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Phenotype diversity of the cyanobacterial genus *Leptolyngbya* in the maritime Antarctic

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Abstract: The common and ecologically important cyanobacterial form-genus *Leptolyngbya* is widely distributed in numerous ecosystems over the Earth's biosphere. Several morphospecies dominate microbial communities in polar habitats, but their diversity and local ecological significance are little known. Several articles characterising strains isolated from Antarctic coastal habitats by molecular methods were published, but knowledge of their phenotype and ecological characters are indispensable for future detailed environmental studies. Distinct morpho- and ecotypes (ecologically important morphospecies) from maritime Antarctica are characterised in this article. Eight dominant *Leptolyngbya* types from subaerophytic and freshwater habitats were recognised, and four of them (*L. borchgrevinkii*, *L. fritschiana*, *L. nigrescens* and *L. vincentii*) are described as new distinct species.

Key words: Maritime Antarctica, Cyanobacteria, *Leptolyngbya*, taxonomy, ecology.

Introduction

The cyanobacterial genus *Leptolyngbya* was defined as a wide natural cluster (genotype) comprising several species of old traditional genera *Lyngbya, Phormidium* and *Plectonema.* Species of this genus have thin filaments (0.5 to 3.5 µm wide) and parietal location of the thylakoids (Anagnostidis and Komárek 1988; Komárek and Anagnostidis 2005). This taxonomic cluster was designated originally as "LPP-group B" by bacteriologists (Rippka *et al*. 1979), and recently supported and justified by molecular analyses (Castenholz 2001; Taton *et al*. 2003; Taton *in* Komárek and Anagnostidis 2005; Casamatta *et al*. 2005). Various species of the genus *Leptolyngbya* (*sensu lato*) are some of the commonest cyanoprokaryotic organisms in many of the world's biotopes, based on recent studies of cyanobacterial microflora from different countries. Numerous morpho- and ecotypes occur in almost all habitats, including some very extreme ones. Several species are common in maritime Antarctic and play an important ecological role in various microbiocenoses in coastal deglaciated zones.

The intrageneric taxonomic classification of the genus *Leptolyngbya* Anagn. *et* Kom. 1988 is difficult, because of its simple morphology and minute dimensions. It comprises filamentous cyanobacteria (cyanophytes, cyanoprokaryotes) with fine and simple trichomes, sometimes with facultative sheaths (usually only up to 3.5 µm, wide incl. a sheath), in the present concept (= LPP group B *sensu* Rippka *et al*. 1979; see also Anagnostidis and Komárek 1988; Albertano and Kováčik 1994; Castenholz 2001; Komárek and Anagnostidis 2005). Various species usually form irregular clusters or mats. Recently, the heterogeneity of *Leptolyngbya* was recognised and separation of a few different genotypes (genera) is expected according to molecular as well as ultrastructural and ecophysiological criteria (*cf*. Albertano and Kováčik 1994; Taton *et al*. 2003; Casamatta *et al.* 2005). The main characters of *Leptolyngbya* in the present concept are included in Table 1.

Table 1

Generic morphological and cytological characters of the form-genus *Leptolyngbya*. Subgeneric categories are preliminary.

	Subgenera		Type with common plectonematoid branching
	Protolyngbya	*Leptolyngbya*	
position of thylakoids	parietal		
pore system in cross walls	one central pore		?
form of thallus	clustered filaments or mats		
filaments with facultative sheaths	+		
width of filaments [µm]	0.5–3.5		
morphology of cells	cylindrical, longer than wide	± isodiametric, short cylindrical to barrel shaped	
false branching	exceptionally		obligatory
absence of gas vesicles	+		
necridic cells	–	+	

Leptolyngbya occurs in the Antarctic as several morphospecies with specific and distinctly delimited ecologies. Various *Leptolyngbya*-types were mentioned in previous papers from maritime Antarctic (*i.a.* Komárek 1999; Komárek and Komárek 2003), however, the present *Leptolyngbya*-cluster from polar regions contains more genetically diverse subclusters, as it follows from detailed molecular and ecophysiological studies (Taton *et al.* 2003; Sabbe *et al.* 2004; Casamatta *et al.* 2005). Several *Leptolyngbya*-types (species) were found to be dominant in massive cyanobacterial mats in special cyanobacterial communities, *e.g.* in benthos of continually frozen lakes or seepages in deglaciated areas of coastal (maritime), humid Antarctic. The morphospecies were usually described without taxonomic evaluation and their ecological significance was characterised under various taxonomic names (Komá-

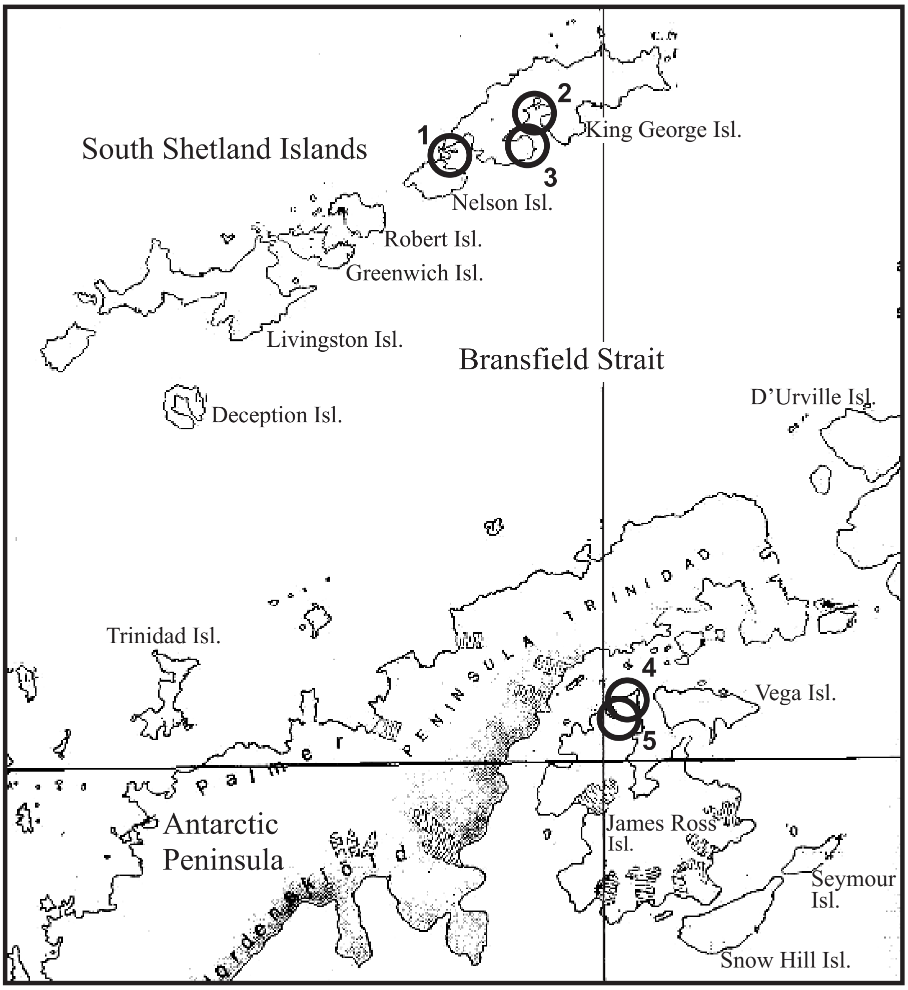


Fig. 1. Region of South Shetlands Islands, northern part of Antarctic Peninsula and James Ross Island with marked areas, from which samples for revision of *Leptolyngbya* populations were collected: 1 – Fildes Peninsula, 2–3 – deglaciated coasts of Admiralty Bay, 4 – Czech Peninsula, 5 – vicinity of Monolith Lake.

rek and Růžička 1966; Seaburg *et al.* 1979; Parker *et al.* 1981, 1982; Broady *et al.* 1984, 1987; Vincent 2000; Komárek and Komárek 2003). Therefore, the different morpho- and ecospecies must be taxonomically revised.

Methods

The taxonomy of cyanobacteria has changed substantially in the last few years as a consequence of the introduction of ultrastructural and molecular methods into

Table 2

Comparison of the *Leptolyngbya* morphospecies from microhabitats of maritime Antarctic and James Ross Island

Taxa	**Width of trichomes [μm]**	**Thallus, filaments**	**Length of cells [μm]**	**Constrictions at cross-walls**
L. antarctica (W. *et* G.S. West) Anagn. *et* Kom. 1988	(0.5)0.6– 0.7(1.0)	solitary or (usually) in massive mats	0.6–1.8	–
L. erebi (W. *et* G.S. West) Anagn. *et* Kom. 1988	(0.6)0.7– 0.9(1.2)	solitary trichomes or in macroscopic colonies (mats)	± longer than wide	–
L. vincentii sp. nov.	(0.5)0.6– 1.0(1.8?)	entangled in mats; straight or slightly flexuous	slightly longer than wide, to 3.2 μm long	–
L. glacialis (W. *et* G.S. West) Anagn. *et* Kom. 1988	(0.6)0.8– 1.2(1.4)	in mats; curved, densely entangled	0.9–2.3	–
L. nigrescens sp. nov.	0.8– 1.8(2.2) filaments to 2.5 μm wide	solitary, or in small clusters; wavy or irregularly coiled	± isodiametric or slightly longer than wide	+
L. fritschiana sp. nov.	(1)1.5– 2.2	grey biofilms; slightly coiled, fasciculated	slightly longer than wide, to 2×	–
L. borchgrevinkii sp. nov.	1.6– 2.4	flat mats; ± straight, wavy to perfectly spirally coiled	–4	–
L. cf. *borchgrevinkii*	(0.8)1.2–2	in mats; ± straight, wavy	–2.5	–
L. scottii (Fritsch) Anagn. *et* Kom. 1988	2.4–3.2	solitary filaments or small clusters; ± straight to slightly coiled	± isodiametric or slightly longer than wide	(+)

the systematic classification of cyanobacteria, and thus many genera had to be re-evaluated and revised. The heterogeneous *Leptolyngbya* is one such cyanoprokaryotic genus, which needs further study. The natural morphology and ecology of important *Leptolyngbya* morphospecies, which were studied during our investigation of Antarctic algal communities in the last few years, is described in the present article. Our review contains the formal taxonomic descriptions, validation and phenotype features and the ecological characteristics of common dominant *Leptolyngbya*-types from King George Island (maritime Antarctic) and James Ross Island (NW Weddell Sea; Fig. 1). The present article contains also formal taxonomic descriptions of four new species (according to botanical nomenclatoric rules), which were mentioned in previous ecological papers (Komárek and Komárek 1999, 2003), and which were studied by optical microscopy (OM) both in living and preserved states. The methods of collection and laboratory treatment of samples are described in more details in the cited articles.

Material to this study was collected during the XXth Polish Antarctic Expedition (*Henryk Arctowski* Station) from November 1995 to February 1996 in the

Table 2 – *continued*.

Taxa	Apical cells	Mat-colour	Sheaths	Ecology
L. antarctica (W. *et* G.S. West) Anagn. *et* Kom. 1988	rounded or conical rounded	dirty greysh-brown	indistinct, diffuse	"planktic in lakes", benthic in frozen lakes
L. erebi (W. *et* G.S. West) Anagn. *et* Kom. 1988	rounded or conical rounded	dull green or colourless	thin, delicate	cryoconits, glacial pools; rarely in wet soils and small stagnant waters
L. vincentii sp. nov.	sometimes slightly narrowed	orange, rusty red or brownish	colourless, thin or thick	orange upper layer of mats in seepages
L. glacialis (W. *et* G.S. West) Anagn. *et* Kom. 1988	rounded	bright blue-green	diffuse	stagnant seepages, in lower (shadowed) layer
L. nigrescens sp. nov.	rounded	black	firm, thin, blackish	subaerophytic, on wet rocks and stones, rarely on surface of mats
L. fritschiana sp. nov.	narrowed or conical-rounded	grey	thin, firm, colourless; mucilage	streaming water, upper parts of glacier streams
L. borchgrevinkii sp. nov.	cylindrical, slightly capitate	orange to chocolate brown	firm, thin	seepages
L. cf. *borchgrevinkii*	cylindrical, slightly capitate	orange to chocolate brown	firm, thin	mats on edges of shallow streams, in seepages
L. scottii (Fritsch) Anagn. *et* Kom. 1988	rounded conical	dirty blue-green	thin, colourless, later thickened	subaerophytic, epiphythic in *Phormidium* mats, drying pools

deglaciated areas of the King George Island, South Shetland Islands (coasts of Admiralty Bay, Demay Peninsula, Fildes Peninsula, Ardley Island, north part of Nelson Island), Uruguayan expedition (*Artigas* Station) in January 2005 (King George Island, Fildes Peninsula) and at the Czech Station *J.G. Mendel* on the James Ross Island in NW Weddell Sea in January and February 2006, from all habitats with dominant occurrence of filamentous cyanobacteria. The mats and colonies were collected to glass vessels, transported to the laboratory, observed alive (by optical microscope with immersion), measured and documented by drawing and photos. Part of material was isolated in culture for following molecular and ecophysiological studies. However, the cultivation was not fully successful; several studied types are ecologically very specific and need special cultivation technique. All material was partly dried and partly preserved by 2% formaldehyde (final concentration), and it is deposited in the collection of preserved samples in the Institute of Botany, Czech Academy of Sciences, Třeboň, Czech Republic. The type species are deposited in the Czech Central Herbarium of Algae (BRNMU), Moravian Museum, Brno, Czech Republic.

Results

Members of *Leptolyngbya* were found in numerous Antarctic microbiotopes, often as the dominant cyanobacteria types. Several species were referred to by previous authors, but these must also be taxonomically and nomenclatorically revised in agreement with modern revisions. The following morphospecies were studied (*cf.* Table 2):

Leptolyngbya antarctica (W. *et* G.S.West) Anagn. *et* Kom.,
Algolog. Stud. 38/39: 390, 1988. (Fig. 2)

Syn: *Phormidium antarcticum* W. *et* G.S.West, Brit. Antarct. Exped. 1(7): 292, 1911.

Thallus. — Solitary filaments or large macroscopic, greyish-brown, massive mats. Filaments nearly straight or irregularly coiled, often oriented ± parallel; trichomes not constricted at cross walls, pale greyish blue-green, 0.5–0.7(1) μm wide, not attenuated towards ends; sheaths indistinct, confluent, or distinctly developed around individual trichomes, colourless, sometimes forming gelatinous mass with attached small detritus particles. Cells up to 2× longer than wide, mainly up to 1.8 μm long; apical cells rounded or conical rounded.

Ecology. — Characteristic in benthos of lakes; it forms massive mats ("recent stromatolites") on the bottom of continually frozen lakes, rarely occurs metaphytic in seepages in littoral of stagnant water bodies. This species (genotype of *L. antarctica*) is probably endemic to the Antarctic, and should be compared with cyanobacterial *Leptolyngbya*-types described from other similar Antarctic habitats (Likens 1964; Komárek and Růžička 1966; Parker *et al.* 1972, 1977, 1981, 1982; Simmons *et al.* 1981; Wharton *et al.* 1981, 1982, 1983; Wharton 1982; Love *et al.* 1983, and others). We have studied populations from Monolith Lake and Phormidium Lake in the northern part of James Ross Island, but we had rich samples also from continually frozen lakes of continental Antarctica (vicinity of *Syowa* and *Novolazarevskaya* stations).

Leptolyngbya erebi (W. *et* G.S.West) Anagn. *et* Kom.,
Algolog. Stud. 38/39: 391, 1988. (Fig. 3)

Syn.: *Lyngbya erebi* W. *et* G.S.West, Brit. Antarct. Exped. 1(7): 289, 1911.

Thallus. — Solitary filaments among other cyanobacteria and algae, or flat, fine expanded thallus up to 3–5 mm thick, dirty blue-green to colourless, usually connected with the edge of water habitats. Filaments almost straight or slightly flexuous; trichomes thin, cylindrical, not narrowed towards ends (only rarely terminal cell), pale greyish blue-green or almost colourless, in masses green, 0.6–1.2 μm wide, without visible cross walls in OM (staining!); sheaths facultative, thin, delicate, colourless. Cells ± longer than wide, cylindrical, without granulation, end

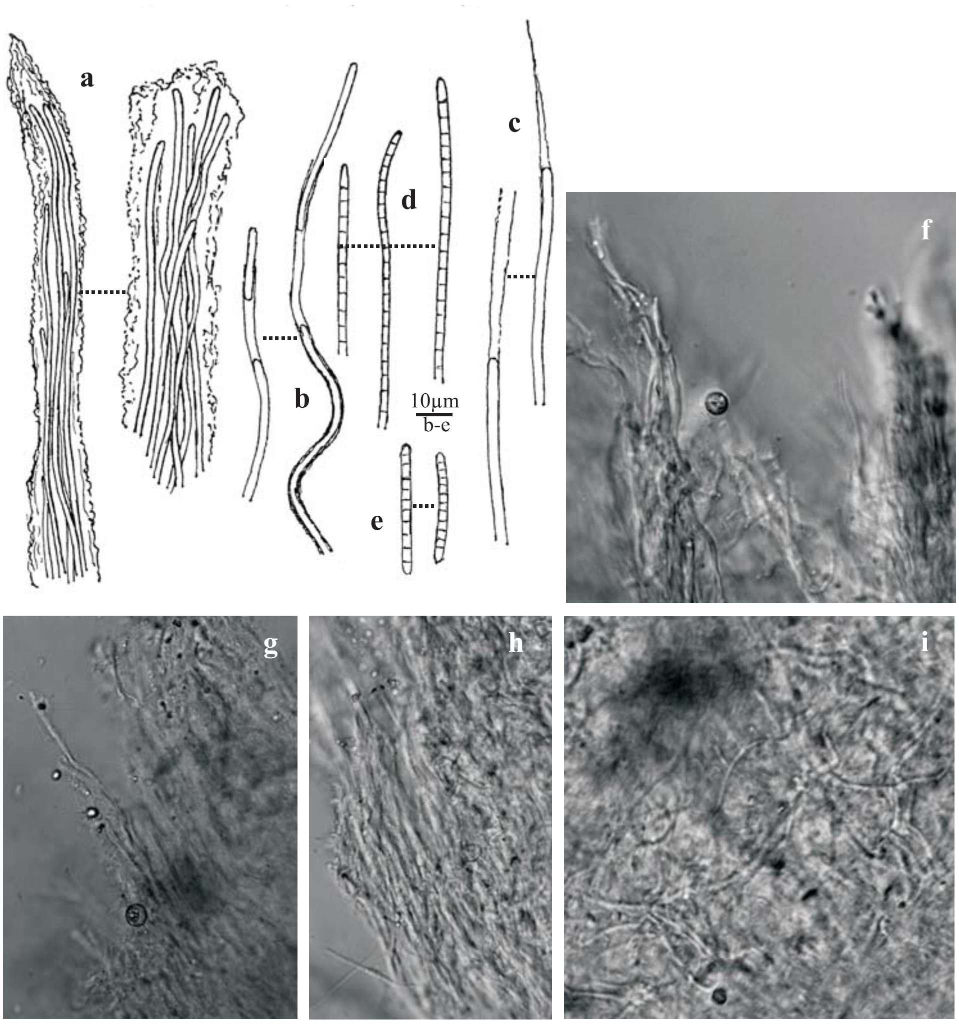


Fig. 2. *Leptolyngbya antarctica*, specimens sampled in the Phormidium Lake, northern part of James Ross Island: a – parts of mats, b – ends of trichomes with sheaths, c – end of filaments with diffuse sheaths, d – detail of trichomes, e – hormogonia, f–h – marginal parts of mats, i – coiled filaments in the centre of colony.

cells rounded at the end, sometimes slightly conical rounded, rarely with terminal granulum.

Ecology. — In small stagnant waters, pools, glacial pools up to wet soils; it occurs also in cryoconits on glaciers. Probably distributed only in the Antarctic (endemic), common, but usually not forming a large biomass. We have studied a few small populations from the edge of wetlands (seepages and creeks) on James Ross Island and Ecology Glacier near Admiralty Bay (King George Island).

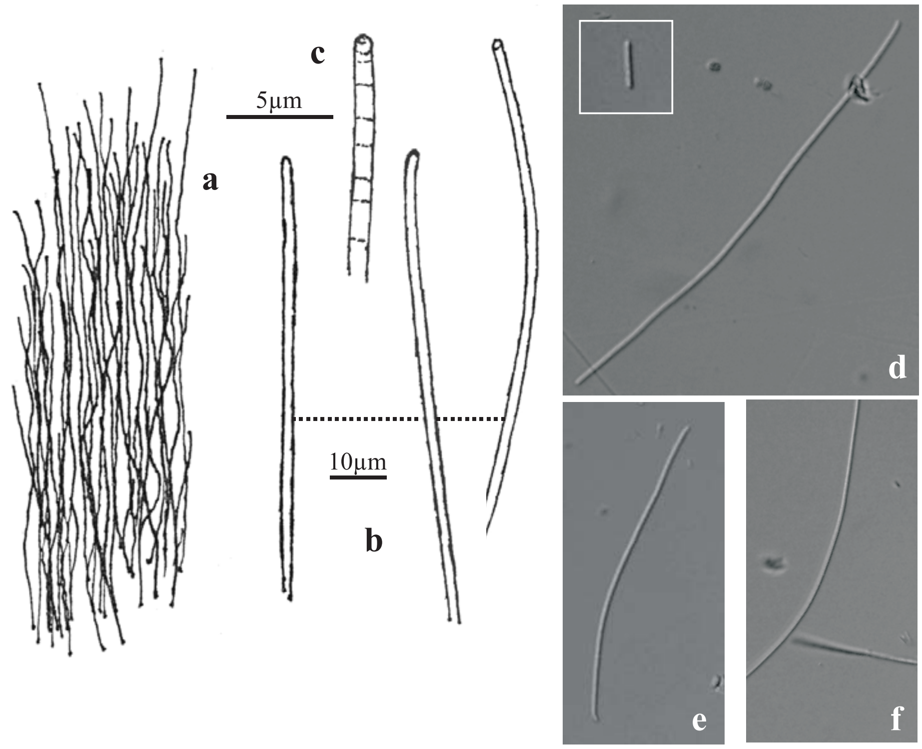


Fig. 3. *Leptolyngbya erebi,* specimens sampled from the upper part of the stream Tern Creek, northern part of James Ross Island: a – part of a mat, b – ends of filaments, c – detail of the end of a trichome, d–f – solitary trichomes.

Leptolyngbya vincentii sp. nov.
(Fig. 4)

Thallus. — Wide orange or reddish-brown surface layer of characteristic, compact cyanobacterial mats in seepages. Filaments densely and irregularly coiled, sometimes, particularly in marginal parts, ± parallel arranged; trichomes thin, cylindrical, not narrowed towards ends, pale greyish blue-green, in masses orange-brown, (0.5)0.6–1.0(1.2) µm wide, not constricted at slightly visible cross walls, cross-walls visible only after staining or at high magnification; sheaths very thin, colourless, in masses often gelatinise and join trichomes in one mass, common. Cells ± isodiametric or rather longer than wide (up to 2.5-times), end cells rounded.

Ecology. — Dominant in surfacial, intense orange layers in developed mats in seepages in maritime Antarctic, which are well-developed in the second period of the summer season. Recorded also from James Ross Island. Common, but outside the characteristic habitat in seepages it occurs rarely only on the edge of wetted moss areas, and in the littoral of creeks and lakes. *L. vincentii* was recorded evi-

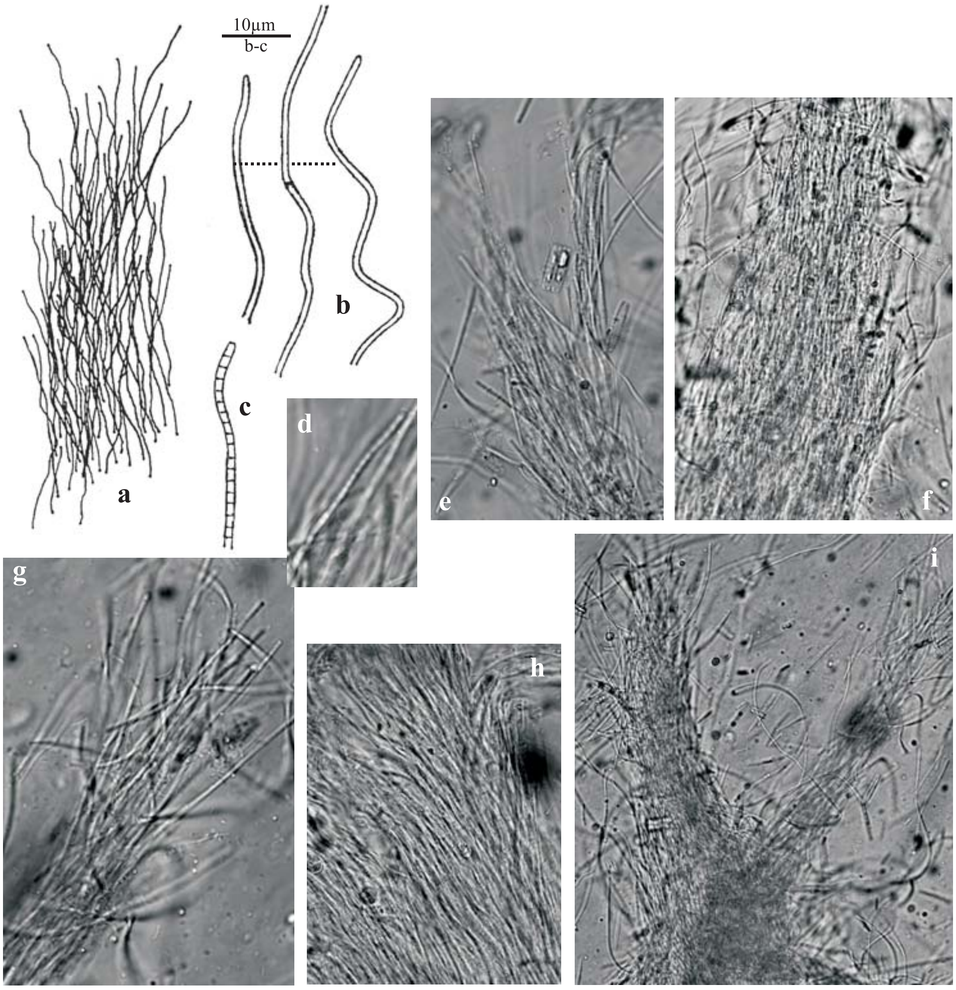


Fig. 4. *Leptolyngbya vincentii,* specimens from seepages near Ornithologists' Creek, Admiralty Bay, King George Island, South Shetland Islands: a – part of a mat, b – ends of filaments, c–d – details of trichomes, e–i – parts of a mat.

dently under different invalid names (Zaneveld 1969; Wharton *et al.* 1983; Vincent 2000, and others).

Diagnosis. — *Thallus macroscopicus, planus, aurantiacus vel vermiculato-lateritius, stratum supernum in coloniis crustaceis in locis humidis irriguisque formans. Filamenta dense irregulariterque intricata, vel plus minusve paralleliter ordinata praecipue in partis marginalis. Trichoma tenues, cylindracea, ad apices non attenuata, pallide griseo-aeruginosa, in massis lateritia, (0.5)0.6–1.0(1.2) µm lata, ad dissepimenta non constricta; dissepimenta vix visibilia. Vaginae tenues, incolores, saepe gelatinosae et diffluentes in massis. Cellulae plus minusve iso-*

diametricae, vel paulo longior quam latae (ad 2–5-plo), cellula apicalis rotundata. – ***Habitatio:*** *Superficie in strata in locis humidis cum aqua deliquescens in Antarctica maritima dominans, in periodis aestivalis antarcticis; locus classicus: Antarctica, insulae "South Shetlands" dictae, insula "King George", sinus "Admiralty Bay", ad rivulo glacialis "Ornithologists' Creek" prope centro Polonico "Henryk Arctowski" (coll. in Jan. anno 1996).* – ***Typus:*** *materia typica BRNM-HY 1411; holotypus hic designatus: figura nostra 4a–h (iconotypus).*

Leptolyngbya glacialis (W. *et* G.S.West) Anagn. *et* Kom.,
Algol. Stud. 38/39: 391, 1988. (Fig. 5)

Syn.: *Phormidium glaciale* W. *et* G.S. West, Brit. Antarct. Exped. 1(7): 291,1911.

Thallus. — Densely coiled filaments, entangled in small clusters, or forming intensely green subsurface layer of characteristic compact cyanobacterial mats in seepages. Filaments intensely irregularly coiled and clustered; trichomes thin, cylindrical, slightly constricted (immersion!), not narrowed towards ends, pale blue-green to bright blue-green in more shadowed habitats, in masses bright blue-green, (0.6)0.8–1.5(2.0?) µm wide, with slightly visible cross walls; sheaths

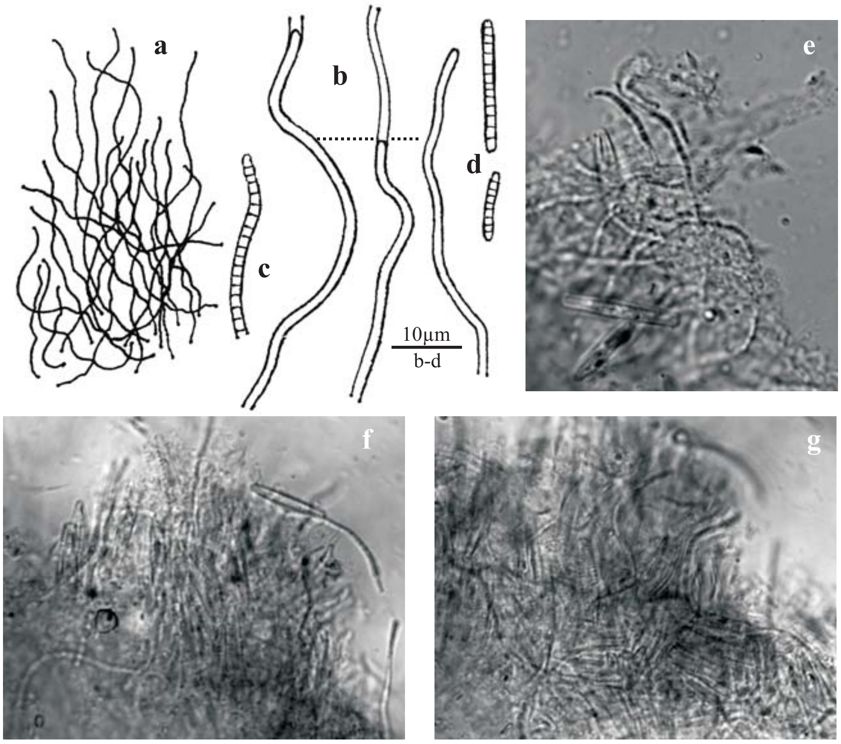


Fig. 5. *Leptolyngbya glacialis*, from seepages near Ornithologists' Creek, Admiralty Bay, King George Island, South Shetland Islands: a – part of mat, b – typical form of filaments, c – detail of terminal part of a trichome, d – hormogonia, e–g – organization of mats.

thin, colourless, sometimes indistinct, diffuse. Cells ± isodiametric up to slightly longer than wide; end cells rounded.

Ecology. — Occurs in small clusters in wet soils, at the edge of seepages and in the littoral of creeks. Co-dominant in seepages, it forms a characteristic compact, dark green subsurface layer in mats. Common in maritime Antarctic, less frequently recorded on James Ross Island. Probably more widely distributed.

Leptolyngbya nigrescens sp. nov.
(Fig. 6)

Thallus. — Solitary freely coiled filaments, or small, free, blackish, mucilaginous clusters. Filaments more or less short, irregularly coiled, up to ± 2–2.5 µm wide, slightly narrowed and less coloured towards ends (sheaths, not trichomes). Trichomes cylindrical, greyish blue-green, 0.8–1.8(2.2) µm wide, not narrowed towards the ends, slightly (indistinctly) or clearly constricted at cross-walls; sheaths thin, firm, smooth or very finely granular on the outside surface, later dark brown to blackish, particularly in central part of filaments. Cells short, ± isodiametric, or slightly longer than wide; apical cells rounded.

Ecology. — Subaerophytic, on wet rock, less frequently on soil and the surface of mats in seepages, not common. Probably endemic to the Antarctic. Our populations were collected mainly on wet rocky walls of the Jardin Peak near Admiralty Bay, King George Island, and from the vicinity of waterfalls near Devils' Rocks, northern part of James Ross Island.

Diagnosis. — *Thallus microscopicus; filamenta libere intricata, vel in fasciculis parvis, irregularibus, nigrescentis, mucilaginisque aggregata. Filamenta irregulariter circinata vel flexuosa, plus minusve 2.0–2.5 µm lata, ad apices leviter attenuata (vaginae). Trichoma cylindrica, pallide griseo-aeruginosa, 0.8–2.2 µm lata, ad apices not attenuata, leviter ad dissepimenta constricta. Vaginae tenues vel distinctae, postea firmae, externe levae vel paucim granulosae, spadiceae vel nigrae in medio filamentis. Cellulae plus minusve curtae, isodiametricae vel paulo longiores quam latae; cellula apicalis rotundata. –* ***Habitatio:*** *Subaerophytice in saxis humidis; locus classicus: Antarctica, insulae "South Shetlands" dictae, insula "King George", sinus "Admiralty Bay", ad saxis humidis montis "Jardin Peak" dicto, prope centro Polonico "Henryk Arctowski" (coll. in Jan. anno 1996). –* ***Typus:*** *materia typica BRNM-HY no. 1412; holotypus hic designatus: figura nostra 6a–b (iconotypus).*

Leptolyngbya fritschiana sp. nov.
(Fig. 7)

Thallus. — Composed from freely coiled filaments, which can be unified in distinct, fascicular, greyish colonies with ± parallel oriented trichomes; enveloped by mucilaginous envelope (not a common sheath), on stony surfaces in streaming

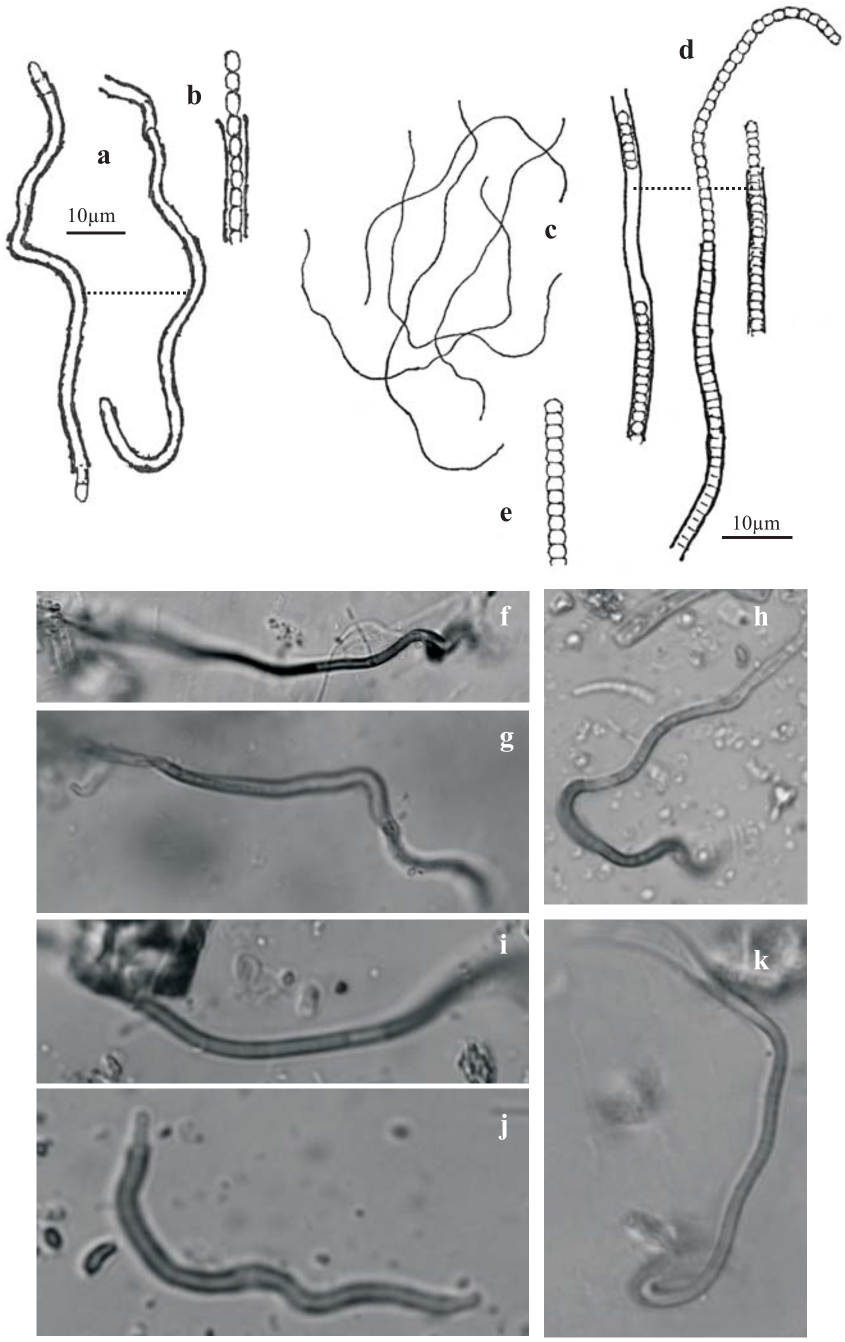


Fig. 6. *Leptolyngbya nigrescens,* from Jardin Peak, Admiralty Bay, King George Island, South Shetlands (a, b), and from Devils Rocks, James Ross Island (c–k): a – solitary filaments, b – end of a filament, c – form of filametns, d – ends of filaments, e – detail of terminal part of a trichome, f–k – solitary trichomes.

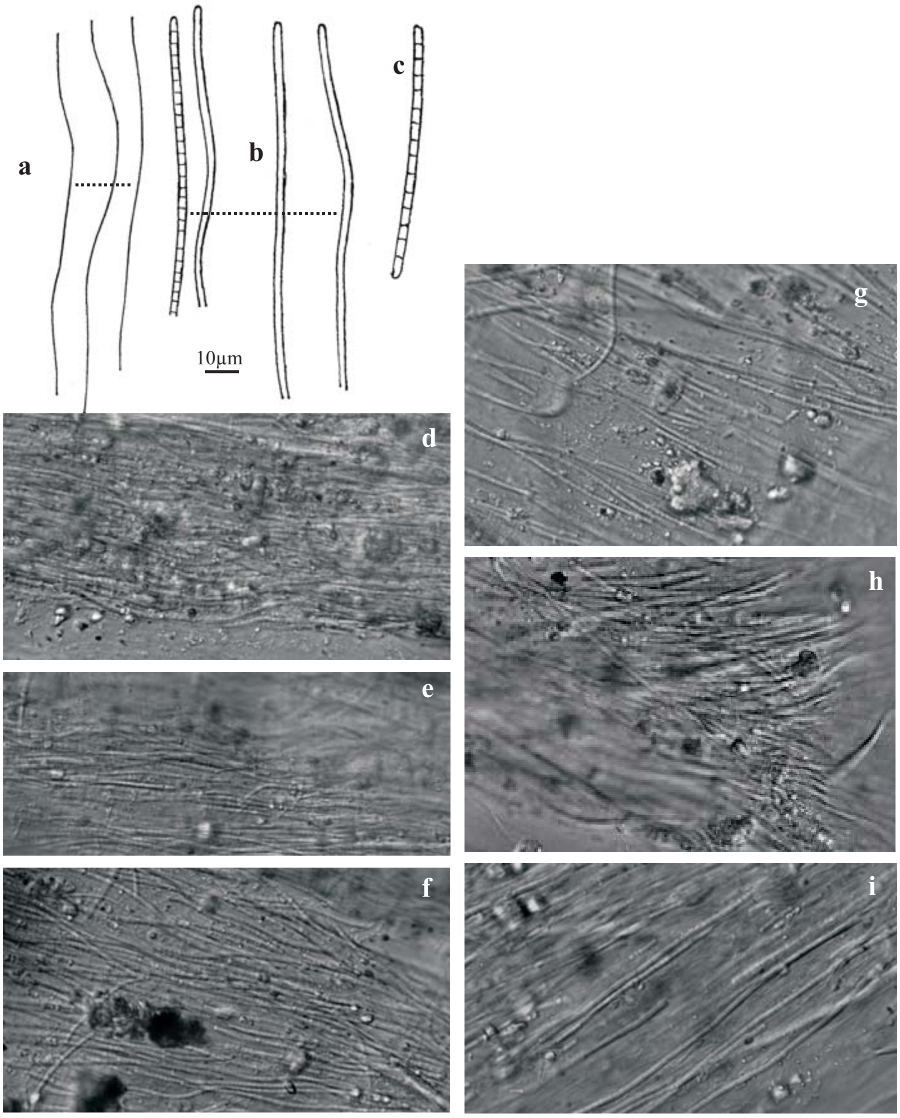


Fig. 7. *Leptolyngbya fritschiana,* from upper part of Water Supply Creek, James Ross Island: a – form of filaments, b – detail of trichome ends, c – hormogonium, d–i – parts of mats.

water (mainly in coastal Antarctic creeks), or in solitary filaments among other algae and cyanobacteria. Trichomes cylindrical, not narrowed towards ends, pale greyish blue-green, sometimes almost colourless, in masses yellowish/brownish, (1.0)1.5–2.2 µm, without constrictions at cross walls, with almost invisible cross walls (staining!); sheaths around trichomes thin, indistinct, colourless, diffuse. Cells slightly longer than wide (up to 2×), without granules, end cells sometimes slightly narrowed and ± rounded.

Ecology. — Part of other cyanobacterial communities, or rarely forming dominant greyish layers on the surface of stones, mainly in streaming waters, at the edge of streams, up to subaerophytic. It is a characteristic morphospecies for the initial seasonal aspect of benthic microvegetation in glacial streams. Characteristic populations were studied mainly from creeks in the northern deglaciated parts of James Ross Island.

Diagnosis. — *Filamenta solitaria vel thallus micro- vel macroscopicus, plus minusve planus, mucilagineus, griseus cum filamentis intricatis, fasciculatis, plus minusve paralleliter ordinatis. Filamenta paucim circinata vel flexuosa, recta ad apices. Trichoma cylindrica, ad apices not attenuata, pallide griseo-aeruginosa ad incolora, in massis luteo-brunescens, 1.0–2.2 μm lata, ad dissepimenta not constricta; dissepimenta vix visibilia. Vaginae tenues, sine colore, diffluentes. Cellulae paucim longiores quam latae (ad 2-plo), sine granulis; cellula apicalis interdum conice rotundata. –* ***Habitatio:*** *In aggregationibus cyanophycearum mixta vel dominans, strata grisea formans ad saxis benthicis in rivulis gelidis (glacialibus) in partis deglaciatis ad oras Antarcticae, in periodis aestivalis; locus classicus: Antarctica, insula "James Ross" dicta, ad saxa in aquis fluentibus, rivulus "Water Supply Creek" dictus (in partes superioribus), prope centro Bohemico "J.G.Mendel" (coll. in Jan. anno 2006). –* ***Typus:*** *materia typica BRNM-HY 1413; holotypus hic designatus: figura nostra 7a–h (iconotypus).*

Leptolyngbya borchgrevinkii sp. nov.
(Fig. 8)

Thallus. — Macroscopic, forming orange, yellow-brownish or chocolate brown, usually fine, watery mats, rarely grows in solitary filaments. Filaments ± straight (particularly at the margin of a mat), or freely coiled or wavy, or densely agglomerated in irregular (sometimes ± parallel) fascicles, sometimes (in old mats) with tendency to form dense spirally coiled formations inside colonies; trichomes strictly cylindrical, pale greyish blue-green or yellowish-brown to pale olive-green, in masses orange-brown, (0.8?)1.2–2.4 μm wide, not or slightly constricted at cross walls; sheaths facultative, but if developed then thin, distinct, firm, and colourless. Cells slightly or distinctly longer than wide (up to 2.5 times), end cells rounded with thickened, refractive outer cell wall (slightly "capitate" – Fig. 8e).

Ecology. — Fine, intense orange-brownish, wide, watery mats in seepages (in water), or at the edge of streams, also in slowly streaming and shallow water. A common and dominant species, especially in places with a continuous supply of water during the summer season, and as an initial aspect of mats in seepages. This species is widely spread in wetlands of maritime Antarctic, but it was identified under various invalid names, such as "*Lyngbya contorta*" *sensu* Luścinska and Kyć (1993) from King George Island, evidently regarding spirally coiled filaments. However, *Lyngbya contorta* (= *Planktolyngbya contorta*) is a typical

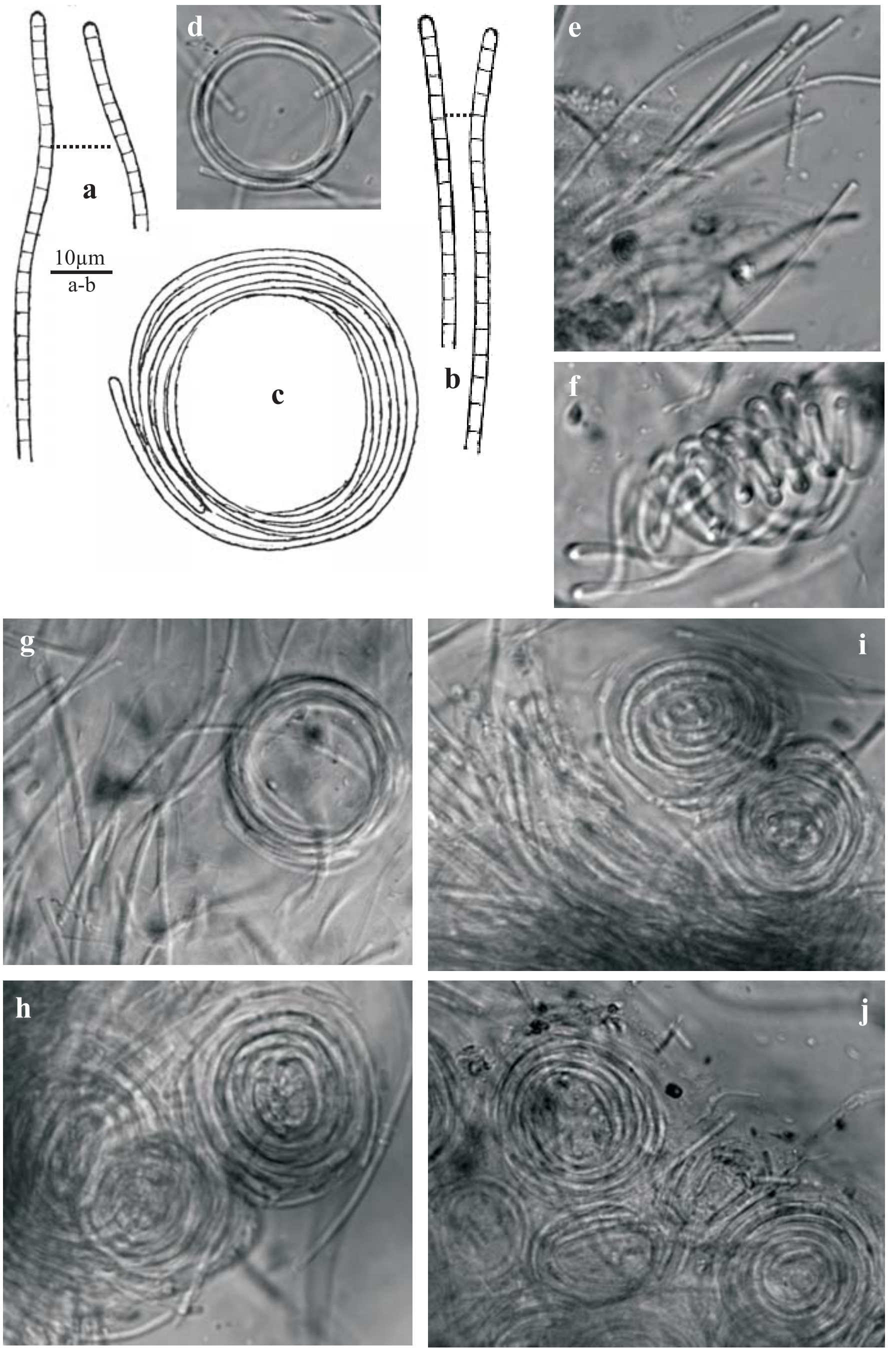


Fig. 8. *Leptolyngbya borchgrevinkii* from littoral of Ornithologists' Creek, Admiralty Bay, King George Island, South Shetland Islands: a–b – terminal parts of trichomes, c–d – trichomes spirally coiled, e – apical ends of straight trichomes, f – partly spirally coiled trichomes, g–j – parts of mats with mixed straight and spirally coiled filaments.

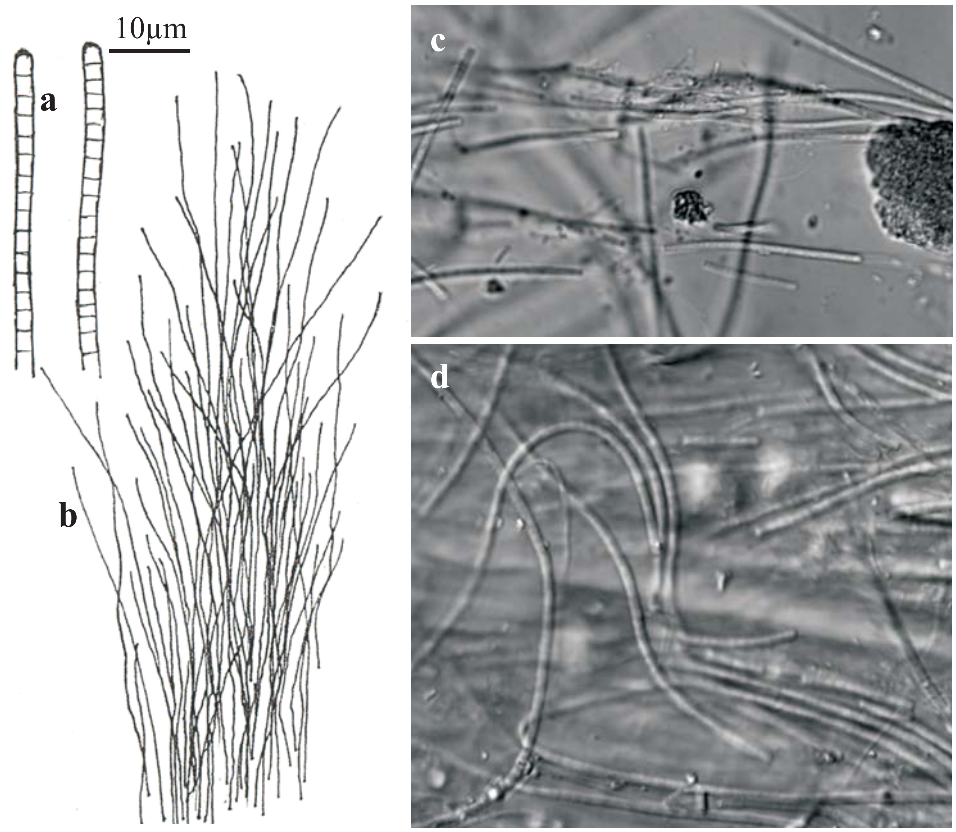


Fig. 9. *Leptolyngbya* cf. *borchgrevinkii* from seepages in northern part of James Ross Island: a – ends of trichomes, b – aggregation of trichomes in a mat, c–d – detail of filaments.

planktic, nordic species living in solitary filaments. *L. borchgrevinkii* was found at James Ross Island less frequently.

Diagnosis. — *Thallus macroscopicus, luteo-brunescens vel aurantiaco-brunescens, strata tenues formans cum superficie laevi. Filamenta plus-minusve recta, paucim circinata vel flexuosa, solitaria ad dense conglomerata in fasciculis irregularis, ad marginem plus minusve paralleliter fasciculatis; aliquot filamenta in fasciculis dense spiraliter circulariterque contorta. Trichoma cylindrica, pallide griseo-aeruginosa vel luteo-fusca, in massis aurantiaco-fusca, 1.2–2.4 µm lata, ad dissepimenta not vel rarissime paucim constricta, ad apices not attenuata. Vaginae facultativae sed distinctae, tenues, firmae, sine colore. Cellulae paucim vel clare longior quam latae (ad 2.5-plo), cellulae terminales rotundatae cum membrana externa paucim incrassata (“capitatae”).* – ***Habitatio:*** *Strata ad parietes rivulis glacialibus vel in locis humidis (“seepages” dictis) vel inundatis, vadosis; saepe dominans per aetate; locus classicus: Antarctica, insulae “South Shetlands” dictae, insula “King George”, sinus “Admiralty Bay”, ad rivulo “Or-*

*nithologist´s Creek" prope centro Polonico "Henryk Arctowski" (coll. in Jan. anno 1996). – **Typus:** materia typica BRNM/HY no. 1414; holotypus hic designatus: figura nostra 8a–h (iconotypus).*

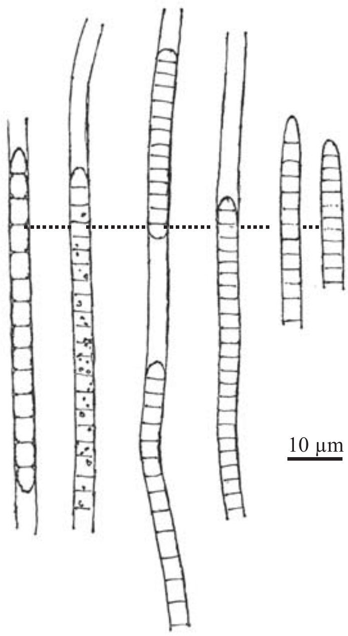
Leptolyngbya cf. *borchgrevinkii.*
(Fig. 9)

This morphotype is morphologically and ecologically similar to *L. borchgrevinkii*, but it differs from this type by smaller dimensions (1.2–2 μm wide trichomes) and shorter cells (isodiametric, or maximally 1.5-times longer than wide); the characteristically spirally coiled filaments never were observed in this type. To what degree this morphotype is different from *L. borchgrevinkii*, must be solved by molecular methods.

Ecology. — A more common type than typical *L. borchgrevinkii* (on James Ross Island), with similar ecology and thallus form (orange-brown, smooth mats). This morphotype is common particularly on James Ross Island.

Leptolyngbya scottii (Fritsch) Anagn. *et* Kom.,
Algolog. Stud. 38/39: 392, 1988. (Fig. 10)

Syn.: *Lyngbya scottii* Fritsch, Nat. Antarct. (Discovery) Exped. 1901-1904, 6 (Freshw. alg.): 29, 1912.



Thallus. — Solitary filaments or their small clusters. Filaments straight to slightly coiled; trichomes slightly constricted at cross walls, 2.5–3.2 μm wide, pale blue-green; sheaths thin, colourless, later thickened (up to 5 μm wide). Cells ± isodiametric or slightly longer than wide, end cells rounded conical, not capitate.

Ecology. — Subaerophytic, epiphytic, often on the surface of colonies of *Phormidium attenuatum* (Fritsch) Anagn. *et* Kom. Common in coastal maritime Antarctic, usually on ornithogenic soils. Cited also from Europe (High Tatra Mountains), but this location must be confirmed. Well developed populations were collected particularly near rookeries and nesting places of birds on King George Island. Rarely found on James Ross Island in eutrophised parts of creeks.

Fig. 10. *Leptolyngbya scottii* from ornithogenic soils near penguin rookeries, Penguin Ridge, Admiralty Bay, King George Island, South Shetland Islands: morphology of filaments and trichomes.

Discussion

The description of new species without molecular support is criticised by numerous authors (*e.g.* Whitton 2002). However, it was recognised, (i) that the morphology is in agreement with the genotype to a certain degree, and (ii) that the genotype analyses from different biotopes yield wider diversity than is recognisable from phenotype identification (Garcia-Pichel 1998; Taton *et al.* 2003). This is a proof of a distinctly wider diversity of eco- and genotypes in nature than the traditional phenotype taxonomy can recognise. If we find, therefore, stable distinct and separated morphotypes, which are ecologically strictly delimited, they should be characterised and validly described. The traditional definition and naming of species according to the botanical nomenclatoric rules (respected more or less also by the bacteriological approach – Castenholz and Waterbury 1989; Castenholz 2001) is still necessary and the only acceptable method for characterisation of cyanobacterial taxonomic (generic and subgeneric) units (ecologically as well as morphologically). Its further advantage is that it is compatible with populations observed in nature as well as with other isolated strains. For the future, ecophysiological research is important information not only about the wide spectrum of genomes, but also for the review of defined modifications designated by univocal names connected with real genotypes and phenotypes recognisable in natural habitats. The jungle of mere strain symbols and arbitrary selected names is sometimes misleading.

The transfer of different ecotypes in culture is important (Holm-Hansen 1964). However, taxonomic evaluation based only on isolated strains and following molecular analysis still has many problems. First, it is difficult to isolate all ecologically distinct types; in the case of the few Antarctic *Leptolyngbya* species collected, we have not yet been successful with isolation. Types from different, ecologically restricted biotopes (*e.g.* from seepages or wet rocks) rarely grow under standardised culture conditions. Numerous *Leptolyngbya* strains were isolated from the Antarctic by various authors, but their origin (ecological specificity) and morphological variation of natural material is usually unclear or neglected (Priscu *et al.* 1998; Gordon *et al.* 2000; Nadeau *et al.* 2001). Moreover, after transfer of a distinct ecotype into culture, the population is always stressed by changed conditions and the adaptation to a new culture can modify its morphology, particularly in simple morphotypes, such as the *Leptolyngbya* species. Of course, these facts do not reduce the importance of cultures for the study of ecological and morphological variability and the genetic basis of the studied taxa. However, the study of variation of taxa from natural habitats remains an important method for orientation in cyanobacterial diversity.

The main Antarctic biotopes, which are dominated by different *Leptolyngbya*-types, include particularly lakes (including permanently frozen reservoirs; Likens 1964; Wilson 1965; Komárek and Růžička 1966; Parker *et al.* 1972, 1980; Simmons *et al.* 1981; Wharton *et al*. 1981), seepages (Vincent 2000, Komárek and Komárek

2003), glacial streams, wet soils and wet rocks (Komárek *et al*. in press). The number of genotypes in coastal Antarctic habitats surely surpasses the number of morphospecies described in this article (Taton *et al.* 2003; Casamatta *et al.* 2005; Taton *in* Komárek and Anagnostidis 2005). However, the newly defined types are distinguishable also ecologically and represent special and recognisable entities in cyanobacterial assemblages in ecologically very restricted habitats. Their definition and description is therefore important for ecological studies; the ecology (and structure of colonies and colour of mats) is typical for different morpho- and genotypes.

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