ISSN 1211-8788 *Acta Musei Moraviae, Scientiae biologicae* (Brno)
95(1): 201–221, 2010

Remarks on the occurrence and ecology of several interesting cyanobacterial morphospecies found in South Moravian wetlands

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SKÁCELOVÁ O. & ZAPOMĚLOVÁ E. 2010: Remarks on the occurrence and ecology of several interesting cyanobacterial morphospecies found in South Moravian wetlands. *Acta Musei Moraviae, Scientiae biologicae* (Brno) **95(1):** 201–221. – Extensive investigation of planktonic, periphytic, metaphytic and benthic cyanobacteria was performed in the years 1986–2009 at South Moravian localities. The occurrence and ecology of eight selected cyanobacterial morphospecies were studied in detail: *Rhabdogloea smithii* (R. et E. Chodat) Komárek, *Merismopedia convoluta* Brébisson in Kützing, 1849, *Merismopedia* sp., *Spirulina major* Kützing ex Gomont, 1892, *Spirulina meneghiniana* Zanardini ex Gomont, 1892, *Spirulina nordstedtii* Gomont, 1892, *Arthrospira jenneri* Stizenberger ex Gomont, 1892, non-planktonic morphospecies of *Anabaena* Bory ex Bornet et Flahault, 1888, and *Anabaenopsis nadsonii* Voronichin, 1929. This research revealed *Anabaenopsis nadsonii* as a species new for the Czech Republic. Further, the environmental preferences of the species studied are here revised and discussed together with data in the literature. *Spirulina meneghiniana* (Kutnar, Pastvisko – Nová okrouhlá tůň Pool, Lednické rybníky fishponds – Prostřední rybník Pond) have been found to display a markedly wider range of conductivity tolerances than had been previously reported. All samples collected in the course of the work have been deposited in the collection of Moravian Museum, Brno and are available for further studies.

Keywords. Cyanobacteria, floristics, ecology, management, succession

Introduction

Previous research into the cyanobacteria of South Moravia has focussed primarily on planktonic species, especially those involved in harmful water blooms. Data on the periphyton are scattered only around floristic studies compiled 80 years or more ago. To date, attention has been biased towards the man-made fish ponds and water reservoirs, while backwaters have become subjects for particular algological research only in the final decade of the 20th century, as a part of ongoing studies of wetlands and their biodiversity. The best-investigated body of water in South Moravia is the Jezírko Kutnar Lake, where several taxonomic groups have been studied (summarized in SKÁCELOVÁ 2009). All the material from algological research has been deposited in the Moravian Museum, Brno and is being methodically studied in detail with respect to selected species and genera. The matter of presence or absence of certain cyanobacterian and algal taxa in assemblages at various localities and biotopes at certain times, often associated with natural succession or the management of backwaters, has added much to out knowledge of ecology.

The selected species investigated within this paper belong to relatively little-known representatives of the cyanobacteria and any new information on their distribution and environmental preferences is therefore highly valuable.

Extensive investigation of the planktonic, periphytic, metaphytic and benthic cyanobacteria took place in the years 1986–2009 at South Moravian localities. The sampling sites included pools and the littorals of ponds and other alluvial wetlands. Attention was devoted not only to general localities and biotope types but also to microhabitats. Species compositions in cyanobacterial flora were evaluated in living field samples from 2005 onwards. The findings were supplemented by a survey of previous preserved samples deposited in the collection of the Moravian Museum (1986–2004).

The research brought to light much that was new on the occurrence and ecology of the species studied, as well as resulting in the discovery of *Anabaenopsis nadsonii* Voronichin, 1929 for the first time in the Czech Republic. Most of the other species described here are considered rare in this region. The preferences for certain biotopes on the part of selected morphospecies were revised in the light of observations from South Moravia. These findings are discussed alongside information provided in established monographs (Geitler 1932, Starmach 1966, Komárek & Anagnostidis 1999, 2005).

The following species are studied in this paper: *Rhabdogloea smithii* (R. et E. Chodat) Komárek, *Merismopedia convoluta* Brébisson in Kützing, 1849, *Merismopedia* sp., *Spirulina major* Kützing ex Gomont, 1892, *Spirulina meneghiniana* Zanardini ex Gomont, 1892, *Spirulina nordstedtii* Gomont, 1892, *Arthrospira jenneri* Stizenberger ex Gomont, 1892, nonplanktonic morphospecies of *Anabaena* Bory ex Bornet et Flahault, 1888, and *Anabaenopsis nadsonii* Voronichin, 1929.

Most of the samples were collected by O. Skácelová (other findings are mentioned together with the name of the collector).

Description of localities

Kutnar

Coordinates. N 48°50′09″ E 16°47′29″

Description and remarks. The Jezírko Kutnar Lake, designated a "Nature Monument" since 1956, is an oxbow pool in the River Dyje alluvium, without connection to the river system, of slightly saline character.

Continuous algological research since 1986 has recorded succession and terrestrialization, restoration, and the reactions of biodiversity to management approaches.

More information about the locality may be found elsewhere (e.g. Skácelová & Komárek 1989; Skácelová 2009).

Samples used for this study:

HY 1508 Kutnar 1992-09-22 in bunches of *Cladophora globulina* and submerged vegetation (*Ceratophylum demersum* filling the whole body of water), pH 8.6.

HY 1518 Kutnar 1995-07-13, leg. J. Heteša (average values 1994–96: pH 7.65; conductivity 1294 µS/cm; Ca^{2+} 207.1 mg/l; Mg^{2+} 52.3 mg/l; Cl 156.2 mg/l; SO_4^{2-} 139.3 mg/l; HETEŠA *et al.* 2004).

HY 1775 Kutnar 2002-06-09 old reed stalks floating in littoral, unshaded, with conspicuous green periphyton (pH 7.5; conductivity 1770 µS/cm) (SKÁCELOVÁ 2004).

HY 1782 Kutnar 2002-07-16 old reed stalks, in algal clumps together with rare filamentous green alga *Schizomeris leibleinii*, pH 7.7; conductivity 1640 µS/cm (SKÁCELOVÁ 2009).

HY 1783 ibid, in crusts.

HY 1938, HY 1939 Kutnar 2007-07-10 in shallow water of upper littoral, mats lining bottom, leg. L. Hájková. First season after restoration (mud removal).

HY 2091 Kutnar 2008-07-10, periphyton on *Batrachium circinatum*, leg. L. Hájková.

Pastvisko

Coordinates. Outflow from wetland: N 48°48′52″ E 16°47′58″, margin of pond N 48°48′50″ E 16°47′16″, lagoon N 48°48′43″ E 16°47′57″, Nová okrouhlá tůň Pool (pool created in winter 2002) N 48°48′40″ E 16°47′52″.

Description and remarks. The largest South-Moravian alluvial wetland, consisting of a mosaic of habitats. One part, resembling a fishpond, is filled with water from the channel system; other parts, rather like lagoons, are filled with ground-water or mixed water, while pools created in the 1970's and 2002 are filled with rainwater and ground-water. Because of this habitat variety, the microflora in the various parts may differ in a single season, while substantial changes were also observed over time (drying out in the summer season in some years).

For more information on the locality and proposed management see SKÁCELOVÁ, O. & PIRO, Z. (1995); information about new pools appears in SKÁCELOVÁ (2009).

Samples used for this study:

HY 776, HY 785, HY 791 Pastvisko, shallow lagoon 1997-06-19 periphyton and metaphyton in *Utricularia australis* and *Lemna trisulca.*

HY 819 1999-09-14 fishpond part, inlets of dark green epipelon on mud.

HY 823 ibid, the shallowest places, enriched with goose droppings (*Anser anser*).

HY 1892 Pastvisko, lagoon 2002-10-18 net plankton.

HY 1893 ibid, littoral (*Sparganium erectum*) pH 7.9; conductivity 300 µS/cm (in 2002, the water level in Pastvisko was high and differences in water chemistry between pond and lagoon were negligible).

HY 1896 Pastvisko, 2003-08-04 drying part of pond (the lagoon dried out completely in summer 2003), islands of brown-greenish epipelon at the margins of pools, mass occurrence of *Euglena* sp. (pH 9.4; conductivity 1880 µS/cm).

HY 1858 Pastvisko, Nová okrouhlá tůň Pool 19.7.2002. (Chemical analyses from the Nová okrouhlá tůň Pool were performed on 2002-02-28: Ca^{2+} 70.1 mg/l; Mg^{2+} 23.1 mg/l ; Cl^- 44.0 mg/l; SO_4^{2-} 91.0 mg/l.)

HY 1898, Pastvisko, Nová okrouhlá tůň Pool 2003-08-04 dense, dusty structures near the coastline (pH 8.4; conductivity 520 µS/cm).
HY 1899 ibid, grey-greenish epipelic clumps.

Bažina u Azontu ("Marsh near Azont")

Coordinates. N 48°49′27″ E 16°46′44″

Description and remarks. A sedge march bordering on the Azont oxbow in Nejdecké louky Meadows near Lednice, isolated from the channel system in dry seasons. Massive occurrence of natant (*Wolffia arrhizza*) and submerged (*Lemna trisulca, Utricularia australis*) vegetation (ŘIČÁNEK *et al.* 1995, Heteša *et al.* 2004).

Samples used for this study:
HY 1049 wetland near Azont 1999-10-19 metaphyton and periphyton in *Lemna trisulca* filling water column, water surface covered with diffluent duckweeds (*Wolffia arrhizza*). (Chemical analyses were not performed in 1999; HETEŠA *et al.* (1997) refers to average concentrations for 1994–96: pH 7.78; conductivity 478 µS/cm;Ca^{2+} 57.1 mg/l; Mg^{2+} 17.3 mg/l ; Cl^{-} 46.4 mg/l; SO_4^{2-} 158.5 mg/l.)

Lednické rybníky fishponds

Coordinates. Mlýnský rybník Pond N 48°46′52″ E 16°49′12″, Prostřední rybník Pond N 48°46′42″ E 16°47′41″.

Description and remarks. National nature reserve with a long tradition of hydrobiological and algological research. Slightly saline character. Water quality heavily influenced by intensive fish-stocking management during the second half of the 20th century (hypertrophic). Better conditions and increased biodiversity were repeatedly observed in seasons with low water levels and less intensive fish-stocking (mainly in Mlýnský rybník Pond). More details in SKÁCELOVÁ (2003) and SUKOP & KOPP (2001).

Samples used for this study:
HY 976 Mlýnský rybník Pond 2000-04-27, right bank near Apollo, crust on old reed stalks. (Data from Mlýnský rybník Pond 2001-04-30: pH 8.80; conductivity 1183 µS/cm, water temperature 19.1 C, water transparency 140 cm.)
HY 1978 Prostřední rybník Pond 2001-06-15, fuzzy periphyton on submerged stones and wood. [Values of chemical analyses performed 2001-06-14: conductivity 1268 µS/cm, pH 7.84, water temperature 19.6°C, water transparency to the bottom at a depth of 150 cm (SUKOP & KOPP 2001).]
HY 2086 Mlýnský rybník Pond 2010-09-09 (pH 8.95, conductivity 1.450 µS/cm, water temperature 23.6°C, water transparency 35 cm, green-yellow-brownish water colour, sample of green dust at sand surface sucked off by pipette.)

Františkův rybník Pond

Coordinates. N 48°43′05″ E 16°51′56″ (at fishpond retaining wall), N 48°43′07″; E 16°51′34″(nearby wetland).

Description and remarks. Nature reserve (halophyte vegetation), from 1995 in private ownership associated with conflict centring around use (eutrophication) and nature protection. Wetland in upper part of nature reserve has became a refuge for organisms retreating from the highly eutrophic fishpond. Both localities have been monitored since 2005, earlier samplings irregular.

HY 1443 Františkův rybník Pond – pond, 1994-09-22 low water level, water body filled with submerged vegetation (*Ceratophylum submersum, Utricularia australis*), no stocking of fish.

HY 2087 Františkův rybník Pond – wetland 2009-09-09 periphyton and metaphyton (in submerged vegetation – *Utricularia vulgaris*). Chemical analyses from Františkův rybník Pond – wetland 1909-05-19: pH 7.17; conductivity 640 µS/cm; Ca^{2+} 80.2 mg/l; Mg^{2+} 33.0 mg/l ; Cl 31.0 mg/l; PO_4^{3-} 5.0 mg/l.

Hustopeče Zadní rybník Pond

Coordinates. N 48°57′55″ E 16°44′06″

Description and remarks. Situated on the Štínkovka river, coastal vegetation *Schoenoplectus tabernaemontani* and *Carex secalina* indicate saline conditions.

Samples used for this study:

HY 2088 Zadní rybník Pond 2090-07-31 net plankton.

HY 2089 ibid, phytobenthos pH 8.48, conductivity 2890 µS/cm [For details of microflora, see Skácelová & Bešta (2010).]

Fishpond on Ponávka river near Jehnice and Mokrá hora, Brno

Coordinates. N 49°15′58″; E 16°35′01″

Description and remarks. Fishpond near Vránův mlýn Mill, the lowest of a cascade of three ponds.

Samples used for this study:

HY 2092 2008-09-14 fishpond on Ponávka river, mass occurrence of green-greyish, macroscopically visible colonies forming undulating sheets, on sandy bottom along banks.

NPP Plané Loučky, Esíčko Pool

Coordinates. N 49°37′18″ E 17°13′51″

Description and remarks. An oxbow in the southern part of the Litovelské Pomoraví Protected Landscape Area north of Olomouc, with abundant charophytes. For more details on algal flora of pools in Plané Loučky, see Skácelová (2000).

Samples used for this study:

HY 477 1997-07-08 Esíčko Pool (Plané Loučky) metaphyton and periphyton.

Sampling methods

Samples of phytoplankton, net plankton, periphyton, metaphyton and phytobenthos were collected from a wide spectrum of microhabitats. Samples of phytoplankton were collected into 0.5–1-litre bottles and concentrated (manual centrifuging of living material or sedimentation of samples preserved with Lugol solution). Net plankton samples (mesh size 80 and 40 µm) were taken both from open water and the littoral. Samples of periphyton and phytobenthos were taken by scraping of crusts and stripping of algal mats. Macroscopic bunches of algae were collected separately. Surface layers of bottom sediments were sucked off by pipette or peeled off, while metaphyton was sampled by washing submerged plants. Sampling was carried out from early spring to late autumn (in one case in January as well) so that rough data on the seasonal dynamics of species composition were obtained. More than thousand samples were collected from localities numbering in the high double figures.

Our attention was focused mainly on the lower part of the River Dyje alluvium (the area between the Nové Mlýny reservoirs and Lednice), with an overlap to the confluence of the Rivers Dyje and Morava. Other data were derived from occasional samplings at various South Moravian localities and in the National Nature Reserve Lednice ponds. Comparative data on the occurrence of selected cyanobacterial morphospecies described from other regions of the Czech Republic or Slovakia are added and discussed.

Systematic archiving of preserved samples

The samples are deposited in the Moravian Museum, subcollection No. 24 "Hydrobiological" and labelled with alphanumerical identification codes in BRNM HY#### format. The importance of this collection lies in its being a knowledge base of species composition and dynamics at the level of whole communities (not only cyanobacteria, but also bacteria, algae, zooplankton, etc.). Further, the collection provides comparative material between original field samples and samples of cultured mono-algal strains, something essential to any taxonomic studies.

Remarks on the morphology and ecology of selected cyanobacterial morphospecies

Rhabdogloea smithii (R. et E. Chodat) Komárek (Figs 1–3)

Synonyms. *Dactylococcopsis Smithii* R. et Chodat, 1925, *Dactylococcopsis rhaphioides* Hansgirg sensu G. M. Smith Hansgirg *sensu* G. M. Smith, 1920.

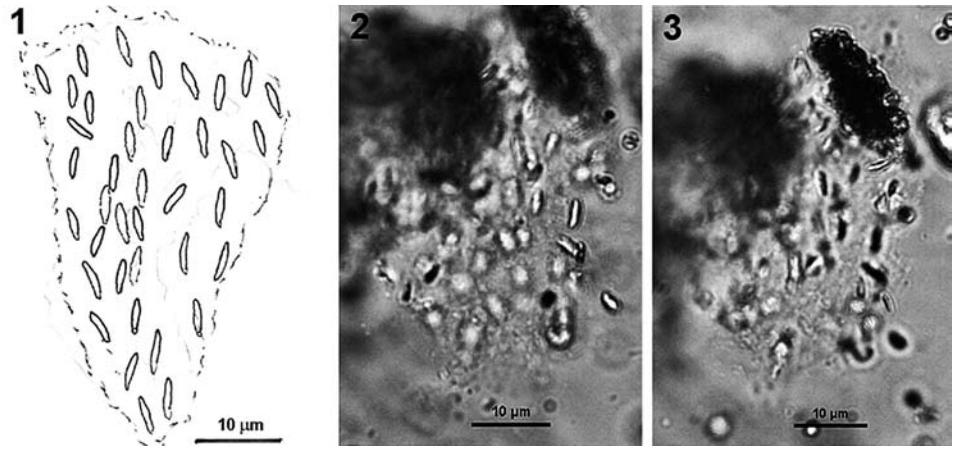
Description. Cells spindle-shaped, slightly curved, pale blue-green, 8.2–9.0 µm long × 4–4.5 µm wide, cells loosely arranged in colourless diffluent slime; the size of a colony consisting of more than thirty cells was 30 × 64 µm.

Occurrence at the localities studied: Františkův rybník Pond in 1994 (a year without fish-stocking) among *Ceratophyllum submersum* (HY 1443).

Previous records from South Moravia: Kyjov, Vlkoš periodical pools on sandy substrate near a small fishpond near Vlkoš, accompanied by other algae typical of peaty waters (Prát 1920/21).

Other records from the Czech Republic: Ponds around Studenec near Třebíč (Nováček 1941, Reichardt 1937); River Jihlava (Nováček 1936).

Discussion. Both Starmach (1966) and Komárek & Anagnostidis (1999) characterized this species as freshwater, planktonic, occurring mainly in large, cold, clear (oligotrophic



Figs 1–3. *Rhabdogloea smithii* from Františův rybník Pond (HY 1443). Scale bar 10 mm.

to mesotrophic) lakes. According to KOMÁREK & ANAGNOSTIDIS (1999) it can also occur rarely in small, clear bodies of water. Our only finding, from the Františkův rybník Pond in 1994, corresponds with the last-mentioned observation: the year 1994 was an extraordinary season for this pond, without fish stock, with low water level and a very high abundance of submerged plants *(Ceratophylum submersum* and *Utricularia vulgaris).* In other seasons, when fish stocks were high, *R. smithii* was not found.

Merismopedia convoluta **Brébisson in Kützing, 1849** (Figs 4–10)

Synonyms. *Pseudoholopedia convoluta* (Brébisson) Elenkin, 1938 pro typo (*non-sensu* Elenkin)

Remarks. The species *Merismopedia willei* Gardner, 1927, described from Puerto Rico probably belongs, according to GEITLER (1932), to the species *M. convoluta*.

According to GEITLER (1932, p. 262), cells of some *Merismopedia* species may be elongated in the direction orthogonal to the plane of the colony: this is the case for the subgenus *Pseudoholopedia,* in particular here the species *Merismopedia (Pseudoholopedia) gigas* Ryppova, 1925. The main feature of *M. convoluta* species, according to Geitler (GEITLER 1932), is not the size of colonies and whether or not they undulate, but cell shapes and dimensions. Geitler did not recommend, therefore, that all large and wavy colonies be allocated to the species *M. convoluta* before cell size and shape have been studied (GEITLER 1932, p. 262). According to Geitler (1932), *M. convoluta* f. *minor* Wille 1922 is a form of the species *M. punctata*.

Geitler (Geitler 1932) separated the genus *Microcrocis* (described under *Holopedia* Lagerheim) from the genus *Merismopedia*. In *Microcrocis,* the cells are arranged in flat colonies more or less irregularly, their shape ellipsoid to cylindrical with rounded ends, oriented upright to the plane of the colony.

Starmach (Starmach 1966) considered *Pseudoholopedia convoluta* (Brébisson) Elenkin and *Merismopedia gigas* Ryppowa as the same species, mentioning only three species of the genus *Microcrocis* with *M. gigas* not included.

According to current taxonomy, *Microcrocis* and *Merismopedia* are two different genera, in agreement with Geitler's morphological description (Komárek & Anagnostidis, 1999). However, molecular analyses (especially 16S rRNA gene sequencing) have not yet been performed in any representatives of the genus *Microcrocis* to clarify its phylogenetic affiliations and taxonomical status.

Description. Cells spherical, after division subspherical, 3.7–4.5 × 4.2–5.1 µm in diameter, colonies flat, large, macroscopically visible as green dust or undulating sheets, with cells arranged into quadrate subcolonies, wavy or rolled up, with a distinct colourless slime. Old colonies found along the banks of a pond near Jehnice, Brno were of an extraordinary size, 3.3 cm, rolled up, composed of quadrate subcolonies, with cell diameters of 4.7–6.7 mm. Colonies found in Pastvisko and Kutnar had dimensions of 0.8–3 × 1.7–4.9 mm. According to Komárek & Anagnostidis (1999), cell dimensions vary from 4–5.2 mm and size of colonies may attain several millimetres.

Occurrence at the localities studied: Pastvisko – green dust or scum on mud surface in very shallow water, from summer to autumn, regularly since 1999 to date, except for 2002 (manipulated increase in water level); found for the first time in a lagoon in 2002. Pastvisko, September 1999 – a part with fishpond character, as patchy mats on mud surface (HY 819); Pastvisko, September 1999 – small hills in shallow parts of pond with water-bird faeces (HY 823); Pastvisko – lagoon 2002 (HY 1892, 1893); Pastvisko, August 2003 – drying part of pond, brown and green patches at the peripheries, dominance of *Euglena* spp., conductivity 1880 µS/cm, pH 9.4 (HY 1896).

Mlýnský rybník Pond, September 2010, pH 8.95, conductivity 1450 µS/cm, green dust on sand surface (HY 2086).

Františkův rybník Pond, September 1994 (a year without fish-stocking), visible biomass near the coastline together with dying biomass of *Anabaena* spp. (HY 1443).

Kutnar, July 2008, on *Batrachium* (HY 2091).

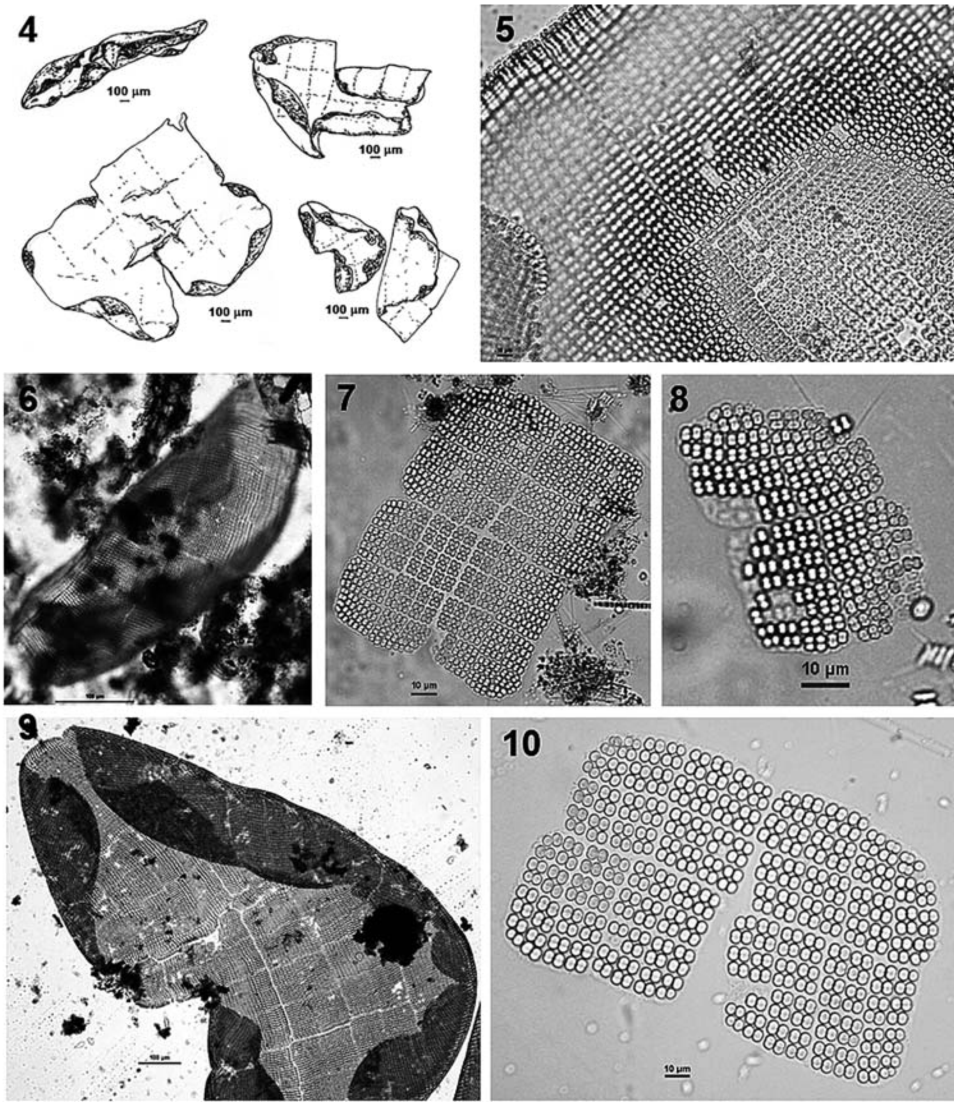
Fishpond near Jehnice, September 2008, visible biomass near the coastline (HY 2092)

Previous records from South Moravia: Lednice, drainage channel behind a vegetable garden (Fischer 1920); Mlýnský rybník Pond, under the outflow (Zapletálek 1932).

Other records from the Czech Republic: Near Prague (Prát 1921), oxbows and marshes in Šumava Mts., oxbows around the brook in Mokrá, peaty oxbow near Lower River Vltava, near Vyšší Brod and Frymburk (Pascher 1906, 1914).

Recent records outside the Czech Republic: Austria, muddy sediment of Grosser Beitsee, an old river branch in Marchauen, near Drösing (Bergauer 1995).

Discussion. Pascher's research was accompanied by neither correct descriptions nor drawings. Habitat characteristics (low pH values) indicate that the presence of *M. convoluta* is unsure; *Merismopedia elegans* is more likely. Geitler (1932, p. 262) recorded the possibility of confusion with *M. punctata*, large colonies of which have been wrongly identified as *Merismopedia convoluta* f. *minor* Wille (see Synonyms).



Figs 4–10. *Merismopedia convoluta.* 4 – general morphology of colonies from Jehnice (HY 2092). Figs 5 and 9 – details of colonies *M. convoluta* from Jehnice (HY 2092). Figs 6–8, 10 – *M. convoluta* from Mlýnský rybník Pond (HY 2086). Scale bars 100 µm (Figs 4, 6, 9), 10 µm (Figs 5, 7, 8, 10)

This cosmopolitan species is known mainly from tropical regions, in Europe from only a few localities (KOMÁREK & ANAGNOSTIDIS 1999). According to Komárek (pers. comm.) it occurs in naturally eutrophic waters unpolluted by allochthonous sources. In literature (STARMACH 1966, KOMÁREK & ANAGNOSTIDIS 1999), *M. convoluta* is characterized as part of metaphyton of stagnant and flowing waters usually rich in submerged macrophytes. Our records came mainly from shallow waters without macrovegetation, both on muddy and sandy bottoms, with fewer records from metaphyton. In all cases, the occurrence of *M. convoluta* was observed for a period, usually around the end of summer, in warm, shallow water. This timing for *M. convoluta* recalls its occurrence in tropical and subtropical regions. In habitats without macrophytes, colonies were large (mainly in the case of a pond near Jehnice); in metaphyton, colony size of colonies was lower. Massive occurrence of this species corresponded with low fish-stocking (Mlýnský rybník Pond after a change of management approach to lower stocks of fish, Pastvisko after reduction of carp stocks, extensive *rybník* near Jehnice). Our finding of *M. convoluta* in Mlýnský rybník Pond (Lednické rybníky National Nature Reserve) near the dam confirmed data from outflow of the Mlýnský rybník Pond 75 years previously (ZAPLETÁLEK 1932) and illustrates the possibility that rare species may return after reduction of fish stocks.

***Merismopedia* sp.** (Figs 11–16)

Description. Cells spherical or subspherical after division, 1.2–2.3 µm in diameter, arranged in irregular rows, at distances equal to or twice cell diameters, pale blue-green to nearly colourless. Colonies flat, slightly curved to waved, with a visible, colourless slime, consisting of 24 to over 300 cells.

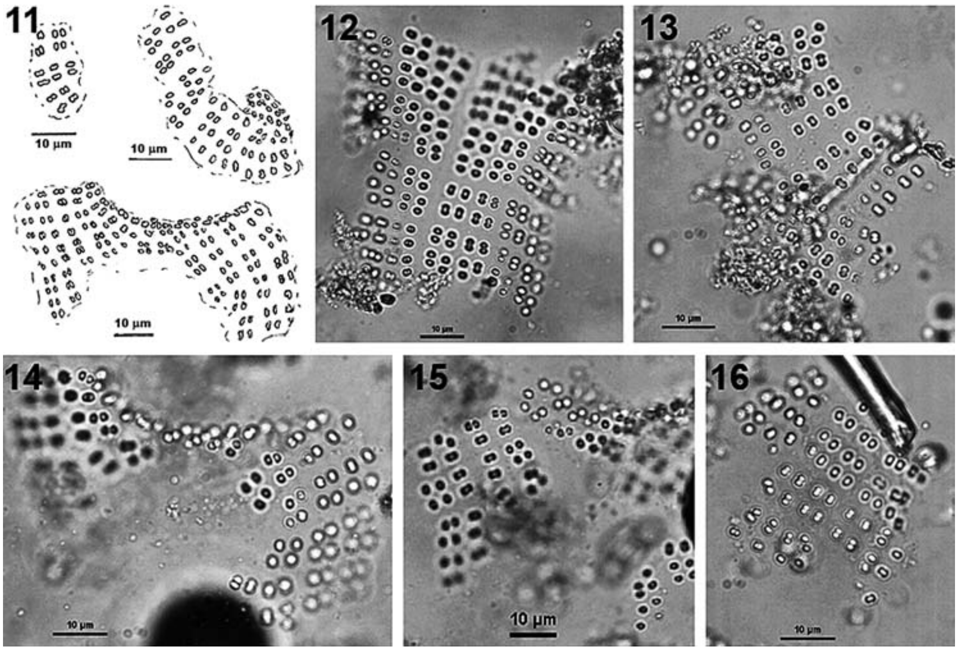
Occurrence at the localities studied: Pastvisko, Nová okrouhlá tůň Pool, August 2003, conductivity 520 µS/cm, pH=8.4, in grey and green epipelic clumps and dusty structures near the coastline (HY 1898, HY 1899).

Discussion. Our material is not similar to any *Merismopedia* species summarized by KOMÁREK & ANAGNOSTIDIS (1999). Cell size and sparsely distributed cells (with large spaces between them) resemble *M. danubiana* but colonies of our species consist of more cells (up to several hundred), while *M. danubiana* has 32 cells at the maximum. Our *Merismopedia* morphotype was found at only one locality (Pastvisko, Nová okrouhlá tůň Pool). It was a young, successive biotope in the second year of existence.

***Spirulina major* Kützing ex Gomont, 1892** (Figs 17–20)

Synonyms. [*Spirulina oscillarioides* Turpin, 1827, pre-starting-point syn.]; *Spirulina major* f. *constans* Emoto et Hirose, 1952; *Oscillatoria oscillarioides* [Turpin] Iltis, 1970, 1972; *Arthrospira major* (Kützing) Chang et Tseng, 1990

Description. width of trichome 1.2–1.9 µm, coils 2.5–3.0 µm wide, distance between spirals 1.7–2.4 µm.



Figs 11–16. *Merismopedia* sp. from Pastvisko, Nová okrouhlá tůň Pool (HY 1898, HY 1899). Scale bar 10 mm.

Occurrence at the localities studied: Zadní rybník Pond at Stínkovka north of Hustopeče (HY 2088, 2089, 2090); Lednické rybníky fishponds – Prostřední rybník Pond (HY 1978).

Previous records from South Moravia: Milotice (PRÁT 1916, 1920/21a); Lednice (FISCHER 1920, ZAPLETÁLEK 1932); Oslava river in Třebíč (DVOŘÁK 1920/21b).

Other records from the Czech Republic: Studenec (DVOŘÁK 1920/21a, NOVÁČEK 1941); Lhotka near Telč (DVOŘÁK 1920/21a), West Moravia (DVOŘÁK 1932); Moravia (FISCHER 1927/28).

Recent records outside the Czech Republic: The species is considered of worldwide distribution, possibly cosmopolitan (KOMÁREK & ANAGNOSTIDIS 2005).

Discussion. All of the localities in which *S. major* was observed were stagnant waters, of relatively high conductivities. This is in a good agreement with the general characteristics of this species recorded in monographs (GEITLER 1932, STARMACH 1966, HINDÁK 1978, KOMÁREK & ANAGNOSTIDIS 2005). The trichome coil distances of *S. major* populations from South Moravia (1.7–2.4 µm) were slightly lower than the description of the taxon given by Komárek and Anagnostidis (KOMÁREK & ANAGNOSTIDIS 2005), i.e. (2–2.4) 2.7–3.4–5 µm.

Spirulina meneghiniana Zanardini ex Gomont, 1892 (Figs 21–25)

Synonyms. *Spirulina meneghiniana* f. *fontinalis* Schwabe, 1944; *Spirulina meneghiniana* f. *crassa* Bharadwaja, 1963; *Spirulina meneghiniana* f. *minor* Hortobágyi, 1963 incl.; *Spirulina oscillarioides* Turpin sensu Hansgirg, 1892 (?).

Description. width of trichome 1.2–2.0 µm, coils 2.3–3.7 (4.1) µm wide, distance between spirals 3.2–5.1 µm.

Occurrence at the localities studied: Kutnar (HY 1518, HY 1782, HY 1783, HY 1939); Pastvisko – Nová okrouhlá tůň (HY 1858); Lednice rybníky fishponds – Prostřední rybník Pond (HY 1978).

Previous records from South Moravia: Brno (NAVE 1863).

Other records from the Czech Republic: River Odra [Oder] (DVOŘÁK 1922, WILLERT 1922/23); Náměšť nad Oslavou (DVOŘÁK 1920/21b); Heraltice near Třebíč (DVOŘÁK 1912); Pozďatín (DVOŘÁK 1920/1921a, b); Western Moravia (DVOŘÁK 1932, 1934).

Recent records outside the Czech Republic: France, Germany, Greece, Hungary (?), Italy, Russia, Spain, Ukraine; beyond Europe: Africa, Chile, Cuba, India, Indonesia, South Africa, USA (KOMÁREK & ANAGNOSTIDIS 2005).

Discussion. Most of the South Moravian localities in which representatives of *S. meneghiniana* occurred were of high conductivity, but not sufficiently so to be classified as saline (e.g. Kutnar 1200–1700 µS/cm). This species is recorded as colonizing marine biotopes, salty swamps and ponds, sometimes thermal springs as well. Freshwater records have been considered questionable and in need of revision (KOMÁREK & ANAGNOSTIDIS 2005). Our records from South Moravia confirm a wider tolerance for *S. meneghiniana* in terms of conductivity values. The species is regarded as cosmopolitan (GEITLER 1932).

Spirulina nordstedtii Gomont, 1892 (Figs 26–27)

Synonyms. none.

Description. width of trichome 1.6–2.5 mm, coils 3.6–3.9 mm wide, distance between spirals 3.0–5.8 mm.

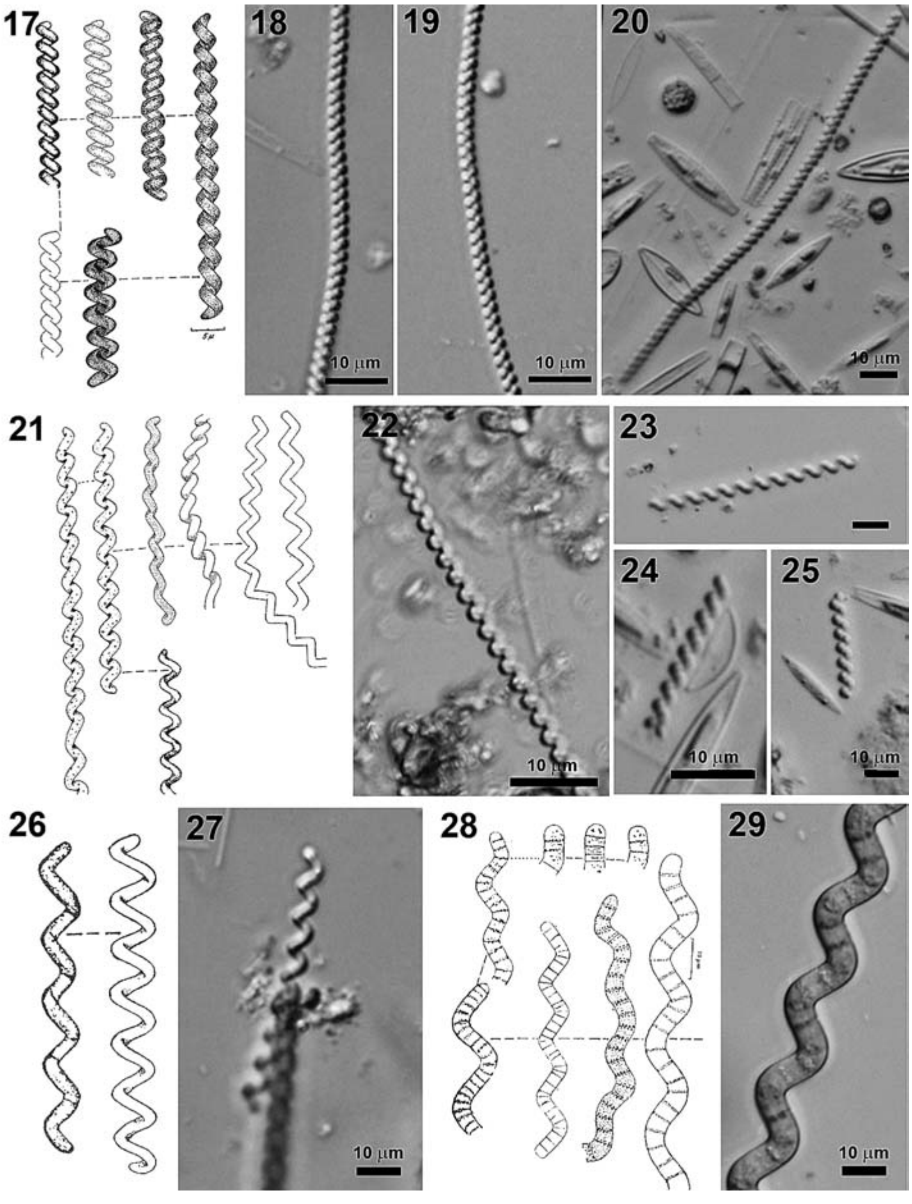
Occurrence at the localities studied: Kutnar (HY 1775); Lednické rybníky fishponds – Mlýnský rybník Pond (HY 976).

Previous records from South Moravia: Moravia (FISCHER 1927/28).

Other records from the Czech Republic: Soos (KOMÁREK & ANAGNOSTIDIS 2005).

Recent records outside the Czech Republic: France, Sweden; outside Europe: North America, Africa (Madagascar).(KOMÁREK & ANAGNOSTIDIS 2005).

Discussion. Water conductivities at the South Moravian localities where representatives of *S. nordstedtii* occurred were relatively high (Kutnar 1770 µS/cm, Lednice rybníky fishponds – Mlýnský rybník Pond 1180 µS/cm). This corresponds well to the known preferences of this species for salty and brackish coastal and inland waters (KOMÁREK & ANAGNOSTIDIS 2005). Trichome coil diameters of *S. nordstedtii* populations from South Moravia (3.6–3.9 µm) were slightly narrower than those given by Komárek and Anagnostidis (KOMÁREK & ANAGNOSTIDIS 2005) for this taxon (4.5–5.0 mm).



Figs 17–29. *Spirulina major*: 17 – after Geitler, de Mazancourt, Komárek, Anagnostidis, Golubić, Palik in Komárek & Anagnostidis (2005). Figs 18–19 – from Zadní rybník Pond near Hustopeče (HY 2090). 20 – from Prostřední rybník Pond (HY 1978). Figs 21–25. *S. meneghiniana*: 21 – after Anagnostidis, Hortobágyi, Gomont from Kondrateva, Komárek in Komárek & Anagnostidis (2005). 22 – from Kutnar (HY 1939). 23 – from Nová okrouhlá tůň pool (HY 1858). Figs 24–25 – from Prostřední rybník Pond (HY 1978). Figs 26–27. *S. nordstedtii*: 26 – after Frémy (in Komárek & Anagnostidis 2005), and Prescott (in Komárek & Anagnostidis 2005). 27 – from Kutnar (HY 1775). Figs 28–29. *Arthrospira jenneri*: 28 – after Gomont, Komárek, Smith in Komárek & Anagnostidis (2005). 29 – from Františkův rybník Pond – wetland (HY 2087). Scale bar 10 µm.

Arthrospira jenneri Stizenberger ex Gomont, 1892 (Figs 28–29)

Synonyms. *Spirulina jenneri* (Stizenberger) Geitler, 1925; *Oscillatoria jenneri* (Gomont) Compère, 1974.

Description. width of trichome 6.4–6.7 µm, coils 12.7–14.3 µm wide, distance between spirals 20.9–21.6 µm.

Occurrence at the localities studied: Františkův rybník Pond – wetland (HY 2087, September 2009).

Previous records from South Moravia: Lednice (Fischer 1920, Zapletálek 1932); Charvatská Nová Ves (Zapletálek 1932); Moravský Písek (Prát 1920/1921b); Rivers Jihlávka and Oslava (Dvořák 1920/1921b); Zborovice (Dvořák 1917).

Other records from the Czech Republic: Studenec (Nováček 1941); West Moravia (Dvořák 1932); Třebíč (Dvořák 1912, Dvořák 1920/1921b); Pozďatín (Dvořák 1920/1921a).

Recent records outside the Czech Republic: River Danube (Szemes 1967).

Discussion. This species was found in the littoral of Františkův rybník Pond, among reed stalks, which corresponds exactly to the environmental preferences of this species given by Komárek and Anagnostidis (Komárek & Anagnostidis 2005): freshwater, periphytic, epiphytic or benthic; widely distributed in temperate and tropical regions. After Geitler (1932), the species is regarded as cosmopolitan.

Anabaena Bory ex Bornet et Flahault, 1888 – nonplanktonic representatives (Figs 30–41)

Remarks. One of our original intentions was to revise the distribution of the most often-reported non-planktonic *Anabaena* species, i.e. *A. oscillarioides* Bory ex Bornet et Flahault 1888*,* in South Moravia.

Previous records of this species from South Moravia are: Brno, Židlochovice, Radešín (Fischer 1920); Lednice (Fischer 1920, Zapletálek 1932); Vlkoš, Lovčice (Prát 1920/21 b); Oslava river (Dvořák 1920/21 a, b); Kutnar reserve (Skácelová & Komárek 1989); sedge marsh and drainage ditch bordering the Azont oxbow (Řičánek *et al.* 1995, Skácelová 2004); Pastvisko near Lednice (Skácelová & Piro 1995, Skácelová 2004); lower catchment area of River Dyje (Heteša *et al.* 1997); Květné jezero oxbow, Křivé jezero oxbow, Ostřicová tůň oxbow, Dlouhé jezero oxbow, Čapkovo jezero oxbow near Podivín, drainage ditch in sandy substrate of former oxbow near Podivín, Zemník Hruštičky near Podivín, Lednické rybníky Ponds – Mlýnský and Prostřední rybník (Skácelová 2004); Božice wetland near Znojmo (Skácelová 2004, Skácelová & Galetová 2005).

Findings of *Anabaena oscillarioides* from other regions of the Czech Republic were recorded from Studenec (Dvořák 1920/21 a); Kojetice (Dvořák 1920/21 b); Třebíč (Dvořák 1912, 1917, 1920/21 a, b); Telč (Dvořák 1924); and Řežabinec rybník Pond (Komárek 1975).

We analyzed 74 samples containing non-planktonic *Anabaena* populations. Species affiliations were possible to determine in only the 32 populations forming the akinetes that are essencial to taxonomic conclusions. The akinete pattern typical for *A. oscillarioides,* i.e. akinetes from one or both sides adjacent to heterocytes, was observed

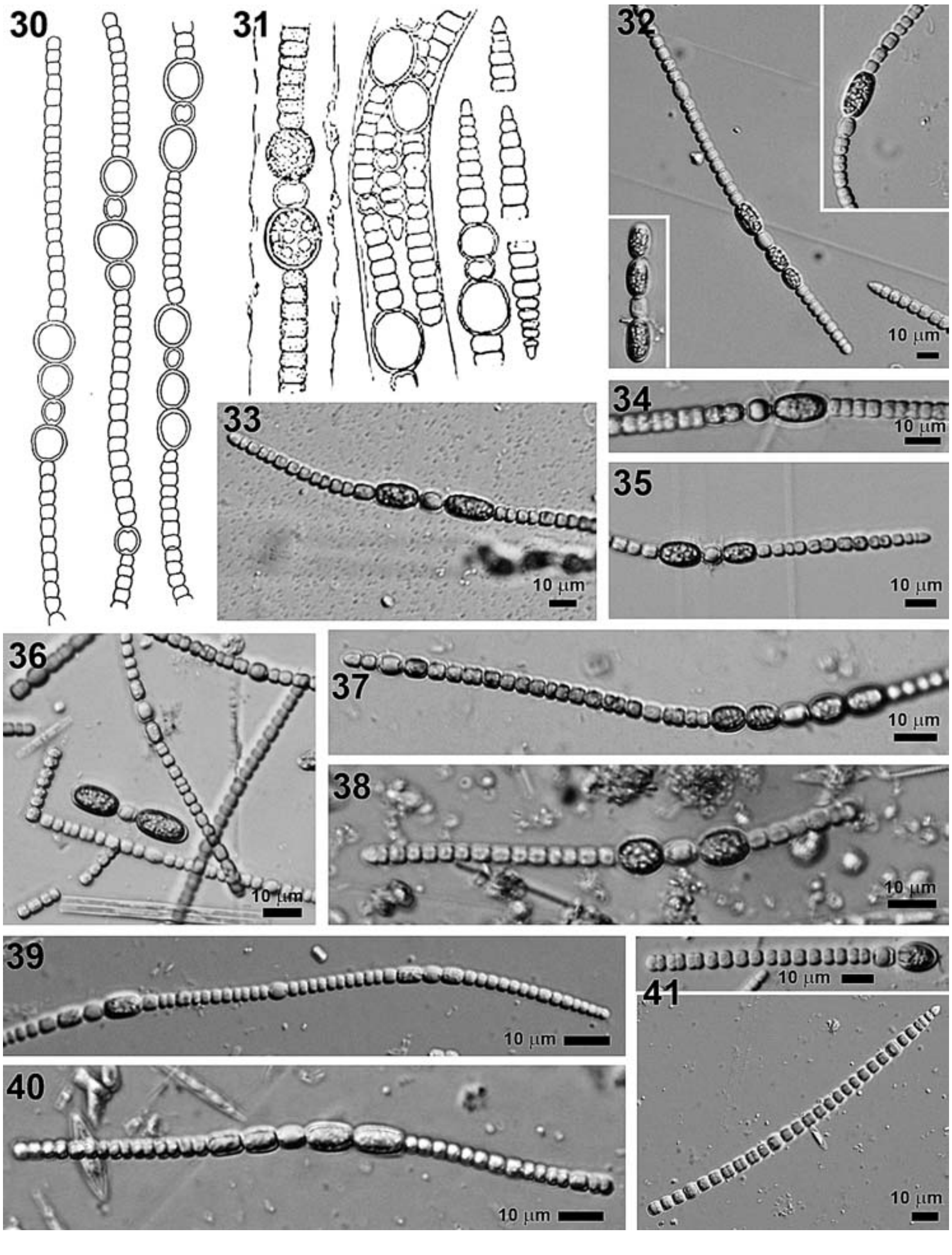
SAMPLE	VEGETATIVE CELLS		HETEROCYTES		AKINETES		TERMINAL CELLS
Code	Length [μm]	Width [μm]	Length [μm]	Width [μm]	Length [μm]	Width [μm]	
HY477	3.4–4.6	4.6–5.6	6.6	7.4	12.5	8.9	conical
HY776	2.7–4.4	3.8–5.6	5.0–8.0	4.7–5.9	13.0–15.4	6.5–8.5	slightly conical
HY785	2.2–5.2	3.4–4.9	6.3–6.8	4.3–5.8	8.5–13.8		conical
HY791	2.4–4.7	3.9–5.2	5.2–7.0	5.0–5.9	9.2–12.7	6.3–7.8	conical
HY976	1.6–3.8	2.7–4.2	4.3–5.7	4.1–5.0	10.0–12.8	5.2–6.8	rounded, slightly narrowed
HY1049	3.2–5.8	4.5–5.8	6.4–8.8	5.5–7.0	13.8–15.9	8.4–10.0	conical
HY1508	2.4–4.7	4.1–5.5	4.8–7.2	4.5–6.4	14.9	8.2	conical
HY1775	2.2–3.0	3.9–4.5	6.4	5.5	9.6–11.0	6.3–6.4	rounded, slightly narrowed
HY1938	2.3–5.2	3.4–4.4	5.1–7.0	5.0–5.8	8.3–10.8	6.1–7.9	conical
HY1939	2.7–4.9	3.4–4.6	6.1–7.5	4.8–5.9	7.6–11.7	6.2–7.9	conical
A. solicola	5.5–6.0 (7.0)		6.0–9.0		11–21 (28)	11–16 (18)	conical
A. sphaerica	5.0–6.0		6.0–7.0		12.0–18.0	12.0	rounded

Table 1. Morphometric parameters of selected non-planktonic *Anabaena* populations from South Moravia and a comparison with characteristics of the species *A. solicola* Kondrateva, 1959 and *A. sphaerica* Bornet et Flahault, 1888 (in bold; Komárek & Anagnostidis *in prep.*). Sampling localities: Bažina u Azontu Marsh (HY 1049); Pastvisko, desiccating part of the lagoon (HY 776); Kutnar (HY 1508); Pastvisko, desiccating part of the lagoon (HY 785, HY 791); Kutnar (HY 1938, HY 1939); Mlýnský rybník Pond (HY 976); Kutnar (HY 1775); Plané Loučky Nature Reserve, Esíčko oxbow (HY 477).

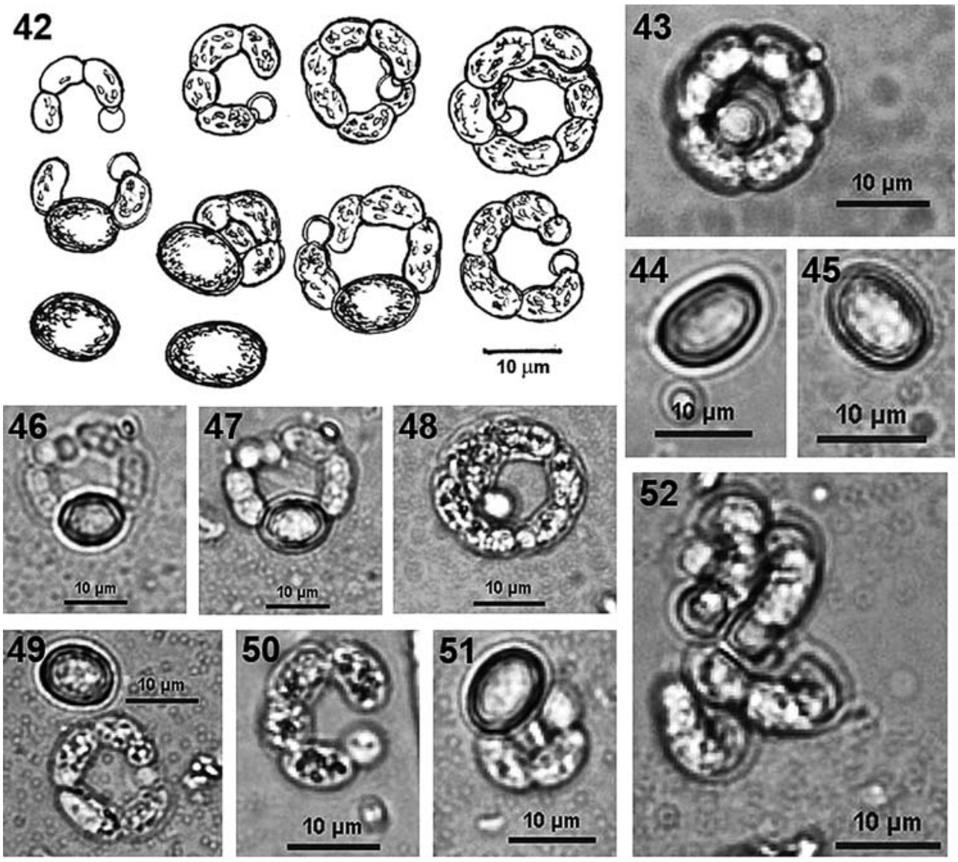
in 21 of these populations. Nevertheless, none of them could be classified as *A. oscillarioides* (one of the main identification features of this species is akinetes longer than 20 mm). We identified eight different species with akinetes adjacent to heterocytes: *A. catenula* (Kützing) Bornet et Flahault 1888, *A. cylindrica* Lemmermann 1896, *A. orthogona* W. West 1891, *A. pirinica* Petkoff 1925, *A. solicola* Kondrateva 1959, *A. sphaerica* Bornet et Flahault 1888, and *A. torulosa* (Carmichael) Lagerheim ex Bornet et Flahault 1888; the eighth morphotype could not be allocated to any of the species described and had probably remained hitherto unknown to science.

Based on these observations we concluded that most records of *A. oscillarioides* from South Moravia are probably misidentifications and should be revised if possible.

Ten out of the total of 21 populations with akinetes next to heterocytes potentially represented two species highly similar from a morphological point of view, i.e. *A. solicola* and *A. sphaerica*. Vegetative cell and akinete dimensions of our populations matched descriptions of these two species relatively closely, but the akinete shapes (length-to-width ratios) were markedly different in all cases. Moreover, *A. solicola* is known only from cultures and was isolated from saline soils in South Ukraine and Kazakhstan (Komárek & Anagnostidis in prep.). All of our populations were observed in water habitats, which indicates *A. sphaerica* far more strongly. The akinetes of this taxon are, nevertheless, almost spherical, and the terminal cells of its trichomes are rounded while the akinetes of all our populations were obviously elongated and the



Figs 30–41. Nonplanktonic *Anabaena* sp. 30 – *Anabaena sphaerica* after Kossinskaja in STARMACH (1966). 31 – *Anabaena solicola* after Kondrateva in STARMACH (1966). 32 – Bažina u Azontu Marsh (HY 1049). 33 – Pastvisko, desiccating part of the lagoon (HY 776). 34 – Kutnar (HY 1508). Figs 35–36 – Pastvisko, desiccating part of the lagoon (HY 785, HY 791, respectively). Figs 37–38 – Kutnar (HY 1938, HY 1939, respectively). 39 – Mlýnský rybník **P**ond (HY 976). 40 – Kutnar (HY 1775). 41– Plané Loučky Nature Reserve, Esíčko oxbow (HY 477). Scale bar 10 µm.



Figs 42–52. *Anabaenopsis nadsonii* from Zadní rybník Pond near Hustopeče (HY 2088, 2089, 2090). Scale bar 10 µm.

terminal cells conical. It is therefore questionable whether our populations really represented the two above-mentioned species or whether they should rather be classified as a specific taxon.

We decided to summarize morphometric characteristics and microphotographs of all these highly similar populations to open up discussion of their identification, since they appear to represent the most frequent non-planktonic *Anabaena* morphotype in South Moravia.

***Anabaenopsis nadsonii* Voronichin, 1929** (Figs 42–52)

Synonyms. none.

Description. Trichomes solitary, coiled, usually with only one (less frequently two) screw, cell number per trichome from 4 to maximum 8. Cells barrel-shaped, 3–4.2 µm wide and 5–10 µm long, with gas vesicles (only absent in a few trichomes without them), heterocytes spherical, 3 µm in diameter, situated at one end (terminal) of a trichome, akinetes widely oval 10.1–12.5 × 7.2–7.5 µm, with colourless, smooth epispore.

The shape of the akinetes is quite similar to *Anabaenopsis hungarica,* other parameters tally with the description of *A. nadsonii*. Komárek (2005) confirms that transitional forms occur between almost all species of the genus *Anabaenopsis* described. The presence or absence of gas vesicles is not a taxonomically important feature. An absence of gas vesicles was also observed in some trichomes of an *Anabaenopsis nadsonii* population in the Szelider See, Hungary (Hortobágyi 1959).

Occurrence at the localities studied: Hustopeče, Zadní rybník Pond, July 2009, pH 8.48, conductivity 2890 µS/cm (HY 2088, 2089, 2090) – coastal vegetation of *Schoenoplectus tabernaemontani* and *Carex secalina* indicated saline conditions.

Discussion. Numerous species of *Anabaenopsis* genus have been described from the plankton of localities with waters mineralised to a greater or lesser degree in warm regions (Komárek 2005). Our finding from the Zadní rybník Pond on the Štínkovka river is the first record of this species in the Czech Republic and it concords with the profile mentioned: this pond has a saline character (water conductivity is two times as high as in the Lednické fishponds, known as slightly saline biotopes) and this thermophilic species was found in high summer in a warm, shallow water. The microregion of Hustopečsko is situated in the Pannonian "corridor" region. Conditions in this biotope may be comparable to the Szelider See in Hungary in which *A. nadsonii* was reported (Hortobágyi 1959).

General discussion and conclusions

Our research revealed *Anabaenopsis nadsonii* as a species new for the Czech Republic. Further, the environmental preferences of the species studied have been revised and discussed in the light of data provided in the literature. *Spirulina meneghiniana* (Kutnar, Pastvisko – Nová okrouhlá tůň Pool, Lednice rybníky fishponds – Prostřední rybník Pond) has been found to display markedly wider conductivity tolerance than had been previously reported. The ecology of *Merismopedia convoluta* was described in detail and the morphology of colonies occurring in various microhabitats was characterized.

Investigation of non-planktonic representatives of the genus *Anabaena* confirmed that knowledge of the ecology and especially the morphological diversity of this cyanobacterial group is inadequate. Many species identified as the most frequent, *Anabaena oscillarioides,* in the past are probably misidentifications, since we found no true *A. oscillarioides* in any of the localities studied. Most of the *Anabaena* specimens from South Moravia with akinetes adjacent to heterocytes corresponded best with

Anabaena solicola and *Anabaena sphaerica.* Nevertheless, there were also serious discrepancies between these morphospecies and our *Anabaena* populations *(A. solicola* is a soil species, while our populations were found in water; *A. sphaerica* should have almost spherical akinetes and rounded terminal cells, while the akinetes of our populations were obviously longer than wide and their terminal cells were largely conical). Thus the above-mentioned populations of non-planktonic *Anabaena* appear rather to represent a species that has not been described to date. More extensive research is required to clarify the status of this morphospecies and its ecological preferences.

The research of selected cyanobacterial species also revealed much that is new about algal and cyanobacterial assemblages in various successional stages of alluvial wetlands. Most of the species studied have previously been overlooked and detailed study of the samples deposited in Moravian Museum may well result in information useful to the management of endangered wetlands aiming to conserve biodiversity.

Acknowledgements

The algological research into alluvial backwaters and pond littorals was supported by the Ministry of Culture of the Czech Republic, grant refs.. MKOCEZOOF2402 (1999–2004) and MK00009486201 (2005–2009). Detailed study of the genus *Anabaena* was backed by grant ref. GAČR P504/10/1501 "Taxonomic revision of the genera *Anabaena* and *Aphanizomenon* (cyanobacteria) based on complex phenotypic and molecular approach" (2010–2012). Collections of the Moravian Museum Brno (BRNM), Subcollection no. 24 "Hydrobiological" (BRNM HY) were used for the study of the morphology and ecology of cyanobacteria.

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