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Dedicated to the late Professor Jadwiga Siemińska

Freshwater red algae in Finland

Pertti Eloranta

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Abstract. There were only less than sixty records of freshwater red algae in Finland until the 1980s, when the author began sampling the running waters of southern and central Finland; 516 new records were made in 1984–2011. More intensive research began in 2012, with a few field teams working at first in Central Finland Province and then covering the whole country. The project continued until 2018. During these studies approximately 3400 new locations were investigated and 3641 new records of 29 taxa were made. Since 2013, 12 ecological variables have also been measured or estimated. The share of positive records from the studied locations varied from 49% to 86% (avg. 72%), being highest in Lapland (85.5%). The most frequent taxa were *Batrachospermum gelatinosum* (36.5%), *Audouinella hermannii* (14.5%), *Sheathia arcuata* (9.3%), *Sirodotia suecica* (8.4%), *Audouinella chalybea* (4.7%), *Lemanea fluviatilis* (3.8%) and *Lemanea fucina* (2.8%). *Batrachospermum elegans*, *Kumanoa virgatodecaisneana* and *Lemanea mamillosa* occurred in southwestern Finland in waters with higher conductivity, whereas *Batrachospermum turfosum* and *Virescentia vogesiaca* were typical taxa of acidic and soft water. *Batrachospermum sporulans* and *Lemanea condensata* occurred only in northern Finland. Some records did not fit the recent morphological keys and should be analysed using molecular methods.

Key words: *Rhodophyta*, freshwater, Finland, algae

Introduction

For Sweden, Israelson (1942) published a comprehensive work on freshwater rhodophytes, with over 2400 records of 28 taxa, but in Finland before the 1950s there were very few floristic notes on freshwater red algae. *Batrachospermum turfosum* (as *B. vagum* or *B. keratophytum*) was mentioned as a common taxon in soft-water, acidic forest lakes (Grönblad 1934; Cedercreutz 1942; Häyren 1945). *Audouinella chalybea* (as *Chantransia chalybea*) was mentioned by Häyren (1945). *Lemanea* sp. was recorded from northeastern Lapland by Cedercreutz (1929) from an area, now part of Russian territory. Skuja (1933) identified old samples dating from the period of 1861–1932 in the Botanical Museum of the University of Helsinki. He identified 16 taxa in those samples. Between 1950 and 1990 there were almost no new records of freshwater red algae from Finland, except for a record of *Hildenbrandia rivularis* (Luther 1954) from southwestern Finland.

Among the macroalgal samples taken from forest lakes during the lake acidification project, (HAPRO) *Batrachospermum turfosum* was found to occur in 23 (20%) of the studied lakes (Eloranta 1987). The author collected at the end of the 1980s diatom and macroalgal samples from 60 river locations in Central Finland Province. Red algae occurred in 39 (65%) of those locations. Altogether 13 taxa were found in that material (Eloranta & Kwandrans 1996). *Tuomeya americana* occurred in samples from two of those locations, a finding which prompted more intensive studies of red algae in Finnish waters (Kwandrans & Eloranta 1994).

Many records of freshwater red algae are limited to floristic data, without ecological information. Israelson (1942) gave some notes on the autecology of rhodophytes in Sweden. Sheath & Hambrook (1990) did the most comprehensive work and reviewed the ecology and biology of rhodophytes, based mostly on data from North America. Necchi Jr. et al. (1999, 2003) published notes from Brazil. From Austria, whereas Pfister (1992), Pipp & Rott (1993) and Rott et al. (1997, 1999) treated the question of Austria about trophy versus saprobity.

This paper treats occurrence the commonness of rhodophytes in the inland waters of Finland, their ecology, and their usability for river quality evaluation and monitoring.

Sinkilätie 13 FI 40530 Jyväskylä, Finland
Corresponding author e-mail: pertti.eloranta@elisanet.fi

Materials and methods

From the beginning of the 1990s sampling of algae in Finnish waters was rather random and occasional, done mostly by the author in the southern and central Finland (516 records). Intensive sampling started in late summer 2012 in one restricted drainage basin when two river restoration scientists from the Centre for Economic Development, Transport and Environment of Central Finland studied. 231 locations and collected 328 samples (Table 1). Sampling was continued in the open water in 2013 and 2014 by three trained teams, which checked 1831 locations and obtained positive records from 47.7% of them. Most of the locations were in the province of Central Finland Province. In the years 2015–2018, sampling was extended to cover all of Finland from the south coast to the northernmost Lapland (Table 2). All together 3444 river segments were studied during 2012–2018, with 72% of positive records and 3702 samples taken (Table 1, Fig. 1).

In the present work, a self-made viewer fitted with an LED lamp and a large pipette (ø 30 mm, length 30 cm) were used for sampling, and the samples were preserved in 2.5% glutardialdehyde (Eloranta et al. 2011, Eloranta et al. 2016). Several habitat variables were measured with a digital meter (WTW GmbH) and recorded in the field: water temperature, pH, conductivity, current velocity (five classes: 0 = standing water, 1 = < 0.2 m s^{-1}, 2 = 0.2–0.5 m s^{-1}, 3 = 0.5–1 m s^{-1}, 4 = > 1 m s^{-1}), water colour and turbidity (value classes 0–3). Also recorded were bottom substrate, channel width (four classes: 0 = < 1 m, 1 = 1–3 m, 2 = 3–10 m, 3 = > 10 m), shade (four classes), abundance (three classes: 1 = 1–2 thalli, 2 = several thalli in river segment, 3 = rich coverage on substrate), substrate of rhodophytes, and water moss abundance (three classes) (Eloranta et al. 2016).

Table 1. Number of studied river sections and red algal samples found.

Year	Stations	Samples
2012	231	328
2013	975	764
2014	856	650
2015	313	466
2016	463	587
2017	400	627
2018	206	280
Total	3444	3702

Table 2. Number of studied locations in different areas of Finland during the project years (2012–2018).

Area	N
S & SW Finland	375
Central Finland Province	1990
N Central Finland	112
West Coast	110
SE Finland	100
E Finland	49
S Lapland	308
N Lapland	400
Total (2012–2018)	3444

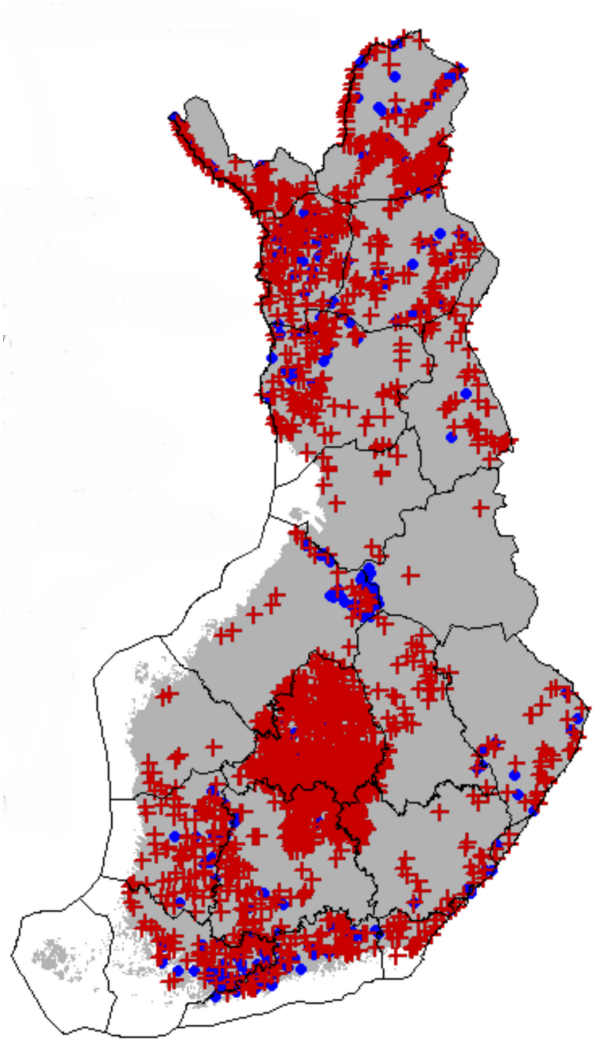

Figure 1. Spatial distribution of project sampling sites (blue dots: no red algae) (*Botanicum* 8: 2018). Map by Sampsa Lommi, Senior Museum Technician.

In the laboratory, samples were cleaned and pre-identified under a stereomicroscope; final identification and documentation was done using an Olympus BX50 research microscope fitted with a Nikon Digital Sight DS-U1 camera. Samples are deposited in the Finnish Museum of Natural History LUOMUS, Helsinki (HU).

Results

The older records (516) of Finnish freshwater red algae taken since the 1980s have been published (Kwandrans & Eloranta 1994; Eloranta & Kwandrans 1996, 2002). The results for macroalgae in acidification- project lakes (Eloranta 1987) contained records of *Batrachopermum turfosum* in 23 lakes. In the early 1990s, results from 60 Central Finnish rapids were published, among them records of *Tuomeya americana*, which was found for the first time in Europe (Kwandrans & Eloranta 1994). All together 17 taxa were found in this material, with *Audouinella pygmaea* and *Sheathia boryana* (as *Batrachospermum boryanum*) being new for Finland. Later there were new records published with 5 new taxa for Finland: *Bangia atropurpurea*, *Virescentia helminthosa*, *B. skujae*,

Table 3. Frequency and average values of ecological variables of freshwater rhodophyte taxa found during the project.

Taxon	Frequency	%	River width class	Curr. veloc. class	Colour class	Turb. class	Temp. °C	Cond. µS cm^{-1}	pH
Audouinella chalybea	159	4.67	1.87	2.48	0.94	0.95	15.8	88.0	6.91
Audouinella hermannii	495	14.53	1.81	2.63	0.89	0.47	14.0	57.7	6.77
Audouinella pygmaea	2	0.06	1.50	2.75	0.00	0.50	14.9	158.5	7.15
Audouinella sp.	19	0.56	2.25	2.77	1.35	0.80	17.3	54.4	6.39
Batrachospermum cf. *gelatinosum*	17	0.50	1.50	1.65	1.13	1.08	18.2	33.1	6.71
Batrachospermum elegans	7	0.21	1.71	2.14	0.79	0.79	18.1	110.8	7.02
Batrachospermum gelatinosum	1244	36.51	1.45	2.14	1.11	0.54	14.6	48.3	6.54
Batrachospermum keratophytum	9	0.26	1.00	1.58	1.57	0.79	14.2	44.3	6.43
Batrachospermum skujae	38	1.12	1.31	2.25	0.98	0.52	12.7	41.3	6.23
Batrachospermum sp.	61	1.79	1.49	2.00	1.37	0.73	15.6	59.6	6.45
Batrachospermum sporulans	12	0.35	1.45	2.14	0.64	0.27	12.5	43.4	7.18
Batrachospermum turfosum	71	2.08	0.97	1.98	1.46	0.54	14.3	26.6	5.81
Hildenbrandia rivularis	1	0.03	3.00	2.50	0.00	1.00	17.0	87.0	7.90
Kumanoa globospora	5	0.15	2.25	2.00	0.75	1.00	18.2	76.2	6.65
Kumanoa sp.	5	0.15	1.50	2.20	0.80	1.20	19.0	118.8	6.84
Kumanoa virgatodecaisneana	11	0.32	2.05	2.57	1.00	0.50	16.0	221.5	7.02
Lemanea borealis	38	1.12	2.07	2.64	0.54	0.17	12.5	33.6	6.57
Lemanea cf. *borealis*	6	0.18	2.00	3.13	0.25	0.75	20.6	59.0	7.00
Lemanea cf. *fluviatilis*	10	0.29	1.88	2.81	1.19	0.81	17.5	52.0	6.30
Lemanea cf. *fucina*	18	0.53	2.47	2.84	0.94	0.63	18.0	60.3	6.87
Lemanea cf. *rigida*	7	0.21	2.00	2.29	1.17	1.10	16.0	73.3	6.75
Lemanea condensata	30	0.88	2.13	2.67	0.95	0.40	11.2	42.5	6.59
Lemanea fluviatilis	130	3.82	2.24	2.63	1.04	0.76	16.8	70.8	6.89
Lemanea fucina	97	2.85	2.11	2.64	0.79	0.67	17.5	62.6	7.05
Lemanea mamillosa	1	0.03	2.00	3.00	0.00	0.50	17.8	43.0	8.00
Lemanea rigida	18	0.53	1.97	2.69	1.06	0.72	15.0	71.7	6.86
Lemanea sp.	33	0.97	2.06	2.52	1.10	0.85	15.0	64.6	6.87
Sheathia arcuata	318	9.33	1.46	2.26	0.96	0.75	15.2	70.6	6.72
Sheathia boryana	13	0.38	2.08	2.45	0.60	0.75	15.0	136.0	7.26
Sheathia cf. *arcuata*	31	0.91	1.19	2.10	1.14	0.72	16.9	42.2	6.46
Sheathia cf. *exigua*	13	0.38	1.42	2.38	1.67	0.67	15.0	43.8	6.55
Sheathia confusa	40	1.17	1.24	2.21	1.12	0.30	14.6	49.4	6.65
Sheathia exigua	39	1.14	1.55	2.34	1.31	0.57	15.6	71.9	6.32
Sirodotia suecica	286	8.39	1.83	2.55	1.23	0.41	14.3	35.5	6.31
Torularia atra	15	0.44	2.13	2.13	1.13	0.60	12.8	90.2	7.01
Virescentia helminthosa	74	2.17	1.54	2.37	0.71	0.76	15.0	108.1	6.97
Virescentia vogesiaca	34	1.00	1.54	2.15	1.83	0.52	13.4	29.1	5.93

Lemanea condensata and *L. borealis*, the latter being the first record for Europe (Eloranta & Kwandrans 2002). During the last intensive period (2012–2018), when the work was extended to include the whole territory of Finland, *Batrachospermum elegans*, *B. sporulans*, *Kumanoa globospora* and *Virescentia vogesiaca* were recorded as new taxa for the country. The most frequent taxa in the material from 2012–2018 were *Batrachospermum gelatinosum* (36.5%), *Audouinella hermannii* (14.5%), *Sheathia arcuata* (9.3%), *Sirodotia suecica* (8.4%) and *Audouinella chalybea* (4.7%) (Table 4, Fig. 2).

Taxonomical notes

According to DNA sequencing results, *Batrachospermum anatinum* is now included in *Sheathia boryana* in spite of morphological differences (Salomaki et al. 2014). Morphological study of specimens previously identified as *Batrachospermum anatinum* has placed them in the recent taxon *Sheathia exigua* (Salomaki et al. 2014). Without DNA sequencing, specimens of the most common taxon, *Batrachospermum gelatinosum*, with thick, and lush thalli, are sometimes difficult to separate without sequencing from monoecious specimens of *Sheathia arcuata*. Therefore, in this paper there are present results there are many records of the both mentioned taxa bearing the names *Batrachospermum* cf. *gelatinosum* or *Sheathia* cf. *arcuata*. Genetic data indicate synonymy of *Batrachospermum skujae* with *B. gelatinosum*, but the final revision has not been done, so, in this work *Batrachospermum skujae* is still shown as a separate taxon here. *Batrachospermum sporulans* was combined with *B. skujae* in morphometric comparison (Vis et al. 1995), due to the common feature of having monospores. The material in that study contained only one *B. sporulans* specimen; this makes its synonymy very doubtful, and DNA sequence results are needed. In our material, *B. skujae* and *B. sporulans* clearly differ morphologically and also in their distribution patterns (Eloranta et al. 2018).

Table 4. Average values of ecological variables in different areas of Finland.

	Stream width	Curr. veloc.	Colour	Turbid.	Temp.	Cond.	pH	Shade
S & SW Finland, 2014	2.02	2.46	0.76	0.97	17.1	88.8	6.96	1.47
S & SW Finland, 2018	1.44	2.26	0.32	0.89	16.0	166.1	7.37	1.44
SE Finland	1.90	2.48	0.41	0.91	14.0	92.8	7.13	1.42
Central Finland	1.45	2.11	1.22	0.86	17.7	50.3	6.50	1.49
West Coast	2.17	2.35	1.99	1.05	19.3	59.1	6.40	1.44
N Central Finland	1.92	2.53	1.62	0.55	15.8	67.0	6.72	1.16
E Finland	1.90	2.45	1.17	0.26	16.2	36.8	6.45	1.49
SE Lapland	1.90	2.19	0.97	0.30	14.7	33.2	7.20	1.21
NE Lapland	1.75	2.32	0.25	0.04	14.1	30.6	6.96	0.91
SW Lapland	1.69	2.56	1.89	0.29	9.3	32.5	6.09	1.21
NW Lapland	1.37	2.86	1.22	0.11	8.0	30.5	6.06	0.55

This study keeps *Batrachospermum turfosum* as a single species. However, DNA data from European material indicate clear genetic differences and show that three different species occur in Europe under that name, two of them in Finland (Necchi Jr. et al. 2013). Those new taxa have not yet been described and named, so those records bear the same name here.

In older publications, monospores are mentioned only for *Batrachospermum skujae* (with *B. sporulans*) and *B. turfosum*. In this study, monospores were found in *Sheathia arcuata* and *Virescentia helminthosa* (Eloranta 2016). Under some seasonal and environmental conditions it is likely that asexual reproduction occurs as an alternative method in many taxa of the order Batrachospermales.

One *Audouinella* sample from early spring greatly differed morphologically from any other known species (Fig. 4). Genetic analyses are needed to determine whether it is a new species or rather an early spring cold-water ecotype. One very small, curved and very dark *Lemanea* sp. that did not fit any current morphological key (Fig. 5) occurred at three locations in eastern Finland.

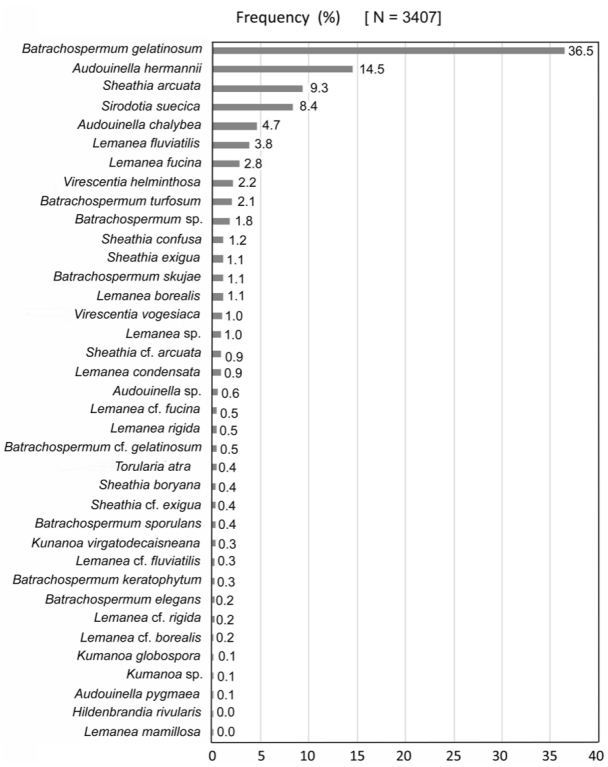

Figure 2. Frequency of taxa recorded in the study project.

Some earlier papers on Finnish freshwater red algae mentioned *Batrachospermum* cf. *pseudocarpum* and *B.* cf. *periplocum* (Eloranta et al. 2016). Sequencing has indicated that they were misidentifications, and that *Batrachospermum* cf. *pseudocarpum* is in fact *Sirodotia suecica* (Lam et al. 2012); however, that peculiar form differed from typical *Sirodotia* in several morphological characters (Fig. 6). Its habit is very delicate. Pseudocarposporophytes occur along the whole thallus, and some monospores also occur.

Ecological and seasonal notes

The bulk of the study material was collected from Central Finland Province, where the water quality varies little. The waters are mostly soft (conductivity <50 µS cm^{-1}), acidic, and often brown with humic matter (Table 4). In southern Finland the soil is more alkaline and therefore conductivity can be 10-fold that of central Finland, with water pH >7. Especially in the rivers of the west and southwestern coast, turbidity rather than humic matter is responsible for increases in water colour values. In Lapland and eastern Finland the waters are rather soft (average conductivity <40 µS cm^{-1}), but water pH differs between eastern and western Lapland. In western Lapland the waters are clearly acidic, whereas in the east they are rather neutral or slightly alkaline. Differences in water quality between different parts of the country are reflected in the respective freshwater rhodophyte floras.

Four taxa are common throughout Finland: *Audouinella hermannii*, *Batrachospermum gelatinosum*, *Sheathia arcuata* and *Sirodotia suecica*. Several taxa occur only in southern and southwestern parts of Finland, with waters that are alkaline and of higher conductivity (e.g. *Batrachospermum elegans*, *Hildenbrandia rivularis*, *Kumanoa virgatodecaisneana*, *Lemanea mamillosa*, *Sheathia boryana*). *Batrachospermum sporulans* and *Lemanea condensata* have a clear northern distribution. *Lemanea fluviatilis* is common throughout the country except for northernmost Lapland (Eloranta et al. 2018). Different taxa show clear preferences for higher or lower conductivity and lower or higher water pH (Fig. 7). Taxa preferring high conductivity (avg. conductivity >100 µS cm^{-1} and pH >7) in our material were *Kumanoa virgatodecaisneana*,

Audouinella pygmaea, *Sheathia boryana*, *Kumanoa* sp., *Batrachospermum elegans* and *Virescentia helminthosa* (Table 3, Fig. 7A). *Batrachospermum turfosum*, *Virescentia vogesiaca*, *Lemanea borealis* and *Sirodotia suecica* were soft-water taxa (average conductivity <40 µS cm^{-1}). The soft-water taxa also prefer acidic waters (average pH <6.5). Besides the abovementioned taxa, that group also includes *Batrachospermum skujae* and *B. keratophytum* (Fig. 7B).

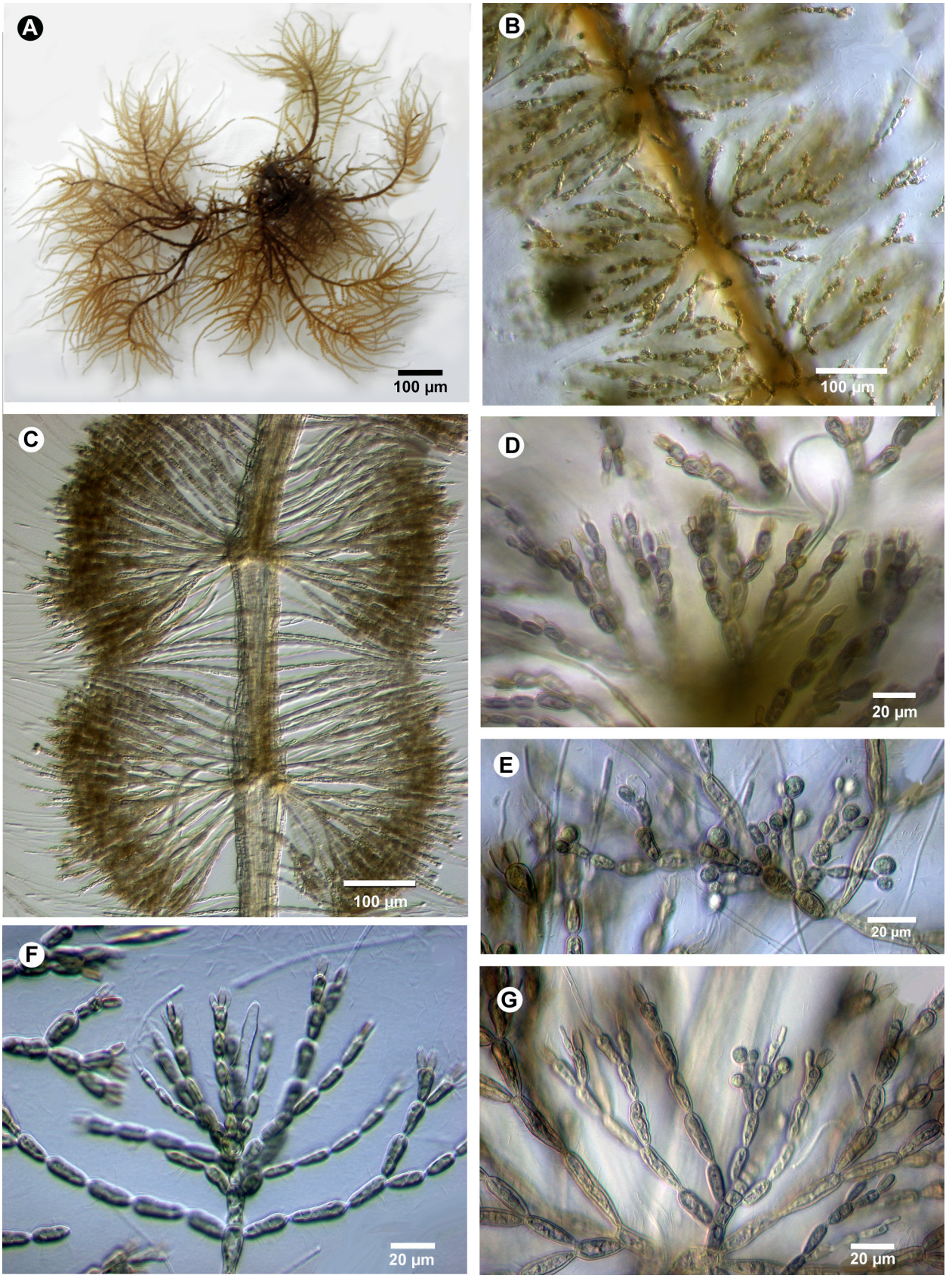

Figure 3. *Batrachospermum sporulans* (FI La7-2011): A – habit; B, C – whorls; D – tips of branchlets with empty monosporangia; E – monospores; F – carpogonial branch with trichogyne; G – group of spermatia.

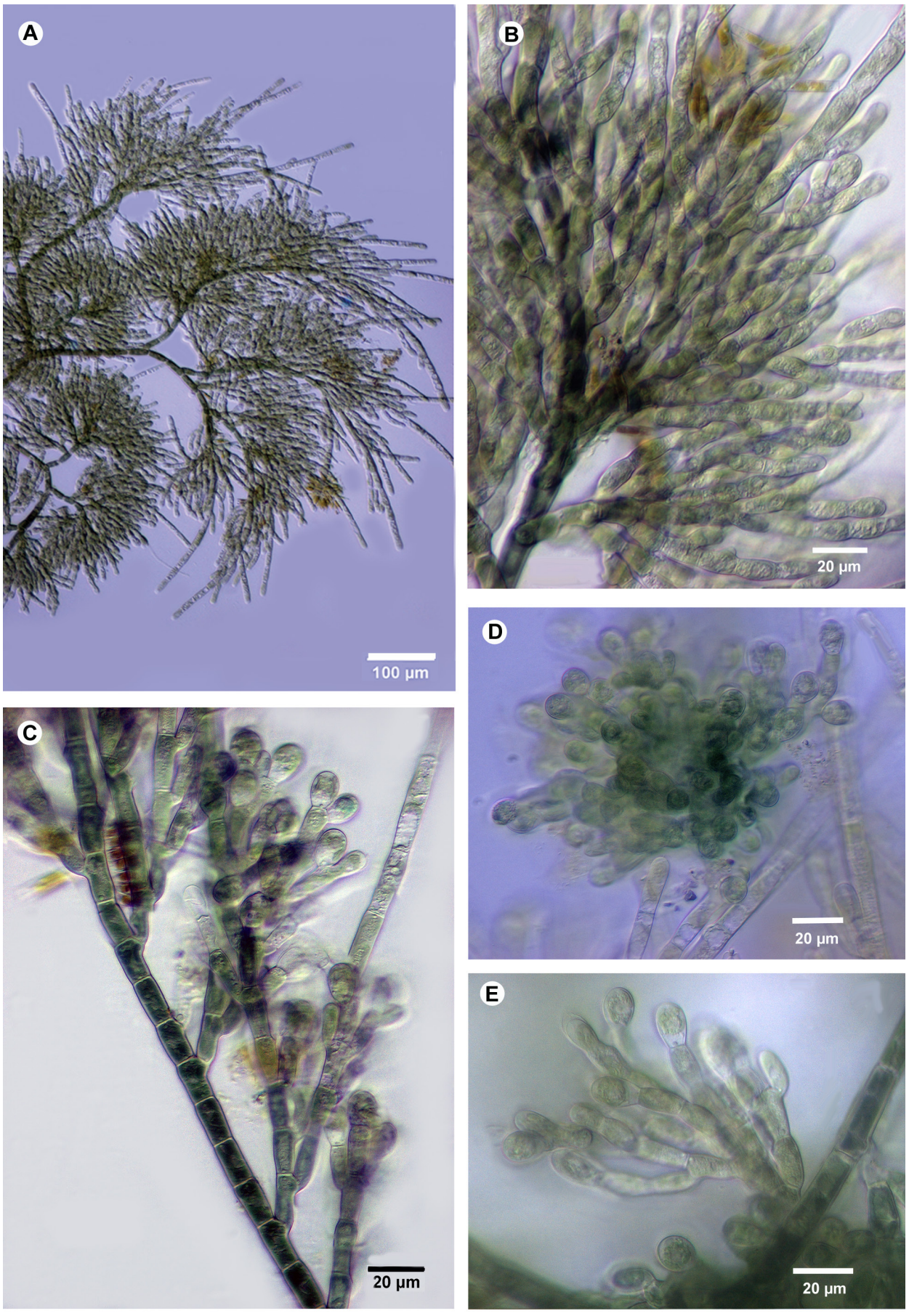

Figure 4. *Audouinella* sp. (FI 9-2013): A – habit; B–E – dense branches with monosporangia.

Figure 5. *Lemanea* sp. (FI 149-2016): A, B – habit; C – single thallus; D – tip of thallus; E, F – cross section of thallus with carpospores inside.

In relation to current velocity, all *Lemanea* spp., *Audouinella hermannii* and *A. pygmaea* were found in faster current, whereas *Batrachospermum keratophytum* and *B. turfosum* favoured slow current or even standing water (lakes) (Fig. 8A), and *Virescentia vogesiaca* also favoured the brownest humic water (Fig. 8B). *Lemanea* spp. occurred in early summer and later only thallus remnants were left in many cases. That was very clearly seen in summer 2018 in southern Finland, where they were found frequently in June but only very infrequently in the same areas in August–September after a very warm summer. During the winter, *Lemanea* spp. were found as very small (10–15 mm) and delicate thalli in open-water rapids. *Audouinella hermannii* was recorded through the winter in open streams, especially on water mosses.

Discussion

Of the 29 known freshwater red algal taxa reported so far for Finland (Eloranta et al. 2018), 26 were found during this study in 2012–2018. *Bangia atropurpurea*, *Porphyridium cruentum* and *Tuomeya americana*, which were recorded earlier (e.g. Eloranta & Kwandrans 1996, 2002), were not found during this project. Later the locations previously given for *Tuomeya* were checked several times unsuccessfully.

New genetic data is continually changing the taxonomy of freshwater red algae, with implications for the nomenclature. Before this project, 117 samples were sent to the United States for gene sequencing in connection with a large Polish red algae project done in 2009–2013. These analyses showed very wide genetic variability in *Batrachospermum gelatinosum*, with 5 out of 12 COI haplotypes and 10 out of 21 ITS haplotypes, being the most diverse taxon in the European material (Keil et al. 2015).

Synonymy between *B. skujae* and *B. sporulans*, which was proposed in a morphometric analysis (Vis et al. 1995), is doubtful and would need verification against sequencing results. *B. skujae* was described after Israelson (1942) by Geitler (1944). Thus Israelson (1942) used *B. sporulans* for all forms with monospores. Starmach (1980) compared his material of both species and found that they differ markedly, as in this study; our DNA sequencing indicated that *Sirodotia tenuissima* is only an ecotype preferring rather slow current (Lam et al. 2012).

Although genetic results for *Batrachospermum turfosum* have shown that the name conceals at least three species occurring in Europe, two of them in Finland, (Necchi Jr. et al. 2013), the different taxa are treated in this study under one name because the species are not yet characterized. During the long sampling trips the samples had to be preserved in the field, making them unusable for DNA analyses. The material often contained atypical forms that would need genetic analyses to be identified.

The red algal flora of Swedish and northern Russian freshwaters are rather similar (Israelson 1942; Chemeris & Bobrov 2009), as are Finnish waters, but they differ

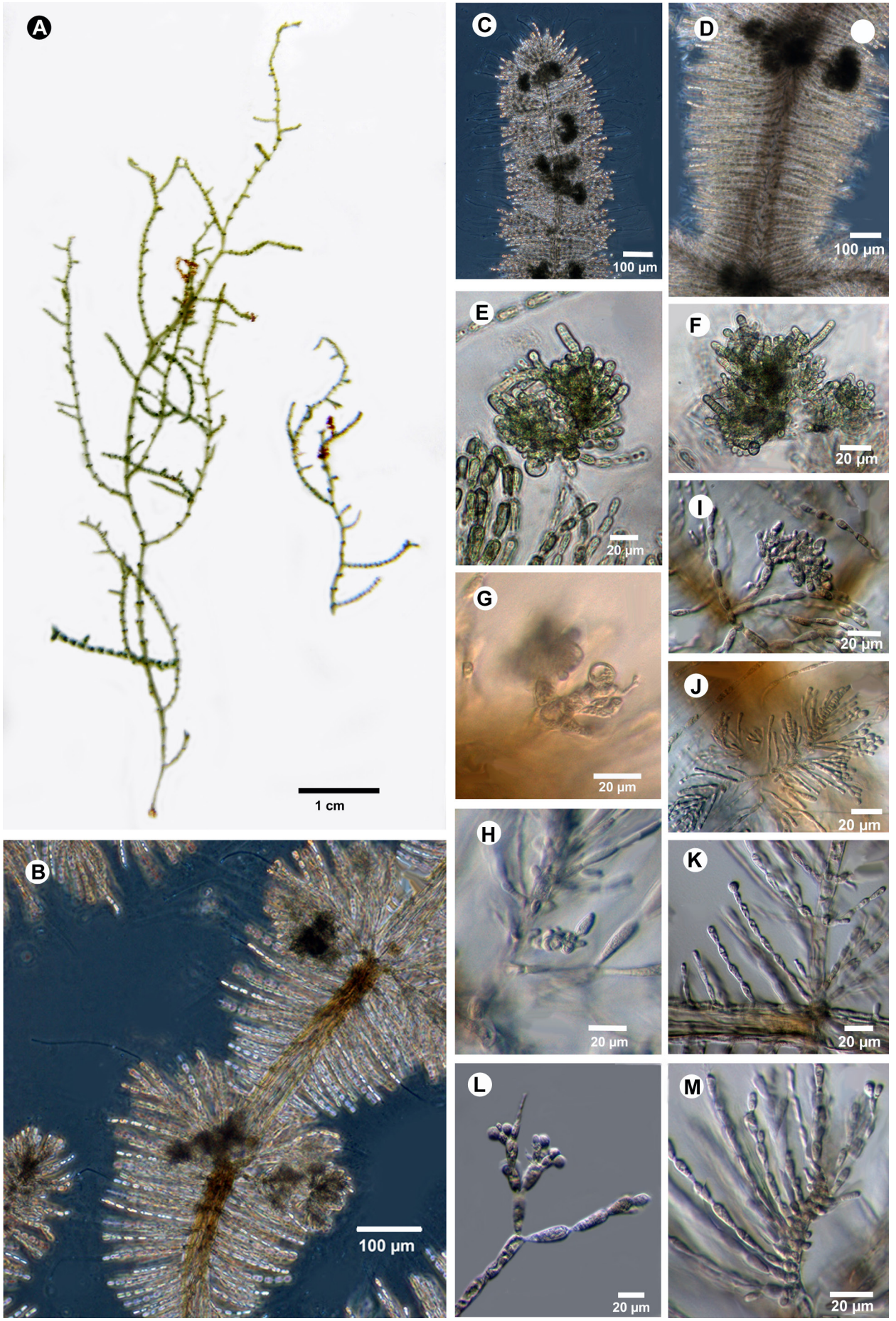

Figure 6. Strange '*Sirodotia*' (FI 23-2009): A – habit; B–D – parts of thallus with dark pseudocarposporophytes; E, F – pseudocarposporophytes; G–I – carpogonial branches; J – new branch initials and carpospores or monospores (?); K, M – branchlets with monospores; L – groups of spermatia.

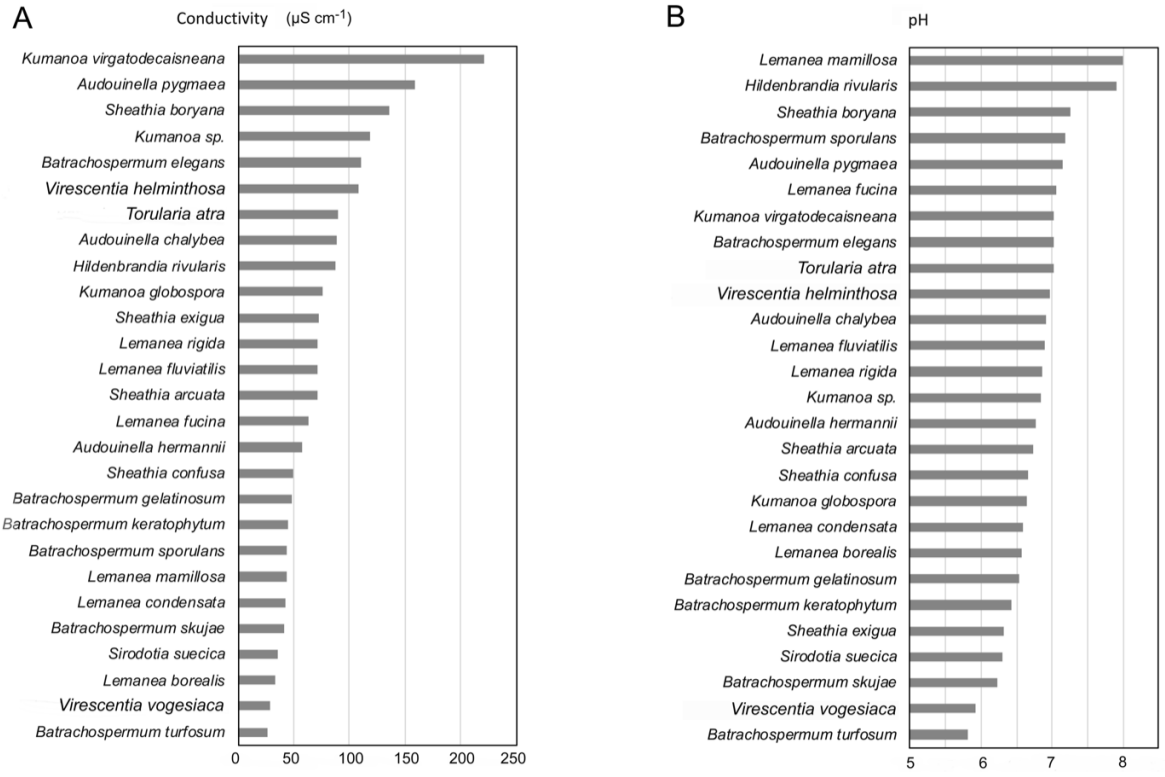

Figure 7. Taxa recorded during the project, ranked by average water conductivity (A) and pH (B).

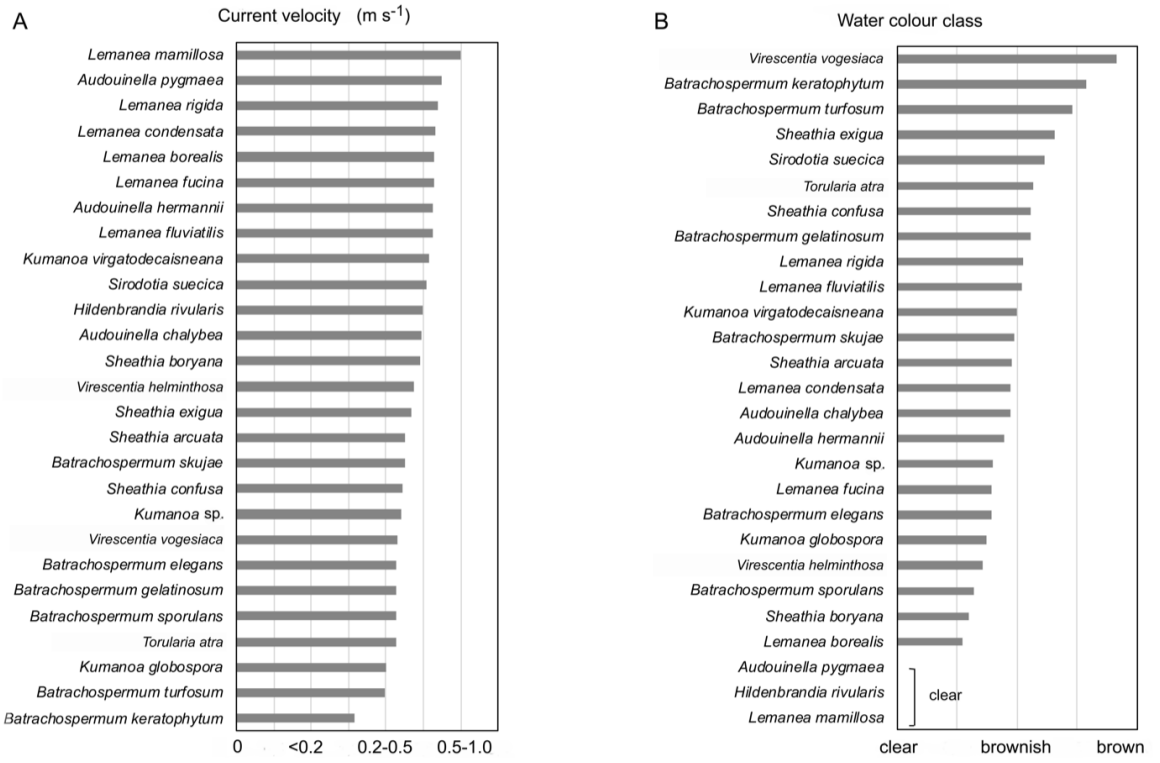

Figure 8. Taxa recorded during the project, ranked by average current velocity (A) and water colour (B).

from the freshwater red algal flora of Poland or the Baltic countries, where water conductivity is much higher. In Finland the most frequent taxa were *Batrachospermum gelatinosum* (36.5%), *Audouinella hermannii* (14.5%), *Sheathia arcuata* (9.3%), *Sirodotia suecica* (8.4%) and *Audouinella chalybea* (4.7%), whereas in Poland the most frequent taxa according to 2009–2013 project results were *Sheathia boryana* (30.9%), *Hildenbrandia rivularis* (17.4%), *Audouinella hermannii* (12.8%) and *Batrachospermum gelatinosum* (6.7%). It is surprising that in Poland, where the waters are more often alkaline and of high conductivity, *Torularia atra* was found only

Table 5. Freshwater Rhodophyta in *The 2019 Red List of Finnish Species* (Hyvärinen et al. 2019).

Kumanoa globospora (Israelson) Entwisle, Vis, Chiasson, Necchi et Sherwood	EN
Batrachospermum elegans Sirodot emend. Sheath, Vis et Cole	VU
Kumanoa virgatodecaisneana (Sirodot) Entwisle, Vis, Chiasson, Necchi et Sherwood	VU
Tuomeya americana (Kützing) Papenfuss	VU
Lemanea mamillosa Kützing	NT
Lemanea rigida (Sirodot) De Toni	NT
Sheathia boryana (Sirodot) Salomaki et M.L. Vis	NT
Torularia atra (Hudson) M.J. Wynne	NT
Virescentia helminthosa (Bory) Necchi, Agostinho et Vis	NT
Virescentia keratophytum Bory emend. Sheath, Vis et Cole	NT
Virescentia vogesiaca (Schultz ex Skuja) Necchi, Agostinho et Vis	NT

once (Kowalski & Kwandrans 2013) and *Virescentia helminthosa* only twice.

Virescentia helminthosa was recorded in June 2018 at 3 locations in southern and southwestern Finland, but in late summer (August–September) it was found at 23 locations in the same areas. It seems to have its main occurrence during late summer. In Sweden, according to Israelson (1942) most records were from late summer and autumn, too. This finding might help explain the spatial occurrence of that species in Finland. It has not been found in eastern Finland (Eloranta et al. 2018), presumably because that area was sampled only in early summer. A second explanation is the low conductivity of eastern Finnish waters.

The project sampling was carried out mainly in running waters. In the future, sampling will be extended to lake littorals. Some taxa might occur on macrophyte stems; examples of such taxa are *Chroothece rupestris*, *Kyliniella latvica* and *Rhodospora sordida*, which were found in Sweden and might be found in Finland as well (Tolstoy & Willén 1997).

On the list of algae designated as threatened in 2000 (Rassi et al. 2001), only 3 freshwater rhodophyte taxa were placed in the NT (near threatened) group: *Hildenbrandia rivularis*, *Torularia atra* and *Tuomeya americana.* There were few records of that group made at that time, not enough to estimate the rarity of different taxa.

The large sampling project carried out at the beginning of the 21st century in Finland documented the frequency and distribution of freshwater rhodophytes in that country. The new list contains one species designated EN (endangered), three species designated VU (vulnerable) and seven species designated NT (near threatened) (Table 5). *The 2019 Red List of Finnish Species* was published this past March (Hyvärinen et al. 2019).

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