October, the pond was drained and, after it was refilled in November, it was recorded that the phytoplankton developed only feebly.

From January to March 1958, a slight development of planktonic algae under the winter ice was again recorded, with the highest numbers reached by *Chlamydomonas* spp. In the following two months, the quantity of phytoplankton remained very low, with diatoms of the genus *Fragilaria* prevailing only in June. A bloom of *Microcystis aeruginosa* developed slowly in July, while other groups played minor roles. The bloom reached maximum development in late August, and disappeared in October, when the pond was drained. After the November refill, the quantity of phytoplankton was low. A slight increase occurred in January and February 1959, when algae of groups Chrysophyceae and Volvocales led to slight vegetation opacity under the ice. In

subsequent months, the phytoplankton remained low, then a cyanobacterial bloom of *Microcystis aeruginosa*, *Dolichospermum flos-aquae* and *Oscillatoria* appeared in June. In July, the bloom became dominated by highly abundant *Dolichospermum flos-aquae*, accompanied by the centric diatom *Aulacoseira granulata* v. *angustissima* (O.Müll.) Simons. In August and September, the cyanobacterial bloom persisted with *Microcystis aeruginosa* dominant; the quantity of the other groups of algae was low. At the end of September, *Aphanizomenon* prevailed in the plankton and subsequently persisted in smaller amounts until the pond was drained for the fish harvest.

The work of HETEŠA & LOSOS (1971, 1973) indicates significant differences in the composition and dynamics of the phytoplankton in the individual ponds, although comparison of the physico-chemical parameters revealed only slight variation between them. Certain differences existed, but are not great enough to explain the variability in the plankton composition. Flow between the ponds during these years was irregular, usually greatest during autumn before the fish-harvesting period and also to some extent in spring, when water is discharged from one pond to another. During the growing season, the flow, if any, is low. In spring, after refilling, each pond in the system becomes a more or less closed habitat, almost isolated from the effects of the one above it. Thus the planktonic communities may develop in different ways during the course of the year.

Possible differences in the natural eutrophication of ponds, which may have occurred previously, were suppressed between 1957 and 1959 by intensive use of fertilizers, applied in approximately the same proportions to all of the ponds in the system. Significant divergences appeared in comparison to past years, especially in the intensity of cyanobacterial blooms. Whereas blooms occurred when BAYER & BAJKOV (1929) and ZAPLETÁLEK (1932a, 1932b) were taking records, they never achieved the high proportions noted by LOSOS & HETEŠA (1971). The cyanobacterial blooms in the Lednice Ponds were characterized by strong successive interchange of individual cyanobacterial species, suggestive of their different demands on the environment. The increase in cyanobacterial bloom intensity may be ascribed to intensive fertilization and liming of the ponds.

In general, between 1957 and 1959 the Lednice Ponds were largely inhabited by the most widespread bloom-forming cyanobacteria of the times, the only exception being the less frequent *Dolichospermum tenericaule*. In comparison with the data of BAYER & BAJKOV (1929), who monitored the ponds in a period in which fertilizers were not added and the fish were not given supplementary feed, LOSOS & HETEŠA (1971) recorded not only increased fish stocks and increases, but also consequent partial convergence in the production capacity of the individual ponds. The latter authors also suggested that density of fish stock was the most important causative factor in changes in phytoplankton composition. Fertilizer tends to affect the intensity of primary production, and usually has no significant impact on the composition of phytoplankton species in hypertrophic ponds. Thus, the species composition remains basically the same but changes may be observed in the intensity of development of individual algae and cyanobacteria.

The ecology and floristics of the fishpond littorals, 1960–1980

A holistic approach to research into fishpond littorals, part of the Czechoslovakian IBP Wetland Project, yielded detailed data on Nesyt Pond in the early 1970s (DYKYJOVÁ & KVĚT 1978). The pond was found to be a heterogeneous complex with a variety of microhabitats. This diversity was a consequence of the arrangement of acrophyte communities, the variable character of the banks, and pollution from inflows derived from the nearby village of Sedlec and a commercial duck farm (MARVAN *et al.* 1973). Observations suggested that the high variability of the environment provided Nesyt Pond with considerable regeneration capacity (HEJNÝ & HUSÁK 1978a, 1978b).

The algal populations related to various macrophyte communities have been described in detail (MARVAN & KOMÁREK 1978). In the 1970s, high trophic activity was demonstrated by a carpet of duckweed (*Lemna gibba* L.) over a relatively large area of open water beyond the reed belt. Filamentous algae (*Cladophora fracta* (O.F.Müll. ex Vahl) Kütz., *Spirogyra* spp., *Oedogonium* spp., *Enteromorpha* (*Ulva*), and colonies of *Fragilaria* spp., loosely attached to plant surfaces, covered the leaves and stems of extensive communities of *Potamogeton pectinatus*, whereas the epiphyton of this microhabitat remained poorly developed. In reed communities, mainly of a bulrush *Bolboschoenus maritimus* (L.) Palla, planktonic algae prevailed over epiphytic species. Benthic mats of cyanobacteria (*Oscillatoria* sp.) in shallow lagoons with warm water in the western part of the pond, isolated from the other littoral communities, were enriched with diverse assemblages of diatoms (including *Cylindrotheca gracilis* and *Caloneis amphisbaena*). The algae that accompany the reed *Phragmitetum* were mainly represented by sessile diatoms (especially *Gomphonema* spp., *Cymbella* spp., *Tabularia fasciculata*, *Ctenophora pulchella*, *Halamphora veneta* (Kütz.) Levkov (syn. *Amphora veneta* Kütz.) and *Achnantheidium minutissimum* (Kütz.) Czarn. (syn. *Achnanthes minutissima* Kütz.), chlorococcal algae (*Characium ensiforme* Herm.), cyanobacteria (*Homoeothrix stagnalis* (Hansg.) Kom. et Kov.), and green filamentous algae (*Stigeoclonium* sp.). Filamentous colonies of *Fragilaria capucina* incl. v. *vaucheriae* (Kütz.) Lange-Bert. were seasonally frequent as well. In the sedge zone, species indicating more or less oligotrophic and slightly acidic conditions (e.g. *Eunotia bilunaris* (syn. *E. curvata*), *Microspora quadrata* Hazen and *Microthamnion kuetzingianum* Näg. ex Kütz.) occurred and a spring peak of *Tribonema* sp. (*T. viride* Pasch., *T. vulgare* Pasch., *T. angustissima* Pasch.) was observed. The algal assemblage that accompanies *Caricetum ripariae* and the landward edge of the littoral *Phragmites* reed communities were rich in halophilous and mesohalic diatoms (*Navicula salinarum*, *N. simplex* Krasske, *Nitzschia commutata* Grunow, *N. vitrea* G. Norman and *Fragilaria* sp. Compared with 1920–30s, habitat conditions in 1960–70s differed markedly in both outer and inner zones of the littoral of Nesyt Pond. Within the central and inner littoral, the algal vegetation contained no typically mesohalic elements and only some halophilous algae were present. When the submerged bottom was suddenly flooded, algal clusters dominated by *Vaucheria* A. P. de Cand. (*V. debaryana* Woron., *V. geminata* (Vauch.) de Cand., *V. arrhyncha* Heiding. observed in May 1972) together with a rich epipellic diatom assemblage (*Navicula cryptocephala* Kütz. and *Nitzschia* spp. as dominants, and

mesohalobic elements such as *Navicula cincta* (Ehrenb.) Ralfs, *N. salinarum*, *N. simplex*, *Hantzschia spectabilis* (Ehrenb.) Hustedt, *Nitzschia vitrea*, *Amphora veneta*, *Diatoma tenuis* Agardh) colonized the shallow water (MARVAN & KOMÁREK 1978).

A detailed description of algal distribution in time and space is given in another section (MARVAN *et al.* 1978a). Benthic mats of cyanobacteria developed from March to June in the shallow and highly eutrophicated western bay. In the littoral with decomposing macrophyte litter and a depth of about 0.5 m, mats of sulphur bacteria and cyanobacteria (mainly *Oscillatoria tenuis* C. Agardh, to a lesser extent *O. limosa* C. Agardh ex Gom., *O. chalybea* Mert. and *Spirulina major* Kütz.), accompanied by euglenophytes and diatoms indicating the slightly halophilous character of this microhabitat (such as *Navicula cincta*, *N. veneta* Kütz., *N. simplex*, *Nitzschia frustulum* (Kütz.) Grunow and *Fragilaria* sp. etc.), occurred. An epilithon formed by *Stigeoclonium* sp. and diatoms *Gomphoneis olivacea* (Lyngb.) Cleve ex Dawson, *Navicula tripunctata* (O. F. Müll.) Bory (syn. *Navicula gracilis* Ehrenb. and *Rhoicosphenia abbreviata* (C. Agardh) Lange-Bert. (syn. *R. curvata* (Kütz.) Grunow was replaced by green filamentous algae (*Cladophora*, *Oedogonium*) in summer. For the epiphyton on reeds, the authors (MARVAN *et al.* 1978a) refer to previous work (MARVAN *et al.* 1973). They identified four types of epiphytic community covering younger and older stems of *Phragmites australis* (Cav.) Steud. and *Typha angustifolia* L. In heavily-shaded microhabitats a “diatom type” community prevailed (dominated by *Cocconeis placentula*, *Gomphonema parvulum* (Kütz.) Kütz., *Nitzschia gracilis* Hantzsch, *Rhoicosphenia abbreviate* and *Homoeothrix stagnalis*) and in irradiated biotopes, a “*Stigeoclonium* type” (typically with *G. parvulum*, *Navicula cryptocephala*, *N. tripunctata*, and *Ulnaria ulna* prevailing). Old leaves and stems of *Phragmites* and *Typha* were inhabited by an “*Oedogonium* type” (with *Oedogonium varians* Wittr. et Lund. and *Oe. capillare* Hirn, diatoms *Fragilaria capucina* v. *vaucheriae*, *Melosira varians*, *Rhoicosphenia abbreviata*, *Tabularia fasciculata* and *Ulnaria ulna*, *Spirogyra* sp.), whereas a “*Cladophora* type” (*Cladophora fracta*, *C. cf. glomerata* (L.) Kütz., *Cocconeis pediculus*, *Rhoicosphenia abbreviata*, *Tabularia fasciculata*, *Oedogonium* spp.) colonized the litter. Free-floating clusters, predominantly of the order Zygnematales (mainly *Spirogyra* spp., mixed with *Oe. varians*, later with *C. fracta*), occurred, mainly in the highly eutrophic western bay in shallows with muddy bottom and warm water, while pure growths of *Spirogyra* sp. occurred near a fertilizer depot. *Spirogyra* spp. also appeared as an accessory species in other algal communities. Sporadic clusters of *Zygnema* C. Agardh were observed, while other floating clusters were made up of *Oedogonium*. In spring, *Oe. varians* associated with *Spirogyra*, *Melosira varians* and *Navicula tripunctata* and with epiphytic *Fragilaria capucina* v. *vaucheriae* and *Tabularia fasciculata* were common. Later in the year, *Oe. capillare* appeared and persisted for long periods, together with epiphytic *Amphora veneta*, associated with *Sphaeroplea annulina* (Roth) C. Agardh, followed later by *Cladophora fracta*. As the most productive cluster-forming alga, *Cladophora fracta* either formed pure stands or was accompanied by codominants *Enteromorpha* (*Ulva*) sp. (probably *U. flexuosa* var. *pilifera*) and *Oedogonium varians*. The latter was an important element of the algal vegetation, mainly in lagoons within the reed belt. During the summer peak,

clusters covered large areas of the open water. Filaments of *C. fracta* were covered with the epiphytes *Ulnaria ulna*, *Ctenophora pulchella*, *Tabularia fasciculata*, *Cocconeis pediculus*, *Rhoicosphenia abbreviata*, *Gomphonema parvulum*, *Aphanochaete repens* A. Braun and *Homoeothrix stagnalis* (syn. *Leptochaete stagnalis*) (MARVAN *et al.* 1978a).

Two-year rotation as a fishpond management approach and its impact on the algal vegetation was described by LOSOS & HETEŠA (1971), later supplemented by observations from the littoral (MARVAN *et al.* 1978b; see also LHOTSKÝ & MARVAN 1975). In the years when Nesyt Pond was understocked with fish, an increase of total hardness and alkalinity, an extremely low concentration of free CO₂, together with permanently alkaline pH, were responsible for a marked increase in the alkalitrophic *Cladophora fracta*, *Enteromorpha (Ulva)* sp. and other filamentous algae in shallow water. In the years when the pond was filled up, floating algae tended to develop less abundantly (MARVAN *et al.* 1978a). Non-planktonic algae increased temporarily and a massive development of littoral filamentous algae was observed later in lagoons (MARVAN *et al.* 1978b).

Green filamentous species of the genera *Oedogonium* and *Cladophora*, early stages of *Tribonema*, and also diatoms (*Ulnaria* spp., *Nitzschia* spp. and *Gomphonema* spp.), including filamentous colonies (strips of *Fragilaria* and chains of *Diatoma tenuis*), are adapted to a free-floating way of life after detachment from the epiphyton. Epiphytes growing on the helophyte litter were found to be more of an important source of natant algal clusters than epiphytes of the living stems (MARVAN *et al.* 1978b).

Succession in 1972 was described with reference to time (MARVAN *et al.* 1978b). After partial winter drainage, Nesyt Pond was refilled in spring, and *Vaucheria* spp. colonized the upper parts of the littoral and formed a carpet in lagoons in May. Macrophyte expansion led to the widespread distribution of *Spirogyra* spp. (in shallow and unshaded parts of the littoral) and *Oedogonium varians*. Soon after the ice melted, *Cladophora fracta* thalli appeared on dead stems, but it developed to a maximum only after *Spirogyra* and *Oedogonium* had gone into partial recession. *Oedogonium capillare* started later than *Oe. varians* and occurred together with *C. fracta*. In summer, *Enteromorpha (Ulva)* sp. replaced *Cladophora* and mass development of the thalli with epiphytic *Amphora veneta* was recorded. Clusters floating on the water surface, although well adapted to summer conditions, were affected by unfavorable effects of strong insolation. It was observed that in loose helophyte stands, slight shading of the algal clusters was evidently convenient for their photosynthetic activity. In these stands on the windward site, algal biomass accumulated and decomposed and provided a food source for swarms of cladocerans.

The phytoplankton of the Lednice Ponds in the 1990s

Further long-term research into the Lednice Ponds took place in the period 1992–1994 in order to detect changes in the biocenosis of the hydrobiont arising out of intensification of fish production, and to make comparisons with previous studies (HETEŠA *et al.* 1994). The compositions (expressed as percentage of cell numbers) for the

Cyanobacteria and algae in the Lednice Ponds

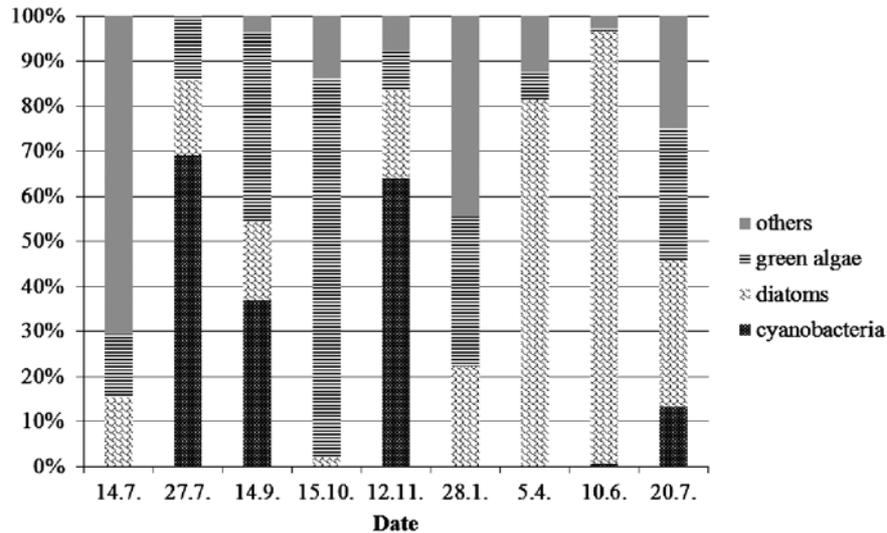


Fig. 2. Percentage composition of the main groups of cyanobacteria and algae of Hlohovecký Pond during the season 1954 and 1955 (% of cell number).

main groups of cyanobacteria and algae in the Lednice Ponds for 1992–1994 are presented in Graph 3.

The inflow of waste water into the Nesyt and Hlohovecký Ponds from the surrounding communities had increased in the previous years, partly because of ducks breeding on the banks of Nesyt. The biological loading on the Prostřední and Mlýnský Ponds remained almost unchanged. Production of the ponds increased, largely in response to higher herbivorous fish stocks and intensive feeding. The ponds also received waste water with nitrogen compounds, while previous intensive fertilizer addition added to phosphorus reserves. What had been a 2–3-year management system was replaced by a one-year cycle and the previous winter and summer drain-and-dry regime was abandoned.

Nesyt Pond saw strong vegetation growth and inorganic turbidity during the 1992–94 monitoring, a result of high fish stocking. Considerable vegetation turbidity consisting of chlorococcal algae appeared as early as April in 1992. The phytoplankton was largely represented by *Dictyosphaerium subsolitarium* Van Goor and the green algae *Chlorella*, *Scenedesmus* and *Monoraphidium*. The predominant cyanobacteria was *Pseudanabaena limnetica* (Lemmerm.) Kom. During the summer, green algae and cyanobacteria predominated, with increasing abundance of *Pseudodidymocystis planctonica* (Korš.) Hegew. et Deason (syn. *Didymocystis planctonica* Korš.) and the cyanobacteria *Chroococcus minimus* (Keissl.) Lemmerm. (syn. *Gloeocapsa minima* f. *smithii*) and *Merismopedia tenuissima* Lemmerm. A similar abundance of cyanobacteria

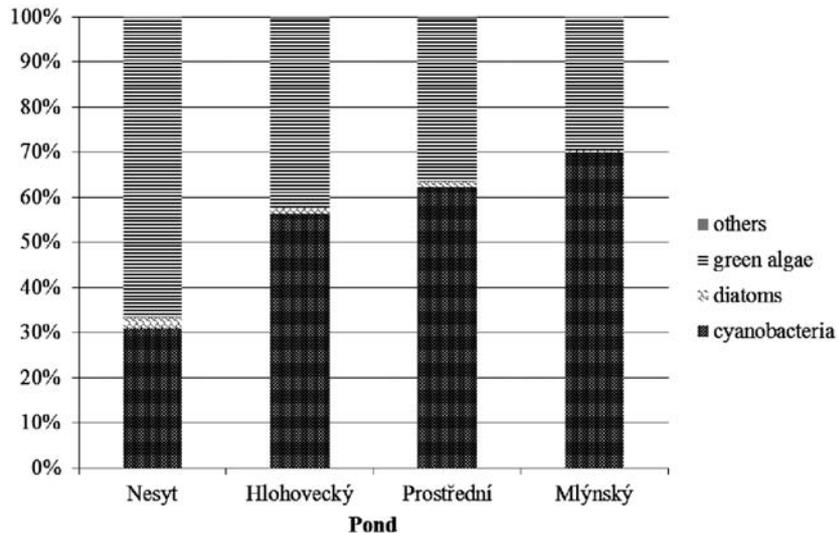


Fig. 3. Percentage composition of the main groups of cyanobacteria and algae of Lednice ponds during seasons 1992 to 1994 (% of cell number).

and algae was recorded in summer 1993. The chlorococcal algae *Dictyosphaerium subsolitarium*, *Chlorella* and cyanobacteria *Chroococcus minimus* predominated. The biomass of algae and cyanobacteria declined significantly in the autumn. Winter 1994 was marked by heavy vegetation turbidity, and in February the fibrous cyanobacteria *Pseudanabaena limnetica* took pride of place at a cell density of over 10^6 /ml, together with the centric diatom *Stephanodiscus hantzschii*. The quantity of phytoplankton fell in April-May, with the green algae *Dictyosphaerium subsolitarium* and the cyanobacteria *Coelosphaerium kuetzingianum* predominating. In summer, at a total cell abundance exceeding 10^6 /ml, the picoplanktonic cyanobacteria *Aphanocapsa incerta* (Lemmerm.) Cronb. et Kom. (syn. *Microcystis incerta*) predominated, together with the green algae *Monoraphidium minutum*. Certain Euglenophyta species appeared in autumn.

The phytoplankton species composition of Hlohovecký Pond was similar to that of Nesyt. The green alga *Dictyosphaerium subsolitarium* and the cyanobacteria *Pseudanabaena limnetica* predominated in spring 1992. This situation lasted until the end of summer, while the numbers of the green algae *Monoraphidium minutum* and *Goniochloris* of the group Xanthophyceae rose. The quantity of all algae decreased in August then increased everywhere in September, when *Dictyosphaerium subsolitarium*, *Pseudanabaena limnetica* and *Chroococcus minimus* became dominant. Very high turbidity was observed in 1993, while the main representatives of the plankton throughout the season were *Pseudanabaena limnetica*, *Monoraphidium minutum* and the

green algae *Chlorella*. During the autumn, the filamentous cyanobacteria *Anabaenopsis nadsonii* Voronichin (syn. *Anabaenopsis kulundinensis* Voronichin) occurred; a growth requiring high water salinity, it had not previously been recorded in the Czech Republic. Hlohovecký Pond saw high turbidity throughout the 1994 vegetation season. High abundances started early, in February, when the predominating species were *Tetrastrum glabrum* (Roll) Ahlstr. et Tiff. and the centric diatom *Stephanodiscus hantzschii*. Cell densities from April to July rose to over 10^6 /ml, dominant organisms primarily *Pseudanabaena limnetica*, *Dictyosphaerium subsolitarium* and *Chlorella*. The amount of phytoplankton fell during August while, in addition to the above species, the green alga *Monoraphidium minutum* occurred frequently. The cyanobacteria *Chroococcus minimus* dominated in Prostřední Pond for the whole of spring 1992. May saw the pond host to mainly the green algae *Dictyosphaerium subsolitarium*, *Coelastrum microporum* and *Chlorella*, as well as the small cyanobacteria *Merismopedia tenuissima*. In late summer and at the end of the vegetation season, *Dictyosphaerium subsolitarium*, *Pseudanabaena limnetica* and *Chroococcus minimus* predominated. The 1993 season was marked by thick vegetation turbidity, largely caused by *Pseudanabaena limnetica*, *Monoraphidium minutum* and *Chlorella*. In 1994, the phytoplankton was well under way in February and a bloom consisting mainly of *Chlorella* and *Dictyosphaerium subsolitarium*, the cyanobacteria *Pseudanabaena limnetica*, the cryptophycean *Chroomonas caudata* and the diatom *Stephanodiscus hantzschii* occurred.

April and May saw the onset of the cyanobacteria *Pseudanabaena limnetica*, with *Anabaenopsis nadsonii* appearing in lower numbers. In July and August, cyanobacteria and chlorococcal algae clearly predominated. At the end of the season the quantities of cyanobacteria and algae were still high, with a higher abundance of *Limnothrix redekei* (V. Goor) Meffert (syn. *Oscillatoria redekei*), *Aphanocapsa incerta* and the alga *Dictyosphaerium subsolitarium*.

Of all the ponds, Mlýnský had the highest quantities of phytoplankton. The cyanobacteria, especially *Planktothrix agardhii* (Gom.) Anagn. et Kom. (Syn. *Oscillatoria agardhii*) and *Chroococcus minimus*, were largely predominant. Also important elements of the plankton were the green algae *Nephrochlamys willeana* (Printz) Korš. and *Dictyosphaerium subsolitarium*. These species continued to make up the main proportion of the phytoplankton throughout the vegetation season and the quantities of cyanobacteria declined steadily. In autumn *Pseudanabaena limnetica*, *Dolichospermum flos-aquae* and *Merismopedia tenuissima* came to the fore. Summer 1993 saw an abundance of cyanobacteria, which reached a cell density of over 4.5×10^6 /ml. Much of this huge quantity consisted of the picocyanobacterial *Aphanocapsa incerta* and the green algae *Dictyosphaerium subsolitarium* and *Monoraphidium minutum*. A high abundance of phytoplankton in Hlohovecký Pond continued until late autumn. In 1994, high quantities were noted in February, with the major planktonic groups largely made up of the filamentous cyanobacteria *Pseudanabaena limnetica* and the green *Chlorella* algae. The green alga *Monoraphidium minutum* made a strong showing in May. The coccal cyanobacteria *Aphanocapsa incerta* and *Merismopedia tenuissima* took over in June, replaced by *Pseudanabaena limnetica* during July-August.

The abundance of certain algae and cyanobacteria remained high (cell density over $2 \times 10^6/\text{ml}$) until autumn, with *Pseudanabaena limnetica*, *Aphanocapsa incerta*, *Limnothrix redekei* and *Dictyosphaerium subsolitarium* predominant.

The 1992–1994 monitoring (HETEŠA *et al.* 1994) disclosed significant changes in both the quantities and structure of the phytoplankton. The cyanobacteria, which had previously been common and regular in the Lednice Ponds, now occurred in only small quantities and never developed massively. Their place was taken by a predomination of picoplankton species of cyanobacteria, such as *Aphanocapsa incerta*, *Merismopedia tenuissima* and *Pseudanabaena limnetica*, otherwise usually native to shallow, hypertrophic ponds with high fish stocks (SCHEFFER *et al.*, 1997, KOPP *et al.* 2008). As well as the cyanobacteria, chlorococcal green algae, especially *Dictyosphaerium subsolitarium*, *Monoraphidium minutum* and *Chlorella* were also plentiful. The previously common occurrence of various types of benthic diatom in the spring was significantly limited, with the small, centric diatom *Stephanodiscus hantzschii*, typical of eutrophic water, the most prolific of them. The quantity of phytoplankton increased significantly during the summer. In earlier years, the cell density had been counted in tens and thousands of cells per millilitre, but during the period monitored this rose into the millions. Much of the phytoplankton was taken up with small species (picoplankton), so an increase of abundance does not necessarily infer an increase in the total biomass of phytoplankton. In terms of species composition, a decrease in oligotrophic species was observed (HETEŠA *et al.* 1994), but the total number of species remained similar. As a result of the intensification of commercial fish production since the early 1950s, which involved the regular use of mineral fertilizers, liming, and the addition of feed, fish stocks grew, the diversity of the zooplankton declined and the water chemistry changed. These changes were also reinforced by increasing eutrophication of the inflow water. The phytoplankton structure simplified, with pico-cyanobacteria beginning to predominate and green algae causing long-term vegetation turbidity and low water transparency. These factors, together with the introduction of herbivorous species of carp, led to limitation of submerged pond vegetation.

The phytoplankton of the Lednice Ponds, 2001–2002

Further detailed research into the composition of the planktonic communities in the Lednice Ponds took place in 2001 and 2002 (SUKOP & KOPP 2001, 2002a, 2002b, 2003). In Nesyt Pond, the quantity of phytoplankton was already considerable in mid-April 2001 (Fig. 4). A large number of primary producers were associated with low water transparency. The diatoms *Navicula* and *Nitzschia* began to predominate, together with *Cryptomonas* and representatives of the Euglenophyta, especially *Trachelomonas*. The green algae made up the largest part of the phytoplankton: *Dictyosphaerium* Näg., *Monoraphidium* and *Scenedesmus*. Cyanobacteria did not occur in large quantities and were represented by *Merismopedia tenuissima*, *Planktothrix agardhii* and *Aphanocapsa incerta*. Increasing water temperature supported the development of cyanobacteria and algae. The quantity of cyanobacteria increased during May–June, especially *Merismopedia tenuissima* and *Aphanocapsa incerta*. *Cryptomonas* and diatoms receded

Cyanobacteria and algae in the Lednice Ponds

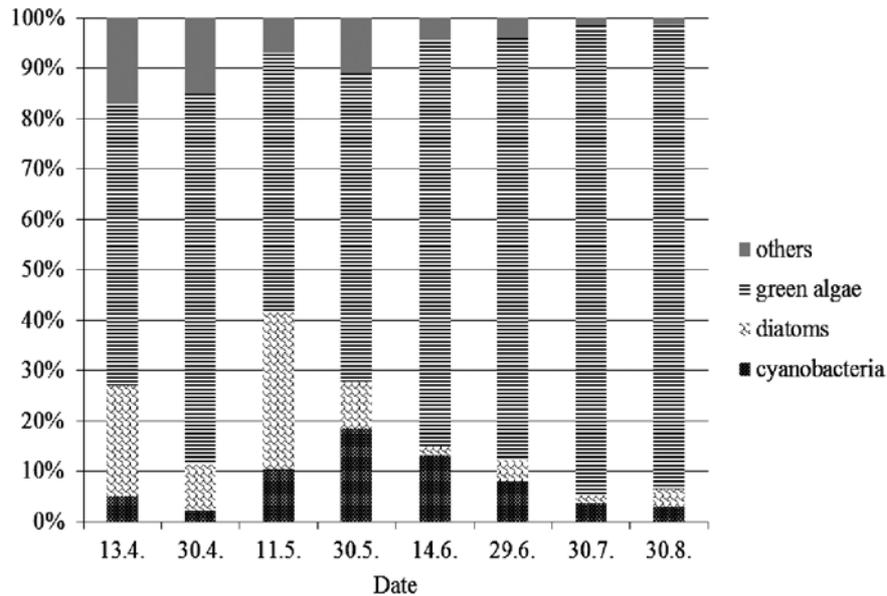


Fig. 4. Percentage composition of the main groups of cyanobacteria and algae of Nesyt Pond during season 2001 (% of cell number).

and Chlorophyta took over, mainly *Dictyosphaerium*, *Monoraphidium*, *Scenedesmus*, *Tetrastrum*, *Tetraedron* and *Oocystis*. The most significant increase in the number of cells was observed in the colonial alga *Dictyosphaerium subsolitarium*, which assumed dominance at the warmest time of year (July-August), with densities in the order of hundreds of thousands of cells per millilitre. The species diversity throughout the phytoplankton remained high for the whole 2001 vegetation season, with a total of 134 taxa recorded.

In Nesyt Pond, as in 2001, the biomass of phytoplankton was already considerable in mid-April 2002 (Fig. 5.) Compared to the previous year, *Euglena* species and the diatom *Nitzschia* predominated over the green algae. The common green algae *Dictyosphaerium subsolitarium* was observed only rarely in this year. The quantity of chlorococcal green algae and cryptomonads rose with higher water temperatures. In May-June, the phytoplankton was composed mainly of *Cryptomonas*, *Scenedesmus* and *Desmodesmus*, and the algae *Dictyosphaerium subsolitarium* started to grow. In the hottest part of the year (July-August) cryptomonads and diatoms retreated and green algae became dominant.

The cyanobacteria were essentially absent from Hlohovecký Pond (Fig. 6). Only in July was a higher biomass of the planktonic filamentous cyanobacterium *Dolichospermum flos-aquae* observed. The species diversity of the phytoplankton remained high for the whole vegetation season, with 107 taxa indentified. The

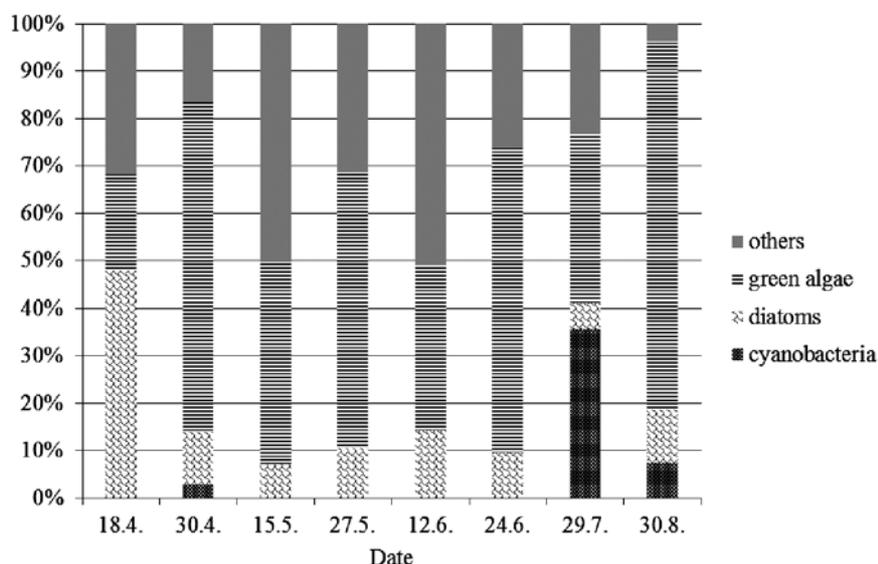


Fig. 5. Percentage composition of the main groups of cyanobacteria and algae of Nesyt Pond during season 2002 (% of cell number).

phytoplankton of Hlohovecký Pond developed only slightly during spring 2001, largely featuring *Navicula* diatoms, or *Cryptomonas* and *Trachelomonas* species. The most prolific species of green algae was *Schroederia setigera* (Schröd.) Lemmerm. Cyanobacteria began to appear sporadically in May-June, but the diatoms *Stephanodiscus hantzschii* and *Cryptomonas marssonii* Skuja were the most common. The main part of the phytoplankton in this period consisted of the green algae *Oocystis* group, largely *Oocystis lacustris*. In July-August, a bloom appeared in Hlohovecký Pond, composed mainly of the potentially toxic cyanobacteria *Microcystis ichthyoblabe* Kütz. Other representatives of the phytoplankton, apart from the desmidialid *Closterium limneticum* Lemmerm, were suppressed, and their occurrence was sporadic. A total of 80 taxa was recorded in the period.

As in the previous year, the phytoplankton of Hlohovecký Pond in spring 2002 (Fig. 7) was only slightly developed, with its largest part made up of the diatoms *Nitzschia* and *Fragilaria*, with other groups such as *Cryptomonas* and the green algae *Dictyosphaerium subsolitarium*. In May and June the cyanobacteria assumed predominance, especially the coccal species *Microcystis aeruginosa*. In July-August the abundance of cyanobacteria fell away in favour of a community of green algae: *Dictyosphaerium*, *Monoraphidium*, *Scenedesmus*, *Tetrastrum*, *Tetraedron* and *Oocystis*. In addition to numerous green algae, there were diatoms of the genus *Stephanodiscus*. Over the whole period, a total of 83 taxa was recorded.

Cyanobacteria and algae in the Lednice Ponds

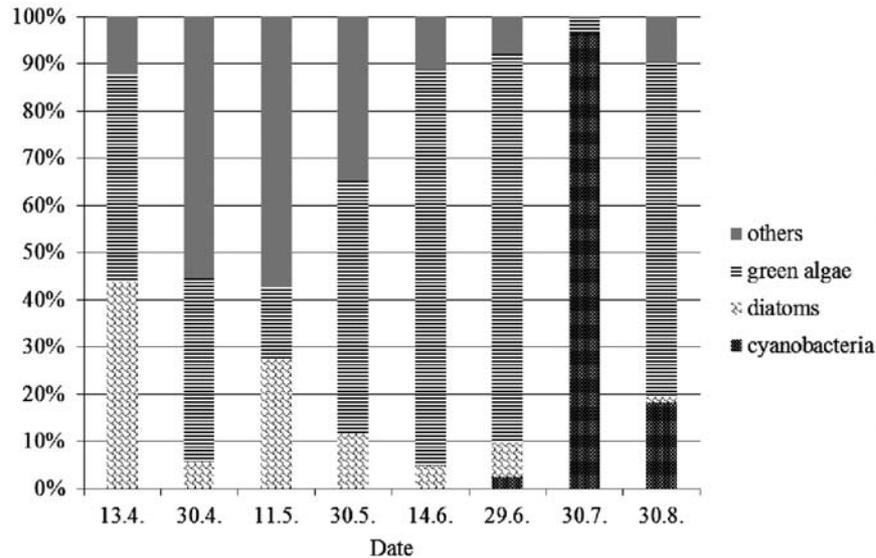


Fig. 6. Percentage composition of the main groups of cyanobacteria and algae of Hlohovecký pond during season 2001(% of cell number).

The phytoplankton of Prostřední Pond was quantitatively and qualitatively quite poor for 2001 (Fig. 8). In April, the main constituents were diatoms (*Nitzschia*), and cryptomonids (*Chroomonas* and *Cryptomonas*). The cyanobacteria and green algae were represented only marginally. The composition of the phytoplankton remained similar in May and June, with just an increase in the number of green algae. A cyanobacterial bloom appeared in Prostřední Pond during the hottest months of the year, composed largely of the coccid cyanobacteria *Microcystis aeruginosa* and two filamentous species, *Dolichospermum flos-aquae* and *Aphanizomenon flos-aquae*. These species of phytoplankton predominated strongly, sporadically accompanied by the usual types of green algae. Over the whole period, a total of 66 taxa was recorded.

Compared to 2001, the phytoplankton of Prostřední Pond in 2002 was considerably richer (Fig. 9). In April, the diatoms (*Nitzschia*), and cryptomonads (*Rhodomonas*) predominated. The green algae were represented by only *Oocystis lacustris*. In late May and June a cyanobacterial bloom started to form, which maintained its high biomass until the end of the vegetation season. The bloom consisted of the colonial cyanobacteria *Microcystis aeruginosa* and four filamentous species: *Dolichospermum flos-aquae*, *Aphanizomenon flos-aquae*, *Aphanizomenon gracile* (Lemmerm.) Lemmerm. and *Anabaenopsis elenkinii* Mill. These predominated and were supplemented by common green algae. Over the whole period, a total of 110 taxa was recorded.

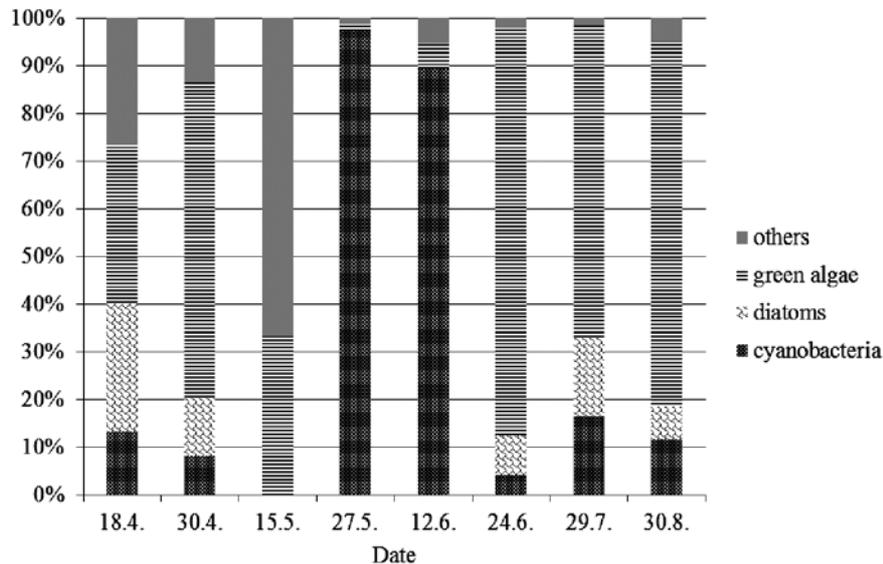


Fig. 7. Percentage composition of the main groups of cyanobacteria and algae of Hlohovecký pond during season 2002 (% of cell number).

The phytoplankton of Mlýnský Pond (Fig. 10.) was quite species-poor for the entire vegetation season of 2001. Early on, the cryptomonad group predominated: *Chroomonas caudata*, *Cryptomonas marssonii*, *Cryptomonas curvata* Ehrenb. and *Cryptomonas*. Included among the other taxonomic groups were the diatoms (*Nitzschia*) and green algae (*Dictyosphaerium subsolitarium*). A *Dolichospermum* bloom appeared in May. The quantity of cryptomonads increased constantly, as did as the numbers of green algae, mainly *Oocystis*. The *Dolichospermum* bloom faded in June and the common planktonic cyanobacteria *Merismopedia* and *Aphanocapsa* began to appear. These do not form blooms and contribute to the vegetation turbidity of green algae. The main role of primary producer was taken over by green algae, consisting of the common species (*Oocystis*, *Dictyosphaerium*, *Chlamydomonas*, *Scenedesmus*, *Tetrastrum*, *Tetraedron*). During the summer season (July-August) common green algae predominated, with a few colonial cyanobacteria. Other phytoplankton groups were rare, with some non-identifiable coccid bacteria found in a water sample only in August. Over the whole period, a total of 87 taxa was recorded.

The composition of the Mlýnský Pond phytoplankton was richer in diatoms in 2002 (Fig. 11), largely species of *Nitzschia*, *Navicula* and *Pinnularia*. The diatoms constituted a large part of the phytoplankton biomass, with the green algae *Ankyra judayi* (G. M. Smith) Fott. dominant. A bloom of the cyanobacteria *Microcystis* occurred during May,

Cyanobacteria and algae in the Lednice Ponds

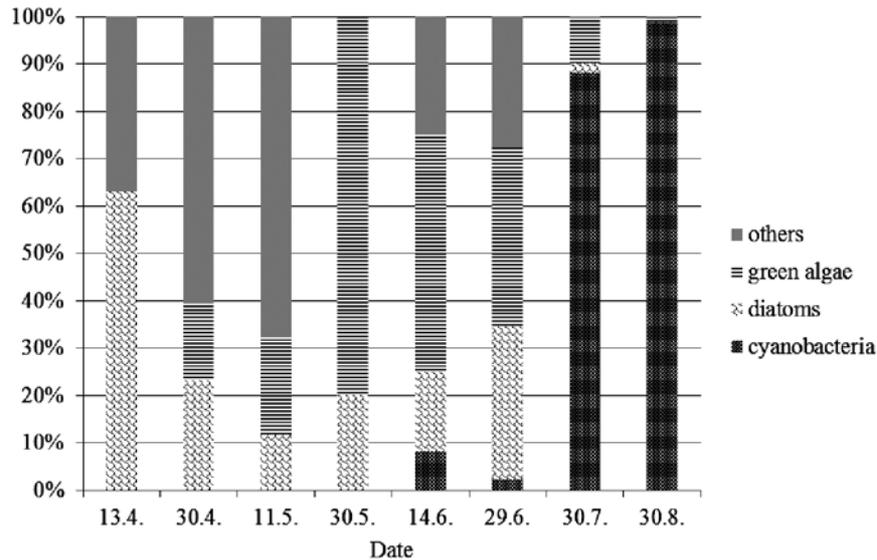


Fig. 8. Percentage composition of the main groups of cyanobacteria and algae of Prostřední pond during season 2001 (% of cell number).

but quantities remained low in other groups. The *Microcystis* bloom predominated in June, when the density of cells rose to the millions per millilitre. Of the other species, only the cryptomonads (*Chroomonas caudata*) and *Chlamydomonas* were noticeably numerous. The *Microcystis* bloom declined in July-August, and the filamentous cyanobacteria *Anabaenopsis elenkinii* came on quite strongly.

The main proportion of the phytoplankton was taken up by the green algae, represented by the common species *Dictyosphaerium*, *Monoraphidium*, *Scenedesmus*, *Tetrastrum*, *Tetraedron* and *Oocystis*. Over the whole period, a total of 104 taxa was recorded.

In 2001–2002, the fishery management of the Lednice Ponds proceeded at a lower intensity than in the previous 30 years. Nesyt Pond was significantly different from the rest of the system, especially in terms of lower water transparency and the limited occurrence of cyanobacterial blooms. In both years, the phytoplankton of this pond was composed mainly of small chlorococcal algae. The other three ponds monitored (Hlohovecký, Prostřední and Mlýnský) were characterized by high transparency and low biomass of cyanobacteria and algae during the spring months. The phytoplankton biomass increased and water transparency decreased at the end of the vegetation season. Cyanobacterial blooms frequently assumed dominance.

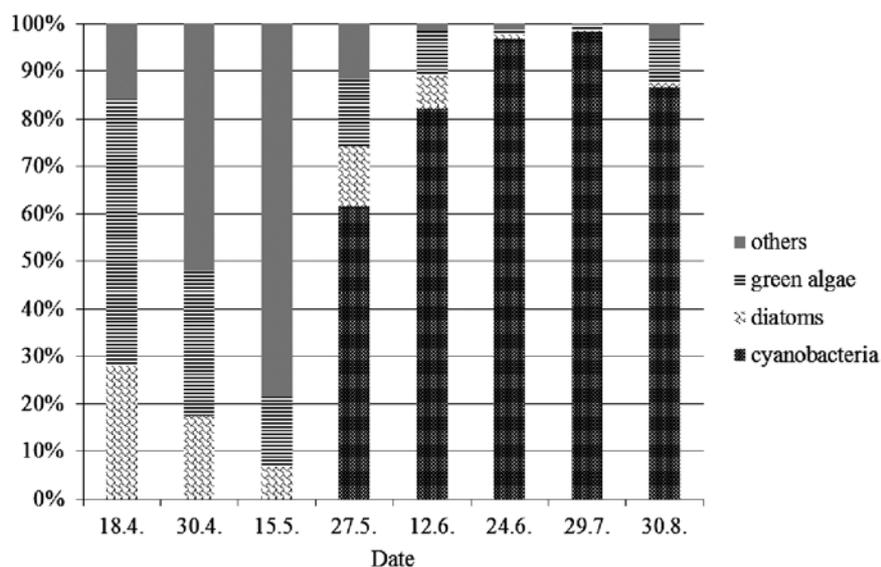


Fig. 9. Percentage composition of the main groups of cyanobacteria and algae of Prostředni pond during season 2002 (% of cell number).

The phytoplankton of the Lednice Ponds, 2005–2007

In 2005–2007 the phytoplankton of the Lednice Ponds was monitored only in the warmest months of the year (July–September) as part of a nationwide survey of toxic cyanobacteria.

In 2005 the composition of phytoplankton in Nesyt Pond (Fig. 12) was largely made up of the picoplankton species *Synechocystis* and *Aphanocapsa*. Representatives of *Cryptomonas* and the common green algae *Chlorella*, *Oocystis*, *Desmodesmus* were found in considerable numbers.

In 2006 the picocyanobacteria and green algae were predominant once more, with diatoms taking over in autumn. The numbers of the green algae *Scenedesmus*, *Oocystis*, *Desmodesmus* and *Tetraedron* rose in June. The most abundant planktonic organisms were the filamentous alga *Planctonema lauterbornii* Schmidle and the cyanobacteria *Aphanocapsa*. In August *Aphanocapsa* and *Aphanothece* predominated. In autumn the numbers of cyanobacteria fell, the biomass of green algae increased and the centric diatoms *Cyclotella* and *Stephanodiscus* advanced considerably. Nesyt Pond was drained and dried for summer 2007, and very dry weather dictated that the draining be complete (normal “summering” leaves a small area of water) at the end of the vegetation season to prevent loss of fish stock.

The development of the phytoplankton was similar to that in previous years, with the hottest part of 2007 predominated by picocyanobacteria, especially *Aphanocapsa*,

Cyanobacteria and algae in the Lednice Ponds

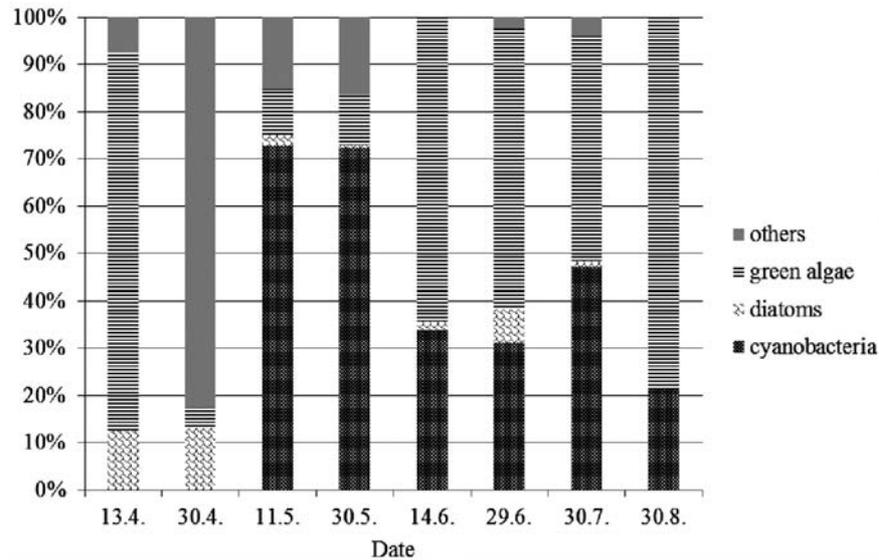


Fig. 10. Percentage composition of the main groups of cyanobacteria and algae of Mlýnský pond during season 2001 (% of cell number).

Aphanothece. and *Synechococcus*. A reduced water level was reflected in the occurrence of *Phormidium*, typically a benthic cyanobacterium in the plankton of the pond. Of the other groups of primary producers, the green coccal algae *Chlorella* and *Kirchneriella* appeared the most frequently. The numbers of diatoms increased in response to a steady reduction of water level in late August. The most abundant benthic cyanobacteria was *Phormidium*, with *Nitzschia* and the centric *Stephanodiscus* as predominant diatoms. As surface area decreased, so inorganic turbidity associated with concentrated fish stocks rose, together with the development of the planktonic cyanobacteria that are tolerant of low light conditions: *Cuspidothrix issatschenkoi* (Usač.) Raja and *Pseudanabaena limnetica*. The diatoms *Stephanodiscus* and *Nitzschia acicularis* (Kütz.) W. Smith remained dominant until the end of vegetation season.

A heavy bloom of cyanobacteria appeared in Hlohovecký Pond in June 2005 (Fig. 13), consisting mainly of *Microcystis aeruginosa*, *Microcystis ichthyoblabe* and *Aphanizomenon flos-aquae*. At the end of the month these species were replaced by the green algae *Scenedesmus*, *Oocystis*, *Desmodesmus* and *Closterium limneticum*. Also present were the diatoms *Nitzschia* and *Cyclotella*, the euglenoids *Euglena* and *Phacus* and the picoplanktonic cyanobacterium *Aphanocapsa*. Remaining at the end of vegetation season were the cyanobacterium *Aphanocapsa* and the euglenoids *Lepocinclis* and *Phacus*. A significant part of the phytoplankton was also made up of common species of green algae: *Oocystis lacustris*, *Pediastrum boryanum* and *Coelastrum microporum*.

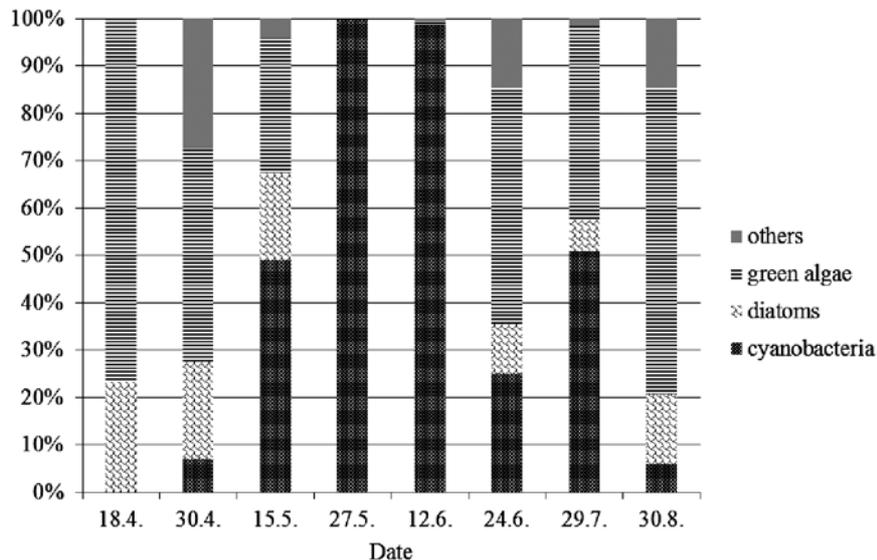


Fig. 11. Percentage composition of the main groups of cyanobacteria and algae of Mlýnský pond during season 2002 (% of cell number).

The picoplanktonic cyanobacteria *Aphanocapsa* and *Aphanothece* maintained exclusive predominance throughout the 2006 season in Hlohovecký Pond. The green algae were quite strongly represented in June, with *Oocystis lacustris*, *Oocystis parva* W.et G.S.West, *Scenedesmus acuminatus* (Lagerh.) Chod. and *Scenedesmus linearis* Kom. in higher abundance. The composition of the phytoplankton was similar in 2007, with a prevalence of the cyanobacteria *Aphanocapsa*, *Aphanothece*, *Pseudanabaena limnetica* and certain other groups of algae: the cryptomonad *Chroomonas caudata*, *Nitzschia* diatoms and green algae (*Pseudodidymocystis planctonica*, *Kirchneriella* and *Monoraphidium*). The green algae, represented by a large number of coccal species, became predominant in August, with *Coelastrum microporum* the most numerous. The diatom *Nitzschia* also made an appearance, as did *Euglena*. At the end of the 2007 season the picocyanobacteria *Aphanocapsa*, especially *Aphanocapsa incerta*, came to the fore again. Among the less dominant groups, the common green algae *Closterium limneticum*, *Chlamydomonas*, *Dictyosphaerium*, *Tetrastrum* and *Oocystis* occurred.

The phytoplankton of Prostřední Pond was very poor in 2005 (Fig. 14), a response to the development of a large species of *Daphnia* water flea. The predominant green algae in June were *Ankyra ancora*, *Ankyra judai*, *Schroederia setigera*, *Pediastrum boryanum* and the diatom *Nitzschia*. The cyanobacteria became clearly dominant in August and a bloom appeared, formed largely of *Microcystis aeruginosa* and *Microcystis ichthyoblabe*. The quantity of cyanobacteria decreased towards the end of vegetation season in the face

Cyanobacteria and algae in the Lednice Ponds

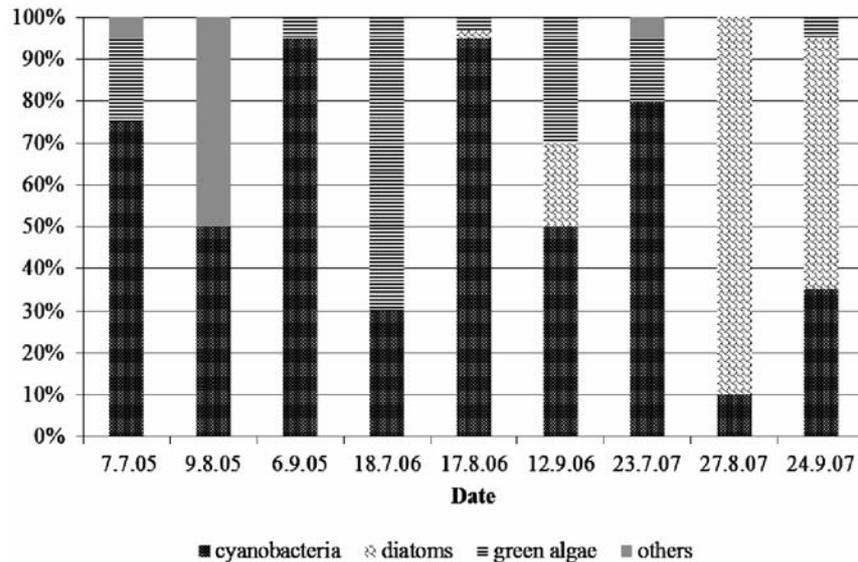


Fig. 12. Percentage composition of the main groups of cyanobacteria and algae of Nesyt pond during seasons 2005 to 2007 (% of cell number).

of expansion by *Euglena*, *Phacus* and *Lepocinclis globulus* Perty (syn. *L. ovum* (Ehrenb.) Lemmerm.).

Nitzschia diatoms, together with common green algae and picoplaktonic cyanobacteria were dominant in 2006. The picocyanobacteria *Aphanocapsa* and *Aphanothece* and the filamentous cyanobacteria *Planktolyngbya limnetica* (Lemmerm.) Kom.-Legn. et Cronb. expanded in August. Among the subdominants were common species of green algae such as *Scenedesmus*, *Oocystis*, *Desmodesmus* and *Closterium*. This composition of phytoplankton persisted in Prostřední Pond until the end of the season. In 2007, the phytoplankton composition was very diverse, but no group of algae or cyanobacteria predominated. An expansion of the diatom *Skeletonema potamos* Weber was worthy of note. *Skeletonema potamos* with *Nitzschia* were of the highest abundance in July. The picocyanobacteria *Aphanocapsa*, *Aphanothece* and the green coccal algae *Chlorella* and *Kirchneriella* also appeared in considerable quantities. The numbers of *Aphanocapsa* increased in August, with the green algae *Pseudodidymocystis planctonica* and *Koliella spiculiformis* (Wisł.) Hind. subdominant. At the end of vegetation season, the green algae *Scenedesmus*, *Oocystis*, *Dictyosphaerium*, the green coccal algae *Chlorella* and the diatoms *Nitzschia* and *Navicula* were the most abundant.

Some 95% of the phytoplankton of Mlýnský Pond (Fig. 15) consisted of picocyanobacteria, largely *Synechocystis*, *Synechococcus* and *Aphanocapsa*. The green algae *Scenedesmus* and *Oocystis* also occurred. The cyanobacteria predominated once

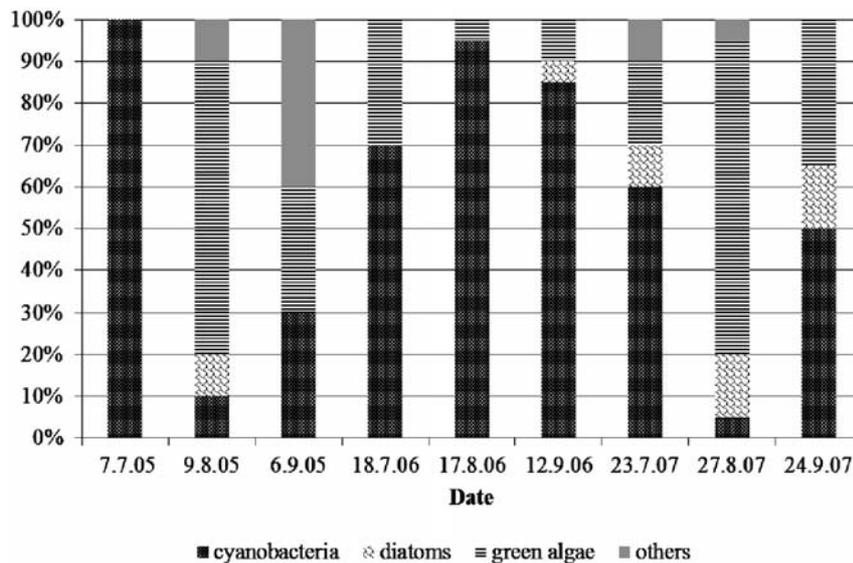


Fig. 13. Percentage composition of the main groups of cyanobacteria and algae of Hlohovecký pond during seasons 2005 to 2007 (% of cell number).

more in 2006, with the filamentous species *Anabaenopsis elenkinii* and *Planktolyngbya limnetica* most dominant. Other groups of algae occurred only sporadically. A *Chlamydomonas* bloom was observed during August. Common planktonic cyanobacteria were in high abundance, mostly *Microcystis* and *Dolichospermum*. At the end of the vegetation season the picocyanobacteria *Aphanocapsa* and *Aphanothece* predominated. In July 2007, other picoplanktonic species of cyanobacteria, such as *Synechococcus* and *Aphanocapsa* were dominant in Mlýnský Pond. Green coccal algae of the genus *Chlorella* also appeared in higher abundance. The planktonic cyanobacteria *Microcystis aeruginosa* and *Dolichospermum mendotae* (Trel.) Wackl., Hoffm. et Kom. (basionym: *Anabaena mendotae*) predominated in August. Subdominant groups of algae included *Nitzschia* diatoms and *Aulacoseira granulata*. The abundance of *Navicula* and *Aulacoseira* increased in September, while representatives of the green algae *Oocystis marssonii* Lemmerm. were numerous. The cyanobacteria, in the form of *Dolichospermum mendotae*, made up only an insignificant part of the plankton community that month.

Very low values for water transparency and a dominance of picocyanobacteria were observed in all the ponds. Other commonly-occurring groups of algae included green algae and euglenoids. Higher fish stocking and phytoplankton composed mainly of picocyanobacteria were recorded for the Mlýnský and Nesyt Ponds throughout the monitored part of 2005.

Cyanobacteria and algae in the Lednice Ponds

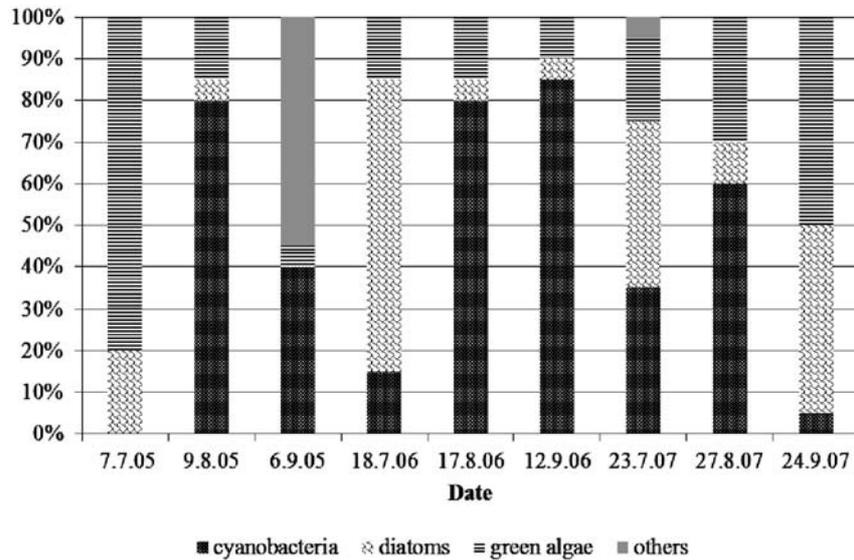


Fig. 14. Percentage composition of the main groups of cyanobacteria and algae of Prostřední pond during seasons 2005 to 2007 (% of cell number).

The intensity at which the fish of the Lednice Ponds were were farmed changed in 2005–2007. First, Prostřední Pond and Hlohovecký Pond were more lightly stocked and the phytoplankton composition was therefore different. The coccal cyanobacterium *Microcystis*, common species of green algae and the euglenoids predominated. The fish stock in these ponds was raised in 2006, and picocyanobacteria predominated once more. The phytoplankton of Hlohovecký Pond exhibited interchanging dominance between various species of green algae in the hottest months, rounded off by a strong development of *Chlamydomonas* in August.

Prostřední Pond, basically without fish stocking, started out as a community largely of diatoms, with some picocyanobacteria and the cyanobacterium *Planktolyngbya limnetica* becoming dominant later. The development of the phytoplankton in the ponds was also affected by higher-than-usual rainfall during August. All the ponds but Mlýnský were quite heavily stocked with fish in 2007. In the phytoplankton of all the ponds this promoted diatoms, and green algae were also frequent. Compared with the previous two years, the cyanobacteria occurred in lower abundance, and the again picocyanobacteria predominated.

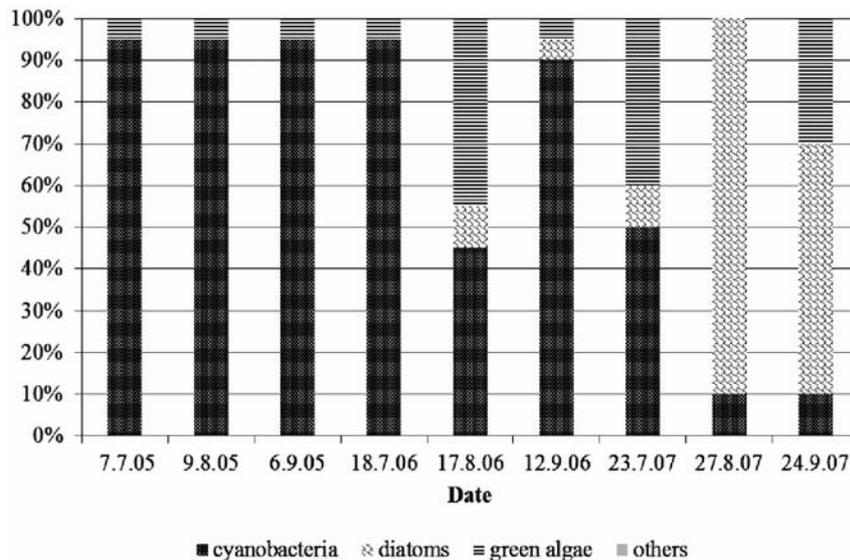


Fig. 15. Percentage composition of the main groups of cyanobacteria and algae of Mlýnský pond during seasons 2005 to 2007 (% of cell number).

The phytoplankton of the Lednice Ponds, 2008–2011

In 2008, the plankton communities of the Lednice Ponds were monitored in the interests of nature conservation (SYCHRA *et al.* 2008). With the exception of Nesyt Pond (Fig. 16), communities tended to be mainly diatomaceous, with the chrysophyte *Synura* dominant. In similar fashion to the other ponds, the biomass of algae and cyanobacteria in Nesyt decreased in response to a higher density of zooplankton in May, and Euglenophyta (genus *Colacium*) predominated. Diatoms took over the lead in June (*Aulacoseira granulata*, *Cocconeis pediculus* and *Nitzschia*), together with green algae *Coelastrum microporum* and *Pediastrum duplex*. The numbers of cyanobacteria began to rise as well, especially the filamentous *Aphanizomenon flos-aquae*, which prevailed absolutely in June. The cyanobacteria receded in August and their dominant place was taken by common species of green algae and Euglenophyta.

The phytoplankton of Hlohovecký Pond (Fig. 17) was made up of a typical community of diatoms (*Navicula* and *Nitzschia* dominant) and partly by epizootic organisms, e.g. *Colacium*. A significant abundance of zooplankton in May led to lower phytoplankton biomass and increased the water transparency. Essentially only the euglenoids, mainly *Colacium* spp., appeared. The whole biomass of phytoplankton increased in June, largely thanks to large numbers of the green algae *Pediastrum* and *Euglena texta* (Dujard.) Hübn. Cyanobacteria began to appear in July (especially *Microcystis aeruginosa*, but green algae and euglenoids were still the main component of

Cyanobacteria and algae in the Lednice Ponds

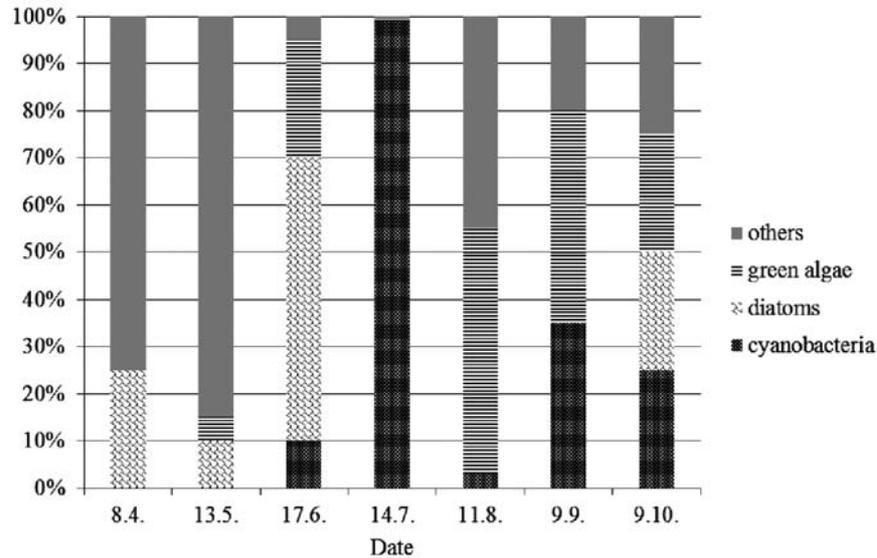


Fig. 16. Percentage composition of the main groups of cyanobacteria and algae of Nesyt pond during season 2008 (% of cell number).

the phytoplankton. From August until the end of the season, the filamentous cyanobacteria *Anabaenopsis elenkinii* was dominant.

In April 2008 the phytoplankton of Prostřední Pond (Fig. 18) was largely made up of typical spring diatoms (*Nitzschia*). An epizootic from the euglena group (*Colacium*) also constituted an important element. A temporary increase in water transparency during May enabled the cyanobacteria *Dolichospermum sigmoideum* Nyg. (basionym: *Anabaena sigmoidea*) and *Aphanizomenon flos-aquae* to become predominant, with the green alga *Botryococcus braunii* frequent. Filamentous species of cyanobacteria took over in June, mainly *Aphanizomenon flos-aquae*, replaced completely in July by *Dolichospermum flos-aquae*, *Anabaenopsis elenkinii* and *Sphaerospermopsis aphanizomenoides* (Forti) Zapomělová (basionym: *Aphanizomenon aphanizomenoides*). In August and September typical coccal green algae (*Scenedesmus acuminatus*, *Desmodesmus communis*, *Golenkinia radiata* Chod.) were recorded, together with centric diatoms (*Cyclotella*, *Stephanodiscus*). The cyanobacteria *Anabaenopsis milleri* Woronich, *Planktothrix agardhii* and *Microcystis aeruginosa*, however, remained predominant. The cyanobacterium *Anabaenopsis elenkinii* predominated in October.

In April 2008, Mlýnský Pond (Fig. 19) featured a typical spring association of diatoms (*Nitzschia*). During May the diatoms occurred only sporadically and coccal green algae predominated at a low biomass (*Botryococcus braunii*, *Coelastrum microporum*). A higher water transparency prevailed. Cyanobacteria predominated from

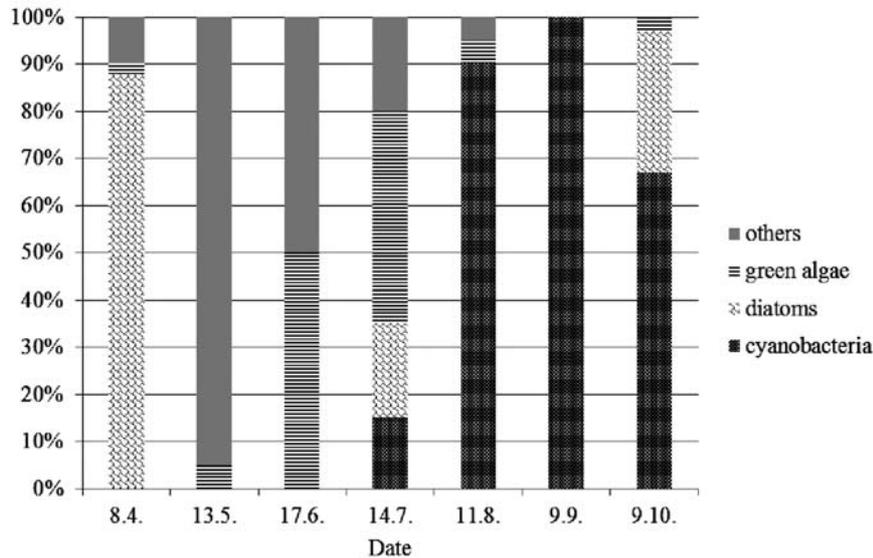


Fig. 17. Percentage composition of the main groups of cyanobacteria and algae of Hlohovecký pond during season 2008 (% of cell number).

June until the end of vegetation season with the community largely made up of filamentous species such as *Anabaenopsis elenkinii*, *Dolichospermum sigmaideum*, *Sphaerospermopsis aphanizomenoides*, *Aphanizomenon flos-aquae*, *Planktolyngbya limnetica* and *Pseudanabaena limnetica* as well as the coccal *Microcystis aeruginosa*.

The composition of the phytoplankton in the Mlýnský, Prostřední and Hlohovecký ponds was of a similar character for whole 2008 season. As is quite usual, groups of diatoms were dominant in April. These declined in May, and the water transparency decreased; only the epizootic *Colacium*, a secondary native of the zooplankton, appeared. This situation occurs in ponds where the fish stock is low, so piscine predatory pressure is too slight effectively to reduce development of the phytoplankton that limits primary producers. The cyanobacteria predominated in June and maintained that position until the end of the vegetation season (until August in Hlohovecký Pond). Such massive cyanobacteria blooms had been observed in the past and were a regular feature of the immediately previous years when carp stocks were reduced. The phytoplankton of Nesyt Pond was still under the influence of interventions made in previous years. No heavy cyanobacterial bloom appeared; in fact, the cyanobacteria were predominant only in July. The phytoplankton was made up of common green algae and euglenoids for the whole season. The development of the phytoplankton was supported by the slow decomposition of organic matter that had been left in the pond after summer drying in previous years. These conditions are suitable for Euglenophyta.

Cyanobacteria and algae in the Lednice Ponds

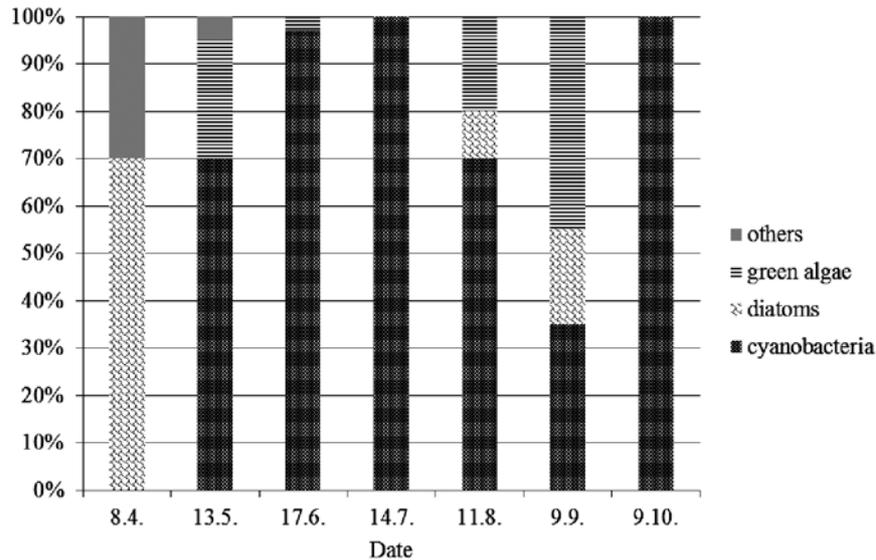


Fig. 18. Percentage composition of the main groups of cyanobacteria and algae of Prostřední pond during season 2008 (% of cell number).

The phytoplankton of Nesyt Pond (Fig. 20) in March-April 2009 consisted mainly of typical spring diatoms (*Nitzschia* predominant), euglenoids (*Euglena* and *Colacium*) and green algae (especially *Pediastrum*). In May, water transparency increased up to 150 cm for a while. The dominant group was green algae, with the highest abundance falling to *Oocystis lacustris* and *Pediastrum duplex*. Planktonic cyanobacteria took over from June until the end of the season, with complete dominance by the filamentous *Planktothrix agardhii*.

The phytoplankton of Hlohovecký Pond (Fig. 21) in March-April was composed mainly of typical spring diatoms (predominantly *Fragilaria*, *Surirella*, centric species (*Melosira varians*) and some euglenoids (*Euglena* and *Colacium*). In April the green algae were strongly represented, mainly *Pediastrum*. Cyanobacteria predominated from May until October, the genus *Dolichospermum* at first, with *Planktothrix agardhii* taking over in August.

The phytoplankton of Prostřední Pond in March-April (Fig. 22) contained mainly green algae, especially the colonial *Botryococcus tryococcus braunii* and filamentous *Spirogyra*. Blooms of cyanobacteria predominated from May onwards, first *Dolichospermum mendotae*, replaced in June by *Aphanizomenon flos-aquae*. Common green algae (*Coelastrum* and *Pediastrum*) began to develop in July-August, accompanied by euglenoids (*Colacium*). Cyanobacteria predominated once more at the end of season (September-October), in the form of filamentous *Planktothrix agardhii*. *Aphanizomenon klebahnii* Elenk., *Anabaenopsis milleri* and *Microcystis aeruginosa* were subdominant.

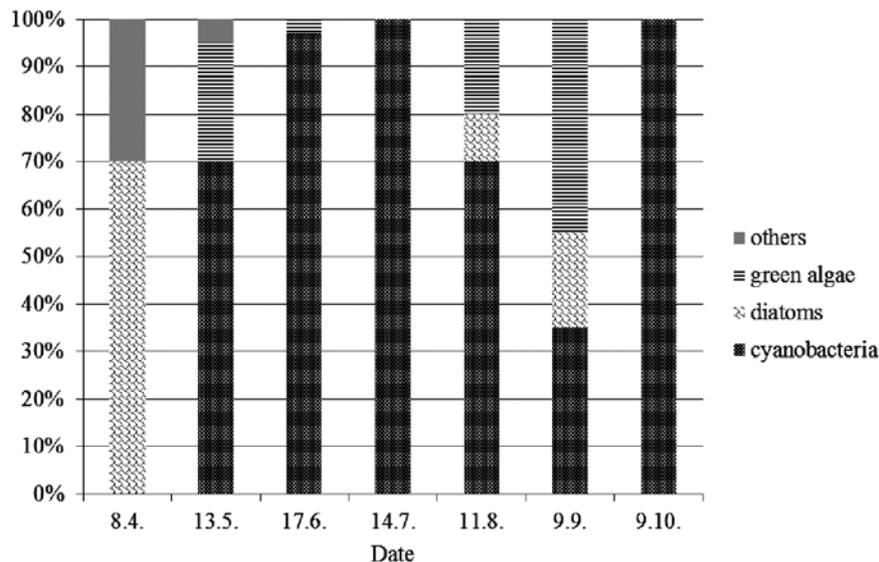


Fig. 19. Percentage composition of the main groups of cyanobacteria and algae of Mlýnský pond during season 2008 (% of cell number).

In March-April the phytoplankton of Mlýnský Pond (Fig. 23) was composed mainly of green algae, with *Botryococcus braunii* and filamentous *Spirogyra* predominating. Picoplanktonic cyanobacteria appeared in May (mainly *Aphanocapsa*), but quickly disappeared in June, to be replaced by the green alga *Botryococcus braunii* and the euglenoid *Colacium*. The abundance of phytoplankton was at its lowest at the end of June. Species-rich cyanobacteria blooms appeared from July until the end of monitored period, largely *Aphanizomenon gracile*, *Microcystis ichthyoblabe* and *Planktothrix agardhii*. At the end of August, the presence of the invasive cyanobacteria *Cylindrospermopsis raciborskii* (Wołosz.) Seen. et S. Raju was noted.

In 2009, all of the Lednice Ponds followed a very similar pattern of phytoplankton development. Green algae and diatoms predominated in spring, as they often do in most standing water. Benthic species frequently broke away from the bottom and were found free in the form of large cakes in the plankton. In May, a significant reduction in phytoplankton abundance took place and water transparency increased. Cyanobacteria blooms appeared after the period of clear water, dominated in this phase by filamentous, colonial and cenobium algae that are not suitable food for zooplankton. Cyanobacteria clearly predominated from June until the end of the season (in Mlýnský Pond until the end of July). These massive blooms of cyanobacteria had been observed in the past and they increased. In comparison with 2008, the year 2009 in all ponds was marked by a predominance of the filamentous cyanobacteria *Planktothrix agardhii*, which grows well

Cyanobacteria and algae in the Lednice Ponds

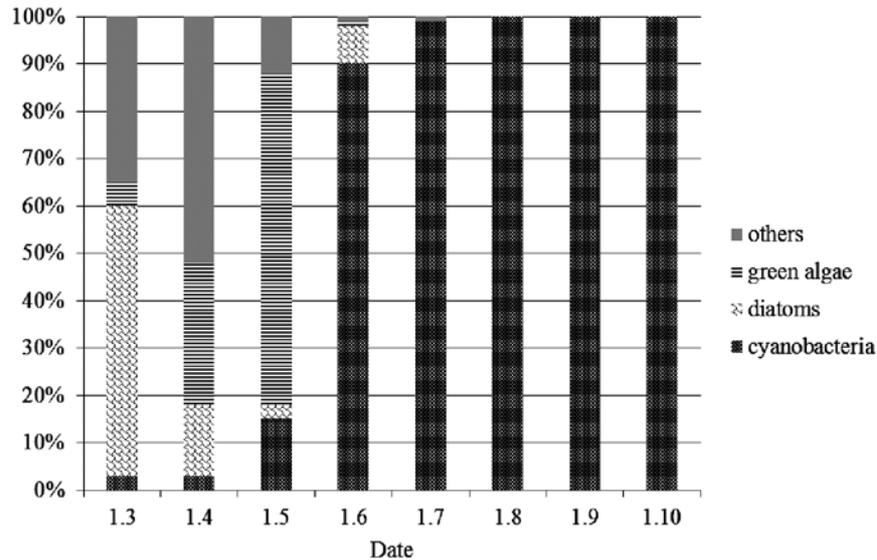


Fig. 20. Percentage composition the main groups of cyanobacteria and algae of Nesyt pond during season 2009 (% of cell number).

at lower light intensities. These conditions occur at very low water transparency (20–40 cm), with massive development of *Planktothrix*. The lower water transparency was a consequence of higher fish stocking. The fish population was also increased by the occurrence of an invasive goldfish, known among aother things as the silver crucian carp (*Carassius gibelio*).

In Nesyt Pond only (Fig. 24), the golden algae *Synura* predominated during April 2010. A further dominant was the filamentous cyanobacteria *Planktothrix agardhii*, while euglenoids, especially *Colacium* were also abundant. The biomass of algae and cyanobacteria fell in May, leaving the field to Euglenophyta (*Colacium*) and the common green algae *Pediastrum duplex*. Water transparency increased and facilitated the occurrence of a cyanobacteria bloom. The quantities of the cyanobacteria *Dolichospermum mendotae* and *Planktothrix agardhii* increased in June. The cyanobacteria predominated in July-August, mainly the filamentous *Aphanizomenon flos-aquae* and coccal *Microcystis ichthyoblabe* and *Microcystis aeruginosa*. Other groups significantly represented included the diatoms, especially *Aulacoseira granulata*. At the end of the vegetation season some green algae appeared (*Desmodesmus communis*, *Pediastrum duplex*, *Botryococcus braunii*), together with the euglenophyta (*Colacium*).

The phytoplankton of Hlohovecký Pond (Fig. 25) in March-April 2010 was composed mainly of filamentous cyanobacteria (*Planktothrix agardhii*) and Euglenophyta, mainly epizootic species (genus *Colacium*). The biomass of the

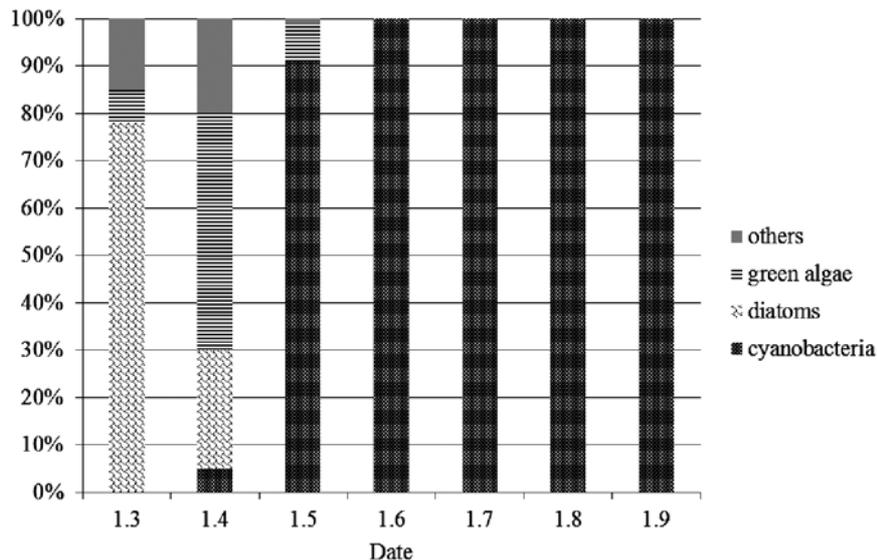


Fig. 21. Percentage composition of the main groups of cyanobacteria and algae of Hlohovecký pond during season 2009 (% of cell number).

phytoplankton decreased in May and higher water transparency led to the green algae (*Coelastrum microporum*, *Pediastrum duplex*) becoming dominant, together with the filamentous green alga *Oedogonium* that originally rose up from the benthos. The euglenoids still maintained quite high abundance (*Colacium*). From the beginning of June, the phytoplankton consisted primarily of cyanobacteria, first *Dolichospermum mendotae*, which was gradually replaced by *Aphanizomenon flos-aquae* at the end of June. The coccal cyanobacteria *Microcystis ichthyoblabe* and *Microcystis aeruginosa* were also recorded. The most frequent additions to the cyanobacteria were coenobial green algae (*Pediastrum duplex*, *Botryococcus braunii*) and *Colacium*. The cyanobacteria receded in October and were replaced by common diatoms (*Navicula*, *Nitzschia* and *Surirella ovata* Kütz.).

The phytoplankton of Prostřední Pond in March-April 2010 (Fig. 26) was composed mainly of epizootic Euglenophyta (genus *Colacium*). Small green algae occurred at the beginning of the season, but were replaced in April by the coenobial species *Pediastrum duplex* and *Botryococcus braunii*. In this period, the cyanobacteria constituted approximately 25% of total cell numbers and were represented by common genera (*Planktothrix*, *Microcystis*, *Aphanizomenon* and *Dolichospermum*). The cyanobacteria predominated from June until the end of the vegetation season, mainly the coccal species *Microcystis ichthyoblabe* and *Microcystis aeruginosa* and the filamentous *Aphanizomenon flos-aquae*. A minority of the plankton consisted of green algae, diatoms and euglenoids (*Botryococcus braunii*, *Nitzschia* and *Colacium*).

Cyanobacteria and algae in the Lednice Ponds

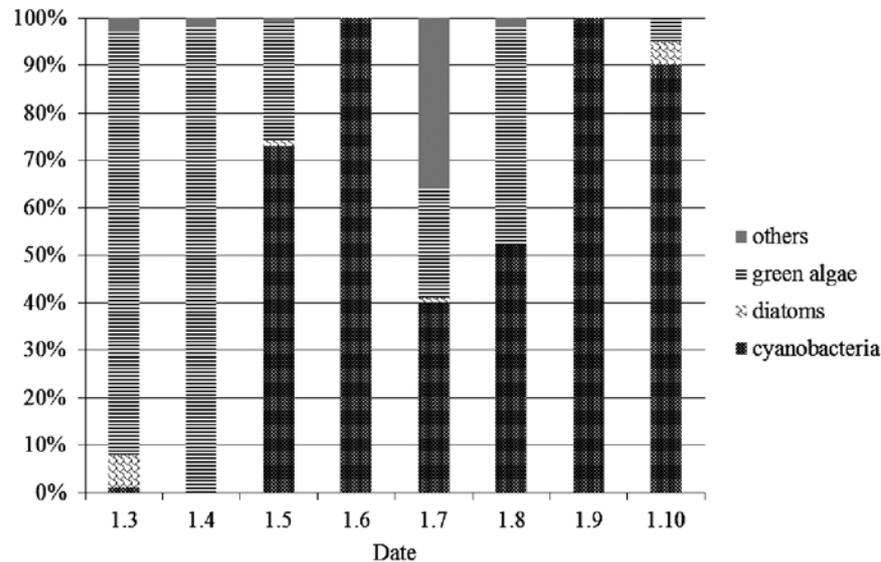


Fig. 22. Percentage composition of the main groups of cyanobacteria and algae of Prostřední pond during season 2009 (% of cell number).

The phytoplankton of Mlýnský Pond in March-April 2010 (Fig. 27) was composed mainly of the coccal cyanobacteria *Microcystis ichthyoblabe* and epizootic species of euglenoids (*Colacium*). Green algae became dominant during May, especially the coccal species *Botryococcus braunii* and filamentous *Spirogyra* algae released from the benthos. The total biomass of cyanobacteria and algae was low, facilitating higher water transparency. Cyanobacteria started to multiply in June and occurred at high abundance until the end of the vegetation season. Heretocystic filamentous types predominated (*Aphanizomenon*, *Dolichospermum* and *Anabaenopsis*), as well as non-heterocyst species (*Pseudanabaena*, *Planktothrix* and *Phormidium*). At the end of August the presence of the invasive cyanobacteria *Cylindrospermopsis raciborskii* was recorded.

The phytoplankton of all the ponds monitored during the 2010 season consisted largely of planktonic cyanobacteria. A higher abundance of zooplankton throughout the season was associated with a significant development of Euglenophyta (*Colacium*). Water transparency was high and biomass of algae generally low, except for planktonic cyanobacteria. Due to adverse weather conditions for spawning cyprinid fish during the spring and early summer, there was no expansion of invasive fish species. A smaller fish stock with lower predatory pressure on the zooplankton allows the development of large species of *Daphnia* water fleas, which limit the phytoplankton for the whole vegetation season. Only those types of phytoplankton that are not suitable food for zooplankton (planktonic cyanobacteria, filamentous, coccal and coenobium algae, etc.) were able to achieve any significant abundance.

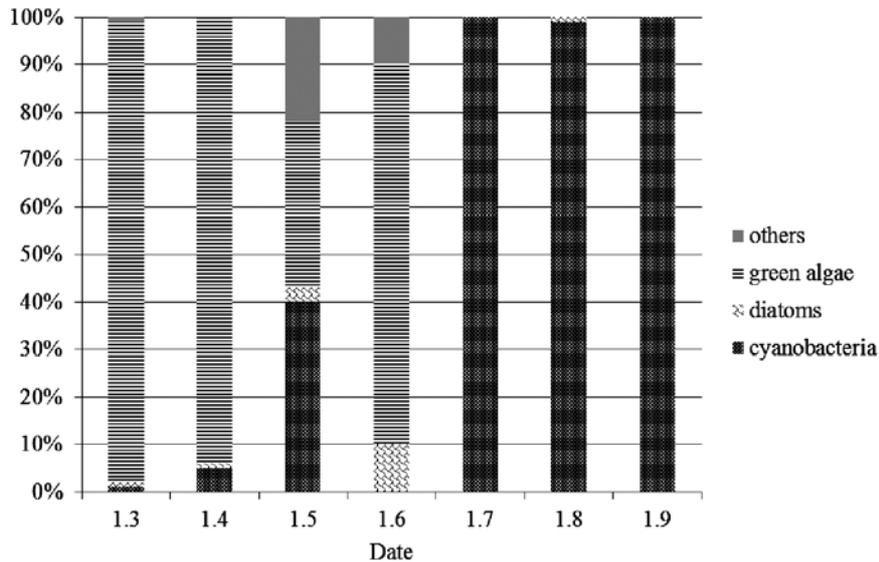


Fig. 23. Percentage composition of the main groups of cyanobacteria and algae of Mlýnský pond during season 2009 (% of cell number).

The diversity of phytoplankton in Nesyt Pond in April 2011 (Fig. 28) was very low. In fact, only *Colacium* was recorded. *Euglena* and *Phacus*, in particular, predominated during May and the green algae *Pediastrum boryanum* and *Pediastrum duplex* also appeared in some quantities. The composition of the phytoplankton community was at its most species-diverse in June; euglenoids were already a minority group, then diatoms appeared (*Aulacoseira granulata*) and green algae as well (*Pediastrum duplex*, *Botryococcus braunii*). The cyanobacteria *Microcystis aeruginosa* and *Planktothrix agardhii* became preominant. From July until the end of the vegetation season there was a clear predominance of filamentous *Planktothrix agardhii* and to a lesser extent *Aphanizomenon flos-aquae*.

The phytoplankton of Hlohovecký Pond in April-May 2011 (Fig. 29.) was composed mainly of Euglenophyta (*Colacium*, *Euglena*). Diatoms (*Fragilaria* and *Nitzschia*) and green algae (*Pediastrum*) were recorded at lower abundances. The cyanobacteria began to appear in the planktonic community in May and predominated in June (*Aphanizomenon flos-aquae*, *Microcystis aeruginosa*). The cyanobacteria receded in July-August, and *Aphanizomenon flos-aquae* disappeared completely; the warmest months of the year were represented by *Microcystis* and *Planktothrix agardhii*. Euglenophyta (*Colacium* and *Euglena*) returned to dominance. Finally, at the end of the vegetation season, all the groups receded, leaving only the single filamentous cyanobacteria *Planktothrix agardhii* to predominate.

Cyanobacteria and algae in the Lednice Ponds

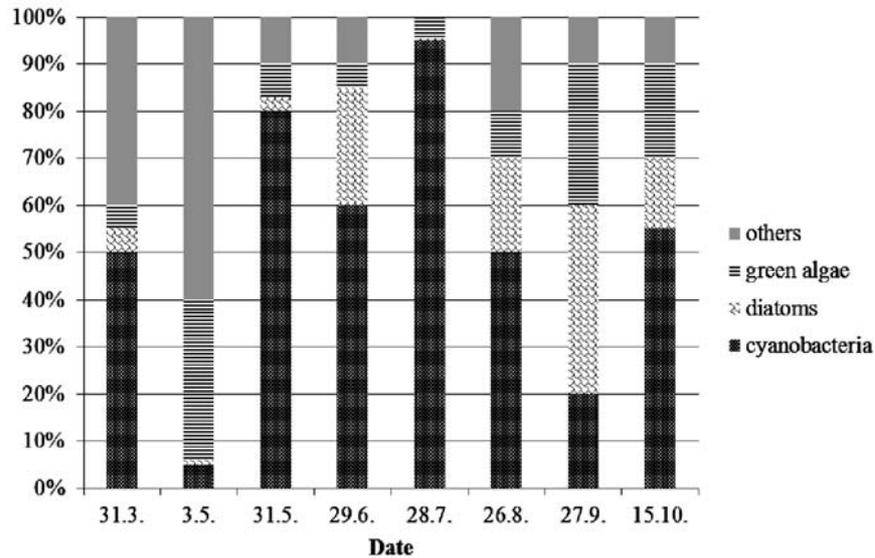


Fig. 24. Percentage composition of the main groups of cyanobacteria and algae of Nesyt pond during season 2010 (% of cell number).

The phytoplankton of Prostřední Pond in April-May 2011 (Fig. 30) was composed mainly of Euglenophyta (*Colacium*, *Euglena*) and the green algae *Pediastrum*. An abnormal bloom of the coccal cyanobacteria *Microcystis aeruginosa* appeared in June. The cyanobacteria receded in July, to be replaced by the green algae *Botryococcus braunii*, then they made a comeback in August (*Microcystis aeruginosa*, *Aphanizomenon flos-aquae* and *Microcystis ichthyoblabe*) The second largest group of algae were the diatoms *Nitzschia* and *Aulacoseira granulata*. At the end of vegetation season, the cyanobacteria predominated, especially *Planktothrix agardhii* and *Aphanizomenon flos-aquae*.

The phytoplankton of Mlýnský Pond was very species-poor in April 2011 (Fig. 31), composed mostly of epizoots released from the benthos (*Colacium*) and some diatoms. The diatoms became dominant during May, with the highest abundance going to *Aulacoseira granulata*, *Fragilaria acus* and *Fragilaria* sp. The green algae were subdominant, largely represented by *Pediastrum boryanum*, *Pediastrum duplex* and *Colacium* euglenoids. The cyanobacteria started move upwards through the ranks of the phytoplankton biomass during June and occurred in high abundance until the end of the season. In June and July, the most frequently-occurring species of cyanobacteria were *Dolichospermum mendotae* and *Aphanizomenon flos-aquae*. The abundance of *Microcystis* increased during July, and it became a clear dominant in August (*Microcystis ichthyoblabe* and *Microcystis aeruginosa*). Water transparency decreased in autumn and

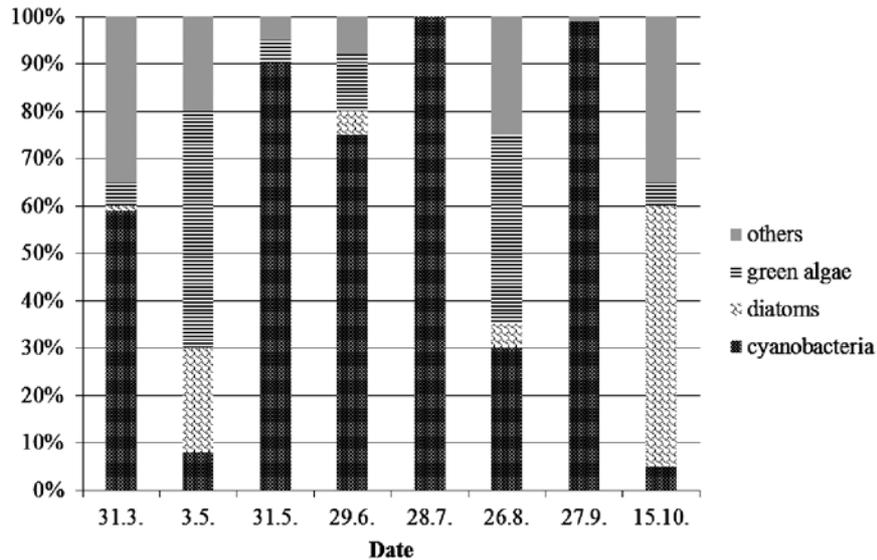


Fig. 25. Percentage composition of the main groups of cyanobacteria and algae of Hlohovecký pond during season 2010 (% of cell number).

the phytoplankton was essentially made up of a population of the filamentous cyanobacteria *Planktothrix agardhii*.

The phytoplankton of all the ponds was composed mainly of planktonic cyanobacteria for the whole of the 2011 vegetation season. A high abundance of zooplankton in spring 2011 led to the recording of a significant development of Euglenophyta, particularly epizoots (*Colacium*). The biomass of the phytoplankton rose gradually and water transparency decreased during the season monitored. Cyanobacteria predominated in all four ponds from June, mainly represented by *Microcystis ichthyoblabe*, *Microcystis aeruginosa*, *Aphanizomenon flos-aquae* and *Planktothrix agardhii*, which was dominant in all ponds at the end of season.

Ecology and floristics of the Lednice Ponds littorals, 1990 to present

At the request of the nature conservation authorities, the benthic algal communities of the Lednice Ponds has been monitored since the 1990s, a task accomplished by the Laboratory of Hydrobiology of the Moravian Museum, Brno (SKÁCELOVÁ 1996, 2000, 2001, 2002, 2003, 2009a, 2010, 2011). In terms of the phytoplankton, attention has centred upon microhabitats in which the occurrence of important micro-organisms capable of surviving intensive fishpond management might be expected. All the samples collected were stored in the museum sub-collection, categorized as “hydrobiological”

Cyanobacteria and algae in the Lednice Ponds

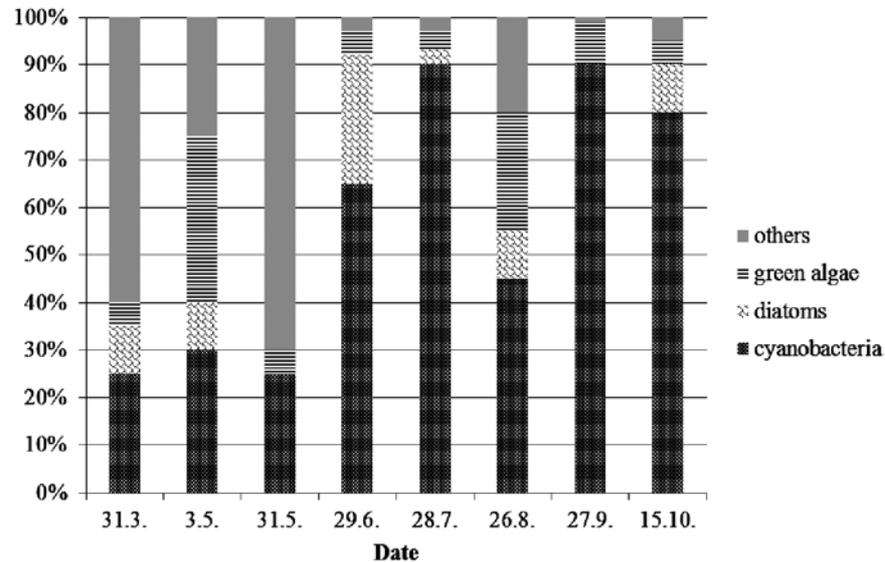


Fig. 26. Percentage composition of the main groups of cyanobacteria and algae of Prostřední pond during season 2010 (% of cell number).

and processed by taxonomists. The following part of this contribution summarizes in brief the characteristics of the phytobenthos of the Lednice Ponds in the sampling periods. Some samples have been studied in detail with reference to particular groups (e.g. benthic cyanobacteria and diatoms). Several interesting benthic cyanobacteria were described in a taxonomic study by SKÁCELOVÁ & ZAPOMĚLOVÁ (2010), while diatom assemblages will be evaluated in a further special study devoted to microhabitats. However, detailed results are not the aim of this study. Here we cover the main features in terms of the overall status of the particular pond described, as we did in the section addressing the phytoplankton.

The phytobenthos of the Lednice Ponds, 1993–1996

Stocks of fish were especially dense during this period (even higher than in the 1970s), particularly in the Nesyt and Hlohovecký Ponds. In 1993, a quantitatively poor periphyton was recorded in Nesyt Pond, although it was rich in phytoplankton overall. However, a meticulously studied sample of the reed periphyton yielded many halophils – *Navicula salinarum* as a subdominant, *Navicula slesvicensis* Grunow, *Nitzschia levidensis*, *Nitzschia hungarica* Grunow, *Amphora veneta*, *Surirella ovalis* Bréb., *Hippodonta capitata* (Ehrenb.) Lange-Bert., Metzel. et Witkow., *Anomoeoneis sphaerophora*, *Pinnularia brebissonii* – in addition to more common species: *Ulnaria*

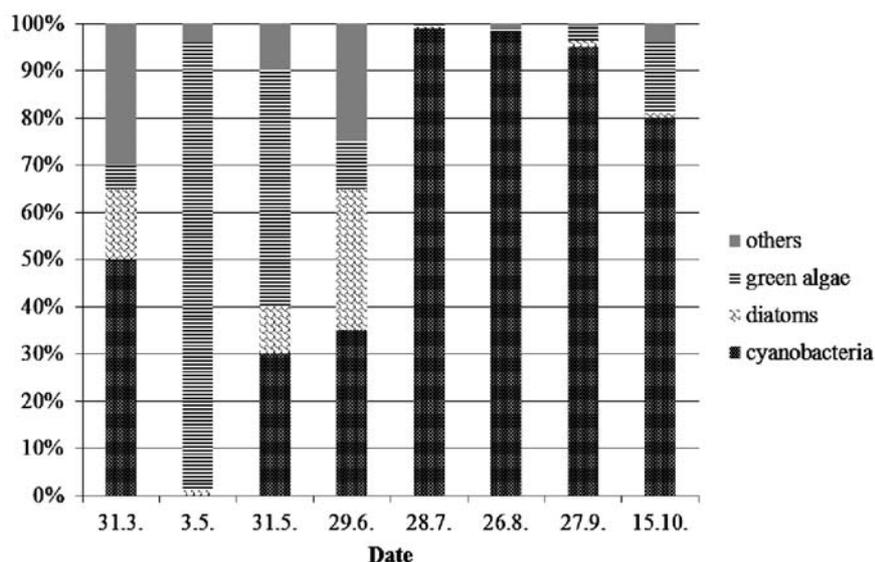


Fig. 27. Percentage composition of the main groups of cyanobacteria and algae of Mlýnský pond during season 2010 (% of cell number).

ulna as a dominant, *Fragilaria capucina* v. *vaucheriae*, *Cymatopleura solea* (Bréb.) W. Smith. In the following season (1994), also rich in phytoplankton, samples of epipelagic cyanobacteria were collected in flowing mats along the reed belt of the south-western bank of the pond. The occurrence of *Epithemia sorex* together with dominant *Nitzschia frustulum*, *N. filiformis* (W. Smith) Van Heurck, *Ulnaria ulna*, *Gomphonema parvulum* (rarely also *Colonies amphisbaena* and *Nitzschia levidensis*) was reported (Fig. 36).

Hlohovecký Pond, the most productive, although rich in phytoplankton, was poor in benthic algae in 1993 and 1996. Only *Fragilaria capucina* colonies were frequent in the 1993 spring sample of. In autumn 1996, infusorians prevailed massively on all substrates, and the algae were represented by only *Amphora pediculus* agg. (several planktonic diatom species were found in a scraped sample) (Fig. 37).

In May 1993, Prostřední Pond bore a strong resemblance to an alluvial pool habitat, with a mass of decomposing macrophyte litter. This condition arose out of the development of massive cyanobacterial mats (dominated by *Anabaena oscillarioides* Bory de Sant-Vincent) mixed with sulphur bacteria. A substantial summer decline in fish stocks arose out of this situation. However, a diatom periphyton including *Rhopalodia gibba* and *Epithemia sorex* was found again in autumn.

Due to its low water level, a different situation was observed in Mlýnský Pond in 1993. Clumps of filamentous conjugatophytes (*Spirogyra communis* (Hass.) Kütz. and *S. longata* (Vauch.) Kütz.), were abundant along the banks in spring. Several benthic

Cyanobacteria and algae in the Lednice Ponds

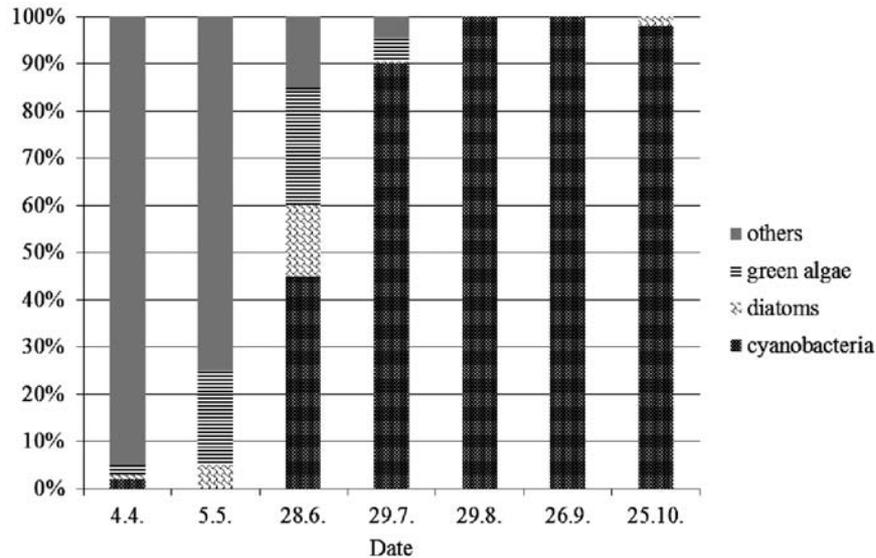


Fig. 28. Percentage composition of the main groups of cyanobacteria and algae of Nesyt pond during season 2011 (% of cell number).

cyanobacteria such as *Cylindrospermum*, *Trichormus*, *Anabaena*, (observed only as filaments without akinetes), *A. cf. oscillarioides*, *Phormidium ambiguum* Gom., and *Nodularia moravica* Hind., Šmarda et Kom. were found in the shallow littoral, together with rich diatom assemblages inhabiting various microhabitats (Fig. 35.).

The phytobenthos of the Lednice Ponds, 2000–2002

In the epilithon of Nesyt Pond, in which fish stocks were slightly reduced but the phytoplankton was rich in 2000, the filamentous alga *Cladophora cf. fracta* occurred as well as diatom assemblages with *Rhoicosphenia abbreviata* as a dominant, accompanied by *Epithemia sorex*, *Navicula cryptotenella* Lange-Bert., *N. tripunctata*, *Nitzschia recta*, and *N. frustulum*, rarely also *Navicula cryptocephala*, *Nitzschia amphibia*, *N. levidensis*, *Fragilaria capucina v. vaucheriae*, and *Amphora pediculus* agg. The cyanobacteria *Phormidium ambiguum* and less commonly *Calothrix braunii* were also recorded.

In the Hlohovecký Pond, a conspicuous difference between the reed stands near the retaining wall and along a northern bank was disclosed. Algal assemblages on various microhabitats near the wall were similar to those of the 1960s (MARVAN & KOMÁREK 1978): a simple structure with a strong dominance of *Melosira varians* in spring, a massive occurrence of *Rhoicosphenia abbreviata* and rare occurrence of *Nitzschia amphibia*, *Cocconeis placentula*, *Planothidium frequentissimum* (Lange-Bert.) Lange-

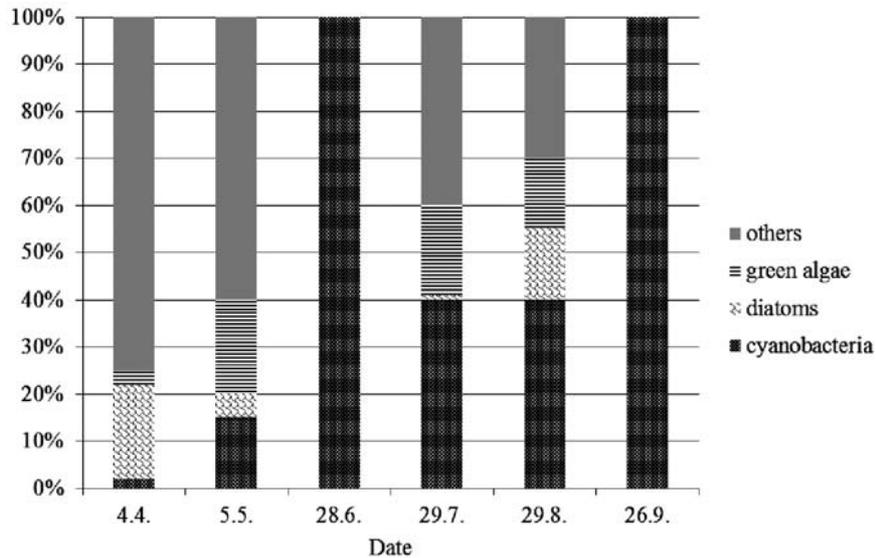


Fig. 29. Percentage composition of the main groups of cyanobacteria and algae of Hlohovecký pond during season 2011 (% of cell number).

Bert. (syn. *Achnanthes lanceolata* ssp. *frequentissima* Lange-Bert.), *Epithemia sorex* and filaments of *Oedogonium* sp. covered with epiphytic *Cocconeis pediculus* in summer. Surprisingly, samples of the epiphyton in the sparse vegetation of the reeds along the northern bank were quite different: *Epithemia sorex* was dominant among the diatoms (80%), accompanied by *Nitzschia frustulum* and *N. incospicua* Grunow, also rarely *Rhopalodia gibba*. Some 20 species commonly found in the Lednice Ponds were also present.

In Prostřední Pond, spring 2000 revealed the consequences of the previous year's management in the form of fish carcasses deposited all over the littoral. In the previous year, the highly eutrophic pond had been left at a low water level until June, so cattails (*Typha* sp.) were growing over a large area of the bottom. To prevent an explosion of them, the pond was filled with water from the upper pond (Hlohovecký) in June. Subsequently, the entire fish stock of the pond died off during the winter. In spring 2000, mats of cyanobacteria covering all substrates and detaching from the bottom as free-floating clusters were abundant along the banks. The cyanobacterium *Phormidium chalybeum* prevailed, accompanied by several diatom species (*Navicula* spp., *Gyrosigma* Hass.). The stone surface of the retaining wall was dominated by *Spirogyra decimina* (O.F.Müll.) Dumor. Further, the summer epilithon was poor in species (only *Rhoicosphenia abbreviata* appeared massively as a dominant, with *Cocconeis pediculus* as subdominant, rarely *Amphora pediculus* agg., *A. libyca* Ehrenb., *Gomphonema*

Cyanobacteria and algae in the Lednice Ponds

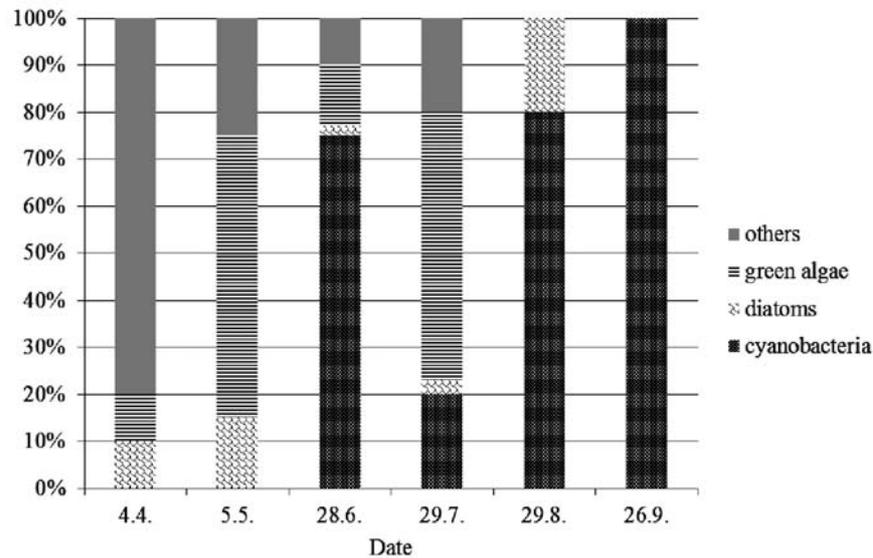


Fig. 30. Percentage composition of the main groups of cyanobacteria and algae of Prostřední pond during season 2011 (% of cell number).

parvulum, *Tabularia fasciculata*, *Navicula cryptotenella*, *Navicula tripunctata*, and *Nitzschia heufleriana*).

In 2000, a low water level after winter drainage gave rise to a variety of microhabitats in Mlýnský Pond. A massive occurrence of conjugatophyte mats on stones (with a basal layer formed by *Calothrix braunii*), and in the form of floating clusters comprised of *Spirogyra setiformis* (Roth) Kütz. and *S. decimina*, associated with the benthic cyanobacteria *Anabaena cf. inaequalis* (Kütz.), Born. et Flah., *Phormidium formosum* (Bory de Saint-Vincent ex Gom.) Anagn. et Kom. and *P. ambiguum* was observed at the end of April, about three weeks after the bottom was flooded. Until late summer, an epipellic bottom crust, consisting of diatom assemblages covering various substrates of the shallow littoral, had developed, with *Nitzschia frustulum* agg. and *Rhoicosphenia abbreviata* as the most frequent species, *Amphora veneta*, *A. libyca*, *Anomoeoneis sphaerophora*, *Caloneis amphisbaena*, *C. permagna* (J.W. Bailey) Cleve, *C. silicula* (Ehrenb.) Cleve, *Ctenophora pulchella*, *Cymbella neocistula* Kramm., *Epithemia sorex*, *E. adnata*, *E. turgida*, *Fallacia pygmaea* (Kütz.) Stickle et Mann, *Fragilaria capucina* v. *vaucheriae*, *Navicula oblonga*, *N. menisculus* Schum., *Nitzschia amphibia* Grunow, *N. hungarica*, *N. levidensis*, *N. tryblionella*, *Pinnularia brebissonii*, *Rhopalodia gibba*, *Surirella brebissonii* Kramm. et Lange-Bert., and *Surirella ovalis*).

A different situation was observed in the Nesyt Pond in 2001. A low water level enabled the formation of warm-water shallows. The epilithon of the stones of the

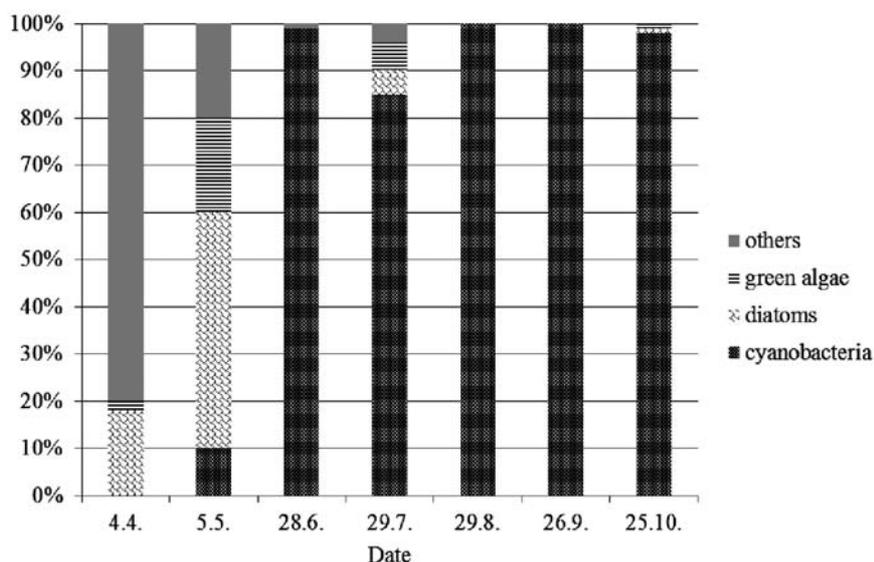


Fig. 31. Percentage composition of the main groups of cyanobacteria and algae of Mlýnský pond during season 2011 (% of cell number).

retaining wall was rich; in addition to common species, it also contained large epipellic diatoms such as *Anomoneis sphaerophora*, *Caloneis amphisbaena*, and others. In the epiphyton, *Anabaena oscillarioides* and diatoms including *Epithemia adnata* and *E. sorex* were recorded. In the upper part of Nesyt Pond, where MARVAN & KOMÁREK (1978) collected halophilous microflora, the occurrence of *Nitzschia tryblionella* and *N. hungarica* was also confirmed in 2001. In the shallow, sandy, south-western littoral, *Tetraspora lemmermannii* Fott and *Ulva flexuosa* occurred. This was the first record of *T. lemmermannii* in the Lednice Ponds. *Ulva flexuosa* had already been reported under other names in the 1970s (MARVAN *et al.* 1973, 1978a), but was found during our sampling between 1993 and 2000. The relevant historical herbarium items from the Lednice ponds have recently been revised and all of them were redetermined as *Ulva flexuosa* var. *pilifera* (MAREŠ *et al.* 2011).

The state of Hlohovecký Pond was very similar to that in previous seasons in terms of the composition of diatom assemblages. Just as in Prostřední Pond, *Cladophora* cf. *globulina* was displaced by *Stigeoclonium* sp. in the epilithon. The water level was high and phytoplankton abundant, so the species typical of shallow littorals did not expand.

In Prostřední Pond, which sustained a massive bloom in 2001, *Stigeoclonium* sp. displaced *Cladophora* cf. *globulina* (Kütz.) Kütz. in the epilithon and the diatoms were poor in species (small *Nitzschia* spp. and *Navicula* spp. prevailed). Benthic cyanobacteria of alkaline waters, *Spirulina major* and *S. meneghiniana* Zanard. ex Gom., were found (SKÁCELOVÁ & ZAPOMĚLOVÁ 2010).

In 2001, the year following partial summer drainage of Mlýnský Pond, high water transparency persisted until late summer. The epilithon was relatively rich, although not as much so as in the littoral period of 2000. *Cladophora* cf. *globulina* with filaments covered with *Cocconeis pediculus* and *Calothrix braunii* in the basal layer were dominant on the stones of the retaining wall. *Surirella ovalis* and *Anomoeoneis sphaerophora* were found among the benthic diatoms. Of the group of benthic cyanobacteria, *Anabaena oscillarioides* and *Phormidium ambiguum* were detected.

Compared with the previous year and its low water level, the situation in Nesyt Pond was relatively poor in phytobenthos diversity in spring 2002, although the values for transparency were high. Some halophilous diatoms and abundant euglenophytes were found in a muddy littoral close to the vegetable gardens in Sedlec. In a littoral along the northern bank, *Cladophora* clumps and *Oedogonium capillare* occurred massively together with diatoms (*Tabularia fasciculata* dominant). *Rhoicosphenia abbreviata* was the most abundant diatom species on the stones of the retaining wall, as well as the main epiphyte on *Cladophora* (*Cocconeis pediculus* and *Epithemia sorex* being very rare).

The benthic flora of Hlohovecký Pond was still poor in 2002. High water level and abundant green alga phytoplankton rendered the development of benthic algae nearly impossible. An interesting habitat emerged near Hraniční zámček castle, in the western part of Hlohovecký Pond. A piece of meadow flooded to form a shallow bay. In June, *Nostoc* sp. formed conspicuous, brown, slimy colonies in flooded grass, and clumps of conjugatophytes (sterile filaments of *Spirogyra* sp.) together with several diatom species filled the warm waters of this shallow body of water. The most abundant were tiny *Nitzschia* sp., with large diatoms such as *Anomoeoneis sphaerophora*, *Nitzschia tryblionella*, and *Craticula cuspidata* less frequent. In August, *Nodularia moravica* and sporadically also *Planktothrix cryptovaginata* (Schkorb.) Anagn. et Kom. occurred in a reed littoral of this bay. These species are rare and were previously known from only a few localities in southern Moravia (SKÁCELOVÁ & KOMÁREK 1989). Along the northern bank, in sparse *Typha* stands, lagoons with *Ulva flexuosa* var. *pilifera* emerged. The epilithon on the stones of the retaining wall and the epiphyton on living reeds and reed litter was of a similar composition to that of previous years (*Rhoicosphenia abbreviata* as a dominant, *Cocconeis pediculus*, *Ulnaria ulna*, *Melosira varians*).

A massive bloom also occurred in Prostřední Pond in 2002, but certain signs of recovery were observed in the phytobenthos. Some *Batrachium* plants appeared along the shore, forming a microhabitat for epiphyton and metaphyton, especially during the period of plant material decay in late summer. The species richness may be illustrated by a list of the diatoms collected on submerged wood (a dead tree) in June 2002: *Fragilaria capucina* v. *vaucheriae* as dominant, *Tabularia fasciculata* and *Rhoicosphenia abbreviata* as subdominants, accompanied by *Ctenophora pulchella*, *Navicula tripunctata* and other less frequent species such as *Amphora libyca*, *A. veneta*, *A. pediculus*, *Caloneis* cf. *bacillum* (Grunow) Cleve, *Gomphonema* cf. *anjae* (Lange-Bert.) Reich., *Cocconeis pediculus*, *Gyrosigma acuminatum* (Kütz.) Rabenh., *Hippodonta hungarica*, *Navicula veneta*, *Nitzschia amphibia*, *N. solita* Hustedt, *Planothidium delicatulum* (Kütz.) Round et Bukht., *Navicula cincta*, *N. clementoides* Hustedt, *N. cryptotenella*, *N. reichardtiana* Lange-Bert., *Nitzschia dissipata* (Kütz.) Grunow, *N.*

constricta, *Pseudostaurosira brevistriata* (Grun.) D.M. Will. et Round and *Sellaphora* cf. *pupula* (Kütz.) Mereschk. Together with the diatoms, *Cladophora* bushes and *Nostoc* colonies were recorded. *Epithemia sorex* appeared massively in this microhabitat in autumn. This species was also found as an epiphyte on tiny willow roots growing through the bank into the water, together with *Surirella brebissonii* and *Anomoeoneis sphaerophora*.

In 2002, partial summer drainage of Mlýnský Pond enabled a spring expansion of filamentous conjugatophytes (several species of *Spirogyra*), which covered more than 10% of the illuminated bottom. Euglenophytes were abundant in floating algal clusters, (several *Euglena*, *Phacus* and *Lepocinclis* species). Epipellic crusts were formed by the large diatom species *Anomoeoneis sphaerophora*, *Caloneis amphisbaena*, *Caloneis permagna*, *Surirella ovalis*, *Craticula cuspidata*, *Navicula oblonga*, *Nitzschia tryblionella*, *Fallacia pygmaea* and the cyanobacterium *Spirulina nordstedtii* Nord. ex Gom. The epiphyton of the reed litter was also rich in diatom species (incl. *Epithemia sorex*, *E. adnata*) and cyanobacteria (*Anabaena oscillarioides*, *Nostoc* sp., *Calothrix* sp., *Cylindrospermum* sp. and *Phormidium* spp. incl. *P. ambiguum*). The stones of the retaining wall were covered in bushes of *Cladophora* with *Cocconeis pediculus* and *Rhoicosphenia abbreviata* attached to its filaments. The occurrence of many halophils in 2002 was appropriate to an increased salinity (185 mS/m) during the period of low water level. Shaded parts of the littoral with litter from deciduous trees hosted just a few epipellic species (*Oscillatoria limosa*, *Phormidium* spp.). Until the autumn sampling in October 2002, the littoral zone completely dried out, so that only benthic algae from the main basin were collected (composition the same as early in the year).

The phytobenthos of the Lednice Ponds, 2005–2008

No data on the periphyton of the Lednice Ponds were collected during 2003 and 2004. With a decrease in the intensity of fishery management (i.e. lower stocks of fish) arising out of conservation projects, the waters showed high transparency from spring until midsummer and then suddenly dropped to low values from August to September. Massive blooms were characteristic for most of the ponds in high summer. Also lacking samples from Mlýnský Pond, we are unfortunately unable to evaluate the succession after summer drainage in 2002.

In 2005, the phytobenthos of Lednice Ponds was sampled once during August. Nesyt Pond was rich in bloom transported by inflow during summer 2005. Clumps of *Cladophora* were occupied by *Rhoicosphenia abbreviata*, and small *Navicula* spp., *Nitzschia* spp. and *Melosira varians* were also abundant. Just as in Mlýnský Pond, the stones of the retaining wall were dominated by the coccoid cyanobacterium *Chlorogloea*, accompanied by *Nostoc* and *Komvophoron*. The composition of the filamentous algae and diatoms was similar in all the microhabitats studied.

Hlohovecký Pond differed from the Mlýnský and Hlohovecký Ponds in its absence of a bloom in 2005. Along the northern bank, *Ulva flexuosa*, together with *Cladophora globulina*, *Stigeoclonium* sp. and diatoms (the most abundantly *Tabularia fasciculata*,

Rhoicosphenia abbreviata, *Cocconeis pediculus*, *Fragilaria capucina*, also frequently *Amphora* spp., *Gomphonema truncatum*) occurred. Benthic *Anabaena* was found in two morphotypes, varying in cell dimensions.

Along the northern bank of Prostřední Pond, clumps of green algae developed massively: *Hydrodictyon reticulatum* (L.) Bory de Saint-Vincent (observed in Lednice ponds by FISCHER, 1920 and ZAPLETÁLEK, 1932, also in Nesyt in the 1970s, Marvan, unpublished), *Ulva flexuosa* var. *pilifera*, *Cladophora* with common diatom epiphytes, namely *Tabularia fasciculata*, *Amphora veneta*, *Gomphonema truncatum* Ehrenb., *Rhoicosphenia abbreviata*, and small *Navicula* spp. Large amounts of *Epithemia sorex* were again found on the old submerged wood near the northern shore.

Mlýnský Pond, with a massive bloom, was sampled from the stones of its retaining wall. In addition to a silted bloom, coccoid epilithic cyanobacteria, and small spherical colonies of *Nostoc* sp. were collected. A more diversified epiphyton was found near the north-eastern shore. A benthic sample scraped from the stones and a submerged bottle contained quantities of *Anomoeoneis sphaerophora*, *Nitzschia tryblionella*, *Sellaphora pupula* and abundant small species of *Navicula*, supplemented by *Calothrix braunii* in a basal layer. Near the sandy beach known as “Apollo”, *Epithemia sorex* occurred massively in the epiphyton, accompanied by *Cocconeis pediculus*, *Rhoicosphenia abbreviata*, *Rhopalodia gibba*, *Epithemia adnata* and other species.

In 2007, sampling of the phytobenthos was done only once in October in Nesyt Pond, which was partially drained. Visible swarms of the cladocerans *Daphnia magna* Straus near the retaining wall and a variety of microhabitats in the shallows demonstrated extensive fish-stocking at this low-water-level season. In muddy places, euglenophytes and chlamydomyces were abundant, together with epipelagic diatoms, such as small *Navicula* spp. but also large species such as *Surirella ovalis*, *Gyrosigma acuminatum*, and *Craticula cuspidata*. Among the benthic cyanobacteria, *Phormidium* sp. dominated, whereas *Nodularia moravica* and *Anabaena* sp. were less abundant. *Vaucheria* sp. covered drying mud surfaces. The situation in the muddy, shallow parts of Nesyt Pond was similar to that in a detailed description by MARVAN & KOMÁREK (1978).

Duckweed plants (*Lemna minor* L. and *Lemna gibba*) were occupied by the epiphytic diatom *Lemnicola hungarica* (Grunow) Round et Basson; other diatom species were rare. The shallows, with sparse aquatic vegetation (*Oenanthe aquatica* (L.) Poir), were much richer in species: *Navicula* spp. (*N. veneta*, *N. menisculus*, *N. cincta*, *N. gregaria* Donkin, *N. salinarum*, *N. slesvicensis*), *Hippodonta hungarica*, *Nitzschia pusilla* Grunow, *N. perminuta* (Grunow) Perag., *Amphora veneta*, *Gyrosigma acuminatum*, and *Tryblionella constricta*.

In 2008, reference phytobenthos samples were collected once in autumn during ornithological and hydrobiological work at the Lednice Ponds. For Nesyt Pond, 2008 was the first season after summer drainage in 2007. The samples were formed mainly by a filamentous *Cladophora* alga covered with abundant *Epithemia sorex* in assemblages with *Rhoicosphenia abbreviata*, *Cocconeis pediculus* and other diatoms. The epilithon was rich in species: *Caloneis amphibaena* was among the dominants, and the rarely-found *Rhopalodia gibba* made an appearance.

Hlohovecký Pond was completely drained in 2008. In Prostřední Pond, the epiphytic filamentous cyanobacteria *Heteroleibleinia* and package-forming coccoid species, probably belonging to the genus *Mantellum* (first finding here), occurred on *Cladophora* filaments. The diatoms *Gomphonema* spp. and *Amphora* spp. were present in small amounts.

In the littoral of Mlýnský Pond, epiphytic *Cocconeis pediculus* and *Achnantheidium minutissimum* dominated on *Cladophora* filaments, but *Epithemia adnata* were also frequent. Bushes of stem-forming ciliates were abundant in the samples.

The phytobenthos of the Lednice Ponds, 2009 to present

From 2009 onwards, detailed research into microhabitats was carried out. In Nesyt Pond, late spring 2009 was characterized by a massive occurrence of floating algal clumps of *Cladophora fracta* covering the water surface near the retaining wall, the littoral zone and a strip of submerged willows that had grown the previous year during summer drainage. The green alga *Aphanochaete repens* was present on most filaments. In small lagoons of loose reed-stands, the reed litter was brought back into dense life with diatoms, including halophils and mesohalobes: abundantly *Craticula cuspidata*, *Gomphonema parvulum*, *G. subclavatum* (Grunow) Grunow, *Nitzschia amphibia*, sporadically *Amphora veneta*, *Fragilaria capucina*, *Hantzschia amphioxys* (Ehrenb.) Grunow, *Navicula veneta*, *N. cincta*, *Nitzschia calida*, *N. commutata*, *N. hungarica*, and *N. sigma* (Kütz.) W. Smith, *Pinnularia brebissonii*, *P. viridis* Ehrenb., *Placoneis protracta* (Grunow) Mereschk. and *Stauroneis* cf. *phoenicenteron*. Also found here were the benthic cyanobacteria *Anabaena oscillarioides*, *Cylindrospermum* sp. and young thalli of *Ulva flexuosa* var. *pilifera*. The situation was similar to that in the 1970s when Nesyt Pond was understocked in the first year of a two-year rotation (MARVAN *et al.* 1978a, b).

In late summer, euglenophytes of many species (e.g. *Euglena texta*, *Phacus tortus* (Lemmerm.) Skvortz., *P. cf. polytrophos* Poch.) were abundant in the littoral. Reed stalks and leaves were occupied by filamentous algae (*Cladophora* sp., *Oedogonium* spp., *Stigeoclonium* sp.) and abundant diatoms (most abundant *Navicula tripunctata*, *Epithemia sorex* and *Ulnaria ulna*, also frequent *Epithemia adnata* and *Rhopalodia gibba*, *Cocconeis pediculus*, *Cymbella* cf. *lanceolata* (Agardh) Kirchn., *Melosira varians*, *Gomphonema subclavatum*, and several *Navicula* species. *Rhoicosphenia abbreviate*, however, was not abundant.

In the microhabitat formed by stone surfaces in the shallow littoral, *Cymbella tumida*, *Hippodonta capitata*, and *Phormidium* sp. were recorded. Tiny reed roots were inhabited, particularly by *Nitzschia tryblionella*, *Pinnularia microstauron* (Ehrenb.) Cleve, and *Gyrosigma* sp. Near the retaining wall, in turbid water with low transparency, young colonies of *Calothrix* sp. and small bushes of *Cladophora* were present. Diatom analyses revealed the dominant presence of *Ulnaria ulna*, the frequent occurrence of *Nitzschia dissipata*, *Navicula cryptotenella*, the less frequent occurrence of *Fragilaria capucina* v. *radians* (Kütz.) Lange-Bert., *Gomphonema parvulum*, *Navicula antonii*

Lange-Bert. et Rumrich, *N. tripunctata*, *Nitzschia amphibia*, *N. frustulum* (even less frequent) and also the sporadic occurrence of *Amphora libyca*, *A. veneta*, *Anomoeoneis sphaerophora*, *Cocconeis pediculus*, *Cymbella* cf. *neocistula*, *Epithemia sores*, *Gomphoneis olivacea*, *Gomphonema truncatum*, *Gyrosigma acuminatum*, *Melosira varians*, *Navicula capitatoradiata* Germ., *N. veneta*, *Nitzschia levidensis* and *Rhoicosphenia abbreviata*. In a fine crust covering submerged parts of *Typha* plants, in addition to species mentioned above, *Rhopalodia gibba*, *Epithemia adnata* and *Surirella peisonis* Pant. were also found, together with the cyanobacteria *Phormidium ambiguum*, *P. formosum* and *Cylindrospermum maius* Kütz. ex Born. et Flah.

The transparency of Hlohovecký Pond was low at the end of May 2009, despite the fact that it had been dried out in the previous year. Nevertheless, the epiphyton was rich in interesting species. The retaining wall was densely covered with *Cladophora fracta* bushes, nearly without epiphytic algae. The epilithon was also poor in species: *Rhoicosphenia abbreviata* and *Tabularia fasciculata* were dominant, whereas *Calothrix* sp. and the diatoms *Encyonema prostratum*, *Epithemia sores*, *Rhopalodia gibba*, *Cocconeis placentula* were found sparsely. Old, submerged wood was covered with crusts dominated by *Tabularia fasciculata* and also by *Gomphonema truncatum*, *Cymbella neocistula*, *Navicula* cf. *cincta* a *N. cf. libonensis* Schoeman. Gravel on the sandy bottom of a shallow edge was covered with a dark green mat of *Calothrix* sp. and *Nostoc* sp. A small amount of reed litter, and old *Phragmites* and *Typha* stalks were inhabited by a crust of *Epithemia sores*, *Fragilaria capucina* and *Tabularia fasciculata*, *Rhoicosphenia abbreviata* which were abundant; other diatoms such as *Cymbella neocistula*, *Epithemia adnata*, *Navicula cincta*, *N. radiosa* Kütz., *N. veneta*, *Nitzschia amphibia*, *N. cf. hungarica*, and *Rhopalodia gibba* occurred infrequently. In this microhabitat, filaments of *Cladophora fracta* were rich in diatom epiphytes (mainly *Epithemia sores*, also *Rhoicosphenia abbreviata* and *Tabularia fasciculata*).

In late summer 2009, a dense algal population in a shallow bay of Hlohovecký Pond near "Hraniční zámek" castle was sampled. Among a compact diatom assemblage with abundant *Caloneis permagna* and *C. amphibaena*, some green neustonic spots of accumulated *Euglena mutabilis* F. Schmitz were observed.

The submerged trunk of an old tree, small stones and filamentous algae in particular were densely covered with algae. *Epithemia sores* was a very abundant epiphyte on *Cladophora* filaments. Samples of epilithon from stones near the northern bank were studied in detail and nearly 40 species were found (most frequently *Achnanthydium minutissimum* and *Navicula cryptotenella*, also *Amphora pediculus* agg., *A. veneta*, *Encyonema caespitosum* Kütz., *Epithemia sores*, *Gomphonema subclavatum*, *Navicula tripunctata*, *Nitzschia inconspicua*, *Pinnularia appendiculata* (Agardh) Cleve., less abundant *Amphora libyca*, *Caloneis bacillum*, *Cocconeis pediculus*, *Craticula cuspidata*, *Cymbella* cf. *neocistula*, *C. tumida*, *Epithemia* cf. *adnata*, *Fragilaria capucina* v. *mesolepta* (Rabenh.) Rabenh., *Fragilaria capucina* v. *radians*, *Gomphonema parvulum*, *G. truncatum*, *Navicula antonii*, *N. veneta*, *Nitzschia amphibia*, *N. dissipata*, *N. frustulum*, *N. hungarica*, *Planorhynchium frequentissimum*, *P. delicatulum*, *Rhoicosphenia abbreviata*, *Rhopalodia gibba*, *Staurosira construens* Ehrenb., *Sellaphora* cf. *pupula*, *Tabularia*

fasciculata and *Ulnaria acus* (Kütz.) Aboal. Cyanobacteria of the genera *Calothrix* and *Leptolyngbya* were also present in the epilithon.

In May 2009, a large part of the surface of Prostřední Pond was covered with the floating large foliate thalli of *Ulva flexuosa* var. *pilifera*, whereas in the littoral of Mlýnský Pond, tubulous forms prevailed. Near the dividing wall between the Prostřední and Hlohovecký Ponds, clumps of *Zygnema pectinatum* (Vauch.) C. Agardh (fertile filaments) accompanied by *Spirogyra* sp. and *Tabularia* cf. *affinis* were abundant in the littoral. Near the dividing wall with Mlýnský Pond, *Cladophora fracta* and *C. globulina*, with the epiphytic diatoms *Rhoicosphenia abbreviate* and *Gomphonema truncatum* were abundant.

Filaments of *Oedogonium*, forming the main part of the epiphyton on *Potamogeton* growing near the northern bank, were abundantly covered with *Characium rostratum*. In a sample scraped from old, submerged wood, the cyanobacterium *Nostoc* sp. prevailed over *Calothrix* sp., and tiny diatoms of the genus *Navicula* (*N. veneta*, *N. cincta* and others) Cladoceran swarms were abundant here, as they were in the reed litter microhabitat. *Tabularia fasciculata* and *Fragilaria capucina* formed dominants on a living *Typha*, accompanied by *Spirogyra* sp. and *Zygnema pectinatum*, *Oedogonium* sp. and rarely *Melosira varians*, *Cymbella neocistula* and *Cocconeis pediculus*.

Until late summer, the water transparency dropped to 45 cm and the water became milky-turbid near the dividing wall between the Prostřední and Mlýnský Ponds. Scattered *Batrachium* plants were poor in epiphyton (together with abundant *Nitzschia palea*, single frustulae of *Navicula* sp. and *Hantzschia amphioxys* agg. were recorded). Decaying plants were covered with a mass of *Euglenaria caudata* (Hübner) A.Karnowska-Ishikawa *et al.* (syn. *Euglena caudata* Hübner). The stones of the retaining wall stones were inhabited by *Calothrix* crusts, the filamentous algae *Cladophora fracta* and *C. globulina*, and the diatoms *Rhoicosphenia abbreviata*, *Gomphonema truncatum*, *Gomphoneis olivacea*, rarely also *Ulnaria ulna*, whereas *Epithemia sorex* and *Rhopalodia gibba* were absent. Epilithic crusts were formed by the cyanobacteria *Phormidium ambiguum* and *Leptolyngbya*. *Ulnaria ulna* was dominant in *Ceratophyllum* stands. Old, submerged wood near the northern shore still was creating a microhabitat of *Epithemia sorex* (dominant), *Rhoicosphenia abbreviata*, *Amphora veneta*, *Navicula tripunctata*, *Amphora libyca*, and *Amphora pediculus*, whereas *Gomphoneis olivacea* and *Nitzschia amphibia* were less abundant there.

A marked decrease in water transparency (from more than 170 cm to 35 cm) was noticed between the spring and autumn sampling in Mlýnský Pond. In spring, scattered specimens of the charophyte *Nitella gracilis* (J.E. Smith) C. Agardh occurred on the sandy and gravel bottom of a shallow tidal zone near the retaining wall and Apollo Beach (a first finding in Lednice Ponds). Small stones were colonized by tetrasporal slimy colonies of *Tetrasporidium javanicum* K. Möb. and more often by diatoms (*Rhoicosphenia abbreviata* as dominant species, *Cymbella neocistula* and *Epithemia adnata*). In the littoral, the tubular thalli of *Ulva flexuosa* were found frequently. Bushes of *Cladophora fracta* massively covered with *Rhoicosphenia abbreviata* formed a strip near the shoreline. In shaded places and in the basal layer of the *Cladophora* bushes, the

epilithon was formed by young *Calothrix* colonies and the coccoid cyanobacterium *Chlorogloea* sp.. *Batrachium* plants along the shores were dominated by *Gomphonema parvulum*, *Rhoicosphenia abbreviata*, *Fragilaria capucina*, *Ulnaria ulna*, *Cocconeis pediculus* and less frequently by *Amphora pediculus* agg., *Gyrosigma* cf. *scalproides* (Rabenh.) Cleve, *Craticula cuspidata*, and *Epithemia sorex*. Of the green algae, *Coleochaete* Breb. was also recorded. Along the reed belt, clumps of filamentous conjugatophytes were abundant (*Spirogyra* sp. as two species accompanied by *Zygnema* cf. *pectinatum*). Filaments of *Cladophora fracta* and *C. globulina* were densely coated with epiphytic diatoms, mainly *Cocconeis pediculus*, *Rhoicosphenia abbreviata* (the most abundant in the microhabitats of the retaining wall stones and *Typha* plants), *Tabularia fasciculata*, *Epithemia sorex* and, in lesser quantities, *E. adnata*, *Cymbella neocistula* and large specimens of *Anomoeoneis sphaerophora* and *Caloneis amphibaena*. Among the cyanobacteria, *Phormidium formosum* and *Arthrospira* were recorded. In the autumn, neither charophytes nor Tetrasporales were present in turbid water with low transparency. A rare cyanobacterial species, *Merismopedia convoluta* Bréb. was found in a microhabitat of sandy bottom in a loose reed stand near Apollo Beach. More details on the occurrence of this species in the Lednice Ponds and other southern-Moravian localities are given by SKÁCELOVÁ & ZAPOMĚLOVÁ (2010).

The ecological characteristics of the halophilous diatom taxa typical of the Lednice Ponds

Brief descriptions of the ecological characteristics of the halophilous diatom species (Fig. 38) mentioned in this article are given below. This facilitates discussion of the environmental development of the Lednice Ponds in the context of the individual ecological preferences of the taxa presented.

Aulacoseira italica (Ehrenb.) Simonsen

A. italica is a very rare species within the area of the Czech Republic, although it used to be more frequent. Sub-fossil findings are quite common (Komořanské Lake – ŘEHÁKOVÁ 1986, National Nature Reserve Soos, near Františkovy lázně – ŘEHÁKOVÁ 1988, RAJDLOVÁ 2011). A rich, viable population was discovered in Jezírko Kutnar, an alluvial pool situated in the lower part of the River Dyje basin, in which the conductivity levels are similar to those recorded for the Lednice Ponds (>1000 µs/cm). In particular, a higher content of sulphates is typical of both localities. The species was dominant there during spring and summer 1988 (monitoring started in 1987). The species abundance decreased in subsequent seasons until it completely disappeared (last occurrence recorded in 1991), to be replaced by *Diatoma tenuis* (SKÁCELOVÁ & HOUK 1993). It was found there once more in 2006, when the water was drained before projected mud removal; it then vanished again. Occasional sparse occurrence has also been recorded from a few Moravian backwaters.

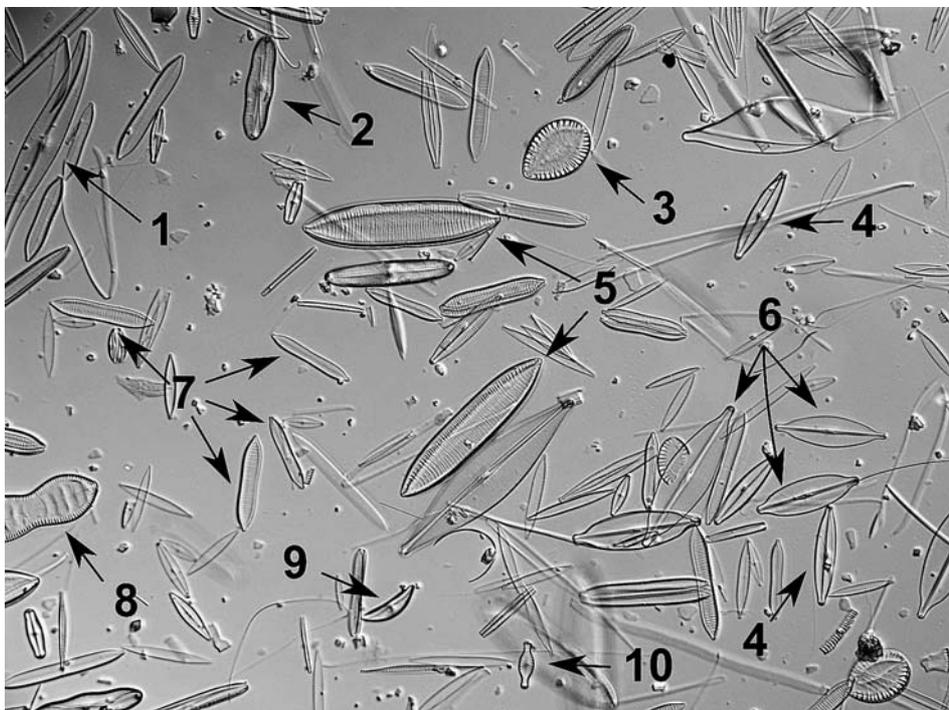


Fig. 32: Nesyt pond, 12-05-1927 (prep. J. Bílý): 1 – *Gyrosigma* sp., 2 – *Caloneis silicula* (Ehrenb.) Cleve, 3 – *Surirella ovalis* Bréb., 4 – *Navicula lanceolata* (Agardh) Ehrenb., 5 – *Nitzschia tryblionella* Hantzsch, 6 – *Craticula cuspidata* (Kütz.) D.G. Mann, 7 – *Nitzschia constricta* (Kütz) Ralfs, 8 – *Cymatopleura solea* (Bréb.) W. Smith, 9 – *Amphora libyca* Ehrenb., 10 – *Hippodonta capitata* (Ehrenb.) Lange-Bert., Metzeltin et Witkowski.

In the last twenty years in Nesyt Pond, *A. italica* has been found in only one sample collected from the littoral in a south-eastern lagoon with reed stands. There were no findings from the littoral outside the lagoon or in pelagic samples. The species usually occurs in inland waters with higher salinity and prefers a slightly or moderately eutrophicated environment (KRAMMER & LANGE-BERTALOT 1991). Its present sporadic distribution could be a consequence of sensitivity to organic pollution (saprobic index SI = 1.3 with narrow valence, Marvan 2011, unpublished), which affects most of our saline localities. Species living in saline habitats are generally more resistant to desiccation – the osmotic stresses resulting either from a high content of salts or from desiccation are similar. This factor could have been important in the case of the episodic occurrence of *A. italica* in the Jezírko Kutnar pool in 2006.

***Epithemia sorex* Kütz.**

A cosmopolitan taxon, *Epithemia sorex* lives epiphytically in the littoral zone of stagnant or slowly-flowing waters. It prefers a moderate-to-high content of salts, and sometimes survives even in brackish conditions (KRAMMER & LANGE-BERTALOT 1988). The current value of saprobic index (1.1, formerly 1.4) classifies *E. sorex* as a “halophilic taxon of clean waters”. During research into the Lednice Ponds and other southern Moravian localities (e.g. the Františkův fishpond situated south of the town of Valtice, fishponds on the River Štínkovka north of Hustopeče – SKÁCELOVÁ & BEŠTA 2010, and Jezírko Kutnar, an alluvial pool – SKÁCELOVÁ 2009b), a remarkable decrease or even disappearance of the species in response to eutrophication of the environment (e.g. as a consequence of increased fish stocks) has been recorded. As trophic pressure alleviated, so the species immediately returned to the locality. The first sparse occurrence of *E. sorex* from Jezírko Kutnar was recorded at the beginning of the 1980s (SKÁCELOVÁ & MARVAN 1993), although it disappeared later. The next record was in 2007, during the growing season after mud removal; this time *E. sorex* was dominant. The species abundance then decreased in the following seasons (*E. adnata* and *Rhopalodia gibba* assumed dominance).

In the Lednice Ponds, *E. sorex* has frequently been found in suitable biotopes in all sampling seasons. The highest abundances were recorded after summer drainage (e.g. Mlýnský Pond in spring 2000, Nesyt Pond in spring 2001 and 2008). This fact can be attributed to the positive effect of the biotope drying out, as observed in the case of *A. italica*. This situation provides a competitive advantage over purely aquatic species to species well adapted to desiccation or to high osmotic pressure. Therefore the gradual replacement of *E. sorex* by the less halophilic species *Rhopalodia gibba* and *E. adnata* in the Jezírko Kutnar locality in the years following the drying period is natural.

***Rhopalodia gibba* (Ehrenb.) O.Müll.**

This species is similar to *E. sorex* (above) in its ecological demands; it is a halophilic species of clean fresh water. It survives higher organic pollution according to its revised ČSN standard (SI = 1.4), although it was previously classified at the much lower SI value of 0.5. However, the variety *R. gibba* var. *parallella* was described only from spring areas and mountain lakes with low electrolyte content; the nominate variety is often found in such oligotrophic localities as well. In our view, deeper discussion of the SI value assigned to this taxon should be seriously considered.

The first record of *R. gibba* from the Lednice Ponds dates to the 19th century (NAVE, 1863), with further records in the 1920s (BAYER & BAJKOV 1929, BÍLÝ 1929). In the 1970s, the species was usually recorded as a rare taxon (SKÁCELOVÁ & MARVAN 1993). Similarly rare are findings from recent sampling seasons, even though these took place after specific interventions designed to improve water quality, e.g. partial summer drainage (Nesyt 2009), winter drainage Mlýnský 2000), and lowering of fish stocks (Nesyt 2000, 2001) (SKÁCELOVÁ 2000, 2001; HETEŠA & MARVAN 2000). It has sometimes

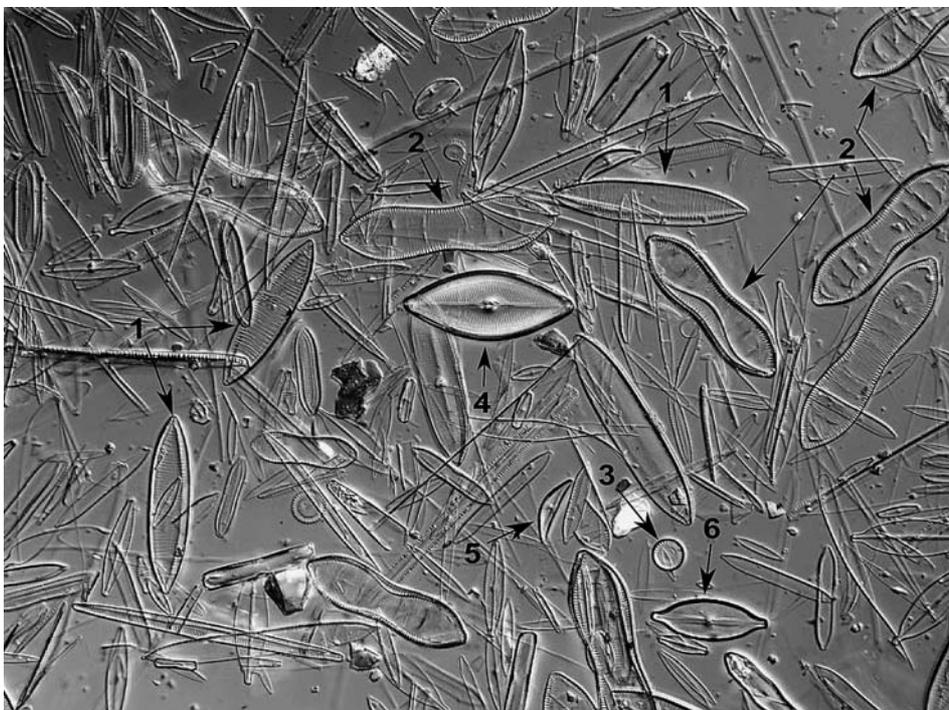


Fig. 33: Hlohovecký pond, 25-08-1927 (prep. J. Bílý): 1 – *Nitzschia tryblionella* Hantzsch, 2 – *Cymatopleura solea* (Bréb.) W. Smith, 3 – *Cyclotella meneghiniana* Kütz., 4 – *Caloneis permagna* (J.W. Bailey) Cleve, 5 – *Amphora libyca* Ehrenb., 6 – *Anomooneis sphaerophora* (Ehrenb.) Pfütz.

been found in localities that lack obvious attempts to improve water quality. Its presence in the Lednice Ponds is generally surprising in view of the high level of eutrophication.

***Encyonema caespitosum* Kütz**

A wide ecological valence is typical of this species. It usually occurs in environments with quite high salinity (KRAMMER & LANGE-BERTALOT 1986). It is relatively rare in the Czech Republic, occurring in small populations, so it is often overlooked. It was noted in southern Moravian species lists by NAVE (1863) and PROCHÁZKA (1924). Recently, it has been recorded from Přední Pond on the River Štítkovka (SKÁCELOVÁ & BEŠTA 2010a). In the Lednice Ponds, it was recorded in only Hlohovecký Pond in 1999, as a rare species.

***Pinnularia appendiculata* (Agardh) Cleve**

This is a cosmopolitan diatom favoring strongly mineralized waters (KRAMMER & LANGE-BERTALOT 1986), often overlooked because of its small size. Within the area of the Czech Republic, larger populations have been found, for example, in sub-fossil material in the Soos National Nature Reserve (ŘEHÁKOVÁ, 1988, RAJDLOVÁ 2011), and in Přední Pond on the River Štítkovka (SKÁCELOVÁ & BEŠTA 2010a). In the Lednice Ponds, it was found in only Hlohovecký Pond in 1999 but it formed a large population there.

***Hippodonta hungarica* (Grunow) Lange-Bert.**

This species is especially typical of saline, eutrophic biotopes. In the past, the name was used for varieties of *Navicula capitata* [for example *N. capitata* v. *hungarica* (Grunow) Ross], however, in the later established genus *Hippodonta* the varieties are treated as valid species. Within the Lednice Ponds, it was noted in species lists by FISCHER (1920), PROCHÁZKA (1924), and ZAPLETÁLEK (1932). Lately it has been recorded as a rare taxon in the Nesyt (2001), Prostřední (2009), Hlohovecký and Mlýnský Ponds (2010). In southern Moravia, it has also been recorded recently in Zadní Pond, near Hustopeče (SKÁCELOVÁ & BEŠTA 2010a).

***Craticula halophila* (Grunow) D.G. Mann**

A typical halophilic species for which sensitivity to organic pollution according to the saprobic system has yet to be established; however MARVAN & SKÁCELOVÁ (1991) categorized *Craticula halophila* as intolerant of eutrophication. It used to be a relatively common species in southern Moravia: RICHTER (1912) found it in the salt marsh near the Hustopeče railway station; BÍLÝ (1926) mentioned several localities including the Lednice Ponds; and MARVAN (pers. com.) reported its occurrence in Nesyt Pond in the 1960s and 1970s. Later, it was recorded in Zápověď, near Terezín, and Rakvice (SKÁCELOVÁ & MARVAN 1991) and from the swimming area in Starý Podvorov (SKÁCELOVÁ & BEŠTA 2010b). In the Lednice Ponds, it was recorded as a very rare taxon in Nesyt Pond in 2010. This suggests that the preliminary conclusions of SKÁCELOVÁ & MARVAN (1991) were correct and the species is adversely affected by the eutrophication brought about by large-scale, intensive carp production.

***Navicula salinarum* Grunow**

This species is typical of sea coasts and brackish inland waters. It sometimes occurs in fresh waters of high electrolyte content (KRAMMER & LANGE-BERTALOT 1986). In the times of Bílý and his coevals, it was found in almost all the saline localities in southern Moravia (RICHTER 1912, BÍLÝ 1926, PROCHÁZKA 1924, ZAPLETÁLEK 1932), including the

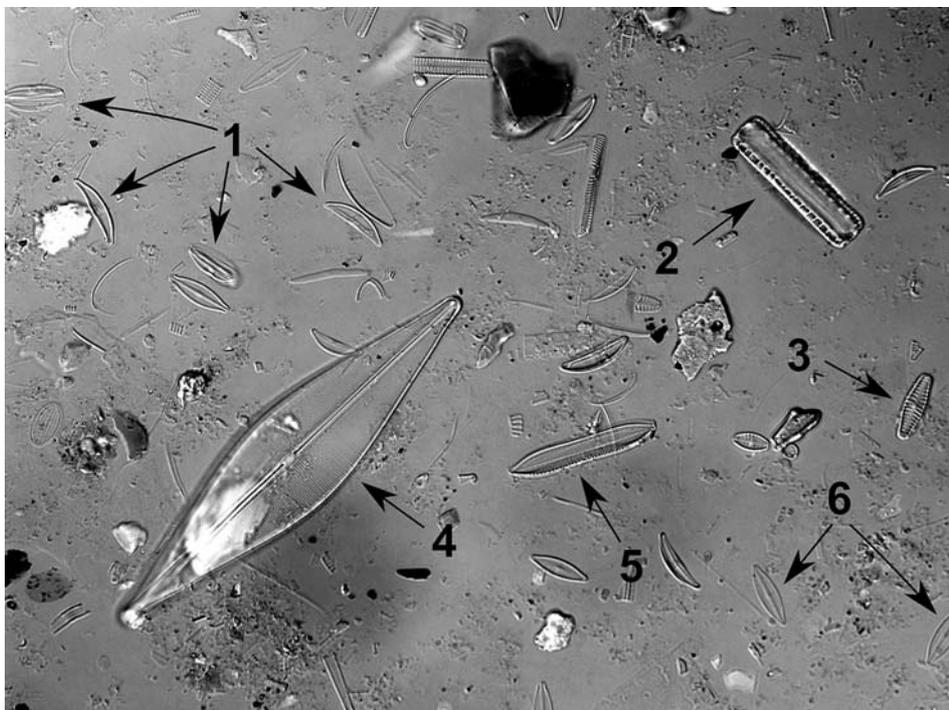


Fig. 34: Mlýnský pond, 23-06-1950 (prep. J. Bílý): 1 – *Halamphora veneta* (Kütz.) Levkov, 2 – *Epithemia adnata* (Kütz.) Bréb., 3 – *Hippodonta cf. hungarica* (Grunow) Lange-Bert., Metzeltin et Witkowski, 4 – *Craticula cuspidata* (Kütz.) D.G. Mann, 5 – *Nitzschia constricta* (Kütz) Ralfs, 6 – *Navicula veneta* Kütz.

Lednice Ponds (BÍLÝ 1926, ZAPLETÁLEK 1932). Further, SKÁCELOVÁ & MARVAN (1991) reported the species from Nesvačilka, Zápověď near Terezín, Dobré pole and Rakvice. Recently it has been reported from Zadní Pond, near Hustopeče, and in a rivulet known as Hrabinková in Starý Podvorov (SKÁCELOVÁ & BEŠTA 2010b). Within the study in hand, it was recorded from only Nesyt Pond (1993); however its populations achieve up to 20% of total diatom abundance.

Anomoeoneis sphaerophora Pfitzer

This species shows a preference for average-to-high electrolyte content, sometimes even appearing in brackish waters (KRAMMER & LANGE-BERTALOT 1986). In the past, it was observed in southern Moravia by PROCHÁZKA (1924) and ZAPLETÁLEK (1932). Further, sub-fossil records from the Czech Republic have appeared for the Soos National Nature Reserve (ŘEHÁKOVÁ 1986, RAJDLOVÁ 2011) and from Tertiary diatomite deposits

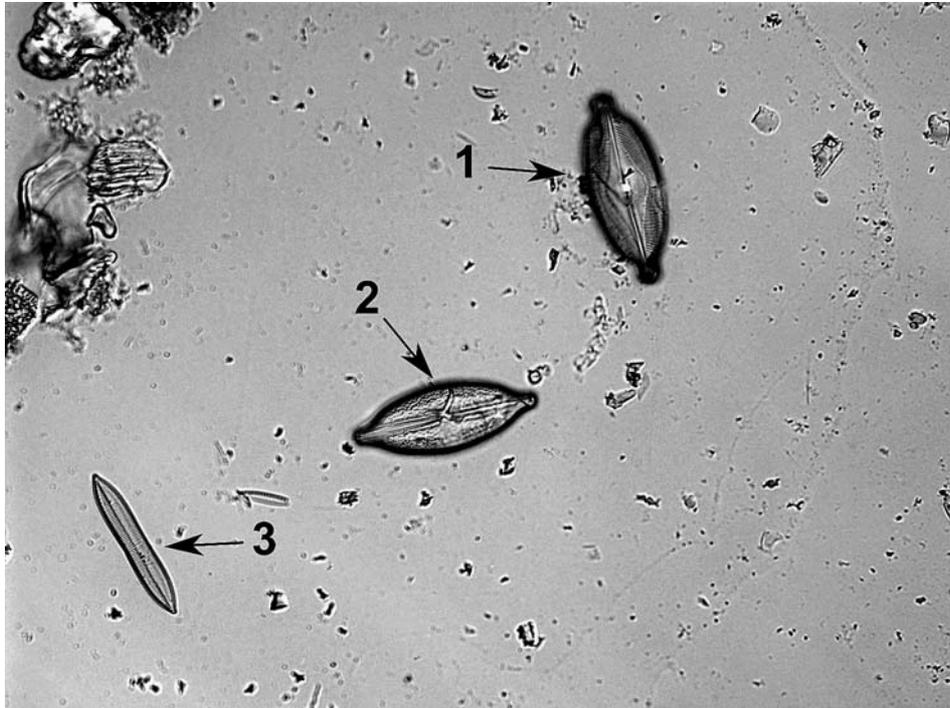


Fig. 35: Mlýnský pond, 05-05-1993: 1 – *Caloneis amphisbaena* (Bory) Cleve, 2 – *Anomoeoneis sphaerophora* (Ehrenb.) Pfitz., 3 – *Nitzschia constricta* (Kütz) Ralfs.

(Bešta, unpubl.). Within the research in hand, it was usually found in higher abundances after summer or winter drainage (Nesyt Pond 2001 and 2009, Mlýnský Pond 2000, Hlohovecký Pond 2010). Generally, it tended to abundance especially in communities of well-developed epipellic crusts.

***Caloneis amphisbaena* (Bory) Cleve**

This cosmopolitan taxon shows a preference for average-to-high electrolyte content; massive development of *Caloneis amphisbaena* populations has been observed only in waters with a high content of electrolytes, but in no brackish environment. It is often found in association with *Anomoeoneis sphaerophora* (Ehrenb.) Pfitz. (KRAMMER & LANGE-BERTALOT 1986) (above). Findings from southern Moravia have been frequent since the beginning of phycological research there (NAVE 1863, BAYER & BAJKOV 1929, PROCHÁZKA 1924, ZAPLETÁLEK 1932). In the Lednice Ponds, it has frequently, and in

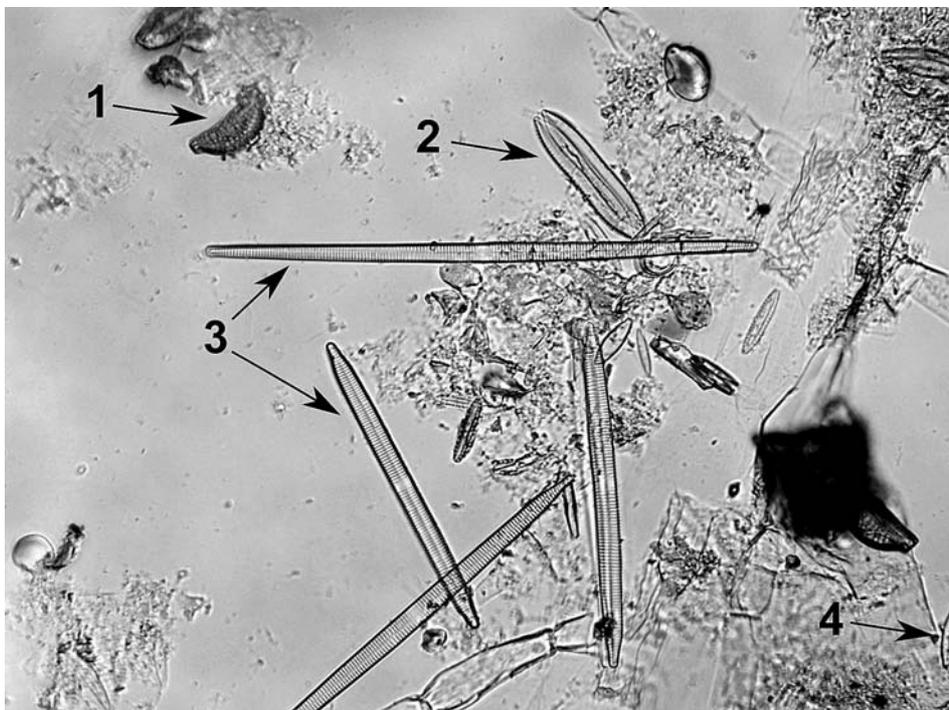


Fig. 36: Nesyt pond, 14-08-1994, SW bank: 1 – *Epithemia sorex* Kütz., 2 – *Nitzschia constricta* (Kütz.) Ralfs, 3 – *Ulnaria ulna* (Nitzsch) Compère, 4 – *Navicula veneta* Kütz.

particular, been recorded in algal epipellic crusts sampled after summer or winter drainage (Nesyt Pond 2001 and 2008, Mlýnský Pond 2000, 2001 and 2002, Hlohovecký Pond 2009 and 2010).

***Caloneis permagna* (J.W. Bailey) Cleve**

A cosmopolitan species of brackish waters, also sometimes found in fresh waters of high electrolyte content (KRAMMER & LANGE-BERTALOT 1986). Historically, it used to be a common inhabitant of saline southern Moravian localities (BÍLÝ 1925, 1926, 1927, 1929, BAYER ET BAJKOV 1929, ZAPLETÁLEK 1932). Recently, it has been reported from the Trkmanec Ponds (2007), and from the Lednice Ponds (Nesyt Pond 2001, Mlýnský Pond 2002, Hlohovecký Pond 2009). Like the previous two species, this taxon is usually found in algal epipellic crusts after summer or winter drainage, or in shallow pond lagoons.

***Halamphora veneta* (Kütz.) Levkov**

A cosmopolitan taxon of habitats with higher electrolyte content; it tolerates organic pollution up to polysaprobic level (KRAMMER & LANGE-BERTALOT 1986). It has been recorded in almost every southern Moravian saline locality – Nesyt Pond in the 1960s–1970's (MARVAN, pers. com.), Jezírko Kutnar pool from 1986 to 1987 (SKÁCELOVÁ & MARVAN 1991) and Přední Pond (SKÁCELOVÁ & BEŠTA 2010a). It has also occurred in flowing waters of higher salinity. In the research in hand, the species was found in nearly every sample examined. This illustrates its wide ecological valence and resistance to deterioration of trophic conditions.

***Nitzschia tryblionella* Hantzsch**

A common species of brackish coastal waters, patchily distributed in inland waters with high salt contents, or as an epipelton in frequently-drying places (KRAMMER & LANGE-BERTALOT 1988). The species occurred very frequently among Bílý's specimens. It was also recorded by BAYER & BAJKOV (1929) and ZAPLETÁLEK (1932). SKÁCELOVÁ & MARVAN (1991) found it in fire-service reservoirs in Žatčany and Nesvačilký near Brno, and on a mass scale in Hlohovecký Pond as well. Recent records from the Lednice Ponds feature a rare occurrence of the taxon in Mlýnský Pond (2000) and its presence in the epipelton of a shallow lagoon in Hlohovecký Pond (2010). It was also very frequent in the inlet of Nesyt Pond (2001).

***Simonsenia delognei* (Grunow) Lange-Bert.**

A tiny species, frequent but easily overlooked, with quite high demands on the salt content of the environment (KRAMMER & LANGE-BERTALOT 1988). Like *Nitzschia tryblionella*, it is good at surviving frequent drying of the habitat. In the Lednice Ponds, it was first recorded in Hlohovecký Pond only in 2010, but such "scarcity" may well be a consequence of the species' inconspicuousness.

***Navicula oblonga* (Kütz.) Kütz**

A cosmopolitan species, *Navicula oblonga* prefers an alkaline environment with a high content of electrolytes, sometimes up to moderately brackish conditions. It tolerates high concentrations of sulphur; it should not, however, be generally characterized as pollution-tolerant (KRAMMER & LANGE-BERTALOT 1986). Historically, it was mentioned by FISCHER (1920), PROCHÁZKA (1924), and ZAPLETÁLEK (1932). In the Jezírko Kutnar pool it was found in muddy sediment along with the cyanobacterium *Planktothrix cryptovaginata* (SKÁCELOVÁ & MARVAN 1993) and later observed again after mud removal in 2007. In south Moravian localities, it was very frequent in Písečný fishpond (in the eutrophic part with muddy sediment), in Pátecká Pool (in black mud on the

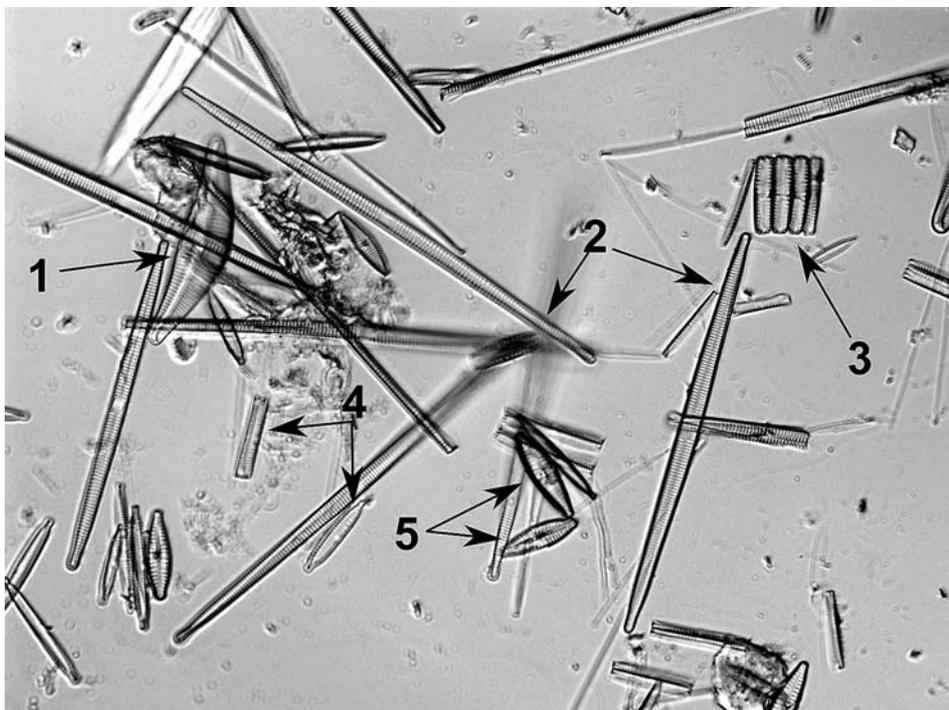


Fig. 37: Hlohovecký Pond, 05-05-1993: 1 – *Cymbella* cf. *neocistula* Krammer, 2 – *Ulnaria ulna* (Nitzsch) Compère, 3 – *Gomphonema* sp. (girdle view), 4 – *Fragilaria capucina* v. *vaucheriae* (Kütz.) Lange-Bert., 5 – *Gomphonema parvulum* (Kütz.) Kütz..

bottom), in a body of water near Vacenovice (a depleted peat-bog), and in a drying swimming pool in Starý Podvorov (SKÁCELOVÁ & BEŠTA 2011). Its dominant occurrence in the saline pools and streamlets of the northern Bohemian coal dumps (SKÁCELOVÁ 2006) illustrates its preference for high concentrations of sulphates. In the Lednice Ponds, it was recorded in high abundances in the epipellic crusts of the Mlýnský Pond after winter drainage in 2000.

***Pinnularia brebissonii* (Kütz.) Rabenh.**

This is a taxon associated with waters of average-to-high electrolyte content (KRAMMER & LANGE-BERTALOT 1986). It is, for example, a dominant taxon of the diatomite deposits of the Soos National Nature Reserve, from which it was originally described (KÜTZING 1844). Within the research in hand, it has been recorded sporadically in Mlýnský Pond (2000).

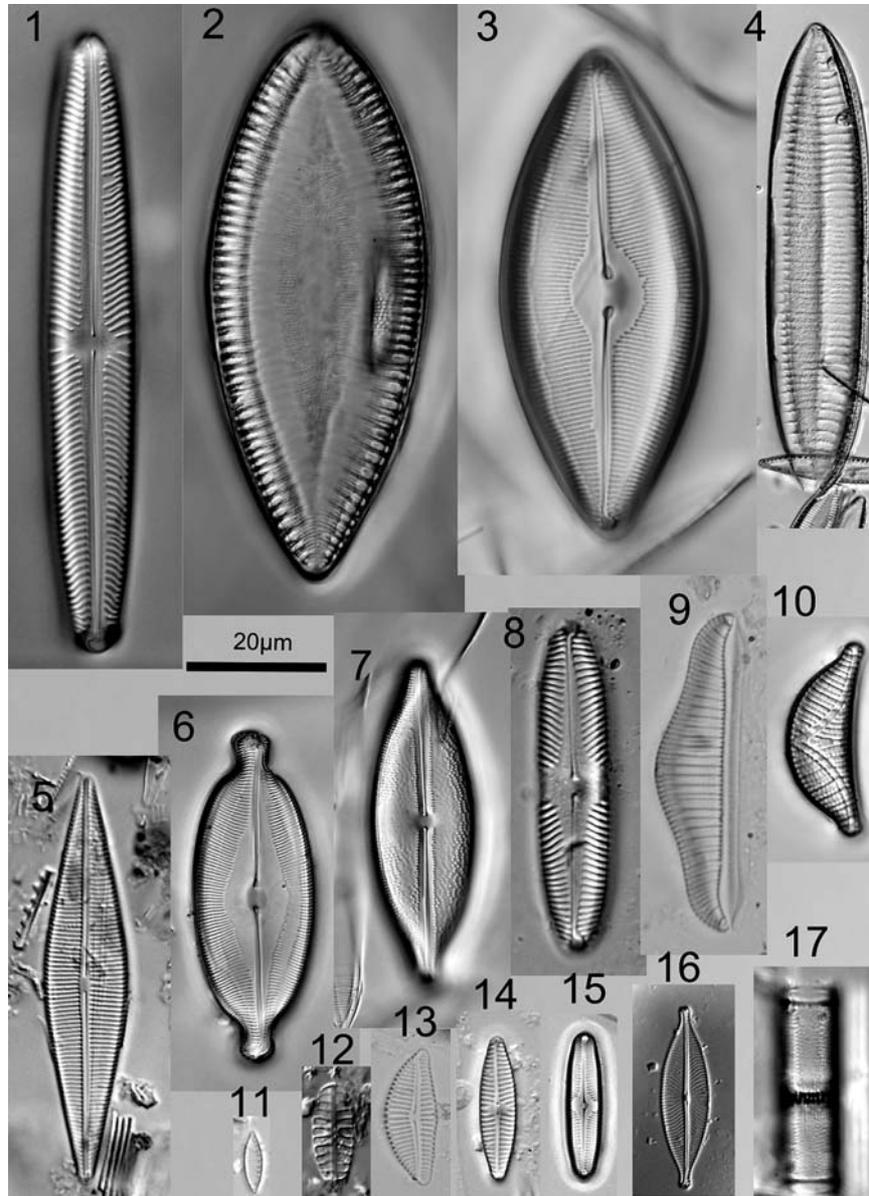


Fig. 38: Halophytic diatoms found in Lednice ponds: 1 – *Navicula oblonga* (Kütz.) Kütz., 2 – *Surirella ovalis* Bréb., 3 – *Caloneis permagna* (J.W. Bailey) Cleve, 4 – *Nitzschia tryblionella* Hantzsch, 5 – *Craticula halophila* (Grunow) D.G. Mann, 6 – *Caloneis amphisbaena* (Bory) Cleve, 7 – *Anomoeoneis sphaerophora* (Ehrenb.) Pfitz., 8 – *Pinnularia brebissonii* (Kützing) Rabenh., 9 – *Rhopalodia gibba* (Ehrenb.) O. Müll., 10 – *Epithemia sorex* Kütz., 11 – *Simonsenia delognei* (Grunow) Lange-Bert., 12 – *Hippodonta hungarica* (Grunow) Lange-Bert., Metzeltin et Witkowski, 13 – *Encyonema caespitosum* Kütz., 14 – *Navicula veneta* Kütz., 15 – *Pinnularia appendiculata* (Agardh) Cleve, 16 – *Craticula halophila* (Grunow) D.G. Mann, 17 – *Aulacoseira italica* (Ehrenb.) Simonsen.

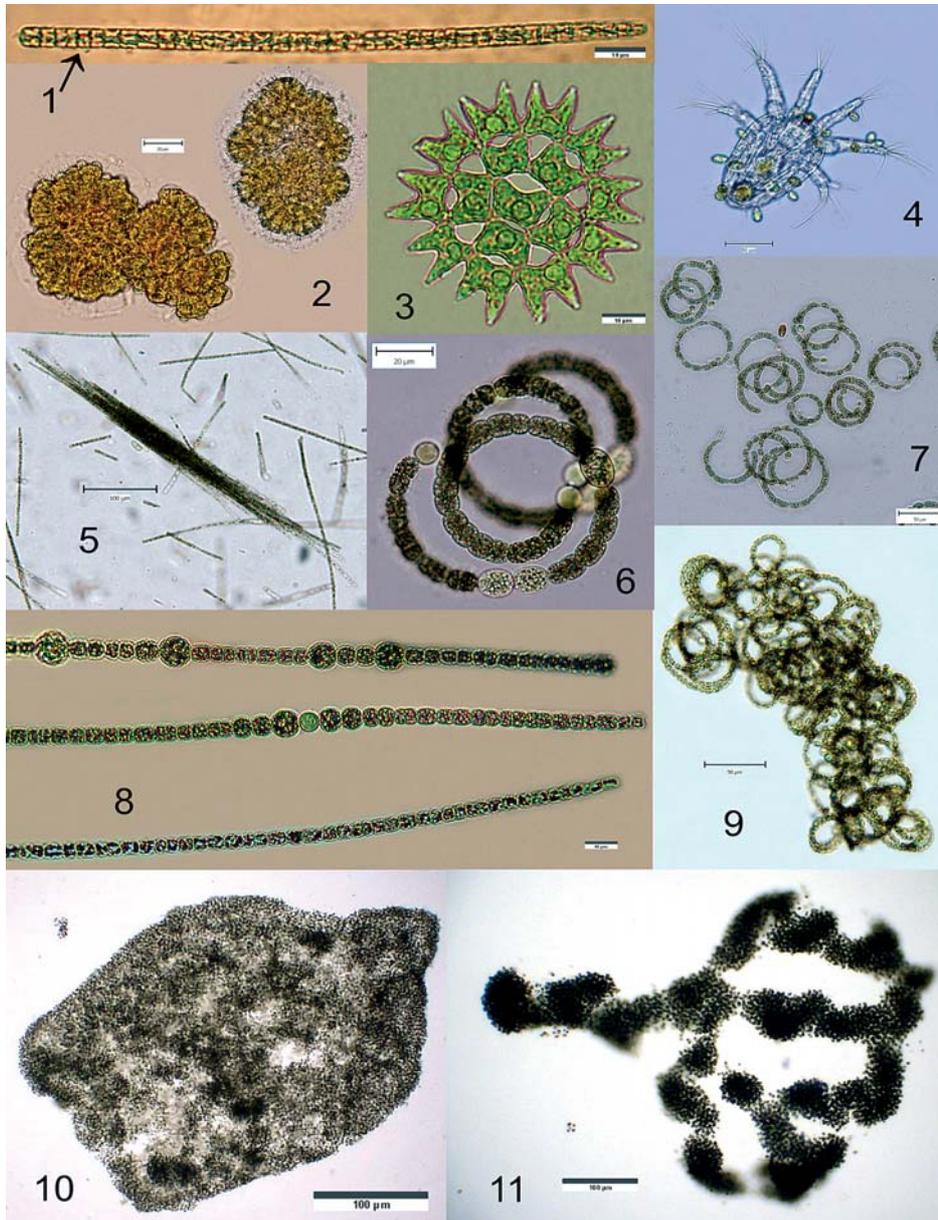


Fig. 39: Cyanobacteria and algae typically occur in Lednice Ponds over the last years: 1 – *Planktothrix agardhii* (Gom.) Anagn. et Kom., 2 – *Botryococcus braunii* Kütz., 3 – *Pediastrum duplex* Meyen, 4 – *Colacium* Ehrenb. (on nauplius larva of a Cyclops copepod), 5 – *Aphanizomenon flos-aquae* (L.) Ralfs ex Born. et Flah., 6 – *Anabaenopsis milleri* Woronich., 7 – *Anabaenopsis elenkinii* Mill., 8 – *Sphaerospermopsis aphanizomenoides* (Forti) Zap., 9 – *Dolichospermum mendotae*(Trel.) Wackl., Hoffm. et Kom., 10 – *Microcystis ichthyoblabe* Kütz., 11 – *Microcystis aeruginosa* (Kütz.) Kütz.



Fig. 40: 1 – Hlohovecký Pond, 2 – Mlýnský Pond, 3 – Nesyt, 4 – Prostřední Pond. Photographed in 2009.

Expansive and rare species of algae and cyanobacteria

Phycological research into the populations of the Lednice Ponds has already been in progress for some considerable time, so the number of recorded species is markedly high. The ponds are also inhabited by relatively thermophilic, non-indigenous species, a situation that may be explained by the location of the ponds in the warmest part of the Czech Republic. A comprehensive list of the alien and expansive species of freshwater cyanobacteria and algae in the Czech Republic was published by KAŠTOVSKÝ *et al.* (2010). In the Lednice Ponds, the presence of the filamentous cyanobacterium *Cuspidothrix issatschenkoi* has been commonplace for approximately the last 15 years; *Sphaerospermopsis aphanizomenoides* has made regular appearances in the last five years. Rare occurrence has been reported for *Cylindrospermopsis raciborskii* and *Dolichospermum compactum* (Nyg.) Wackl, Hoffm. et Kom. From the expansive diatom species, the phytoplankton of the Lednice Ponds is commonly inhabited by *Skeletonema potamos*. In all of the ponds studied, two species of expansive green algae, *Pediastrum simplex* Meyen and *Staurastrum planctonicum* Teil, are also commonly present. Unclear taxonomy and a number of synonyms in circulation lead to the latter species often being referred to as *Staurastrum manfeldtii* complex Coes.

With respect to the indigenous taxa of algae and cyanobacteria, there are interesting historical data, among them the dominance of the currently relatively rare filamentous cyanobacteria *Dolichospermum tenericaule* in Mlýnský Pond in 1957 (LOSOS & HETEŠA 1971), *Anabaenopsis nadsonii* abundant in Hlohovecký Pond, and less so in Prostřední Pond in 1993 (HETEŠA *et al.* 1994). Among recent interesting findings are the presence of the cyanobacterium *Planktolyngbya limnetica*, which was found in higher numbers in the Prostřední and Mlýnský Ponds in 2006 and 2008, and the presence of the rare colonial coccoid cyanobacterium *Merismopedia convoluta* (SKÁCELOVÁ & ZAPOMĚLOVÁ 2010).

Conclusions

In the course of the 20th century and the beginning of the 21st century, the Lednice Ponds complex has undergone significant changes in both hydrology and management strategy. The Lednice Ponds have always suffered from a simple quantitative insufficiency of water. Although located in a warm climatic region with strong surface evaporation, the pond complex has been topped up with water by only a few small inlets, of which the most important is a stream known as Mikulovská strouha. The largest of the ponds is Nesyt, which served simultaneously as a retention reservoir and was a source of water for the other three large ponds – Hlohovecký, Prostřední, and Mlýnský. The ponds cannot be independently filled and drained as they possess no peripheral drainage. The perennial water shortage was especially exacerbated during the transition of the fish-farming management approach from single-year production to a multi-production system, in which the ponds were drained and refilled every year. During the 20th century, a gradual decrease in both the ground-water level and the strength of existing tributaries took place. When the upper reservoir of VD Nové Mlýny was completed (part of a massive water management project that flooded a very large area in southern Moravia, comparatively close to Lednice), the Lednice Ponds complex acquired a new potential water source, led by an irrigation channel from the reservoir into the Šibeník and Nový Mikulov Ponds, then from there to Nesyt Pond. These ponds were used as retention reservoirs for irrigation water, which was then distributed over the surrounding land areas by pumping stations. In 1992, the price of irrigation water rose sharply and consequently water was no longer pumped into the channel. The chemical properties of the water in Lednice Ponds changed markedly. Compared with the first data on the physico-chemical parameters of the ponds, overall salinity increased. The quantities of chlorides, calcium and, in particular, organic compounds, also climbed. There was a substantial increase in biogenic compounds, in particular phosphates, ammonium salts and nitrates. In around the last 15 years, a decrease in content of the majority of the parameters monitored has been noted. Significantly lower values have emerged for organic compounds, phosphorus, calcium, potassium, chlorides and water alkalinity. Water transparency has increased, while values of dissolved oxygen and pH have fluctuated widely in waters of high trophic activity – thus waters of high primary production. Despite significant improvements in the treatment of waste water from nearby villages, reductions in agricultural and fisheries production, exclusion of manure fertilization of the ponds and

significant reductions in fish feeding, the ponds are still of a strongly eutrophic character and the concentrations of nutrients are relatively high; phosphorus, in particular, is in surplus.

A characteristic feature of the Lednice Ponds is the occurrence of cyanobacterial blooms. The very first studies in the 1920s described the dominance of planktonic cyanobacteria in all four ponds. The vast majority of the waters of the ponds were inhabited by representatives of the cyanobacterial genera *Microcystis*, *Aphanizomenon* and *Dolichospermum*. Step by step, the dominance of individual species changed in each of the ponds during the growing season. Representatives of all the above genera were usually reported. The mass development of cyanobacterial blooms was facilitated by lower fish stocks. Predatory pressure from fish declined to the point at which it failed to prevent the development of *Daphnia* at the beginning of spring, so perfectly-filtered water enabled expansion of cyanobacteria at the end of spring. In 1957, blue-green algae even caused the death of the zooplankton and all of the fish stock in Prostřední Pond (HETEŠA et LOSOS 1962).

Later, a gradual intensification of fish management took place and the ichthyofauna of the ponds was enriched by new species of herbivorous fish. Fertilizer was regularly added to the ponds and additional feed provided for the fish. This situation had an important influence on the composition of species in the phytoplankton. The quantities of phytoplankton increased substantially and nanoplanktonic species became the dominant organisms, although the total biomass of the phytoplankton did not increase. The cyanobacteria of the blooms occurred in only small quantities in summer and never achieved mass development. The dominants were made up largely of small species of green chlorococcal algae and nanoplanktonic species of cyanobacteria, and in spring by centric diatoms as well. Such a phytoplankton composition led to long-term vegetation opacity; the transparency dropped to a few decimetres. A complete suppression of submerged vegetation in the ponds was observed. High stocking of carp led to limited development in coastal vegetation, as well as in other organisms associated with it, including benthic cyanobacteria and algae.

The condition of the Lednice Ponds described above lasted until the early 1990s, when significant transformations were once more under way. Approaches to management changed: maximization of fish production was no longer the priority, and the primary concern became the need to restore the species diversity of the ponds and to improve conditions for general nature conservation. In response to substantive changes, the structure of the phytoplankton shifted substantially. Reduction of the fish stock and the reintroduction of at least partial summering of the ponds (draining and drying out most of the pond area) resulted in the return of dominant planktonic bloom-forming cyanobacteria and a suppression of nanoplanktonic species. The species structure was extended by other representatives, e.g. *Anabaenopsis*; and new species, previously undescribed in the ponds, such as *Planktolyngbya limnetica*, *Sphaerospermopsis reniformis* (Lemmerm.) Zapomělová et al. Expansive species such as *Sphaerospermopsis aphanizomenoides* appeared. At the same time, benthic species sensitive to pollution began to show themselves again (mainly diatoms, but also cyanobacteria and green

algae). With reductions in fish stock and repeated partial summering (accomplished since the 1990s, in particular for Mlýnský Pond), benthic species typical of cleaner waters with submerged vegetation were recorded frequently in some seasons. Even in the ponds that were not summered, thorough sampling revealed the presence of inhabitants of the phytobenthos microhabitats, which were different from the rest of the pond environment, basically lacking in particular interest. Such microhabitats were formed by, for example, submerged logs in Prostřední Pond, around which the diatom *Epithemia sorex* was regularly found; a shoreline of Hlohovecký Pond outside the reeds with sands and a varied phytobenthos; a shallow bay in the upper part of the same pond with halophilic algae; and a lagoon with reed stands in the upper part of Nesyt Pond. With respect to the composition of the phytobenthos, an evaluation of reductions in fish stock becomes possible: on the one hand emerge problems with strong cyanobacterial blooms, on the other, it is an intervention positively reflected in an increase in biodiversity.

In recent years, thanks to tight regulations for commercial fish production in the ponds, a higher incidence of undesirable pest fish species has been noted. Also, in spring, when the zooplankton developed in large numbers, the phytoplankton was made up largely of euglenophytes (genus *Colacium*) and the total phytoplankton biomass was very low. After a short period of green algae development, cyanobacteria prevailed and carried on in high abundance until the end of the growing season. With the progressive lowering of water transparency during the year, the species composition of cyanobacteria changed as well. By the end of the season, the waters were dominated by types adapted to low-light conditions, mostly *Planktothrix agardhii*.

The Lednice Ponds are naturally eutrophic, with a high content of nutrients even in their sediments. An earlier higher inflow of sewage waters into the ponds has been significantly reduced in recent years by the construction of waste-water treatment plants. The direct application of fertilizers and indirect leaching through from surrounding farmland have decreased. The species composition and the phytoplankton biomass are thus mostly affected by fisheries management in which, after the exclusion of fertilization of the ponds and supplementary feeding of fish, the size of the fish stock and whatever ameliorative measures are chosen (summering and wintering of the ponds, etc.) have the greatest influence. The meteorological conditions in individual years also play an important role as a determining factor for the development of phytoplankton. Given the limitation of fishery management and the requirements of nature protection, a dominance of planktonic bloom-forming cyanobacteria, thus provided with optimum conditions for development, may be expected in the Lednice Ponds in the immediate future.

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Summary

Soustava Lednických rybníků prodělala během 20. století a na počátku století 21. značné změny, jak pokud se týká jejich hydrologických poměrů, tak způsobu obhospodařování. Lednické rybníky trpěly vždy nedostatkem vody. V teplé klimatické oblasti se silným povrchovým výparem byla celá soustava napájena pouze několika drobnými přítoky, z nichž nejvýznamnější je Mikulovská strouha. Nesyt jako největší z rybníků soustavy sloužil současně jako retenční nádrž a byl zdrojem vody pro další tři velké rybníky – Hlohovecký, Prostřední a Mlýnský. Rybníky nelze nezávisle na sobě napouštět a vypouštět, nemají obvodovou stoku. Nedostatek vody se prohloubil zejména při přechodu z vícehorkového způsobu hospodaření na jednohorkový, kdy se rybníky vypouštěly a napouštěly každý rok znovu. V průběhu 20. století docházelo v oblasti k pozvolnému poklesu hladiny spodních vod a intenzita stávajících přítoků se snižovala. Po dobudování horní nádrže VD Nové Mlýny získala rybníční soustava nový potenciální zdroj vody, který je veden zavodňovacím kanálem z této nádrže do rybníků Šibeník a Nový u Mikulova a odtud do Nesytu. Rybníky sloužily jako retenční nádrže závlahové vody, která byla čerpacími stanicemi distribuována na plochy okolních pozemků. V roce 1992 došlo k výraznému zdražení závlahové vody a voda se přestala do kanálu čerpat.

Chemismus vody Lednických rybníků se výrazně měnil. Ve srovnání s prvními údaji o hodnotách základních fyzikálně-chemických parametrů rybníků se zvýšila jejich celková salinita. Zvýšilo se množství chloridů a vápníku a výrazně narostlo množství organických látek. Výrazný je nárůst základních biogenů, zejména fosfátů, amonných solí a dusičnanů. V posledních přibližně 15 letech lze zaznamenat pokles obsahu většiny sledovaných parametrů. Výrazně klesl obsah organických látek ve vodě rybníků, snížilo se i množství fosforu, vápníku, hořčíku, draslíku, chloridů a alkalita vody. Koncentrace nutrientů jsou přesto pořád vysoké, především obsah fosforu je stále v nadbytku. Průhlednost vody se zvýšila, hodnoty rozpuštěného kyslíku a pH jsou vzhledem k vysoké trofii vod, a tím i vysoké primární produkci, velmi rozkolísané. Přes výrazné zlepšení čistění odpadních vod z okolních obcí, snížení intenzity zemědělské a rybářské produkce, vyloučení hnojení rybníků a výrazné omezení přikrmování ryb jsou rybníky stále silně eutrofního charakteru.

Charakteristickým znakem Lednických rybníků je výskyt vodních květů sinic. Již první výzkumy z 20. let 20. století popisují dominanci planktonních sinic na všech čtyřech rybnících. Převážnou většinou se na rybnících vyskytovaly zástupci sinic z rodů *Microcystis*, *Aphanizomenon* a *Dolichospermum*. Na jednotlivých rybnících se v průběhu vegetační sezóny postupně měnila dominance jednotlivých druhů, většinou byl zaznamenán výskyt zástupců ze všech výše jmenovaných rodů. Masový rozvoj sinic vodního květu umožňovaly nižší obsádky ryb, které svým predačním tlakem nedokázaly omezit jarní rozvoj perlooček, dokonale profiltrovaná voda na konci jara tak umožnila nástup sinic. V roce 1957 dokonce sinice způsobily úhyn zooplanktonu a celé rybí obsádky na Prostředním rybníce (HETEŠA & LOSOS 1962).

Postupně docházelo k intenzifikaci chovu ryb, ichtyofauna rybníků byla obohacena o nové druhy býložravých ryb, rybníky byly pravidelně přihnojovány a rybí obsádky přikrmovány. Tento stav měl výrazný vliv na změnu druhového společenstva fytoplanktonu. Kvantita fytoplanktonu výrazně narostla, dominantními organizmy se stali pikoplanktonní druhy, celková biomasa fytoplanktonu se tak ale příliš nezvýšila. Sinice vodního květu se v letním období objevovaly jen v malém množství a nikdy nedosahovaly masového rozvoje. Dominantními organizmy se staly převážně drobné druhy chlorokokálních zelených řas, pikoplanktonní druhy sinic a na jaře i centrické rozsivky. Tato skladba fytoplanktonu způsobila dlouhodobý vegetační zákal a průhlednost vody klesala na několik decimetrů. Došlo k úplnému potlačení submerzní vegetace rybníků, vysoké obsádky kapra vedly až k omezování přibřežní vegetace včetně její živočišné složky i bentických sinic a řas.

Tento stav na Lednických rybnících trval až do počátku 90. let 20. století, kdy začalo docházet opět k výrazným změnám. Pohled na způsob hospodaření se změnil, maximalizace produkce ryb ustoupila do pozadí a prvotním zájmem je obnovit druhovou diverzitu rybníků a zlepšit podmínky pro ochranu přírody. Tento stav se výrazně projevil i na struktuře fytoplanktonu. Snížení nasazovaných obsádek ryb a opětovné zavedení alespoň částečného letnění rybníků způsobilo návrat dominance výskytu planktonních sinic vodního květu a omezení pikoplanktonních druhů. Druhá struktura sinic se rozšířila o další zástupce, kromě již uvedených rodů sinic se zvýšil výskyt rodu *Anabaenopsis*, objevily se i druhy zcela nové, dříve na rybnících nepopsané, jako *Planktolyngbya limnetica*, *Sphaerospermopsis reniformis* nebo expanzivní druh *Sphaerospermopsis aphanizomenoides*. Zároveň se znovu začaly objevovat bentické druhy (zejména rozsivky, ale i sinice a zelené řasy) citlivé na znečištění. Se snížením rybích obsádek a opakovaným částečným letněním (to se dělo od 90. let zejména na Mlýnském rybníce) se v některých sezónách objevovaly i hojně nárostové druhy typické pro čistší zarostlé vody. I na rybnících, které nebyly letněny, byly při podrobném posbírání alespoň v malé míře nalazány

mikrohabitaty fyto bentosu odlišného od druhově nezajímavého prostředí většiny rybníka. Takovým mikrobiotopem jsou například ponořené kmeny na Prostředním rybníce, kde se pravidelně vyskytovala až masově rozsivka *Epithemia sorex*, nebo pobřežní linie Hlohoveckého rybníka vně rákosin s písčinou oživenou pestřejším fyto bentosem, mělká zátoka v horní části téhož rybníka s halofilními řasami či laguny v rákosinách horní části Nesytu. Vzhledem ke složení fyto bentosu, lze hodnotit snížení rybích obsádek, které na druhé straně přináší problémy se silnými vodními květy, jako zásah pozitivně se promítající ve zvýšení biodiverzity.

V posledních letech díky razantnímu omezení nasazovaných ryb dochází na rybnících k vyššímu výskytu nežádoucích plevných ryb. Struktura fytoplanktonu je pak v jarním období, kdy se na rybnících objevuje vysoký počet velkých zooplanktonních druhů, tvořena převážně zástupci ze skupiny krásnooček (rod *Colacium*) a celková biomasa fytoplanktonu je velice nízká. Po krátkém rozvoji zelených řas nastupují sinice, které se většinou na rybnících udrží ve vyšší abundanci až do konce vegetačního období. S postupným snižováním průhlednosti v průběhu roku, se mění i druhová skladba sinic, kdy na konci vegetace dominují druhy nenáročné na světelné podmínky, nejčastěji druh *Planktothrix agardhii*.

Lednické rybníky jsou přirozeně eutrofní s vysokým obsahem živin i v sedimentech. Dřívější vyšší přísun odpadních vod do rybníků byl v posledních letech díky stavbě čistíren výrazně omezen, rovněž aplikace a splach hnojiv z okolní zemědělsky obhospodařované půdy se snížil. Druhové složení a biomasa fytoplanktonu rybníků je tak nejvíce ovlivňována rybářským hospodařením, kdy při vyloučení hnojení rybníků a příkrmování ryb má největší vliv velikost obsádky a prováděná meliorační opatření (letnění, zimování rybníků aj.). Významným určujícím faktorem pro rozvoj fytoplanktonu jsou i meteorologické podmínky v jednotlivých letech. Vzhledem k omezení rybářského hospodaření na základě požadavků ochrany přírody, lze v budoucnosti na Lednických rybnících očekávat podobně jako v letech minulých dominanci planktonních sinic vodního květu, které mají na rybnících optimální podmínky ke svému rozvoji.

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