Cyanobacteria of the West Carpathian Mts spring fens: single samplings

Sinice pramenišť západních Karpat: jednorázové odběry

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Abstract

The presented study focuses on the cyanobacterial diversity and variability in the West Carpathian Mts spring fens. Samples were collected at 32 sites on the border between the Czech and Slovak Republics. Moss assemblages inhabited particulary by subaerophytic cyanobacteria and diatoms dominated the investigated spring fens. Cyanobacteria were isolated from fresh moss samples and identified using light microscope. Environmental variables were measured using mobile instruments (WTW Company) and statistic software Canoco (TER BRAAK & ŠMILAUER, 1998) was applied for data evaluation. Altogether 51 cyanobacterial species were identified, including several interesting taxa: *Aphanocapsa parietina*, *Cyanothece aeruginosa*, *Phormidium formosum*, and *Pseudocapsa* cf. *dubia*. Morphology and ecology of the mentioned species are discussed and documented by drawings and distribution maps.

Introduction

The West Carpathian spring fens are the most unique unpolluted places on the territory of the Czech and Slovak Republics boundary. The majority of them have been covered by rich communities of vascular or nonvascular plants (HÁJEK et al. 2002) forming a curious substrates for epiphytic or subaerophytic cyanobacteria and diatoms. The floristic data with relations to ecological variables were published earlier by HAŠLER & POULÍČKOVÁ (2005), and POULÍČKOVÁ et al. (2001, 2004). The West Carpathian Mts area can be devided into two regions. The south-western part is warmer and drier, with lower altitudes, and the bedrock and groundwaters are calcium rich here. On the contrary, the north-eastern fens are at higher altitudes, the climate is more humid and cooler here and the waters contain much less calcium (HÁJEK & HEKERA, in press).

Material and methods

Sampling of 32 sloping spring fens was performed in August 2002 (Fig 1). Most investigated localities belong to the Slovak part of the West Carpathian Mts (Table 1). The Velká Fatra and Chočské vrchy represent the central part of the West Carpathian Mts, formed of limestones. Transitional limestone-marly part is represented by the Strážovské vrchy, bordering on the outer flysch part with the Bílé Karpaty, Biele Karpaty and Javorníky. The altitudes of sampling sites ranged from 382 m a.s.l. (Horná Závrská, the Biele Karpaty, Slovakia) to 780 m a.s.l. (Studničná, the Chočské vrchy, Slovakia). Autumn and spring are more humid while the summer is drier (1991-2001: average annual temperature t=5,5°C, precipitation 1 260 mm, Czech Hydrometeorological Institute).

Table 1: List of investigated localities and their parameters (Cond-conductivity in $\mu S.cm^{-1}$, Redox-redox potential in mV, SV-Strážovské vrchy, JV-Javorníky, VF-Velká Fatra, ChV-Chočské vrchy, BKs-Biele Karpaty (Slovakia), BK-Bílé Karpaty)

No	*Locality*	*Area*	*Altitude*	*Co-ordinates*	*pH*	*Cond*	*Redox*
1	Vápeč	SV	597	485624/182017	7.3	387	-140
2	Rematina	SV	712	485645/182716	7.3	343	-117
3	Hanušová	SV	723	485651/182909	6.9	486	-230
4	Čiernianka	SV	550	490542/183424	7.3	340	-300
5	Velká Čierna	SV	501	490529/183538	6.6	460	-300
6	Kapustové	SV	452	490652/183325	7.5	335	-280
7	Biela Voda	SV	406	490602/183340	7.8	440	-180
8	Podhorie, vachta	SV	408	490539/183258	6.9	417	-310
9	Štiavnik, Ráztoka	JV	665	491904/182516	6.9	423	-277
10	Čierny potok II.	SV	623	490959/183413	7.5	363	-180
11	Čierny potok I.	SV	424	490945/183407	8.0	390	-254
12	Rojkov	VF	433	490855/190920	6.0	564	-231
13	Stankovany	VF	437	490912/190912	6.6	1087	-299
14	Nad PR Močiar	VF	482	490927/190902	6.9	498	-360
15	Švošov, Komj.	ChV	475	490732/191259	7.3	430	-250
16	Studničná	ChV	780	490755/191548	6.8	360	-340
17	Selenec	VF	747	485433/190014	6.9	294	-350
18	Rakytovská dolina I.	VF	736	485320/185841	7.3	309	-282

19	Rakytovská dolina II.	VF	733	485329/185838	7.5	256	-290
20	Blatnická d.	VF	579	485501/185651	7.1	339	-325
21	Rakša	VF	512	485245/185324	7.4	398	-305
22	Omšenská Baba	SV	476	485431/181402	7.1	451	-363
23	U Šifflov	BKs	434	484752/172404	7.3	476	-350
24	Žalostinná	BKs	539	484852/172550	7.1	420	-346
25	Borotová	BKs	437	484948/173841	7.5	459	-272
26	Záhradská	BKs	410	485005/174114	7.1	481	-300
27	Tlstá hora	BKs	400	485320/175337	7.3	380	-292
28	Horná Závrská	BKs	382	485845/175634	7.6	467	-260
29	Mituchovci	BKs	436	485646/175823	7.2	445	-321
30	Bošáca, Grúň	BKs	443	485339/174755	7.1	450	-331
31	Hrubý Mechnáč	BK	642	485633/144754	7.9	310	-309
32	Hrnčarky	BK	448	485431/174034	7.4	543	-310

Mosses and higher plants were collected into plastic bags. Stones and soil surfaces were scraped with scalpel. Collected samples were transported in a cool-box. Bryophyte samples were dominated by *Aulacomnium palustre* (HEDW.) SCHWÄGR., *Bryum pseudotriquetrum* (HEDW.) P. GAERTN., B. MEY. et SCHREB., *Calliergon stramineum* (BRID.) KINDB., *Calliergonella cuspidata* (HEDW.) LOESKE, *Campylium stellatum* (HEDW.) LANGE et C.E.O. JENSEN, *Palustriella commutata* (HEDW.) OCHYRA, *Dicranum bonjeanii* DE NOT., *Warnstorfia exannulata* (B.S.G.) LOESKE, *Drepanocladus revolvens* (SW.) WARNST., *Fissidens adianthoides* HEDW., *Hypnum pratense* (RABENH.) W.D.J. KOCH ex HARTM., *Philonotis calcarea* (B.S.G.) SCHIMP., *P. fontana* (HEDW.) BRID., *Polytrichum commune* HEDW., *Sphagnum capillifolium* (EHRH.) HEDW., *S. palustre* L., *S. papillosum* LINDB., *S. flexuosum* DOZY et MOLK., *S. fallax* (H. KLINGGR.) H. KLINGGR., *S. teres* (SCHIMP.) ANGSTR. ex HARTM., *S. warnstorfii* RUSSOW., *Tomenthypnum nitens* (HEDW.) LOESKE (nomenclature according to KUBINSKÁ 1998).

Cyanobacteria were isolated into sterile Zehnder medium (Staub 1961) and cultured on 1.5% agar plates or in liquid medium with sterile cotton wool. Cultures were incubated under the temperature of 20ºC, illumination 20 $\mu mol.m^{-2}.s^{-1}$ and light/dark regime 16/8 hours. Cyanobacteria were studied under the Zeiss LM and indentified according to STARMACH (1966), ANAGNOSTIDIS & KOMÁREK (1988), and KOMÁREK & ANAGNOSTIDIS (1989, 1999).

Detrended correspondence analysis (DCA) was used for statistic evaluation, Canoco for Windows (TER BRAAK & ŠMILAUER 1998). The evaluation focuses on the differences in species data among the sampling sites. The basic detrending method was made by segments without any transformation and with respect to downweighting of rare species.

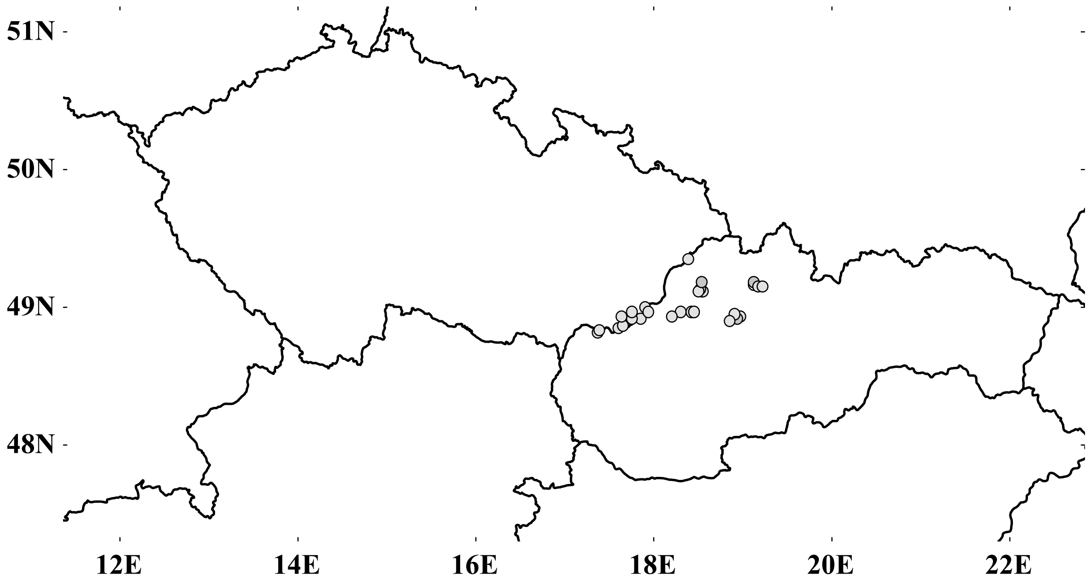

Fig. 1: The studied area and investigated localities

Results and discussion

Altogether 51 cyanobacterial taxa were identified during our study. The taxa as *Aphanocapsa parietina*, *Chroococcus* spp., *Leptolyngbya* spp., *Nostoc commune*, *Nostoc muscorum* and *Phormidium* spp. were found as the most frequent in this area (Table 2), similar to records of HAŠLER & POULÍČKOVÁ (2005), UHER & KOVÁČIK (2002). The comments to the most interesting species are discussed below.

Table 2: List of species from the West Carpathian Mts.

Species	***Locality***
Aphanocapsa parietina NÄGELI	1,4,6,7,24,30
Aphanocapsa cf. *parietina* NÄGELI	13
Aphanocapsa sp.	7,14,19,28
Aphanothece castagnei (BRÉB.) RABENH.	32
Aphanothece cf. *castagnei* (BRÉB.) RABENH.	17

Aphanothece pallida (KÜTZ.) RABENH.	14
Aphanothece saxicola NÄGELI	9,15,27
Aphanothece sp.	3,4,25
Calothrix sp.	1
Chamaesiphon cf. *incrustans* GRUNOW in RABENH.	27
Chamaesiphon minutus (ROSTAF.) LEMMERM.	2,8,11
Chamaesiohon cf. *minutus* (ROSTAF.) LEMMERM.	20
Chamaesiphon polonicus (ROSTAF.) HANSG.	3,4,31
Chamaesiphon cf. *polonicus* (ROSTAF.) HANSG.	7
Chroococcus helveticus NÄGELI	6,11,17,18,32
Chroococcus lithophilus ERCEG.	2,3,4,6,22
Chroococcus minor KÜTZ.	5,15,21,23,26
Chroococcus cf. *minor* KÜTZ.	27
Chroococcus minutus KÜTZ.	9,30
Chroococcus cf. *minutus* KÜTZ.	28
Chroococcus tenax (KIRCHN.) HIERON.	26
Chroococcus turgidus (KÜTZ.) NÄGELI	1,9,12,13,14
Chroococcus sp.	7,24
Cyanothece aeruginosa (NÄGELI) KOMÁREK	4,9,12,26
Gloeocapsa cf. *alpina* (NÄGELI) BRAEND	9
Gloeocapsa atrata KÜTZ.	2,17
Gloeocapsa compacta KÜTZ.	4,20
Gloeothece fusco-lutea NÄGELI	9
Gloeothece palea (KÜTZ.) RABENH.	1,4,5,7,19,22
Gloeothece cf. *palea* (KÜTZ.) RABENH.	23
Gloeothece sp.	7
Leptolyngbya boryana (GOMONT) ANAGN. et KOMÁREK	5,8,22
Leptolyngbya cf. *boryana* (GOMONT) ANAGN. et KOMÁREK	7,24,27
Leptolyngbya cf. *fragilis* (GOMONT) ANAGN. et KOMÁREK	16
Leptolyngbya sp.	1,4,6,9,11,12,14,15,18,19,21,22,26,30,32
Microchaete tenera THUR. ex BORNET et FLAHAULT	5
Nostoc commune VAUCHER ex BORNET et FLAHAULT	4,8,9,14,15,16,17,21,25
Nostoc microscopicum CARMICH. ex BORNET et FLAHAULT	30
Nostoc cf. *microscopicum* CARMICH. ex BORNET et FLAHAULT	32,
Nostoc muscorum C.AGARDH ex BORNET et FLAHAULT	2,4,20,22,25,31
Nostoc cf. *muscorum* C.AGARDH ex BORNET et FLAHAULT	7,18,23
Nostoc sp.	3,6,17,30,31

Oscillatoria simplicissima GOMONT	21,23
Oscillatoria tenius C.AGARDH	20
Oscillatoria sp.	7,12,22,32
Phormidium amoenum Kütz.	14,20,24,27
Phormidium cf. *animale* (C.AGARDH ex GOMONT) ANAGN. et KOMÁREK	6
Phormidium autumnale KÜTZ.	3,12,19
Phormidium cortianum (MENEGH. ex GOMONT) ANAGN. et KOMÁREK	13,18,24
Phormidium formosum (BORY ex GOMONT) ANAGN. et KOMÁREK	2,5,7,8,11,15,17
Phormidium cf. *interruptum* KÜTZ.	25
Phormidium cf. *irriguum* (KÜTZ. ex GOMONT) ANAGN. et KOMÁREK	26
Phormidium retzii (C.AGARDH) GOMONT	28
Phormidium cf. *tenue* (C.AGARDH ex GOMONT) ANAGN. et KOMÁREK	3
Phormidium tenuissimum WORON.	31
Phormidium sp.	4,11
Pleurocapsa minor HANSG.	5
Pleurocapsa cf. *minor* HANSG.	24
Pseudocapsa cf. *dubia* ERCEG.	3,14
Schizothrix sp.	16
Scytonema hofmanii C.AGARDH ex BORNET et FLAHAULT	27
Tolypothrix cf. *tenuis* KÜTZ. ex BORNET et FLAHAULT	7
Trichormus variabilis (KÜTZ. ex BORNET et FLAHAULT) ANAGN. et KOMÁREK	2

DCA showed that the first axis explains 10.8% of species data variability and the second axis explains 17.5% of species data variability. Two major groups of localities can be distinguished approximately according to the distribution and similarity of cyanobacteria (Fig 2). The group A is represented especially by the Velká Fatra Mts. and the group B includes the Bílé Karpaty and Biele Karpaty Mts.

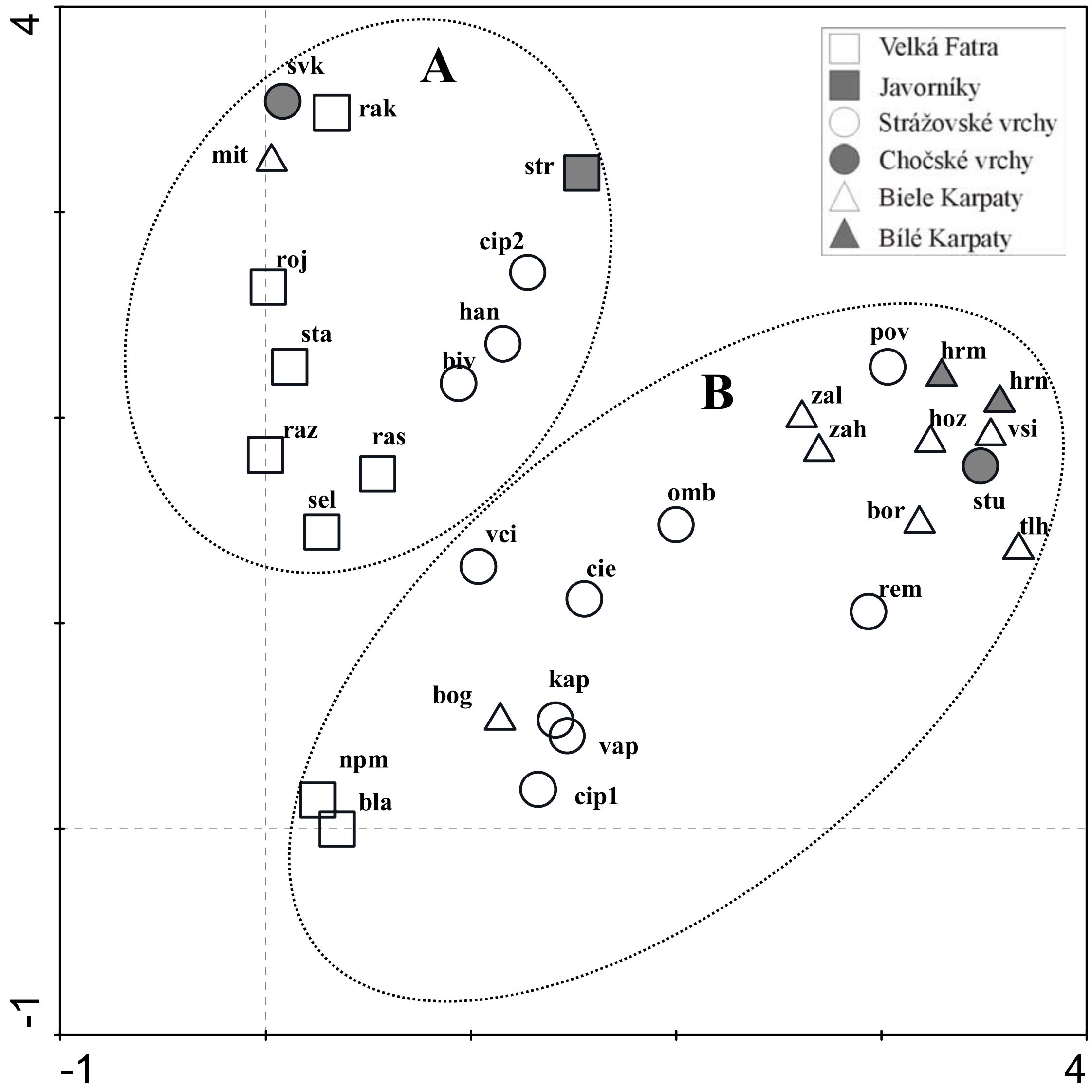

Fig. 2: DCA ordination diagram of sampling sites based upon similarity of cyanobacterial communities.
Group A: biv-Biela Voda, cip2-Čierny potok I., han-Hanušová, mit-Mituchovci, rak-Rakša, ras-Rokytovská dolina I., raz-Rokytovská dolina II., roj-Rojkov, sel-Selenec, sta-Stankovany, str-Štiavnik,Ráztoka, svk-Šošov,Komj., Group B: bla-Blatnická dolina, bog-Bošáca,Grúň, bor-Borotová, cie-Čiernianka, cip1-Čierny potok II., hoz-Horná,Závrská, hrm-Hrubý Mechnáč, hrn-Hrnčarky, kap-Kapustové, npm-Nad PR Močiar, omb-Omšenská Baba, pov-Podhorie,vachta, rem-Rematina, stu-Studničná, tlh-Tlstá hora, vap-Vápeč, vci-Velká Čierna, vsi-U Šifflov, zah-Záhradská, zal-Žalostinná.

Comments to the most interesting taxa

Chroococcales, Merismopediaceae, Merismopedioideae
Aphanocapsa parietina NÄGELI 1849 (Fig 4/1, Fig 5/1)

Small gelatinous colonies or mass from dark green to blue-green on agar plates, enclosed by diffluent mucilage envelope. Cells spherical, 5-6 µm in diameter, brown-green coloured and with slightly visible chromatoplasma. The species occurs usually on limestone rocks and alkaline soils (KOMÁREK & ANAGNOSTIDIS 1999). Our observations are from limestone-marly and/or flysch areas with pH higher than 7 and approximately at the altitude of 400 m a.s.l. UHER & KOVÁČIK (2002) found this species in the gorges of the National Park Slovak Paradise.

Chroococcales, Synechococcaceae, Aphanothecoideae
Cyanothece aeruginosa (NÄGELI) KOMÁREK 1976 (Fig 3/2, Fig 5/2)

Cells solitary, wide rounded and shortly cylindrical, usually 15-25 x 10-20 µm. Cells contain fine granule and visible keritomized chromatoplasma. Some cells were enclosed by fine and colourless mucilage layer. It is a common species (see GEITLER 1932, STARMACH 1966, KONDRATEVA 1968, KOMÁREK & ANAGNOSTIDIS 1999) with cosmopolitan distribution at unpolluted sites from lowlands to mountains, usually on wet rocks or in swamps with pH below 7 (KOMÁREK & ANAGNOSTIDIS 1999). Our records are also from sites with pH slightly below 7, rather sporadically occuring in the samples. Komárek (1976) established the genus Cyanothece with respect to cell division, shape, the distribution of thylakoids and the structure of the cell wall. A few records were achieved in the highlands of the Slovak Republic (ROSA 1963, HAZSLINSZKY, F. 1868); both published data were reviewed by LHOTSKÝ et al. (1974).

Chroococcales, Chroococcaceae
Pseudocapsa cf. ***dubia*** ERCEG. 1925 (Fig 3/1, Fig 5/3)

Few celled colonies up to 10 cells were dispersed among other cyanobacteria. Colonies were covered by colourless or slightly yellowish, thick and firm envelopes. Cells rounded and oval, 5-9 µm in diameter, changed into irregular with homogenous and/or sporadically fine granulate content. An important genus feature, the arrangement of cells in a colony (see KOMÁREK & ANAGNOSTIDIS 1999), was observed in stages dominated by irregular cells. UHER & KOVÁČIK (2002) found this species on limestone walls in the gorges of the National Park Slovak Paradise. The species is common in limestone areas, caves and mountains.

Oscillatoriales, Phormidiaceae, Phormidioideae

Phormidium formosum (BORY ex GOMONT) ANAGN. et KOMÁREK 1988 (Fig 4/2, Fig 5/4)

We observed filamentous, uniseriate trichomes, slightly constricted at the cross walls, without false or true branching, forming dark green to brown-green mats on the soil among mosses. Isodiametric or slightly shorter cells, 5-6.5 μm, were able to form necridic cells (Fig 4/2a) disintegrating trichomes into hormogonia (Fig 4/2b). Facultative sheaths occured sporadically, mainly within old populations affected by water stress. The species is common especially in the Strážovské vrchy under various conditions (pH range from 6.6 to 8, altitude from 400 to 730 metres). It is previously recorded in the Czech and Slovak Republics on the mud of the Piešťany thermal spa BOLLA (1860), in the southern and western Bohemia PRÁT et al. (1951, 1948), ROSA (1961, 1962, 1968, 1969). The species is reported from mesotrophic sites but, according to our experience, its ecological tolerance will be probably wider. All published data were reviewed by LHOTSKÝ et al. (1974) and POULÍČKOVÁ et al. (2004).

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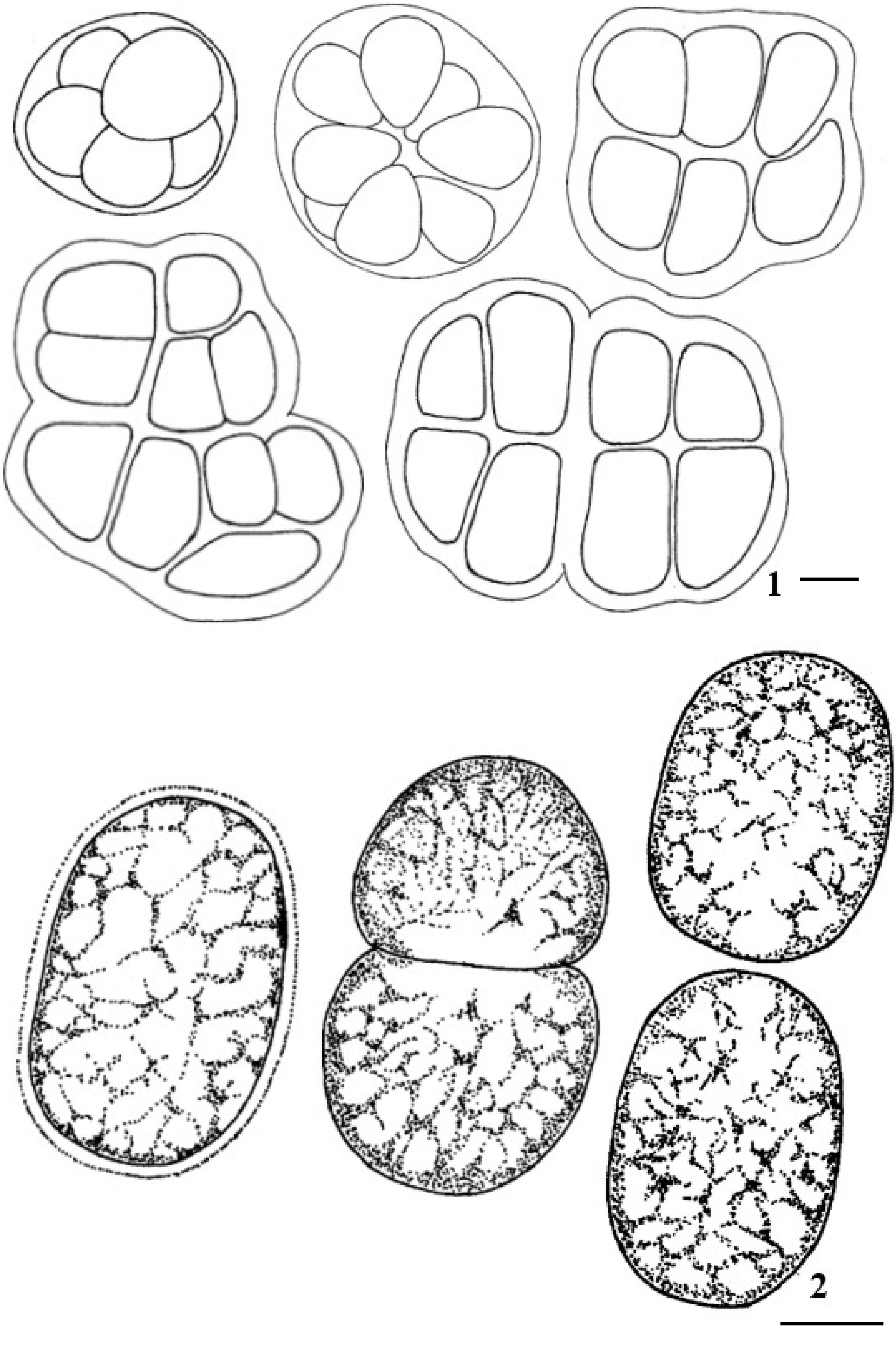

Fig. 3: Development of two chroococcal species from the West Carpathians: 1 – *Pseudocapsa* cf. *dubia*, 2 – *Cyanothece aeruginosa*, bar scale 5 µm

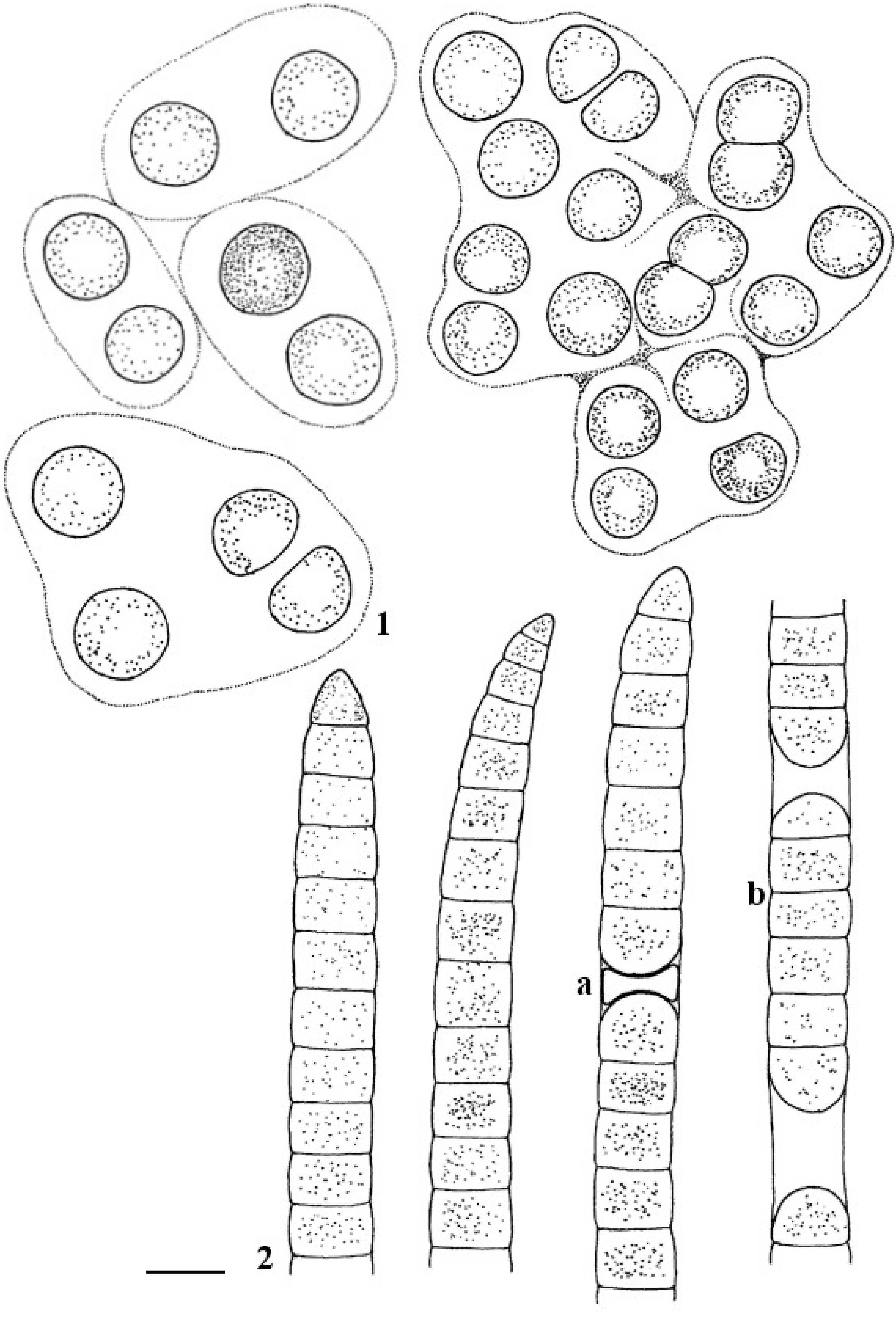

Fig. 4: Development of main cyanobacterial species from the West Carpathians: 1 – *Aphanothece parietina*, 2 – *Phormidium formosum*, a – necridic cell, b – hormogonia, bar scale 5 μm

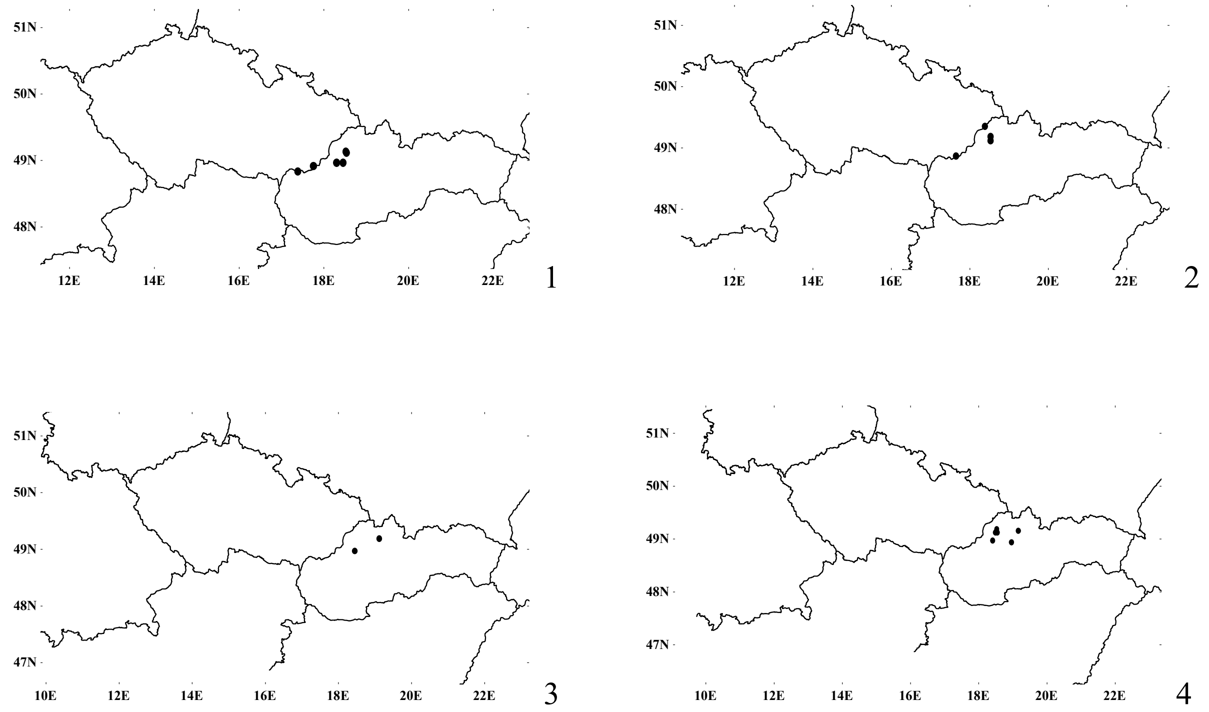

Fig. 5: Distribution of selected cyanobacteria in the West Carpathians, 1-*Aphanocapsa parietina*, 2-*Cyanothece aeruginosa*, 3-*Pseudocapsa* cf. *dubia*, 4-*Phormidium formosum*