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A review of the alien and expansive species of freshwater cyanobacteria and algae in the Czech Republic

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Abstract The invasion and spread of non-native species of many different kinds of organisms is of increasing interest to researchers. Invasions by microscopic organisms, however, are poorly understood, and their impact on the environment is probably underestimated. We collected available data on non-native and invasive/expansive algae and cyanobacteria in the Czech Republic; we mapped their distribution

and assessed their impact on local species and other real or potential risks resulting from their spread. The list of alien species in the Czech Republic contains 10 species of cyanobacteria, 9 species of Bacillariophyceae, 1 species of Dinophyta, 1 species of Ulvophyceae, 2 species of Chlorophyceae, and 1 species complex of Zygnematophyceae. The literature on the worldwide occurrence of these taxa is also reviewed.

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Introduction

Like other kinds of organisms, algae are capable of causing extinction of native species, reduction in diversity, and irreversible changes of habitat when they invade new areas. Most of our knowledge about invasions by non-native algae concerns marine macroscopic algae (Boudouresque and Verlaque 2002; Piazzzi et al. 2007; Williams and Smith 2007). These macrophytes are similar to vascular plants in terms of thallus size and biogeography, and their spread is easier to study than that of microscopic algae. The thalli of macrophytes are transported to new areas of oceans and seas as a consequence of aquaculture (Smith et al. 2002; Tsiamis et al. 2008) or because they are frequently attached to ship hulls (Mineur et al. 2008) or are present in the ballast water (Flagella et al. 2007).

The number of invasive or non-native marine algal species varies considerably across information sources, ranging from 10 (IUCN—Global Invasive Species Database (as of 10th February 2009); www.issg.org/database/welcome) to 187 taxa in European seas alone mentioned in European Database of Invasive and Non-Native Species (DAISIE database (as of 10th February 2009)). Because the latter number is based on data that are not supported by literature citations, it is probably an overestimate.

Relative to the spread of macroscopic algae in marine environments, the spread of non-native, invasive species in freshwaters has been much less studied, in part because these freshwater species are largely microscopic. According to a number of sources, the most important freshwater invasive taxa are the cyanobacterium *Cylindrospermopsis raciborskii* and the diatom *Didymosphenia geminata* (more information on these species is provided in the “Results” and “Discussion”). Other invasions by freshwater algae involve *Cyclotella comensis* in Naroch Lake in Belarus (Mikheyeva and Genkal 2006), *Bangia* *atropurpurea* in Lake Michigan (Lin and Blum 1977), and *Hydrodictyon*

reticulatum in New Zealand (Hawes et al. 1991). The following species are also considered to be non-native: *Thalassiosira baltica* in the Great Lakes, USA (Edlund et al. 2000); *Thalassiosira lacustris* in the Ohio River tributaries (Smucker et al. 2008); *Chara connivens* in the Baltic Sea (Luther 1979); the tropical cyanobacteria *Planktolyngbya microspira*, *P. circumcreta*, and *Cyanodictyon tropicale*, and the desmid *Staurostrum excavatum* var. *planctonicum* in lakes in Aquitania, France (Cellamare et al. 2010); and *Anabaena bergii* and *Sphaerospermopsis (Aphanizomenon) aphanizomenoides* in Central Europe (e.g., Padisák and Kovács 1997; Stüken et al. 2006; Zapomělová et al. 2009). Other invasions reported in the DAISIE database are not supported by validly published results; these include *Actinocyclus normanii* in Russia, *Skeletonema subsalsum* in Russia and Ireland, *Thalassiosira incerta* in Russia, and undetermined species of *Spirulina* in Romania. Findings of the diatom *Asterionella formosa* in numerous lacustrine sediments of New Zealand starting with the European settlement (Harper 1994) also illustrate an invasive event.

The occurrence of non-native algae and cyanobacteria has seldom been studied in the Czech Republic. Although several minor taxonomic studies list the potential non-indigenous species, they do not describe their distribution within the country (Gardavský 1989; Marvan et al. 1997). A few isolated causal studies deal with individual species (Gágyorová and Marvan 2002; Kaštovský 2006; Kaštovský et al. 2006a, b; Znachor and Jezberová 2005). Species that are considered to be alien or potentially expansive in the Czech Republic are: *Anabaena bergii*, *Cuspidothrix (Aphanizomenon) issatschenkoi*, *Cylindrospermopsis raciborskii*, *Dolichospermum (Anabaena) compactum*, *Geitleribactron periphyticum*, *Gloeotrichia echinulata*, *Planktothrix rubescens*, *Raphidiopsis mediterranea*, *Sphaerospermopsis (Aphanizomenon) aphanizomenoides*, *Synechococcus capitatus* (Cyanobacteria); *Actinocyclus normanii*, *Cyclostephanos delicatus*, *Didymosphenia geminata*, *Discostella woltereckii*, *Fragilaria reicheltii*, *Frustulia weinholdii*, *Navicula schroeteri*, *Skeletonema potamos*, *Staurosirella berolinensis* (Bacillariophyceae), *Peridiniopsis kevei* (Dinophyta), *Ulva flexuosa* (Ulvophyceae); *Pediastrum simplex*, *Pleodorina indica* (Chlorophyceae), and the *Staurostrum manifoldii* complex (Zygnematophyceae).

The purpose of this review is to list the known non-native freshwater algal and cyanobacterial species in the Czech Republic, to record what is known about their distributions, and to evaluate their possible impact on indigenous species of the region.

Methods

The primary sources for the data in the current report are the collections of the phytoplankton, benthos, and periphyton from the entire area of the Czech Republic by many authors; non-published information on single species distributions obtained from the members of the Czech Phycological Society; and published results for the Czech Republic.

For visualization of species distribution on maps, the DMAP computer programme was used (Morton 2003).

Results

Cyanobacteria

Anabaena bergii Ostenfeld 1908

(= *Anabaena bergii* var. *minor* Kiselev, *Anabaena bergii* f. *minor* (Kiselev) Kosinskaja,

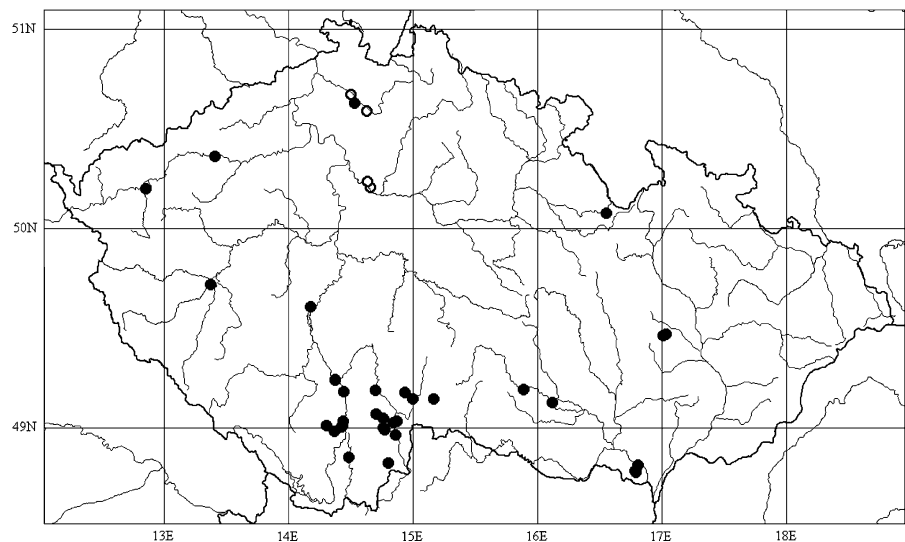
Not: *Anabaena bergii* var. *limnetica* Couté et Preisig = *A. minderi* Huber-Pestalozzi.)

Original distribution: *A. bergii* was described from the plankton of brackish waters of Lake Aral, where it can still be found (Orlova and Rusakova 1999). This species also lives in the Caspian Sea (Gogorev 2008; Hollerbach et al. 1953; Kondratyeva 1968).

Non-native distribution in the world: Outside of Russia, *A. bergii* was first observed in Turkey (Cirikaltindag et al. 1992), where it is presently found (Celekli et al. 2007). Turkey could be a part of the original distribution area. The species has also been reported from Slovakia (Hindák 1992, 2008), Australia (Fergusson and Saint 2003; Schembri et al. 2001), the USA (Yilmaz et al. 2008), Egypt (Hamed 2008), and Argentina (de Tezanos Pinto personal communication). *A. bergii* is monitored in Germany as an alien species (Stüken et al. 2006).

Distribution in the Czech Republic: This rare cyanobacterium has been found only at four mesotrophic localities in recent years (Máchovo jezero recreation pond, sand-pit lake Dubice nearby Česká Lípa, and two sand-pit lakes near Stará Boleslav, Fig. 1). Nevertheless, *A. bergii* is potentially dangerous because it produces the toxin cylindrospermopsin (Schembri et al. 2001).

Fig. 1 Distribution of the alien species *Anabaena bergii* (filled circle) and *Dolichospermum compactum* (open circle) in the Czech Republic



Cuspidothrix issatschenkoi (Usačev) Rajaniemi et al. 2005b

(*Aphanizomenon issatschenkoi* (Usačev) Proškina-Lavrenko = *Anabaena issatschenkoi* Usačev)

Original distribution: *C. issatschenkoi* was originally found in the Caspian region and near the Volga River. It is halophytic and has been reported from the Caspian Sea and the Sea of Azov (Jablonskaja 1971; Proškina-Lavrenko and Makarova 1968).

Non-native distribution in the world: This species is spreading in the temperate area both to the east (in Japan since 1985; Watanabe 1985) and to the west, where it has been recorded from Slovakia (Hindák 1992, 2008), the brackish waters of the south Baltic Sea and the Gulf of Finland (Hällfors 2004), the Finnish lake Tuusulanjärvi (Rajaniemi et al. 2005a), freshwater localities of Poland (Pelechaty and Owsianny 2003; Strzelecki and Poltorak 1971), France (Rajaniemi et al. 2005b), and also Canada (Canadian Museum of Nature 2007). *C. issatschenkoi* is commonly reported from tropical parts of Australia (Bormans et al. 2005; Bowling 1994) but confusion with *A. tropicalis* is possible in this case.

Distribution in the Czech Republic: *C. issatschenkoi* was not recorded in the Czech Republic until the 1990s. Today, it is an abundant species, and because it is common, researchers tend not to report its occurrence, with the exception of the study of

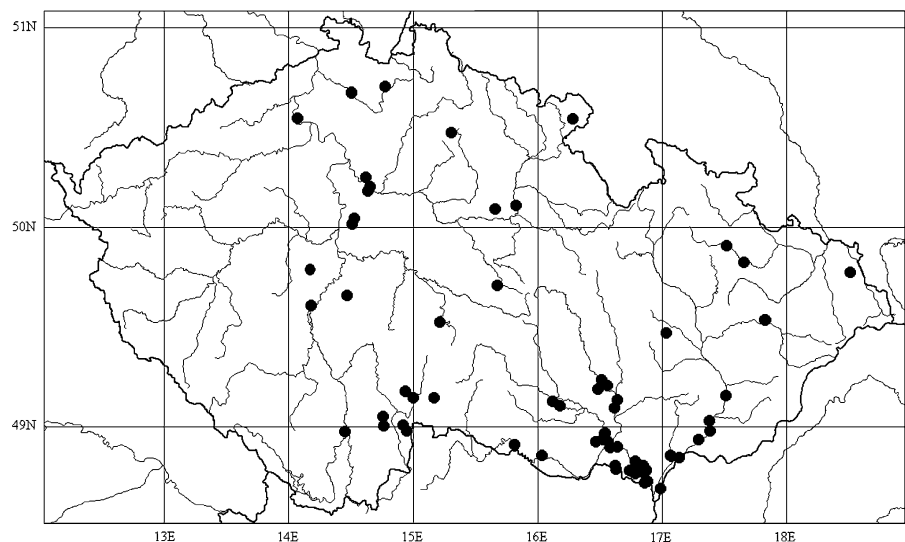
Albay and Pokorný (Albay and Pokorný 1999). This species is frequently found in standing or moderately flowing eutrophic, exceptionally mesotrophic waters of ponds and reservoirs (its occurrence in more than 70 localities has been documented, Fig. 2). Although the original environment of this taxon is fresh to brackish standing water (as noted, it tends to be halophytic), in the Czech Republic it inhabits standing water regardless of salinity. *C. issatschenkoi* can be dangerous to some native biota because it is toxic to small crustaceans (Li et al. 2003).

Cylindrospermopsis raciborskii (Wołoszyńska) Seenayya et Subba Raju 1972

(= *Anabaena raciborskii* Wołoszyńska = *Anabaenopsis raciborskii* (Wołosz.) Elenkin)

Original distribution: *C. raciborskii* is a very abundant pantropical species. It was described from Indonesia (Java) and was subsequently discovered in India and Thailand (Komárek and Komárková 2003), Japan (Chonudomkul et al. 2004), the Philippines, Egypt (Komárek and Komárková 2003), Senegal (Briand et al. 2004), Brazil (Bouvy et al. 2000; Molica et al. 2002), Cuba (Komárek and Komárková 2003), Chile (Lagos 1998), Uruguay (Vidal and Kruk 2008), Australia (Komárek and Komárková 2003), New Zealand (Wood and Stirling 2003), and Florida (Dobberfuhl 2003).

Fig. 2 Distribution of the alien species *Cuspidothrix issatschenkoi* (filled circle) in the Czech Republic



Non-native distribution in the world: The first European record of *C. raciborskii* is probably from Lake Kastoria (Orestiada) in Greece (Skuja 1937). Its occurrence was also documented in Hungary in 1942 (Szalai 1942). Subsequently, *C. raciborskii* was reported from Austria (Claus 1961); from the south Ukraine close to Odessa (Kondrateva 1968), the Don River (Aksenova 1974), and the region of Pannonia in the late 1960s (Hamar 1977; Horecká and Komárek 1979; Schmidt 1977); from Poland (Burhardt 1977); from Spain between 1980 and 1988 (Romo and Miracle 1994); from Slovakia (Hindák 1988, 2008; Maršálek et al. 2000); from Hungary again between 1991 and 1997 (Padisák 1991, 1997); and from its far northern locality in Germany in the North of Branderburg region in 1994 (Krienitz and Hegewald 1996). Its presence was then again confirmed in Austria from 1996 until now (Dokulil and Mayer 1996; Dokulil and Teubner 2000; Mayer et al. 1997), in France from 1997 until now (Briand et al. 2002, 2004; Coute et al. 1997; Druart and Briand 2002), and in the Danube delta in 2002 (Kaštovský original data). In 2003, *C. raciborskii* was reported again from Germany (Fastner et al. 2003; Mischke 2003), Italy (Ventura personal communication), Bulgaria (Stoyneva 2003), and Portugal (Saker et al. 2003). The most recent data document its permanent presence in Greece (Vardaka et al. 2005) and Poland

(Kokociński et al. 2009; Stefaniak and Kokociński 2005). This species is also spreading through the temperate part of the USA and Canada (Hamilton et al. 2005; Kling 2009).

Distribution in the Czech Republic: *C. raciborskii* was first found in waters of a gravel-pit lake in Chomutov (Horecká and Komárek 1979), and later it was mapped at various localities in South Moravia (Kopp 2006; Maršálek et al. 1996). At present, 23 additional localities in the Czech Republic are known; almost all are (meso-) eutrophic ponds (Fig. 3).

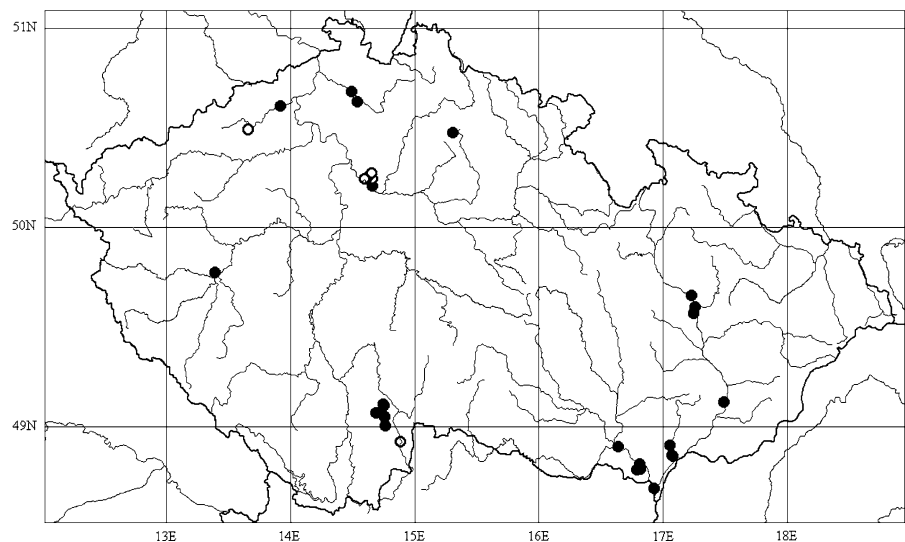
This cyanobacterium represents a significant health risk when present in drinking water reservoirs. The first description of human health problems (hepatoenteridia) caused by *C. raciborskii* came from Palm Island, Australia (Bourke et al. 1983). *C. raciborskii* is very toxic (Skulberg et al. 1993), and it often forms water blooms, which makes its evident invasiveness especially dangerous.

Dolichospermum compactum (Nygaard) Wacklin et al. 2009

(*Anabaena compacta* (Nygaard) Hickel = *Anabaena spiroides* var. *minima* f. *compacta* Nygaard)

Original distribution: The native range of *D. compactum* is the northern temperate zone of Europe.

Fig. 3 Distribution of the alien species *Cylindrospermopsis raciborskii* (filled circle) and *Planktothrix rubescens* (open circle) in the Czech Republic



It was described from Lake Emdrup in Denmark (Hickel 1985; Nygaard 1949), from Sweden and North Germany (Hickel 1982), and also from Finland (Rajaniemi et al. 2005a).

Non-native distribution in the world: Except for reports from the Balaton Lake in Hungary (Padisák and Kovács 1997) and Slovakia (Hindák 2008), *D. compactum* has not been reported from localities outside its native range. The spread of this species to other sites, however, is likely.

Distribution in the Czech Republic: *D. compactum* commonly inhabits rather eutrophic standing or moderately flowing waters of fishponds and is also rarely found in water reservoirs (33 localities have been documented) (Fig. 1). Presently, it occurs in quite high numbers but is always accompanied by other taxa, and thus does not seem to represent a serious danger.

Geitleribactron periphyticum Komárek 1975

Original distribution: The native range of *G. periphyticum* includes Finland, Switzerland, and Germany (Schwarzwald). The species grows on various substrates and on water plants in the littoral zone of oligotrophic lakes and ponds (Komárek and Anagnostidis 1998).

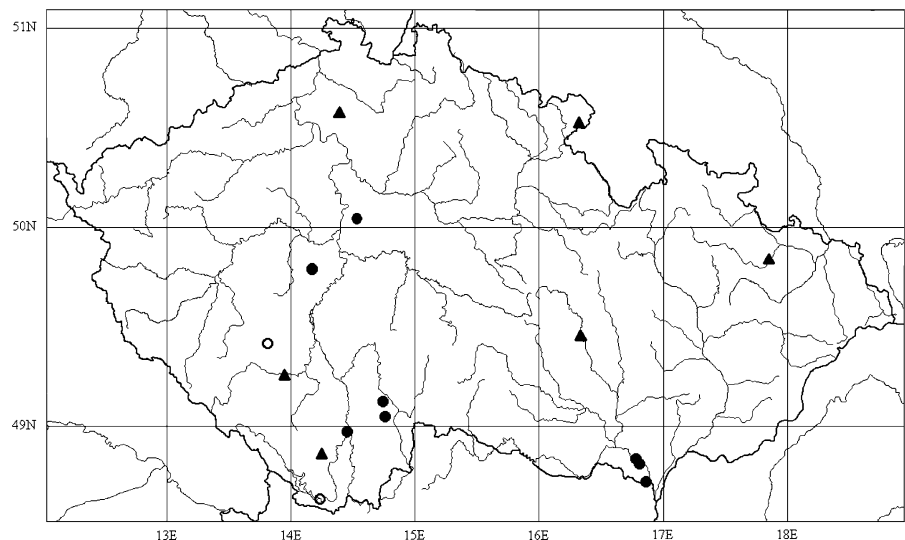
Non-native distribution in the world: *G. periphyticum* has been reported from Slovakia (Hindák 2008).

Distribution in the Czech Republic: In the Czech Republic, this species was first recorded when during its mass outbreak on walls of drinking water treatment facilities at Hájská near Strakonice in 1994 (Fig. 4) (Hubáčková and Sládečková 2001). When not occurring in massive numbers, it is very small and inconspicuous. In current research studies, *G. periphyticum* was rarely found in springs or smaller streams. It seems to be a native species that is capable of very rapid expansion. Outbreaks of *G. periphyticum* cause potential technological problems for water treatment (Sládečková 2005). The species is not considered dangerous because only one outbreak has been recorded.

Gloeotrichia echinulata (J.E. Smith) P.G. Richter 1894

Original distribution: *G. echinulata* was originally recorded from standing, rarely flowing waters of the northern temperate zone of Europe (Geitler 1932). It has been recorded in Sweden (Cronberg 1999; Forsell and Pettersson 1995), northern Russia (Gromov et al. 1996), Denmark (Jacobsen 1993), northern England (Talling and Parker 2002), and Estonia (Laugaste and

Fig. 4 Distribution of the alien species *Raphidiopsis mediterranea* (filled circle), *Gloeotrichia echinulata* (open circle), and *Geitleribactron periphyticum* (triangle) in the Czech Republic



Lessok 2004), and also in the northern temperate zone of America (Geitler 1932; Komárek et al. 2003) and Japan (Hirose and Hirano 1981). *G. echinulata* is also able to spread into moderately brackish waters, e.g., the northern Baltic Sea (Pankow 1976).

Non-native distribution in the world: *G. echinulata* was not reported from localities outside the originally defined native range, except for the finding in the Czech Republic. The species probably has a broader distribution that has simply not been documented.

Distribution in the Czech Republic: The first record of *G. echinulata* occurring in large numbers in the Czech Republic was from 1946 to 1947 from Velký Pálenec Pond near Blatná (Komárek 1958; Marvan et al. 1997). It was also sporadically encountered later, e.g., in 1959 (Komárková personal communication), and it appeared in Lipno reservoir during 1994–1996 (Znachor 1997) (Fig. 4). Its more recent presence in other localities is not known. Presumably, *G. echinulata* does represent any danger in the Czech Republic, although it tends to form water blooms in its home range.

Planktothrix rubescens (De Candolle ex Gomont)
Anagnostidis et Komárek 1988

(= *Oscillatoria rubescens* De Candolle ex Gomont 1892)

Original distribution: *P. rubescens* originated in the Holarctic area and primarily in two regions: southern and central Norway (Komárek and Anagnostidis 2005), and the western alpine area, especially large lakes in Switzerland (Bürgi 1987; Bürgi and Stadelmann 2002; Walsby 2005), Austria (Dokulil and Teubner 2005), Italy (Legnani et al. 2005; Salmaso 2003), Germany (Teubner et al. 2003), Slovenia (Grach-Pogrebinsky et al. 2003), and France (Jacquet et al. 2005; Jann-Para et al. 2004). The similarity of European and North American populations is being examined (confusion with *P. prolifica* is likely); data from the tropics are probably misidentifications in that *P. prolifica* is probably confused with *P. pseudagardhii*.

Non-native distribution in the world: *P. prolifica* is periodically found in different parts of Europe, e.g., in northeastern Poland (Krupa and Czernas 2003;

Pawlik-Skowrońska et al. 2004), northern Germany (Nixdorf and Rücker 2004; Schmidt et al. 2002), the Netherlands (Janse et al. 2005), and central Spain (Barco et al. 2004).

Distribution in the Czech Republic: *P. prolifica* was first recorded in two consecutive years in the early 1980s in sand-pit lakes in South Bohemia (Marvan et al. 1997); later, it was detected at five other localities, mainly in mesotrophic sand-pit ponds but also in eutrophic fishponds. This species can form water blooms (in the Czech Republic, water blooms occurred in the sand-pit lake Ovčáry near Kostelec nad Labem in 2000 and 2001), which, together with its toxicity, suggests that it should be considered as a potential danger. At present, *P. prolifica* inhabits only a few localities (Fig. 3).

Raphidiopsis mediterranea Skuja 1937

Original distribution: *R. mediterranea* is a subtropical species that is not very abundant. It was described from Lake Kastoria (Greece); later it was reported from India (Zafar 1986), Spain (Lopez-Archilla et al. 2004), Egypt (Mohamed 2007), Vietnam (Nguyen et al. 2007), Central China (Li et al. 2008), and Brazil (Fonseca and Bicudo 2008).

Non-native distribution in the world: *R. mediterranea* has spread from subtropical regions to the temperate zone. It has been reported from lakes in Minnesota, USA (Hill 1970), Slovakia (Maršálek et al. 2000), Japan (Watanabe et al. 2003), Lithuania (Kasperovičiene et al. 2005), and New Zealand (Wood et al. 2007).

Distribution in the Czech Republic: Since the first report in 1997 (Keršner 1997), *R. mediterranea* has been continually reported from South Moravia (southeastern part of the Czech Republic, Hindák et al. 2006). Recently, large populations of *R. mediterranea* were recorded in two localities in Central Bohemia (one eutrophic fishpond and one eutrophic reservoir used for recreation). It was also detected at two localities in South Bohemia (Fig. 4). *R. mediterranea* is probably more widespread throughout the Czech Republic than indicated by reports but previous findings might have confused *R. mediterranea* with a similar, better-known invasive species, *Cylindrospermopsis raciborskii*.

Sphaerospermopsis aphanizomenoides (Forti)
Zapomělová et al. 2009

(= *Aphanizomenon aphanizomenoides* (Forti) Horecká et Komárek, *Anabaena aphanizomenoides* Forti, *Aphanizomenon sphaericum* Kisselev)

Original distribution: This planktonic cyanobacterium was described from lakes in Anatolia (Turkey), where it is still found, although not in high numbers (Cirikaltindag et al. 1992; Ersanli and Gönülol 2006). In the 1970s, *S. aphanizomenoides* was rarely recorded in the Caspian Sea (Gogorev 2008), which is probably a geographically and ecologically continuous part of the original distribution area.

Non-native distribution in the world: *S. aphanizomenoides* has been reported from Japan (Hirose and Hirano 1981), Australia (Day et al. 1995), and North America (Komárek et al. 2003). Reports of its occurrence in Cuba are probably incorrect (Komárek 2005). The oldest European records are from Hungary (in the 1970s, Herodek et al. 1982), where the species has evidently been present to the current time (Padisák and Kovács 1997; Kusel-Fetzmann 1998; Borics et al. 1998). Occurrence was noted also in Slovakia (Hindák 2000, 2008), Romania (Caraus 2002), Great Britain (John et al. 2002), the Netherlands (Janse et al. 2005), Morocco (Sabour et al. 2005), Germany (Stüken et al. 2006), and France (Brient et al. 2008).

Distribution in the Czech Republic: *S. aphanizomenoides* was first recorded in the Czech Republic in the late 1970s in a sand-pit lake in middle Moravia (Horecká and Komárek 1979). Today, this species is a dominant component of the phytoplankton in more than 20 localities throughout the Czech Republic and is especially common in eutrophic fish ponds. *S. aphanizomenoides* is less common in mesotrophic standing waters (Fig. 5).

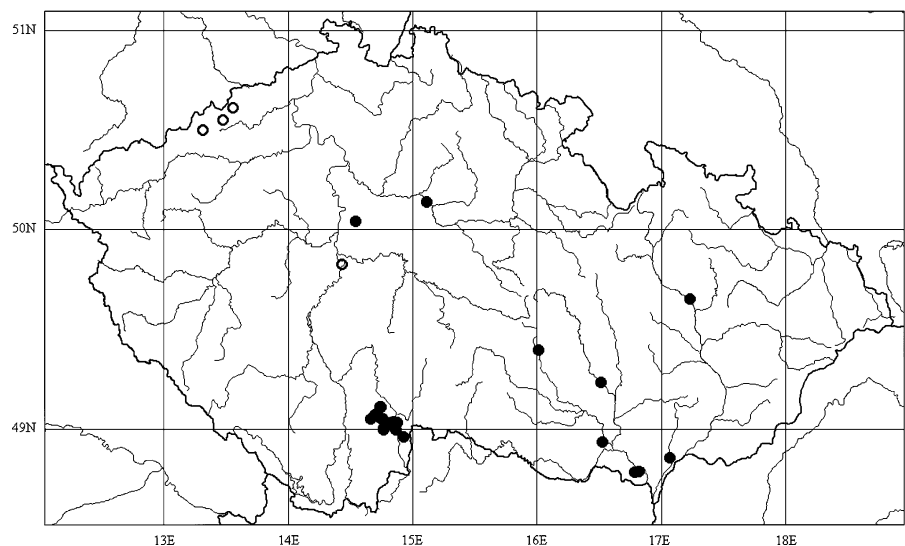
Synechococcus capitatus Bailey-Watts et Komárek
1991

Original distribution: As a member of the plankton of large cold lakes, *S. capitatus* is native to Scotland (Loch Leven, with the first instance of local mass overproduction occurring in 1967), Scandinavia, northern Japan (Bailey-Watts and Komárek 1991; Komárek and Anagnostidis 1998), and northern Wales (Happeywood 1991).

Non-native distribution: *S. capitatus* has not reported from any non-native localities other than the Czech Republic.

Distribution in the Czech Republic: The first record of *S. capitatus* in the Czech Republic was in the 1980s, when high numbers of the species were found in the Janov water reservoir (Ambrožová 1999); in 1995, this population bloomed. The species is still present in the Janov water reservoir and also

Fig. 5 Distribution of the alien species *Sphaerospermopsis aphanizomenoides* (filled circle) and *Synechococcus capitatus* (open circle) in the Czech Republic



found in the Křimov and Jezeří water reservoirs. In the Slapy water reservoir, a picoplanktonic cyanobacterium, identified as *Synechococcus* cf. *capitatus*, was detected in 1998–1999 (Komárková 2000, Fig. 5). Because *S. capitatus* is very small, it would not be trapped by common plankton nets, and we therefore assume that it is probably more widespread than reported. This species has already caused problems in drinking water reservoirs, because it is so small that it passes through water plant filters. A bloom of *S. capitatus* even caused the closing of the Janov water reservoir for 3 months (Micka and Holleová 1997). Although no toxicity has been associated with this species (Ambrožová 1999), it could cause serious problems for water-treatment plants if it continues to spread.

Diatoms

Actinocyclus normanii f. *subsalsus* (Juhlin-Dannfelt) Hustedt 1957

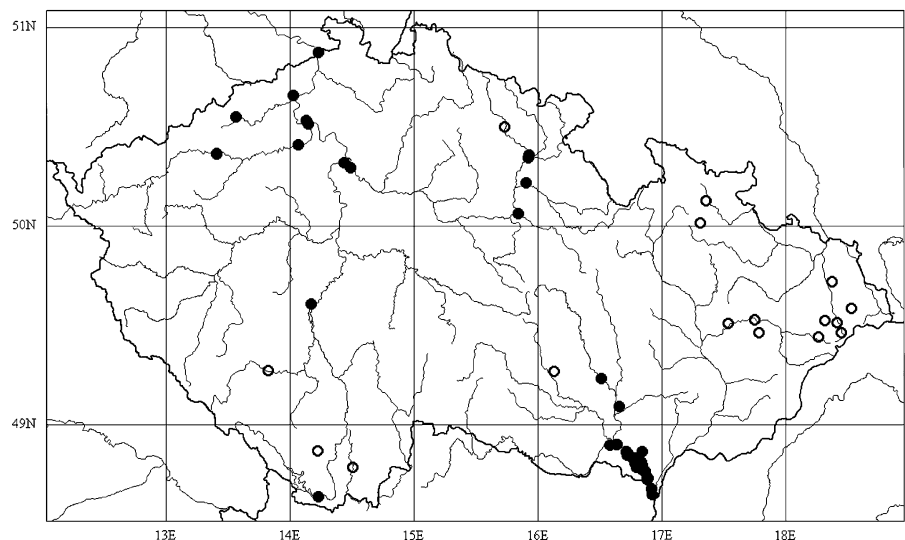
(= *Coscinodiscus subsalsus* Juhlin-Dannfelt 1882)

Original distribution: *A. normanii* f. *subsalsus* is found in eutrophic inland waters with medium or slightly elevated salt concentration in the Netherlands and around the lower Rhine (Niederrheingebiet) (Krammer and Lange-Bertalot 1991).

Non-native distribution in the world: *A. normanii* f. *subsalsus* has spread into common freshwaters (Kiss et al. 1990), e.g., in Russia (Korneva 2001), England (Belcher and Swale 1979), Finland (it first appeared in Vesijärvi Lake in 1989, and since then, it has been one of the most important local diatoms; Liukkonen et al. 1997), and Germany (Kohler et al. 1993). In Slovakia, *A. normanii* f. *subsalsus* was first reported in 1994 from the Morava River as a dominant species of the phytoplankton (Hindáková 1994); later, it was found in the alluvium of several rivers, in gravel-pit lakes, and also in water reservoirs and ponds (Hindák and Hindáková 1996, 1997a, b, 1998, 2000, 2003, 2004; Hindáková 1997). After spreading in a nearly explosive manner at the end of the last century, this species started to decline (Hindáková 2001). *A. normanii* f. *subsalsus* still represents a common part of the phytoplankton in Slovakia, but it only forms small populations. It was also considered invasive in North America, specifically in the Great Lakes (Hasle 1977) and in the Parker River in Massachusetts (Hughes et al. 2000). Its occurrence in South America in waters with high conductivity (Samborombón and Buñirrigio Rivers in the Rio de La Plata region; Mercado 2003) and in Israel (Barinova et al. 2004) is questionable.

Distribution in the Czech Republic: From about 1980 to 1994, numbers of *A. normanii* f. *subsalsus*

Fig. 6 Distribution of the alien species *Actinocyclus normanii* (filled circle) and *Didymosphaenia geminata* (open circle) in the Czech Republic



increased greatly, especially in South Moravia; numbers first increased in reservoirs and rivers, and later in smaller streams (Skácelová and Marvan 1991). The numbers then declined quickly, and only empty frustules are currently found in Moravia. *A. normanii* f. *subsalsus* is still relatively common in the western Czech Republic, although it is never as abundant as reported in the past (Fig. 6).

A. normanii f. *subsalsus* is a halophytic species whose spread is probably explained by eutrophication of surface waters.

Cyclostephanos delicatus (Genkal) Casper et Scheffler 1990

(= *Stephanodiscus delicatus* Genkal 1985)

Original distribution: *C. delicatus* was described from the Rybinsk Reservoir on the Volha River in Russia (Genkal 1985, 1992).

Non-native distribution in the world: From 1996, *C. delicatus* spread to the west. It was detected in Slovakia, and specifically in the Morava, Danube, and Ipeľ Rivers (Hindák and Hindáková 2004; Hindák et al. 2002), in mesotrophic standing waters (e.g., gravel-pit lakes), as well as in productive fishponds (Hindák and Hindáková 2001, 2002). It was also found in Dagow Lake in North Germany, and the Elbe River (Casper and Scheffler 1990). Outside

Europe, *C. delicatus* was reported from strongly eutrophic waters with high pH and high conductivity, including the Lazy Lagoon in Iowa (USA), the Red River in Manitoba (Canada), North Dakota (USA), and Lake Winnipeg in Manitoba (Canada) (Håkansson and Kling 1990).

Distribution in the Czech Republic: In the Czech Republic, *C. delicatus* is known from two water reservoirs; the Dyje, Vltava, Nežárka, and Lužnice Rivers; and several small streams in South Bohemia (Fig. 7).

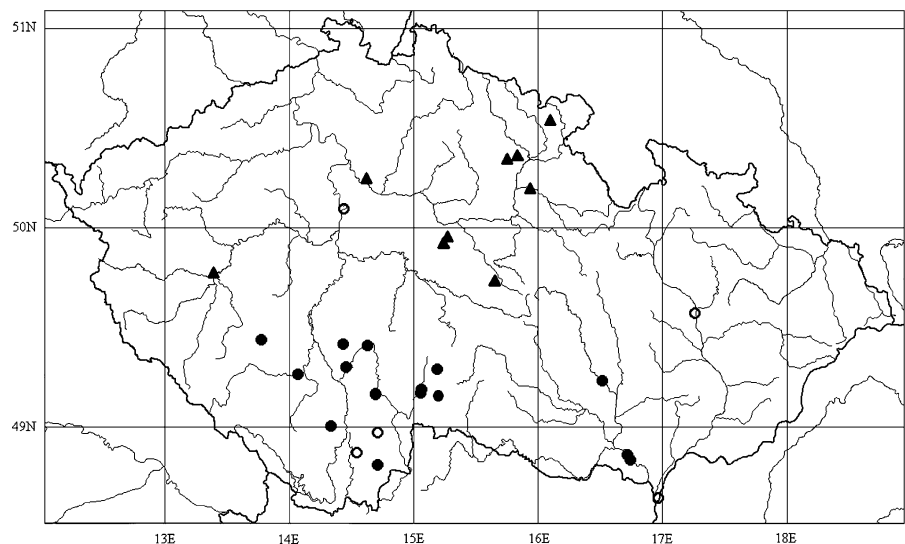
The invasiveness of this species might be overestimated because it might have been incorrectly identified in the past. For instance, *C. delicatus* was incorrectly identified and reported in samples collected around 1920 from alpine lakes.

Didymosphenia geminata (Lyngb.)
M. Schmidt 1899

(= *Echinella geminata* Lyngbye 1819 = *Gomphonema geminatum* (Lyngbye) C. Agardh 1823)

Original distribution: *D. geminata* was described from the Faroe Islands; its typical habitats are flowing waters of the Nordic region and alpine lakes in the Alps. Outside Europe, it is known from Asia and North America (Krammer and Lange-Bertalot 1997). In Central Europe, *D. geminata* was recorded only

Fig. 7 Distribution of the alien species *Cyclostephanos delicatus* (filled circle), *Discostella wolterecki* (open circle), and *Fragilaria reichelii* (triangle) in the Czech Republic



on the Polish and Slovak side of the High Tatra Mountains (Bílý 1941; Siemińska 1964). More distant populations were located on the upper Tizsa River (Hamar 1977) and Veliko Jaažinačko Lake in Serbia (Urošević 1994). A complete summary of recent occurrences of *D. geminata* throughout Europe has been published (Blanco and Ector 2009).

Non-native distribution in the world: New findings of *D. geminata* from lower altitudes were reported from Great Britain (Antoine and Bensonevans 1983), the Inn River below Innsbruck (Rott and Binder 2002), several rivers in southern Poland (Kawecka and Sanecki 2003), the Danube River below Belgrade, and the lower Tisza River (Subakov-Simić and Cvijan 2004). The first water bloom of *D. geminata* in North America was reported by Sherbot and Bothwell (1993). Today, *D. geminata* has spread into several states of the USA and Canada (Kirkwood et al. 2007; Spaulding and Elwell 2007). Intensive blooms have been recorded from New Zealand since 2004 (Kilroy 2004).

Distribution in the Czech Republic: *D. geminata* was first recorded in the Czech Republic in 2001 during its massive development in the Morávka River below the Morávka Valley reservoir in the Moravian-Silesian Beskyd Mountains (Gágyorová and Marvan 2002). It can be found there in large numbers up to now. Since 2001, *D. geminata* has spread into lower locations such as the Odra and Bečva River drainages, into streams in the foothills of the Jeseníky Mountains (Hašler personal communication), and into several streams and rivers in South Bohemia. Repeated findings of dead frustules in the upper Elbe River near Debrné suggest that it is spreading into the Krkonoše Mountains (Sukačová personal communication) (Fig. 6).

The original habitats of this species are probably cold oligotrophic streams with low conductivity, and sometimes it is reported as acidophilic. Its distribution in the Czech Republic is restricted to higher and medium altitudes, where the rivers flow relatively fast and the species produces massive, moss-like mats formed by thick, stalk-bearing cells. *D. geminata* prefers sites below valley reservoirs, where nutrients are abundant. Because it can out-compete native diatom species and because the mats it produces stink, invasion by *D. geminata* is undesirable. It is potentially the most serious algal invasion in the Czech Republic.

Discostella woltereckii (Hustedt) Houk et Klee 2004

(= *Cyclotella woltereckii* Hustedt 1942)

Original distribution: *D. woltereckii* was described from Java (Hustedt 1942); later, it was reported as a pantropical species (Day et al. 1995).

Non-native distribution in the world: From the 1990s, reports have indicated that *D. woltereckii* is spreading from the tropics to Europe. It was found in Germany (Hübener 1999; Klee and Houk 1996) and in Slovakia, especially in rivers (Hron, Ipeľ, Morava, Danube) and unpolluted mesotrophic waters near rivers (gravel-pit lakes, sand-pit lakes, etc.) (Hindák and Hindáková 2001; Hindák et al. 2002).

Distribution in the Czech Republic: In the 1990s, *D. woltereckii* was discovered in inundation lakes of the Morava River drainage (Houk and Marvan 1993), in the Vltava River in Prague, and rarely in small streams (Fig. 7).

The taxonomic status of *D. woltereckii* is unclear; it is sometimes considered synonymous with *D. pseudostelligera* or *D. stelligera* (Haworth and Hurley 1984). Therefore, it is possible that this species was always present in the Czech Republic but was recorded under a different name.

Fragilaria reicheltii (Voigt) Lange-Bertalot 1986

(= *Centronella reicheltii* Voigt 1902 = *Centronella rostafinskii* Wołoszyńska 1922)

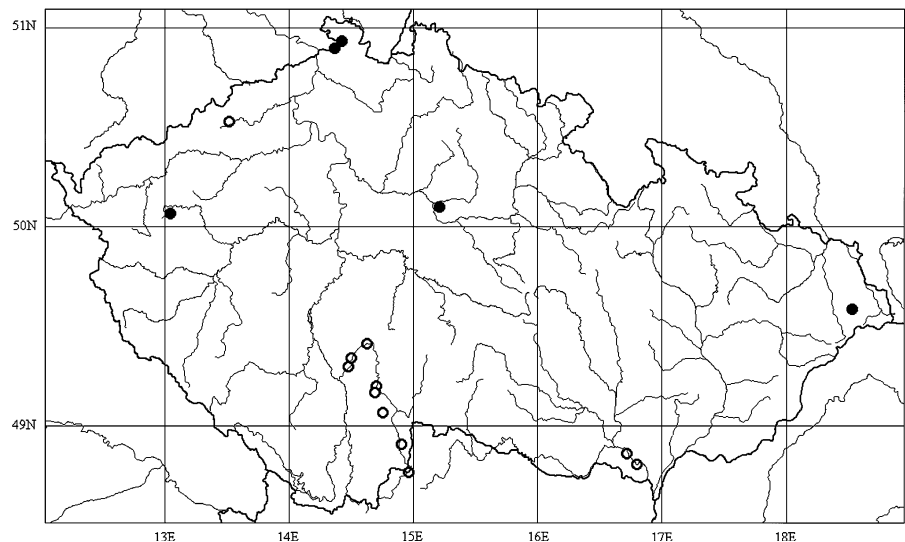
Original distribution: The original distribution of *F. reicheltii* includes lakes in northern Germany and Poland (Marvan et al. 1997) and lakes in eastern France (Krammer and Lange-Bertalot 1997).

Non-native distribution in the world: In 1989, *F. reicheltii* appeared in two flooded sand-pit lakes in Slovakia (Marvan and Hindák 1989), where it can be sporadically found up to now. Later, it was recorded from a fishpond in Bratislava (Hindáková 1997).

Distribution in the Czech Republic: *F. reicheltii* was first recorded in the Czech Republic in Bolevecké ponds near Plzeň in 1999 and 2000 (Volfová personal communication). Recently, the species was detected in nine localities, mostly eutrophic or rarely mesotrophic fishponds and sand-pit lakes (Fig. 7).

F. reicheltii seems to be quite widespread, even though its biomass is never large. Its taxonomic status, however, is questionable, and it might represent an abnormality of some other diatom species that

Fig. 8 Distribution of the alien species *Frustulia weinholdii* (filled circle) and *Staurosirella berolinensis* (open circle) in the Czech Republic



forms a third arm of the frustule only when stressed (*Fragilaria crotonensis* is under consideration) (Schmidt 1997). Thus, it is possible that detection of *F. reicheltii* is not evidence of an invasion but is instead evidence of a change in morphology caused by stress.

Frustulia weinholdii Hustedt 1937

Original distribution: *F. weinholdii* is a cosmopolitan species in waters with low conductivity (Krammer and Lange-Bertalot 1997). In North America, it is a frequently detected in streams (Brian 2000; Hill et al. 2003; Johansen et al. 2007; Potapova and Charles 2007; Ratnasabapathy and Deason 1977; Stoermer et al. 1999; Waite et al. 2006; Wunsam et al. 2002), and it is also found in the marine intertidal zone at the water's edge or on river estuaries (Patrick 1994). *F. weinholdii* was also observed in Cuba (Marvan unpublished), in inland waters of Australia (Day et al. 1995), and in a highland stream in Kenya (Mpawenayo and Mathooko 2005). In Europe, it has been reported from France (Coste et al. 2009) and Ireland (Ní Chatháin et al. 2004).

Non-native distribution in the world: The non-native distribution of *F. weinholdii* is unknown.

Distribution in the Czech Republic: *F. weinholdii* was first found in the Czech Republic in 2005 in a tributary of the Morávka River above the Skalka

water reservoir. Since then, the species has been reported from four other small streams (Veselá 2007) (Fig. 8).

Navicula schroeteri F. Meister 1932

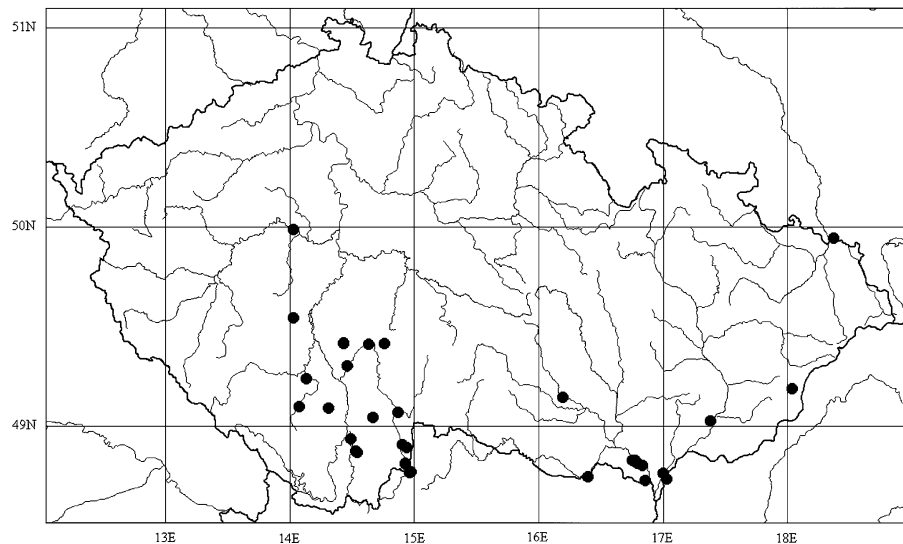
(= *Navicula simulata* Manguin 1942 = *Navicula symetrica* Patrick 1944 = *Navicula schroeterii* var. *escambia* Patrick 1959)

Original distribution: *N. schroeteri* is scattered worldwide in freshwaters with medium to higher electrolyte content; it forms large populations in brackish biotopes (Krammer and Lange-Bertalot 1997; Lange-Bertalot 2001).

Non-native distribution in the world: The non-native distribution of *N. schroeteri* is unknown.

Distribution in the Czech Republic: Although it was described a relatively long time ago, *N. schroeteri* was not included in taxonomic keys for countries neighboring the Czech Republic (e.g., Hustedt 1930; Siemińska 1964). It was first recorded in the Czech Republic in a drying puddle with high electrolyte concentration in South Moravia around 1995; because its appearance is characteristic, it is unlikely that *N. schroeteri* was overlooked in the past. At present, more than 20 localities are known, and these include wetland pools, small streams, and rivers, mainly in South Moravia and South Bohemia (Fig. 9). With the exception of the first records from

Fig. 9 Distribution of the alien species *Navicula schroeteri* (filled circle) in the Czech Republic



1995, *N. schroeteri* has not been observed in large numbers.

Skeletonema potamos (Weber) Hasle 1976

(= *Microsiphonia potamos* Weber 1970 = *Stephanodiscus subsalsus* (A. Cleve) Hustedt 1928 – non *Melosira subsalsa* Cleve 1912)

Original distribution: *S. potamos* is cosmopolitan and is sparsely distributed in eutrophic slowly flowing or standing waters (Hasle and Evensen 1976; Krammer and Lange-Bertalot 1991). It has not been reported from Central Europe.

Non-native distribution in the world: From the 1990s, invasive spread of *S. potamos* was reported in Slovakia; it was found in larger rivers, clean standing waters, as well as in eutrophic fishponds (Hindák and Hindáková 1997a, 1998, 2002, 2004; Hindák et al. 1999, 2002; Hindáková 1994; Makovinská et al. 2003). It was also studied in the Danube River near Budapest in Hungary (Kiss et al. 1993).

Distribution in the Czech Republic: *S. potamos* in the Czech Republic was first detected in 1975 from South Bohemia (Marvan et al. 1997); since then, it has been commonly found in the phytoplankton. *S. potamos* was recorded in more than 100 localities including mesotrophic to eutrophic reservoirs and slowly flowing rivers during diatom peaks in spring and sometimes also in fall.

This species is very small and lacks distinguishing morphological characteristics; therefore, it is likely that it was present but not noticed before 1975. Because the frustules are inconspicuous and lightly silicified, they can be overlooked in samples and they can also be damaged during the preparation of permanent slides. Moreover, the color of the chloroplast of living cells is very close to that of yellow-green algae (Xanthophyceae), and this can confuse the identification.

Staurosirella berolinensis (Lemmermann) Bukhtiyarova 1995

(= *Synedra berolinensis* Lemmermann 1900 = *Fragilaria berolinensis* Lange-Bertalot 1989)

Original distribution: The original distribution of *S. berolinensis* included Western Europe and Asia; it was also recorded in Africa (Krammer and Lange-Bertalot 1991). *S. berolinensis* is not known from Central Europe.

Non-native distribution in the world: The spread of *S. berolinensis* has been studied in Slovakia; whereas the diatom was known from only one locality in 1995 (Čunovská, earlier Hrušovská reservoir; Onderíková 1995), it was subsequently detected in several other localities (sand-pit lakes, fishponds, and rivers) in western and southern Slovakia (Hindák and Hindáková 2002, 2004; Hindák et al. 2002; Hindáková 2001; Marvan et al. 2004).

Distribution in the Czech Republic: *S. berolinensis* has been found in several localities in South Moravia and South Bohemia; these include fishponds, reservoirs, rivers, and their cutoffs (Fig. 8). *S. berolinensis* never produces significant biomass. The latest paleontological studies suggest that *S. berolinensis* is not an alien species; it was found in Atlantic sediments of the defunct Komořanské Lake (Bešta unpublished). In modern samples from the Czech Republic, however, it was not observed until the 1990s.

Other algae

Peridiniopsis kevei Grigorszky et Vasas 2001

(= *Peridiniopsis corillionii* Leitao, Ten-Hage, Mascarell et Couté 2001 = *Peridiniopsis rhomboides* Krakhmalny 2002)

Original distribution: *P. kevei* was described from tributaries of the Tisza River in Hungary. However, its true original distribution is unknown.

Non-native distribution in the world: In the 1980s, *P. kevei* was noted as an unknown species from Italy, Germany, France, Romania, Austria, and Slovakia (Grigorszky et al. 2001). Because *P. kevei* has a distinctive morphology, it is quite improbable that it was overlooked in earlier determinations. Since the 1980s, *P. kevei* has been reported from Croatia (Gligora et al. 2006), Hungary (Grigorszky et al. 2001), Italy (Hansen and Flaim 2007), and Poland (Owsianny and Grabowska 2009). A type denoted as *Peridiniopsis* cf. *kevei* was also reported from Toyama Prefecture, Japan (Takano et al. 2008)

Distribution in the Czech Republic: *P. kevei* was first reported from the Czech Republic in 2007 (Geriš and Jahodová 2007). In the summer of 2009, we confirmed its presence in another locality. Both sites are large, eutrophic reservoirs.

Ulva flexuosa Wulfen 1803

(= *Enteromorpha tubulosa* var. *ramosa* Schiffner = *Conferva flexuosa* Roth 1800 = *Enteromorpha intestinalis* var. *tubulosa* Kützinger 1845 = *Enteromorpha tubulosa* (Kützinger) Kützinger 1856 = *Enteromorpha flexuosa* (Wulfen) J. Agardh 1883 = *Enteromorpha lingulata* J. Agardh 1883 = *Enteromorpha prolifera*

var. *tubulosa* (Kützinger) Batters 1902 = *Enteromorpha intestinalis* f. *tubulosa* (Kützinger) V.J. Chapman 1937)

Original distribution: This taxonomically complicated macroalgal species is distributed in coastal seawaters nearly worldwide. *U. flexuosa* has many different morphological forms but has several important, unifying characteristics (branching, cell structure, and chloroplast structure). The genetic distance among subspecies and forms is unclear. Importantly, one of the subspecies, *Ulva flexuosa* subsp. *pilifera* (Kützinger) M.J. Wynne 2005, has been reported as an exclusively freshwater alga from several European localities, mostly ponds or smaller streams with somewhat increased salinity in Sweden, the Netherlands, France, England, and Croatia (Bliding 1963; Koeman and van den Hoek 1984), Poland (Kowalski 1975), and Germany (Kützinger 1849).

Non-native distribution in the world: The only non-native occurrence of *U. flexuosa* was reported from a coastal zone of Lake Michigan, USA (Lougheed and Stevenson 2004), where in autumn 2003, an alga identified as *U. flexuosa* subsp. *flexuosa* and subsp. *paradoxa* covered up to 80% of the water surface in the littoral zone. *U. flexuosa* also occasionally forms blooms in enriched waters in its native range, where it can be considered as an expansive species; these include ponds near Łódź in Poland (Sitkowska 1999) and the Mecklenburg Lakes in Germany (Gardavský in Skácelová 2004).

Distribution in the Czech Republic: Only *Ulva intestinalis* L. has traditionally been reported from the Czech, and mostly from two distinct localities: a salt marsh in the Soos National Natural Reserve in West Bohemia (Brabec 1941; Lederer et al. 1998) and ponds and pools with increased salinity in South Moravia (Nave 1863; Zapletálek 1932; Heteša 1962; Marvan and Komárek 1978; Skácelová 2004, and many others).

In 1980s, massive occurrences of *U. intestinalis* were reported from other localities (Wolgemuth et al. 1984). Because the alga was found in heavily eutrophicated ponds with mineral input from agriculture and sewage water, its spread was attributed to the anthropogenic enrichment of surface waters.

At the end of the twentieth century, different authors used different taxonomic approaches, which further obscured the complicated taxonomy of these algae. Marvan et al. (1997) identified expansive

populations from several sites in the Czech Republic as *Ulva* cf. *flexuosa*, and because the alga could not have been attributed to the only supposedly native species (*Ulva intestinalis*), the authors hypothesized a non-native origin. Interestingly, *U. flexuosa* was also found by Lederer et al. (1998) at one of the original localities, the Soos Salt Marsh. This finding was accompanied by a modern, taxonomic description. The presence of *U. flexuosa* in the area, including native localities in South Moravia, was also discussed by Skácelová (Skácelová 2004).

On the other hand, some authors, led mainly by observations of macroscopic morphology, identified specimens with leaf-like curly thalli as *Ulva linza* or *U.* cf. *linza* (Heteša and Sukop 1998, 2001; Kaštovský et al. 2006a), and even suggested that this typically marine species was non-indigenous and possibly invasive.

According to our own observations, all populations (from both original and secondary localities) in the Czech Republic should be regarded as *Ulva flexuosa*. Between 2007 and 2009, we collected several samples throughout the country, including the Soos Salt Marsh and ponds in South Moravia (sites of indigenous occurrence) but also enriched streams and stagnant waters in East and North Bohemia. Using respected literature (Bliding 1963; Brodie et al. 2007; Koeman and van den Hoek

1984), we identified all collected populations and also historical herbarium specimens as *U. flexuosa*. Our conclusions are supported by several previously cited observations by modern authors (Lederer et al. 1998; Marvan et al. 1997; Skácelová 2004).

It should be noted that the freshwater part of the former *U. intestinalis* was later transferred to *U. flexuosa* subsp. *pilifera*. Thus, the specimens from the eighteenth and early nineteenth centuries were probably identified as *U. intestinalis* according to the taxonomic view of that time, and they were identical with the contemporary *U. flexuosa*.

As for *U. linza*, our examination of leaf-like thalli leads us to conclude that these were only unfolded vegetative stages of *U. flexuosa*, perhaps induced by certain environmental conditions.

In our opinion, *Ulva flexuosa* is probably the only species to occur in the area. It seems to be a native species with an ability to expand into secondary habitats, mostly enriched stagnant or flowing surface waters. It is capable of forming massive agglomerations of biomass. However, no serious negative impacts on native ecosystems have been reported. Its further spread probably will depend on policies of wastewater management and agriculture. At present, more than 20 localities are known, mostly streams, fishponds, and channels (Fig. 10).

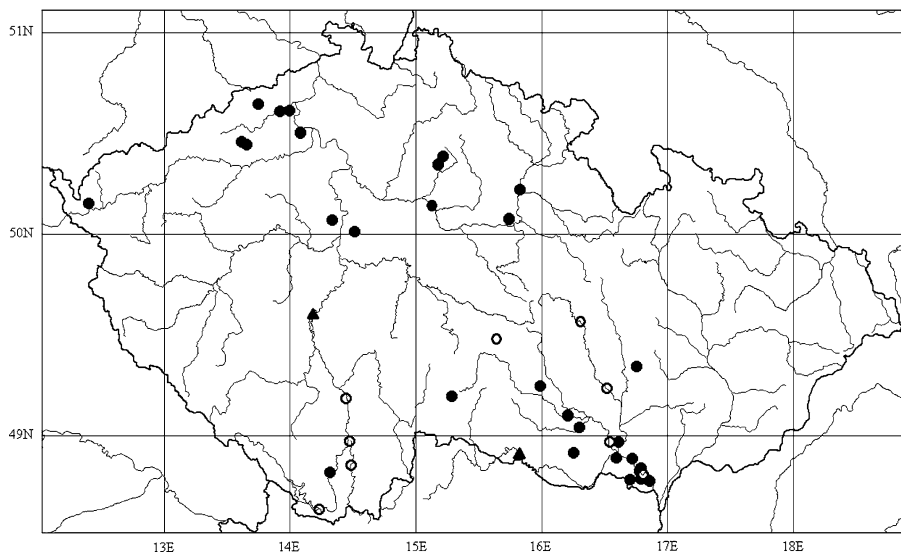


Fig. 10 Distribution of the alien species *Ulva flexuosa* (filled circle), *Pleodorina indica* (open circle), and *Peridiniopsis keve* (triangle) in the Czech Republic

Pediastrum simplex Meyen 1829

(= *Micrasterias simplex* (Meyen) Kützing = *Monacetus simplex* (Meyen) Corda = *Helierella simplex* (Meyen) Brébisson)

Original distribution: *P. simplex* is a pantropical planktonic species whose distribution extends into Mediterranean areas. It was reported from Bangladesh (Ali et al. 1986), Turkey (Gonulol 1998), Japan (Protist Information Server 2009), Florida (Work 2009), China (Wang and Li 2004), Albania (Rakaj et al. 2000), Egypt (Rashid 2009), and Costa Rica (Chow et al. 1994). *P. simplex* is often found in paleontological sediments, where it is considered an indicator of elevated temperature (Komárek and Jankovská 2001).

Non-native distribution in the world: *P. simplex* was recorded in both standing and slowly flowing waters of North Italy (Salmaso 2002), Germany (Kusber and Jahn 2000), the Netherlands (Beket 2005), Canada (Canadian Museum of Nature 2007), and Slovakia (Hindák and Hindáková 2004; Hindák 2005) and also from brackish water of Chesapeake Bay, Virginia (Wass 1972). However, it is highly likely that the distribution of this species is much broader.

Distribution in the Czech Republic: *P. simplex* is not invasive but is an important expansive taxon in the Czech Republic. In early reports, Hansgirg (1889) and Pascher (1906) listed this species as rare. In the 1950s, the species began to spread rapidly throughout the Czech Republic: the first records of high abundance in the fishpond plankton community came in 1957 (Sládečková-Vinniková 1957); subsequently, the spread and biomass increase of *P. simplex* was studied by several authors (Ettl and Fott 1959; Mitiska 1962; Perman and Lhotský 1963; Sládečková-Vinniková 1958; Štěpánek et al. 1958). In the 1960s, the species had become widespread throughout the Czech Republic (more than 500 localities), especially in the plankton of meso- to eutrophic standing waters (pools, fishponds, water reservoirs) and rivers.

Pleodorina indica (Iyengar) Nozaki 1989

(= *Eudorina indica* Iyengar 1933)

Original distribution: *P. indica* was first described in India (Iyengar 1933) but later was also found in Mexico and Argentina (Zalocar 1993).

Non-native distribution in the world: At the turn of the twentieth century, molecular methods showed that the *Pleodorina* sp. ASW05153 isolated from eutrophic water of the Danube River cutoff (Giessgang, Greifenstein, and Lower Austria) was *Pleodorina indica* (Angeler et al. 1999; Coleman 2002). Other localities in Europe have not been recognized so far.

Distribution in the Czech Republic: This inconspicuous species was first recorded in the Czech Republic during the extremely hot summer of 2003 in the Malše River in České Budějovice, where it formed an extensive water bloom (Znachor and Jezberová 2005). One year later, it was observed in the same locality, but the biomass was much smaller. At the same time, *P. indica* was found in the Hněvkovice water reservoir about 50 km downstream from the original locality, in one other reservoir, and in one eutrophic pond (Znachor and Lodeová 2005); it was later found in three other ponds and four reservoirs (Fig. 10).

In the native tropical to subtropical environment, *P. indica* inhabits wetlands and standing or slowly flowing waters. In the Czech Republic, it is found in very slowly flowing rivers, water reservoirs, and fishponds. The occurrence is always recorded only in the warmest period of the year.

In the Czech Republic, the only substantial population that has formed a water bloom (which persisted for 2 years) was found in the lower Malše River. In 2005, the biomass in this main locality was significantly reduced or even eliminated by extended dredging of bottom sediments. Populations at other localities were smaller. The water bloom was seen only once, but its size and persistence indicate potential future problems, especially if summer temperatures are abnormally high.

Staurostrum planctonicum Teiling 1947

This taxon is commonly known under this name (or sometimes under the name *S. pingue*) but it is highly likely that it is synonymous with several other types, and the correct name should be “*Staurostrum manifoldii* complex” (Coesel 1992).

Original distribution: *S. planctonicum* is an oligotroph native to mesotrophic lakes of North Europe and alpine lakes (Lenzenweger 1996).

Non-native distribution in the world: The non-native distribution of the *S. planctonicum* is unknown.

Distribution in the Czech Republic: *S. planctonicum* was first reported from the Jihlava River in 1974 (Dočkal & Sládeček 1974 in Pouličková et al. 2004), and later it appeared in higher numbers in the gravel-pit lake Kvasice near the Morava River in 1987 (Marvan et al. 1997; Sládečková and Bernard 1987). Its general distribution throughout the Czech Republic is dated back to the beginning of the 1990s, when it was commonly found in many water reservoirs (Desortová and Brandl 1994; Gagyorová 1993; Marvan et al. 1997).

Today, this species is widespread in the Czech Republic, especially in all types of mesotrophic to eutrophic standing waters (more than 500 localities). In a few documented cases, this species produced massive biomass and out-competed other species in the water reservoir (Marvan et al. 1997).

Discussion

According to our view, there are several groups of alien and expansive species that have invaded or could invade the Czech Republic:

1. Taxonomically well-defined, easily identified, and conspicuous species that are highly unlikely to have been overlooked in the past and that are actually established in the Czech Republic; typical members of this group are *Cylindrospermopsis raciborskii*, *Cuspidothrix issatschenkoii*, *Raphidiopsis mediterranea*, *Sphaerospermopsis aphanizomenoides*, *Actinocyclus normanii*, *Didymosphenia geminata*, *Staurosirella berolinensis*, *Navicula schroeteri*, *Peridiniopsis kevei*, and *Pleodorina indica*.
2. Well-defined and easily identified alien species that occur in only a few localities and that are not currently found in the Czech Republic; these include *Gloeotrichia echinulata*, *Planktothrix rubescens*, and *Frustulia weinholdii*.
3. Species recently described, new to the flora of the Czech Republic, and perhaps misidentified in the past; these include *Dolichospermum compactum* and *Cyclostephanos delicatus*.
4. Inconspicuous species that could have been overlooked in past; these include the small cyanobacteria *Geitleribactron periphyticum* and *Synechococcus capitatus* and the diatom *Skeletonema potamos*.
5. Species that are likely to have been misidentified because the taxonomic distinction is problematic: these include *Fragilaria reicheltii* (x *F. crotonensis*), *Ulva (intestinalis x linza x flexuosa)*, *Staurostrum manfeldii* complex (x *S. planctonicum* x *S. pingue*) and *Discostella woltereckii*.
6. The expansive species *Pediastrum simplex*; in the last 50 years, this once rare species has become one of the most common taxa of the plankton in standing waters.

The general evaluation of the groups given above indicate that the non-native species have yet to cause serious problems in the Czech Republic in that no obvious impact on the native species has been observed. In other countries, large increases in populations of the diatom *Didymosphenia geminata* have come at the expense of other species, but its distribution is only local in the Czech Republic at the present. Those invasive species with a strong tendency to form water blooms represent potential threats; however, blooming biomass has been observed only locally in *Planktothrix rubescens*. The expansive species *Pediastrum simplex* has not been observed to outcompete any native species; rather, it has integrated into the invaded community without otherwise changing its original composition.

From a human perspective, the most important dangers posed by invasive freshwater cyanobacteria and algae are the occurrences of toxic cyanobacterial species (*Planktothrix rubescens* and *Sphaerospermum aphanizomenoides*) and technological problems caused by the small cyanobacterium *Synechococcus capitatus*, which passes through the filters of waterworks (Micka and Holleová 1997). Even an anthropocentric view, however, cannot lead to the conclusion that any of these “invasions” are very dangerous.

We are not able to track the general spread of the non-native species throughout the Czech Republic. Today, species originating in the tropics can be found in the country (e.g., the cyanobacteria *Cylindrospermopsis raciborskii* and *Raphidiopsis mediterranea*; the green algae *Pleodorina indica* and *Pediastrum simplex*; and the diatom *Discostella woltereckii*), which could lead to the inference that this is evidence of or a consequence of global warming. This inference is probably incorrect because equivalent numbers or even larger numbers of species have come to the

Czech Republic from Nordic regions, or have descended from montane habitats (e.g., *Dolichospermum compactum*, *Geitleribactron periphyticum*, *Gloeotrichia echinulata*, *Planktothrix rubescens*, *Synechococcus capitatus*, and *Didymosphenia geminata*). Moreover, invasions have originated not only from the north and south but also from the east (*Anabaena bergii*, *Cuspidothrix issatschenkoi*, *Sphaerospermopsis aphanizomenoides*, and *Cyclostephanos delicatus*) and from the west (*Dolichospermum compactum* and *Actinocyclus normanii*). Other species spread as a result of other anthropogenic influences to the environment. For example, the application of salt to roads during winter or the incorrect management of industrial sewage can probably cause an expansion of halophytic species such as *Ulva flexuosa*.

Organisms can spread throughout the world in a variety of ways. Dispersal of marine organisms by solid ballast or ballast water from areas with shipping activities is quite well monitored (Mills et al. 1993; Gollasch 2006; Nicholls 2001). The situation is more complicated in the case of inland freshwater biota, in which the transport mechanisms are mostly unknown and unresearched (Kristiansen 2000).

Algae and cyanobacteria are thought to be spread by wind (e.g., Sharma et al. 2007), water, and larger organisms such as beetles, dragonflies, mammals (Kristiansen 1996), or turtles (Burgin and Renshaw 2008). However, the most important vectors are migratory water-birds, which can transport the algae to very distant places in a short time; this rapid transport is especially important for those planktonic organisms that are susceptible to desiccation (Kristiansen 2007). The vegetative stages of the organisms are likely transported in an exozoochoric manner (on feathers or legs); endozoochoric transport in the digestive system of the birds is conceivable for those algal cells with thick wall such as cysts and other dormant stages (Atkinson 1980; Kristiansen 1996; Figuerola and Green 2002; Charalambidou and Luis Santamaría 2005). It is important to note that migratory birds can transport the algae both southward and northward as they migrate between areas used for reproduction and overwintering.

The invasion by substantial numbers of alien species from the East is probably closely linked to the spread of Asian fish species in Central Europe. These fish are either intentionally introduced (silver carp *Hypophthalmichthys molitrix*, grass carp *Ctenopharyngodon*

idella) or came as invasive migrants (stone moroco *Pseudorasbora parva*). The spread of algae and cyanobacteria associated with exotic water macrophytes is not considered to be significant (Cellamare et al. 2010). The dynamics of the macrophytes is not autochthonous because their movement is mostly related to human activities (e.g., the invasion of *Elodea canadensis* into European was caused by aquarists) or to water-birds.

The direct spread of invasive algae and cyanobacteria by people has not yet been proved; still, humans are highly unpredictable vectors whose activities often correlate with algal dispersal. For example, Kristiansen (2007) noted that planktonic organisms were likely transmitted from one locality to another by poorly rinsed nets and bottles during scientific fieldwork. The spread of *Didymosphenia geminata* throughout New Zealand resulted from the transfer of boats from one drainage basin to another (Kilroy 2004).

We can also speculate that the spores of most of the invasive algae and cyanobacteria have continually been transported to the target areas, but that the organisms were able to establish only when the changing climate became suitable (Cellamare et al. 2010).

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References

- Aksenova EI (1974) Redkie predstaviteli sinezelených vodorošlej planktona nižnego Dona i Cimljanskogo vodochranilišča (Cyanophyceae rae in plankto tanaidis inferioris (Nizhnij Don) inventae. Novosti Sistematiķy Nizšich Rastenij. Nauka, Moskva, pp 76–84
- Albay M, Pokorný J (1999) Evolution of fishponds restoration project in South Bohemia (Czech Republic). J Fish Aquat Sci (special issue): 251–261
- Ali MM, Rahmatullah SM, Ahsan Bin Habib M (1986) Inter-specific correlations in some dominant species of phytoplankton. Banglad J Microbiol 3:29–36
- Ambrožová J (1999) Vliv biologického oživení údolní nádrže Janov na technologii úpravy vody. In: Pouličková A, Kočárková A (eds) Rasy a prostředí. Jola, Kostelec na Hané

- Angeler DG, Schagerl M, Coleman AW (1999) Phylogenetic relationships among isolates of *Eudorina* species (Volvocales, Chlorophyta) inferred from molecular and biochemical data. *J Phycol* 35:815–823
- Antoine SE, Bensonevans K (1983) Polymorphism and size variation in *Didymosphenia geminata* from Great Britain. *Br Phycol J* 18:199–200
- Atkinson KM (1980) Experiments in dispersal of phytoplankton by ducks. *Br Phycol J* 15:49–58
- Bailey-Watts AE, Komárek J (1991) Towards a formal description of a new species of *Synechococcus* (Cyanobacteria/Cyanophyta) from freshwater picoplankton. *Archiv für Hydrobiologie/Algal Stud* 61:5–19
- Barco M, Flores C, Rivera J, Caixach J (2004) Determination of microcystin variants and related peptides present in a water bloom of *Planktothrix* (Oscillatoria) *rubescens* in a Spanish drinking water reservoir by LC/ESI-MS. *Toxicon* 44:881–886
- Barinova SS, Anissimova OV, Nevo E, Jarygin MM, Wasser SP (2004) Diversity and ecology of algae from the Nahal Qishon river, northern Israel. *Plant Biosyst* 138:245–259
- Beket HJ (2005) Leven in de Kralingse Plas. In: <http://www.kralingen.nl/index.php?id=12>. Accessed 2005-05-01
- Belcher JH, Swale EMF (1979) English freshwater records of *Actinocyclus normanii* (Greg.) Hustedt (Bacillariophyceae). *Br Phycol J* 14:225–229
- Bílý J (1941) Příspěvek ku poznání květeny rozsivek Vysokých Tater. *Práce Moravské přírodovědecké společnosti* 13:1–12
- Blanco S, Ector L (2009) Distribution, ecology and nuisance effects of the freshwater invasive diatom *Didymosphenia geminata* (Lyngbye) M. Schmidt: a literature review. *Nova Hedwigia* 88:347–422
- Bliding C (1963) A critical survey of European taxa in Ulvales. Part I. Capsosiphon, Percusaria, Blidingia, Enteromorpha. *Opera Botanica* 8
- Borics G, Grigorszky I, Szabó S, Padišák J (1998) Phytoplankton associations in a small hypertrophic fishpond in East Hungary during a change from bottom-up to top-down control. In: 11th Workshop of the International Association of Phytoplankton Taxonomy and Ecology (IAP). Shrewsbury, England, pp 79–90
- Bormans M, Ford PW, Fabbro L (2005) Spatial and temporal variability in cyanobacterial populations controlled by physical processes. *J Plankton Res* 27:61–70
- Boudouresque CF, Verlaque M (2002) Biological pollution in the Mediterranean Sea: invasive versus introduced macrophytes. *Mar Pollut Bull* 44:32–38
- Bourke ATC, Hawes RB, Neilson A et al. (1983) An outbreak of the hepatointeritis (the Palm island mystery disease) possibly caused by algal intoxication. *Toxicon* (Suppl 3):45–48
- Bouvy M, Falcao D, Marinho M, Pagano M, Moura A (2000) Occurrence of *Cylindrospermopsis* (Cyanobacteria) in 39 Brazilian tropical reservoirs during the 1998 drought. *Aquat Microb Ecol* 23:13–27
- Bowling L (1994) Occurrence and possible causes of a severe cyanobacterial bloom in lake Cargelligo, New-South-Wales. *Aust J Mar Freshw Res* 45:737–745
- Brabez R (1941) Zur Kenntnis der Algenflora des Franzensbader und Sooser Thermenbereiches. *Botanische Zentralblatt Beiheft* A61:137–236
- Brian N (2000) Check-list of non-vascular plants of Grand Canyon National Park, Arizona. The academy of Natural Sciences of Philadelphia
- Briand JF, Robillot C, Quiblier-Lloberas C, Humbert JF, Coute A, Bernard C (2002) Environmental context of *Cylindrospermopsis raciborskii* (Cyanobacteria) blooms in a shallow pond in France. *Water Res* 36:3183–3192
- Briand JF, Lebourlanger C, Humbert JF, Bernard C, Dufour P (2004) *Cylindrospermopsis raciborskii* (Cyanobacteria) invasion at mid-latitudes: Selection, wide physiological tolerance, or global warming? *J Phycol* 40:231–238
- Brient L, Lengronne M, Bormans M, Fastner J (2008) First occurrence of *Cylindrospermopsis* in freshwater in France. *Environ Toxicol*
- Brodie JF, Maggs CA, John DM (2007) Green Seaweeds of Britain and Ireland. The British Phycological Society, London
- Burchardt L (1977) Changes in phytoplankton composition of Lake Patnowskie, receiver of heated water and waste water from sugar factory (1972/73). Adam Mickiewicz University Press, Poznań
- Bürgi H (1987) Long-term development of blue-green-algae in lake Lucerne with special reference to *Oscillatoria* (Planktothrix) *rubescens*. *Schweizerische Zeitschrift Fur Hydrologie-Swiss J Hydrol* 49:375–377
- Bürgi H, Stadelmann P (2002) Change of phytoplankton composition and biodiversity in Lake Sempach before and during restoration. *Hydrobiologia* 469:33–48
- Burgin S, Renshaw A (2008) Epizootic, algae and the Australian eastern long-necked turtle *Chelodina longicollis* (Shaw). *Am Midl Nat* 160(1):61–68
- Canadian Museum of Nature (2007) The nature of Rideau River. <http://www.nature.ca/rideau/b/b7a-e.html>. Accessed 15. February 2009
- Caraus I (2002) The algae of Romania. *Studii si Cercetari, Universitatea Bacau. Biologie* 7:1–694
- Casper SJ, Scheffler W (1990) Cyclostephanos-delicatus (Genkal) Casper et Scheffler nomb-nov from waters in the northern part of Germany. *Archiv für Protistenkunde* 138:304–312
- Celekli A, Obali O, Kulkoyluglu O (2007) The phytoplankton community (except Bacillariophyceae) of Lake Abant (Bolu, Turkey). *Turk J Bot* 31:109–124
- Cellamare M, Leitaio M, Coste M, Dutartre A, Haury J (2010) Tropical phytoplankton taxa in Aquitaine lakes (France). *Hydrobiologia* 639:129–145
- Charalambidou I, Luis Santamaría L (2005) Field evidence for the potential of waterbirds as dispersers of aquatic organisms. *Wetlands* 25(2):252–258
- Chonudomkul D, Yongmanitchai W, Theeragool G, Kawachi M, Kasai F, Kaya K, Watanabe MM (2004) Morphology, genetic diversity, temperature tolerance and toxicity of *Cylindrospermopsis raciborskii* (nostocales, cyanobacteria) strains from Thailand and Japan. *Fems Microbiol Ecol* 48:345–355
- Chow N, Umana G, Hernandez F (1994) Electron-microscope comparison of phytoplankton in bays of the Arsenal Reservoir. *Rev Biol Trop* 42:333–338
- Cirikaltindag S, Coute A, Cirik S (1992) Some uncommon cyanophyceae from the Bafa lake (Turkey). *Cryptogamie Algologie* 13:235–246

- Claus G (1961) Contribution to the knowledge of the blue-green algae of the Salzlackengebiet in Austria. *International Revue der Gesamten Hydrobiologie* 46:514–541
- Coesel PFM (1992) The *Staurastrum-manfedtii* complex (Chlorophyta, Desmidiaceae)—morphological variability and taxonomic implications. *Archiv Fur Hydrobiologie*: 69–83
- Coleman AW (2002) Comparison of *Eudorina*/*Pleodorina* ITS sequences of isolates from nature with those from experimental hybrids. *Am J Bot* 89:1523–1530
- Coste M, Boutry S, Tison-Rosebery J, Delmas F (2009) Improvements of the Biological Diatom Index (BDI): description and efficiency of the new version (BDI-2006). *Ecol Indic* 9:621–650
- Coute A, Leitaio M, Martin C (1997) First observation of the genus *Cylindrospermopsis* (Cyanophyceae, Nostocales) in France. *Cryptogamie Algologie* 18:57–70
- Cronberg G (1999) Qualitative and quantitative investigations of phytoplankton in Lake Ringsjon, Scania, Sweden. *Hydrobiologia* 404:27–40
- DAISIE (2009) DAISIE European Invasive Alien Species Gateway. In: <http://www.europe-aliens.org/>. Accessed 10 February 2009
- Day SA, Wickham RP, Entwistle TJ, Tyler PA (1995) Bibliographic check-list of non-marine algae in Australia
- Desortová B, Brandl Z (1994) Krásivka *Staurastrum* jako příčina zbarvení vody Slapské nádrže. *Sborníkvlastivědných prací z Podblanicka* 34:43–49
- Dobberfuhl DR (2003) *Cylindrospermopsis raciborskii* in three Central Florida Lakes: Population dynamics, controls, and management implications. *Lake Reserv Manag* 19:341–348
- Dokulil M, Mayer J (1996) Population dynamics and photosynthetic rates of a *Cylindrospermopsis-Limnathrix* association in a highly eutrophic urban lake, Alte Donau, Vienna, Austria. *Archiv für Hydrobiologie/Algol Stud* 83:179–195
- Dokulil MT, Teubner K (2000) Cyanobacterial dominance in lakes. *Hydrobiologia* 438:1–12
- Dokulil MT, Teubner K (2005) Do phytoplankton communities correctly track trophic changes? An assessment using directly measured and palaeolimnological data. *Freshw Biol* 50:1594–1604
- Druart JC, Briand JF (2002) First record of *Cylindrospermopsis raciborskii* (Woloszynska) Seenayya et Subba Raju (Cyanobacteria) in a lotic system in France. *Annales De Limnologie-International J Limnol* 38:339–342
- Edlund MB, Taylor CM, Schelske CL, Stoemer EF (2000) *Thalassiosira baltica* (Grunow) Ostenfeld (Bacillariophyta), a new exotic species in the Great Lakes. *Can J Fish Aquat Sci* 57:610–615
- Ersanli E, Gönül A (2006) A study on the phytoplankton of Lake Simenit, Turkey. *Cryptogamie Algologie* 27:289–305
- Ettl H, Fott B (1959) Fytoplankton údolní nádrže na Želivce. *Preslia* 31:213–246
- Fastner J, Heinze R, Humpage AR, Mischke U, Eaglesham GK, Chorus I (2003) *Cylindrospermopsis* occurrence in two German lakes and preliminary assessment of toxicity and toxin production of *Cylindrospermopsis raciborskii* (Cyanobacteria) isolates. *Toxicon* 42:313–321
- Fergusson KM, Saint CP (2003) Multiplex PCR assay for *Cylindrospermopsis raciborskii* and *cylindrospermopsis*-producing cyanobacteria. *Environ Toxicol* 18:120–125
- Figuerola J, Green AJ (2002) Dispersal of aquatic organisms by waterbirds: a review of past research and priorities for future studies. *Freshw Biol* 47:483–494
- Flagella MM, Verlaque M, Soria A, Buia MC (2007) Macroalgal survival in ballast water tanks. *Mar Pollut Bull* 54:1395–1401
- Fonseca BM, Bicudo CED (2008) Phytoplankton seasonal variation in a shallow stratified eutrophic reservoir (Garças Pond, Brazil). *Hydrobiologia* 600:267–282
- Forsell L, Pettersson K (1995) On the seasonal migration of the cyanobacterium *Gloetrichia-echinulata* in lake Erken, Sweden, and its influence on the pelagic population. *Mar Freshw Res* 46:287–293
- Gagyorová K (1993) K biologie vodárenské nádrže Kružberk. Aktuální otázky vodárenské biologie. Praha, pp 203–206
- Gágyorová K, Marvan P (2002) *Didymosphenia geminata* a *Gomphonema ventricosum* (Bacillariophyceae) v Moravskoslezských Beskydech. *Czech Phycol* 2:61–68
- Gardavský A (1989) Příspěvek A. Gardavský. *Zprávy Československé botanické společnosti* 24:71–72
- Geitler L (1932) Cyanophyceae. Rabenhorst's Kryptogamen-Flora von Deutschland, Österreich und der Schweiz. Akademische Verlagsgesellschaft, Leipzig, pp 1196
- Genkal SI (1985) Novyj vid iz roda *Stephanodiscus* EHR. (Bacillariophyta). *Species nova a genere Stephanodiscus* EHR. (Bacillariophyta). *Novosti systematiky nižších rastenij* 22:30–32
- Genkal SI (1992) Atlas diatomových vodoroslej planktona reki Volgi. *Gidrometeoizdat, Sankt Peterburg*
- Geriš R, Jahodová D (2007) Obrněnkový vegetační zákal v nádrži Vranov. *Zpravodaj Povodí Moravy* 4:11
- Gligora M, Kralj K, Plenković-Moraj A, Grigorszky I, Kiss K, Ács E, Borics G, Makk J (2006) Tekatni dinoflagelati slatkovodnih ekosustava Hrvatske. In: Besendorfer V, Klobučar GIV (eds) *Proceedings of 9. Hrvatski biološki kongres s međunarodnim sudjelovanjem, Hrvatsko biološko društvo 1885, Zagreb*, pp 151–153
- Gogorev R (2008) Check-list for Caspian Sea phytoplankton. In: *Caspian Sea Environment Program*. http://www.zin.ru/projects/caspidiv/caspian_phytoplankton.html. Accessed 12 February 2009
- Gollasch S (2006) Overview on introduced aquatic species in European navigational and adjacent waters. *Helgol Mar Res* 60(2):84–89
- Gonulol AOO (1998) Seasonal variations of phytoplankton blooms in Suat Ugurlu (Samsun–Turkey). *Turk J Bot* 22:93–97
- Grach-Pogrebinsky O, Sedmak B, Carmeli S (2003) Protease inhibitors from a Slovenian Lake Bled toxic waterbloom of the cyanobacterium *Planktothrix rubescens*. *Tetraedron* 59:8329–8336
- Grigorszky I, Vasas F, Borics G, Klee R, Schmidt A, Borbély G (2001) *Peridiniopsis kevei* sp. nov., a new freshwater dinoflagellate species (Peridiniaceae, Dinophyta) from Hungary. *Acta Botanica Hungarica* 43(1–2):163–174
- Gromov BV, Vepritsky AA, Mamkaeva KA, Voloshko LN (1996) A survey of toxicity of cyanobacterial blooms in Lake Ladoga and adjacent water bodies. In: 1st

- international Lake Ladoga symposium on ecological problems of Lake Ladoga. St Petersburg, Russia, pp 149–151
- Håkansson H, Kling H (1990) The current status of some very small freshwater diatoms of the genera *Stephanodiscus* and *Cyclostephanos*. *Diatom Res* 5:273–287
- Hällfors G (2004) Check list of Baltic Sea Phytoplankton Species. Helsinki Commission, Baltic Marine Environment Protection Commission, Helsinki
- Hamar J (1977) Data of knowledge of the blue-green alga *Anabaenopsis raciborskii* Wolosz. *Tiscia* 12:17–20
- Hamed AF (2008) Biodiversity and distribution of blue-green algae/cyanobacteria and diatoms in some of the Egyptian water habitats in relation to conductivity. *Aust J Basic Appl Sc* 2:1–21
- Hamilton PB, Ley LM, Dean S, Pick FR (2005) The occurrence of the cyanobacterium *Cylindrospermopsis raciborskii* in Constance Lake: an exotic cyanoprokaryote new to Canada. *Phycologia* 44:17–25
- Hansen G, Flaim G (2007) Dinoflagellates of the Trentino Province, Italy. *J Limnol* 66:107–141
- Hansgirg A (1889) *Prodromus českých řas sladkovodních, díl první*. Fr. Řivnác—E. Grégr, Praha
- Happeywood CM (1991) Temporal and spatial patterns in the distribution and abundance of pico, nano and micro-phytoplakton in an upland lake. *Freshw Biol* 26:453–480
- Harper MA (1994) Did Europeans introduce *Asterionella formosa* Hassall to New Zealand? In: Kociolek P (ed) 11th international diatom symposium. *Memoirs of the Californian Academy of Sciences*, pp 479–485
- Hasle GR (1977) Morphology and taxonomy of *Actinocyclus normanii* f. subsals (Bacillariophyceae). *Phycologia* 16:321–328
- Hasle GR, Evensen DL (1976) Brackish water and freshwater species of diatom genus *Skeletonema*. 2. *Skeletonema potamos* comb. nov. *J Phycol* 12:73–82
- Hawes I, Howardwilliams C, Wells R, Clayton J (1991) Invasion of water net, *Hydrodictyon reticulatum*—the surprising success of an aquatic plant new to our flora. *NZ J Mar Freshw Res* 25:227–229
- Haworth EY, Hurley MA (1984) Comparison of the stelligeroid taxa of the centric diatom genus *Cyclotella*. In: Ricard M (ed) 8th international diatom symposium. O. Koeltz, Paris, pp 43–58
- Herodek S, Voros L, Toth F (1982) The mass, production of phytoplankton, the eutrophication in Lake Balaton III. The Balatonszemes basin in 1976–1977 and the Siofok basin in 1977. *Hidrológiai Közlöny* 62:220–229
- Heteša J (1962) Rozvoj fytoplanktonu Hlohoveckého rybníka v letech 1954–55. *Sborník VŠCHT* 6:407–428
- Heteša J, Sukop I (1998) Hydrobiologický průzkum a sledování sukcese na lokalitách Podešovky I a II v Horním lese v návaznosti na realizovanou revitalizační opatření. LIMNI, s.r.o., Brno, Lednice
- Heteša J, Sukop I (2001) Hydrobiologický průzkum a sledování sukcese na lokalitách v Horním lese v návaznosti na realizovanou revitalizační opatření. LIMNI, s.r.o., Brno, Lednice
- Hickel B (1982) A helical, bloom-forming *Anabaena*-like blue-green-alga (Cyanophyta) from hypertrophic lakes. *Archiv für Hydrobiologie* 95:115–124
- Hickel B (1985) Observations on *Anabaena compacta* (Nyg-aard) nov. comb. (Cyanophyta) with helical, planctonic filaments and macroscopical aggregates. *Archiv für Hydrobiologie/Algol Stud* 38(39):269–270
- Hill H (1970) A new form of *Raphidiopsis mediterranea* Skuja found in Minnesota lakes. *Phycologia* 9:73
- Hill BH, Herlihy AT, Kaufmann PR, DeCelles SJ, Van der Borgh MA (2003) Assessment of streams of the eastern United States using a periphyton index of biotic integrity. *Ecol Indic* 2:325–338
- Hindák F (1988) Planktic species of two related genera *Cylindrospermopsis* and *Anabaenopsis* from western Slovakia. *Archiv für Hydrobiologie/Algol Stud* 50–53:283–302
- Hindák F (1992) Several interesting planktic Cyanophytes. *Archiv für Hydrobiologie/Algol Stud* 66:1–15
- Hindák F (2000) Morphological variation of four planktic nostocalean cyanophytes—members of the genus *Aphanizomenon* or *Anabaena*? *Hydrobiologia* 438:107–116
- Hindák F (2005) Zelené kokálne riasy (Chlorococcales, Chlorophyceae). CD, ISBN 80-969265-1-9, Slovenská vodohospodárska spoločnosť ZSVTS pri VÚVH, Bratislava
- Hindák F (2008) *Colour Atlas of Cyanophytes*. VEDA, Bratislava, 256 p
- Hindák F, Hindáková A (1996) Rozsievková flóra štyroch štrkoviskových jazier v Bratislave. *Bulletín Slovenskej Botanickej Spoločnosti, Bratislava* 18:23–27
- Hindák F, Hindáková A (1997a) Druhové zloženie fytoplanktónu slovenského úseku rieky Moravy. *Bulletín Slovenskej Botanickej Spoločnosti, Bratislava* 19:89–95
- Hindák F, Hindáková A (1997b) Sinice a riasy inundačných jazier Stará Morava v Devíne. In: Feráková V (ed) *Flóra, geológia a paleontológia Národnej prírodnej rezervácie Devínska Kobyla*. APOP, Bratislava, pp 36–57
- Hindák F, Hindáková A (1998) Druhové zloženie fytoplanktónu dvoch vodných nádrží pri Mochovciach. *Bulletín Slovenskej Botanickej Spoločnosti, Bratislava* 20:1–6
- Hindák F, Hindáková A (2000) Checklist of the cyanophytes/cyanobacteria and algae of the Slovak stretch of the Danube river. *Biologia, Bratislava* 55: 7–34
- Hindák F, Hindáková A (2001) Invázne cyanobaktérie a riasy. *Životné prostredie* 35:93–95
- Hindák F, Hindáková A (2002) Cyanobaktérie a riasy štrkoviskových jazier v Rusovciach a Čunove v Bratislave. *Bulletín Slovenskej Botanickej Spoločnosti, Bratislava* 24:7–13
- Hindák F, Hindáková A (2003) Cyanobaktérie a riasy štrkoviskových jazier Veľký Draždiak a Malý Draždiak v Petržalke (Bratislava, západné Slovensko). *Bulletín Slovenskej Botanickej Spoločnosti, Bratislava* 23:7–15
- Hindák F, Hindáková A (2004) Diverzita fytoplanktónu rieky Moravy a Dunaja v Bratislave r. 2003. *Bulletín Slovenskej Botanickej Spoločnosti, Bratislava* 26:9–17
- Hindák F, Hindáková A, Makovinská J, et al. (1999) Druhové zloženie a biomasa fytoplanktónu rieky Váh. *Bulletín Slovenskej Botanickej Spoločnosti, Bratislava* 20:7–14
- Hindák F, Hindáková A, Makovinská J, Tóthová L, Elexová E (2002) Biodiverzita a biomasa fytoplanktónu rieky Ipľ v r. 1992–2001. *Bulletín Slovenskej Botanickej Spoločnosti, Bratislava* 24:15–24

- Hindák F, Hindáková A, Marvan P, Heteša J, Hašler P (2006) Diversity, abundance and volume biomass of the phytoplankton of the Morava River (Czech Republic, Slovakia) and the Dyje River (Czech Republic) in November 2005. *Czech Phycology*, Olomouc, 6:77–97
- Hindáková A (1994) Planktic diatoms of the river Morava at Bratislava-Devín, Slovakia. *Ekológia (Suppl 1)*:37–42
- Hindáková A (1997) Rozsievková flóra štyroch lesných rybníkov na Železnej Studienke v Bratislave. *Bulletín Slovenskej Botanickéj Spoločnosti*, Bratislava 19:86–89
- Hindáková A (2001) K problematike expanzívneho šírenia rozsievok na Slovensku. *Hydrobiologický kurz*. Rajčské Teplice, pp 14–19
- Hirose H, Hirano M (1981) Class Cyanophyceae. In: Hirose H, Yamagishi T (eds) *Illustrations of the Japanese fresh-water algae*, 2nd edn. Uchida Rokahuho Publ. Co., Tokyo, p 151
- Hollerbach MM, Kosinskaja EK, Poljanskij VI (1953) Sinezelenye vodorosli. *Sovetskaja Nauka*, Moskva
- Horecká M, Komárek J (1979) Taxonomic position of three planktonic blue-green algae from the genera *Aphanizomenon* and *Cylindrospermopsis*. *Preslia* 51:289–312
- Houk V, Marvan P (1993) Klíč k určování našich centrických rozsievok. *Národní ústav hygieny a epidemiologie*, Bratislava
- Hubáčková J, Sládečková A (2001) Realizace výsledků aplikovaného výzkumu při optimalizaci a inovaci vodárenských technologií. *Využití nových technologií na úpravách vod*. Jihlava, pp 29–35
- Hübener T (1999) Morphology and ultrastructure of a population of *Cyclotella wolkowii* Hustedt (Bacillariophyceae) in Northern Germany. *Nova Hedwigia* 68:469–476
- Hughes JE, Deegan LA, Peterson BJ, Holmer RM, Fry B (2000) Nitrogen flow through the food web in the oligohaline zone of a new England estuary. *Ecology* 81:433–452
- Hustedt F (1930) *Bacillariophyta (Diatomeae)*. Gustav Fischer, Jena
- Hustedt F (1942) Süßwasserdiatomeen des indomalayischen Archipels und der Hawaii-Inseln. *Int Rev Gesamten Hydrobiol* 42:1–252
- IUCN—Global Invasive Species Database (2009) In www.issg.org/database/welcome Accessed 10 February 2009
- Iyengar MOP (1933) Contributions to our knowledge of the colonial Volvocales of South India. *J Linn Soc Bot* 49:323–373
- Jablonskaja EA (1971) Pitanie donnych bespozvonočnych i trofičeskaja struktura bentosa morej Kaspijskovo, Azovskovo i Aralskovo. *Naučnyj otčet po teme No.13 „Is-polzovanie kormovyh resursov i trofičeskoje svjazy v južnyh morjach”*. VHIRO, Moscow, pp. 3-44
- Jacobsen BA (1993) Bloom formation of *Gloeotrichia echinulata* and *Aphanizomenon flos-aquae* in a shallow, eutrophic, Danish lake. 9th Workshop of the International-Association-for-Phytoplankton-Taxonomy-and-Ecology. Mont Rigi, Belgium, pp 193–197
- Jacquet S, Briand JF, Lebourlanger C, Avois-Jacquet C, Oberhaus L, Tassin B, Vincon-Leite B, Paolini G, Druart JC, Anneville O, Humbert JF (2005) The proliferation of the toxic cyanobacterium *Planktothrix rubescens* following restoration of the largest natural French lake (Lac du Bourget). *Harmful Algae* 4:651–672
- Jann-Para G, Schwob I, Feuillade M (2004) Occurrence of toxic *Planktothrix rubescens* blooms in lake Nantua, France. *Toxicon* 43:279–285
- Janse I, Kardinaal WEA, Kamst-van Agterveld M, Meima M, Visser PM, Zwart G (2005) Contrasting microcystin production and cyanobacterial population dynamics in two *Planktothrix*-dominated freshwater lakes. *Environ Microbiol* 7:1514–1524
- Johansen JR, Lowe RL, Carty S, Fucikova K, Olsen CE, Fitzpatrick MH, Ress JA, Furey PC (2007) New algal species records for Great Smoky Mountains National Park, with an annotated checklist of all reported algal taxa for the park. *Southeast Nat* 6:99–134
- John DM, Whitton BA, Brook AJ (2002) *The freshwater algal flora of the British Isles*. Cambridge University Press, Cambridge
- Kasperovičienė J, Koreviene J, Paskauskas R (2005) Cyanoprokaryotes and microcystins dynamics in shallow hypertrophic lake (South-eastern Lithuania). *Oceanol Hydrobiol Stud* 34:93–104
- Kaštovský J (2006) *Pleodorina indica* (Iyengar) Nozaki 1989. In: Mlíkovský J, Stýblo P (eds) *Nepůvodní druhy fauny a flóry České Republiky*. ČSOP, Praha, pp 17–18
- Kaštovský J, Heteša J, Komárek J (2006a) *Enteromorpha linza* (Linnaeus) Agardh 1883. In: Mlíkovský J, Stýblo P et al (eds) *Nepůvodní druhy fauny a flóry České Republiky*. ČSOP, Praha, p 16
- Kaštovský J, Komárek J, Zapomělová E (2006b) *Pediastrum simplex* Meyen 1829. In: Mlíkovský J, Stýblo P (eds) *Nepůvodní druhy fauny a flóry České Republiky*. ČSOP, Praha, pp 16–17
- Kawecka B, Sanecka J (2003) *Didymosphenia geminata* in running waters of southern Poland—symptoms of change in water quality? *Hydrobiologia* 495:193–201
- Keršner V (1997) Two rare planktic cyanophytes from Southern Moravia (Czech Republic). *Biologia* 52:485–488
- Kilroy C (2004) A new alien diatom *Didymosphenia geminata* (Lyngbye) Schmidt: its biology, distribution, effects and potential risks for New Zealand fresh waters. NIWA Client Report. National Institute of Water and Atmospheric Research, New Zealand, pp 34
- Kirkwood AE, Shea T, Jackson L, McCauley E (2007) *Didymosphenia geminata* in two Alberta headwater rivers: an emerging invasive species that challenges conventional views on algal bloom development. *Can J Fish Aquat Sci* 64:1703–1709
- Kiss KT, Le Cohu R, Coste M, Genkal SI, Houk V (1990) *Actinocyclus normanii* (Bacillariophyceae) in some rivers and lakes in Europe. Morphological examinations and quantitative relations. In: Ricard M (ed) *Ouvrage dédié à H. Germain*. Koeltz, Königstein, pp 111–123
- Kiss KT, Ács É, Kovács A (1993) Ecological observation on *Skeletonema potamos* (Weber) Hasle in the River Danube, near Budapest (1991–92, daily investigations). 9th Workshop of the International-Association-for-Phytoplankton-Taxonomy-and-Ecology. Mont Rigi, Belgium, pp 163–170
- Klee R, Houk V (1996) Morphology and ultrastructure of *Cyclotella wolkowii* HUSTEDT (Bacillariophyceae). *Archiv für Protistenkunde* 147:19–27

- Kling HJ (2009) *Cylindrospermopsis raciborskii* (Nostocales, Cyanobacteria): A brief historic overview and recent discovery in the Assiniboine River (Canada). *Fottea* 9:45–47
- Koeman RPT, van den Hoek C (1984) The taxonomy of Enteromorpha Link, 1820, (Chlorophyceae) in The Netherlands I. The sections Flexuosae and Clathratae and an addition to the section Proliferae. *Cryptogamie Algologie* 5:21–61
- Kohler J, Nixdorf B, Hoeg S (1993) Lake Muggelsee and the inflowing river Spree—comparison of phytoplankton communities 1980–1990. *Int Rev Gesamten Hydrobiol* 78:345–358
- Kokociński M, Dziga D, Spoof L, Stefaniak K, Jurczak T, Mankiewicz-Boczek J, Meriluoto J (2009) First report of the cyanobacterial toxin cylindrospermopsin in the shallow, eutrophic lakes of western Poland. *Chemosphere* 74:669–675
- Komárek J (1958) Die taxonomische Revision der planktischen Blaualgen der Tschechoslowakei. In: Komárek J, Ettl H (eds) *Algologische Studien*. Nakladatekství ČSAV, Praha, pp 10–206
- Komárek J (2005) Studies on the cyanophytes (Cyanobacteria, cyanoprokaryota) of Cuba 11. Freshwater *Anabaena* species. *Preslia* 77:211–234
- Komárek J, Anagnostidis K (1998) *Cyanoprokaryota*, 1. Teil/ 1st Part: Chroococcales. Gustav Fischer, Jena
- Komárek J, Anagnostidis K (2005) *Cyanoprokaryota*, 2. Teil/ 2nd Part: Oscillatoriales. Elsevier/Spektrum Akademischer Verlag, München
- Komárek J, Jankovská V (2001) Review of the Green Algal Genus *Pediastrum*; Implication for Pollen-Analytical Research. *Bibliotheca Phycologica* 108:1–127
- Komárek J, Komárková J (2003) Phenotype diversity of the cyanoprokaryotic genus *Cylindrospermopsis* (Nostocales); review 2003. *Czech Phycol* 3:1–30
- Komárek J, Kling H, Komárková J (2003) Filamentous Cyanobacteria. In: Wehr J, Sheath RG (eds) *Freshwater algae of North America*. Academic Press, San Diego, pp 117–196
- Komárková J (2000) *Pikoplankton, jeho koloniální formace a koncentrace celkového chlorofylu v nádržích Slapy a Římov*. XII. společná konference ČLS a SLS. Česká limnologická společnost, Kouty
- Kondratieva N (1968) Sino-zeleni vodorosti-Cyanophyta. *Viznachnik Prissnodnykh Vodorostej Ukr. RSR*, Kyiv 1/ 2:1–388
- Kopp R (2006) Phytoplankton of the Zámecký Pond. *Czech Phycol* 6:111–125
- Korneva LG (2001) On the distribution patterns and dispersal of *Actinocyclus normanii* (Greg.) Hust. emend. Genkal et Korneva (Bacillariophyta) in the reservoirs of the Volga River Basin. *Int J Algae* 5:1–10
- Kowalski W (1975) Occurrence of the species of a marine green alga Enteromorpha Link (1820) in the Szczecin Pomerania inland waters. *Fragm Flor et Geobot* 21:527–536
- Krammer K, Lange-Bertalot H (1991) *Bacillariophyceae*. 3. Teil: Centrales, Fragilariaceae, Eunotiaceae. Gustav Fischer, Stuttgart
- Krammer K, Lange-Bertalot H (1997) *Bacillariophyceae*. 1. Teil: Naviculaceae. Gustav Fischer, Stuttgart
- Krienitz L, Hegewald E (1996) Über das Vorkommen von wärmeliebenden Blaualgenarten in einem norddeutschen Gewässer. *Lauterbornia* 26:55–63
- Kristiansen J (1996) Dispersal of freshwater algae—a review. *Hydrobiologia* 336:151–157
- Kristiansen J (2000) Cosmopolitan chrysophytes. *Syst Geogr Pl* 70:291–300
- Kristiansen J (2007) Dispersal and biogeography of silica-scaled chrysophytes *Biodivers Conserv* (2008) 17:419–426
- Krupa D, Czernaś K (2003) Mass appearance of cyanobacterium *Planktothrix rubescens* in Lake Piaseczno, Poland. *Water Qual Res J Can* 38:141–152
- Kusber W-H, Jahn R (2000) Algen im Teltowkanal, Berlin-Treptow, am GEO-Tag der Artenvielfalt, 2. & 3. Juni 2000. In: <http://www.bgbm.org/jahn/GEO-Tag/Algen.htm>. Accessed 16 March 2009
- Kusel-Fetzmann E. (1998) *Das Phytoplankton*. WUV. Universitätsverlag der Hochschülerschaft and der Universität Sien Ges.m.b.H, Sien
- Kützing FT (1849) *Species algarum*. F.A. Brockhaus, Leipzig
- Lagos N (1998) Microalgal blooms: a global issue with negative impact in Chile. *Biol Res* 31:375–386
- Lange-Bertalot H (2001) *Navicula sensu stricto*, 10 Genera Separated from *Navicula sensu lato*, *Frustulia*. A.R. Gantner Verlag, Vaduz
- Laugaste R, Lessok K (2004) Planktonic algae and epiphyton of the littoral in Lake Peipsi, Estonia. *Limnologia* 34:90–97
- Lederer F, Gardavský A, Lukešová A, Kubečková K, Čápková R, Lodrová E, Trojánková K (1998) Biodiverzita a ekologie sinic a řas minerálních pramenů a rašelinišť na území NPR Soos a v okolí Františkových Lázní a Mariánských Lázní. In: Lederer F and Chocholoušková Z (eds) *Sborník katedry biologie PeF ZČU. Plzeň*, pp 68–107
- Legnani E, Copetti D, Oggioni A, Tartari G, Palumbo MT, Morabito G (2005) *Planktothrix rubescens* seasonal dynamics and vertical distribution in Lake Pusiano (North Italy). *J Limnol* 64:61–73
- Lenzenweger R (1996) *Desmidiaceenflora von Österreich*, Teil 1. J. Cramer, Berlin
- Li RH, Carmichael WW, Pereira P (2003) Morphological and 16S rRNA gene evidence for reclassification of the paralytic shellfish toxin producing *Aphanizomenon flos-aquae* LMECYA 31 as *Aphanizomenon issatschenkoi* (Cyanophyceae). *J Phycol* 39:814–818
- Li R, Wilhelm SW, Carmichael WW, Watanabe MM (2008) Polyphasic characterization of water bloom forming *Raphidiopsis* species (cyanobacteria) from central China. *Harmful Algae* 7:146–153
- Lin CK, Blum JL (1977) Recent invasion of a red alga (*Bangia atropurpurea*) in Lake-Michigan. *J Fish Res Board Can* 34:2413–2416
- Liukkonen M, Kairesalo T, Haworth EY (1997) Changes in the diatom community, including the appearance of *Actinocyclus normanii* f. subsalsus, during the biomanipulation of Lake Vesijärvi, Finland. *Eur J Phycol* 32:353–361
- Lopez-Archilla AI, Moreira D, Lopez-Garcia P, Guerrero C (2004) Phytoplankton diversity and cyanobacterial dominance in a hypereutrophic shallow lake with biologically produced alkaline pH. *Extremophiles* 8:109–115

- Lougheed VL, Stevenson RJ (2004) Exotic marine macroalga (*Enteromorpha flexuosa*) reaches bloom proportions in a coastal lake of Lake Michigan. *J Great Lakes Res* 30:538–544
- Luther H (1979) *Chara connivens* in the Baltic sea area. *Annales Botanici Fennici* 16:141–150
- Makovinská J, László F, Gulyás P, Elexová E, Hock B, Csányi B, Tevané-Bartalis É, Horváth L, Hizsniak G (2003) Trends and dynamics of water quality changes of the river Danube and its tributaries. *Práce a štúdie VÚVH Bratislava* 148:1–61 + annex 1–12
- Maršálek B, Keršner V, Marvan P (1996) *Vodní květy sinic. Nadatio flos-aquae*, Brno
- Maršálek B, Bláha L, Hindák F (2000) Review of toxicity of cyanobacteria in Slovakia. *Biologia* 55:645–652
- Marvan P, Hindák F (1989) Morphologische Variabilität von *Centronella reicheltii* (Bacillariophyceae) aus der West-slowakei. *Preslia* 61:1–14
- Marvan P, Komárek J (1978) Algal populations related to different macrophyte communities. *Archiv für Hydrobiologie/Algol Stud* 28:65–95
- Marvan P, Keršner V, Komárek J (1997) Invazní sinice a řasy. In: Pyšek P, Prach K (eds) *Invazní rostliny v české flóře. Česká botanická společnost, Praha*, pp 13–19
- Marvan P, Heteša J, Hindák F, Hindáková A (2004) Phytoplankton of the Morava river (Czech Republic, Slovakia): past and present. *Oceanol Hydrobiol Stud Gdańsk* 33(4):42–60
- Mayer J, Dokulil MT, Salbrechter M, Berger M, Posch T, Pfister G, Kirschner AKT, Velimirov B, Steitz A, Ulbricht T (1997) Seasonal successions and trophic relations between phytoplankton, zooplankton, ciliate and bacteria in a hypertrophic shallow lake in Vienna, Austria. *Hydrobiologia* 342:165–174
- Mercado LM (2003) A comparative analysis of the phytoplankton from six pampean lotic systems (Buenos Aires, Argentina). *Hydrobiologia* 495:103–117
- Micka J, Holleová J (1997) Biologické problémy při úpravě vody z nádrže Janov. Aktuální otázky vodárenské biologie. Praha, pp 45–48
- Mikheeva TM, Genkal SI (2006) The invasion of *Cyclotella comensis* Grun. (Bacillariophyta) in the Lake Naroch (Belarus) ecosystem during de-eutrophication. *Int J Algae* 8:243–254
- Mills EL, Leach JH, Carlton JT, Secor CL (1993) Exotic species in the Great Lakes—a history of biotic crises and anthropogenic introductions. *J Great Lakes Res* 19(1):1–54
- Mineur F, Johnson MP, Maggs CA (2008) Macroalgal introductions by hull fouling on recreational vessels: seaweeds and sailors. *Environ Manag* 42:667–676
- Mischke U (2003) Cyanobacteria associations in shallow polytrophic lakes: influence of environmental factors. *Acta Oecologica-Int J Ecol* 24:S11–S23
- Mitiska J (1962) An investigation of the Jordán Reservoirs, Bohemia. *Sborník VŠCHT, Technologie vody. VŠCHT, Praha*, pp 437–485
- Mohamed ZA (2007) First report of toxic *Cylindrospermopsis raciborskii* and *Raphidiopsis mediterranea* (Cyanoprokaryota) in Egyptian fresh waters. *Fems Microbiol Ecol* 59:749–761
- Molica R, Onodera H, Garcia C, Rivas M, Andrinolo D, Nascimento S, Meguro H, Oshima Y, Azevedo S, Lagos N (2002) Toxins in the freshwater cyanobacterium *Cylindrospermopsis raciborskii* (Cyanophyceae) isolated from Tabocas reservoir in Caruaru, Brazil, including demonstration of a new saxitoxin analogue. *Phycologia* 41:606–611
- Morton A (2003) DMAP—distribution mapping software. 7.2 edn., Winkfield, UK
- Mpawenayo B, Mathooko JM (2005) The structure of diatom assemblages associated with *Cladophora* and sediments in a highland stream in Kenya. *Hydrobiologia* 544:55–67
- Nave J (1863) *Algen Mährens und Schlesiens. Verh Nat Ver Brunn* 2:15–58
- Nguyen LTT, Cronberg G, Larsen J, Moestrup O (2007) Planktic cyanobacteria from freshwater localities in Thuathien-Hue Province, Vietnam. I. Morphology and distribution. *Nova Hedwigia* 85:1–34
- Ní Chatháin B, Harrington TJ, McCarthy J, Kellyquinn M, Bradley C, Baars JR (2004) Preliminary results from the investigation of benthic diatoms from potential reference river sites in Ireland. *Oceanol Hydrobiol Stud* 33:3–15
- Nicholls KH (2001) New and little known *Mallomonas* (Synurophyceae) taxa from Ontario, Canada. *Nord J Bot* 21:551–560
- Nixdorf B, Rucker J (2004) Die Burgunderblutalge *Planktothrix rubescens* in Schleswig-Holstein- Erste Untersuchungen an drei ausgewählten Seen. In: Rucker J, Nixdorf B (eds) *Gewasserreport. BTU, Cottbus*, pp 61–81
- Nygaard G (1949) Hydrobiological studies on some Danish ponds and lakes. I Kommission hos ejnar Munksgaard, Copenhagen
- Onderíková V (1995) *Atlas vodných organizmov zdrže Hrušov—Gabčíkovo. Hydrotechnológia, Bratislava*
- Orlova MI, Rusakova OM (1999) Characteristics of coastal phytoplankton near Cape Tastubec (northern Aral Sea), September 1993. *Int J Salt Lake Res* 8:7–18
- Owsianny PM, Grabowska M (2009) Bruznice Wigier i zbiorników przyległych—gatunki nowe, rzadkie, inwazyjne. In: http://www.wigry.win.pl/konferencja_wodna/Owsianny.pdf. Accessed: 200–10-26 2009
- Padisák J (1991) Occurrence of *Anabaenopsis raciborskii* Wołosz. in the pond Tumulom near Sopron, Hungary. *Acta Botanica Hungarica* 36:163–165
- Padisák J (1997) *Cylindrospermopsis raciborskii* (Wołoszyska) Seenayya et Subba Raju, an expanding, highly adaptive cyanobacterium: worldwide distribution and a review of this ecology. *Archiv für Hydrobiologie/Monogr Stud* 4:563–593
- Padisák J, Kovács A (1997) *Anabaena compacta* (Nygaard) Hickel—a new blue green algal species in the sediments and plankton of lake Balaton. *Hidrológiai Közlöny* 77:29–32
- Pankow H (1976) *Algenflora der Ostsee. Gustav Fischer Verlag, Stuttgart*
- Pascher A (1906) *Neuer Beitrag zur Algenflora des südlichen Böhmerwaldes. Lotos, Prag* 54:1–36
- Patrick R (1994) *Rivers of the United States. John Wiley, Somers*
- Pawlik-Skowrońska B, Skowronski T, Pirszel J, Adamczyk A (2004) Relationship between cyanobacterial bloom

- composition and anatoxin-A and microcystin occurrence in the eutrophic dam reservoir (SE Poland). *Pol J Ecol* 52:479–490
- Pelechaty M, Owsianny PM (2003) Horizontal distribution of phytoplankton as related to the spatial heterogeneity of a lake—a case study from two lakes of the Wielkopolski National Park (western Poland). *Hydrobiologia* 510:195–205
- Perman J, Lhotský O (1963) Über das Vorkommen von Wasserblüten in einigen Wasserbuken Nordböhmens. *Sborník VŠCHT, Technologie vody. VŠCHT, Praha*, pp 305–327
- Piazzi L, Balata D, Cinelli F (2007) Invasions of alien macroalgae in Mediterranean coralligenous assemblages. *Cryptogamie Algologie* 28:289–301
- Potapova M, Charles DF (2007) Diatom metrics for monitoring eutrophication in rivers of the United States. *Ecol Indic* 7:48–70
- Pouličková A, Lhotský O, Dřímlová D (2004) Prodrómus sinic a řas České republiky. *Czech Phycol* 4:19–34
- Proškina-Lavrenko AI, Makarova IV (1968) Vodorosli planktona Kaspijského morja. Nauka, Leningrad
- Protist Information Server (2009) *Pediastrum simplex*. <http://protist.i.hosei.ac.jp/PDB/Images/Chlorophyta/Pediastrum/simplex/index.html>. Accessed 12 February 2009
- Rajaniemi P, Hrouzek P, Kaštovská K, Willame R, Rantala A, Hoffmann L, Komárek J, Sivonen K (2005a) Phylogenetic and morphological evaluation of the genera *Anabaena*, *Aphanizomenon*, *Trichormus* and *Nostoc* (Nostocales, Cyanobacteria). *Int J Syst Evol Microbiol* 55:11–26
- Rajaniemi P, Komárek J, Willame R, Hrouzek P, Kaštovská K, Hoffmann L, Sivonen K (2005b) Taxonomic consequences from combined molecular and phenotype evaluation of selected *Anabaena* and *Aphanizomenon* strains. *Archiv für Hydrobiologie/Algol Stud* 117:371–391
- Rakaj M, Hindák F, Hindáková A (2000) Phytoplankton species diversity of the Albanian part of Lake Shkodra in 1998–1999. *Biologia* 55:329–342
- Rashid MM (2009) Some additional information on limnology and fisheries of Lakes Nasser (Egypt) and Nubia (Sudan). In: FAO. <http://www.fao.org/docrep/008/v6455e/v6455e05.htm>. Accessed: 2009-02-18
- Ratnasabapathy M, Deason TR (1977) Phytoplankton of the Black Warrior River, Alabama. *Phytologia* 37:1–22
- Romo S, Miracle MR (1994) Population-dynamics and ecology of subdominant phytoplankton species in a shallow hypertrophic lake (Albufera of Valencia, Spain). *Hydrobiologia* 273:37–56
- Rott E, Binder N (2002) 16. Treffen Deutschsprachiger Diatomologen mit internationaler Beteiligung, 15–17, März 2002, Innsbruck. Kurzfassungen der Vorträge und Poster. 16. Treffen Deutschsprachiger Diatomologen. Institute für Botanik, Universität Innsbruck, Innsbruck, pp 75
- Sabour B, Loudiki M, Oudra B, Vasconcelos V, Oubraim S, Fawzi B (2005) Contributed article dynamics and toxicity of *Anabaena aphanizomenoides* (Cyanobacteria) waterblooms in the shallow brackish Oued Mellah lake (Morocco). *Aquat Ecosyst Health Manag* 8:95–104
- Saker ML, Nogueira ICG, Vasconcelos VM, Neilan BA, Eaglesham GK, Pereira P (2003) First report and toxicological assessment of the cyanobacterium *Cylindrospermopsis raciborskii* from Portuguese freshwaters. *Ecotoxicol Environ Saf* 55:243–250
- Salmasso N (2002) *Fitoplankton*. In: http://www.bio.unipd.it/limno/informa/infoEcol/immagini_fitoplankton.htm. Accessed: 2009-02-18
- Salmasso N (2003) Life strategies, dominance patterns and mechanisms promoting species coexistence in phytoplankton communities along complex environmental gradients. *Hydrobiologia* 502:13–36
- Schembri MA, Neilan BA, Saint CP (2001) Identification of genes implicated in toxin production in the cyanobacterium *Cylindrospermopsis raciborskii*. *Environ Toxicol* 16:413–421
- Schmidt AMM (1977) Adatok dél-magyarországi vizek algáinak ismeretéhez I. (Contribution to the knowledge about the algae of water of southern Hungary I.). *Botanikai Közlemények Budapest* 64:183–195
- Schmidt AMM (1997) Intracolonial variation of the tripolar pennate diatom “*Centronella reicheltii*” in culture: Strategies of reversion to the bipolar *Fragilaria*-form. *Nova Hedwigia* 65:27–45
- Schmidt W, Willmitzer H, Bornmann K, Pietsch J (2002) Production of drinking water from raw water containing cyanobacteria—Pilot plant studies for assessing the risk of microcystin breakthrough. *Environ Toxicol* 17:375–385
- Sharma NK, Rai AK, Singh S, Brown RM (2007) Airborne algae: their present status and relevance. *J Phycol* 43(4):615–627
- Sherbot DMJ, Bothwell ML (1993) *Didymosphenia geminata* (Gomphonemaceae). A review of the ecology of *D. geminata* and the physicochemical characteristics of endemic catchments on Vancouver Island. National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchewan
- Siemińska J (1964) *Bacillariophyceae—Okrzemki*. Państwowe wydawnictwo naukowe, Warszawa
- Sitkowska M (1999) *Dwa nowe stanowiska Enteromorpha flexuosa* subsp. *pilifera* (Chlorophyta) w Polsce. *Fragm. Flor. Geobot. Ser. Polonica* 6:301–304
- Skácelová O (2004) *Flóra sinic a řas tůní v inundačních pásmech řek*. Faculty of Biological Sciences. University of South Bohemia, České Budějovice, pp 143
- Skácelová O, Marvan P (1991) A comparative study of the past and present diatom flora of South-Moravian saline habitats. *Acta Musei Moraviae—Scientiae Naturae* 73:133–143
- Skuja H (1937) *Süßwasseralgen aus Griechenland und Kleinasien*. *Hedwigia* 77:15–70
- Skulberg OM, Carmichel WE, Codd GA, Skulberg R (1993) Taxonomy of toxic Cyanophyceae (Cyanobacteria). In: Falconer IR (ed) *Algal toxin in seafood and drinking water*. Academic Press, London, pp 145–164
- Sládečková A (2005) Problematika vzdušné kontaminace vodárenských objektů. *VODA—Zlín*. Zlín, pp 53–61
- Sládečková A, Bernard M (1987) Znečištění a eutrofizace štěrkovitě Kvasice. Aktuální otázky vodárenské biologie. Praha, pp 93–110
- Sládečková-Vinníková A (1957) Fytoplankton dvou severočeských rybníků. *Preslia* 29:320–329
- Sládečková-Vinníková A (1958) Ein Beitrag zur Hydrobiologie des Hirschberger Grossteiches. *Sborník VŠCHT, odd. FPTV*. Praha, pp 121–150

- Smith JE, Hunter CL, Smith CM (2002) Distribution and reproductive characteristics of nonindigenous and invasive marine algae in the Hawaiian Islands. *Pacific Sci* 56:299–315
- Smucker NJ, Edlund MB, Vis ML (2008) The distribution, morphology, and ecology of a non-native species, *Thalassiosira lacustris* (Bacillariophyceae), from benthic stream habitats in North America. *Nova Hedwigia* 87:201–220
- Spaulding S, Elwell L (2007) Increase in nuisance blooms and geographic expansion of the freshwater diatom *Didymosphenia geminata*. Recommendations for response. Federation of Fly Fishers and USA Environmental Protection Agency, Livingston, Montana
- Stefaniak K, Kokociński M (2005) Occurrence of invasive cyanobacteria species in polymictic lakes of the Wielkopolska region (western Poland). *Oceanol Hydrobiol Stud (Suppl 3)*:137–148
- Štěpánek M, Chalupa J, Červenková E, Votavová M (1958) Limnological study of the Reservoir Sedlice near Želiv. II. Biological part. Sborník VŠCHT, odd. FPTV. VŠCHT Praha, pp 313–564
- Stoermer EF, Kreis JRG, Andresen NA (1999) Checklist of diatoms from the Laurentian Great Lakes, II. *J Great Lakes Res* 25:515–566
- Stoyneva MP (2003) Steady-state phytoplankton assemblages in shallow Bulgarian wetlands. *Hydrobiologia* 502:169–176
- Strzelecki J, Poltorak T (1971) Plankton przymorskiego jeziora Gardno w okresie letnim. *Acta Hydrobiologica* 13:269–294
- Stüken A, Rucker J, Endrulat T, Preussel K, Hemm M, Nixdorf B, Karsten U, Wiedner C (2006) Distribution of three alien cyanobacterial species (Nostocales) in northeast Germany: *Cylindrospermopsis raciborskii*, *Anabaena bergii* and *Aphanizomenon aphanizomenoides*. *Phycologia* 45:696–703
- Subakov-Simić G, Cvijan M (2004) *Didymosphenia geminata* (Lyngb.) M.Schmidt (Bacillariophyta) from the Tisza river (Serbia)—its distribution and specific morphological and ecological characteristics. *Archiv für Hydrobiologie/Algal Stud* 114:53–66
- Szalai I (1942) Adatok a Körösök pseudophytoplanktonja ismeretéhez. *Acta Universitatis Szegediensis, Pars Botanica* 1:113–154
- Takano Y, Hansen G, Fujita D, Horiguchi T (2008) Serial replacement of diatom endosymbionts in two freshwater dinoflagellates, *Peridiniopsis* spp. (Peridinales, Dinophyceae). *Phycologia* 47:41–53
- Talling JF, Parker JE (2002) Seasonal dynamics of phytoplankton and phytobenthos, and associated chemical interactions, in a shallow upland lake (Malham Tarn, northern England). *Hydrobiologia* 487:167–181
- Teubner K, Tolotti M, Greisberger S, Morscheid H, Dokulil MT (2003) Steady state phytoplankton in a deep pre-alpine lake: species and pigments of epilimnetic versus metalimnetic assemblages. *Hydrobiologia* 502:49–64
- Tsimis K, Panayotidis P, Zenetos A (2008) Alien marine macrophytes in Greece: a review. *Botanica Marina* 51:237–246
- Urošević V (1994) Alge visokoplaninskih jezera Siriničke strane Šir-planine. Univerzitet u Prištini, Priština, p 95
- Vardaka E, Moustaka-Gouni M, Cook CM, Lanaras T (2005) Cyanobacterial blooms and water quality in Greek waterbodies. *J Appl Phycol* 17:391–401
- Veselá J (2007) Ekologie a rozšíření sinic a řas malých vodních toků v NP České Švýcarsko (Ecology and distribution of cyanobacteria and algae in small streams of NP České Švýcarsko). Faculty of Science. Charles University, Prague, pp 69
- Vidal L, Kruk C (2008) *Cylindrospermopsis raciborskii* (Cyanobacteria) extends its distribution to Latitude 34°53'S: taxonomical and ecological features in Uruguayan eutrophic lakes. *Pan-Am J Aquat Sci* 3:142–151
- Wacklin P, Hoffmann L, Komárek J (2009) Nomenclatural validation of the genetically revised cyanobacterial genus *Dolichospermum* (Ralfs ex Bornet et Flahault) comb. nova. *Fottea* 9(1):59–64
- Waite IR, Sobieszczek S, Carpenter KD, Arnsberg AJ, Johnson HM, Hughes CA, Sarantou MJ, Rinella FA (2006) Effects of Urbanization on Stream Ecosystems in the Willamette River Basin and Surrounding Area, Oregon and Washington. In: Scientific Investigations Report 2006–5101–D. U.S. Geological Survey. <http://pubs.usgs.gov/sir/2006/5101-D/index.html>. Accessed: 2006-07-02
- Walsby AE (2005) Stratification by cyanobacteria in lakes: a dynamic buoyancy model indicates size limitations met by *Planktothrix rubescens* filaments. *New Phytol* 168:365–376
- Wang Q, Li H (2004) Study of the Algae in Shanghai Jiudu-an-sha Wetland Nature reserve. Islands of the World VIII International Conference. Kinmen Island, Taiwan
- Wass ML (1972) A Check List of the Biota of Lower Chesapeake Bay. In: <http://www.vcrlter.virginia.edu/cgi-bin/w3-msql2/biod/query/msql2/form4.html?QOBS=BIOD974826>. Accessed: 2009-02-16
- Watanabe M (1985) Phytoplankton studies of Lake Kasumigaura (2). On some rare or interesting algae. *Bull Natl Sci Mus* 11:137–142
- Watanabe MF, Tsujimura S, Oishi S, Niki T, Namikoshi M (2003) Isolation and identification of homoanatoxin-a from a toxic strain of the cyanobacterium *Raphidiopsis mediterranea* Skuja isolated from Lake Biwa, Japan. *Phycologia* 42:364–369
- Williams SL, Smith JE (2007) A global review of the distribution, taxonomy, and impacts of introduced seaweeds. *Annu Rev Ecol Syst* 38:327–359
- Wolgemuth E, Trnková J, Sutorý K (1984) Výskyt slano-milné řasy *Enteromorpha intestinalis* (L.) Grev. na Třebíčsku. *Acta Sci. Musei Morav. Occidentalis Třebíč* 13:53–57
- Wood SA, Stirling DJ (2003) First identification of the *Cylindrospermopsis*-producing cyanobacterium *Cylindrospermopsis raciborskii* in New Zealand. *NZ J Mar Freshw Res* 37:821–828
- Wood SA, Rasmussen JP, Holland PT, Campbell R, Crowe ALM (2007) First report of the cyanotoxin anatoxin-A from *Aphanizomenon issatschenkoi* (cyanobacteria). *J Phycol* 43:356–365

- Work K (2009) Lake Okeechobee Plankton. In. http://www.stetson.edu/~kwork/lake_okee_plankton.htm. Accessed: 2009-02-17
- Wunsam S, Cattaneo A, Bourassa N (2002) Comparing diatom species, genera and size in biomonitoring: a case study from streams in the Laurentians (Quebec, Canada). *Freshw Biol* 47:325–340
- Yilmaz M, Philips EJ, Szabo NJ, Badylak S (2008) A comparative study of Florida strains of *Cylindrospermopsis* and *Aphanizomenon* for cylindrospermopsin production. *Toxicon* 51:130–139
- Zafar AR (1986) Seasonality of phytoplankton in some South-Indian lakes. *Hydrobiologia* 138:177–187
- Zalocar Y (1993) Volvocales colonials (Chlorophyta) del nordeste Argentino. *Folia Botanica et Geobotanica Correntesiana* (Herbarium Humboldtianum, Universidad Nacional del Nordeste, Gorriente, Argentina) 9:1–18
- Zapletálek J (1932) Nástin poměrů algologických na Lednicku. *Hydrobiologická studia rybníků lednických*. Acta Univ Agric Brno sign C24:1–70
- Zapomělová E, Jezberová J, Hrouzek P, Hisem D, Řeháková K, Komárková J (2009) Polyphasic characterization of three strains of *Anabaena reniformis* and *Aphanizomenon aphanizomenoides* (cyanobacteria) and their re-classification to *Sphaerospermum* gen. nov. (incl. *Anabaena kisseleviana*). *J Phycol* 45(6):1363–1373
- Znachor P (1997) Diversita fytoplanktonu, koncentrace fosforu v řasách a prostorová heterogenita přehraní nádrže Lipno. Faculty of Biological Sciences. University of South Bohemia, České Budějovice, pp 51
- Znachor P, Jezberová J (2005) The occurrence of a bloom-forming green alga *Pleodorina indica* (Volvocales) in the downstream reach of the River Malse (Czech Republic). *Hydrobiologia* 541:221–228
- Znachor P, Lodeová J (2005) Kalamita na řece Malši. *Sci Am* (Czech Edition) 2005:52–55