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COCCOID GREEN ALGAE FLORA IN PLANKTON OF SMALL LAKES OF THE BALTIC UPLANDS

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Abstract

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One hundred and thirty four species of coccoid green algae ascribed to 12 families and 49 genera were recorded in 28 small lakes located in the Eastern part of the Baltic Uplands. They comprised almost half of the known coccoid algae species (283) in Lithuania. *Scenedesmaceae* (41 species), *Chlorellaceae* (24), *Oocystaceae* (19) families and *Scenedesmus* (26), *Pediastrum* (12) genera were the most diverse. Very rare species worldwide *Echinosphaeridium nordstedtii* Lemmermm., *Monoraphidium flexuosum* Komárek, *Pseudokirchneriella roselata* (Hindák) Hindák, *Thorakochloris nygaardii* Fott were among 34 species new to the Lithuanian *Chlorococcales* algae flora. The discrepancies in number and size of cells, colonies, coenobia as well as atypical morphological structures were evident in the lakes characterised by high anthropogenic impact and extreme environmental conditions.

Keywords: coccoid green algae, *Chlorococcales*, diversity, lakes, Lithuania.

INTRODUCTION

The world Algae Base includes about 55 thousand species of marine, brackish, fresh water and terrestrial algal species; these lists are continuously supplemented with new species (Guiry & Nic Dhonncha, 2004; http://www.sp2000.org/cdbooklet2003.pdf). Freshwater green algae are characterised by high species diversity (~12 000 species; John, 1994). The orders *Zygnematales* and *Chlorococcales* are the most species-rich. *Chlorococcales* algae are more widespread in freshwaters of the world than *Zygnematales,* which are restricted to the swamps and peat bogs. Several European countries have national algae checklists (Hindák & Hindákova, 1998; Mikheeva, 1999; Whitton et al., 2003; etc.) or floras of different algal taxonomic groups (Starmach, 1989; Tsarenko, 1990; etc.).

In Lithuania, the algological studies were started at the end of the 18th century. Junzill (1791, 1811) was the first who mentioned the macroscopic algae species in his publications. Vilkaitis (1924–26, 1936, 1940) investigations of desmids in the peat bogs of Lithuania were followed by recent studies of this green algae group (Jakimavičiūtė et al., 2006; Briskaite et al., 2008). Over the past fifty years, phytoplankton studies in lakes, rivers, the Curonian Lagoon and the Baltic Sea were carried out (Minkevičius, 1958; Ūselytė, 1961; Jankavičiūtė, 1965, 1966, 1990; Kavaliauskienė, 1996; Olenina, 1996; Snoeijs & Kasperovičienė, 1996; Kasperovičienė, 2001, 2007; Kostkevičienė, 2001). These studies were mostly of hydrobiological and ecological character; only few of them included morphological measurements, habitat descriptions and distribution data. The manual of Lithuanian freshwaters algae (Jankavičiūtė, 1996)

and a full-scale study on phytoplankton of more than hundred lakes (Kavaliauskienė, 1996) have been published. The checklists of cyanobacteria (Vitėnaitė, 2001), desmids (Kostkevičienė et al., 2003) and macroalgae (Kostkevičienė & Sinkevičienė, 2008) were compiled. The floristic-taxonomic studies on algal species diversity and peculiarities of their morphology, ecology were initiated in the recent years (Koreivienė & Kasperovičienė, 2003; Kostkevičienė & Laučiūtė, 2005; Karosienė & Kasperovičienė, 2008, 2009; Kostkevičienė & Vitonytė, 2008 Vitonytė & Kostkevičienė, 2008).

The aim of this study was to investigate coccoid green algae in plankton of small lakes located in Eastern part of the Baltic Uplands as well as to evaluate their significance to the flora of Lithuanian coccoid green algae.

MATERIALS AND METHODS

Plankton samples for the investigations of coccoid green algae were taken from the deepest parts of 28 small water bodies (21 lakes and 7 ponds) during the 1997–2002 vegetation seasons. Algae were collected from the surface (up to 0.5 m) water layer using Ruttner sampler and a plankton net (25 µm mesh). Algae were investigated in fresh and preserved material using "Biolar" light microscope (magnification × 600–1350). Samples were preserved by adding 40 % formaldehyde to reach 2 % concentration in the final sample. The classical taxonomic system for *Chlorococcales* algae was used (Komárek & Fott, 1983). The identification of coccoid green algae was performed following: Hindák (1977, 1980, 1984, 1988, 1990), Starmach (1989), Tsarenko (1990), John & Tsarenko (2002) as well as different articles. Original drawings of the taxa are presented; scale bars of all illustrations are 10 µm. Species occurrence in Lithuanian waters was evaluated as follows: very rare species that occurred in 0.1–1.9 %, rare – in 2–9.9 %, rather rare – in 10–19.9 %, frequent – in 20–39.9 %, very frequent – in more than 40 % of investigated water bodies.

The checklist of *Chlorophyceae* taxa was compiled summarising the published and typescript material (91 sources). Taxa higher than order were given according to Parker (1982). For the comparison with the flora of Lithuanian *Chlorococcales* algae, checklists of some European countries – Belarus (Mikheeva, 1999), Great Britain (Whitton et al., 2003), Scandinavia (Zetterberg, 1995), Slovakia (Hindák & Hindáková, 1998), Ukraine (Tsarenko, 1990), Germany (Mauch et al., 2003), European part of Russia (Trifonova, 1990; Ština, 1997) – were unified according to Komárek & Fott (1983). Stugren-Radulescu (Stugren & Rădulescu, 1961), Jaccard (Jaccard, 1908) and Sørensen (Sorensen, 1948) indices were calculated to evaluate the similarity of the *Chlorococcales* flora in Lithuanian and other countries/regions.

The physical and chemical characteristics (water temperature, pH, dissolved oxygen, conductivity) were measured *in situ* using portable universal meter MultiLine F/Set-3 (WTW). Water transparency was evaluated with Secchi disk; nutrients (phosphorus and nitrogen) in unfiltered samples were determined according to a standard methodology of water analysis (Grasshoff et al., 1983).

STUDY SITE

The investigated water bodies are situated in the Eastern part of Baltic Uplands and belong to the basins of small tributaries (length from 2.7 to 29 km) of the river Neris – Antavilis, Dūkšta, Riešė, Saidė-Vosylytė and Sudervė (catchment area from 20.5 to 137 km^2). All lakes are of glacigenic origin and belong to small and very small groups of world lakes. Buivydiškės Ponds were created in the 18th century by damming the Sudervė stream. Fifteen lakes are located in the protected areas. In Table 1 lakes are grouped according to morphometric characteristics and water transparency.

Transparency values ranged from 0.5 to 7.2 m in different water bodies. The amount of dissolved oxygen varied from 5.41 to 19.5 mg/l in the surface layer, oxygen saturation – 54.8–141.4 %, pH – 5.53–8.96, conductivity – 31–471 µS/cm. Based to lakes' trophy scale suggested by Trifonova (1990), majority of investigated lakes of Baltic Uplands are regarded as mesotrophic or eutrophic, only Gineitiškės lake falls into the range of hypertrophic water bodies (mean value of chlorophyll *a* – 32.1 mg/m^3). Total phosphorus concentration varied from 0.01 to 0.21 mg/l, total nitrogen – 0.34–2.57 mg/l in the surface water layer.

RESULTS

Taxonomic spectrum and new to Lithuania *Chlorococcales* species. In total, 134 taxa of the *Chlorococcales* algae, ascribed to 12 families and 49 genera, were identified in 28 small lakes in the Eastern part of Baltic Uplands (Table 2). Families *Scenedesmaceae* (41 species), *Chlorellaceae* (24), *Oocystaceae* (19) and genera *Scenedesmus* (26),

Table 1. Morphometric characteristics of the Baltic Uplands lakes

Lake's group	Relatively deep and large	Rather deep and large	Shallow and large	Shallow and small
Lakes	Skaistis, Luka, Vilnoja, Balsys, Gilužis, Bildžiai	Gulbinas, Mažasis Gulbinas, Raistelis, Antavilis, Topeliai	Riešė, Gineitiškės	Juodis, Baluosys, Akis, Dumblė, Ilgelis, Salotė, Piliškės, Bevardis, Buivydiškės Ponds
Surface area, km^2	0.20–3.08	0.10–0.36 (Raistelis 0.012)	0.24–0.88	0.008–0.134
Volume, 10^3 m^3	1332–30152	585–1514 (Raistelis 38.9)	400–2140	5.2–261.0
Max. depth, m	16.4–38.8	11.1–13.6	3–6	1.2–7.0
Mean depth, m	5.6–15.2	4.2–5.6	1.5–2.5	0.7–3.7
Mean Secchi depth, m	> 3 (Vilnoja 2.4)	1.5–3.0	< 1	till the bottom

Pediastrum (12) were the most species-rich. Coccoid green algae made up about 50 % of green algae diversity (279 species) and about 20 % of the total algae diversity (688 species) in the studied water bodies. Thirty-four *Chlorococcales* species were recorded for the first time in Lithuania (Fig. 1–4). They are ascribed to 9 families, the most species-rich being *Botryococcaceae* and *Scenedesmaceae* (Table 2). The highest number of new species was recorded in Lakes Gineitiškės (13 species) and Salotė (9).

The distribution of *Chlorococcales* algae species. The majority of coccoid green algae species occur rarely in the lakes of the Baltic Uplands (Fig. 5 A). Rather rare and frequent species made a quarter of the recorded species. Among them, *Eutetramorus* cf. *fottii* (Hindák) Komárek, *Oocystis lacustris* Chodat., *Pediastrum boryanum* (Turpin) Menegh., *P. tetras* (Ehrenb.) Ralfs, *Scenedesmus armatus* Chodat., *Tetraedron minimum* (A. Braun) Hansg. were very frequent.

On the other hand, half of coccoid green algae species registered in Baltic Uplands are cosmopolitan and frequent worldwide (Fig. 5 B). Forty-six species are known only in the temperate zone. Rare and very rare species made only one-third of the total number of *Chlorococcales* species recorded in the lakes of Baltic Uplands. The highest number of worldwide

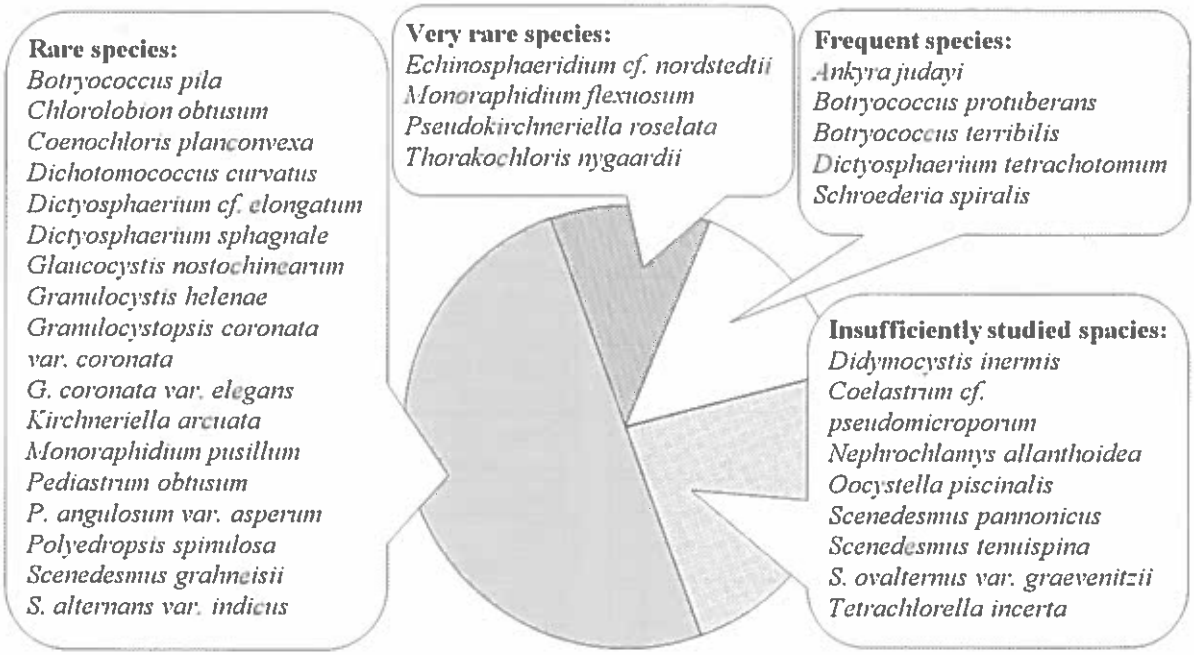

Fig.1. New to Lithuania *Chlorococcales* species and their occurrence in freshwaters of the world

Table 2. Taxonomic spectrum of *Chlorococcales* algae in the Baltic Uplands lakes and other water bodies of Lithuania

Family, Genus	Taxa number		
	Baltic Uplands lakes	New species to Lithuania	Lithuania
CHLOROCOCCACEA	–	–	**3**
Chlorococcum	–	–	3
PALMELLACEAE	**1**	**–**	**5**
Planctococcus	–	–	1
Planktosphaeria	1	–	1
Sphaerocystis	–	–	2
Trebouxia	–	–	1
CHARACIACEAE	**3**	**2**	**11**
Ankyra	1	1	2
Characium	–	–	4
Korschikoviella	–	–	2
Schroederia	2	1	3
TREUBARIACEAE	**1**	**–**	**3**
Treubaria	1	–	3
GOLENKINIACEAE	**3**	**2**	**5**
Echinosphaeridium	1	1	1
Golenkinia	1	–	3
Polyedropsis	1	1	1
HYDRODICTYACEAE	**14**	**2**	**22**
Euastropsis	1	–	1
Hydrodictyon	–	–	1
Pediastrum	12	2	19
Sorastrum	1	–	1
MICRACTINIACEAE	**3**	**–**	**6**
Dicellula	–	–	1
Golenkiniopsis	–	–	1
Micractinium	2	–	3
Siderocystopsis	1	–	1
BOTRYOCOCCACEAE	**11**	**7**	**16**
Dactylosphaerium	1	–	1
Dichotomococcus	1	1	1
Dictyosphaerium	4	3	8
Quadricoccus	1	–	2
Botryococcus	4	3	4
OOCYSTACEAE	**19**	**6**	**35**
Francea	1	–	2
Lagerheimia	4	–	8
Eremosphaera	–	–	2
Granulocystis	1	1	1
Granulocystopsis	2	2	2
Oocystis / Oocystella	7	1	15
Nephrocytium	1	–	1

Family, Genus	Taxa number		
	Baltic Uplands lakes	New species to Lithuania	Lithuania
Nephrochlamys	2	1	3
Glaucocystis	1	1	1
RADIOCOCCACEAE	**7**	**2**	**13**
Coenochloris	2	1	5
Coenocystis	1	–	2
Dispora	–	–	2
Eutetramorus	2	–	2
Radiococcus	1	–	1
Thorakochloris	1	1	1
CHLORELLACEAE	**24**	**5**	**53**
Ankistrodesmus	6	–	8
Chlorella	–	–	2
Chlorolobion	1	1	2
Choricystis	–	–	2
Closteriopsis	–	–	2
Hyaloraphidium	–	–	2
Keratococcus	–	–	2
Kirchneriella	6	2	9
Monoraphidium	5	2	12
Quadrigula	2	–	3
Raphidocelis	–	–	1
Tetraedron	4	–	8
COELASTRACEAE	**7**	**1**	**13**
Actinastrum	1	–	4
Coelastrum	6	1	9
SCENEDESMACEAE	**41**	**7**	**98**
Coronastrum	1	–	1
Dimorphococcus	1	–	1
Crucigeniella	1	–	4
Crucigenia	2	–	3
Komarekia	–	–	1
Pseudotetrastrum	–	–	1
Rayssiella	–	–	1
Tetrastrum	2	–	8
Tetrachlorella	3	1	4
Westella	1	–	1
Willea	1	–	2
Didymocystis	2	1	3
Scenedesmus	26	5	66
Tetradesmus	1	–	2
Total	134	34	283

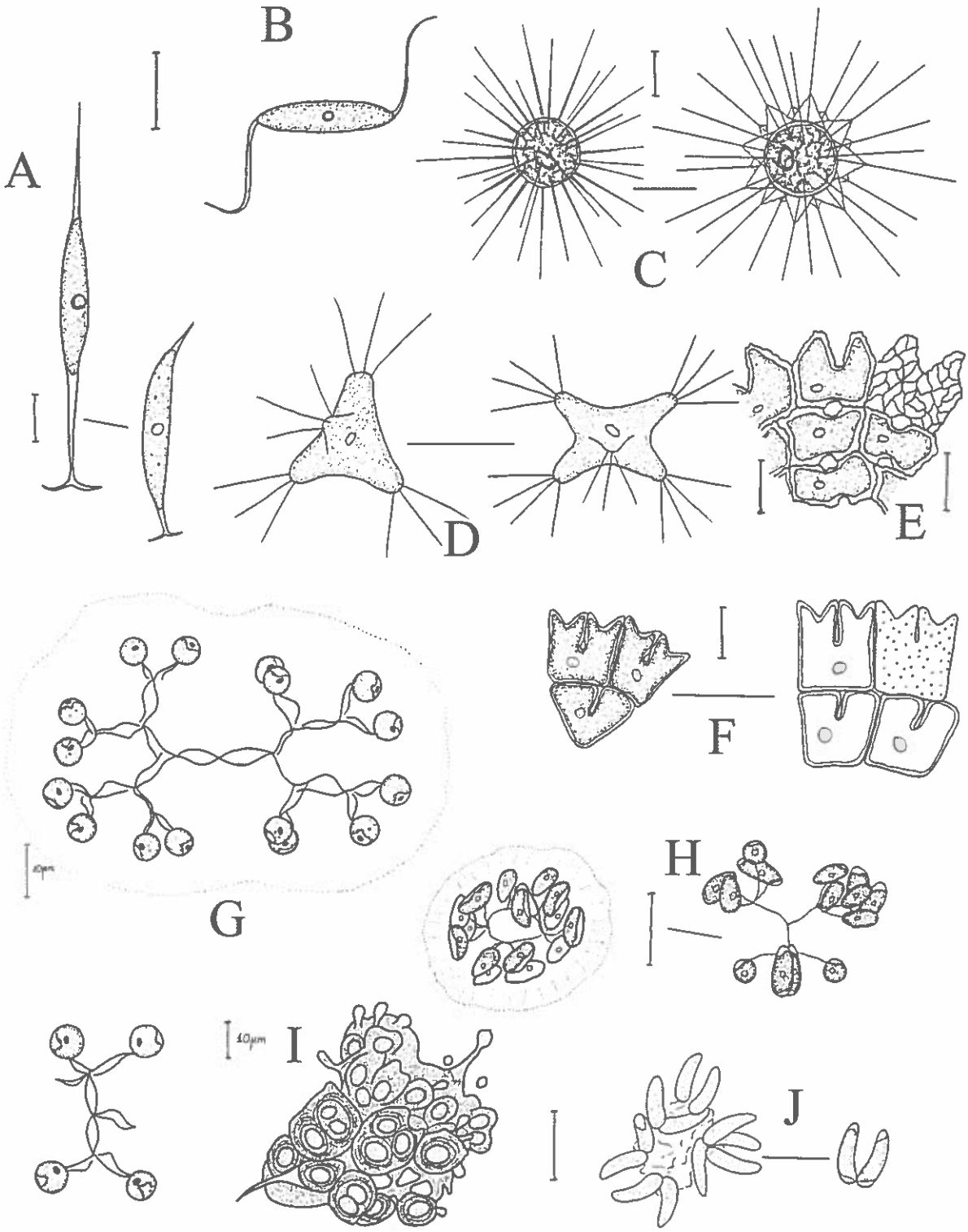

Fig. 2. New to Lithuania *Chlorococcales* species. ***Characiaceae***: **A** – *Ankyra* cf. *judayi*; **B** – *Schroederia spiralis* (Printz.) Korshikov; ***Golenkiniaceae***: **C** – *Echinosphaeridium* cf. *nordstedtii*; **D** – *Polyedropsis spinulosa* (Schmidle) Schmidle; ***Hydrodictyaceae***: **E** – *Pediastrum angulosum* var. *asperum*; **F** – *Pediastrum obtusum* Lucks; ***Botryococcaceae***: **G** – *Dictyosphaerium sphagnale*; **H** – *Dictyosphaerium* cf. *elongatum* Hindák; **I** – *Botryococcus* cf. *pila* Komárek et Marvan; **J** – *Dichotomococcus curvatus* Korshikov

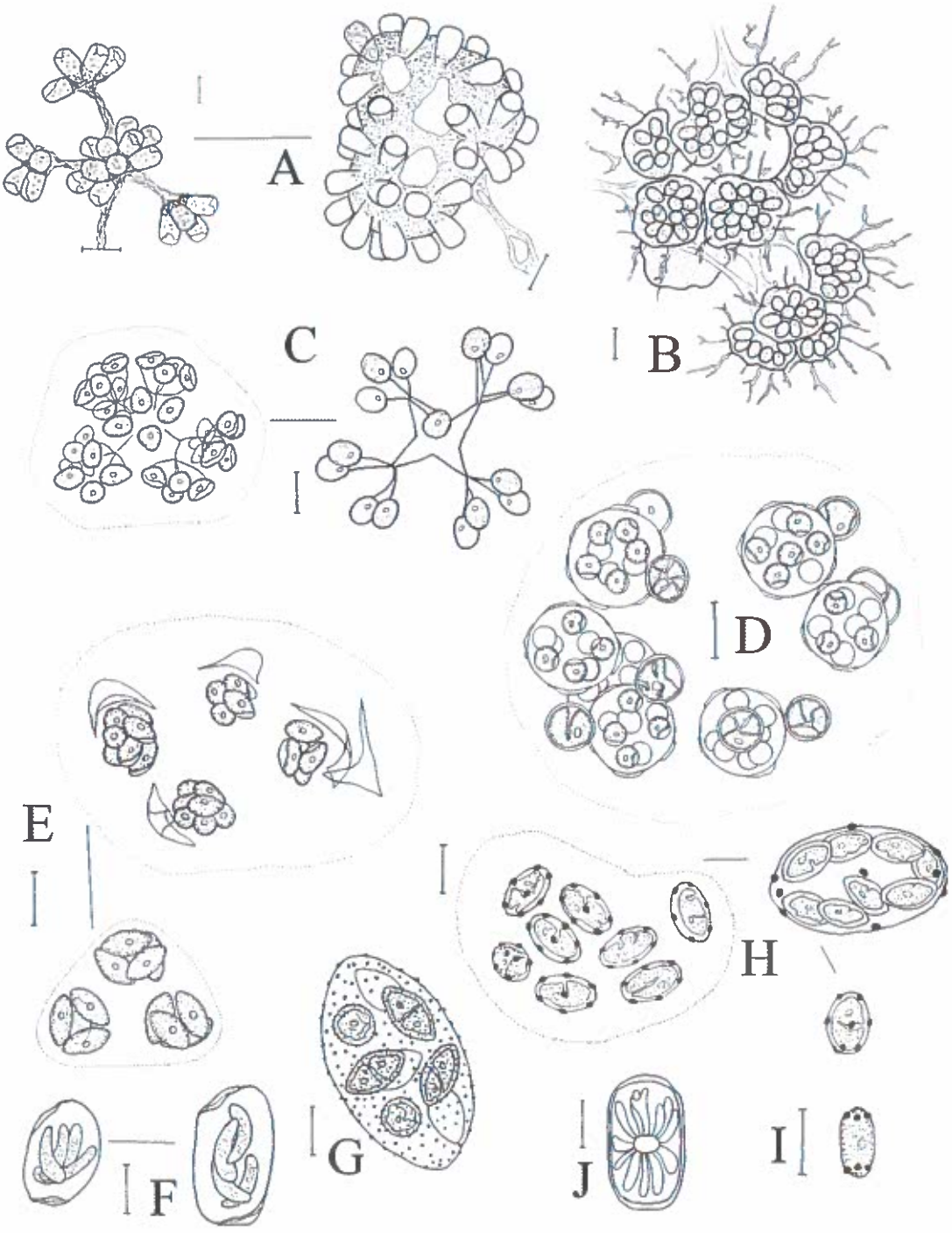

Fig. 3. New to Lithuania *Chlorococcales* species. ***Botryococcaceae***: **A** – *Botryococcus protuberans* W et. G. S. West; **B** – *B. terribilis*; **C** – *Dictyosphaerium tetrachotomum*; ***Radiococcaceae***: **D** – *Thorakochloris nygaardii*; **E** – *Coenochloris planconvexa* Hindák; ***Oocystaceae***: **F** – *Nephrochlamys alantoidea* Korshikov; **G** – *Granulocystis helene* Hindák; **H** – *Granulocystopsis coronata* var. *elegans* (Fott) Komárek; **I** – *G. coronata* (Lemmerm.) Hindák var. *coronata*; **J** – *Glaucocystis nostochinearum* Itzigson

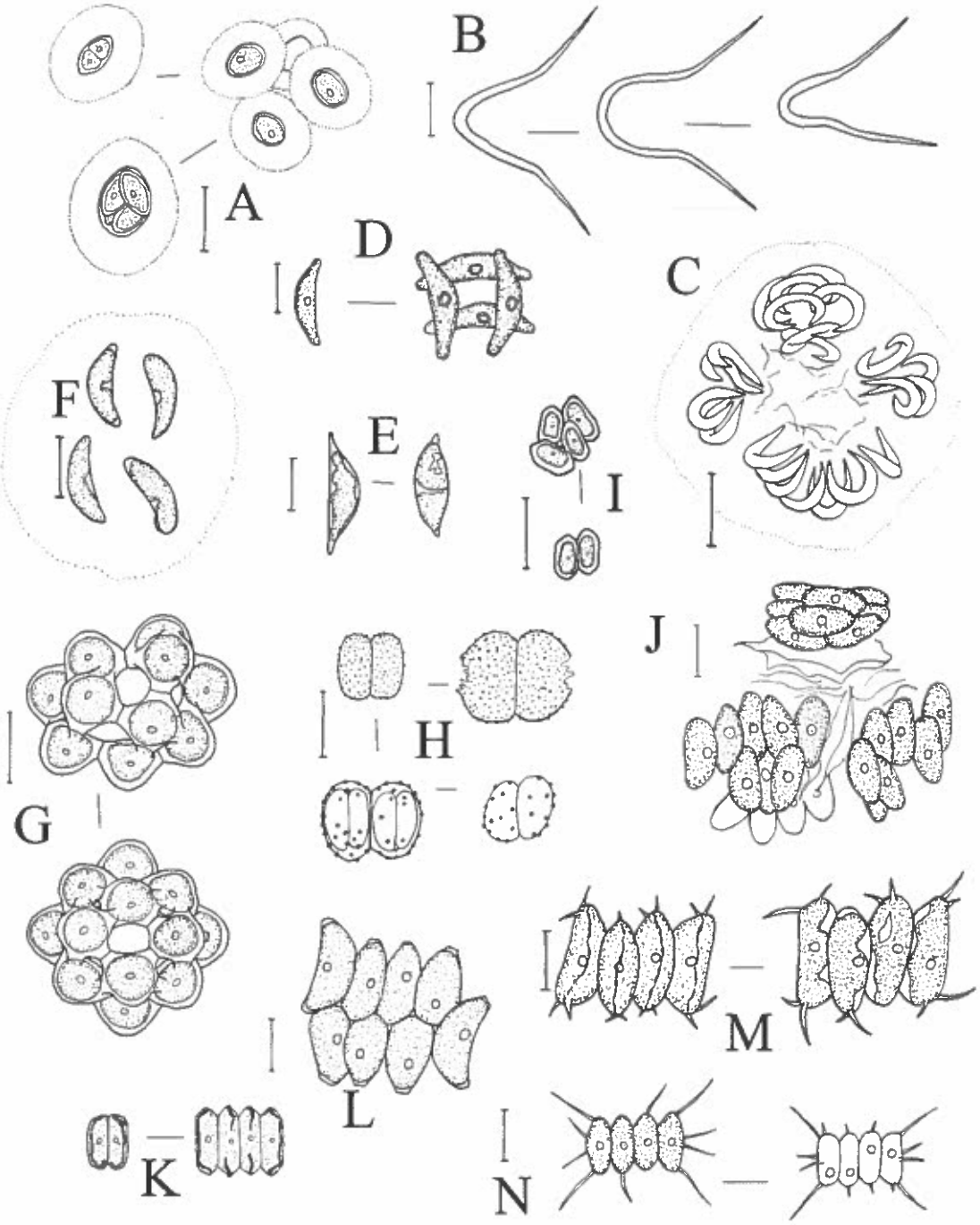

Fig. 4. New to Lithuania *Chlorococcales* species. ***Oocystaceae:*** **A** – *Oocystella piscinalis*; ***Chlorellaceae***: **B** – *Monoraphidium flexuosum*; **C** – *Pseudokirchneriella roselata*; **D** – *Chlorolobion obtusum* Korshikov; **E** – *Monoraphidium pusillum* (Printz.) Kom.-Legn.; **F** – *Kirchneriella arcuta* G. M. Smith; ***Coelastraceae***: **G** – *Coelastrum* cf. *pseudomicroporum*; ***Scenedesmaceae***: **H** – *Didymocystis inermis*; **I** – *Tetrachlorella incerta*; **J** – *Scenedesmus ovalternus* var. *gravenitzii* (Bern.) Chodat; **K** – *S. grahneisii* (Heinig) Fott; **L** – *S.* cf. *alternans* var. *indicus* (Hortob.) Kirj. **M** – *S. pannonicus* Hortobagyi; **N** – *S. tenuispina* Chodat

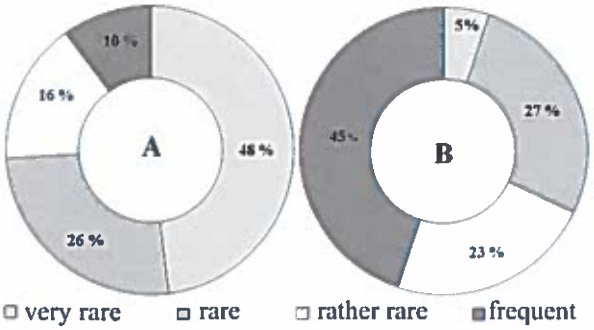

Fig.5. The occurrence of *Chlorococcales* species in the studied lakes (A) and in the water bodies worldwide (B)

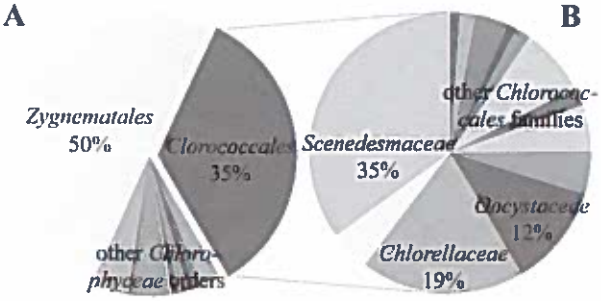

Fig. 6. The taxonomic spectrum of *Chlorophyceae* (A) and *Chlorococcales* (B) in the Lithuanian inland waters

rare species was recorded in Lakes Gineitiškės, Salotė and peat-bog lakes in the Varnikai Reserve (7–13 species). The research results revealed high diversity of *Chlorococcales* species (20–42 species) as well as high number of rare species in peat bog lakes (23.8–35.0 % of the total number of *Chlorococcales* species in a lake).

The checklist of *Chlorococcales* algae in water bodies of Lithuania. Up to 2003, algae have been investigated in approximately 450 water bodies of various types, corresponding to 3–4 % of lakes and less than 1 % of rivers and ponds of Lithuania. The checklist of green algae of Lithuanian water bodies was compiled based on our investigations and on the works of other phycologists. It includes 803 species and infraspecific taxa ascribed to 12 orders and 38 families. The highest species diversity is characteristic of two orders – *Zygnematales* (399 species) and *Chlorococcales* (283) (Fig. 6 A). The majority of coccoid green algae species belong to families *Scenedesmaceae, Chlorellaceae, Oocystaceae* (Fig. 6 B). Only coccoid algae checklist including species occurrence in Lithuania is published yet (Koreivienė & Kasperovičienė, 2005, 2006).

The majority of the recorded *Chlorococcales* species are rare and very rare in Lithuania, rather rare and

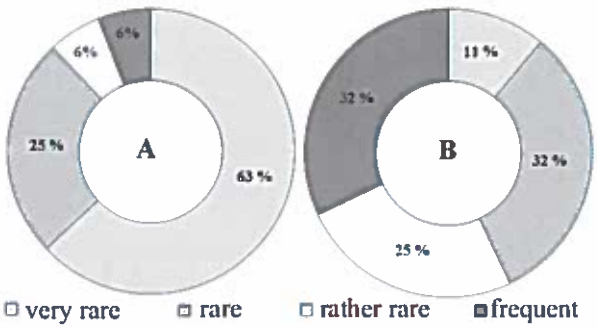

Fig. 7. *Chlorococcales* algae species found in Lithuania and their occurrence in the inland waters of Lithuania (A) and worldwide (B)

frequent species comprise only 11 % (Fig. 7 A). 43.3 % of coccoid green algae species from the Lithuanian green algae checklist are very rare and rare in the world, about one-third of the species are frequent (Fig. 7 B). About two-thirds of coccoid green algae species found in Lithuania are cosmopolitan, one-third of the species are recorded in the temperate zone; two species are characteristic of the warm regions of the world.

DISCUSSION

Coccoid green algae, widespread in different freshwaters of the world, are characterised by high species diversity (~1200–1400 species; Komárek & Fott, 1983; Krienitz et al., 2002). The species recorded in the lakes of Baltic Uplands comprised about 10 % of the total diversity of coccoid green algae in the world. The most species-rich families and genera were the same in Lithuania and other European countries (Tables 3–4). *Scenedesmaceae* comprises 23.8–37.3 %, *Chlorellaceae* – 14.1–28.6 %, *Oocystaceae* – 10.3–15.3 %, while *Scenedesmus* comprises 14.4–32.5 %, *Pediastrum* – 5.1–8.9 % of the total number of coccoid green algae species. Certain taxonomic differences of the *Chlorococcales* order were predetermined by relatively small number of investigated water bodies in the Baltic Uplands compared to other European countries. Relative number of species of the *Golenkiniaceae, Hydrodictyaceae* and *Botryococcaceae* families was higher and of the *Characiaceae* and *Treubariaceae* was lower in the studied lakes (Table 3). The majority of the *Characiaceae* family species live attached to submerged substrates, therefore, their diversity recorded in the plankton of the investigated lakes was lower.

Among thirty-four new to Lithuania species found during the study, 21 are rare and very rare in freshwaters

Table 3. The most species-rich *Chlorococcales* families in the lakes of the Baltic Uplands and some European countries

	Family			Total taxa number
	Oocystaceae	*Chlorellaceae*	*Scenedesmaceae*	
	Taxa number (percentage of coccoid green algae taxa)			
Baltic Uplands lakes	**19** (14.1)	**25** (18.5)	**41** (30.4)	135
Lithuania	**35** (12.3)	**54** (19.0)	**98** (34.5)	284
Belarus	**38** (13.8)	**62** (22.5)	**75** (27.3)	275
Germany	**24** (11)	**42** (19.2)	**75** (34.2)	219
Russia	**23** (14.7)	**36** (22.9)	**41** (26.1)	157
Scandinavian countries	**44** (14.6)	**65** (21.5)	**98** (32.5)	302
Slovakia	**57** (13.2)	**124** (28.6)	**103** (23.8)	433
Ukraine	**27** (10.3)	**37** (14.1)	**98** (37.3)	263
United Kingdom	**41** (15.3)	**59** (22)	**68** (25.4)	268

Table 4. The most species-rich *Chlorococcales* genera in the lakes of Baltic Uplands and some European countries

	Genus (**taxa number** – percentage of coccoid green algae taxa)
Baltic Uplands lakes	*Scenedesmus* (**26**–19.2), *Pediastrum* (**12**–8.9), *Oocystis* (**7**–5.2)
Lithuania	*Scenedesmus* (**66**–23.2), *Pediastrum* (**19**–6.7), *Oocystis* (**15**–5.3), *Monoraphidium* (**11**–4.2)
Belarus	*Scenedesmus* (**48**–17.5), *Pediastrum* (**20**–7.3), *Tetraedron* (**14**–5.1), *Oocystis* (**12**–4.4)
Germany	*Scenedesmus* (**44**–20.4) *Pediastrum* (**16**–7.4), *Monoraphidium* (**12**–5.6)
Russia	*Scenedesmus* (**24**–15.3), *Oocystis* (**9**–5.7), *Pediastrum, Lagerheimia, Kirchneriella, Coelastrum* (7–4.5)
Scandinavian countries	*Scenedesmus* (**51**–24.2), *Pediastrum* (**14**–6.6), *Coelastrum* (**11**–5.2), *Oocystis* (**10**–4.7)
Slovakia	*Scenedesmus* (**62**–14.4), *Monoraphidium* (**21**–4.9), *Kirchneriella* (**16**–3.7), *Oocystis* (**14**–3.3)
Ukraine	*Scenedesmus* (**93**–32.5), *Pediastrum* (**15**–5.3), *Oocystis, Monoraphidium, Lagerheimia* (**8**–2.8)
United Kingdom	*Scenedesmus* (**49**–17.7), *Pediastrum, Oocystis* (**14**–5.1), *Monoraphidium* (**13**–4.7)

worldwide (Fig. 1). Some of them occupy very specific ecological niches. For example, *Monoraphidium flexuosum* Komárek was found only in the water bodies with low conductivity, while *Pediastrum angulosum* var. *asperum* Sulek and *Dictyosphaerium sphagnale* Hindák thrived in swamp lakes. Four recorded species were found just in a few localities of the world as well. *Echinosphaeridium* cf. *nordstedtii* Lemmerm. was found in United Kingdom, France, Sweden (Komárek & Fott, 1983), *Thorakochloris nygaardii* Fott – in Canada, Denmark, Sweden (Bourrelly, 1966; Tsarenko, 1990), *Pseudokirchneriella roselata* (Hindák) Hindák – in Slovakia, Germany, Spain, Bulgaria (Hindák, 1984; Heynig & Krienitz, 1987; Economou-Amilli & Spartinou, 1989; Stoyneva, 1998), *Monoraphidium flexuosum* – in Denmark, Canada (Komárek, 1974; Komárek & Fott, 1983).

Only five of the new species are frequent in the world; the distribution of eight species is studied insufficiently (Fig. 1). They could have been overlooked because of their small size (up to 6–7 μm; e. g. *Tetrachlorella incerta* Hindák, *Didymocystis inermis* (Fott) Fott) or similarity to other morphologically close species (*Dictyosphaerium tetrachotomum* Printz, *Ankyra* cf. *judayi* (G. M. Sm.) Fott). *Botryococcus terribilis* Komárek et Marvan, *Coelastrum* cf. *pseudomicroporum* Korshikov, *Oocystella piscinalis* Hindák and some other species have been described only recently. Cultivation and life cycle observations are necessary for more precise identification of some species found in

the Baltic Uplands (*Echinosphaeridium* cf. *nordstedtii*, *Coelastrum* cf. *pseudomicroporum*, etc.).

Morphology of 28 *Chlorococcales* species recorded in lakes of the Baltic Uplands showed discrepancy in number and size of cells, colonies, coenobia as well as differences in morphological structures (spines, mother cell wall remnants). From these species, six taxa exhibited atypical morphological structures and appeared in small numbers mainly in waters characterised by high anthropogenic impact and extreme environment conditions. Stoyneva (1998) also noted that abnormal single specimens of *Scenedesmus*, *Pediastrum* and *Tetraedron* were found mainly in highly eutrophic lakes of Bulgaria. *Pediastrum duplex* var. *subgranulatum* Racib. from highly eutrophic lake in the Baltic Uplands formed denticle-like cell wall ornamentation instead of typical granulation (Fig. 8 A). In hypertrophic lake *Micractinium pusillum* Fresen formed atypical to the species but characteristic to *M. bornhemiense* (Corn.) Korshikov multicellular, pyramidal colony (Fig. 8 B). *Dictyosphaerium sphagnale* cells in peat-bog lakes of the Baltic Uplands were spherical and attached to dichotomously branched strands (Fig. 2 G), whereas in original *D. sphagnale* description, cells are oval to broadly oval attached to tetrachotomously branched strands. Hindák (1988)

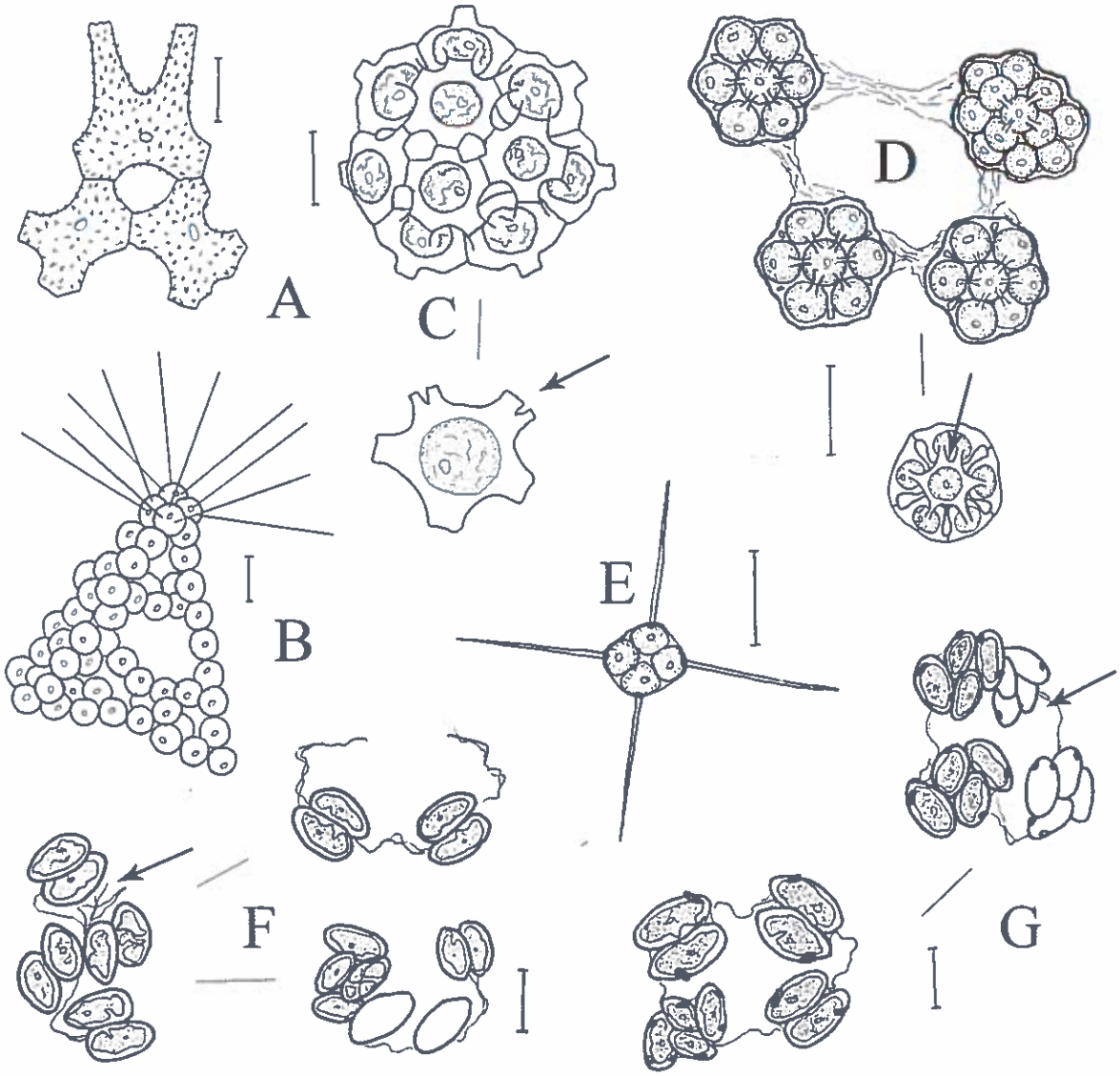

Fig. 8. Atypical *Chlorococcales* species from the Baltic Uplands lakes. **A** – *Pediastrum duplex* var. *subgranulatum*; **B** – *Micractinium pusillum*; **C** – *Coelastrum cambricum*; **D** – *Coelastrum reticulatum*; **E** – *Lagerheimia genevensis*; **F** – *Tetrachorella alternans*; **G** – *T. ornata* (arrows show atypical morphological characters)

observed similar atypical specimens of *D. sphagnale* from peat-bog lake of High Tatra. In a typical *Coelastrum cambricum* W. Archer neighbouring cells were joined by a single cell wall outgrow, while few coenobia from a swamp lake had dichotomously branched outgrows between two cells (Fig. 8 C). Atypical joining between neighbouring cells with two cell wall outgrows was also observed in *Coelastrum reticulatum* (P. A. Dangeard) Senn from a mesotrophic lake (Fig. 8 D). Few syncoenobia of *C. reticulatum* usually occur in the populations, while in eutrophic lake very high number (up to 75 %) of joined coenobia have been observed. Reproducing *Lagerheimia genevensis* (Chodat) Chodat at 4 autospores formation stage was very similar to *Tetrastrum elegans* Playfair (Fig. 8 E). According to Hindák (1980, 1984), mother cell wall remnants of *Tetrachorella alternans* (G. M. Smith) Korshikov and *T. chlorelloides* (Buck) Hindák remain for some time joining new formed coenobia. During this study, the joining mother cell wall remnants were observed in *T. ornata* Korshikov as well as in *T. alternans* (Fig. 8 F, G); it reveals that the mentioned feature is characteristic of the *Tetrachlorella* genus.

Identification of some *Chlorococcales* algae specimens from lakes of the Baltic Uplands was confusing. Two-celled *Euastropsis*-like coenobia, which differed from typical *E. richterii* (Schmidle) Lagerh. by having lateral lobe of the cell, were observed. Coenobia from swamp (Fig. 9 B a, b) and eutrophic lakes (Fig. 9 B c) differed by lateral lobe orientation, form and wideness of outer incision between lobes. Some *Pediastrum* species with similar morphology of marginal cells (*P. privum* (Printz) Hegew., *P. longecornutum* (Gutw.) Comas, *P. tetras* (Ehrenb.) Ralfs) could form two-celled coenobia as well. *Dictyosphaerium* sp. (Fig. 9 D) similar to *D. coacervatum* Comas by cells shape, cells irregular compact arrangement in the colony, wide gelatinous stalks, colony shape was found. However, in specimens from lake of the Baltic Uplands colonies were smaller, cells without evident polar thickenings, not covered with gelatinised mother cell wall remnants, and sometimes they were attached to thin irregular gelatinous stalks. *D. coacervatum* is characterised by a very narrow geographical distribution as well. For the final identification of *Dictyosphaerium* from Baltic Uplands, a more detailed study is required. Two *Botryococcus* specimens showed differences from already described species. *Botryococcus* sp.$_1$ (Fig. 9 A) found in autumn in a deep mesotrophic lake formed dense dark green colonies; cells were radially orientated and fully embedded into opaque gelatinous cups. The species looked similar to *B. braunii,* which was already found in the lake in summer, and all differences might be caused due to seasonal environment changes. One more atypical specimen with the features of three *Botryococcus* species was found in swamp lake (Fig. 9 C). The colony shape, cells immersion into mucilaginous cups was like in *B. braunii,* however gelatinous caps on the cells apexes were absent, cells size and shape (elongated with truncated ends) were similar to *B. protuberans* W. et G. S. West. Additionally there were long branched gelatinous processes characteristic to *B. terribilis* Komárek et Marvan.

Chlorococcales is the second species-rich (284 species) family of green algae in Lithuanian flora. Similarly to other European countries (Table 3), *Oocystaceae, Chlorellaceae,* families are the most diverse (Fig. 6 B). The comparison of *Chlorococcales* flora in Lithuania and some European countries is presented in Table 5. The highest number of shared species (205) is detected in the floras of Lithuania and Slovakia. According to indices of floristic similarities, *Chlorococcales* flora of Lithuania showed the closest similarity to those of Scandinavia, Belarus and Ukraine. However, it should be viewed with caution because of significantly differing coverage and scope of algal ecological groups, as well as their habitats investigations among the countries.

Table 5. The similarity of *Chlorococcales* flora in Lithuania and some European countries

Country	Similarity indices			Number of the shared speces
	Stugren-Radulescu	Jacaard	Sørensen	
Lithuania – Scandinavia	**-0.03**	**0.48**	**0.65**	190
Lithuania – Ukraine	**-0.05**	**0.47**	**0.64**	175
Lithuania – Belarus	**-0.07**	**0.47**	**0.64**	177
Lithuania – Germany	-0.09	0.45	0.62	156
Lithuania – United Kingdom	-0.15	0.43	0.60	164
Lithuania – Slovakia	-0.19	0.40	0.57	**205**
Lithuania – Russia (European part)	-0.24	0.38	0.55	121

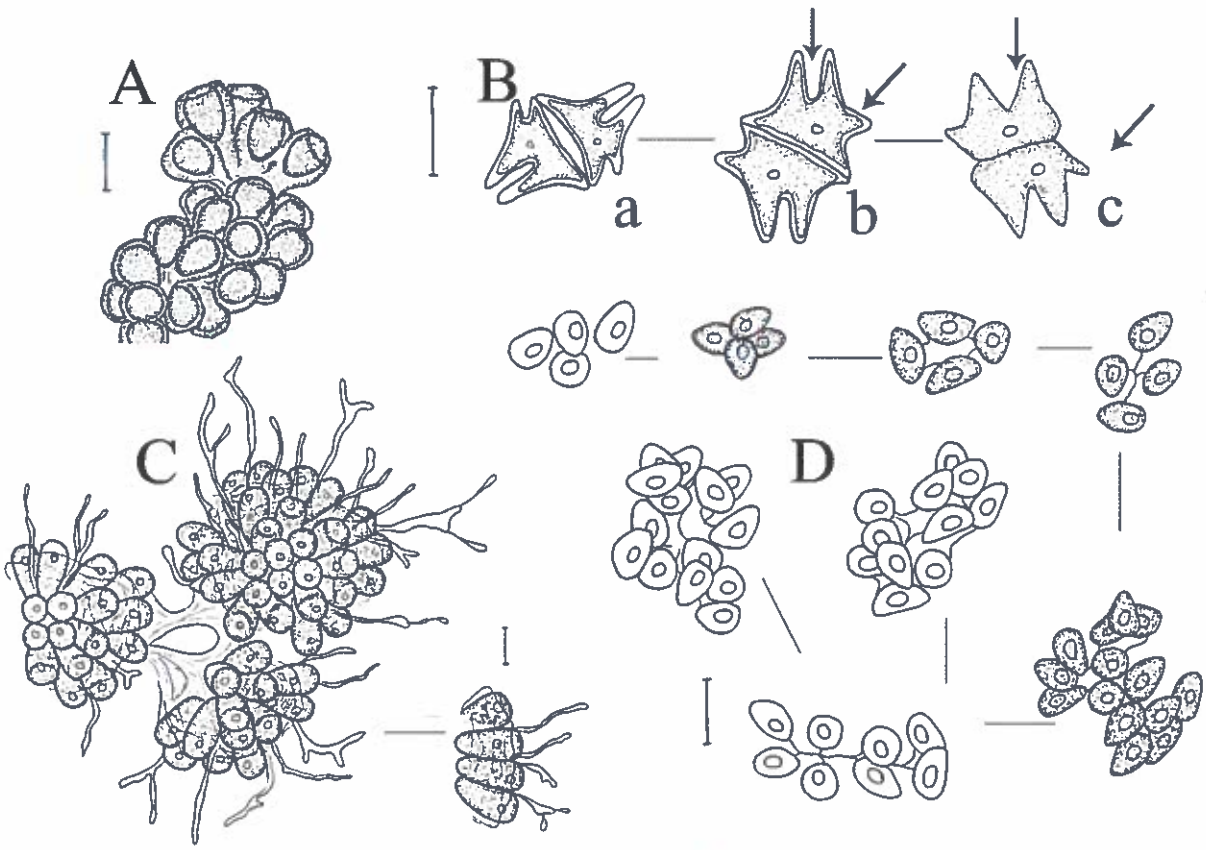

Fig. 9. Confusing *Chlorococcales* specimens from the Baltic Uplands. **A** – *Botryococcus* sp.; **B** – cf. *Euastropsis* sp.; **C** – *Botryococcus* sp.; **D** – *Dictyosphaerium* sp. (arrows show atypical morphological characters)

CONCLUSIONS

During the study period, 134 taxa of *Chlorococcales* algae, ascribed to 12 families and 49 genera, were recorded in 28 small lakes located in the Eastern part of Baltic uplands. The highest species diversity is characteristic of the *Scenedesmaceae* (41 species), *Chlorellaceae* (24), *Oocystaceae* (19) families and *Scenedesmus* (26), *Pediastrum* (12) genera. 34 new to Lithuanian species of *Chlorococcales* algae were recorded. The majority of the new species belong to the *Botryococcaceae* and *Scenedesmaceae* families. Two-thirds of the new to Lithuania species are rare in freshwaters of the world; *Echinosphaeridium nordstedtii, Monoraphidium flexuosum*, *Pseudokirchneriella roselata*, *Thorakochloris nygaardii* are very rare. Tventy eight taxa from the small lakes of the Baltic Uplands showed discrepancy in number and size of cells colonies, coenobia and different morphological structures. Untypical *Chlorococcales* species morphological features are more evident in lakes characterised by high anthropogenic impact and extreme environment conditions.

Chlorococcales species from the Baltic Uplands represent 48 % and 10 % of coccoid green algae species found in Lithuania and in the world, respectively. *Eutetramorus* cf. *fottii*, *Oocystis lacustris*, *Pediastrum boryanum*, *P. tetras*, *Scenedesmus armatus*, *Tetraedron minimum* are very frequent in the studied lakes. However, the majority of the recorded species are rare, especially those found in peat-bog lakes. Worldwide frequent species comprised almost half of the coccoid green algae species recorded during the period of investigations, most of them being cosmopolitan and ubiquitous. *Chlorococcales* algae comprise about one-third (283 species) of all species included in the Lithuanian green algae checklist. The most species-rich are *Scenedesmaceae* (98 species), *Chlorellaceae* (54), *Oocystaceae* (35) families.

REFERENCES

Bourrelly P., 1966: Les algues d'eau douce. Initiation á la systématique. VIII. *Chlorococcales*. – Bull. Macrosc. Appl., **11(5)**: 1–26.

Briskaite R., Kostkeviciene J., Naujalis J. R., 2008: Desmids (*Chlorophyta, Zygnematophyceae*) from the Girutiskis mire complex reserve (East Lithuania). – Biologia (Bratislava), **63(6)**: 903–910.

Economou-Amilii A., Spartinou M., 1989: Rare and interesting planktic species of coccal green algae (*Chlorococcales*) from Greece. – Algological Studies, **54**: 49–66.

Grasshoff K., Kremling K., Ehrhardt M. (eds.), 1983: Methods of seawater analysis. – Weinheim.

Guiry M. D., Nic Dhonncha E., 2004: *AlgaeBase version 2.1*. World-wide electronic publication, National University of Ireland, Galway (http://www.algaebase.org searched on 29 November 2004).

Heynig H., Krienitz L., 1987: Interessante coccale Grünalgen (*Chlorellales*) aus einem Altwasser der Elbe (DDR). – Archiv fuer Protistenkunde, **134**: 49–58.

Hindák F., 1977: Studies on *Chlorococcal* algae (*Chlorophyceae*). Biologickié práce, I. – Bratislava.

Hindák F., 1980: Studies on *Chlorococcal* algae (*Chlorophyceae*). Biologickié práce, II. – Bratislava.

Hindák F., 1984: Studies on *Chlorococcal* algae (*Chlorophyceae*). Biologickié práce, III. – Bratislava.

Hindák F., 1988: Studies on *Chlorococcal* algae (*Chlorophyceae*). Biologickié práce, IV. – Bratislava.

Hindák F., 1990: Studies on *Chlorococcal* algae (*Chlorophyceae*). Biologickié práce., V. – Bratislava.

Hindák F., Hindákova A., 1998: Sinice / cyanobakterie a riasy. – In: Marhold K., Hindak F. (eds.), Zoznam nizsich a vyssich rastlin Slovenska: 11–100. – Bratislava.

Jaccard P., 1908: Nouvelles recherches sur la distribution florale. – Bulletin de la Societe Vaudoise des Sciences Naturelles, **44**: 223–270.

Jakimavičiūtė I., Kostkevičienė J., Briškaitė R., 2006: New for Lithuania species of the genera *Pleurotaenium*, *Xanthidium*, *Staurodesmus*, and *Desmidium* (*Desmidiales*, *Chlorophyta*) from Dubičiai bog lakes. – Botanica Lithuanica, **12(1)**: 31–37.

Jankavičiūtė G., 1965: Fitoplankton ozera Dysnai i ego dinamika. Periodičeskie izmenenija v razvitii fitoplanktona. – Trudy AN LSR, B **3(38)**: 3–16.

Jankavičiūtė G., 1966: Fitoplankton ozera Dysnai i ego dinamika. Vertikal'noe raspredelenie fitoplanktona. – Trudy AN LSR, B **1(39)**: 15–22.

Jankavičiūtė G., 1990: Vidovaja struktura fitplanktona Kutšskogo zaliva. – Ekologija, **1**: 5–22.

Jankavičiūtė G., 1996: Lietuvos vandenų vyraujantys dumbliai. – Vilnius.

John D. M., 1994: Alteration of generations in algae: its complexity, maintenance and evaluation. – Biology Review, **69**: 275–291.

Joiin D. M., Tsarenko P. M., 2002: Order *Chlorococcales*. – In: John D. M., Whitton B. A., Brook A. J. (eds.), The freshwater algal flora of the British Isles. An identification guide to freshwater and terrestrial algae: 327–408. – Cambridge.

Junzill S. B., 1791: Opisanie roslin w prowincij W.X.L. naturalnie rosnących według układu Linneusza. – Wilno.

Junzill S. B., 1811: Opisanie roslin Litewskiech według układu Linneusza. – Wilno.

Karosienė J., Kasperovičienė J., 2008: Epiphyton *Chroococcales* cyanobacteria species new to algaeflora of Lithuanian. – Botanica Lithuanica, **14(3)**: 159–169.

Karosienė J., Kasperovičienė J., 2009: Filamentous epiphyton cyanobacteria (*Oscillatoriales*, *Nostocales*) new to algal flora of Lithuanian freshwaters. – Botanica Lithuanica, **15(2)**: 79–91.

Kasperovičienė J., 2001: The summer phytoplankton structure of some lakes located in Lithuanian protected areas. – Biologija, **2**: 80–83.

Kasperovičienė J., 2007: Assessment of ecological status of the Dovinė river catchment area lakes according to phytoplankton data. – Ekologija, **53(2)**: 13–21.

Kavaliauskienė J., 1996: Lietuvos ežerų dumbliai. – Vilnius.

Komárek J., 1974: *Monoraphidium flexuosum*, a new chlorococcal alga from lakes of northwestern Ontario (Canada). – Preslia, **46**: 118–122.

Komárek J., Fott B., 1983: *Chlorophyceae* (Grünalgen), Ordnung *Chlorococcales*. – Die Binnengewässer, **16/7(1)**. – Stuttgart.

Koreivienė J., Kasperovičienė J., 2003: Diversity, morphology and distribution of *Coelastrum* (*Chlorophyceae*) in plankton of lakes in the environs of Vilnius. – Botanica Lithuanica, **9(1)**: 25–41.

Koreivienė J., Kasperovičienė J., 2005: The checklist of *Chlorococcales* (*Chlorophyta*) from the water bodies of Lithuania (*Chlorococcaceae* – *Coelastraceae*). – Botanica Lithuanica, **11(4)**: 221–234.

Koreivienė J., Kasperovičienė J., 2006: The checklist of *Chlorococcales* (*Chlorophyta*) from the water bodies of Lithuania (*Chlorellaceae*, *Scenedesmaceae*). – Botanica Lithuanica, **12(1)**: 39–56.

Kostkevičienė J., 2001: Lietuvos upių ir upelių fitoplanktonas. – Daktaro disertacija. – Vilnius.

Kostkevičienė J., Briškaitė R., Bakūnaitė J., Jakimavičiutė I., 2003: Desmids (*Chlorophyta, Desmidiales*) from Lithuania. – Biologia (Bratislava), **58(4)**: 681–691.

Kostkevičienė J., Laučiūtė R., 2005: The freshwater red algae species of *Batrachospermum* sect. *Batrachospermum* (*Batrachospermales*, *Rhodophyta*) new to Lithuania. – Botanica Lithuanica, **11(3)**: 151–159.

Kostkevičienė J., Sinkevičienė Z., 2008: A preliminary checklist of Lithuanian macroalgae. – Botanica Lithuanica, **14(1)**: 11–27.

Kostkevičienė J., Vitonytė I., 2008 a: New data on red algae species *Audouinella hermanii* and *Chroodactylon ornatum* in Lithuania. – Botanica Lithuanica, **14(3)**: 171–175.

Krienitz L., Hegewald E., Hepperle D., Wolf M., 2002: Systematisches Konzept von Familien und Gattungen coccaler Grünalgen: morphologie versus 18S rRNA-Gen-Sequenzen. – Deutsche Gesellschaft für Limnologie (DGL): 585–588.

Mauch E., Schmedtje U., Maetze A., Fischer F., 2003: Informationsberichte des Bayerischen Landsamtes für Wasserwirtschaft. – München (www.lfu.bayern.de/wasser/gewaesserqualitaet_fluesse/qualitaetssicherung/doc/taxa_einleitender_textteil.pdf).

Mikheeva T. M., 1999: Al'goflora Belarusi. Taksonomičeskij katalog. – Minsk.

Minkevičius A., 1958: Trakų ežerų fitoplanktonas 1954 m. vasarą. – VU Mokslo darbai, biologija, geografija, geologija, **19(5)**: 5–15.

Olenina I., 1996: Fitoplankton zaliva Kuršju Marios i pribrežnoi zony jugovostočnoj časti Baltijskogo morja i osobennosti ego razvitija. Doktorskaja disertacija. – Vilnius.

Parker S. P. (ed.), 1982: Synopsis and classification of living organisms. I, II. – New York.

Snoeijs P., Kasperovičienė J., 1996: Intercalibration and distribution of diatom species in the Baltic Sea. IV. – Uppsala.

Sørensen T., 1948: A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. Det Kongelige Danske Videnskabers Selskab. – Biologiske Skrifter, **5(4)**: 1–34.

Starmach K., 1989: Plankton roślinny wód słodkich. – Warszawa-Kraków.

Stoyneva M. P., 1998: On the occurrence of teratological forms in some green (*Chlorococcales*) algae of genera *Scenedesmus* Meyen, *Pediastrum* Meyen and *Tetraedron* Kütz. in Bulgarian natural lowland wetlands. – Algologia, **84**: 351–359.

Stugren B., Rădulescu M., 1961: Metode matematice in zoogeografia regionala. – Stud. biol., **12(1)**: 8–24.

Ština E. A., 1997: Flora vodoroslej bassejna reki Vjatki. – Kirov.

Trifonova I. S., 1990: Ekologija i sukcessija ozernogo fitoplanktona. – Leningrad.

Tsarenko P. M., 1990: Kratkij opredelitel' khlorokokkovykh vodoroslej Ukrainskoj SSR. – Kiev.

Ūselytė S., 1961: Baltijos jūros prie Lietuvos TSR krantų kompleksiniai tyrimai. Fitolanktonas ir jo ryšys su Kuršių mariomis. – Lietuvos TSR MA darbai, C **3(26)**: 101–113.

Vilkaitis V., 1924–26: Truputis medžiagos Lietuvos desmidiacėjų florai. – Žemės ūkio akademijos metraštis, 303–306.

Vilkaitis V., 1936: Kamanų desmidiacėjos. Kamanos. Geologiškai botaniška studija. – Žemės Ūkio akademijos metraštis, **10(3–4)**: 253–265.

Vilkaitis V., 1940: Šepetos desmidiacėjos. Šepeta. Aukštapelkio monografija. – Žemės ūkio akademijos metraštis, **13(4)**: 110–130.

Vitėnaitė T., 2001: Lietuvos vandens telkinių melsvadumblių (*Cyanophyta*) sąvadas. – Botanica Lithuanica, **7(4)**: 343–364.

Vitonytė I., Kostkevičienė J., 2008: New to Lithuania Cyanobacteria species in benthos of streams. – Botanica Lithuanica, **14(4)**: 223–231.

Whitton B. A., John D. M., Kelly M. G., Haworth E. Y., 2003: A Coded List of Freshwater Algae of the British Isles. 2nd edition. – London.

Zetterberg G., 1995: Code of List PX Phytoplankton, version PX950907-GUZ, Stockholm Stockholm. – ftp://nrm.se/pub/nrm/ittermlist).

RYTINĖS BALTIJOS KALVYNO DALIES MAŽŲJŲ EŽERŲ PLANKTONO KOKOIDINIŲ ŽALIADUMBLIŲ FLORA

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Santrauka

Dvidešimt aštuoniuose rytinės Baltijos kalvyno dalies mažuosiuose ežeruose aptikta 134 *Chlorococcales* eilės žaliadumblių rūšys ir vidurūšiniai taksonai, priklausantys 12 šeimų ir 49 genčių. Jie sudaro beveik pusę Lietuvoje aptinkamų kokoidinių žaliadumblių rūšių. Didžiausia rūšių įvairove išsiskyrė *Scenedesmaceae* (41 rūšis), *Chlorellaceae* (24), *Oocystaceae* (19) šeimos ir *Scenedesmus* (26), *Pediastrum* (12) gentys. *Eutetramorus* cf. *fottii* (Hindák) Komárek, *Oocystis lacustris* Chodat., *Pediastrum boryanum* (Turpin) Menegh., *P. tetras* (Ehrenb.) Ralfs, *Scenedesmus armatus* Chodat. ir *Tetraedron minimum* (A. Braun) Hansg. – labai dažnos tirtuose ežeruose rūšys. Aptiktos 34 naujos Lietuvoje *Chlorococcales* žaliadumblių rūšys, tarp jų labai retos pasaulyje: *Echinosphaeridium nordstedtii* Lemmermm., *Monoraphidium flexuosum* Komárek, *Pseudokirchneriella roselata* (Hindák) Hindák, *Thorakochloris nygaardii* Fott. Lyginant su tipinėmis rūšimis, *Chlorococcales* dumblių ląstelių, kolonijų, cenobių ir kitų morfologinių struktūrų dydžio ir skaičiaus skirtumai ypač išryškėjo antropogeninę apkrovą patiriančiuose bei ekologinių sąlygų ekstremumais išsiskiriančiuose vandens telkiniuose.