Folia Cryptog. Estonica, Fasc. 32: 5–8 (1998)

A revision of *Cladonia stricta*

Teuvo Ahti
Department of Ecology and Systematics, P.O. Box 4, FIN-00047 University of Helsinki, Finland

Abstract: The arctic lichen *Cladonia stricta* (Nyl.) Nyl. is divided into three species, viz. *C. stricta* s. str., *C. trassii* Ahti, sp. nov.., and *C. uliginosa* (Ahti) Ahti, comb. nov. *Cladonia trassii* and *C. uliginosa* have centrally proliferating scyphi and constantly produce atranorin, while in *C. stricta* the scyphi are marginally proliferating and atranorin is inconstant. All the three species are essentially arctic to subarctic, circumpolar, but the ranges are poorly known.

Kokkuvõte: T. Ahti. Ülevaade liigist *Cladonia stricta*.

Arktiline samblik *Cladonia sticta* (Nyl.) Nyl. jagatakse siin kolmeks liigiks: *C. stricta* s. str., *C. trassii* Ahti sp. nov. ja *C. uliginosa* (Ahti) Ahti comb. nov. Liikidel *C. trassii* ja *C. uliginosa* on keskelt prolifitseeruvad karikad ning nad sisaldavad püsivalt atranoriini; liigi *C. stricta* karikad prolifitseeruvad servadest ning atranoriin kas esineb või puudub. Kõik kolm liiki on peamiselt arktilise kuni subarktilise (tsirkumboreaalse) levikuga, siiski on nende areaalide ulatust seni vähe uuritud.

INTRODUCTION

Cladonia stricta (Nyl.) Nyl. was adopted by me (Ahti, 1978) as the correct name for a widespread arctic lichen that was earlier called *C. lepidota* "Nyl.", *C. gracilescens* (Flörke) Vain. or *C. cerasphora* Vain. The lectotype specimen of *C. stricta* is from Taimyr Peninsula, Siberia. At the same time I also somewhat provisionally segregated *C. stricta* var. *uliginosa* Ahti for a taxon which Vainio (e.g., 1894) had recognized as as a distinct species under the misapplied name *C. gracilescens*.

However, when outlining the distribution of var. *uliginosa* I noted that the populations of *C. stricta* in East Asia and western North America are in need of a more through taxonomic analysis. I have later continued the study of *C. stricta* in these regions. The final impetus for a revision of my concept of *C. stricta* was provided by Dr Taimi Piin, who pointed me out that the type of *C. stricta* apparently represents a species distinct from most of the material under this name from Fennoscandia.

I had no possibility to make an extensive revision of material in many herbaria, but a new taxonomic scheme of the complex is given below. It still does not include a treatment of all variation noted in Canada and coastal East Asia in this group.

Cladonia stricta (Nyl.) Nyl. (Figs. 1, 2)

Flora 52: 294. 1869. – *Cladonia degenerans* var. *stricta* Nyl. in Middendorff, Reise Sibir. 4, Anh. 6(2): 4. 1867. Type: Russia. Krasnoyarsk Terr.: Taimyr Peninsula, 1843, von Middendorff s.n. (H-NYL 38841, lectotype, designated by Ahti, 1978: 11).

Cladonia degenerans f. *fuscescens* Nyl., Notiser Sällsk. Fauna Fl. Fenn. Förhandl. [Lich. Lappon. Orient.] 8: 109. 1866 (preprint). Type: Russia. Murmansk Region: island Bolshoy Oleniy ("Olenji"), 1861, Fellman (H, lectotype, here designated).

Cladonia cerasphora Vain., Acta Soc. Fauna Fl. Fenn. 10: 167. 1894, nom. illeg. superfl. for *C. stricta* (Ahti, 1978).

Illustration. Thomson (1984: 164).

Primary thallus evanescent, consisting of small squamules, 1–2 mm wide. Podetia dark brown to grey, at base strongly melanotic; 3–12 cm tall, 1.5–3 mm thick, slender, slightly branched by dichotomy, axils closed or perforated; sterile tips usually subsubulate, ascyphose; scyphi absent or present, narrow (0.5–3 mm), often with 2–7 teeth or long proliferations at margins, shallow to deep, frequently tips appearing trifurcate, indistinctly scyphose; scyphi soon becoming perforate, older scyphi with many perforations; central proliferations in scyphi absent or very rare; surface matt, clearly arachnoid, especially towards the tips, verruculose-corticate, towards the base checkered; podetial wall 200–300 mm, cortex 50–70 mm, soft medulla 100–150 mm,

Fig. 1. *Cladonia stricta.* Lectotype (H-NYL 38841). Scale = 1 cm.

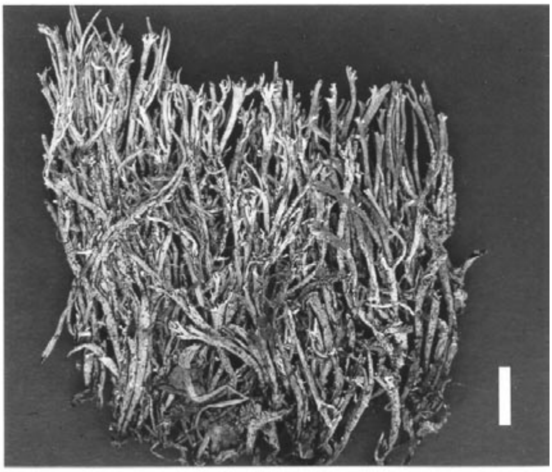


Fig. 2. *Cladonia stricta.* Canada, Ahti 31953 (H). Scale = 1 cm.

stereome 50–100 mm, central canal densely papillate. Conidiomata at tips of podetia, ovoid, with hyaline slime, conidia 7–9 mm, falciform. Hymenial discs infrequent, 2–5 mm wide, dark brown, spores 10–15 × 2.5–3 mm, fusiform.

Chemistry. Fumarprotocetraric acid, often with atranorin (e.g., in lectotype), traces of protocetraric and confumarprotocetraric acids. An HPLC analysis cited under *Cladonia phyllophora* Hoffm. by Huovinen et al. (1990: 223, no. 465). No convirensic acid (Cph-1) has been detected with TLC, though that substance is not uncommon in *C. phyllophora.*

Habitats. Observed in the field in Alaska, the Yukon, and Sweden, and mostly seen growing in rock fields in timberline areas, either in lower mountain tundra or in upper woodlands. Judged from specimen labels probably mainly in dryish upland communities rather than in wet habitats.

Distribution. Essentially circumpolar, arctic-hemiarctic, extending to mountains in the boreal zone. Recorded from Norway (incl. Svalbard), Sweden, Finland, Kola Peninsula, arctic Siberia, Chukotka, Alaska, the Yukon, British Columbia, Northwest Territories.

Representative specimens.
SVALBARD: Spitsbergen, ca. 10 km SE of Longyearbyen, 300–500 m, 1985 Kashiwadani 23537 (H, TNS). NORWAY. Troms: Tromsö, 1906 Havås, Lich. Exs. Norv. 528 (H), 1990 Schindler 14174 (H, KR). SWEDEN. Jämtland: Åre, Mt. Åreskutan, 1280 m, 1975 Ahti 30303 (H). Torne Lappmark: Jukkasjärvi, Riksgränsen, 1958 Bäck (H, UPS); Karesuando, Laukkuåive, 1910 Montell (H); Kummaeno, 1910 Lynge (H). FINLAND. Lapponia enontekiensis: Enontekiö, Karesuvanto, 1867, Norrlin (H). RUSSIA. Murmansk Region: Lavna-tundra, 600 m, 1987 Dudoreva 298/5 (H, KPABG). Tyumen Region: Station 126 on Vorkuta–Labytnangi railway, 1986, Zhurbenko 8618 (H). Krasnoyarsk Territory: Putorana, Lake Lama, 1984, Zhurbenko 848 (H); Severnaya Zemlya, SW of Cape Barano, 1991, Safronova 913 & Andreev (H). Magadan Region: Chukotka, Anyuy Range, 1978, Andreev (H). ALASKA. Point Barrow, 1958, Thomson et al., Lich. Arct. 34 (US); Mt. Fairplay, 1967, Ahti 25270 (H). CANADA. British Columbia: km 108 on Haines Highway, 1976, Otto 5897 (H). Yukon: Mile 96 Haines Highway, 1967, Ahti 23356 (H). Northwest Territories: District of Mackenzie, Hyndman Lake, 1966, Scotter 8045 (H), Nahanni Natl. Park, Hole-in-the-Wall Lake, 1200 m, 1977, Ahti 31953 (CANL, H, TU); District of Keewatin, Parson's Lake, 1959, Thomson & Larsen 5883 (US).

Cladonia stricta s. str. is the "apparently new species" mentioned under *C. phyllophora* Hoffm. by Thomson & Ahti (1994: 146) and in connection with *C. alaskana* A. Evans by Ahti & Zhurbenko (1994). Perhaps most of the material of *C. stricta* is found under *C. phyllophora* in herbaria. It is noteworthy that *C. stricta* occasionally contains atranorin and such specimens have often been referred to *C. stricta* while morphologically similar specimens without atranorin have been placed in *C. phyllophora.*

In specimens with well-developed scyphi the numerous perforations of the scyphi constitute a good diagnostic character.

Cladonia trassii **Ahti sp. nov.**

Thallus primarius persistens aut demum evanescens, squamis 5–12 mm longis. Podetia 3–8 cm alta, elongata, irregularia, parce ramosa, ascypha vel scyphis angustis, a centro scyphorum prolifera, glaucescentia, cortice subcontinuo, apice pruinoso, subtomentoso, basi areolato, medulla melanotica. Atranorinam et acidum fumarprotocetraricum continens.

Type. Sweden. Torne Lappmark: Gällivare ("Gellivare"), Mt. Patjanen, 550 m, 1922, Stenholm, Sandstede: Clad. Exs. 1134 (H, holo-type; TU, isotype; as *Cladonia gracilescens*).

Illustration. Krog et al. (1994: 169, as *Cladonia stricta*).

Etymology. Named in honour of the Estonian lichenologist Professor Hans Trass.

Primary thallus persistent to evanescent, consistings of fairly large squamules, 1–5 mm wide. Podetia 3–8 cm tall, 1–3 mm thick, extremely variable in shape; glaucous-grey, often browned in part, base melanotic, with checkered surfafe; usually slightly branched by dichotomy, axils closed; scyphose but scyphi usually very few and irregularly shaped, if well-developed, then centrally proliferating; ascyphose tips bluntish; surface areolate-corticate, rather smooth but often largely decorticate and squamulose, slightly arachnoid and pruinose towards the tips; podetial wall 200–380 mm, cortex 20–40 mm, medulla 80–150 mm, stereome 100–190 mm; central canal slightly papillate. Conidiomata at tips of podetia, globose to mammiform, pycnidial slime hyaline, conidia 6–8 × 1 mm, falciform. Hymenial discs infrequent, dark brown, 2–5 mm wide, spores 12–14 × 2.5–3 mm, fusiform.

Chemistry. PD+ red, K+ yellow; contains atranorin, fumarprotocetraric acid and traces of protocetraric and confumarprotocetraric acids.

Habitats. Mainly in arctic and alpine late snow-lie communities.

Distribution. Arctic-alpine, circumpolar in the northern hemisphere, probably somewhat oceanic. A single locality reported from Tierra del Fuego, Argentina (Stenroos & Ahti, 1991: 324, as *C. stricta*).

Representative specimens.
SWEDEN. Jämtland: Åre, Mt. Snasahögarna, Silverfallet, 900 m, 1975 Ahti 30313 (H, UPS). RUSSIA. Khabarovsk Territory: Anoy River, 1956, Rosenberg 44 (US). ALASKA. Thompson Pass, 1967, Thomson 20974 & Ahti (US). CANADA. Northwest Territories: Baffin Island, Clyde Fjord, 1950, Hale 301 (US). Québec: Mt. Albert, 1940, Lepage 6287 (US). GREENLAND. Hansen: Lich. Groenl. Exs. 92 (H, US).

Cladonia trassii is actually a new name for what Vainio (1894, 1922) called *C. cerasphora* and what has recently been called *C. stricta* var. *stricta* (e.g., Ahti, 1977, 1978; Krog et al., 1994), though some material of *C. stricta* s. str. has been included in the previous descriptions.

Cladonia uliginosa **(Ahti) Ahti comb. nov.**

Cladonia stricta var. *uliginosa* Ahti, Ann. Bot. Fennici 15: 11: 1978. Type: Russia. Murmansk Region (formerly Finland. Kuusamo: Salla): Korja, "ad pedem montis Nurmitunturi", 1937, Laurila, Räsänen: Lich. Fenn. Exs. 475 (H, holotype; BM, H, UPS, isotypes).

Illustration. Krog et al. (1994: fig. VII, as *Cladonia stricta*, in colour!).

For description see Vainio (1922), as *Cladonia gracilescens*.

Chemistry. As in *C. trassii*, but with additional minor unknown substances (Huovinen et al., 1990: 225).

Habitat. In periodically wet places in woodlands near timberline.

Distribution. Not uncommon in northern boreal forest regions of Fennoscandia but its total distribution is little known. There are few records from North America. In Finland it is commoner than *C. trassii* but in Sweden and Norway it seems to be less common common than that species.

Representative specimens.
NORWAY. Hordaland: Granvin, 225 m, 1918, Havås, Lich. Norv. Occid. Exs. 101 (H). SWEDEN. Torne Lappmark: Karesuando, Virkakursu, leg. Lång, Crypt. Exs. Vindob. 1867 (H). FINLAND. Ostrobottnia ultima: Simo, 1942, Räsänen, Lich. Fenn. Exs. 790

(H). RUSSIA. See type. ALASKA. Alaska Peninsula, Naknek, 1948, Lepage 22634 (US); Lake Peters, 1948, Scholander & Flagg (US).

Cladonia uliginosa is characterized by constant occurrence of distinct, centrally proliferating scyphi and numerous podetial squamules. It is very close to *C. trassii* and I earlier (Ahti, 1978) treated it as a variety (under *C. stricta*). I have not found distinct intermediates, but further field investigations are required to confirm the differences in relation to *C. trassii*. The latter species usually has no or no well-developed scyphi. Many of the North European exsiccata distributed as *C. gracilescens* belong to *C. trassii* rather than *C. uliginosa*, which has confused the recognition of these species.

ACKNOWLEDGMENTS

This contribution is dedicated to Prof. Hans Trass who, among many other things, has studied European and Siberian arctic macrolichens. I am further indebted to Dr Taimi Piin (Tallinn), Dr Mikhail P. Zhurbenko (St. Petersburg), and Ms. Tamara Dudoreva (Kirovsk), Prof. Henry A. Imshaug (East Lansing, MI), who have given me material or observations on *C. stricta*. Dr George W. Scotter and Prof. John W. Thomson provided me opportunities to study this group in field in Canada and Alaska. The study was financially supported through a grant from the Academy of Finland, and at the last stage through an Andrew W. Mellon Senior Fellowship.

REFERENCES

Ahti, T. 1977. *Cladonia* Wigg. In *Bestimmungsschlüssel europäischer Flechten. Ergänzungsheft* (eds. Poelt, J. & Vêzda, A.) 1: 45–95. J. Cramer, Vaduz.

Ahti, T. 1978. Nomenclatural and taxonomic remarks on European species of *Cladonia. Ann. Bot. Fenn.* 15: 7–14.

Ahti, T. & Zhurbenko, M. P. 1994. Distribution of *Cladonia alaskana* in Asia. *Graphis Scripta* 6: 11–14.

Krog, H., Østhagen, H. & Tønsberg, T. 1994. Lavflora. *Norske busk- og bladlav*. Edn. 2. Universitets-forlaget. 368 pp.

Huovinen, K., Ahti, T. & Stenroos, S. 1990. The composition and contents of aromatic lichen substances in *Cladonia* section *Cladonia* and group *Furcatae. Bibl. Lichenol.* 38: 209–241.

Stenroos, S. & Ahti, T. 1991 (‘1990’). The lichen family Cladoniaceae in Tierra del Fuego: problematic or otherwise noteworthy taxa. *Ann. Bot. Fenn.* 27: 317–327.

Thomson, J. W. 1984. *American arctic lichens. Vol. 1. The macrolichens*. Columbia University Press, New York.

Thomson, J. W. & Ahti, T. 1994. Lichens collected on an Alaska Highway expedition in Alaska and Canada. *Bryologist* 97: 138–157.

Vainio, E. A. 1894. Monographia Cladoniarum universalis. Vol. 2. *Acta Soc. Fauna Fl. Fenn.* 10: 1–498.

Vainio, E. A. 1922. Lichenographia fennica. Vol. 2. Baeomyceae et Lecideales. *Acta Soc. Fauna Fl. Fenn.* 53: 1–340.

Folia Cryptog. Estonica, Fasc. 32: 9–14 (1998)

Opegrapha trassii sp. nov., a new lichenicolous fungus on *Heterodermia*

Brian J. Coppins* and Sergey Y. Kondratyuk#
*Royal Botanic Garden Edinburgh, Inverleith Row, Edinburgh EH3 5LR, UK
#N. G.Kholodny Institute of Botany, 2 Tereshchenkivska St., 252601 Kiev, Ukraine

Abstract: A new lichenicolous fungus, *Opegrapha trassii* S. Kondratyuk & Coppins (*Opegraphaceae*), parasitizing several species of *Heterodermia* (*Physciaceae*) is described and illustrated, and comments about its differences from related taxa are provided. The new fungus is widely distributed and so far known from Sierra Leone, Uganda, Zambia, Malawi, Angola, South Africa, India, Mauritius, Japan, New Zealand, USA (incl. Hawaii Islands and Puerto Rico) and Surinam.

Kokkuvõte: B. J. Coppins ja S. J. Kondratjuk. *Opegrapha trassii* sp. nov., uus lihheniseerunud seene liik sambliku *Heterodermia* tallustelt.

Kirjeldatakse uus lihheniseerunud seene liik *Opegrapha trassii* S. Kondratyuk & Coppins (*Opegraphaceae*), mis parasiteerib sambliku *Heterodermia* (*Physciaceae)* tallustel. Lisatud on ka uue liigi erinevused lähedastest taksonitest. *O. trassii* on laialt levinud, uuritud eksemplaride leiukohtadena on märgitud Sierra Leone, Uganda, Sambia, Malaavi, Angoola, Lõuna-Aafrika, India, Mauritius, Jaapan, Uus-Meremaa, USA (s.h. Havai ja Puerto-Rico) ning Surinam.

INTRODUCTION

The ascomycete genus *Opegrapha* comprises c. 300 species, mostly lichenized species (Hawksworth et al., 1995). However, some of the species are lichenicolous, several being previously assigned to the genus *Leciographa* A. Massal. In their world key to lichenicolous fungi, Clauzade et al. (1989) recognized about 20 species of lichenicolous *Opegrapha*, but since then a further 24 species have been newly described, validated or introduced (or re-introduced) into the genus: *O. stereocaulicola* Alstrup & D. Hawksw. on *Stereocaulon* (Alstrup & Hawksworth, 1990), *O. physciaria* (Nyl.) D. Hawksw. & Coppins on *Xanthoria parietina* (Atienza, 1992; Coppins et al., 1992); *O. sphaerophoricola* Isbrand & Alstrup on *Sphaerophorus* (Isbrand & Alstrup, 1992); *O. geographicola* (Arnold) Hafellner on *Rhizocarpon geographicum, O. rotunda* Hafellner on *Physconia* and *O. zwackhii* (A. Massal. ex Zwackh) Källsten on *Phlyctis argena* (Hafellner, 1994); *O. brevissima* Kalb & Hafellner on *Haematomma hilare* (Kalb et al., 1995), *O. leuckertii* S. Kondratyuk & D.J. Galloway on *Pseudocyphellaria* and *Sticta* (Kondratyuk & Galloway, 1995), *O. physcidiae* Kalb & Elix on *Physcidia* sp. (Kalb & Elix, 1995), *O. rouxiana* Nav.-Ros. & Hladun on *Polyblastia* (Navarro-Rosinés & Hladun, 1995), *O. cryptotheciae* Matzer on *Cryptothelia, O. ectolechiaceaum* Matzer & R. Sant. on foliicolous *Ectolechiaceae, O. epiporina* Matzer on *Porina, O. kalbii* Matzer on *Byssoloma, O. mazosiae* Matzer on *Mazosia, O. phyllobathelii* Matzer & R. Sant. on *Phyllobathelium, O. phylloporinae* Müll. Arg. and *O. sipmannii* Matzer on *Porina epiphylla* gr., *O. porinicola* Matzer on *Phyllophiale alba* and *Porina epiphylla, O. strigula* Matzer & R. Sant. and *O. uniseptata* Matzer on foliicolous *Strigula* (Matzer, 1996); *O. phlyctidicola* (Vouaux) Etayo on *Phlyctis agelaea* (Etayo, 1996); *O. encephalographoidea* Diederich & Aptroot on *Pyrenula,* and *O. pleactocarpoidea* Diederich on *Phaeographis* (Aptroot et al., 1997). Furthermore, we are aware of several additional, undescribed species, one of which is widely occurring on various species of *Heterodermia* (*Physciaceae*).

Recent, more critical morphological studies of lichenicolous *Opegrapha* have shown each species to have a restricted host range, most being either species- or genus-specific, or more rarely family-specific (e.g. *O. ectolechiacearum* on foliicolous *Ectolechiaceae* and *O. rupestris* Pers. on crustose, foveolate *Verrucariaceae* on limestones), and no species has yet been reliably reported from hosts of different families. No *Opegrapha* or *'Leciographa'* has hitherto been reported on *Heterodermia*, and the fungus on this genus clearly differs from other *Opegrapha* species on hosts belonging to the *Physciaceae*. Accordingly, the collections on *Heterodermia* are here referred to the species newly described below.

Opegrapha trassii **S. Kondratyuk & Coppins sp. nov.**

Fungus lichenicola in thallo specierum *Heterodermiae*; cortex hospitis brunneolescens. Ascomata lirelliformia, aggregata, simplicia vel interdum breviter furcata, epruinosa, 200–300(–420) µm longa, 125–160(–200) µm lata, disco rimiformi vel demum hianti. Excipulum integrum, fuscoatrum, admodum K-. Hymenium (40–)45–63.5(–72.5) µm altum, I+ caeruleum. Asci clavati cum annulo apicali amyloideo minuto, (30.5–)32.5–40(–47) × (11–)12–14.5(–16) µm, (2–)4–6(–8)-spori. Ascosporae 3(–4–5)-septatae, hyalinae vel demum granulis brunneascentes, 12.5–17.5(–19) × (3.6–)4.5–5(–5.5) µm. Pycnidia pauca, ±immersa, c. 40–50 µm diam., conidiis bacilliformibus 3.8–5 × 0.5–0.7 µm.

Type: [SOUTH AFRICA]: B. G. Hope, on *Heterodermia* sp., date and collector unmentioned [Herb. Archibald Menzies (1754–1842)] (BM – holotype; E – isotype [South Africa: Cape of Good Hope, on *H. speciosa*, 1791, A. Menzies]).

Etymology: *Opegrapha trassii* is named after the famous Estonian lichenologist Prof. Hans Trass in recognition of his important contribution to our knowledge on the flora of Estonia and other regions of Eurasia, as well as on the family Physciaceae, especially the genus *Heterodermia*.

Lichenicolous fungus, parasitic on thalli (rarely on thalline margin of host apothecia) on various *Heterodermia* species. Ascomata arising, ±superficially (i.e. not developing below, and bursting through, the host cortex), in clusters up to 3.5 mm across and containing up to 15(–38) ascomata; surrounding host tissue discoloured brown; clusters characteristically elliptical, with the long axis of the clusters and most individual ascomata parallel with that of the lobes of the host. Individual ascomata

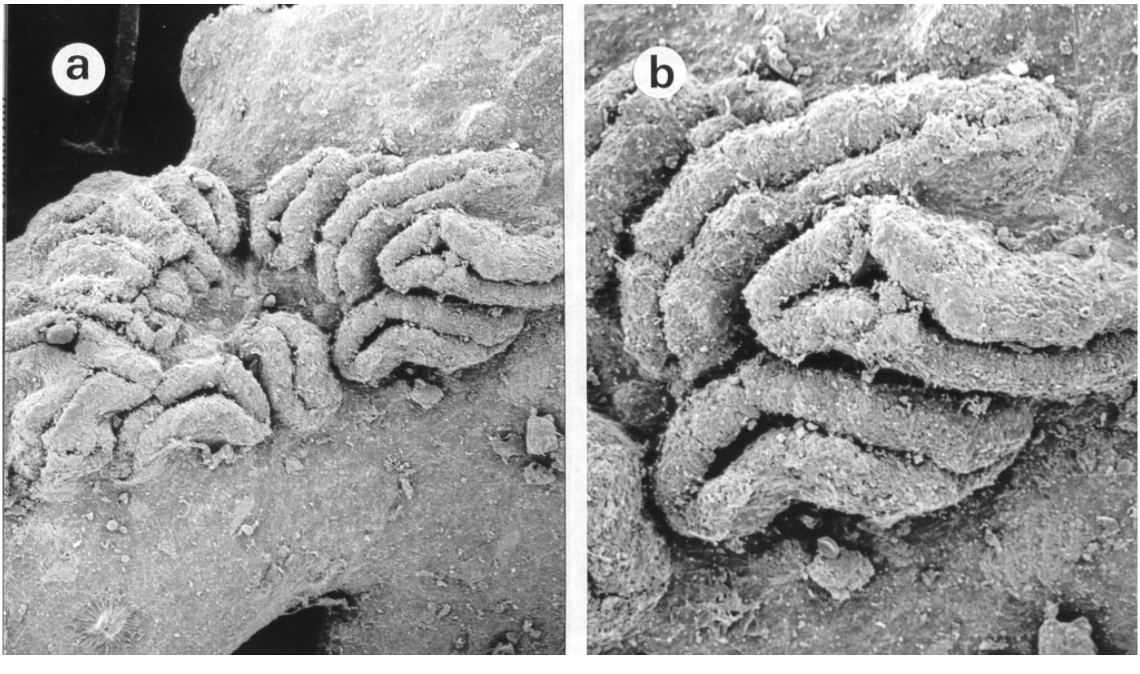


Fig. 1 a–b. *Opegrapha trassii.* a: habitus of ascomata on the host thalli (× 72); b: part of ascomata (× 48).

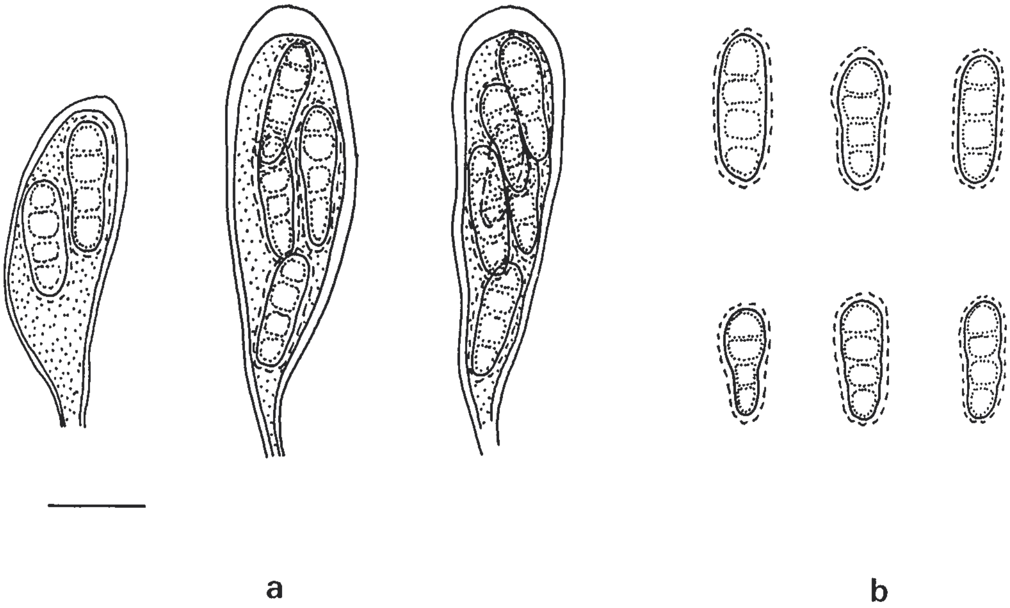


Fig. 2 a–b. *Opegrapha trassii*. a: asci, b: ascospores. Scale 7 µm.

black, epruinose, 200–300(–420) µm long, 125–160(–200) µm wide, and, in sections, (127–)140–150 µm tall; simple or occasionally shortly 1–2-furcate, straight or slightly curved, disc slit-like or eventually gaping. Exciple well developed, entire, 18–27(–32.5) µm wide laterally, (21.5–)30–43(–53) µm wide below, dark brown to blackish brown, sometimes with reddish tinge K- or K+ fuscous brown (loosing red tinge) or slightly olivaceous (never bright green or red-brown). Hymenium hyaline, (40–)45–63.5(–72.5) µm tall, I+ blue, K/I+ blue; epihymenium absent, with the excipulum remaining incurved over the top of the hymenium or becoming evident in widely gaping ascomata and then hyaline to pale brown, 9.0–21.5 µm tall. Hypohymenium dilute brownish, K- or K+ slightly olivaceous, (12.5–)16–23.5 µm tall. Paraphyses branched, 1–1.5(–2) µm wide (in KOH). Asci broadly clavate, (30.5–)32.5–40(–47) × (11–)12–14.5(–16) µm, with K/I+ blue ring around the top of the ocular chamber, (2–)4–6(–8)-spored. Ascospores hyaline, 3(–4–5)septate, upper 2 (3 or 4) cells somewhat more swollen than the lower cells, 12.5–17.5(–19) × (3.6–)4.5–5(–5.5) µm, apices obtuse, sometimes with a thin perispore <1 µm thick; old spores released from asci sometimes pale brown due the external deposition of minute brown granules. Pycnidia sometimes present around the outside of the ascomatal clusters, immersed in the host tissue, dark brown to black, c. 40–60 µm diam.; wall tissue dark brown, K-; conidia (microconidia) bacilliform, 3.8–5 × 0.5–0.7 µm (Fig. 1, 2).

Opegrapha trassii is very variable with respect to the numbers of spores in the ascus; this can be 2, 4, 6 or 8, and all four types have been seen in sections of a single ascoma. However, asci with 4 or 6 spores are those most commonly encountered.

Only two species of *Opegrapha* have been previously described from hosts in the *Physciaceae*, and both differ from *O. trassii* in having rounded ascomata and larger ascospores: *O. rinodinae* Vêzda on *Phaeorrhiza nimbosa* (ascospores 22–26 × 4–6 µm) and *O. rotunda* Hafellner on *Physconia* (ascospores 18–22 × 5–6 µm) (Hafellner, 1994). Despite its specific epithet*, O. physciaria* (Nyl.) D. Hawksw. & Coppins grows on *Xanthoria parietina* (*Teloschistaceae*) and has 8-spored asci that lack an apical K/I+ blue ring. Two collections in E have an unidentified *Opegrapha* on *Pyxine cocoes* (*Physciaceae*) from Botswana

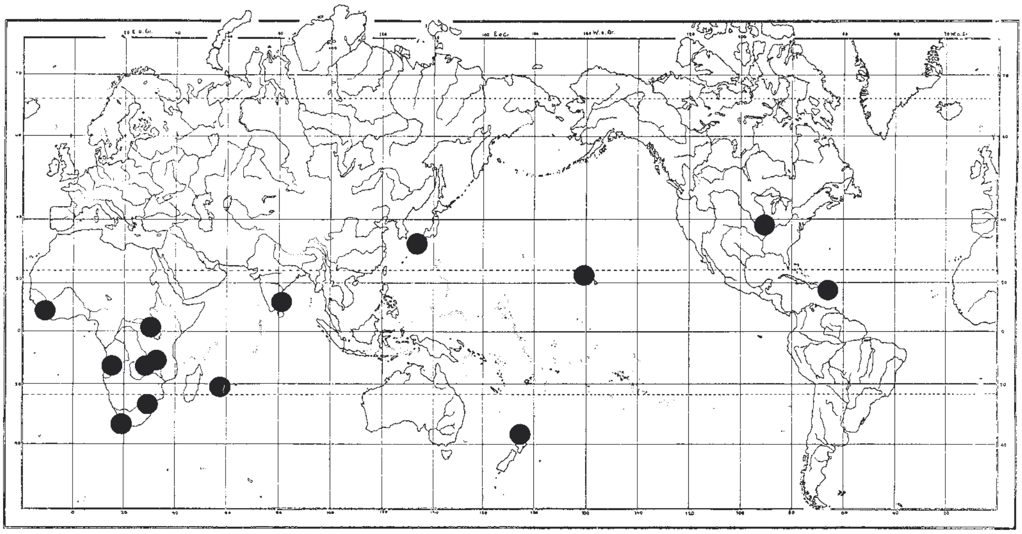


Fig. 3 Distribution of *Opegrapha trassii.*

(Long 12449, Long & Rae 881). They differ from *O. trassii* in that the clusters of ascomata arise below and eventually burst through the cortex of the host, the asci are 8-spored, and the ascospores are somewhat broader, with many reaching a width of 5.5–6 µm.

What seems to be an additional *Opegrapha* species on *Heterodermia*, has recently been found. A small specimen, collected in Papua New Guinea and sent to the first author by Dr P. Diederich, differs from *O. trassii* in having more robust ascomata with a soon expanding disc, to 460 µm wide. In sections the ascomata are much taller (to 280 µm) with a taller hymenium (80–85 µm) and much taller combined hypothecium and lower exciple (to 200 µm; mostly less than 60 µm in *O. trassii*). The asci are 4-spored, but the ascospores are consistently 5-septate at maturity (no mature 3-septate ascospores being detected), and longer (17.5–21.5 × 4.5–6,5 µm). It seems unlikely that this collection (Diederich 10317) represents an extreme morphotype of *O. trassii*, and further collections will surely prove it to be a distinct species.

Additional specimens (all on *Heterodermia* spp.) (Fig. 3). INDIA: Madras: Nilgias district, 3000 ft, on *H. leucomela*, November 1886 *J.S.Gamble* 18438 (BM); Madras, on *H. leucomela*, 1775 (collector unknown) [Herb. Ind. Oc. Hook fil. & Thomson] (BM). MAURITIUS: on *H. obscurata*, no date, *Dr Ayres* (E). JAPAN: Shikoku, Pref. Ehime, Odamachi, Ochira ca. 560 m alt., on rock, on *H. obscurata,* 18 Nov. 1972 *M. Inoue* 2227 (BM). SIERRA LEONE: Loma Mountains, Camp 2, on tree at edge of forest gallery at about 1400 m alt., on *Anaptychia boryi* [=*H. leucomela subsp. boryi*], 15 March 1971 *P. W. Richards* R7253L (BM). UGANDA: Toro, Burahya, Street in Fort Portal, Lat. 0°40'N, Long. 30°16'E, alt. 1500 m, SR-95-75, trunk of tree in avenue, on *H. leucomela*, Juny 1970 *T.D.V. Swinscow* 2U 17/18-2 (BM; 1 km N of Fort Portal. Toro. Common on tree bole in avenue, on *H. leucomela*, 25.07.1971 *A.Pentecost* RE29 (BM). ZAMBIA [N. Rhodesia], Namwala, Kafue National Park, Lubalansuki Hill, Bald granite Hill, on *H. pseudo-speciosa*, 7 May 1964 *Mitchell* (BM). MALAWI: Mlanje, S.Province, D.C.'s grounds, alt. 3200 ft, on *H. magel-lanica*, April 1969 *M. Jellicoe* (BM). ANGOLA: Welwitsch, Iter Angolense, No. 34. Hab. frequens in summis jugis de Serra de Etella et circa Mumpulla ad 4500 ped. elev., truncis *Iarchonanthi* spec. adnascens. Distr. Huilla (3800–5500 ped. elev.). Inter 14 et 16° Lat austr., on *Anaptychia neoleuco-melaena* f. *squarrosa* [=*H. leucomela* subsp. *boryi*], Jun. 1860 *L. Welwitsch* (BM – isotype of *A. neo-leucomelaena* f. *squarrosa*). SOUTH AFRICA: Cape Province, E. prov, on a small dead bush, on *H. leuco-mela*, 15 March 1898 *R.E.Raud* (BM); Cape of Good Hope, on *H. lepidota*, date and collector unmentioned (BM, from Herb. A.Menzies. Recd. 1886). Natal: Umgae Mountains, SW Plant, on *H.* sp. ('*Physcia leucomelas* v. *subcomosa* [Syn. p. 415]'), 1853 (Collector uncertain) (BM). USA: Louisiana: East Feliciana Parish, 5.6 km SE of Clinton, Idlewild Research Station, 30°48'N, 90°45'W, on *H. albicans*, 18 April 1984, *S.C.Tucker* 26346 (E); Puerto-Rico, Coamo, on *H.* sp., 13 December 1885 *P. Sintenis* (BM ex K sub *Parmotrema tinctorum*); Hawaii, Sandwich Islands, on *H.* sp. [without date and collector] [Herb. A. Menzies. Recd. 1886] (BM). SURINAM: Paramaribo, Palmgarden, 0 m alt., on *H. albicans* on *Roystonea regia*, 25–29 January 1985, *A. Aptroot* 14842a (Herb. Aptroot). NEW ZEALAND: loc. uncertain, on *H. speciosa* [date unknown], *Knight* [Herb. Leighton] (BM). North Island, Mantime rocks, Russell, on *Anaptychia obscurata*, 9.3.1966 Wade (BM); North Island, coast rocks, Mount. Maunganui, on *H. obs-curata*, 24–26 May 1966, *Wade* (BM).

ACKNOWLEDGEMENTS

We are grateful to the curators and keepers of the cited herbaria for assistance with loan of specimens, Dr A. Aptroot for sending his collection of *O. trassii* from Surinam, and to Dr P. Diederich for sending us material of the probable second *Opegrapha* species on *Heterodermia*. K.S.Y. is also thankful to Ms A.M.Coppins and to the first author for extremely warm hospitality and generous help with accommodation during his stay in Edinburgh. He acknowledges the invaluable help given him by staff at E, during his stay there in 1996, and is grateful to the Royal Society for financial support too.

REFERENCES

Alstrup, V. & Hawksworth, D. L. 1990. The lichenicolous fungi of Greenland. *Medd. Grønland, Bioscience* 31: 1–90.

Aptroot, A., Diederich, P., Sérusiaux, E. & Sip-man, H. 1997. Lichens and lichenicolous fungi from New Guinea. *Bibl. Lichenol.* 64: 1–220.

Atienza, V. 1992. *Peridiothelia oleae* (Körber) D. Hawksw. and *Opegrapha physciaria* (Nyl.) D. Hawskw. et Coppins, two poorly known west mediterranean fungal taxa. *Anales Jard. Bot. Madrid.* 50: 159–162.

Clauzade, G., Diederich, P. & Roux, C. 1989. Nelikenigintaj fungoj likenlogaj. *Bulletin Soc. Linn. Provence, Numéro spécial* 1: 1–142.

Coppins, B. J., James, P. W. & Hawksworth, D. L. 1992. New species and combination in "The lichen Flora of Great Britain and Ireland". *Lichenologist* 24: 351–370.

Etayo, J. 1996. Aportación a la flora liquénica de las Islas Canarias. I. Hongos liguenícolas de gomera. *Bull. Soc. Linn. Provence* 47: 93–110.

Hafellner, J. 1994. Beitrage zu einem Prodromus der lichenicolen Pilze Osterreichs und angrenzender Gebiete. I. Einige neue oder seltene Arten. *Herzogia* 10: 1–28.

Hawksworth, D. L., Kirk, P. M., Sutton, B. C. & Pegler, D. N. 1995. *Ainsworth & Bisby's Dictionary of the Fungi.* 8th edn. Wallingford: CAB International.

Isbrand, S. & Alstrup, V. 1992. *Opegrapha sphaerophoricola* sp. nov. *Bryologist* 95: 233–234.

Kalb, K. & Elix, J. 1995. The lichen genus *Physcidia. Biblioth. Lichenol.* 57: 265–296.

Kalb, K. Hafellner, J. & Staiger, B. 1995. *Haematomma*-Studien. II. Lichenicole Pilze auf arten der Flechtengattung *Haematomma. Biblioth. Lichenol.* 59: 199–222.

Kondratyuk, S. & Galloway, D. J. 1994. Liche-nicolous fungi and chemical patterns in *Pseudo-cyphellaria. Bibl. Lichenol.* 57: 327–345.

Matzer, M. 1996. Lichenicolous ascomycetes with fissitunicate asci on foliicolous lichens. *Mycol. Papers* 171: i–x, 1–202.

Navarro-Rosinés, P. & Hladun, N. L. 1995. *Opegrapha rouxiana* sp. nov., nelikeniginta fungo likenloga ce enpetraj *Polyblastia. Bull. Soc. linn. Provence* 46: 25–90.

Folia Cryptog. Estonica, Fasc. 32: 15–20 (1998)

A revision of the *Lecanora subfusca* group in Estonia

Inga Jüriado
Institute of Botany and Ecology , University of Tartu, 38 Lai St., EE2400 Tartu, Estonia

Abstract: 12 species of the *Lecanora subfusca* group are known in Estonia, 10 of them are present in the contemporary flora, one species is considered extinct, and one doubtful. *Lecanora circumborealis* is new for the country, four species are very rare (*L. caesiosora*, *L. epibryon*, *L. glabrata*, *L. impudens*) and seven species are common in Estonia. A key to the species of the *L. subfusca* group in Estonia is presented.

Kokkuvõte: I. Jüriado. Ülevaade *Lecanora subfusca* rühmast Eestis.

Eestist on teada 12 samblikuliiki, mis kuuluvad *Lecanora subfusca* rühma, neist 10 on kindlasti esindatud Eesti kaasaegses flooras, üks liik on tõenäoliselt hävinud ja üks – kaheldav. *Lecanora circumborealis* on uus liik Eesti lihhenoflooras; neli liiki on väga haruldased (*L. caesiosora*, *L. epibryon*, *L. glabrata*, *L. impudens*) ja seitse liiki on üsna või väga tavalised Eestis. Käesolevas töös on esitatud nende liikide määramistabel ja üldine levik Eestis. Tutvustatud on ka liikide määramiseks vajalikke anatoomilisi tunnuseid.

INTRODUCTION

The name "*Lecanora subfusca*" has been used by many authors as a collective name for a group of epiphytic and epilithic species, many of which are widely distributed in the Northern Hemisphere. The combination *Lecanora subfusca* (L.) Ach. was proposed by Acharius in 1810, who divided the species into eight varieties, seven of which were later raised to the specific level. Today the name *L. subfusca* is out of use according to the proposal of Vitikainen & Brodo (1985) to include it in the list of rejected names.

The characteristic features of this group are:

* ellipsoid to broadly ellipsoid ascospores (approximately 10–20 × 6–9 mm),
* apothecial discs are generally reddish brown,
* apothecial margin (amphithecium) contains calcium oxalate crystals,
* thallus and apothecial margin react K + yellow (atranorin),
* thallus is crustose, ± grey (Brodo, 1984; Eigler, 1969).

The aim of this study was to revise the *L. subfusca* group in Estonia. A list of species, data on their distribution and some ecological notes are presented. This study is part of a larger project to compile a new checklist of Estonian lichens. As morphological features in the *L. subfusca* group are very variable and overlapping, it is necessary to study apothecial anatomy while identifying the species. Therefore some aspects of apothecial anatomy (epihymenium and amphithecium types) in this group are briefly discussed following Brodo (1984).

MATERIALS AND METHODS

The study was based on collections in the herbarium materials of the Institute of Botany and Ecology at the University of Tartu (TU); the specimens collected in Estonia and kept in the Universities of Helsinki (H) and Riga (RIG) were also considered. Altogether about 1100 specimens were studied. Additional material for comparison was received from Helsinki (H). Besides the herbarium materials, publications by Bruttan (1870), Mereschkowski (1913), Räsänen (1931), Trass (1967, 1970) were taken into account when composing the list of species.

Cross-sections of apothecia were made by hand and examined by light microscope (MBI - 3). Spot tests were made with 10 % potassium hydroxide (K) and paraphenylenediamine in ethanol (Pd); K and 50 % nitric acid (HNO_3) were used to determine the solubility of epihymenial granules, HNO_3 was used also for hymenial colour tests. The secondary substances were identified using thin-layer chromatography (TLC) described by Culberson & Kristinsson (1970) and Culberson (1972) only in a few occasions – when inevitable for the identification of species (in 31 specimens).

The herbarium data were sorted using the computer program BRAHMS and the program DMAP was used to compose the distribution map in Estonia.

The figures 1 and 2 (from Brodo, 1988, drawn by Susan Laurie-Bourque) are reproduced with permission from the Canadian Museum of Nature, Ottawa, Canada.

The following key books and papers were used to identify the specimens and to compose the key: Brodo (1984), Brodo & Vitikainen (1984), Brodo et al. (1994), Foucard (1990), Poelt & Vêzda (1981), Purvis et al. (1992), Tønsberg (1992), Wirth (1995).

RESULTS AND DISCUSSION

Important apothecial characters in the *Lecanora subfusca* group

The anatomy of the *L. subfusca* group has been studied in detail by different authors (Brodo, 1984; Eigler, 1969; Magnusson, 1932; Poelt, 1952). Several types of apothecia have been described according to the structure of the epihymenium and amphithecium. Hereafter only some of those epihymenium types – occuring in Estonian species - will be discussed.

The epihymenium is the upper layer of the hymenium that is differentiated by pigmentation (within or between the tips of the paraphyses) and granulation (above or between the tips of the paraphyses) (Brodo, 1984).

Epihymenium types (according to Brodo, 1984):

1. ***chlarotera*-type** – epihymenium coarsely granular, granules are on the surface of the hymenium, soluble in KOH and HNO_3; not pigmented or pigmented reddish brown to olivaceous brown (pigmentation disappears in KOH, in dark apothecia epihymenium HNO_3 + reddish) (Fig. 1);
2. ***pulicaris*-type –** epihymenium finely granular (granules are much smaller than in *chlarotera*-type epihymenium), located on the surface of the hymenium and between the tips of paraphyses (up to 20 mm in depth), soluble in KOH but insoluble in HNO_3; pigmented brown to olivaceous brown (pigmentation disappears in KOH, in dark apothecia epihymenium HNO_3 + reddish) (Fig. 1);

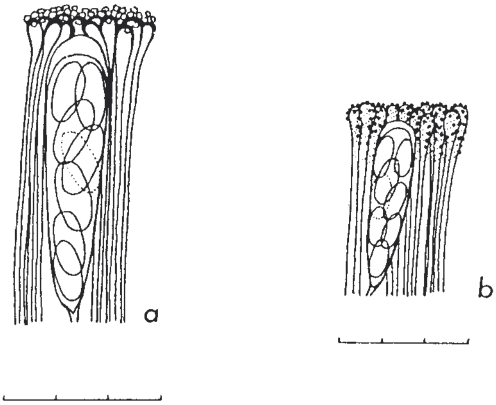


Fig. 1. Epihymenial granules: (a) *chlorotera*-type, (b) *pulicaris*-type in *L. hybocarpa*. Scale: each unit = 10 µm.

3. ***glabrata*-type** – epihymenium not granular or inspersed, pigmented clear reddish brown (pigmentation persists in KOH).

The amphithecium has been considered to be all those tissues external to the hypothecium and hymenium, and includes also the cortex (Brodo, 1984).

Three **amphithecium types** can be distinguished in the group (according to Brodo, 1984):

1. ***pulicaris*-type** – very large, irregular crystals in clumps in amphithecial medulla (Fig. 2);
2. ***campestris*-type** – small, irregular crystals entirely or partially filling amphithecial medulla, not entering the cortex;
3. ***allophana*-type** – small, irregular crystals extending from the medulla into the cortex (Fig. 2).

In some cases the amphithecial crystals may be rather few or even absent, but generally they are abundant. The *pulicaris*-type is usually easily recognized while the differences between the *campestris*- and *allophana*-types are less obvious. Combining the epihymenium and amphithecium types, the species can be divided into groups (Table 1).

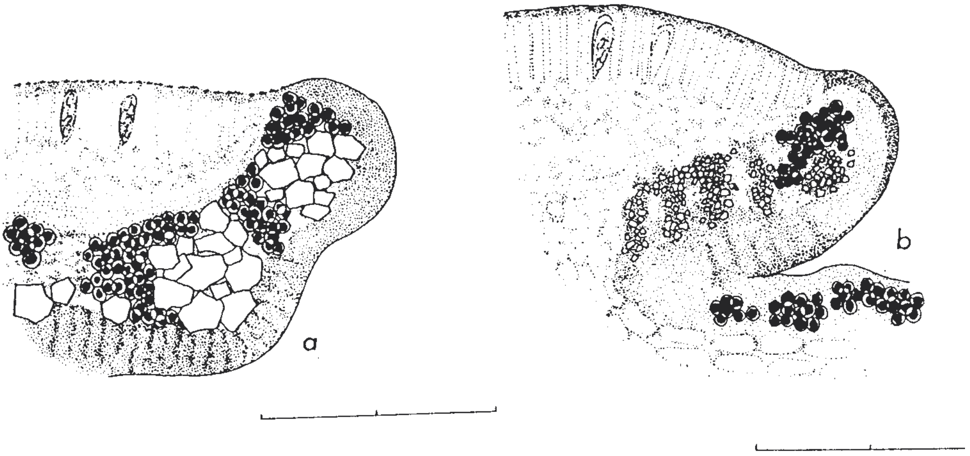


Fig. 2. Amphithecium types:(a) *pulicaris*-type in *L. rugosella*, (b) *allophana*-type in *L. glabrata*. Scale: each unit = 100 μm.

Table 1. The epihymenium and amphithecium types in *L. subfusca* group in Estonia

Epihymenium *glabrata*-t.		Epihym. *chlarotera*-t.	Epihym. *pulicaris*-t.
Amphit. with small crystals (*allophana*- or *campestris*-t. [*])	Amphit. with large crystals (*pulicaris*-t.)	Amphit. with large crystals (*pulicaris*-t.)	Amphit. with large crystals (*pulicaris*-t.)
L. allophana *L. campestris* * *L. epibryon* *L. glabrata* *L. impudens*	*L. argentata*	*L. caesiosora* *L. cenisia* *L . chlarotera* *L. rugosella*	*L. circumborealis* *L. pulicaris*

List of species of the *Lecanora subfusca* group in Estonia

Ten species are present in the contemporary flora, one species (marked with asterisk *) is considered extinct, and one (marked with ?) is doubtful. Only those synonyms in the *Lecanora subfusca* group are listed that are mentioned in the checklist of Estonian lichens by Trass (1970).

Lecanora allophana Nyl. – very widely spread all over the country (more than 200 localities), common in parks in the countryside and also in towns. On deciduous trees (*Acer*, *Fraxinus*, *Populus*, *Tilia*), rarely on wood.

L. allophana f. sorediata Nyl. – rare in Estonia, four specimens from the western, northern and southern parts of Estonia, on *Populus tremula* (TLC: atranorin, terpenoids).

L. argentata (Ach.) Malme (syn. *L. subfuscata* H. Magn., *L. subrugosa* Nyl.) – very common in wooded meadows and deciduous forests in western regions, frequent also in other parts of Estonia. On deciduous trees (*Acer*, *Fraxinus*, *Populus*, *Quercus*, *Sorbus*, *Tilia*), rarely on wood.

L. caesiosora Poelt – very rare, only one locality in western Estonia: Hiiumaa Co., Saarnaki Is., on stone fence, 16 Aug. 1974, leg. E. Sander, det. I. Brodo (TLC 1120-16 by Brodo 1993: atranorin, chloroatranorin, roccellic acid) (TU) (Jüriado, 1997).

L. campestris (Schaer.) Hue – quite frequent in western and northern Estonia, only one specimen has been collected at an inland location (from southern Estonia). On calcareous and siliceous rocks, also on man-made substrata.

L. CENISIA Ach. [syn. *L. atrynea* (Ach.) Nyl.] – quite common on the coast and islands in western and northern Estonia, sparse inland. On siliceous rocks, sometimes also on wood.

L. CHLAROTERA Nyl. – very common all over the country (more than 100 localities), in forests and parks in the countryside and in towns. On deciduous trees, also on wood (14 specimens have been studied by TLC: atranorin, gangaleoidin, ± norgangaleoidin, ± roccellic acid).

L. CIRCUMBOREALIS Brodo & Vitik. – new for Estonia, rare – five localities distributed in different parts of Estonia (Fig. 3).

Specimens examined. 1. Harjumaa Co., near Vasalemma, on *Betula pubescens*, 15 June 1947, leg. E. Parmasto, verified by O. Vitikainen (TLC: atranorin, roccellic acid) (TU). 2. Harjumaa Co., near Maardu, on *Betula* sp, 23 May 1942, leg. J. Seim (TLC: atranorin) (TU). 3. Läänemaa Co., Vormsi Is., Diby, on wood, July 1987, leg. R. Allmäe (TLC: atranorin) (TU). 4. Valgamaa Co., Kääriku, on *Betula pendula*, 27 March 1966, leg. H. Trass (TLC: atranorin, roccellic acid) (TU). 5. Viljandimaa Co., Vihi, on wood, 30 July 1996, leg. I. Jüriado (TLC: atranorin) (TU).

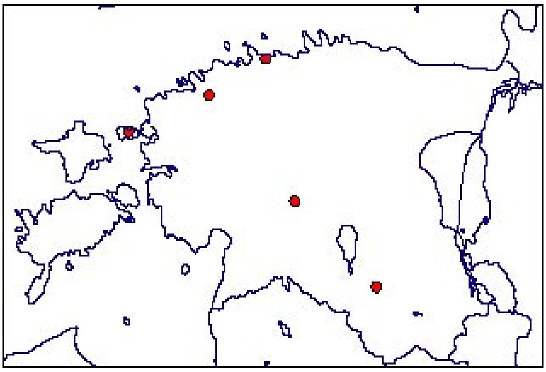


Fig. 3. Distribution of *Lecanora circumborealis* in Estonia.

*L. EPIBRYON (Ach.) Ach. – very rare, only one locality from the last century: Saaremaa Co., Muhu Is. (Moon) (TU), “an der Erde über Mossen” (Bruttan, 1870).

?L. GLABRATA (Ach.) Malme – very rare, one locality; mentioned by Mereschkowski (1913) (Harjumaa Co., Tallinn), the specimen is not available and, therefore, it is not possible to verify the taxon. According to the literature (Santesson, 1993), the species occurs mainly on *Fagus*, which does not occur in Estonia. Today we still include the species in the checklist of Estonian lichens but consider it doubtful.

L. IMPUDENS Degel. – very rare, two localities only: Saaremaa Co., Kuressaare, on *Fraxinus excelsior*, 28 June 1980, leg. & det. T. Rand-lane, verified by G. Thor 1991 (TLC: atranorin) (TU) (Randlane, 1986); Tartumaa Co., Luunja, in humid forest on *Tilia cordata*, 1 Jan. 1949, leg. H. Trass (TLC: atranorin) (TU).

L. PULICARIS (Pers.) Ach. [syn. *L. chlarona* (Ach.) Nyl., *L. coilocarpa* (Ach.) Nyl., *L. pinastri* (Schaer.) H. Magn.] – widespread in all parts of Estonia (more than 200 localities). On coniferous trees (very often on *Pinus sylvestris*), frequently on wood, on deciduous trees (*Alnus incana*, *Betula*, *etc.*).

L. RUGOSELLA Zahlbr. – very common all over the country (more than 100 localities), in forests and parks, in the countryside and in towns. On deciduous trees, also on wood.

Comments on the species’ list of the *Lecanora subfusca* group in Estonia

Lecanora circumborealis is morphologically and anatomically very close to *L. pulicaris* and therefore, it is necessary to use the complex of characteristics to distinguish the two taxa (p. 19); for more information see Brodo (1984) and Brodo & Vitikainen (1984).

L. impudens is morphologically rather similar to *L. allophana* f. *sorediata* but, according to Tønsberg (1992), their terpenoid patterns differ. TLC was carried out on four local specimens and showed that two specimens of *L. im-pudens* contained only atranorin, while two specimens of *L. allophana* f. *sorediata* contained some terpenoids in addition to atranorin.

Lecanora rugosella has been treated as a form or synonym of *L. chlarotera* (Clauzade & Roux, 1985; Poelt, 1952; Wirth, 1995) or also as a distinctive species (Brodo, 1984; Purvis *et al.* 1992; Santesson, 1993; Vitikainen *et al.* 1997). They both have the same epihymenium and amphithecium types (Table 1), and other anatomical and chemical features are also similar. These species have been separated according to their morphology: *L. rugosella* has coarsely verrucose thallus and more thicker and verrucose apothecial margin than *L. chlarotera*. In Estonian herbarium material some specimens of *L. chlarotera* are slightly sorediose, and there are quite a number of specimens with soralia-like heaps among both *L. chlarotera* and *L. rugosella*. Further investigation of those species is needed.

Those specimens, which earlier were determined as *L. subrugosa*, are now considered extreme morphological variants of *L. argentata* caused by the substrate; no anatomical differences between those species could be observed, futhermore, morphological intermediates exist (Lumbsch & Feige, 1996). Morphological intermediate specimens are also present among Estonian herbarium materials, and the distinguishing between these two species was often impossible.

Key to the species of the *Lecanora subfusca* group in Estonia

A Saxicolous

1 Thallus sorediate, soralia pale yellow to yellowish white, usually rounded, slightly convex to hemisphaerical, 1–2 mm in diameter, thallus grey, whitish or yellowish white. Apothecia infrequent .... *L. caesiosora*

– Thallus not sorediate, thallus greyish white to grey, apothecia frequent 2

2 Thallus whitish grey to grey, apothecial discs red-brown to almost black, epruinose, margins smooth and even. Epihymenium *glabrata*-type, amphithecium with small crystals .... *L. campestris*

– Thallus greyish white, apothecial discs varying in color - yellowish brown, greyish brown to almost black, usually lightly pruinose, margins smooth to verrucose. Epihymenium *chlarotera*-type, amphithecium with large crystals .... *L. cenisia*

B Muscicolous

Thallus thick, verrucose, apothecia constricted at the base, crowded, discs red-brown. On moss and dead vegetation .... *L. epibryon*

C Corticolous or lignicolous

1 Thallus sorediate 2

– Thallus not sorediate 3

2 Soralia mostly rounded, flat to convex, discrete or coalescing into larger, continuous patches. Apothecia rare , <1 mm in diameter .... *L. impudens*

– Soralia flat to hemiglobose, usually discrete. Apothecia abundant, larger than 1 mm .... *L. allophana* f. *sorediata*

3 Amphithecium with small crystals (*allophana*-type) 4

– Amphithecium with large crystals (*pulicaris*-type) 5

4 Apothecia large, 1–3 mm diameter, constricted at the base, margin prominent, commonly flexuose. Spores 12–21 × 7–11 mm .... *L. allophana*

– Apothecia small, 0.3–0.6 mm diameter, closely adnate, margin even with disc, finally excluded. Spores 9–13 × 6–8 mm .... *L. glabrata*

5 Epihymenium granular (*pulicaris*- or *chlarotera*-type) 6

– Epihymenium without granules (*glabrata*-type) 10

6 Epihymenium *pulicaris*-type 7

– Epihymenium *chlarotera*-type 8

7 Apothecial disks pale reddish brown to dark brown, thallus and/or only apothecial margin Pd+ red (sometimes Pd-). Apothecial cortex 18–25 mm laterally, expanded to (25) 30–45 (66) mm at the base, spores 11–15 × 7.5–9.5 mm, walls 0.8–1.0 mm .... *L. pulicaris*

– Apothecial discs dark red-brown to black, thallus and apothecial margin Pd+ yellow or Pd-. Apothecial cortex 22–38 mm laterally, expanded to 35–65 (90) mm at the base, spores 13–17.5 × 8–12 mm, walls 1.0–1.2 mm .... *L. circumborealis*

8 Apothecial discs usually dark brown to brown-black, often lightly pruinose, apothecial margins becoming blackish, adjacent to disc. On lignum .... *L. cenisia*
– Apothecial discs pale dull brown, orange- or red-brown, pruinose or not, apothecial margins remain unblackened. On bark, sometimes on lignum 9
9 Thallus coarsely verrucose, apothecia constricted at the base, raised, margin very thick and verrucose, discs often lightly pruinose .... *L. rugosella*
– Thallus smooth to verrucose, apothecia sessile, margin thin or thick, smooth to verrucose, discs usually epruinose .... *L. chlarotera*
10 Thallus thin or thick, rough to verrucose, apothecia broadly attached or constricted at the base, apothecial margin thin or thick, ± smooth, crenulate to verrucose .... *L.argentata*

ACKNOWLEDGEMENTS

The author is very grateful to her supervisors T. Randlane and A. Saag, sincere thanks also to O. Vitikainen and A. Piterans for their help and the opportunities to visit the herbaria in Helsinki and Riga. Dr. I. Brodo is thanked for kindly permitting to reprint the figures of anatomical characters. The stydy was undertaken as part of the project "Composition and analysis of Estonian lichen flora" financed by the Estonian Science Foundation (Grant No. 1297).

REFERENCES

Brodo, I. M. 1984. The North American species of the *Lecanora subfusca* group. *Beih. Nova Hedwigia* 79: 63–185.

Brodo, I. M. 1988. *Lichens of the Ottawa region.* Second Edition. Ottawa Field Naturalist's Club Special Publication 3, Ottawa. 115 pp.

Brodo, I. M., Owe-Larsson, B. & Lumbsch, H. T. 1994. The sorediate, saxicolous species of the *Lecanora subfusca* group. *Nord. J. Bot.* 14: 451–461.

Brodo, I. M. & Vitikainen, O. 1984. The typification of *Lecanora subfusca* (L.) Ach., its varieties, and some of its related taxa published before 1850. *Mycotaxon* 21: 281–298.

Bruttan, A. 1870. Lichen Est-, Liv- und Kurlands. *Arch. Naturk. Liv-, Ehst- u. Kurl.* Zweite Serie 7: 163–326.

Clauzade, G. & Roux, C. 1985. Likenoj de okcidenta Europo. *Bull. Soc. Bot. Centre-Ouest Nouv. s. Num. Spec.* 7: 1–893.

Culberson, C. F. 1972. Improved conditions and new data for the identification of lichen products by a standardized thin-layer chromatographic method. *J. Chromatogr.* 72: 113–125.

Culberson, C. F. & Kristinsson, H. 1970. A standardized method for the identification of lichen products. *J. Chromatogr.* 46: 85–93.

Eigler, G. 1969. Studien zur Gliedrung der Flechtengattung *Lecanora. Diss. Bot.* 4: 1–195.

Foucard, T. 1990. *Svensk skorplavs flora.* Lund. 306 pp.

Jüriado, I. 1997. Epilithic species of the lichen genera *Lecanora*, *Protoparmelia* and *Tephromela* in Estonia. *Folia Cryptog. Estonica* 31: 26–29.

Lumbsch, H. T. & Feige, G. B. 1996. Comments on the exsiccat "Lecanoroid Lichens" III. *Mycotaxon* 58: 259–267.

Magnusson, A. H. 1932. Beiträge zur Systematic der Flechtengruppe *Lecanora subfusca. Meddel. Göteborgs Bot. Trädg.* 7: 65–87.

Mereschkowski, K. 1913. *The checklist of lichens in the Baltic provinces* (in Russian). Kazan.

Poelt, J. 1952. Die *Lecanora subfusca*-Gruppe in Süddeutschland. *Ber. Bayer. Bot. Ges.* 29: 58–69.

Poelt, J. & Vêzda, A. 1981. Bestimmungsschlüssel europäischer Flechten. Erg. II. *Bibl. Lichenol.* 16.

Purvis, O. W., Coppins, B. J., Hawksworth, D. L., James, P. W. & Moore, D. M. (eds.) 1992. *The lichen flora of Great Britain and Ireland.* Natural History Publications, London. 710 pp.

Randlane, T. 1986. New species to the Estonian lichen-flora (in Russian). *Folia Cryptog. Estonica* 21: 8–10.

Räsänen, V. 1931. Die Flechten Estlands. Helsinki, 162 pp.

Santesson, R. 1993. *The lichens and lichenicolous fungi of Sweden and Norway.* SBT-förlaget, Lund. 240 pp.

Tønsberg, T. 1992. The sorediate and isidiate, corticolous, crustose lichens in Norway. *Sommerfeltia* 14: 1–331.

Trass, H. 1967. *Analysis of the lichen-flora of Estonia* (in Russian). Doctoral dissertation. Tartu State University.

Trass, H. 1970. The elements and development of the lichen-flora of Estonia (in Russian). *Pap. Bot.* 9: 5–233.

Vitikainen, O., Ahti, T., Kuusinen, M., Lommi, S. & Ulvinen, T. 1997. Checklist of lichens and allied fungi of Finland. *Norrlinia* 6: 1–123.

Vitikainen, O. & Brodo, I. M. 1985. Proposal to reject *Lichen subfuscus* L. (Lichenized fungi). *Mycotaxon* 34: 533–534.

Wirth, V. 1995. *Flechtenflora.* Ulmer, Stuttgart. 661 pp.

Folia Cryptog. Estonica, Fasc. 32: 21–25 (1998)

A catalogue of *Heterodermia (Physciaceae)*

Syo Kurokawa
1101 Kurose 47, Toyoma 939–8213, Japan

Abstract: All taxa of *Heterodermia* known at present are listed with special reference to the priority of combinations, especially when the same combination was proposed in two or more times. New combinations under *Heterodermia* are proposed for 12 species.

Kokkuvõte: S. Kurokawa. *Heterodermia (Physciaceae)* kataloog.

Loetletud on kõik perekonna *Heterodermia* praegu teada olevad liigid viidetega prioriteetsetele kombinatsioonidele. Uute kombinatsioonidena esitatakse 12 *Heterodermia* liiki.

INTRODUCTION

Since the genus *Heterodermia* Trevis. was resurrected by Poelt (1965), various authors have proposed new combinations under the genus. They are Culberson (1966), Skorepa (1972), Follmann & Rédon (1972), Awasthi (1973), Follmann (1974, 1983), K. P. Singh & S. R. Singh (1976), Swinscow & Krog (1976), Hale (Vêzda, 1976), Dey (1976), Wetmore (1976), K. P. Singh (1979), A. Singh (1980), Weber (1981), Hawksworth (Shaw, 1984), Elix (1985), Wei & Jiang (1986), Weber (Egan, 1987), Wei (1991) and Trass (1992). However, there are some confusions in author citation. For instance, the combination *Heterodermia boryi* was proposed by three different authors in 1976. Although *H. boryi* (Fée) Kr. P. Singh & S. R. Singh is earliest as shown below and keeps the priority, *H. boryi* (Fée) Hale was employed by Park (1990). Even though Trevisan (1861) did not propose such a combination, Aptroot (1987) used *Heterodermia galactophylla* (Tuck.) Trevis. In the present paper, all taxa now considered to belong to *Heterodermia* will be listed, with special reference to the priority of combination under the genus. A number of new species of the genus described by various authors in recent years are also included. In addition, new combinations under *Heterodermia* are proposed for 12 species, which have not yet been transferred to the genus.

The present paper is dedicated to Prof. Dr H. Trass who has been contributing to the taxonomy of lichens, especially to that of the *Physciaceae*.

ENUMERATION OF TAXA

HETERODERMIA ALBICANS (Pers.) Swinscow & Krog, Lichenologist 8: 113. 1976.
  Heterodermia speciosa var. *domingensis* (Ach.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 614. 1868.
  Heterodermia domingensis (Ach.) Trevis., Nuovo Giorn. Bot. Ital. 1: 114. 1869.

HETERODERMIA ALBIDIFLAVA (Kurok.) D. D. Awasthi, Geophytology 3: 113. 1973.

HETERODERMIA ALBOPRUINOSA (Kurok.) Kurok., comb. nov.
  Anaptychia albopruinosa Kurok., Beih. Nova Hedwigia 6: 32. 1962.

HETERODERMIA ALLARDII (Kurok.) Trass, Folia Cryptog. Estonica 29: 6. 1992.

HETERODERMIA ANGUSTILOBA (Müll. Arg.) D. D. Awasthi, Geophytology 3: 113. 1973.

HETERODERMIA ANTILLARUM (Vain.) Swinscow & Krog, Lichenologist 8: 114. 1976.

HETERODERMIA APPALACHENSIS (Kurok.) W. L. Culb., Bryologist 69: 479. 1966.

HETERODERMIA APPENDICULATA (Kurok.) Swinscow & Krog, Lichenologist 8: 114. 1976.

HETERODERMIA ARSENEI (Kurok.) Kurok., comb. nov.
  Anaptychia arsenei Kurok., Beih. Nova Hedwigia 6: 89. 1962.

HETERODERMIA AWASTHII (Kurok.) D. D. Awasthi, Geophytology 3: 113. 1973.

HETERODERMIA BARBIFERA (Nyl.) Kr. P. Singh, Bull. Bot. Survey India 21: 221. 1979.
  Heterodermia barbifera (Nyl.) W. A. Weber, Mycotaxon 13: 101. 1981.
  Heterodermia barbifera (Nyl.) J. C. Wei, Enum. Lich. China 106. 1991.

HETERODERMIA BORYI (Fée) Kr. P. Singh & S. R. Singh, Geophytology 6: 33. 1976 (July 31).

Heterodermia boryi (Fée) Swinscow & Krog, Lichenologist 8: 124. 1976 (October).

Heterodermia boryi (Fée) Hale in Vêzda, Lich. Selecti Exs., Fasc. 57, no. 1421. 1976 (October).

Heterodermia neoleucomelaena (Kurok.) Follmann & Rédon, Willdenowia 6: 446. 1972.

Heterodermia neoleucomelaena f. *circinalis* (Zahlbr.) Follmann & Rédon, Willdenowia 6 : 446. 1972. – *Heterodermia circinalis* (Zahlbr.) W. A. Weber, Mycotaxon 13 : 101. 1981. – *Heterodermia boryi* var. *squarrosa* f. *circinalis* (Zahlbr.) J. C. Wei in Wei & Jiang, Lich. Xizang 110. 1986.

Heterodermia neoleucomelaena (Kurok.) D. D. Awasthi, Geophytology 3: 114. 1973.

Heterodermia neoleucomelaena f. *sorediosa* (Jatta) D. D. Awasthi, Geophytology 3: 114. 1973. – *Heterodermia boryi* var. *squarrosa* f. *sorediosa* (Jatta) J. C. Wei., Enum. Lich. China 107. 1991.

Heterodermia neoleucomelaena f. *soredobullata* (D. D. Awasthi) D. D. Awasthi, Geophytology 3: 114. 1973.

Heterodermia neoleucomelaena f. *squarrosa* (Vain.) D. D. Awasthi, Geophytology 3: 114. 1973. – *Heterodermia boryi* var. *squarrosa* (Vain.) J. C. Wei in Wei & Jiang, Lich. Xizang 110. 1986.

HETERODERMIA CASSARETTIANA (A. Massal.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 624. 1868.

HETERODERMIA CHILENSIS (Kurok.) Swinscow & Krog, Lichenologist 8: 115. 1976.

HETERODERMIA CHONDROIDEA W. A. Weber & D. D. Awasthi, Bryologist 74: 181. 1971.

HETERODERMIA COMOSA (Eschw.) Follmann & Rédon, Willdenowia 6: 446. 1972.

Heterodermia comosa (Eschw.) D. D. Awasthi, Geophytology 3: 113. 1973.

Heterodermia comosa (Eschw.) Follmann & L. I. Ferrago in Follmann, Philippia 5: 118. 1983.

HETERODERMIA CONGOENSIS (Kurok.) Swinscow & Krog, Lichenologist 8: 116. 1976.

HETERODERMIA CORALLOPHORA (Taylor) Skorepa, Bryologist 75: 490. 1972.

Heterodermia hypoleuca var. *dactylina* * *isidiophora* Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 615. 1868.

HETERODERMIA CORONATA (Kurok.) D. D. Awasthi, Geophytology 3: 113. 1973.

HETERODERMIA CROCEA R. C. Harris, Some Florida Lichens 78. 1990.

HETERODERMIA CUBENSIS (Kurok.) Trass, Folia Cryptog. Estonica 29: 10. 1992.

HETERODERMIA CYATHIFORMIS (Kurok.) Kurok., comb. nov.

Anaptychia cyathiformis Kurok., J. Hattori Bot. Lab. 37: 602. 1973.

HETERODERMIA DACTYLIZA (Nyl.) Swinscow & Krog, Lichenlogist 8: 117. 1976.

Heterodermia hypoleuca var. *dactyliza* ("*dactylina*") (Nyl.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 615 1868.

HETERODERMIA DENDRITICA (Pers.) Poelt, Nova Hedwigia 9: 31. 1965.

HETERODERMIA DIADEMATA (Taylor) D. D. Awasthi, Geophytology 3: 113. 1973.

Heterodermia dispensa (Nyl.) Trévis., Atti Soc. Ital. Sci. Nat. Milano 11: 615. 1868.

Heterodermia speciosa var. *cinerascens* (Nyl.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 615. 1868.

Heterodermia diademata f. *brachyloba* (Müll. Arg.) D. D. Awasthi, Geophytology 3: 113. 1973.

HETERODERMIA DISSECTA (Kurok.) D. D. Awasthi, Geophytology 3: 113. 1973.

Heterodermia dissecta var. *koyana* (Kurok.) D. D. Awasthi, Geophytology 3: 113. 1973.

Heterodermia dissecta var. *koyana* (Kurok.) J. C. Wei, Enum. Lich. China 109. 1991.

HETERODERMIA ECHINATA (Taylor) W. L. Culb., Bryologist 69: 481. 1966.

HETERODERMIA ERINACEA (Ach.) W. A. Weber in Egan, Bryologist 90: 163. 1987.

HETERODERMIA FAURIEI (Kurok.) Kurok., comb. nov.

Anaptychia fauriei Kurok., Beih. Nova Hedwigia 6: 83. 1962.

HETERODERMIA FIRMULA (Nyl.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 615. 1868.

HETERODERMIA FLABELLATA (Fée) D. D. Awasthi, Geophytology 3: 113. 1973.

Heterodermia flabellata var. *rottbollii* (Vain.) J. C. Wei, Enum. Lich. China 109. 1991.

HETERODERMIA FLAVOSQUAMOSA Aptroot & Sipman in Sipman, Willdenowia 19: 546. 1990.

HETERODERMIA FOLLMANNII Sipman in Daniels, Schulz & Peine, Flechten Follmann 333. 1995.

HETERODERMIA FRAGILISSIMA (Kurok.) J. C. Wei & Y. M. Jiang, Lich. Xizang 111. 1986.

Heterodermia fragilissima (Kurok.) J. C. Wei, Enum. Lich. China 109. 1991.

Heterodermia fragilissima (Kurok.) Trass, Folia Cryptog. Estonica 29: 12. 1992.

HETERODERMIA GALATOPHYLLA (Tuck.) W. L. Culb., Bryologist 69: 482. 1966.

HETERODERMIA GRANULIFERA (Ach.) W. L. Culb., Bryologist 69: 482. 1966.

*Heterodermia hypoleuca * isidiophora* Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 615. 1868.

HETERODERMIA HIMALAYAENSIS (D. D. Awasthi) D. D. Awasthi, Geophytology 3: 113. 1973.

HETERODERMIA HYPOCAESIA (Yasuda) D. D. Awasthi, Geophytology 3: 113. 1973.

HETERODERMIA HYPOCHRAEA (Vain.) Swinscow & Krog, Lichenologist 8: 119. 1976.

HETERODERMIA HYPOLEUCA (Ach.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 615. 1868.

HETERODERMIA INCANA (Stirt.) D. D. Awasthi, Geophytology 3: 114. 1973.

HETERODERMIA INDICA (H. Magn.) D. D. Awasthi, Geophytology 3: 114. 1973.

HETERODERMIA INTERMEDIA Trass, Folia Cryptog. Estonica 29: 23. 1992.

HETERODERMIA ISIDIOPHORA (Nyl.) D. D. Awasthi, Geophytology 3: 114. 1973.

*Heterodermia speciosa ** isidiophora* (Nyl.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 614. 1868.

Heterodermia speciosa var. *domingensis * isidiophora* (Nyl.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 614 1868.

HETERODERMIA ISIDIOSA (Kurok.) Kurok., comb. nov.

Anaptychia rugulosa var. *isidiosa* Kurok., Beih. Nova Hedwigia 6: 41. 1962.

HETERODERMIA JAPONICA (M. Satô) Swinscow & Krog, Lichenologist 81: 122. 1976.

HETERODERMIA KUROKAWAE Trass, Folia Cryptog. Estonica 29: 14. 1992.

HETERODERMIA LAMELLIGERA (Taylor) Follmann & Rédon, Willdenowia 6: 446. 1972.

Heterodermia lamelligera (Taylor) Trass, Folia Cryptog. Estonica 29: 15. 1992.

HETERODERMIA LEPIDOTA Swinscow & Krog, Lichenologist 8: 122. 1976.

HETERODERMIA LEUCOMELA (L.) Poelt, Nova Hedwigia 9: 31. 1965.

Heterodermia leucomela f. *albociliata* (Nyl.) D. D. Awasthi, Geophytology 3: 114. 1973.

Heterodermia verruculifera (Kurok.) W. A. Weber, Mycotaxon 13 : 102. 1981.

HETERODERMIA LORIFORMIS (Kurok.) Swinscow & Krog, Lichenologist 8: 129. 1976.

HETERODERMIA LUTESCENS (Kurok.) Follmann, Philippia 2: 73. 1974.

HETERODERMIA MAGELLANICA (Zahlbr.) Swinscow & Krog, Lichenologist 8: 130. 1976.

HETERODERMIA MICROPHYLLA (Kurok.) Skorepa, Bryologist 75: 490. 1972.

Heterodermia microphylla (Kurok.) Swinscow & Krog, Lichenologist 8: 132. 1976.

Heterodermia microphylla f. *granulosa* (Kurok.) J. C. Wei, Enum. Lich. China 111. 1991.

HETERODERMIA MULTICILIATA (Kurok.) Follmann & Rédon, Willdenowia 6: 446. 1972.

Heterodermia multiciliata (Kurok.) Trass, Folia Cryptog. Estonica 29: 16. 1992.

HETERODERMIA NAMAQUANA Brusse, Bothalia 22: 183. 1992.

HETERODERMIA OBESA (Pers.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 614. 1868.

Heterodermia obesa var. *caesiocrocata* (Nyl.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 614. 1868.

Heterodermia obesa (Pers.) Trass, Folia Cryptog. Estonica 29: 16. 1992.

HETERODERMIA OBSCURATA (Nyl.) Trevis., Nuovo Giorn. Bot. Ital. 1: 114. 1869.

Heterodermia speciosa var. *obscurata* (Nyl.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 614. 1868.

HETERODERMIA PACIFICA (Kurok.) Kurok., comb. nov.

Anaptychia pacifica Kurok., J. Hattori Bot. Lab. 37: 592. 1973.

HETERODERMIA PALPEBRATA (Taylor) Trass, Folia Cryptog. Estonica 29: 17. 1992.

HETERODERMIA PANDURATA (Kurok.) J. C. Wei, Enum. Lich. China 112. 1991.

Heterodermia pandurata (Kurok.) Trass, Folia Cryptog. Estonica 29: 17. 1992.

HETERODERMIA PAPUANA Aptroot & Sipman, Willdenowia 20: 241. 1991.

HETERODERMIA PELLUCIDA (D. D. Awasthi) D. D. Awasthi, Geophytology 3: 114. 1973.

HETERODERMIA PERUVIANA (Kashiw. & Kurok.) Kurok., comb. nov.

Anaptychia peruviana Kashiw. & Kurok., Bull. Nat. Sci. Museum, Tokyo, ser. B, 16: 154. 1990.

HETERODERMIA PINNATA Sipman in Daniels, Schulz & Peine, Flechten Follmann 330. 1995.

HETERODERMIA PODOCARPA (Bél.) D. D. Awasthi, Geophytology 3: 114. 1973.

HETERODERMIA POLYRHIZA (Kurok.) Kurok., comb. nov.

Anaptychia polyrhiza Kurok., Beih. Nova Hedwigia 6: 32. 1962.

HETERODERMIA PROPAGULIFERA (Vain.) J. P. Dey in Parker & Roane, Distr. Hist. Biota S. Appalachians 4: 403. 1976.

Heterodermia dendritica var. *propagulifera* (Vain.) Poelt, Nova Hedwigia 9: 31. 1965.

Heterodermia dendritica var. *propagulifera* (Vain.) Ajay Singh, Lichenol. Ind. Subcont. 1966–1977. 47. 1980 (nom. illeg., basionym not cited).

HETERODERMIA PSEUDOSPECIOSA (Kurok.) W. L. Culb., Bryologist 69: 484. 1966.

HETERODERMIA PUNCTIFERA (Kurok.) D. D. Awasthi, Geophytology 3: 114. 1973.

HETERODERMIA RUBESCENS (Räsänen) D. D. Awasthi, Geophytology 3: 114. 1973.

HETERODERMIA RUGULOSA (Kurok.) Wetmore, Bryologist 79: 304. 1976.

Heterodermia rugulosa (Kurok.) Trass, Folia Cryptog. Estonica 29: 19. 1992.

HETERODERMIA SITCHENSIS Goward & W. J. Noble in Goward, Bryologist 87: 366. 1984.

HETERODERMIA SPECIOSA (Wulf.) Trevis., Atti Soc. Ital. Sci. Nat. Milano 11: 614. 1868.

HETERODERMIA SPINIGERA (Kurok.) Kurok., comb. nov.

Anaptychia spinigera Kurok., Beih. Nova Hedwigia 6: 66. 1962.

HETERODERMIA SPINULOSA (Kurok.) J. C. Wei, Enum. Lich. China 113. 1991.

Heterodermia spinulosa (Kurok.) Trass, Folia Cryptog. Estonica 29: 20. 1992.

HETERODERMIA SQUAMULOSA (Degel.) W. L. Culb., Bryologist 69: 484. 1966.

HETERODERMIA STELLATA (Vain.) W. A. Weber, Mycotaxon 13: 102. 1981.

HETERODERMIA SUBASCENDENS (Asahina) Trass, Folia Cryptog. Estonica 29: 20. 1992.

Heterodermia subascendens (Asahina) W. L. Culb. in Wei, Enum. Lich. China 113. 1991. (nom. invalid., basionym not cited).

HETERODERMIA SUBCOMOSA (Nyl.) Elix, Lich. Austr. Exs., no. 80. 1985.

Heterodermia subcomosa (Nyl.) Trass, Folia Cryptog. Estonica 29: 20. 1992.

HETERODERMIA SUBISIDIOSA (Kurok.) Kurok., comb. nov.

Anaptychia magellanica var. *pectinata* f. *subisidiosa* Kurok., Beih. Nova Hedwigia 6: 68. 1962.

HETERODERMIA SZECHUANENSIS (J. D. Zhao, L. W. Hsu & Z. M. Sun) J. C. Wei, Enum. Lich. China 113. 1991.

Heterodermia szechuanesis f. *albo-marginata* (J. D. Zhao, L. W. Hsu & Z. M. Sun) J. C. Wei, Enum. Lich. China 113. 1991.

HETERODERMIA TOGASHII (Kurok.) D. D. Awasthi, Geophytology 3: 114. 1973.

HETERODERMIA TRANSLUCENS (Kurok.) D. Hawksw. in Shaw, Microorgan. PNG Res. Bull. 33: 252. 1984.

HETERODERMIA TREMULANS (Müll. Arg.) W. L. Culb., Bryologist 69: 485. 1966.

HETERODERMIA TRICHOPHORA (Kurok.) Trass, Folia Cryptog. Estonica 29: 21. 1992.

HETERODERMIA TRICHOPHOROIDES (Kurok.) Kurok., comb. nov.

Anaptychia trichophoroides Kurok., Beih. Nova Hedwigia 6: 101. 1962.

HETERODERMIA TROPICA (Kurok.) Kurok., comb. nov.

Anaptychia tropica Kurok., Beih. Nova Hedwigia 6: 36. 1962.

HETERODERMIA UNDULATA (J. D. Zhao, L. W. Hsu & Z. M. Sun) J. C. Wei, Enum. Lich. China 113. 1991.

HETERODERMIA USAMBARENSIS (Kurok.) Swinscow & Krog, Lichenologist 8: 137. 1976.

HETERODERMIA VULGARIS (Vain.) Follmann & Rédon, Willdenowia 6: 447. 1972.

HETERODERMIA YUNNANENSIS (J. D. Zhao, L. W. Hsu & Z. M. Sun) J. C. Wei, Enum. Lich. China 113. 1991.

ACKNOWLEDGEMENTS

My sincere appreciation is expressed to Dr. D. D. Awasthi in India, Dr. J. A. Elix of the Australian National University, Dr. R. C. Harris of the New York Botanical Garden, Dr. D. L. Hawksworth of the International Mycological Institute, Kew, Dr. K. P. Singh of the Botanical Survey in India and Dr. D. K. Upreti of the National Botanical Research Institute, Lucknow for their cooperations in providing informations about the literature.

REFERENCES

Aptroot, A. 1987. *Pyxidaceae*. In *Flora of the Guianas*, series E: *Fungi and Lichens* 1(ed. van Rijn, A. R. A.), pp. 1–59. Utrecht.

Awasthi, D. D. 1973. On the species of *Anaptychia* and *Heterodermia* from India and Nepal. *Geophytology* (Lucknow) 3: 113–116.

Culberson, W. L. 1966. Chemistry and taxonomy of the lichen genera *Heterodermia* and *Anaptychia* in the Carolinas. *Bryologist* 69: 472–487.

Dey, J. P. 1976. Phytogeographic relationships of the fruticose and foliose lichens of the Southern Appalachian Mountains. In *The Distributional History of the Biota of the Southern Appalachians.* IV (eds Parker, B. C. & Roane, M. K.), pp. 398–416. Charlottesville.

Egan, R. S. 1987. A fifth checklist of the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. *Bryologist* 90: 77–173.

Elix, J. A. 1985. *Lichenes Australisici Exiccati*, Fasc. 4. Australian Nat. Univ., Canberra.

Follmann, G. 1974. Zur Nomenklatur der Lichenum. I. Ergänzungen und Neukombinationen. *Philippia* 2: 73–74.

Follmann, G. 1983. Schedae ad Lichenes Exiccati Selecti ab Instituto Botanico Universitatis Colo-niensis Editti XX Fasciculus. *Philippia* 5: 111–126.

Follmann, G. & J. Rédon. 1972. Ergänzungen zur Flechtenflora der nordchilenischen Nebeloasen Fray Jorge und Talinay. *Willdenowia* 6: 431–460.

Moberg, J. R. 1990. The lichen genus *Physcia* in Central and South America. *Nord. J. Bot.* 10: 319–342.

Park, Y. S. 1990. The macrolichen flora of South Korea. *Bryologist* 93: 105–160.

Poelt, J. 1965. Zur Systematik der Flechtenfamilie *Physciaceae*. *Nova Hedwigia* 9: 21–32.

Shaw, D. E. 1984. Microorganisms in Papua New Guinea. *Research Bulletin* 33. Port Moresby.

Singh, A. 1980. *Lichenology in Indian Subcontinent* 1966–1977. 112 pp. Economic Botany Inforamtion Service, National Botanical Research Institute, Lucknow.

Singh, Krishna P. 1979. Some new records of lichens from India. *Bull. Bot. Survey India* 21: 221–223.

Singh, Krishna P. & S. R. Singh 1976. Enumeration of macrolichens from Nilgiri Hills, India. *Geophytology* (Lucknow) 6: 27–34.

Skorepa, A. C. 1972. A catalogue of the lichens reported from Tennessee. *Bryologist* 75: 481–500.

Swinscow, T. D. V. & Krog, H. 1976. The genera *Anaptychia* and *Heterodermia* in East Africa. *Lichenologist* 8: 103–138.

Trass, H. 1992. Synopsis of the lichen genus *Heterodermia* (*Ascomycotina, Physciaceae sive Pyxidaceae*). *Folia Cryptog. Estonica* 29: 2–24.

Trevisan, V. G. 1861. Über *Atestia*, eine neue Gattung der Ramalineen aus Mittel-America. *Flora* 44: 49–53.

Vêzda, A. 1976. *Lichenes Selecti Exiccati*, Fasc. 57, Nos 1401–1425. Brno.

Weber, W. A. 1981. *Lichenes Exiccati* distributed by the University Colorado Museum, Boulder, Fascicle 1–15, Nos. 1–600, 1961–1074. *Mycotaxon* 13: 85–104.

Wei, J. C. 1991. *An Enumeration of Lichens in China.* 278 pp. Intern. Academic Pr., Bejing.

Wei, J. C. & Y. M. Jiang 1986. *Lichens Xizang.* 130 pp. Science Pr., Bejing.

Wetmore, C. M. 1976. Macrolichens of Big Bend National Park, Texas. *Bryologist* 70: 296–313.

Folia Cryptog. Estonica, Fasc. 32: 27–35 (1998)

Problems related to the marine lobate and subfruticose species of *Caloplaca*

E. Ingvar Kärnefelt
The Botanical Museum, Lund University, Östra Vallgatan 18, S-223 61 Lund, Sweden

Abstract: 25 lobate and subfruticose species of *Caloplaca* occurring mainly on coastal rocks are discussed. This special group of lichens is relatively well-known from western Europe and North America. However, for other parts of the world with suitable environmental conditions such as in Australia, southern Africa and South America, there are still large gaps of information on this basically ecologically delimited group of lichens.

Kokkuvõte: E. I. Kärnefelt. Mariinsete hõlmiste ja poolpõõsasjate kuldsamblike (*Caloplaca*) liikidega seotud probleemid.

Käsitletakse 25 hõlmadega või poolpõõsasja tallusega kuldsambliku (*Caloplaca*) liiki, mis levivad peamiselt rannakaljudel. Need samblikud on Lääne-Euroopas ja Põhja-Ameerikas üsna hästi uuritud. Teistest piirkondadest – Austraaliast, Lõuna-Aafrikast ja Lõuna-Ameerikast – on selle ökoloogiliselt hästi piiritletud samblike rühma kohta veel vähe teada.

INTRODUCTION

The supergenus *Caloplaca* (Fr.) Th. Fr. comprises a large diversity of presumably near 1100 species, and can partly be divided in more or less distinctive species groups (Kärnefelt, 1989; Poelt & Hinteregger, 1993; Wetmore & Kärnefelt, 1998). It is under discussion whether some of these groups could represent genera or not (Kärnefelt, 1989; Poelt & Pelleter, 1984). This is also a matter of principles and different generic concepts (Kärnefelt, 1991; Nimis, 1997). Here, I guess we will always have to deal with personal views related to what value one could assign to important characters, in addition to general knowledge of the diversity and variation in a certain group.

In the relatively new Estonian macrolichen flora by Trass & Randlane (1994) several placodioid groups were included. One of these groups was *Caloplaca* sect. *Gasparrinia* comprising 11 species, of which *C. marina, C. microthallina, C. scopularis, C. thallincola* and *C. verruculifera* were treated, all well-known from western Europe occurring in the spray zone on coastal rocks (Nordin, 1972; Purvis et al., 1992). Coastal rocks in mainly temperate and subtropical regions are fairly richly colonized by lichens of the *Teloschistaceae*, particularly of the genus *Caloplaca* but also *Teloschistes* and *Xanthoria.* Presumably the combination of several factors, involving nutrient rich sites, exposure and competition, have made this group of lichens successful in coastal situations throughout the world.

Is *Caloplaca* section *Gasparrinia* worth being recognized taxonomically at generic level, or is it just one of these names which has been mentioned in floras from time to time? An answer like ”usually the *Gasparriniae* can be easily recognized” shows some weak points. Seen from the character (1) ”lobed or with distinctive marginal lobes”, there are species which will be difficult to place within a possible genus. The other important characters defining a possible genus *Gasparrinia* are (2) ”anthraquinone pigmented lobes” and (3) ”cortical layers with more or less distinctive paraplectenchymatous hyphae” (Wetmore & Kärnefelt, 1998). However, there are species within the grey or black species group which are both lobed and lack anthraquinones. Most of the yellow and lobed species have distinctive paraplectenchymatous cortical layers, but there are also species in this group with different cortical structures.

The aim of this paper, in connection with other projects in the genus *Caloplaca* (Wetmore & Kärnefelt, 1998), is the present an overview, worldwide, of these species.

DISCUSSION

The lobate species of *Caloplaca* occurring on coastal rocks have been fairly well investigated in western Europe (James, 1962; Nordin, 1972; Purvis et al., 1992) and recently also in North America (Arup, 1995b). In other parts of the World, however, the knowledge of this group is much less well documented. The most spectacular maritime belt dominated by *Teloschistaceae* is generally found on the western parts of the continents, mainly in temperate but also in subtropical regions, where the species encounter the large ocean waters.

List of marine lobate and subfruticose species discussed

C. BONAE-SPEI Almb. & Poelt
C. BRATTEI Weber
C. CORALLOIDES (Tuck.) Hult.
C. CRIBROSA (Hue) Zahlbr.
C. EUDOXA (Müll. Arg.) Zahlbr.
C. FRAGILLIMA Wern.
C. GOMERANA J. Steiner
C. IGNEA Arup
C. IMPOLITA Arup
C. ISIDIOCLADA Zahlbr.
C. ISIDIOSA (Vain.) Zahlbr.
C. LITTOREA Tav.
C. LUCENS (Nyl.) Zahlbr.
C. MARINA (Wedd.) Zahlbr.
C. MAURITANICA Wern.
C. MICROTHALLINA (Wedd.) Zahlbr.
C. ORA Poelt & Nimis
C. ORTHOCLADA Zahlbr.
C. REGALIS (Vain.) Zahlbr.
C. ROSEI Hasse
C. SCOPULARIS (Nyl.) Lett.
C. SUBLOBULATA (Nyl.) Zahlbr.
C. THALLINCOLA (Wedd.) Du Rietz
C. THAMNODES Poelt
C. VERRUCULIFERA (Vain.) Zahlbr.

The Arctic and adjacent regions

Coastal rocks, particularily in the arctic and adjacent regions, are rarely colonized by a rich lichen cover. This is probably associated to the harsh environmental conditions during the long winter season. In King Karls Land in eastern Svalbard, where I spent the summer of 1980, I did not observe any marine *Teloschistaceae* at all, apart from scattered *Xanthoria elegans* .

Extensive field work has been carried out especially in Greenland within the Arctic region. However, Hansen et al. (1987) only recorded *C. scopularis* and *C. verruculifera* from coastal rocks.

Western Europe

The most frequent species along the sea coast in western Europe is probably *C. marina,* an exclusively littoral species, well adapted to its habitat and with rather limited morphological variation. *Caloplaca marina* varies, however, in the development of the marginal lobes and it has been discussed whether it should be treated among the lobate species or not (Arup, 1992; Wetmore & Kärnefelt, 1998). *Caloplaca littorea*, known from the British Isles and the southern part of the European coast line, characterized by small isidia and with less well developed marginal lobes, is presumably closely related with *C. marina* (Kärnefelt, 1990b; Purvis et al., 1992). Nordin (1972) treated *C. microthallina* in the *Gasparrinae*. This species, characterized by a rather small thallus composed of squamulose lobules, is probably more closely related to the *C. squamosa* group (Wetmore & Kärnefelt, 1998).

Three other species with marginal lobes are rather widespread along the European sea coast, i.e. *C. scopularis, C. thallincola* and *C. verruculifera. Caloplaca scopularis* is the smallest of these species, characterized by lobes with normal paraplectenchymatous layers and polarilocular spores. *Caloplaca thallincola* is usually much larger, with distinctly effigurated lobes. The citriform shape of the ascospores, however, suggests that this species is more closely related to two mainly inland species, *C. aurantia* and *C. flavescens. Caloplaca verruculifera* is unique in having verruciform or globular isidia covering the lobes (Kärnefelt, 1990b). The cortex also differs in the presence of more conglutinated or prosoplectenchymatous hyphae. Presumably, *C. verruculifera* is most closely related to *C. granulosa,* which can also occur at much higher altitudes (Nimis, 1993; Poelt & Romauch, 1977). Seen particularly on the cortical structure and general habitat ecology *C. verruculifera* could also show affinities with *C. gomerana* from the Mediterranean region, and furthermore with *C. lucens* and *C. orthoclada* from South America.

The Mediterranean region and northern Africa

This region seems in general to be poor in lobate species occurring on coastal rocks. In the first place this might be related to the warmer climatic conditions and to warmer water.

Among the species discussed so far, *C. thallincola* occurs extremely rarely from coastal rocks in the Mediterranean region (Nimis & Poelt, 1987; Nimis, 1993). This beautiful species is otherwise more widespread in the southern parts of western Europe and in the British Isles, where it prefers calcareous rocks. The most closely related species, *C. aurantia* and *C. flavescens,* are both relatively widespread in the Mediterranean region also in coastal situations (Clauzade & Roux, 1985; Ozenda & Clauzade, 1970).

Among the species known from coastal rocks in the Mediterranean region there are entities within the *C. marina* group, which, as mentioned before, not really belong to the lobate species. *Caloplaca ora* was separated from *C. marina* on the generally smaller thallus with thinner lobes, spores, and paraphyses (Nimis & Poelt, 1987). It is obviously widespread in the Mediterranean region. *Caloplaca littorea* was listed by Nimis from Sardinia, where it is, however, very rare (1993).

Another beautiful species, *C. gomerana* or until recently referred to as *C. gloriae,* known from the eastern Iberian Peninsula and from north-western Africa and Macaronesia (Hafellner, 1995), is not a strictly littoral species, occurring mainly near the coast up to 250 m altitudes. *Caloplaca gomerana* is unique in its laminal pseudocyphellae and a special type of cortical layers (Llimona & Werner, 1975). Similar pseudocyphellae are occasionally developed in *C. verruculifera*, to which this species is probably related (Arup, 1994).

Eastern North America

The marine species of *Caloplaca* occurring on sea shore rocks in North America were treated by Arup (1995b). Five species, of which at least two have distinct marginal lobes, i.e. *C. scopularis* and *C. verruculifera* were recorded for eastern North America (Arup, 1994). Many plant groups, and biota in general, distributed in western Europe, occur in corresponding habitats in eastern North America, which is linked both by pre-Pleistocene history and reinvasion of biota after Pleistocene glaciations (Hultén, 1963; Kärnefelt, 1979). Of the two species mentioned, however, *C. verruculifera* also occurs on the North American west coast.

Arup (1994) also treated the squamulose *C. microthallina* from both the eastern and western coasts.

Western North America

Arup (1992, 1995a) treated several different species of *Caloplaca* occurring on coastal rocks in western North America. Among these, however, only three belong to the lobate group. One of them is *C. brattiae*, a strictly littoral species occurring in the lowest belt along the Californian coast line (Arup, 1995a). It is presumably closest to *C. scopularis*. These two species actually behave as vicarious taxa, having only minor differences in spore size, quantity of apothecia and structure of lobe tips. *Caloplaca scopularis* only occurs on sea shore rocks on the north American east coast and *C. brattiae* on the west coast. *Caloplaca brattiae* differs from *C. verruculifera*, which occurs further north, in the structure of the cortical layer.

Two other species, *C. ignea* and *C. impolita,* confined to the coast line, have distinctive marginal lobes (Arup, 1995a). *Caloplaca ignea,* characterized by bright orange to reddish lobes and the central portions covered with apothecia, is not a strictly littoral species and may occur as high up as to 500 m. This species is probably most closely related the *C. saxicola* group. *Caloplaca impolita*, which has much broader and flatter marginal lobes, may also occur at slightly higher altitudes and not only on the shore. Both species are mainly distributed along the southwestern coast from central California to Baja California (Arup, 1995a; Wetmore & Kärnefelt, 1998).

Arup (1992) also reported *C. marina* from the North American west coast. *Caloplaca rosei*, which occurs within the same range as *C. marina*, has less well developed marginal lobes and a more continuously areolated thallus.

The most unusual species occurring on coastal rocks in western North America, however, is *C. coralloides* (Arup, 1995a; Poelt & Pelleter, 1984; Wetmore & Kärnefelt, 1998). This is a strictly littoral species, known from Oregon to Baja California and characterized mainly by a subfruticose thallus consisting of yellowish coralloid lobes (Poelt & Pelleter, 1984). A slightly different species, *C. thamnodes*, with broader and more dark orange, coralloid lobes and scattered pseudocyphellae, occurs further south in the northern coast of Baja California, where both species may occur in the same habitat on rather exposed coastal rocks. Otherwise these species do not differ much in anatomical features, both being characterized by rather massive prosoplectenchymatous cortical layers and by the typical subfruticose shape of the thallus. It is remarkable that a similar pair of species, *C. bonae-spei* and *C. eudoxa*, has developed under similar environmental conditions along the Atlantic coast in Southern Africa (Kärnefelt, 1991).

Eastern Asia

The lichen flora in the eastern asiatic region has not been well investigated, perhaps with the exception of Japan. There are also relatively few duplicate collections of maritime species of *Caloplaca* distributed in European and North American herbaria.

There seem to be rather few lobate marine species in *Caloplaca* from this region. *Caloplaca scopularis* seems to be one of the most common species, at least reported from Japan (Yoshimura, 1987). This species dominates the coastal rocks I studied in Petrov Island in Primorye, Russia in 1991. Presumably, *C. brattiae* could also occur in this region, which is much more probable than the occurrence of *C. scopularis* judging from their biogeographical patterns. There are many examples of Amphi-Beringian plants which have wide distributions in western North America, over the Aleutains, down to Kamtchatka and the Far East region (Kärnefelt, 1979). *Caloplaca scopularis* does not match this pattern at all, belonging to an eastern North American and Amphi-Atlantic element.

Caloplaca marina probably occurs rarely in the far eastern region seen from my own collections from Japan and Primorye.

Australasia and New Zealand

There are several, strictly littoral species of *Caloplaca* in Australia. Some of them are still undescribed and the whole genus is currently being treated for the Flora of Australia project. Among the littoral species, however, only a few have marginal lobes, the most conspicuous being *C. sublobulata.* This species, which originally was described from southernmost South America, has been slightly misunderstood due to its broad morphological variation (Kärnefelt, 1988; Santesson, 1944). During my fieldwork in Australia in October–November 1997, I observed large populations of *C. sublobulata* both from coastal rocks in Western Australia and from Victoria in southeasternmost Australia (Fig. 1). I have seen material of this distinctive species also from New Zealand. Among the other littoral species, I also recorded a few small populations of *C. marina* on coastal rocks in Victoria.

Caloplaca cribrosa occasionally occurs on coastal rocks in Tasmania and New Zealand (Poelt & Pelleter, 1984). This species is characterized by rather coarse lobes with distinct pseudocyphellae which occasionally are also slightly raised like in the other subfruticose species (Fig. 2). It is strange that this species does not seem to occur on the Australian mainland such as in the SW region or along the southern coast. Furthermore, *Caloplaca cribrosa* does not form a biogeographical pair similar with the related species occurring in SW North America and in SW Africa. *Caloplaca cribrosa* is more likely to be associated with *C. regalis* in the Western Hemisphere. The anatomical characters in the cortical layers are otherwise the same in this species and in the American and African ones known (Fig. 3).

Africa

Apart from various local floristic works, Africa is still a lichenologically very much underinvesitgated continent. I have seen almost no records of littoral species of *Caloplaca* from the large tropical regions north of the southern African states. In South Africa *C. sublobulata* has been recorded from coastal rocks along with a closely related isidiate species *C. isidiosa* (Kärnefelt, 1990a, b). *Caloplaca marina* also occurs scattered in the same region.

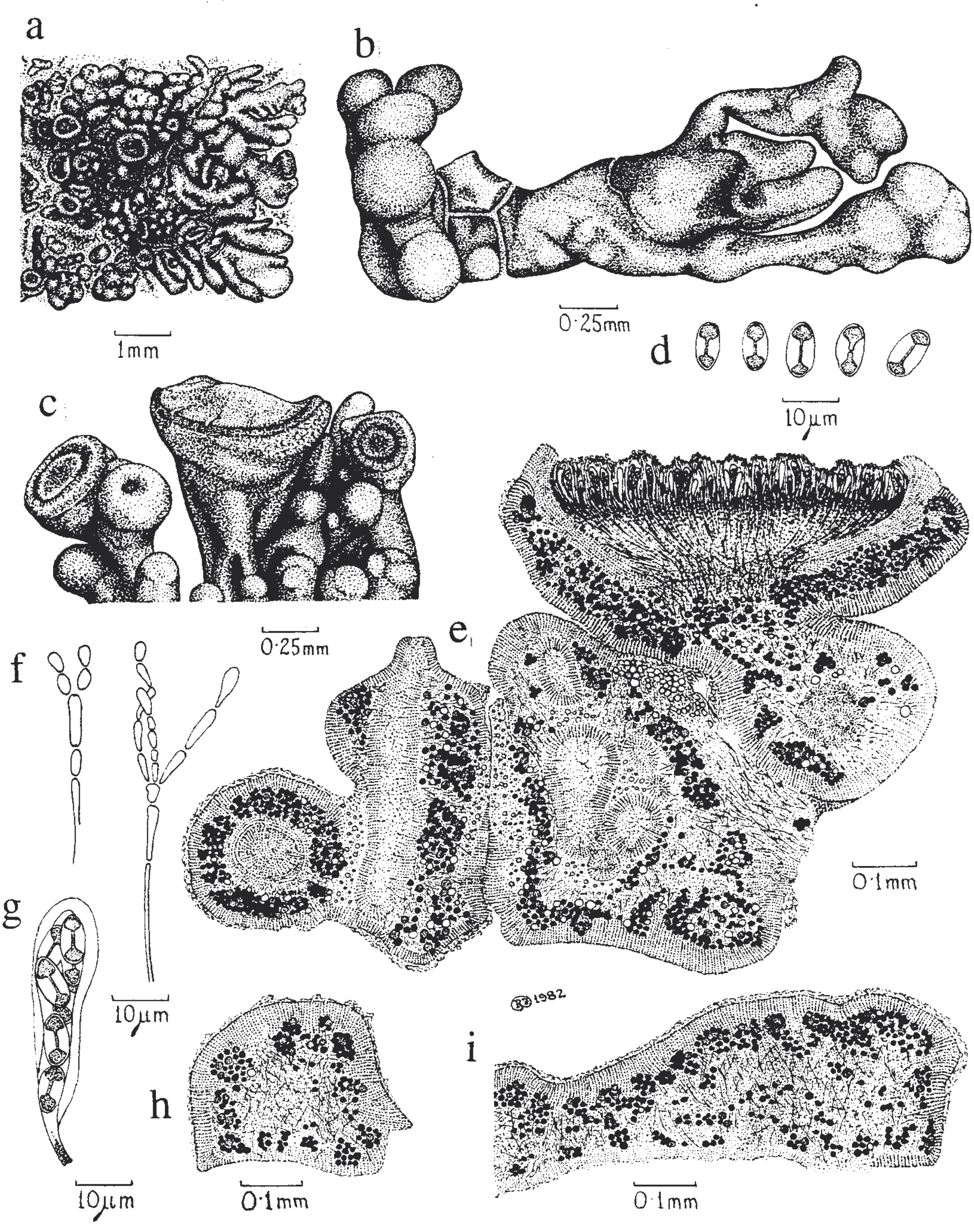


Fig. 1. *Caloplaca sublobulata* . a. Habitus, b. details of lobes, c. apothecia, d. ascospores, e. cross section of thallus portion with apothecium, f. paraphyses, g. ascus, h. cross section of lobe, i. longitudinal section of lobe (MEL 1031729) (drawing by Rex Filson).

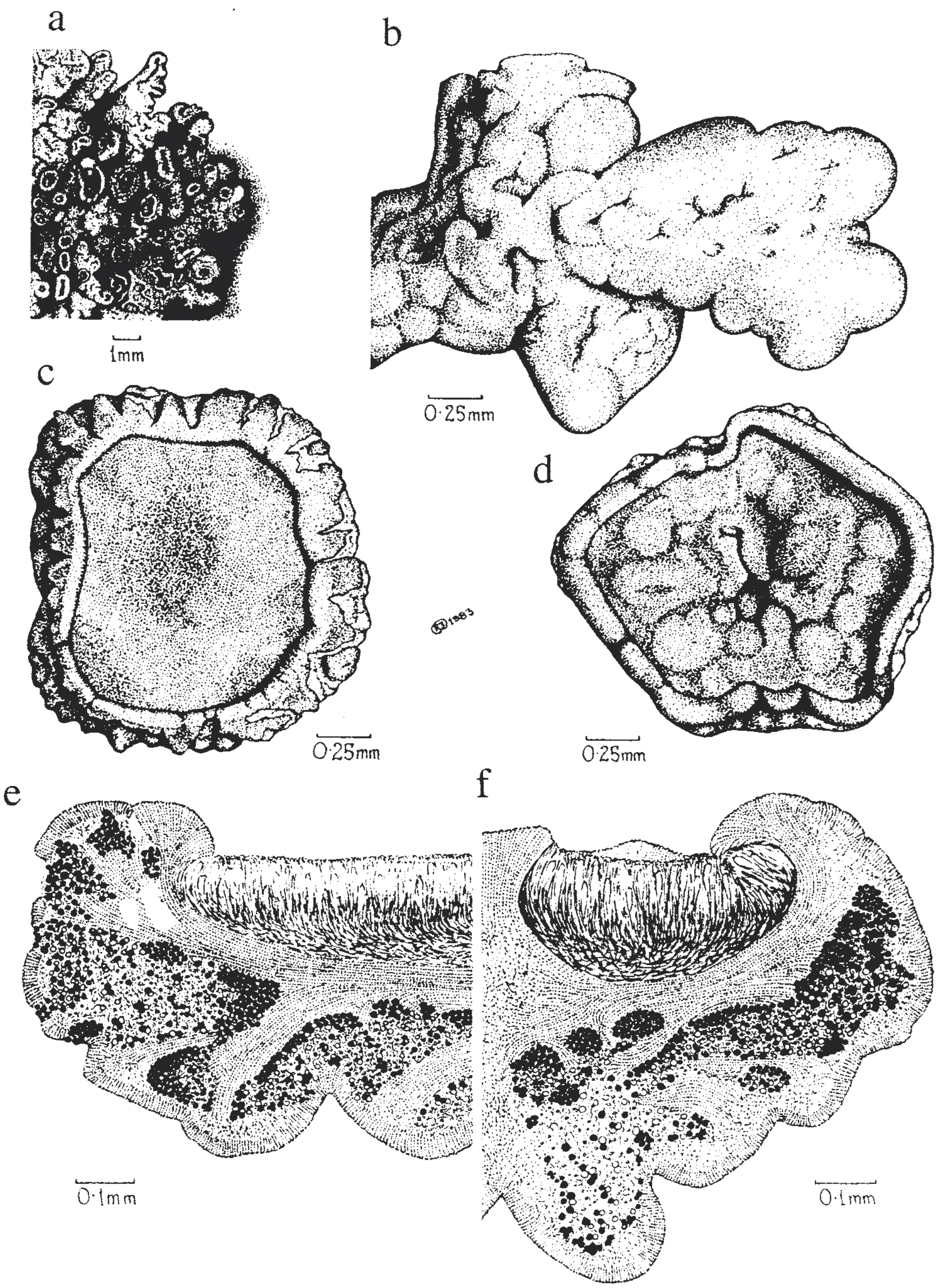


Fig. 2. *Caloplaca cribrosa*. a. Habitus, b. details of lobe (MEL 1000439), c. apothecium, e. cross secion of apothecium (MEL 1012612), d. apothecium with pseudocyphellate margin, f. cross section (MEL 1000439) (drawing by Rex Filson).

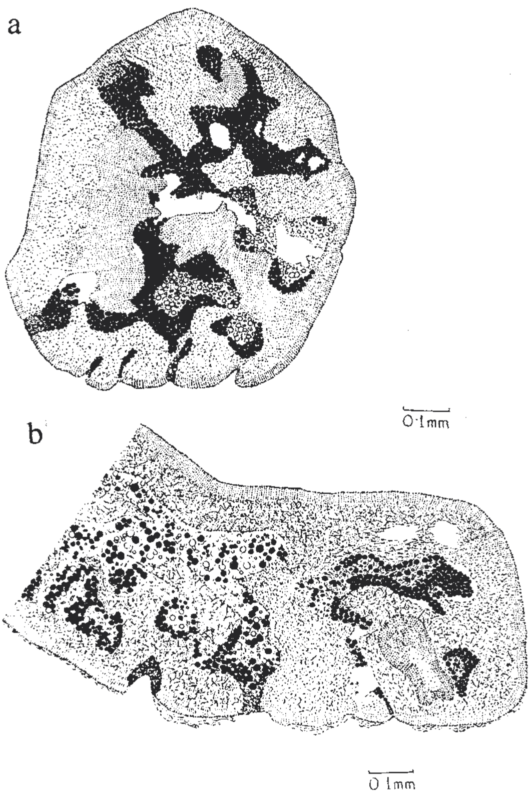


Fig. 3. *Caloplaca cribrosa.* a. Cross section, b. longitudinal section (MEL 1000439) (drawing by Rex Filson).

Two of the unique subfruticose species occur within the western part of southern Africa on coastal rocks, *C. bonae-spei* from the southernmost part, and the closely related *C. eudoxa* further north from central Namibia to southern Angola (Kärnefelt, 1991; Poelt & Pelleter, 1984). *Caloplaca bonae-spei* is a strictly littoral species, often occurring within populations of *C. isidiosa* and *C. sublobulata*, while *C. eudoxa* can occur also in the inland. Much further north in Mauritania, a third species *C. mauritanica* has been recognized within this remarkable group of lichens. I have not seen any material from the only known locality, situated more inland and not really littoral. But I would guess that *C. mauritanica* is extremely close to, or even identical with, *C. eudoxa.* The whole subfruticose group preferably seems to be littoral in its ecological approach, or at least coastal. If any, this group of seven species, characterized by a combination of anatomical and morphological characters and habitat selection, should be separated at generic level (Figs 2, 3).

The Antarctica and adjacent regions

Søchting & Øvstedal (1991) made a survey of the genus in the Western Antarctic region. In spite of the limited open land available and of the many scientific expeditions, the lichen flora of this region is still very poorly known. Fourteen *Caloplaca* species were recorded altogether, but only a few of them develop distinctive marginal lobes and occur on coastal rocks, i.e. *C. isidioclada, C. lucens, C. sublobulata* and *C. regalis.* Of these species *C. isidioclada, C. lucens* and *C. sublobulata* have all more or less distinctive marginal lobes, while *C. regalis* belongs to the group of subfruticose species. *Caloplaca isidioclada* is mainly characterized by lobes partly being covered by finger-like to coralloid isidia and cortical layers composed of paraplectenchymatous cells (Søchting & Øvstedal, 1992). Its relation to *C. isidiosa* (Vain.) Zahlbr. is unclear, and type material has to be examined.

The identity of *C. lucens* is still somewhat unclear. The material referred to by Søchting & Øvstedal (1992) is saxicolous, while the type from Kerguelen Island was based on lignicolous material (Santesson, 1944). This species, furthermore, is probably not very closely related to the other marginally lobed species, apart from *C. gomerana, C. verruculifera* and the inland species *C. trachyphylla* (Hansen et al., 1987; Wetmore & Kärnefelt, 1998). *Caloplaca lucens* and the other species have more or less rough convex lobes with isidia or papillae, tiny or distinct pseudocypheallae and prosoplectenchymatous cortical layers.

Caloplaca regalis belongs to the group of subfruticose taxa (Poelt & Pelleter, 1984). It differs slightly from the pairs *C. bonae-spei/C. eudoxa* and *C. coralloides/C. thamnodes* in the presence of more horizontally directed marginal lobes and thin paraplectenchymatous external cortical layers. Furthermore *C. regalis* does not seem to be strictly littoral, but it is more general coastal, occurring higher up to several hundred meters above sea level. *Caloplaca ambitiosa,* which was described from the subantarctic islands, has shown to fall within the variation of *C. regalis* (Søchting & Øvstedal, 1992).

South America

South America is a large continent with a very long coastal line and, similarily to Africa and Australia, with a relatively little known lichen flora. Apart from a few special treatments, e.g. by Malme (1926) on the *Teloschistaceae*, only larger coastal species of *Caloplaca* have been mentioned (Grassi, 1952; Santesson, 1944). Among the species already discussed *C. isidiosa* is known from scattered localities in Brasil and in the Galapagos Islands (Kärnefelt, 1988, 1990a, b).

Other littoral lobate species known are *C. sublobulata,* mainly from southernmost South America (Kärnefelt, 1988; Santesson, 1944). From Chile I have seen material of a species named *C. orthoclada*, which in some ways reminds of *C. lucens* with distinctly effigurated marginal lobes. The surface of the lobes, however, is not rough as in *C. lucens,* but the cortical layer composed of prosoplectenchymatous layers is, of the same structure. Type materials must be more carefully examined in these taxa in order to settle possible affinities.

Among the subfruticose species, *C. regalis* is known from coastal situations in southernmost South America including the Falkland Islands. Further north along the Chilean coast near Valparaiso, another species, *C. fragillima,* has been recognized, growing on coastal rocks (Poelt & Pelleter, 1984). *Caloplaca fragillima*, known only from the type locality, is presumably very closely related to *C. coralloides* or even identical with this species. Much more field work should be carried out along the great Pacific coastline, and also along the Atlantic coast in South America which probably will reveal very interesting material for phytogeographical discussions and theories on evolution and affinities especially among Southern Hemisphere entities.

ACKNOWLEDGMENTS

I wish to thank Drs Lars Fröberg, Pier Luigi Nimis and Arne Thell for valuable comments and suggestions for improvement of the text. I also wish to thank Dr Cliff Wetmore, St Paul for company during the field work in Australia and Magn. Bergvalls Stiftelse for financial support. Dr Rex Filson, Boral, N.S.W., is greatly thanked for providing me with his research material on the genus from Australia including the illustrations.

REFERENCES

Arup, U. 1992. *Caloplaca marina* and *C. rosei*, two difficult species in North America. *Bryologist* 95: 148–160.

Arup, U. 1994. The genus *Caloplaca* on seashore rocks in eastern North America. *Bryologist* 97: 377–392.

Arup, U. 1995a. Eight species of *Caloplaca* in coastal western North America. *Bryologist* 98:92–111.

Arup, U. 1995b. Littoral species of *Caloplaca* in North America: A summary and a key. *Bryologist* 98: 129–140.

Clauzade, G. & Roux, C. 1985. Likenoj de okcidenta Europo. *Bull. Soc. Bot. Centre-Ouest Nouv. s. Num. Spec.* 7: 1–893.

Grassi, M. M. 1952. Contribución al catálogo de liquenes Argentinos, I. *Lilloa* 24: 5–294.

Hafellner, J. 1995. A new checklist of lichens and lichenicolous fungi of insular Laurimacaronesia including a lichenological bibliography for the area. *Fritschiana* 5: 1–132.

Hansen, E. S., Poelt, J. & Søchting, U. 1987. Die Flechtengattung *Caloplaca* in Grönland. *Meddelelser om Gronland, Bioscience* 25:1–52.

Hultén, E. 1963. Phytogeographical connections of the North Atlantic. In *North Atlantic Biota and their history* (eds Löve, A. & Löve, D.), pp. 45–72. Oxford, London, New York & Paris.

James, P. W. 1962. Angiocarpous lichens in the British Isles: 2. *Lichenologist* 2: 86–94.

Kärnefelt, I. 1979. The brown fruticose species of *Cetraria. Opera Botanica* 46: 1–150.

Kärnefelt, I. 1988. Morphology and biogeography of saxicolous *Caloplaca* in southern Africa. *Monographs in Systematic Botany. Missouri Botanical Garden* 25: 51–56.

Kärnefelt, E. I. 1989. Morphology and phylogeny in the Teloschistales. *Cryptogamic Botany* 1: 147–203.

Kärnefelt, E. I. 1990a. Evidence of a slow evolutionary change in the speciation of lichens. *Bibl. Lichenol.* 38: 291–306.

Kärnefelt, E. I. 1990b. Isidiate taxa in the Teloschistales and their ecological and evolutionary significance. *Lichenologist* 22 (3): 307–320.

Kärnefelt, E. I. 1991. Evolutionary rates in the Teloschistaceae. In *Systematics, ecology, and conservation of tropical lichens* (ed. Galloway, D. J.) *The Systematics Association Special Volume* 43: 105–121.

Llimona, X. & Werner, R. G. 1975. Quelques lichens nouveaux ou intéressants de la Sierra de Gata (Almeria, SE de l'Espagne). *Acta Phytotaxonomica Barcinonensia* 16: 1–32.

Malme, G. O. A. 1926. Lichenes blasteniospori Herbarii Regnelliani. *Arkiv för Botanik* 20 A, 9: 1–51.

Nimis, P. 1993. The lichens of Italy. Museo Regionale di Scienze Naturali Torino, Monografia 12, 897 pp.

Nimis, P. L. 1997. Topic: Genus concepts in lichenology. *International Lichenological Newsletter* 30, 1:15–16.

Nimis, P. L. & Poelt, J. 1987. The lichens and lichenicolous fungi of Sardinia (Italy), and annotated list. *Studia Geobotanica* 7, Suppl. 1: 1–269.

Nordin, I. 1972. *Caloplaca, sect. Gasparrinia i Nordeuropa. Taxonomiska och ekologiska studier.* Uppsala. 184 pp.

Ozenda, P. & Clauzade, G. 1970. *Les Lichens, Étude biologique et flore illustrée.* Masson, Paris. 801 pp.

Poelt, J. & Hinteregger, E. 1993. Beiträge zur Kenntnis der Flechtenflora des Himalayas. VII Die Gattungen *Caloplaca*, *Fulgenisa* und *Ioplaca* (mit Bestimmungsschlüssel). *Bibl. Lichenol.* 50: 1–247.

Poelt, J. & Pelleter, U. 1984. Zwergstrauchige Arten der Flechtengattung *Caloplaca. Plant Systematics and Evolution* 148: 51–88.

Poelt, J. & Romauch, E. 1977. Die Lagerstrukturen placoidaler Küsten- und Inlandflechten. In *Beiträge zur Biologie der niederen Pflanzen* (eds Frey, W., Hurka, H. & Oberwinkler, F.), pp. 141–153. Jena, Gustav Fischer-Verlag.

Purvis, O., Coppins, B., Hawksworth, D., James, P. & Moore, D. 1992. *The Lichen Flora of Great Britain and Ireland.* London. ix + 710 pp.

Santesson, R. 1944. Contributions to the lichen flora of South America. *Arkiv för Botanik* 31 A, 7: 1–28.

Søchting, U. & Øvstedal, D. O. 1992. Contributions to the *Caloplaca* flora of the western Antarctic region. *Nordic Journal of Botany* 12, 1: 121–134.

Trass, H. & Randlane, T. (eds) 1994. *Eesti suursamblikud.* Tartu. 399 pp.

Wetmore, C. & Kärnefelt, E. I. 1998. The lobate and subfruticose species of *Caloplaca* in North America and Central America. *Bryologist* (in press).

Yoshimura, I. 1987. Lichen flora of Japan in color. Higashi-ku, Osaka. 349 pp.

Folia Cryptog. Estonica, Fasc. 32: 37–42 (1998)

Bioindication of air quality by lichens in a small town Viljandi in southern Estonia

Siiri Liiv & Enel Sander
Tallinn Botanic Garden, 52 Kloostrimetsa Rd., EE0019 Tallinn, Estonia

Abstract: Air quality was estimated in Viljandi in 1987, 1991 and 1997 by the method of mapping of the distribution of indicator lichens growing on small-leaved lime (*Tilia cordata*) and Norway maple (*Acer platanoides*). The data obtained in these years show constant deterioration of air quality in Viljandi. Basing on the results of 1997, we distinguished four lichen zones: I, the zone of lichens tolerant to strong acidic air pollution (acidification of the substrate); II, the zone of lichens tolerant to moderate acidic air pollution; III, the zone of lichens tolerant to alkaline dust pollution (eutrophication of the substrate) and IV, the zone of lichens sensitive to acidic air pollution.

Kokkuvõte: S. Liiv ja E. Sander. Õhu seisundi lihhenoindikatsiooniline hindamine Viljandis.

Viljandis on õhu seisundit hinnatud 1987., 1991. ja 1997. a., kasutades harilikul pärnal (*Tilia cordata*) ja harilikul vahtral (*Acer platanoides*) kasvavate indikaatorsamblike leviku kaardistamise meetodit. Nende kolme aasta andmete põhjal võib täheldada õhu kvaliteedi jätkuvat halvenemist Viljandis. 1997. a. tulemuste põhjal eraldati 4 tsooni: I – õhu tugevat happelist saastet taluvate samblike tsoon; II – õhu mõõdukat happelist saastet taluvate samblike tsoon; III – tolmusaastet (substraadi eutrofeerumist) taluvate samblike tsoon; IV – õhu happelise saaste suhtes tundlike samblike tsoon.

INTRODUCTION

In recent years relatively numerous investigations into the accumulation of elements in lichens as a characteristic of air quality have been conducted. However, beside this method of the bioindicational assessment of air quality, also the classical method of mapping of the distribution of indicator species is used, often combined with the index method (Wirth, 1987; Hosiaisluoma, 1994; Hobohm, 1994; Kirschbaum, 1995; van Dobben, 1996; Liiv & Sander, 1996). The method of mapping of the distribution of indicator lichens serves as the quickest and simplest way for establishing the problematic areas of air pollution, but also for fixing the improvement in air quality in some region on the basis of the distribution of indicator species (Hobohm, 1994; van Dobben, 1996; Ammann, 1997).

In Estonia, the use of lichens as bioindicators for the assessment of air quality was initiated in the late 60s at the then Tartu State University with the study of lichen groupings growing on trees in the town of Tartu (Trass, 1968 a, b). In Viljandi, irregular assessments of air quality have been performed since 1972, using different methods of lichen analysis. In this year field works were started to collect material for a graduation thesis under the supervision of Prof. Hans Trass (Liiv, 1973). Lichen studies were repeated in Viljandi in 1976 and 1983 (Liiv, 1978, 1987, 1989 a, b; Eensaar, Liiv, 1983). Analyses of epiphytic lichen groupings in Viljandi were carried out also in 1987 and 1991. These were mostly aimed at solving the methodical problems of using lichens as bioindicators. The present paper gives a brief comparison of the results of the lichen analyses performed in Viljandi in these years with the data we obtained during mapping of indicator lichens in 1997.

MATERIAL AND METHODS

Viljandi is a small town (22 000 inhabitants) in Southern Estonia (Fig. 1). Viljandi is a holiday town by the picturesque Lake Viljandi with Castle Park and old wooden houses. As a county centre Viljandi traditionally accommodates enterprises involved in food production. Enterprises involved in production of building materials are mainly situated in Männimäe industrial district, southwestern part of Viljandi.

Assessing air quality, we mapped the distribution of indicator lichens and evaluated the state of lichens.

In 1997 we conducted 252 analyses of lichen groupings on 126 trees in Viljandi – 68 on small-leaved lime (*Tilia cordata* Mill.) and 58 on Norway maple (*Acer platanoides* L.) bark of which has relatively similar properties to that of lime. The results of the study of lichen groupings in 1987 and 1991 were used for comparison. In 1987 we performed 94 analyses on 45 limes and 2 maples; in 1991 128 analyses were made on 57 maples and 7 limes.

Mapping the distribution of indicator lichens on lime and maple, we used the plan of Viljandi on the scale of 1:10 000, where the town is divided into 500 × 500 m quadrats. In 1997 lichen groupings were analysed in 30 quadrats. All lichens in two, mostly N and S expositions at a height of 1.3 m on a tree were identified and their cover in per cent was estimated using a 20 × 20 cm grid, divided into hundred units of 2 × 2 cm. Additionally, we identified lichens on the trunk at a height of 0.5–2 m. Selecting the substrate, we followed the standardization requirements set for this method: we chose faultless, upright, solitary trees with the average circumference of 130 cm.

Indicator lichens are selected and grouped according to differences in their relative toxicity-tolerance, by comparing the frequency of lichens growing on lime and data on the coexistence of species in areas with comparatively different pollution levels in Estonia (Liiv, 1989 a, b; 1992). This selection of indicator species coincides largely with the scale of indicator species elaborated in other European countries by different methods and used for the bioindication of air quality (Skye, 1979; Hultengren et al., 1991; Hosiaisluoma, 1994; Hobohm, 1994; Wirth, 1995).

By the compilation of the lichen-zonal map we based on the data of the distribution of the following indicator lichens: *Hypocenomyce scalaris* (Ach.) M. Choisy, *Lepraria incana* s.lat., *Scoliciosporum chlorococcum* (Graewe ex Stenh.) Vêzda, *Hypogymnia physodes* (L.) Nyl. **tolerant to strong acidic air pollution (acidification of the substrate);** *Pseudevernia furfuracea* (L.) Zopf., *Platismatia glauca* (L.) W.L. Culb. & C.F. Culb., *Tuckermannopsis chlorophylla* (Willd.) Hale, *Vulpicida pinastri* (Scop.) J.-E. Mattsson & M.J. Lai **tolerant to moderate acidic air pollution**; *Phaeophyscia nigricans* (Flörke) Moberg, *P. orbicularis* (Neck.) Moberg, *Physconia enteroxantha* (Nyl.) Poelt, *Xanthoria candelaria* (L.) Th. Fr., *X. parietina* (L.) Th. Fr. **tolerant to strong alkaline dust pollution (eutrophication of the substrate) and acidic air pollution;** *Anaptychia ciliaris* (L.) Körb., *Melanelia subargentifera* (Nyl.) Essl., *Physconia distorta* (With.) J.R. Laundon, *Ramalina fastigiata* (Pers.) Ach., *R. fraxinea* (L.) Ach., *R. pollinaria* (Westr.) Ach. **tolerant to alkaline dust pollution but sensitive to acidic air pollution.**

RESULTS AND DISCUSSION

In 1997 we identified 58 lichen species on lime and maple; the data on the distribution of 46 species are presented in a manuscript report (Liiv & Sander, 1997). In 1987, when we studied lichen flora mostly on lime, we identified 45 species in Viljandi, and in 1991 we determined 55 species predominantly on maple. Differences in the number of epiphytic lichens in Viljandi are mainly caused by the tree species under observation – the abundance of lichens growing on the maple with the subneutral bark is higher than on the lime with the subacidic bark. This was also confirmed by the results of the investigations of 1993–95 when we analysed lichen groupings on 693 lime and 777 maple trees growing outside the towns in parks of estates and country cemeteries.

Basing on the distribution of indicator lichens, we distinguished four zones in Viljandi (Fig. 1).

Zone I, the zone of lichens tolerant to strong acidic air pollution, is located in the centre of Viljandi. The area of the zone is about 0.4 km^2.

This zone is characterised by frequent occurrence of the indicators of strong acidic pollution *H. scalaris, L. incana, S. chlorococcum* and *H. physodes* on trees with the subacidic and subneutral bark. *H. physodes* grows on lime and maple also outside the towns, in parks of estates and country cemeteries (Table 1). The other three extremely toxicity-tolerant lichens *H. scalaris, L. incana* and *S. chlorococcum* have not been recorded on lime and maple outside the town areas.

Poleophobous species sensitive to acidic pollution *A. ciliaris, M. subargentifera, P. distorta, R. fastigiata, R. fraxinea* and *R. pollinaria*, occurring commonly on lime and

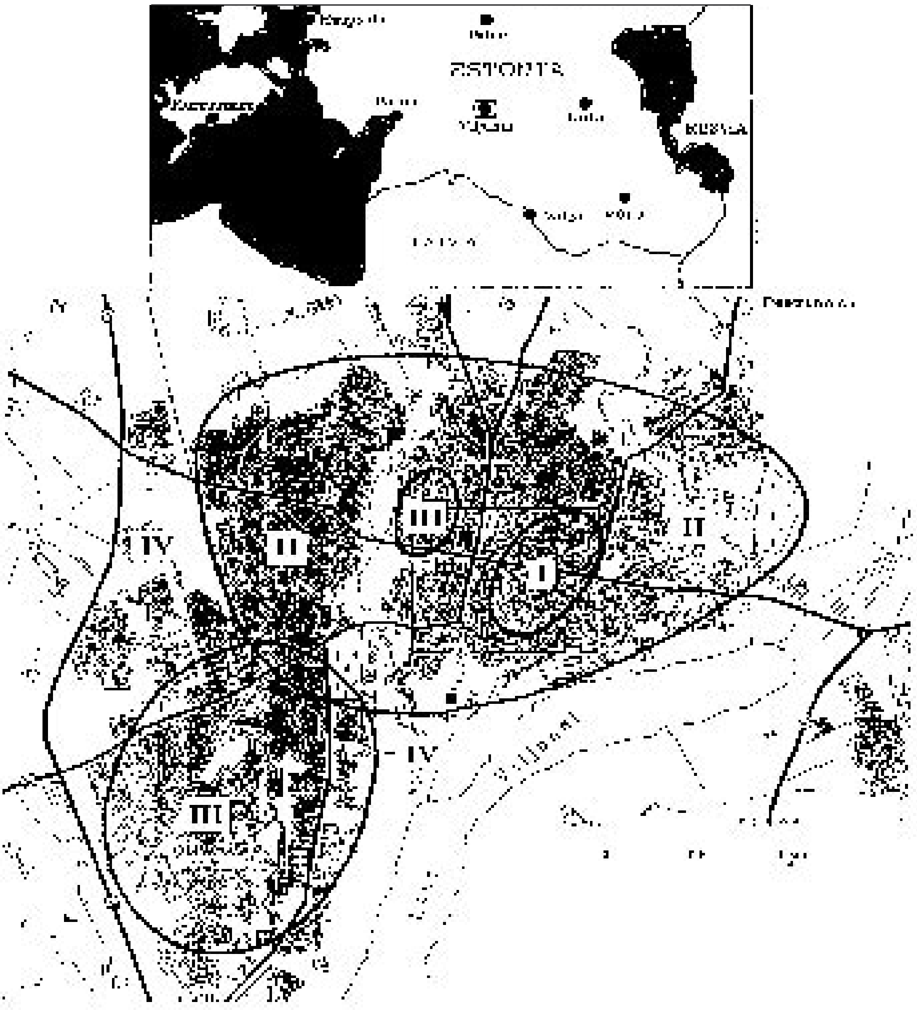


Fig. 1. Lichen zones in Viljandi. I – zone of lichens tolerant to strong acidic air pollutions; II – zone of lichens tolerant to moderate acidic air pollution; III – zone of lichens tolerant to strong dust pollution; IV – zone of lichens sensitive to acidic air pollution.

maple in relatively unpolluted air outside the towns, are completely lacking in zone I (Table 1, 2). Indicators of dust pollution are represented in zone I by *P. orbicularis, P. enteroxantha, X. candelaria* and *X. parientina*, but also by other comparatively toxicity-tolerant lichens as *Buellia punctata* (Hoffm.) A. Massal., *Melanelia exasperatula* (Nyl.) Essl., *Lecanora carpinea* (L.) Vain., *L. chlarotera* Nyl. and *L. hagenii* (Ach.) Ach. growing on eutrophicated substrate. In all, we identified 28 lichen species on lime and maple in this zone. However, lichens showing tolerance to acidic air pollution, e.g. *Evernia prunastri* and *Ramalina farinacea* or indicators of moderate acidic pollution *P. furfuracea* and *T. chlorophylla*, but also more tolerant *Parmelia sulcata* and *H. physodes*, are extremely tiny, strongly deformed and hidden in bark cracks, being on the verge of dying or already dead. The conditions are highly suitable for *H. scalaris, S. chlorococcum* and *L. incana* only. The mean general cover of lichens on trees of the quadrats analysed is only 4% in this zone.

Table 1. Frequency (%) of indicator lichens on lime and maple in Viljandi in 1987, 1991 and 1997, and in Estonian parks outside the towns in 1993–95

Indicator lichens	Viljandi			
	1987	1991	1997	Parks
Anaptychia ciliaris	15	17	13	56
Hypocenomyce scalaris		2	3	
Hypogymnia physodes	40	47	65	20
Lepraria incana	15	6	17	
Melanelia subargentifera	11	13	5	17
Phaeophyscia nigricans	6	6	2	
P. orbicularis	43	36	21	39
Physconia distorta	13	33	13	30
P. enteroxantha	34	50	52	62
Pseudevernia furfuracea	9		16	3
Ramalina fraxinea	15	13	23	40
R. pollinaria	17	2	4	39
Scoliciosporum chlorococcum	13	3	7	
Tuckermannopsis chlorophylla		9	14	
Vulpicida pinastri			2	
Xanthoria candelaria	9	17	10	16
X. parietina	36	44	32	45

Zone II, the zone of lichens tolerant to moderate acidic air pollution, comprises almost the entire northern part of Viljandi (Fig. 1). The area of the zone is about 6 km^2 and it takes up most of Viljandi's territory.

This zone is characterised by the distribution of *P. furfuracea, P. glauca, T. chlorophylla* and *V. pinastri*, tolerant to moderate acidic pollution, also *H. physodes*, very tolerant to acidic pollution and *P. orbicularis, P. enteroxantha, X. candelaria* and *X. parietina* which are tolerant to alkaline dust and acidic air pollution, but also by poleophobous *A. ciliaris, M. subargentifera, P. distorta, P. perisidiosa, R. fastigiata, R. fraxinea* and *R. pollinaria*. Tolerant to strong acidic pollution *H. scalaris* and *S. chlorococcum* are missing in this zone. In all, 52 lichen species have been identified in zone II. Such a large number of lichens should be put down to the cemetery at Riia Road, but also to Viljandi Lossipark with great biomass. In this area poleophobous lichens grow side by side with indicators of moderate acidic pollution. Thus zone II represents a so-called transitional zone for lichens, showing the occurrence of poleophobous species as well as indicators of acidic air pollution. *H. physodes* has been identified even on 89% of trees (Table 2). Many dead lichens are found on trees as well.

As a rule, the cover of lichens on trees is higher in relatively unpolluted air. The mean general cover of lichens is 20% in zone II, but the highest value of 26% is recorded in zone IV.

Zone III, the zone of lichens tolerant to strong dust pollution, spreads mostly in two regions (Fig. 1). A 0.2 km^2 area occurs as an island in the zone of moderate acidic pollution. The other dust pollution area of 2.2 km^2 embraces most of the Männimäe industrial and residential district.

On 89% of the trees examined in the so-called dust zone grow *P. nigricans, P. orbicularis, P. enteroxantha, X. candelaria* and *X. parietina*, tolerant to strong dust pollution and moderate acidic pollution (Table 2). Indicators of acidic pollution are represented in this zone by *H. physodes* and *L. incana* on single trees, but *H. scalaris* and *S. chlorococcum*, tolerant to strong acidic pollution, and *P. furfuracea, P. glauca,*

Table 2. Frequency (%) of groups of indicator lichen zones of Viljandi in 1997

Groups of indicator lichens	Lichen zones			
	I	II	III	IV
Hypocenomyce scalaris, Lepraria incana, Scoliciosporum chlorococcum	75	11	10	
Hypogymnia physodes	94	89	10	
Pseudevernia furfuracea, Platismatia glauca, Tuckermannopsis chlorophylla, Vulpicida pinastri	63	36		
Phaeophyscia nigricans, P. orbicularis, Physconia enteroxantha, Xanthoria candelaria, X. parietina	43	51	89	100
Anaptychia ciliaris, Melanelia subargentifera, Physconia distorta, Ramalina fastigiata, R. fraxinea, R. pollinaria		41	44	78

T. chlorophylla and *V. pinastri*, which are tolerant to moderate acidic pollution, are lacking.

The total number of lichen species is 32 in the dust zone, whereas on 44% of the trees grow also poleophobous, tolerant to dust pollution *A. ciliaris, M. subargentifera, P. distorta, P. perisidiosa, R. fastigiata* and *R. fraxinea*, which, however, are sensitive to acidic pollution.

Zone IV, the zone of lichens sensitive to acidic air pollution, comprises the marginal areas of the town (Fig. 1). In the zone of relatively unpolluted air of Viljandi 30 lichens have been identified. The main indicators of this zone *A. ciliaris, M. subargentifera, P. distorta, R. fastigiata, R. fraxinea* and *R. pollinaria*, which tolerate weak dust pollution but are sensitive to acidic pollution, grow on 78% of the trees investigated for lichen groupings. The lichens indicative of dust pollution, which occur relatively frequently on lime and maple also outside the town areas, grow in this zone even on all trees (Table 1, 2).

The lichen flora on lime and maple of Viljandi provokes a lot of interest as most of the town falls in the zone of moderate acidic pollution, where lichens of the trees with the subacidic and subneutral bark "compete" with the lichens characterising the trees with the acidic bark. This accounts for a relatively large number of lichens in zone II in comparison with the zones of lichens tolerant to dust pollution (III) or sensitive to acidic air pollution (IV). Lichens are relatively numerous also in the most polluted zone of Viljandi, as we considered as growing every at least recognisable or damaged lichen remain. A very expressive characteristic is the comparatively low cover of lichens which makes 4% in this zone. Moreover, most of this value represents the cover of crustaceous lichens *P. argena* and *L. incana* tolerant to pollution, or of *H. physodes* which is also very tolerant to acidic pollution.

Considering the results of mapping of indicator lichens in 1987 and 1991, we note that the number of thalli of dead lichens as well as of damaged and mutilated lichens was greater in 1997. The location of the zones coincided in all three years. As compared to the years of 1987 and 1991, the frequency of some lichens indicative of acidic air pollution has increased (Table 1). The distribution of *H. scalaris*, the indicator of strong acidic pollution, has widened. In 1987 this species was not identified in Viljandi, in 1991 it grew on lime in the Park of Coloured Fountains. The frequency of *H. physodes*, *L. incana* and *P. furfuracea* has more increased on lime. The reason of lower increase on maple may be not only the differences of bark of different tree species but also a shorter time interval between maple-analyses (1991/1997) compared with lime-analyses (1987/1997).

Among indicators of moderate acidic pollution of air *V. pinastri* was not identified on lime and maple in 1987 and 1991, but now it occurs in three town quadrats. Analyses of lichen groupings, performed mostly on maple in 1991, did not show the occurrence of *P. furfuracea*, which we identified on lime in two town quadrats in 1987 and in six quadrats in 1997. The distribution of toxicity-tolerant *H. physodes* has expanded considerably as well. These facts indicate the growth of acidic air pollution in Viljandi. Although for some years lichens stay inert in response to changes in air properties, we may affirm that air quality is constantly deteriorating in Viljandi, as the state of lichens has worsened practically in the whole town. More sensitive lichens, of which only fragments have preserved, are dying out. The intact exterior and great increment of lichens indicative of acidic pollution, however, give evidence of moderate and not strong acidic pollution in the most part of the town. Still, young thalli of poleophobous lichens were recorded nowhere in Viljandi. On the contrary, their cover has decreased almost everywhere, the state of lichens has deteriorated also on the outskirts.

ACKNOWLEDGMENTS

Financial support to carry out this study has been received from the Environmental Fund of Estonia. The authors are grateful also to Agu Eensaar and Anne Noor.

REFERENCES

Ammann, K. 1997. Flechten als Bioindikatoren. *Uni Press*, 94: 18–25.

Eensaar, A. & Liiv, S. 1983. Viljandi õhu seisund. In *Väikelinnade ja maa-asulate keskkonnakaitse ning maastikuhooldus.* Ettek. teesid. Tallinn – Viljandi. Lk. 104–107.

Hobohm, C. 1994. Baumflechten und Luftbelastungen in Lüneburg und Umgebung – eine neue Methode der Bioindikation auf der Basis von Zeigerwerten. *Beiträge zur Naturkunde Niedersachsens* 47, 2: 49–61.

Hosiaisluoma, V. 1994. Pääkaupunkiseudun puistopuiden jäkälistö ilmanlaadun kuvaajana. *Pääkaupunkiseudun julkaisusarja* C, 2: 1–52.

Hultengren, S., Martinsson & P-O., Stenström, J. 1991. *Lavar och luftföroreningar. Känslighetsklassning och indexberäkning av epifytiska lavar.* Naturvårdsverket RAPPORT 3967. 113 pp.

Kirschbaum, U. 1995. Immissionsbezogene Flechtenkartierung von Hessen nach der neuen Richtlinie VDI 3799, Blatt 1. *Staub – Reinhaltung der Luft* 55: 305–309.

Liiv, S. 1973. Linnade õhu saastatuse astme bioindikatsioonist. Diplomitöö. Tartu. 84 lk. Käsikiri Tartu Ülikoolis.

Liiv, S. 1978. Lichenoindicational mapping of air pollution in Tartu and Viljandi (in Russian). In *Studies on problems of ecology and rational exploitation of natural resources,* pp. 5–8. Tartu.

Liiv, S. 1987. Lichenoindication of air pollution in towns in southern Estonia (in Russian). Dissertation. Tallinn. 230 pp.

Liiv, S. 1989 a. Kas samblikud tulevad tagasi? *Eesti Loodus* 9: 554–560.

Liiv, S. 1989 b. Kas samblikud tulevad tagasi? *Eesti Loodus* 10: 648–654.

Liiv, S. 1992. Eestin ilmanlaatu jäkäläkartoituksella mitattuna. *Ilmansuojelu-uutiset* 1: 8–12.

Liiv, S. & Sander, E. 1996. Distribution of epiphytic lichens indicating air pollution in Estonia. In: *Progress and Problems in Lichenology in the Nineties.* Abstracts of the third symposium IAL 3. Salzburg, Austria 1–7 September 1996. P. 231.

Liiv, S. & Sander, E. 1997. Viljandi linna õhu seisundi hindamine lihhenoindikatsiooni meetodil. Tallinn, 29 lk. Käsikiri Tallinna Botaanikaaias.

Skye, E. 1979. Lichens as biological indicators of air pollution. *Ann. Rev. Phytopathol.* 17: 325–341.

Trass, H. 1968 a. Samblikud – õhu saastatuse indikaatorid. *Eesti Loodus* 2: 80–83.

Trass, H. 1968 b. Indeks samblikurühmituste kasutamiseks õhu saastatuse määramisel. *Eesti Loodus* 10: 628.

Van Dobben, H. F. 1996. Decline and recovery of epiphytic lichens in an agricultural area in The Netherlands (1900–1988). *Nova Hedwigia* 62, 3–4: 477–485.

Wirth, V. 1987. *Die Flechten Baden-Württembergs.* Eugen Ulmer Verlag. Stuttgart. 528 pp.

Wirth, V. 1995. *Flechtenflora.* Bestimmung und ökologische Kennzeichnung der Flechten Südwestdeutschlands und angrenzender Gebiete. Eugen Ulmer Verlag. Stuttgart. 661 pp.

Folia Cryptog. Estonica, Fasc. 32: 43–46 (1998)

List of Estonian calicioid lichens and fungi

Piret Lõhmus
Institute of Botany and Ecology, University of Tartu, 38 Lai St., EE2400 Tartu, Estonia

Abstract: In the beginning of the 1970s 34 species of calicioid lichens and fungi were reported from Estonia. However, after critical revision of herbarium material only 23 species, according to the present taxonomy, can be confirmed. In the last two decades 25 new to Estonia species have been found and thus, altogether 48 species are verified in Estonia today. In addition, two previously reported species are treated as doubtful because of the lack of vouchers. A map of the frequency of the species in different parts of Estonia is presented, and species that may occur in Estonia are discussed.

Kokkuvõte: P. Lõhmus. Eesti kalitsioidsete samblike ja seente nimestik.

1970. aastate alguseks oli Eestist teada 34 kalitsioidse sambliku ja seene liiki (Trass, 1967, 1970; Sõmermaa, 1970). Pärast herbaarmaterjalide kriitilist läbivaatust, arvestades muutusi süstemaatikas ning lisades hilisemad andmed, võib Eestist tõestatuks lugeda 48 kalitsioidse sambliku ja seene liiki. Kahe liigi (*Chaenotheca cinerea*, *Sclerophora peronella*) esinemine Eestis jääb kaheldavaks, kuna varasem herbaarmaterjal puudub ja uusi leide seni pole. Võrreldes Trassi (1967, 1970) ning Sõmermaa (1970) esitatud nimestikega on lisandunud 25 liiki. Esmakordselt avaldatakse järgmised liigid: *Calicium denigratum*, *C. parvum*, *Chaenotheca gracillima, C. laevigata*, *C. subroscida*, *C. xyloxena, Chaenothecopsis consociata*, *C. debilis, C. epithallina, C. nana, C. pusiola*, *C. savonica, C. viridireagens, Cyphelium sessile*, *Phaeocalicium populneum*. Umbes 40% levikuruutudest (10'E–W × 6'N–S) on kogutud vähemalt üks kalitsioidse sambliku või seene liik. Edasistel uuringutel võib praegustele lisanduda veel vähemalt kümme liiki.

INTRODUCTION

Trass (1967, 1970) and Sõmermaa (1970) reported a total of 34 species of calicioid lichens and fungi from Estonia. During the last decades new species have been added and some previously published species were redetermined. The aims of this paper are (1) to check critically the species in Trass (1967, 1970) and Sõmermaa (1970), (2) to compile an updated list, (3) to discuss the state of knowledge about Estonian calicioid lichens and fungi, and (4) to present the species that may occur in Estonia.

MATERIAL AND METHODS

The study is based mainly on the material of calicioid lichens and fungi kept in the herbaria of the University of Tartu (TU), the Botanical Garden of Tallinn (TBA), the Institute of Ecology in Tallinn (IE), the University of Helsinki (H) and the University of Riga (RIG). Altogether over 1700 specimens were examined, 740 of them were collected by the author within the last three years.

The morphology and anatomy of the lichens were studied with a stereo lens and light microscope, and the colour tests of apothecia were made with 10% KOH, 50% nitric acid and Lugol's solution. For identification the following publications were used: Foucard (1990), Purvis et al. (1992), Tibell (1975, 1976, 1978, 1980). Additional comparsion material was received from H. The nomenclature follows Santesson (1993), the abbreviations of authors' names are given according to Kirk & Ansell (1992).

The herbarium data were sorted with the computer program BRAHMS. To illustrate the distribution of collected material, a map was compiled with the DMAP 6.4 program for Windows. As a record unit a square 10'(E–W) × 6'(N–S) was used.

Using the species lists of the 15 best studied squares (with more than 10 species in each; representing a total of 37 species) the rate of discovery of new species is shown. For this purpose the lists were taken at random and for each list the number of new species (not recorded in previous lists) was determined.

RESULTS

After critical revision of herbarium material only 21 species of calicioid lichens and fungi presented in Trass (1967, 1970) and Sõmermaa (1970) can be confirmed according to the present taxonomy. Furthermore, the occurrence of four species (*Chaenotheca cinerea, C. chlorella, C. hispidula, Sclerophora peronella*) could not be confirmed, because voucher material was not found. However, *Chaenotheca chlorella* and *C. hispidula* have been collected later again. Two additional species are not known from Estonia with certainty. The following species were excluded from the lists in Trass (1967, 1970) and Sõmermaa (1970) because of previous uncorrect identification: *Calicium corynellum* was redetermined (®) as *Microcalicium arenarium* (det. V. Räsänen; RIG), *C. lenticulare* ® *C. abietinum* and *C. glaucellum* (det. P. Lõhmus; TU), all specimens (except three) of C*haenotheca chlorella* ® *Chaenotheca phaeocephala* (det. P. Lõhmus; TU), *Chaenothecopsis faginea* ® *C. pusilla* (det. P. Lõhmus; TU), *C. viridireagens* ® *C. epithallina* (det. A. Titov; TU), *Phaeocalicium populneum* ® *Mycocalicium subtile* and *Chaenothecopsis consociata* (det. P. Lõhmus, A. Titov; TU). Some of these taxa were later found as new to the Estonian lichen flora.

List of calicioid species in Estonia

A checklist of Estonian calicioid lichens and fungi is compiled. New taxa for Estonia (compared with Trass 1967, 1970; Sõmermaa 1970, taking into account redeterminations) are given in **bold**; doubtful species are marked with ?. As synonyms only these names are added which have been used in Trass (1970) and Sõmermaa (1970). In the right column the total number of records in Estonia in 1998 is presented.

Calicium Pers.	
abietinum Pers.	49
adspersum Pers.	5
denigratum (Vain.) Tibell	1
glaucellum Ach.	60
parvum Tibell	13
quercinum Pers.	18
salicinum Pers.	28
trabinellum (Ach.) Ach.	22
viride Pers.	120
Chaenotheca (Th. Fr.) Th. Fr.	
brachypoda (Ach.) Tibell = *Coniocybe sulphurea* (Retz.) Nyl.	19
brunneola (Ach.) Müll. Arg.	16
chlorella (Ach.) Müll. Arg. = *C. carthusiae* (Harm.) Lett.	11
chrysocephala (Turner ex Ach.) Th. Fr.	118
? cinerea (Pers.) Tibell = *Calicium schaereri* DNot., *C. schaereri* (DNot.) Zahlbr.	1
ferruginea (Turner & Borrer) Mig. = *C. melanophaea* (Ach.) Zwackh.	123
furfuracea (L.) Tibell = *Coniocybe furfuracea* (L.) Ach.	67
gracillima (Vain.) Tibell = *Calicium gracilis* (Nadv.) Oxn.	2
hispidula (Ach.) Zahlbr.	4
laevigata Nádv.	3
phaeocephala (Turner) Th. Fr.	37
stemonea (Ach.) Müll. Arg.	21
subroscida (Eitner) Zahlbr.	10
trichialis (Ach.) Th. Fr.	93
xyloxena Nádv.	39
Chaenothecopsis Vain.	
consociata (Nádv.) A.F.W. Schmidt	8
debilis (Turner & Borrer ex Sm.) Tibell	1
epithallina Tibell	3
nana Tibell	4
pusilla (Ach.) A.F.W. Schmidt = *Calicium alboatrum* Flörke, *Calicium pusillum* Flörke *Calicium. subpusillum* Vain.	35
pusiola (Ach.) Vain.	1
rubescens Vain.	2
savonica (Räsänen) Tibell	4
subparoica (Nyl.) Tibell	1
vainioana (Nádv.)Tibell	1
viridireagens (Nádv.) A.F.W. Schmidt = *Calicium viridireagens* Nádv.	1
Cyphelium Ach.	
inquinans (Sm.) Trevis.	7
lucidum (Th. Fr.) Th. Fr.	1
sessile (Pers.) Trevis.	1
tigillare (Ach.) Ach.	3
Microcalicium Vain. emend. Tibell	
arenarium (Hampe ex A. Massal.) Tibell = *Calicium arenarium* Hampe	4
disseminatum (Ach.) Vain.	5
Mycocalicium Vain.	
subtile (Pers.) Szatala = *Calicium subtile* Pers.	86
Phaeocalicium A.F.W. Schmidt	
populneum (Brond. ex Duby) A.F.W. Schmidt = *Calicium populneum* De Brond.	1
Sclerophora Chevall.	
coniophaea (Norman) Mattson & Middelb.	2
farinacea (Chevall.) Chevall.	4
nivea (Hoffm.) Tibell = *Coniocybe pallida* (Pers.) Fr.	10
? peronella (Ach.) Tibell = *Coniocybe hyalinella* Nyl.	1

Sphaerophorus Pers.	
globosus (Huds.) Vain.	2
Stenocybe (Nyl.) Körb.	
pullatula (Ach.) Stein	27
Thelomma A. Massal.	
ocellatum (Körb.) Tibell	3

Thus there are 48 verified and two doubtful species of calicioid lichens and fungi in Estonia today. Most common species (over 50 localities) are *Calicium glaucellum*, *C. viride*, *Chaenotheca chrysocephala*, *C. ferruginea*, *C. furfuracea*, *C. trichialis*, *Mycocalicium subtile*. Twelve species – *Calicium denigratum*, *Chaenotheca gracillima*, *Chaenothecopsis debilis*, *C. pusiola*, *C. subparoica*, *C. vainioana*, *C. viridireagens*, *Cyphelium lucidum*, *C. sessile*, *Phaeocalicium populneum*, *Sclerophora coniophaea* and *Sphaerophorus globosus* – have been found only once or twice.

In the present list 25 species are new to Estonia, compared to Trass (1967, 1970) and Sõmermaa (1970). Eleven of these have already been published by Randlane (1978, 1986; *Chaenotheca phaeocephala*, *Cyphelium inquinans*), Ekman et al. (1991; *Calicium glaucellum*, *Chenothecopsis subparoica*, *C. vainioana*, *Microcalicium disseminatum*, *Sclerophora coniophaea*, *S. farinacea*, *Thelomma ocellatum*), Nilson et al. (1997; *Cyphelium lucidum)* and Thor et al. (1998; *Cyphelium* sessile). A.Titov, having checked some TU herbarium material of calicioid lichens and fungi in 1984, identified *Chaenotheca subroscida*, *C. xyloxena*, *Chaenothecopsis consociata*, *C. epithallina* and *C. pusiola* for the first time. My revisions of all herbarium material and additional fieldwork in 1995–1997 added *Calicium denigratum* (leg. H. Ting, 1963), *C. parvum* (leg. A.-L. Sõmermaa, 1967), *Chaenotheca gracillima* (leg. P. Lõhmus, 1997), *C. laevigata* (leg.A.-L. Sõmermaa, 1967), *Chaenothecopsis debilis* (leg. I. Jüriado, 1996), *C. nana* (leg. P. Lõhmus, 1997), *C. savonica* (leg. P. Lõhmus, 1996), *C. viridireagens* (leg. P. Lõhmus, 1997) and *Phaeocalicium populneum* (leg. M. Sarv, 1995) to the list.

DISCUSSION

A map of the geographical frequency of all calicioid lichens and fungi species in Estonia is presented where the squares are numbered according to the abundance of species in the squares (Fig. 1). Altogether in ca. 40% of squares at least one species has been collected, this indicates that thorough investigations have been

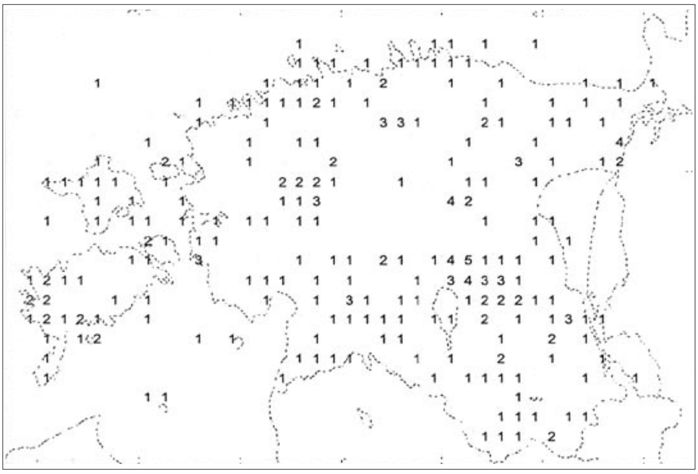


Fig. 1. The known distribution of calicioid species of lichens and fungi and the abundance of known species in squares (1 = less than 6; 2 = 6–10; 3 = 11–15; 4 = 16–20; 5 = more than 20 species).

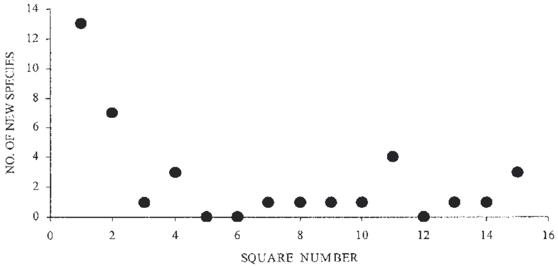


Fig. 2. The rate of discovery of new species in the 15 best studied (with more than 10 species) squares with a total of 37 species. For the analysis the squares were taken in random order.

done only in a few regions. The best studied areas are Alam-Pedja Nature Reserve (22 species are known in 260 km²), Endla Nature Reserve (18 species in 81 km²) and Poruni primeval forest with its surroundings (16 species in 0.5 km²). Preferred habitats for calicioid lichens and fungi (mire complexes, old deciduous forests and abandoned homesteads) are typical for these areas. The knowledge of calicioid flora in central Estonia and mainland western Estonia is still very poor and needs more attention in the future research.

An analysis of the rate of discovery of new species has been carried out in 15 best studied squares (Fig. 2). After the first decline the rate of adding new species has remained stable in Estonia, i. e. a significant part of calicioid lichens and fungi seems to have been not found yet. In southern Finland 63 species (Vitikainen et al., 1997; biogeographical provinces No. 1–7) and in Latvia 23 species (Piterans, 1982, *pers. comm.*) are known. Considering the distribution and habitats of the species in these lists, I guess that at least *Calicium adaequatum*, *C. lenticulare*, *Chaenothecopsis hospitans*, *C. viridialba*, *Cybebe gracilenta*, *Cyphelium notarisii* and *Sphinctrina anglica* might be found in Estonia. Probably about ten species are as yet not discovered in Estonia.

ACKNOWLEDGEMENTS

I am grateful to the curators of herbaria H , IE, RIG and TBA. My warm thanks are due to A. Saag for his advices about the computer programs BRAHMS and DMAP, and to T. Randlane, L. Tibell and A. Lõhmus for criticism on the manuscript. The study was undertaken as part of the project “Composition and analysis of Estonian lichen flora” financed by the Estonian Science Foundation (Grant No. 1297).

REFERENCES

Ekman, S., Fröberg, L., Kärnefelt, J., Sundin, R., Thor, G. 1991. New or interesting lichens from Estonia. *Folia Cryptog. Estonica* 28: 5–25.

Foucard, T. 1990. *Svensk skorplavs flora.* Lund. 306 pp.

Kirk, P. M. & Ansell, A. E. 1992. *Authors of fungal names.* C.A.B. International, Wallingford. 95 pp.

Nilson, E., Kannukene, L., Truus, L., Ratas, U., Puurmann, E., Tobias, M. 1997. Biological diversity. In *Small islands of Estonia* (eds. Ratas, U. & Nilson, E.), pp. 149–153. Tallinn.

Piterans, A. 1982. *Lichens of Latvia* (in Russian). Zinante, Riga. 352 pp.

Purvis, O. W., Coppins, B. J., Hawksworth, D. L., James, P. W. & Moore, D. M. (eds.) 1992. *The lichen flora of Great Britain and Ireland.* Natural History Publications, London. 710 pp.

Randlane, T. 1978. New lichen species to the Estonian lichen-flora from the Viidumäe Nature Reserve (Island Saaremaa). *Folia Cryptog. Estonica.* 11: 7–8.

Randlane, T. 1986. New species to the Estonia lichen-flora. *Folia Cryptog. Estonica.* 21: 8–10

Santesson, R. 1993. *The lichens and lichenicolous fungi of Sweden and Norway.* SBT-förläget, Lund. 240 pp.

Sõmermaa, A. 1970. Epiphytic lichens found in main forest types of Estonia. *Pap. Bot.* 9: 265–297.

Thor, G. & Nordin, A. 1998. 16 lichens new to Estonia. *Folia Cryptog. Estonica.* 32: 123–125.

Tibell, L. 1975. The *Caliciales* of Boreal North America. *Symb. Bot. Upsal.* XXI: 2.

Tibell, L. 1976. *Calicium denigratum* (Vain.) L. Tibell, comb. nov. Notes on Caliciales 3. *Bot. Notiser* 129: 131–136.

Tibell, L. 1978.The genus *Microcalicium. Bot. Notiser* 131: 229–246.

Tibell, L. 1980. The lichen genus *Chaenotheca* in the northern hemisphere. *Symb. Bot. Upsal.* XXIII: 1.

Trass, H. 1967. *Analysis of the lichen-flora of Estonia* (in Russian). Doctoral dissertation. Tartu State University.

Trass, H. 1970. The elements and development of the lichen-flora of Estonia (in Russian). *Pap. Bot.* 9: 5–233.

Vitikainen, O., Ahti, T., Kuusinen, M., Lommi, S. & Ulvinen, T. 1997. Checklist of lichens and allied fungi of Finland. *Norrlinia* 6: 1–123.

Folia Cryptog. Estonica, Fasc. 32: 47–55 (1998)

Epiphytic macrolichens in Estonian forests

Ljudmilla Martin & Jüri Martin
International Center for Environmental Biology at Tallinn University of Educational Sciences,
PO Box 676, Tallinn EE 0026, Estonia

Abstract: Estonian forests were studied in 116 random sample plots to estimate epiphytic macrolichen distribution frequency. 57 lichen species were recorded 1164 times on 2328 trees. Lichen species were divided into seven frequency classes. Frequency class 1 (1–15 records) includes 42 species which belong to 5 geographic elements. Multiregional species *Hypogymnia physodes* and *Parmelia sulcata* demonstrate the highest frequency. Several rare and floristically interesting macrolichen species belong to frequency class 1: *Alectoria sarmentosa, Bryoria furcellata* (new species to Estonia), *Hypocenomyce friesii, Lobaria pulmonaria, Menegazzia terebrata, Physcia semipinnata, Usnea fulvoreagens, U. scabrata.*

Kokkuvõte: L. Martin ja J. Martin. Epifüütsed suursamblikud Eesti metsades.

Eesti metsades uuriti epifüütsete suursamblike sagedust 116 juhuslikult valitud punktis. 57 samblikuliiki registreeriti 1164 korral 2328 puul. Samblikuliigid jagunesid seitsmesse sagedusklassi. Suurima liikide arvuga (42) oli esimene sagedusklass (1–15 leidu). Need liigid kuuluvad viide geograafilisse elementi. Suurima sagedusega olid multiregionaalsed samblikuliigid *Hypogymnia physodes* ja *Parmelia sulcata*. Esimesse sagedusklassi kuuluvad haruldased ja floristiliselt huvitavaid liigid *Alectoria sarmentosa, Bryoria furcellata* (uus liik Eesti lihhenoflooras), *Hypocenomyce friesii, Lobaria pulmonaria, Menegazzia terebrata, Physcia semipinnata, Usnea fulvoreagens, U. scabrata.*

INTRODUCTION

Estonian lichen flora is relatively well studied and includes about 800 species (Trass, 1970). The last review and identification key "Macrolichens of Estonia" (Trass & Randlane, 1994) includes records of 332 species of macrolichens. Among them, 42 species have been recorded before 1950 and are considered as extinct from the Estonian lichen flora. In this review, 131 species are registered as epiphytic macrolichens (excluding the genus *Cladonia*), and 20 of them have not been recorded after 1950.

A. Sõmermaa (1972) published a monographic study on the ecology of epiphytic lichens in the main Estonian forest types. In her study the distribution of 26 epiphytic macrolichen species (excluding the genus *Cladonia*) in different forests was described.

The latest review of forest lichens in Estonia was presented by H. Trass (1996) in the study of Estonian natural (old-growth) forests flora. He presented data on the distribution and frequency of 95 lichen species that are considered as indicators of virgin forests. This list includes 47 epiphytic macrolichen species.

The main goal of the present study is to make an inventory of epiphytic macrolichen flora in the Estonian forests and to evaluate and quantify the frequency of epiphytic macrolichens. In 1994–1997 lichen data were collected under the co-operative Baltic–US Forest Ecological Monitoring Project and Estonian State Environmental Monitoring Program.

This is the first paper in a series of publications to analyze different aspects of lichen species distribution in relation to structure and composition of Estonian forests.

MATERIAL AND METHODS

The general methodology and the forest sample plot design are described in "Forest Health Monitoring Field Methods Guide (International)" (1994, 1995, 1996) and in "Forest Ecological Monitoring in the Baltic Countries" (1996). According to this methodology forest stand was considered as a forested area of more than 0.4 ha and sample trees were >12.5 cm in diameter. Sample plots in the forested areas were selected by a randomized sampling grid (Overton et al., 1990). The locations of sample plot centers were estimated using satellite and topographic maps. In the field the location of sample plot was identified by a GPS unit.

Table 1. Macrolichen species recorded for Estonian forests

	Geogr.	*Pinus*	*Betula*	*Picea abies*		*Alnus*	*Populus*	*Alnus*	*Quercus*	*Salix*	*Sorbus*	*Corylus*	*Fraxinus*	*Juniperus*	*Malus*	*Tilia*		Freq.
Macrolichen species	element**	*sylvestris*	*ssp.*	twigs	trunk	*incana*	*tremula*	*glutinosa*	*robur*	*caprea*	*aucuparia*	*avelana*	*excelsior*	*communis*	*sp.*	*cordata*	Records	class
		71***	**45**	**33**	**38**	**18**	**16**	**8**	**5**	**3**	**3**	**2**	**2**	**2**	**2**	**1**		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Alectoria sarmentosa (Ach.) Ach.	hol			1													1	1a
Anaptychia ciliaris (L.) Körb.	nem		1			2	8										11	1b
Bryoria capillaris (Ach.) Brodo & D.Hawksw.	bor	1	1	7													9	1b
B. furcellata (Fr.) Brodo & D. Hawksw.	bor	5	1	1													7	1b
B. fuscescens (Gyeln.) Brodo & D.Hawksw.	bor	10	2	2													14	1b
B. nadvornikiana (Gyeln.) Brodo & D.Hawksw.	bor		1	5	1												7	1b
B. subcana (Nyl.ex Stizenb.) Brodo & D.Hawksw.	subm	2		4													6	1b
Bryoria sp.1		2	1	3													6	1b
*Cladonia spp.**		36	24	2	15	3	3	2	1		1					1	88	6
Evernia prunastri (L.) Ach.	nem	4	7	10		4		1		1			1	1			29	2
Hypocenomyce friesii (Ach. in Lilj.) P.James & Gotth. Schneid.	bor	3															3	1b
H. scalaris (Ach.) M. Choisy	hol	17	1														18	2
Hypogymnia farinacea Zopf	bor	4	2														6	1b
H. physodes (L.) Nyl.	mult	67	39	31	35	14	5	6	4			1				1	203	7
H. tubulosa (Schaer.) Hav.	bor	6	6	23	3	2			1	2							43	3
Imshaugia aleurites (Ach.) S.L.F. Meyer	bor	25	4	1	2												32	3
Lobaria pulmonaria (L.) Hoffm.	nem						1										1	1a
Melanelia exasperata (De Not.) Essl.	nem		1														1	1a
M. exasperatula (Nyl.) Essl.	nem		2	6	1					1		1					11	1b
M. fuliginosa (Fr. ex Duby) Essl	nem					3	2	2	2	1	1	1		1	1		14	1b
M. olivacea (L.) Essl.	bor	1	8								1						10	1b
M. subargentifera (Nyl.) Essl.	bor						2										2	1b
M. subaurifera (Nyl.) Essl.	bor		2	2	2	8							1				15	1b
Menegazzia terebrata (Hoffm.) A. Massal.	subm		1					1		1							3	1b
Parmelia saxatilis (L.) Ach.	mult		1														1	1a
P. sulcata Taylor	mult	12	29	15	8	12	7	6	3	2			1	1	2	1	99	7
Parmeliopsis ambigua (Wulfen) Nyl.	bor	50	18	1	9	3		2		1				1			85	6
P. hyperopta (Ach.) Arnold	bor	3			1												4	1b

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Phaeophyscia ciliata (Hoffm.) Moberg	bor		1				3				1						5	1b
P. nigricans (Flörke) Moberg	hol						1										1	1a
P. orbicularis (Neck.) Moberg	mult		1				4										5	1b
Physcia adscendens (Fr.) H. Olivier	nem					1	5			1	1	1					9	1b
P. aipolia (Ehrh. ex Humb.) Fürnr.	mult						4						1				5	1b
P. semipinnata (J. F. Gmelin) Moberg	nem						2			1							3	1b
P. stellaris (L.) Nyl.	mult		1				2										3	1b
P. tenella (Scop.) DC. in Lam. & DC.	nem	2	3	2	1	2	1			1	1		1		1		15	1b
Physconia distorta (With.) J.R. Laundon	nem						5			1							6	1b
P. enteroxantha (Nyl.) Poelt	nem					1				1	1				1		4	1b
P. perisidiosa (Erichsen) Moberg	nem						2										2	1b
Platismatia glauca (L.) W.L.Culb. & C F.Culb.	mult	25	8	25	8	2			2			1		1			72	5
Pseudevernia furfuracea (L.) Zopf	bor	32	6	20	1				1	1					1		62	5
Ramalina baltica Lettau	nem				1										1		2	1b
R. farinacea (L.) Ach.	nem	3	7	4	1	10	7	3	3	1	2		1			1	43	3
R. fastigiata (Pers.) Ach.	nem						1			1						1	3	1b
R. fraxinea (L.) Ach.	nem									1							1	1a
R. pollinaria (Westr.) Ach.	mult		1														1	1a
Tuckermannopsis chlorophylla (Willd.) Hale	bor	4		12	2					1							19	2
T. sepincola (Ehrh.) Hale	mult	1	2	2													5	1b
Usnea filipendula Stirt.	hol		1	6	1												8	1b
U. fulvoreagens (Räsänen) Räsänen	bor				1												1	1a
U. hirta (L.) Weber ex F.H. Wigg.	bor	26	5	16	2												49	4
U. scabrata Nyl.	bor							1									1	1a
U. subfloridana Stirt.	bor	5	3	13	1			1									23	2
Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai	bor	29	20	3	10	3								1			66	5
Xanthoria fulva (Hoffm.) Poelt & Petutschning	?				1												1	1a
X. parietina (L.) Th. Fr.	mult	2	1			2	7				1						13	1b
X. polycarpa (Hoffm.) Th. Fr. ex Rieber	hol	1	2	1	1					1	1						7	1b
Records		378	214	218	108	72	72	25	17	20	11	5	6	6	7	5	1164	
Number of lichen species		28	36	27	23	16	20	10	8	18	10	5	6	6	6	5	57	

* Several steril *Cladonia* samples found on tree trunks higher than 0.5 m were included in *Cladonia* spp.

** Geographic elements of lichen species: bor - boreal, hol - holarctic, mult - multiregional, nem - nemoral, subm - submonatneous

*** This row indicates number of forest plots where particular tree species was observed

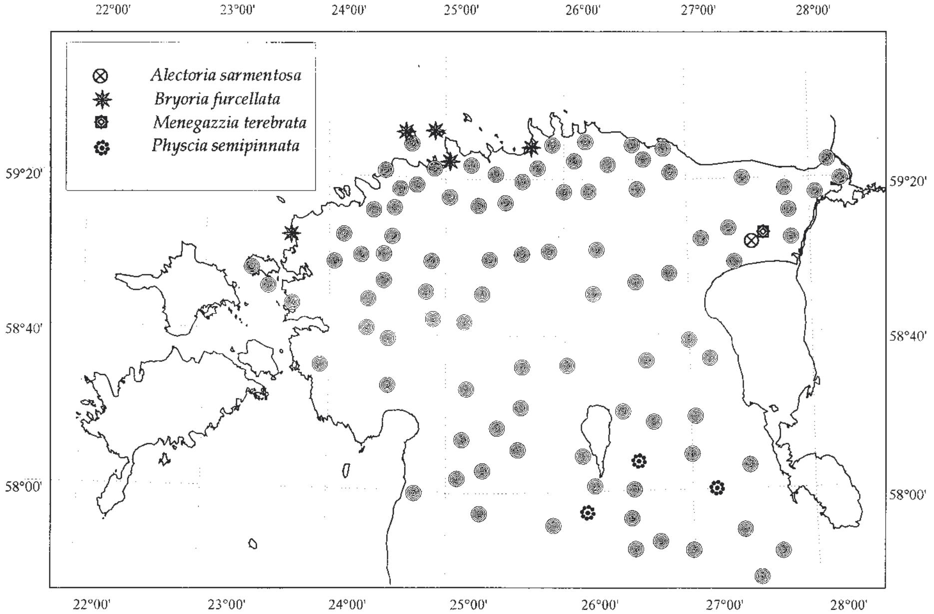


Fig. 1. Forest epiphytic macrolichens sample plots.

The lichen sample area ("lichen plot") was a circular area with 34.7 m radius (0.378 ha) around the forest sample plot center. On each lichen plot the occurrence of the lichen species on different tree species (at least 10 trunks of each tree species) was noted. Macrolichens were recorded at a height of more than 0.5 m from the tree base up to 2.5 m and separately for twigs of *Picea abies*. In addition, six sampled forest sites along the air pollution gradient crossing Estonia from northeast to south-west (Martin et al., 1994) were included in the database (Table 1). In this study 2328 tree trunks were observed. The lichen species were recorded on fourteen tree species including *Coryllus avellana*, *Malus* sp. and *Juniperus communis*. The most frequent tree species in this sample was *Pinus sylvestris* (71 plots) and the least frequent *Tilia cordata* (1 plot). Location of the 116 sampled forest sites is shown in Fig. 1. During the field work, more than 1000 lichen samples were collected for identification in the laboratory. The nomenclature presented by R. Santesson (1993) was followed.

Similarity of epiphytic lichen cover species composition registered on more frequent phorophytes was calculated by Sørensen's similarity coefficient.

The classification of geographical elements proposed by H. Trass (1970) was used for macrolichen flora characterization.

The collected specimens were deposited in the Herbarium of the International Center for Environmental Biology, Tallinn (ICEB).

RESULTS

In the studied forests 57 macrolichen species were identified and total number of macrolichen records selected by substrate types (phorophytes) was 1164 (Table 1). The highest similarity in lichen vegetation was found between *Pinus sylvestris* trunks and *Picea abies* twigs (Table 2). The lowest similarity value was between *Picea abies* twigs and *Populus tremula*.

Using the data presented in Table 1 the lichen species frequency classes' intervals were calculated using the following formula:

$$c = \frac{x_N - x_1}{\sqrt{N} - 1}$$

where c is frequency class interval, x_N – maximal variant (99, number of records for *Parmelia sulcata*), x_1 – minimal variant ($x_1 = 1$) and N – number of observations (number of species, $N = 57$). The calculated class interval was 15

Table 2. Similarity of lichen vegetation species composition (Sørensen's similarity coefficient) on different sampled phorophytes

	Picea abies, twigs	*Pinus sylvestris*	*Picea abies,* trunks	*Betula* spp.	*Alnus incana*	*Alnus glutinosa*	*Populus tremula*
Picea. abies, twigs	1						
Pinus sylvestris	0.800	1					
Picea abies, trunks	0.760	0.627	1				
Betula spp.	0.710	0.698	0.621	1			
Alnus incana	0.512	0.500	0.513	0.510	1		
Alnus glutinosa	0.378	0.368	0.364	0.356	0.538	1	
Populus tremula	0.213	0.250	0.233	0.400	0.500	0.333	1

(14.98). Frequency class 1 was further divided into two subclasses: 1a (1 record) and 1b (2–15 records).

Using the data presented in Table 1 and the calculated frequency class intervals a lichen species frequency distribution curve was created (Fig. 2). The recorded epiphytic lichen species were divided into 7 classes.

Several rare and floristically interesting lichen species are included in frequency class 1. Some of the new findings of these species are described below.

Lichen species in frequency class 1a (10 species, 18%) are as follows. *Alectoria sarmentosa*,* a very rare holarctic epiphyte, in Estonia previously recorded once in 1930. In the current study this lichen species was found on *Picea abies* twigs (North-East Estonia, Alutaguse, Kivinõmme, HEX 104386, 59°08'48"N, 27°30'18"E) in spruce-pine-birch mixed stand, age >120 years (Fig.1.).

*Lobaria pulmonaria**, a nemoral species, recorded locally over the whole territory of Estonia on deciduous trees, mostly in broad-leaved

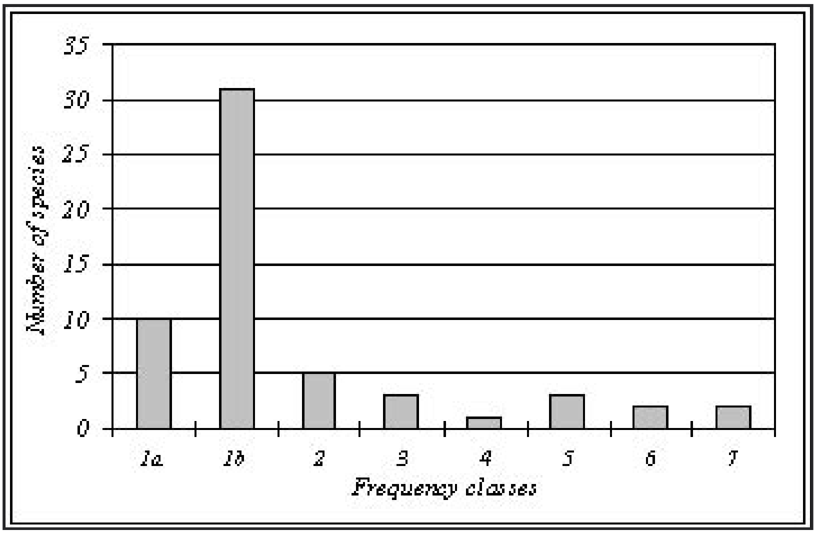


Fig. 2. Frequency distribution of the epiphytic macrolichen species in the studied forests.

---

* Asterisk indicates lichen species, which are included in the draft proposal for the Red Data Book of Estonia.

mixed spruce forests. In this study, *L. pulmonaria* was recorded once on *Populus tremula* (North-East Estonia, Oonurme, HEX 106135, 59°07'21"N, 26°57'46"E) in spruce-pine-birch-aspen mixed stand, age >120 years.

Usnea fulvoreagens, a boreal lichen, has been found earlier in Estonia in less than 20 localities. In this study *U. fulvoreagens* was found on *Picea abies* (Vetla, HEX 111451, 59°12'23"N, 25°29'19"E) in spruce-pine stand, age >120 years.

*Usnea scabrata**, a boreal lichen, has been recorded earlier in Estonia for more than 20 localities. In present study *U. scabrata* was recorded on *Alnus glutinosa* (Hageri–Adila, HEX 115043, 59°09'04"N, 24°35'15"E).

Frequency class 1b (32 species, 56%) includes also some rare lichen species in Estonia. First of all, *Bryoria furcellata* – new for the lichen flora of Estonia species (Randlane et al., 1997) and up to now has been recorded 7 times for 6 localities in Estonian forests (Aegna: 59°34'31"N, 24°45'49"E; 59°34'52"N, 24°45'25"E; Naissaar, 59°34"54"N, 24°31'10"E; Nõva, 59°13'53"N, 23°38'21"E ; Tallinn, Kloostrimetsa, 59°28'12"N, 25°02'16"E; HEX 113220, 59°32'08"N, 25°36'16"E): 5 records on *Pinus sylvestris*, 1 on *Betula pubescens* and 1 on *Picea abies* twigs. This species was always found in similar habitats in open forests on sandy soils in the coastal zone (Fig. 1).

Hypocenomyce friesii, a boreal lichen, and in Estonia recorded earlier for three localities. In the current sample this lichen was also recorded three times for *Pinus sylvestris* (Aegna, 59°34'52"N, 24°45'25"E; 59°34'49"N, 24° 45'46"E; Naissaar, 59° 34"54"N, 24° 31'10"E).

*Menegazzia terebrata**, a rare submontaneous lichen, was found on the same forest plot as *A. sarmentosa* on *Betula pubescens*, *Alnus glutinosa*, and *Salix caprea* (Fig.1). Several interesting and relatively rare microlichen species were also collected here, i.e. *Dimerella pineti* (Ach.) Vêzda, *Lecanactis abietina* (Ach.) Körb., *Mycoblastus sanguinarius* (L.) Norman, etc. *M. terebrata* is considered as endangered in Europe (Trass, 1997). In Estonia this lichen was earlier known from 6 localities.

*Physcia semipinnata**, a nemoral epiphytic lichen, usually found on trunks of broad-leaved trees (less than 10 records in Estonia). In this study *P. semipinnata* was found on three forest plots in South-Eastern Estonia (Fig.1): twice on *Populus tremula* (HEX 99245, 58°00'18"N, 27°08'37"E; HEX 100966, 58°08'51"N, 26° 46' 00"E) and once on *Salix caprea* (HEX 102700, 57°57'03"N, 26°05'43"E).

In addition to the species listed above, in frequency class 1 were included: (1) lichen species which usually grow in old forests on conifers and *Betula* spp. – *Bryoria capillaris* , *B. fuscescens* , *B. nadvornikiana* , *B. subcana* , *Hypogymnia farinacea* , *Melanelia olivacea, Parmeliopsis hyperopta, Tuckermannopsis sepincola, Usnea filipendula*; (2) species usually inhabiting on deciduous trees such as *Anaptychia ciliaris, Melanelia exasperata, M. exasperatula, M. fuliginosa, M. subargentifera* , *M. subaurifera, Phaeophyscia ciliata, P. nigricans* , *P. orbicularis, Physcia adscendens, P. aipolia, P. stellaris, P. tenella* , *Physconia distorta, P. enteroxantha, P. perisidiosa, Ramalina baltica, R. fastigiata, R. fraxinea, R. pollinaria* , *Xanthoria fulva, X. parietina, X. polycarpa*.

In some cases listed species were found on not typical for them substrata (for example, *Physcia tenella* on *Pinus sylvestris*, on twigs and trunk of *Picea abies*, *Xanthoria parietina* on *P. sylvestris*, *X. fulva* on *P. abies*).

Frequency class 2 (4 species, 7%) includes lichen species that are locally common in different habitats but relatively rare in the sampled forests: *Evernia prunastri*, *Hypocenomyce scalaris* , *Tuckermannopsis chlorophylla*, *Usnea subfloridana*.

Frequency class 3 (3 species, 5%) includes lichen species common in old coniferous forests *Hypogymnia tubulosa*, *Imshaugia aleurites* and *Ramalina farinacea* found on twigs of spruces as well on trunks of deciduous trees.

Frequency class 4 (1 species, 2%) has only one relatively frequent species for *Picea abies*, *Pinus sylvestris* and *Betula* spp. – *Usnea hirta*.

Frequency class 5 (3 species, 5%) includes group of species that are typical for forests: *Platismatia glauca*, *Pseudevernia furfuracea*, *Vulpicida pinastri*.

Frequency class 6 (2 species, 4%) includes a frequent for several phorophytes lichen *Parmeliopsis ambigua,* and several species of *Cladonia* usually inhabiting on tree base but sometimes climbing up on trunk.

Frequency class 7 (2 species, 4%) includes multiregional and very frequent in forests *Hypogymnia physodes* and *Parmelia sulcata*.

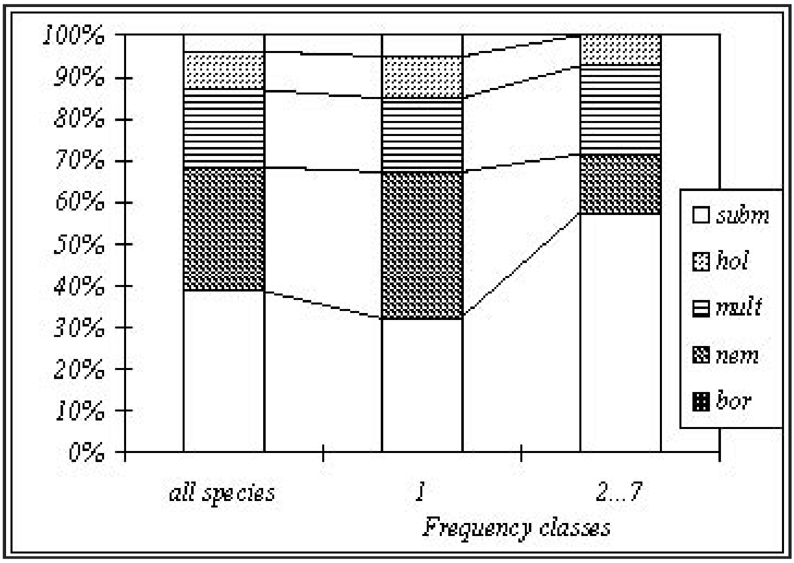


Fig. 3. Distribution of the epiphytic macrolichen species belonging to different geographic elements in the studied forests.

The sampled forests epiphytic macrolichen lichen flora (Fig. 3, column 1) consists of 39% boreal species, 30% nemoral species, 18% multiregional species, 9% holarctic species, and 4% submontaneous species.

Lichen species in the frequency class 1 belong to the 5 geographic elements (Fig. 3, column 2). In the higher frequency classes (2 to 7) species of the submontaneous geographic element were absent and the percentage of boreal and multiregional species was higher (Fig. 3, column 3).

DISCUSSION

Lichens are considered as excellent biomonitors of change in air quality, climate change, and change in the structure of the forest community. Indicative value of lichen communities variables, such as presence/absence, frequency, coverage, etc. has been recognized by many researchers (Alstrup, 1996; Goward, 1992; Kuusinen, 1994, 1996; McCune, 1993; Smith, et al., 1993; Trass, 1996).

Decreasing area and continuity and increasing fragmentation of forests due to forest management have led to the situation where many forest lichen species are in danger. For example, about half of the 138 endangered lichen species in Finland belong to the forest lichens (Kuusinen, 1996).

H. Trass (1997) presented the list of lichen species and their frequencies in 5 grade scale found in natural forests in Estonia. Most of macrolichens included in this list were recorded in present study but with lower frequency values (mostly in our frequency classes 1 and 2). It means that so-called indicator or typical species of the old or natural forests become rare in other forested areas. For example, such species are: *Bryoria capillaris, B. fuscescens, Hypogymnia farinacea, Lobaria pulmonaria, Melanelia fuliginosa, M. olivacea, Menegazzia terebrata, Parmeliopsis hyperopta, Tuckermannopsis sepincola, Usnea fulvoreagens, U. scabrata.* From 21 common species in these two studies only *Platismatia glauca* and *Vulpicida pinastri* had comparable values of the frequency.

Although the lichen species distribution and vegetation of the boreal forests has been studied quite extensively in Northern Europe, there is limited number of published data with which the present results can be compared.

P.-A. Esseen (1981) found 18 macrolichens on *Pinus sylvestris* and 24 on *Picea abies* in Central Sweden (middle and southern boreal subzones).

A. Sõmermaa (1972) surveyed the epiphytic lichen vegetation of several forest types in Estonia (hemiboreal zone, Ahti et al., 1968), where the number of epiphytic macrolichen species (except *Cladonia*) on *P. sylvestris* was 23, *P. abies* 19, on *Betula pendula* and *B. pubescens* 17, and 14 on *Alnus glutinosa.*

M. Hyvärinen et al. (1992) described 32 macrolichen species on *P. sylvestris* including 14 *Cladina* and *Cladonia* species, and 23 on *P. abies* including 8 *Cladonia* species.

Differences between the total numbers of epiphytic macrolichen species recorded by A. Sõmermaa, P.-A. Esseen and M. Hyvärinen et al. and in present study are relatively small, approximately 7 lichen species per tree species in average.

At the same time the comparison of the species percentage frequencies established in present study and presented by M. Hyvärinen et al. (1992) for Muhos (Oulu region, the middle boreal zone) showed considerable differences. From 14 common species only three found on pines (*Hypogymnia physodes, Parmeliopsis ambigua, Platismatia glauca*) and two found on spruces (*H. physodes, P. sulcata*) had close frequencies. In central part of Finland frequency values for most of the macrolichen species were higher than estimated in present study.

These differences could be explained partly by differnces in study site selection. M. Hyvärinen et al. (1992) as well A. Sõmermaa (1972) studied typical forests sites. In present study all sites were selected randomly and several forest plots were placed in transition areas.

The epiphytic lichen vegetation is known to differ greatly between branches and trunks of conifers (Pike et al., 1975, 1977). The trunks of *P. abies* receive less light, which could be the main reason for the greater abundance of macrolichens on their branches than on the trunks. We found in literature just one publication concerning lichen distribution on *P. abies* branches (Hilmo, 1994). She recorded 16 macrolichen species on *P. abies* branches in central Norway. Comparison is difficult because of *Bryoria* and *Usnea* species were not identified and she studied mean cover of the lichen species on branches. In present study 27 macrolichen species were found on *P. abies* twigs. It is interesting to point out that the similarity between macrolichen species on the *P. abies* twigs and *P. sylvestris* trunks was higher than between *P. abies* twigs and trunks (Sørensen's similarity coefficients respectively 0.8 and 0.76).

Most of the recorded lichen species (42 species or 74 %) had relatively low frequency (class 1). The most frequent lichen species in sampled forests belonged to the nemoral, boreal and multiregional geographic elements, which may be due to their wide amplitude to habitat conditions.

ACKNOWLEDGMENTS

The authors are grateful to colleagues H. Pärn and M. Temina for their cooperation during the field work. Also we owe thanks to T.Randlane, University of Tartu , for consultations in identification of some *Usnea* taxa and Oleg Blum, Central Botanical Garden of the Ukrainian National Academy of Sciences, for fruitful discussion of *Ramalina* species. The financial support has been received from the Bowling Green State University, US EPA, US DA Forest Service, and from the Estonian Ministry of the Environment to carry out Forest Monitoring Program.

REFERENCES

Ahti, T., Hämet-Ahti, L. & Jalas, J. 1968. Vegetation zones and their sections in northwestern Europe. *Ann. Bot. Fenn.* 5: 169–211.

Alstrup, V. 1996. Natural forests and endangered lichens in Denmark. In *IAL 3: Progress and Problems in Lichenology in the Nineties,* p. 43. Salzburg.

Esseen, P.-A. 1981. Host specifity and ecology of epiphytic macrolichens in some central Swedish spruce forests. *Wahlenbergia* 7: 73–80.

Forest Ecological Monitoring in the Baltic Countries. 1994. (Martin, J., ed.). 1996. Tallinn. 106 pp.

Forest Health Monitoring Field Methods Guide (International). US DA Forest Service, 1994, 1995, 1996.

Goward, T. 1992. Epiphytic lichens going down with trees. In *Proceedings of the Symposium "Community Action for Endangered Species"*, pp. 153–158. Vancouver, B.C., Canada.

Hilmo, O. 1994. Distribution and succession of epiphytic lichens on *Picea abies* branches in a boreal forest, central Norway. *Lichenologist* 26 (2): 149–169.

Hyvärinen, M., Halonen, P.& Kauppi, M. 1992. Influence of stand age and structure on the epiphytic lichen vegetation in the middle-boreal forests of Finland. *Lichenologist* 24: 165–180

Kuusinen, M. 1994. Epiphytic lichens flora and diversity on *Populus tremula* in old-growth and managed forests of southern and middle boreal Finland. *Ann. Bot. Fenn.* 31: 245–260.

Kuusinen, M. 1996. Effect of forestry on epiphytic lichen diversity in boreal forests of Finland. In *IAL 3: Progress and Problems in Lichenology in the Nineties,* p. 48. Salzburg.

Martin, J., Aaspõllu, J., Jaenes, A., Martin, L., Mehtijeva, N., Piin, T., Pärn, H., Tekko S., Vilde, R. & Virolainen, V. 1994. Atmospheric pollution deposition gradient studies in Estonia. In *Climate and Atmospheric Deposition Studies in Forests* (eds Solon, J., Roo-Zielinska, E. & Bytnerowicz, A.), pp. 117–136.

McCune, B. 1993. Gradients in epiphyte biomass in three Pseudotsuga-Tsuga forests of different age in Western Oregon and Washington. *Bryologist* 96: 405–411.

Overton, W. S., White, D. & Steven, D. L. 1990. *Design report for EMAP, Environmental Monitoring and Assessment Program,* I.

Pike, L. H., Denison, W. C., Tracy, D., Sherwood, M. & Rhoades, F. 1975. Floristic survey of epiphytic lichens and bryophytes growing on living, old-growth conifers in western Oregon. *Bryologist* 78: 391–404.

Pike, L. H., Rydell, R.A. & Denison, W. C. 1977. A 400-year-old Douglas fir tree and its epiphytes: biomass, surface area and their distribution. *Can. J. Forest Res.* 7: 680–699.

Randlane, T., Jüriado, I., Martin, J., Martin, L., Nilson, E. & Temina, M. 1997. Lichens of Naissaar Island (Gulf of Finland, Estonia). *Folia Cryptog. Estonica* 31: 20–25.

Santesson, R.1993. *The lichens and lichenicolous fungi of Sweden and Norway*. Lund. 240 pp.

Smith, C., Geiser, L., Gough, L., McCune, B., Ryan, B. & Showman, R. 1993. Species and communities. Chapter 4. In *Lichens as Bioindicators of Air Quality*. US DA Forest Service Gen. Tech. Rep. RM-224.

Sõmermaa, A. 1972. Ecology of epiphytic lichens in main Estonian forest types. *Scripta Mycol.* 4: 1–117.

Trass, H. 1970. The elements and development of the lichen flora of Estonia (in Russian). *Pap. on Bot.* 9: 5–233.

Trass, H.1996. Eesti põlislooduse taimekoosluste bioindikatsioon: teoreetilised alused, meetodid ja koosluste seisundi analüüs. Tartu Ülikooli Botaanika ja ökoloogia instituut, Eesti Teadusfond. (Manuscript, 47 pp.).

Trass, H. 1997. Lichen mapping in Europe: *Letharia vulpina*, *Menegazzia terebrata. Proc. Estonian Acad. Sci. Biol. Ecol.* 46: 4, 195–213.

Trass, H. & Randlane, T. (eds.) 1994. *Eesti suursamblikud.* Tartu. 399 pp.

Folia Cryptog. Estonica, Fasc. 32: 57–62 (1998)

Lichens of the islets of Kolga bay (Gulf of Finland, Estonia). I. Distribution and frequency of epiphytic lichen species

Eva Nilson[1] **and Taimi Piin**[2]
[1]Institute of Ecology, Tallinn University of Educational Sciences, 2 Kevade St., EE0001 Tallinn, Estonia
[2]Tallinn Botanic Garden, 52 Kloostrimetsa Rd., EE0019 Tallinn, Estonia

Abstract: Distribution and frequency of the most common epiphytic lichen species on five islets of Kolga bay (Gulf of Finland, Estonia) are described based on floristic data. The most wide-spread and frequent lichen species are those indicating eutrophication of bark substrate. Commonly overlooked crustose species are shown to be quite frequent, whereas some more easily detectable species common for pine in the mainland part of Estonia are rarely met on the islets studied. The similarity of epiphytic lichen flora of the islet pairs is briefly discussed, as compared to the data on vascular plants and bryophytes.

Kokkuvõte: E. Nilson ja T. Piin. Kolga lahe väikesaarte samblikud. I. Epifüütsete samblikuliikide levik ja sagedus.

Floristiliste andmete alusel kirjeldatakse epifüütsete samblike levikut ja sagedust Kolga lahe väikesaartel. Kõige sagedamini esinevad neil saartel epifüütsed liigid, mis viitavad puukoore eutrofeerumisele. Mitmed kooriksamblike liigid, mis kogumisel võivad jääda märkamata ja mida seetõttu on peetud harvaesinevaiks, osutusid materjali läbitöötamisel üsna sagedasteks, seevastu mõned Eesti mandriosas tavalised männil kasvavad samblikuliigid on Kolga lahe väikesaartel suhteliselt haruldased. Lühidalt on võrreldud saarte soon- ja sammaltaimede ning epifüütsete samblike floora sarnasust saarepaaride vahel.

INTRODUCTION

The lichen flora of the islands at the northern coast of Estonia was very poorly known until recently. During the Soviet time the islands belonged to the closed frontier zone and were nearly inaccessible for scientists. Up to now, the lichen species list is published for Naissaar (Randlane et al., 1997).

Kolga bay at the northern coast of Estonia has the greatest concentration of small islands (islets) in this area (Figure 1). The islets are situated between 59°30'–59°40'N and 25°10'–25°30'E. They belong to the landscape region of North-Estonian Coastal Lowland (Varep, 1964) and to the corresponding geobotanical region of Northern Maritime Estonia – *Estonia maritima borealis* (Lippmaa, 1935). Administratively the islets belong to the municipalities of Jõelähtme and Kuusalu, Harjumaa County.

The islets lie on Vendian and Cambrian sedimentary rocks covered with Quaternary deposits of various composition (Karukäpp & Malkov, 1993). The prevalent landforms are plains, escarpments, terraces and dunes. Northern and western coasts of the islets are characterised by presence of escarpments and coarse-grained

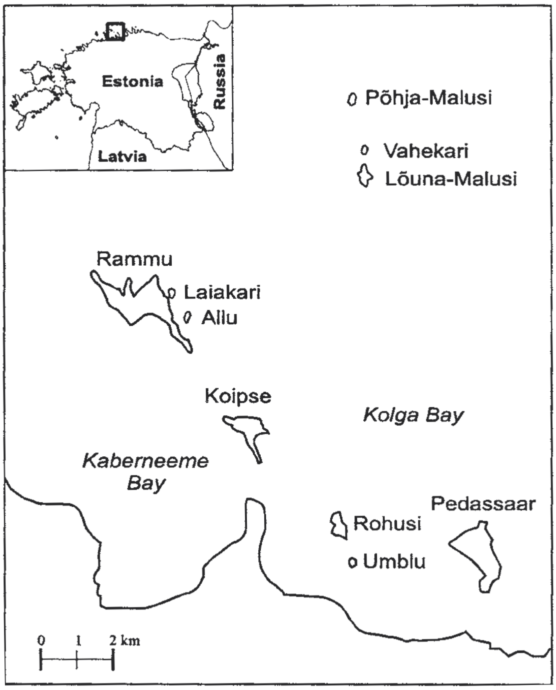


Fig. 1. Location of the islets of Kolga bay.

sediments (cobbles, boulders), while southern and eastern coasts are normally flat and sandy (Lepland, 1995). Parent material of soils (marine and aeolic sands, coastal deposits consisting much crystalline pebble) is poor in calcareous matter. Soils are mainly podzols, sod-podzolic soils, gley-podzols and saline littoral soils. Species diversity of flora and vegetation types of the islets depend on age, area, elevation a.s.l. and landscape diversity of the islets, as well as on their management history and the influence of seabird colonies (Ratas et al., 1995). Smaller islets (Allu, Põhja-Malusi, Vahekari and Umblu) carry heavily bird-influenced, fragmentary and sparse herbaceous vegetation. Various types of woody vegetation that make possible the occurrence of epiphytic lichens are met on five bigger islets (Lõuna-Malusi, Rohusi, Koipse, Pedassaar and Rammu).

A grove of young aspen trees (*Populus tremula* L.), some older trees of mountain ash (*Sorbus aucuparia* L.) and Scots pine (*Pinus sylvestris* L.), as well as a number of juniper *(Juniperus communis* L.) and elder (*Sambucus racemosa* L.) shrubs are met on Lõuna-Malusi. One third of the area of Rohusi island is covered with pine forest with the undergrowth of mountain ash and elder. Old trees of mountain ash, aspen, black alder (*Alnus glutinosa* L.) and goat willow (*Salix caprea* L.) are met on forest edges near the seashore. Woody vegetation is represented mostly by juniper scrub on Koipse. A grove of deciduous trees on this island consists of aspen and birch (*Betula pubescens* Ehrh.), while conifers are represented by some single trees of Scots pine and Norwegian spruce [*Picea abies* (L.) Karst.]. The *Calluna* – *Empetrum* heath in the southern part of the islet has been planted with pine seedlings in 1987–88. Pedassaar, the second largest islet of the group examined, has nearly 98% of its territory covered with dry pine forests with the undergrowth of mountain ash and juniper. Black alder, aspen, mountain ash and goat willow are met on forest edges. The largest islet, Rammu, carries two small pine groves of natural origin, surrounded by developing juniper scrub – one around a little lakelet in the central part and another on a long sandy spit extending to southeast. Deciduous trees are very scarce on this islet. The *Empetrum* heath in the eastern part of the islet is afforested with pine seedlings.

For the islets of Kolga bay the following lichen species are mentioned in earlier literature: *Cladina arbuscula* (Wallr.) Hale & W. L. Culb., *Cladina rangiferina* (L.) Nyl*.*, *Cladonia fimbriata* (L.) Fr. (Rebassoo, 1987); *Cetraria islandica* (L.) Ach*.*, *C. nivalis* (L.) Ach., *Tremolecia atrata* (Ach.) Hertel, *Xanthoparmelia mougeotii* (Schaer. ex D. Dietr.) Hale (Nilson & Piin, 1993); *Cyphelium lucidum* (Th. Fr.) Th. Fr. and *Peltigera scabrosa* Th. Fr. (Nilson et al., 1997).

In the 1990s the Kolga Bay Islets' Nature Reserve (consisting of ten islets) was established to protect breeding bird populations and rare or interesting plant communities. For conservation of any group of organisms basic information on distribution diversity and dynamics is needed. Representative data on the frequency of epiphytic lichens is of key importance when these organisms are used as bioindicators of air pollution or when Red Lists are to be established

Table 1. Area, elevation a.s.l. (Loopmann, 1996) and species number of vascular plants (Ploompuu, 1995), bryophytes (Ratas et al., 1995) and epiphytic lichens of the islets of Kolga bay

Islet	Area, ha	Max elevation, m	Vascular plants	Bryophytes	Epiphytic lichens
Rammu	102.6	4	229	68	29
Pedassaar	90.5	13	161	58	79
Koipse	34.3	7	189	65	68
Rohusi	12.5	6	175	44	74
Lõuna-Malusi	7.0	6	126	4	35
Põhja-Malusi	3.1	3	72	2	0
Allu	1.6	2	57	0	0
Umblu	1.6	3	50	0	0
Vahekari	0.6	2	36	0	0

Table 2. Distribution and frequency of the most common epiphytic lichen species on the islets of Kolga bay on different phorophytes

Lichen species	N	Island					Phorophyte*								
		Ra	Pe	Ko	Ro	LM	Pi	Ju	Al	Be	Po	Sal	Sam	So	Sy
Xanthoria polycarpa (Hoffm.) Th. Fr. ex Rieber	**295**	30	60	62	77	66	48	42	40	1	15	27	10	107	5
Hypogymnia physodes (L.) Nyl.	**288**	6	121	63	98		148	56	17	5		10	1	48	2
Scoliciosporum chlorococcum (Graewe ex Stenh.) Vêzda	**196**	7	82	46	60	1	88	26	21	2	8	10	2	31	6
Parmelia sulcata Taylor	**165**	5	72	40	46	2	37	19	27	4		16	4	55	3
Lecanora hagenii (Ach.) Ach.	**156**	10	43	28	36	39	21	26	26	1	11	14	2	54	1
Physcia tenella (Scop.) DC.	**141**	10	27	28	53	23	3	2	34	1	5	14	7	69	6
Lecanora carpinea (L.) Nyl.	**95**	5	33	19	19	19		3	11	3	7	8		61	2
Lecidella elaeochroma (Ach.) M. Choisy	**89**	3	24	9	32	21		1	22		8	14		39	5
Physcia stellaris (L.) Nyl.	**86**	8	15	22	29	12	4	12			12	15	4	37	2
Lecanora symmicta (Ach.) Ach.	**77**	5	30	21	16	5	19	21	7	1	6	5	1	15	
Lecanora pulicaris (Pers.) Ach.	**67**	3	19	30	15		28	32		1	3			3	
Lecanora expallens Ach.	**59**		24	4	30	1	56		3						
Ramalina farinacea (L.) Ach.	**49**	3	9	4	32	1	20		8	2		7	1	11	
Xanthoria parietina (L.) Th. Fr.	**48**	2	2	14	12	18			3		8	7	1	23	6
Catillaria nigroclavata (Nyl.) Schuler	**44**	1	28	1	10	4	42		1					1	
Amandinea punctata (Hoffm.) Coppins & Scheid.	**41**	1	8	4	22	6	14	1	19			3		4	
Xanthoria candelaria (L.) Th. Fr.	**41**	6		9	8	18	5	1	10			1	6	18	
Melanelia olivacea (L.) Essl.	**35**	3	17	7	8		11	4	7			1		11	
Rinodina pyrina (Ach.) Arnold	**34**	1	17	7	8	1		3	4		6	3	1	16	
Hypogymnia tubulosa (Schaer.) Hav.	**33**		17	8	8		10	3	6			1	2	11	
Usnea hirta (L.) Weber ex Wigg.	**31**		16	8	7		24	7							
Evernia prunastri (L.) Ach.	**30**		16	2	12		20	2	2			2		4	
Melanelia exasperata (De Not.) Essl.	**29**	2	6	2	19		1	1			3	5		18	1
Ramalina fraxinea (L.) Ach.	**29**	2	3	4	12	8			6		3	3	1	15	1
Rinodina sophodes (Ach.) A. Massal.	**25**		3	3	15	4		3	6		2	3		10	1
Tuckermannopsis chlorophylla (Willd.) Hale	**22**		5		17		19		2					1	
Tuckermannopsis sepincola (Ehrh.) Hale	**18**		4	14			3	14							
Melanelia exasperatula (Nyl.) Essl.	**17**		3	1	12	1	3		3			2		8	1
Physcia dubia (Hoffm.) Lettau	**15**	8	1		3	3			6			1		8	

Table 2 (continued)

Lichen species	N	Island					Phorophyte*								
		Ra	Pe	Ko	Ro	LM	Pi	Ju	Al	Be	Po	Sal	Sam	So	Sy
Cliostomum griffithii (Sm.) Coppins	**13**		1		8	4	8							5	
Physcia adscendens (Fr.) H. Olivier	**13**	1		3	3	6					2	1	2	8	
Vulpicida pinastri (Scop.) J.-E. Mattsson & M. J. Lai	**13**		4	5	4		5	6		1					
Lecanora chlarotera Nyl.	**12**	2	3	3	4				1	1	3	3		4	
Phaeophyscia orbicularis (Necker) Moberg	**11**			5	2	4					7			4	
Lecanora varia (Hoffm.) Ach.	**8**		1		7		8								
Parmeliopsis ambigua (Wulfen) Nyl.	**8**		8				7								
Chaenotheca ferruginea (Turner & Borrer) Mig.	**7**		5		2		7								
Pseudevernia furfuracea (L.) Zopf	**7**		4	1	2		5						1	1	
Ramalina fastigiata (Pers.) Ach.	**7**				6	1			3			2		2	
Cyphelium lucidum (Ach.) Ach.	**6**		2		4		6								
Melanelia fuliginosa (Th. Fr.) Th. Fr.	**6**		5	1			1		4					1	
Bryoria fuscescens (Gyelnik) Brodo & D. Hawksw.	**5**		2	2	1		3	2							
Lecanora leptyrodes (Nyl.) Degel.	**5**			1	1	3		1			1			3	
Physconia distorta (With.) J.R. Laundon	**5**				5						1	2		2	

Abbreviations:
N, total number of records (both as main and accompanying species)
Islets: Ra, Rammu; Pe, Pedassaar; Ko, Koipse; Ro, Rohusi; LM, Lõuna-Malusi
Phorophytes: Pi, *Pinus sylvestris*; Ju, *Juniperus communis*; Al, *Alnus glutinosa*; Be, *Betula* spp.; Po, *Populus tremula*; Sal, *Salix caprea*; Sam, *Sambucus racemosa*; So, *Sorbus aucuparia*; Sy, *Syringa vulgaris;* * records on *Calluna* and *Empetrum* are not included.

(Dietrich & Scheidegger, 1997). The first part of our lichen studies on the islets of Kolga bay deals with distribution and frequency of most common epiphytic lichens, based on floristic data. The similarity of epiphytic lichen flora of different islets is briefly discussed, as compared with the data on vascular plants and bryophytes.

MATERIAL AND METHODS

The material (820 herbarium specimens) was collected on the islands of Kolga bay mostly in 1991 and 1993 and is kept in the Herbarium of Tallinn Botanic Garden (TBA). Each piece of bark was examined carefully and not only the species for what it was collected, but all accompanying species were identified or recorded as well. In all 2890 identifications and checking of epiphytic lichens (140 species) were made by the second author. The nomenclature of lichen species follows mainly Santesson (1993).

The lichens were collected on 9 woody plant species: *Pinus sylvestris* (57 trees), *Juniperus communis* (10), *Sorbus aucuparia* (21), *Populus tremula* (5), *Alnus glutinosa* (5), *Betula pubescens* (2), *Salix caprea* (5), *Syringa vulgaris* (1), *Sambucus racemosa* (1), altogether on 109 trees or shrubs.

Some numeric characteristics of the islets of Kolga bay, the number of epiphytic lichen species recorded on each islet included, are represented in Table 1.

RESULTS AND DISCUSSION

The highest number of corticolous lichen species has been recorded from the islets of Pedassaar (79) and Rohusi (74) that are covered with forest in great extent.

Table 2 includes more frequent lichen species (5 or more records), showing their distribution on the islets and on the most common phorophytes. *Sorbus aucuparia, Pinus sylvestris* and *Alnus glutinosa* are the phorophytes that carry the highest number of lichen species. *Lecanora hagenii, L. symmicta, Physcia tenella, Scoliciosporum chlorococcum* and *Xanthoria polycarpa* are ubiquitous lichen species inhabiting the islets of Kolga bay. They are met on all kinds of phorophytes on all islets. The named species belong to the rich bark species (Du Rietz, 1945) and their occurrence on normally nutrient-poor and acidic bark (incl. that of conifers) indicates bark eutrophication under the influence of sea-water aerosols and ammonia derived from bird excrements. *Hypogymnia physodes* and *Parmelia sulcata* are also very frequent and are found on their usual bark substrates, as well as on boulders and on sand of coastal grey dunes.

Table 3. The similarity of vascular plant flora (Sørensen's similarity coefficient, %, left bottom) and number of species in common (top right) on four islets of Kolga Bay. Abbreviations of the islet names see Table 2.

Islet	Ra	Pe	Ko	Ro
Ra	=	109	130	118
Pe	56	=	101	103
Ko	62	58	=	119
Ro	58	61	65	=

Table 4. The similarity of bryophyte flora (Sørensen's similarity coefficient, %, left bottom) and number of species in common (top right) on four islets of Kolga Bay. Abbreviations of the islet names see Table 2.

Islet	Ra	Pe	Ko	Ro
Ra	=	24	33	24
Pe	46	=	33	30
Ko	61	64	=	27
Ro	50	65	56	=

Table 5. The similarity of epihytic lichen flora (Sørensen's similarity coefficient, %, left bottom) and number of species in common (top right) on five islets of Kolga Bay. Abbreviations of the islet names see Table 2.

Islet	Ra	Pe	Ko	Ro	LM
Ra	=	26	29	27	20
Pe	44	=	44	51	26
Ko	53	53	=	49	27
Ro	48	87	61	=	32
LM	60	42	50	55	=

Owing to careful examination of every piece of bark, many crustose species, such as *Amandinea punctata, Catillaria nigroclavata, Cliostomum griffithii, Rinodina pyrina, R. sophodes,* that could be easily overlooked in field are recorded with quite high frequency. Some easily detectable epiphyte species, characteristic to pine in the mainland part of Estonia, such as *Chaenotheca ferruginea, Hypocenomyce scalaris* (Ach.) M. Choisy, *Parmeliopsis ambigua, Platismatia glauca* (L.) W.L. Culb. & C.F. Culb., *Pseudevernia furfuracea* and *Vulpicida pinastri* were rarely met on pines on the islets of Kolga bay.

Similarities of vascular plant and bryophyte floras are compared between four islands (Tables 3 and 4), Lõuna Malusi is left out. The island is inhabited with large seabird colonies that have influenced the vegetation heavily by trampling and manuring, so the species diversity of ground vegetation is much lower on Lõuna Malusi than on other islets (see Table 1). As epiphytic lichens are more independent on bird activities, Lõuna Malusi is included into the analysis of similarity of lichen floras (Table 5).

The data in the Table 3 allows to conclude that there are no big differences between the Sørensen's coefficients of similarity between the islets in regard of the composition of vascular plant floras. The most dissimilar are floras of Rammu and Pedassaar. It concerns vascular plants (similarity 56 %), as well as bryophytes (46%) and epiphytic lichens (44%). These two largest islets have nearly equal areas, but differ largely in landscape diversity and dominant vegetation types (Ratas et al., 1995). The most similar are the bryophyte (65%) and especially the epiphytic lichen (87%) floras of Pedassaar and Rohusi islets, although the area of Rohusi is less than 1/8 of Pedassaar. Pine forest is dominant and fairly extensive on both islets and the same species of deciduous trees are spread on forest edges along the shoreline.

ACKNOWLEDGEMENTS

Thanks are due to Mari Sarv for identification and verification of *Rinodina* species, to Leiti Kannukene for making available unpublished data on bryophytes and to Laimdota Truus for preparing the map. Financial support from the Environmental Department of Harjumaa County Government is gratefully acknowledged.

REFERENCES

Dietrich, M. & Scheidegger, C. 1997. Frequency, diversity and ecological strategies of epiphytic lichens in the Swiss Central Plateau and Pre-Alps. *Lichenologist* 29: 237–258.

Du Rietz, E. 1945. Om fattigbark- och rik-barksamhällen. *Svensk Bot. Tidskr.* 39: 147–148.

Karukäpp, R. & Malkov, B. 1993. Pinnamood. (Summary: Bottom topography). In *Geology of the Estonian shelf* (eds Lutt, J. & Raukas, A.), pp. 22–29. Tallinn.

Lepland, A. 1995. Kolga lahe saarte randade geoloogia (Summary: Coastal geology of the islands of the Kolga Bay). *Eesti Looduseuurijate Seltsi Aastaraamat* 76: 109–136.

Lippmaa, T. 1935. Eesti geobotaanika põhijooni. *Acta Comm. Univ. Tartuensis* A 28: 1–151.

Loopmann, A. 1996. *Eesti meresaarte nimestik.* Tallinn. 84 pp.

Nilson, E., Kannukene, L., Truus, L., Ratas, U., Puurmann, E. & Tobias, M. 1997. Biological diversity. In *Small islands of Estonia. Landscape ecological studies* (eds Ratas, U. & Nilson, E.) *Inst. of Ecol. Publ.* 5: 131–179. Tallinn.

Nilson, E. & Piin, T. 1993. Kuni 300 samblikuliiki. *Eesti Loodus* 4: 140.

Ploompuu, T. 1995. Harjumaa klindieelsete saarte soontaimed (Summary: Vascular plants of the preglint islands of the Harjumaa county). *Eesti Looduseuurijate Seltsi Aastaraamat* 76: 15–49.

Randlane, T., Jüriado, I., Martin, J., Martin, L., Nilson, E. & Temina, M. 1997. Lichens of Naissaar Island (Gulf of Finland, Estonia). *Folia Cryptog. Estonica* 31: 20–25.

Ratas, U., Nilson, E., Truus, L.& Kannukene, L. 1995. Development of landscapes on the islands of the Kolga Bay. *Eesti Looduseuurijate Seltsi Aastaraamat* 76: 137–163.

Rebassoo, H. 1987. *Biocoenoses of Eastern Baltic islets, their composition, classification and protection.* II (in Russian). Tallinn. 142 pp.

Santesson, R. 1993. *The lichens and lichenicolous fungi of Sweden and Norway.* Lund. 240 pp.

Varep, E. 1964. The landscape regions of Estonia. *TRÜ Toimetised* 156, *Geograafia-alaseid töid* IV: 3–28.

Folia Cryptog. Estonica, Fasc. 32: 63–66 (1998)

Athelia arachnoidea, a lichenicolous basidiomycete in Estonia

Erast Parmasto
Institute of Zoology & Botany, Estonian Agricultural University, 181 Riia St., EE 2400 Tartu, Estonia

Abstract: *Athelia arachnoidea* (Berk.) Jülich is a frequent lichenicolous basidiomycete that often grows in Estonia in towns and along roadsides, and destroys epiphytic algae and lichens. In "wild" forests it has not been detected in Estonia. Mycelium growth is extremely vigorous in winter, at about 1–3 °C. The fungus distributes probably with small white sclerotia, spore-bearing basidia have been noticed only rarely. Anamorphic state of this species, *Fibulorhizoctonia carotae* (Rader) G. Adams & B. Kropp is a cold-storage pathogen of carrot; it has not been found in Estonia.

Kokkuvõte: E. Parmasto. Parasiitnahkis (*Athelia arachnoidea*), samblikel kasvav kandseen Eestis.

Athelia arachnoidea (Berk.) Jülich on Eesti linnades, asulates ja teeäärtes üha sagedasem parasiitseen, mis rõngana laiemaks kasvades hävitab puutüvedel vetikaid ja mitmeid samblikuliike. Metsades pole sellist kahjustust Eestis seni täheldatud. Seeneniidistiku kasv on eriti intensiivne talvel sulailmaga, kui õhu temperatuur on vaid 1–3 °C. Seen levib meil tõenäoliselt peamiselt väikeste valgete sklerootsiumide abil, eoseid produtseerivaid viljakehasid on täheldatud väga harva. *A. arachnoides*'e anamorf *Fibularhizoctonia carotae* (Rader) G. Adams & B. Kropp tekitab porgandite külmsäilitamisel nende haigestumist; Eestist teda seni leitud pole.

INTRODUCTION

In Estonian towns and along roadsides, thalli of *Xanthoria parietina*, *Physcia tenella* and several other lichens are sometimes "moldy", damaged by a fungus. I have seen such lichens since 1943 when Hans Trass and me studied lichens together in our hometown Nõmme and avoided collecting such "bad" specimens. Only decades later I found out that the "mold" is not less interesting than its host lichens.

TAXONOMY

Athelia arachnoidea (Berk.) Jülich, Willdenowia Beih. 7: 53 (1972). Basionym: *Corticium arachnoideum* Berk., Ann. Mag. Nat. Hist. 13: 345 (1844); syn.: *Hypochnus bisporus* J. Schröt., Pilze Scles. 3 (1): 415 (1888), *Athelia epiphylla* Pers., Mycol. Eur. 1: 84 (1822) sensu auct. plur. **Anamorph:** *Fibularhizoctonia carotae* (Rader) G. Adams & B. Kropp, Mycologia 88 (3): 464 (1996); basionym: *Rhizoctonia carotae* Rader, Phytopathology 38: 444 (1948).

Good descriptions and figures: Jülich, 1972: 53, Fig. 8; Eriksson & Ryvarden, 1973: 103, Fig. 37; Poelt, 1975, Fig. 1; Arvidsson, 1976, Fig. 1; Gilbert, 1988, Fig. 1.

Damaged by the fungus lichens and algae, but also surrounding tree bark is covered with thin and loose cobweb-like (arachnoid) white or slightly creamish mycelium. Later small white spherical granules ("sclerotia") 0.2–0.7–(1) mm in diam. develop on mycelium in groups. Basidioma (fruit-body) of the fungus is similar but covered with thin pellicle formed by basidia. Microscopically both mycelium and basidioma consist of loosely interwoven thin-walled hyphae 3–7 µm in diam., which are branched under right angle; septa numerous, without clamps or with few clamps mainly on basal hyphae. The hyphae attached to and near the algal cells are up to 8 µm in diam., richly branched, somewhat torulose and with slightly monilioid short side-branches. At the margin of a mycelium there are some straight very long hyphae. Basidia are clavate, 20–30 × 5–7 µm, with 2–4 (mainly 2) sterigmata. Spores are narrowly ellipsoid, thin-walled, 7–9–(10) × 3.5–5 µm.

Basidiomata have been described in several monographs and key books without mentioning characteristic small white sclerotia. Reason for such an omitting is simple: only full-developed basidiomata have been described not paying attention to the surrounding these marginal area of aerial mycelium.

Hyphae of this species have been described and figured as smooth, i. e. without crystals. In all specimens studied by me (about 30), several or many hyphae of mycelium, but sometimes also of basidiomata, are covered with short rode-like crystals of calcium oxalate-dihydrate as shown in Adams & Kropp (1996: 464, Fig. 5).

RESULTS

Distribution and hosts in Estonia

A. arachnoidea has been found in almost all suitable places where it was searched for (Parmasto, 1995; Fig. 1). Typical localities are living trunks of deciduous trees (mainly *Tilia cordata*) and dead twigs of *Syringa vulgaris* on roadsides, at alleys and in parks. It is growing on many lichen species and protococcoid algae; *Xanthoria parietina* (L.) Th. Fr. and *Physcia tenella* (Scop.) DC. are the most common hosts in Estonia; it has been found also on *Anaptychia ciliaris* (L.) Körb., *Lecanora conizaeoides* Nyl., *Melanelia exasperatula* (Nyl.) Essl., *Parmelia sulcata* Taylor, *Physconia distorta* (With.) J.R. Laundon.

A. arachnoidea has been seen since the 40ies of this century in Estonia but was never so widespread as during the last 5–8 years. For example, in Tartu more and more trees covered with lichens and algae are infected since the beginning of the 90ies. This is possibly caused by relatively warm winters with frequent and long thaw periods.

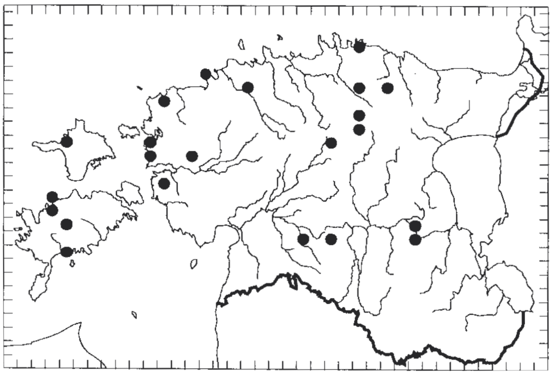


Fig. 1. Localities of *Athelia arachnoidea* in Estonia.

Cycle of development

Late autumn and in winter, mycelium of *A. arachnoidea* is frequently seen on tree trunks as glittering white circles up to 40 cm long (Fig. 2); sometimes these circles unite and form an infected area up to 5 m along a trunk. When it is thawing after severe frosts, the circles appear again after some few days. In this stage, mycelium is web-like, loose, in many cases with white loose sclerotia turning brownish, and more compact later. Hyphae are always covered with numerous crystals; no basidia or free spores were seen.

We have no collections of this species before May, but possibly they survive. From July, mycelium can be seen on lichens again. Pellicular hymenium with developed and spore-bearing basidia has been seen in 3 specimens (of 30), namely in August and September. First, usually small and white sclerotia can be seen rarely in August, frequently in September and later.

DISCUSSION

Taxonomy of the *Athelia epiphylla*-complex is unclear; several species have been described based on small differences in spore form and size without any statistical study on variability of these characters. Under the name *A. arachnoidea* fungi growing parasitically on lichens or algae, and on wood (bark) have been united.

There is also another species found sometimes on lichens, *A. epiphylla*. Main difference between these species is that basidia of *A. arachnoidea* have usually two sterigmata (and spores), *A. epiphylla* – four. This is a vague character: most of the specimens growing on lichens and algae are sterile, i. e. without basidia and spores. Among Estonian specimens there are some with almost equal number of 2- and 4-spored basidia (TAA 152154, 152433).

The specimens collected in Estonia are similar to each other, and support J. Eriksson's (in Arvidsson, 1976) and Arvidsson's idea that only one species in this species group is growing on lichens and algae, characterized by the production of sclerotia. Correct name for this taxon is *A. arachnoidea*: its type was "creeping over mosses and lichens on fallen sticks". However, this species has been found also on

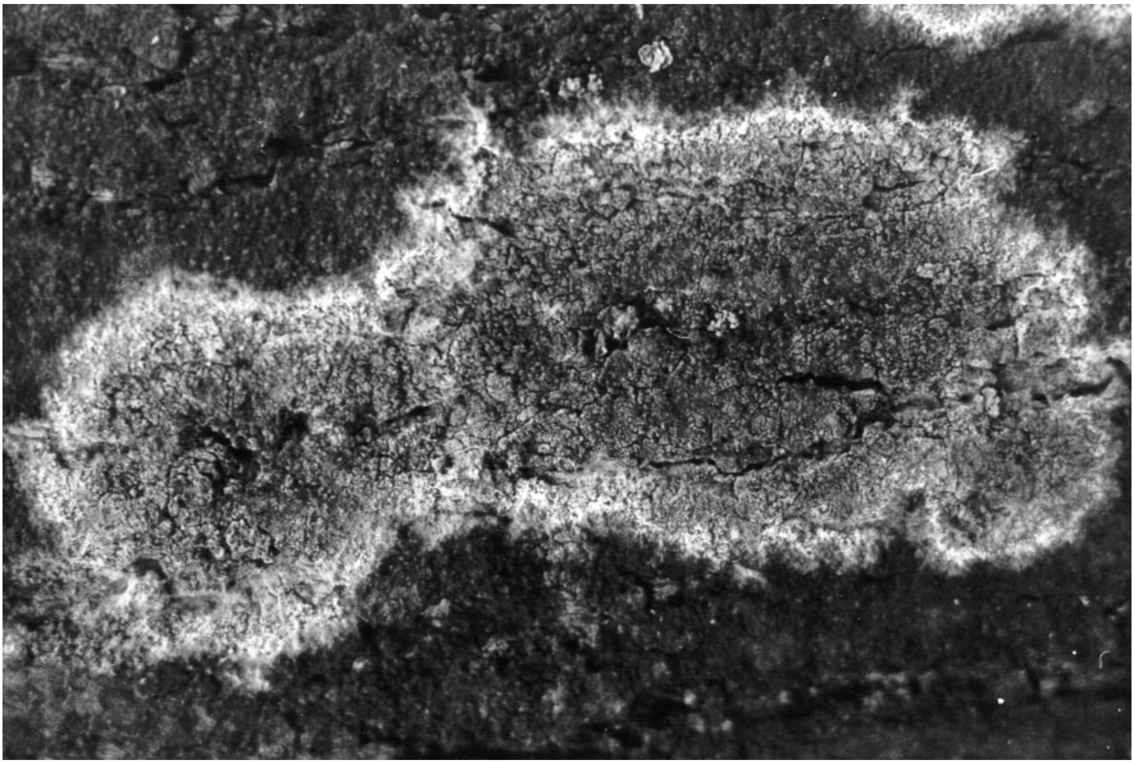


Fig. 2. White-margined lesions on algal cover on a lime tree, formed by *Athelia arachnoidea.* Tartu, 18 Jan 1998. Photo by E. Parmasto.

dead leaves of deciduous trees, and I have seen it spreading from lichens to surrounding tree bark and wood.

Diederich (1986) mentioned that he had not seen specimens with fructifications (= specimens with developed hymenium) in Luxembourg. During two-years' observations in Sheffield area (Great Britain), Gilbert (1988) did not observe any spores produced by this fungus. In Estonia, of the 30 specimens studied only one has quite well developed hymenium. Possibly the main way of distribution in this species is by sclerotium-like propagula which are loosely attached to mycelium, as said already by Poelt (1975: 7).

There are two ecological peculiarities in *A. arachnoidea*. In Estonia, it has been found only in anthropogenic localities, never in "wild" forests. According to Arvidsson (1976: 7), "the parasite appears to be less common outside towns or in areas with no air pollution". Poelt & Jülich (1969) described it as found in Berlin, but also in forests near the city. Only in England, the fungus is widespread in open woodland as well as in valley bottoms (Gilbert, 1998: 183).

Another interesting feature is vigorous growth of its mycelium at low air temperature (in Estonia, at about 1–4 °C in winter). Air pollution and low temperature seem to weaken lichens and algae infected thereafter with *A. arachnoidea*. In England, radial extension of the mycelium occurred only during the winter months from November to February (Gilbert, 1988: 185).

As demonstrated by Adams & Kropp (1996), anamorphic state of this species, *Fibulorhizoctonia (Rhizoctonia) carotae* is a cold-storage pathogen of carrot in Europe, North America and India, developing mainly at temperature 1–3 °C and 92–96 % relative humidity. These environmental conditions are the same as for development of the fungal mycelium and sclerotia on lichens in Estonia in wintertime. Occurrence of *A. arachnoidea* as an agent causing crater rot of carrot roots in their storage has not yet been studied in Estonia.

ACKNOWLEDGEMENTS

The author of this paper is greatly indebted to Dr Tiina Randlane for identification of several lichen species – hosts of *A. arachnoidea*, and to Dr Alan Morton for providing his mapping program DMAP for WINDOWS.

REFERENCES

Adams, G. C. & Kropp, B. R. 1996. *Athelia arachnoidea*, the sexual state of *Rhizoctonia carotae*, a pathogen of carrot in cold storage. *Mycologia* 88 (3): 459–472.

Arvidsson, L. 1976. *Athelia arachnoidea* (Berk.) Jül. and its influence on epiphytic cryptogams in urban areas. *Göteborgs Svampklubb Årsskrift* 1975–76: 4–10.

Diederich, P. 1986. Lichenicolous fungi from the Grand Duchy of Luxembourg and surrounding areas. *Lejeunia* II 119: 1–26.

Eriksson, J. & Ryvarden, L. 1973. *The Corticiaceae of North Europe.* Vol. 2. Fungiflora, Oslo. Pp. 57–261, pl. 1–24.

Gilbert, O. L. 1988. Studies on the destruction of *Lecanora conizaeoides* by the lichenicolous fungus *Athelia arachnoidea*. *Lichenologist* 20 (2): 183–190.

Jülich, W. 1972. Monographie der Athelieae (Corticiaceae, Basidiomycetes). *Willdenowia Beih.* 7: 3–283.

Parmasto, E. 1995. Nõiaringid puutüvedel. *Eesti Loodus* 1: 23.

Poelt, J. 1975. Basidioflechten eine in den Alpen lange übersehene Pflanzengruppe. In *Jubiläumsjahrbuch 1900–1975, 40. Band des Vereins zum Schutze der Alpenpflanzen und -Tiere e. V. München,* pp. 1–16.

Poelt, J. & Jülich, W. 1969. Über die Beziehungen zweier corticioider Basidiomyceten zu Algen. *Österr. Bot. Z.* 116: 400–410.

Folia Cryptog. Estonica, Fasc. 32: 67 (1998)

The first record of *Ochrolechia szatalaënsis* in Estonia

Taimi Piin[1] & Lea Lensment[2]
[1] Tallinn Botanic Garden, 52 Kloostrimetsa Rd., EE0019 Tallinn, Estonia
[2] Tallinn University of Educational Sciences, 25 Narva Rd., EE0001 Tallinn, Estonia

Abstract: *Ochrolechia szatalaënsis* Verseghy is reported for the first time from Estonia, lichen was found on bark of *Acer platanoides*.

Kokkuvõte: T. Piin ja L. Lensment. Sambliku *Ochrolechia szatalaënsis* esmasleid Eestis.

Esmakordselt teatatakse *Ochrolechia szatalaënsis* Verseghy leiust Eestis, samblik kasvas vahtra (*Acer platanoides*) koorel.

Ochrolechia szatalaënsis Verseghy was described from Bulgaria (Verseghy, 1958). An improved, detailed description was given by I. M. Brodo (1991).

This corticolous lichen has an oceanic and suboceanic distribution in Holarctic Kingdom: Boreal and Tethyan Subkingdoms. *O. szatalaënsis* prefers bark of conifers (*Picea*, *Abies*) in Central and Southern Europe and bark of deciduous trees (*Sorbus*, *Salix*, *Betula*, *Quercus*, *Corylus*) in Western and Northern Europe (Purvis et al., 1994). The species occurs in western North America on bark and wood of different kinds including *Betula*, *Alnus*, *Quercus*, *Pseudotsuga*, and *Thuja* (Brodo, 1991). The nearest locations of this species to Estonia are in Gotland, Sweden (Santesson, 1993).

The second author collected *O. szatalaënsis* in the northern part of our country, Raplamaa Co., in the vicinity of Märjamaa settlement (60 km south of the Gulf of Finland; 58°54'N 24°26'E) during a bioindication study in 1994. The specimen examined was found on the stem bark of *Acer platanoides* L. (exposition S, at the height of 1.5 m, not abundant) in Märjamaa Orthodox Cemetery (Herbarium of Tallinn Botanic Garden, TBA). The associated species included *Lecidella elaeochroma* (Ach.) M. Choisy and *Pertusaria leucostoma* A. Massal.

O. szatalaënsis belongs to the *upsaliensis*-group of *Ochrolechia* following I. M. Brodo (1991). Its good diagnostic features are the almost white, thin thallus, white-pruinose apothecia and discs (all UV+ and C+ yellow). This species is closely related to *O. upsaliensis* (L.) Massal., a common arctic-alpine terricolous lichen species.

We suppose that this species belongs by its distribution pattern to holarctic suboceanic element in the lichen flora of Estonia (Trass, 1970).

The detailed description of the specimen will given in future together with other *Ochrolechia* species in Estonia which are just under revision. The following species of *Ochrolechia* A. Massal. have been published for Estonia in former times: *O. alboflavescens* (Wulfen) Zahlbr., *O. androgyna* (Hoffm.) Arnold, *O. arborea* (Kreyer) Almb., *O. frigida* (Sw.) Lynge, *O. microstictoides* Räsänen, *O. pallescens* (L.) A. Massal. and *O. turneri* (Sm.) Hasselrot (Trass, 1970; Ekman et al., 1991).

REFERENCES

Brodo, I. M. 1991. Studies in the lichen genus *Ochrolechia*. 2. Corticolous species of North America. *Canad. J. Bot.* 69: 733–772.

Ekman, S., Fröberg, L., Kärnefelt, I., Sundin, R. & Thor, G. 1991. New or interesting lichens from Estonia. *Folia Cryptog. Estonica* 28: 1-32.

Purvis, O.W., Jørgensen, P. M., Coppins, B. J. 1994. *Ochrolechia szatalaënsis* Vers., new to Great Britain and Ireland. *Lichenologist* 26: 393–397.

Santesson, R. 1993. *The lichens and lichenicolous fungi of Sweden and Norway*. SBT-förlaget, Lund. 240 pp.

Trass, H. 1970. The elements and development of the lichen-flora of Estonia (in Russian). *Pap. Bot.* 9: 5–233.

Verseghy, K. 1958. Studien über die Gattung *Ochrolechia* II. Neue Flechten. *Ann. Hist.-Nat. Mus. Natl. Hung.* 50: 76–85.

Folia Cryptog. Estonica, Fasc. 32: 69–73 (1998)

Deterioration of the lichen flora in the National Nature Reserve Rozsutec (the Malá Fatra Mts, Slovakia)

Ivan Pišút & Anna Guttová
Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 14, SK-84223, Bratislava, Slovakia

Abstract: So far 273 lichen taxa have been listed from the territory. The analysis of the results gathered in the course of the 1970s within the area of Vel'ký Rozsutec Mt., the Malá Fatra Mts, demonstrated intensifying antropogenous pressure. The contemporary research (1996–1997) confirmed 124 species, recorded 55 taxa new to the area and gave evidence of threat of 59 lichens (21.7%), enrolled in the local red list presented here. The process of impoverishment affects mainly epiphytes dependent on air humidity and the alpine muscicolous and terricolous taxa concentrated about the summit. Over the period of elapsed 25 years several toxitolerant, acidofilous and nitrofilous species emerged.

Kokkuvõte: I. Pišút ja A. Guttová. Lihhenofloora vaesustumine Rozsuteci looduskaitsealal (Malá Fatra, Slovakkia).

Kokku on looduskaitsealalt teada 273 samblikuliiki. 70-ndatel a-tel läbiviidud uurimus viitas tugevale antropogeensele survele. Käesoleva töö (1996-1997) käigus täheldati 124 liigi esinemist ja leiti 55 piirkonnale uut liiki; 59 samblikuliiki (21,7%) tuleb pidada ohustatuks ning need lülitati kohalikku punasesse nimekirja. 25 viimase aasta jooksul on lisandunud paljud vähetundlikud, happe- ja lämmastikulembesed liigid .

INTRODUCTION

The National Nature Reserve (NNR) Rozsutec (734.74 ha), situated in the northern part of the Malá Fatra Mts, covers up the geobiological complex of the landscape dominant Vel'ký Rozsutec Mt. Its crest is built of dolomite and limestone both forming vivid mosaic of rock faces. The lower parts are of calcareous sandstone and schist. The vast area stretches within the altitude limits from 600 to 1610 m. The beech and fir forest formations, relict mountain maple woods and mountain pine belt with scattered spruce keep their natural character to a significant extent (Klinda, 1985). The average annual precipitation falls vary from 900 to 1000 mm; the average annual temperature amounts are from 2 to 5°C (Intribus, 1981).

The NNR Rozsutec is exhaustively examined. The first notes date back to the second half of the 19th century (Brancsik, 1862). More intensive investigation started in the 1920s and 1930s (Servít, 1954; Servít and Cernohorský, 1935; Suza, 1926, 1934, 1943, 1944) and then in the 1960s and 1970s (Pišút, 1966, 1968, 1969, 1971, 1974; Vêzda, 1958, 1965a, 1965b, 1970, 1972, 1973, 1978). The collective information on the local lichenflora was presented by Pišút (1981). By 1973, 218 species were recorded (Pišút, 1981, 1992, 1996). In the meantime, the antropogenous influence upon this domain, exposed in terms of orography and tourism, increased.

MATERIAL AND METHODS

The study is based on two field visits in 1996 and 1997. The observations were guided by the steps given in Pišút (1981). The research conducted after 25 years is comparable. Floristic knowledge is updated as well. The species with localities are listed in Pišút & Guttová (1998, in press). Moreover, the adjacent area (the Vrátna dolina valley, Štefanová and Zázrivá villages) is included. Regarding the changes in the diversity of the lichenflora, which no way could be neglected, the local red list (Table 1) is elaborated. Material from BRA, SAV and SLO was studied and revised.

The nomenclature as well as the categories of threat follow Pišút et al. (1996). The figures in the Tables 2, 3, 4 giving the number of species in the NNR and the surroundings, cannot be added up to obtain the total number, as some of the taxa occur in both areas.

The specimens collected are at disposal at the Institute of Botany, Slovak Academy of Sciences, Bratislava (SAV).

RESULTS AND DISCUSSION

The isolated massif of Veľký Rozsutec Mt. (alt. 1606 m) functions as a natural barrier to emission particles transported mostly by north-western winds. While in the first quarter of the 20th century this factor played minor role (the only eventual source of pollutants was Zilina, a town 26 km westward, with a population of less than 10,000 then), the 1950s were the turning point. Since 1952 Veľký Rozsutec Mt. has been attacked from smelters in Istebné (10 km SE), since 1965 from Široká (18 km E) and a couple of decades by emission generated in chemical, textile and power supply industries as well as engineering of 100,000-inhabitant Zilina. Veľký Rozsutec Mt., the distinct elevation, is the „ideal destination“ for long-distance emissions originating in the industrial area of Ostrava (80 km NW, Czech Republic) and Silesia (120 km, Poland).

The field work in the 1970s documented the impoverished diversity of mostly epiphytic lichens, which was the great contrast looking back to 1920s and 1930s. Even in 1973 several more susceptible epiphytes died out (e.g. *Bryoria bicolor*, *Collema fragrans*, *C. nigrescens*, *Evernia divaricata*, *Hypogymnia bitteri*, *Nephroma resupinatum*, *Normandina pulchella*, *Peltigera collina*, *Ramalina calicaris*, *Ramalina farinacea*). The others, e.g. *Graphis scripta*, *Lobaria pulmonaria*, and the representatives of the genera *Bryoria* and *Usnea* were extremely rare. The remarkable thing was the extinction of the lignicolous species *Cladonia botrytes*, once not that uncommon.

The contemporary research (1996–1997) gave evidence of the extinction or alternatively missing of *Belonia herculina*, *Cetrelia cetrarioides*, *Hypogymnia bitteriana*, *Lecanora albella*, *L. intumescens*, *Lobaria pulmonaria*, *Ochrolechia alboflavescens*, *Pertusaria flavida*, *P. leioplaca*, the *Usnea* species. The domination of the antropogenous influences over the epiphytic lichenflora, with consequences on its diversity, is supported by the following examples.

1. Suza (1934) examined *Populus pyramidalis*, *P. tremula* and *Fraxinus excelsior* between the villages Terchová and Zázrivá (north periphery of the Rozsutec Mt.), writing down subsequent taxa: *Candelaria concolor*, *Collema fragrans*, *Leptogium saturninum*, *Parmelia caperata*, *P. exasperata*, *P. glabra*, *P. subargentifera*, *P. subaurifera*, *Phaeophyscia nigricans*, *P. orbicularis*, *Physcia stellaris*, *Physconia distorta*, *P. enteroxantha*, *P. grisea*, *Xanthoria candelaria*, *X. fallax*, *X. parietina*.

In 1996 we recorded here *Physconia distorta*, *Xanthoria parietina* (both with high cover degree), *Candelariella reflexa*, *Lecania cyrtella*, *Parmelia submontana*, *Phaeophyscia orbicularis*, *Physcia tenella*.

2. As for the north slope of Rozsutec (900–1000 m), **Suza (1934)** made reference to the occurrence of *Lobaria pulmonaria*, *Nephroma resupinatum* (rather abundant), *Leptogium saturninum*, *Bryoria bicolor*, *Collema nigrescens*, *Graphis scripta*, *Hypogymnia physodes*, *Normandina pulchella*, *Parmelia glabratula*, *P. sulcata*, *Peltigera collina*, *P. praetextata*, *Platismatia glauca*, *Pyrenula nitida*, *Ramalina farinacea*, all growing on *Fagus sylvatica*.

In 1996 *Lecanora argentata*, *L. carpinea*, *Graphis scripta* (one thallus) and *Pyrenula nitida* (one thallus) were put on record on the south slope of the mountain (*Fagus sylvatica*). The east slope was slightly more varied with *Cladonia fimbriata*, *Hypogymnia physodes*, *Lecanora conizaeoides*, *L. pulicaris*, *Parmelia glabratula*, *P. saxatilis*, *P. sulcata*, *Parmeliopsis ambigua*, *Phlyctis argena*, *Platismatia glauca*, *Pseudevernia furfuracea* and *Pyrenula nitida* (rarely).

In contrast to the elevations and the outskirts of the mountain region, one can find relatively rich epiphytic lichen flora at the protected lower altitudes. The Vrátna dolina valley, shielded by surrounding mountain ridges, illustrates the fact appropriately. Being a ski-centre, thus influenced by more or less heavy traffic, notwithstanding, one can still find *Acrocordia gemmata*, *Anaptychia ciliaris*, *Bacidia rubella*, *Caloplaca cerina* var. *cerina*, *Caloplaca herbidella*, *Evernia prunastri*, *Lecanora allophana*, *Leptogium saturninum*, *Opegrapha varia*, *Parmelia caperata*, *P. flaventior*, *P. glabra*, *P. glabratula*, *P. pastillifera*, *Pertusaria albescens*, *Physconia distorta*, *P. perisidiosa* and *Xanthoria parietina* growing on *Fraxinus excelsior* or *Tilia parviflora* (Guttová, 1997).

The diversity of muscicolous and terricolous lichens decreases, apparently, mainly on the top of Veľký Rozsutec Mt. and along the paths. In this case, antropogenous influences are found the crucial cause, although one cannot omit the role of emission from near and distant sources. Enormous rise in the number of tourists (the Malá Fatra Mts is on the 2nd position, right after the Vysoké Tatry Mts) has been bringing about not only direct trampling of the soil cover, but also a supply of nitrates. Even in the 1970s Pišút (1981) could not confirm the occurrence of several species such as *Cetraria cucullata*, *C. nivalis*, *Omphalina hudsoniana, Pannaria pezizoides*, *Peltigera aphthosa*, *P. venosa* and *Thamnolia vermicularis*. The investigation in 1996–1997 confirmed the increase in the antropogenous pressure and further decrease in lichen diversity. The species *Arthroraphis citrinella*, *Biatorella hemisphaerica*, *Caloplaca sinapisperma*, *Cladonia macrophylla*, *Icmadophila ericetorum*, *Lecanora epibryon*, *Peltigera leucophlebia*, *Pertusaria glomerata*, *Vulpicida tubulosus* were not found. In total, 59 lichen species (21.7%) are enrolled in the local red list (Tab. 1). Total account of the recorded species is given in Tables 2, 3, 4.

Gradual acidification of the substrata in the 1970s is documented by the presence of *Scoliciosporum chlorococcum*, found at three localities, exclusively on *Picea abies* at 1200–1300 m. This acidophilous lichen was very rare in the late 1960s in Slovakia, up to 1970 known only from 11 grid squares (Pišút, 1985), as well as *Lecanora conizaeoides* and *Hypocenomyce scalaris,* typical invasively spreading acidophilous, toxitolerant lichens. The former species is now found on timber, *Picea abies*, *Larix decidua*, *Abies alba* and *Fagus sylvatica* at 700–1320 m. Similarly, the latter one grew on *Picea excelsa*,

Table 1. Local red list of NNR Rozsutec and the adjacent area

Extinct/missing – Ex	Endangered – E	Vulnerable – V	Rare – R
Belonia herculina	*Acrocordia gemmata*	*Candelaria concolor*	*Agonimia tristicula*
Ochrolechia alboflavescens	*Anaptychia ciliaris*	*Cetraria islandica*	*Calicium salicinum*
Bryoria bicolor	*Bacidia rubella*	*Cliostomum corrugatum*	*Ochrolechia arborea*
Cetraria cucullata	*Bryoria capillaris*	*Fulgensia bracteata*	*Parmelia subargentifera*
Pannaria pezizoides	*Caloplaca herbidella*	*Chromatochlamys muscorum*	*P. tiliacea*
C. nivalis	*Cetraria sepincola*	*Megaspora verrucosa*	*Peltigera monticola*
Cetrelia cetrarioides	*Evernia prunastri*	*Physconia perisidiosa*	*Toninia verrucarioides*
Cladonia botrytes	*Graphis scripta*	*Thelopsis melathelia*	
L. intumescens	*Hypogymnia tubulosa*	*Xanthoria fulva*	
Peltigera aphthosa	*Leptogium saturninum*	*X. polycarpa*	
Collema fragrans	*Parmelia caperata*		
C. nigrescens	*P. pastillifera*		
P. leucophlebia	*P. submontana*		
Lobaria pulmonaria	*Pertusaria pertusa*		
Evernia divaricata	*Pyrenula nitida*		
Hypogymnia bitteri	*Ramalina fastigiata*		
H. bitteriana	*R. fraxinea*		
Lecanora albella	*Usnea filipendula*		
Peltigera venosa			
Pertusaria flavida			
P. glomerata			
P. leioplaca			
Ramalina calicaris			
Thamnolia vermicularis			
Total: 24	18	10	7

Larix decidua and *Abies alba* at 900–1100 m. More than that, other *Hypocenomyce* taxa are spreading over Slovakia (*H. caradocensis* – 2 localities, fertile specimen at one of them. *H. leucococca* – 2 localities. *H. praestabilis* – fertile specimen, 1 locality).

Table 2. Number of lichens reported in NNR Rozsutec and the adjacent area prior to 1973

Lichens	NNR	Adjacent area	Total number
Epiphytic	58	46	86
Epilithic	77	4	78
Terricolous	35	7	36
Muscicolous	7	0	7
On plant debris	7	1	7
Epixylic	3	1	4
Total number	187	59	218

Table 3. Number of lichens reported from NNR Rozsutec and the adjacent area 1996–1997

Lichens	NNR	Adjacent area	Total number
Epiphytic	38	50	71
Epilithic	54	13	63
Terricolous	12	2	13
Muscicolous	15	2	16
On plant debris	5	0	5
Epixylic	10	2	11
Total number	134	69	179

Table 4. Number of newly recorded taxa in the years of 1996–1997

Lichens	NNR	Adjacent area	Total number
Epiphytic	12	12	22
Epilithic	14	3	14
Terricolous	3	0	3
Muscicolous	3	1	4
On plant debris	2	0	2
Epixylic	9	2	10
Total number	44	20	55

Even the application of the Index of Ecological continuity – IEK, (Pišút, 1997) confirms not only decrease in indicatory epiphytic lichen species, but also deterioration of the territorial quality in environmental terms. While the occurence of 15 indicatory species (IEK 15) in the 1920s and 1930s pointed at a high quality of the forest formations, the number of 8 in the 1970s (IEK 8) marked a poorer quality. The contemporary research gives only 4 taxa (IEK 4), which represents the area of poor quality, and supports the statements on increasing antropogenous pressure.

ACKNOWLEDGEMENT

Financial support of the Slovak Grant Agency (Projects Nos. 731 and 1181) is gratefully acknowledged. The authors are intebted to the head office of the National Park Malá Fatra Mts, who made the investigation possible.

REFERENCES

Brancsik, K. 1862. Der Rosudec in Ungarn. *Oest. bot. Zeitschr.* 12: 322–326.

Guttová, A. 1997. Zaujímavé nálezisko epifytických lišajníkov vo Vrátnej doline, Malá Fatra, Slovensko [Interesting locality of epiphytic lichens in the Vrátna dolina valley, Malá Fatra Mts., Slovakia]. *Bryonora*, 20: 17–18.

Intribus, R. 1981. Bioklimatická charakteristika Štátnej prírodnej rezervácie Rozsutec. In *Rozsutec Štátna prírodná rezervácia* (eds. Janík, M. & Štollmann, A.), pp. 197-212. Osveta, Martin.

Klinda, J. 1985. *Chránené územia prírody v Slovenskej socialistickej republike.* Obzor, Bratislava, 319 pp.

Pišút, I. 1966. *Lichenes Slovakiae exsiccati.* Fasc. IV. (nos.76–100). 7 pp.

Pišút, I. 1968. Die Arten der Flechtengattung Collema G. H. Web. in der Slowakei. *Zborn. Slov. nár. múz. Prír. vedy*, 14, 2: 5–71.

Pišút, I. 1969. *Lichenes Slovakiae exsiccati.* Fasc. VII. (Nos. 151–175). 7 pp.

Pišút, I. 1971. Verbreitung der Arten der Flechtengattung Lobaria (Schreb.) Hue in der Slowakei. *Zborn. Slov. nár. múz. Prír. vedy*, 17, 1: 105–130.

Pišút, I. 1974. Doplnky k poznaniu lišajníkov Slovenska 7 [Nachträge zur Kenntnis der Flechten der Slowakei 7]. *Zborn. Slov. nár. múz. Prír. vedy*, 20: 37–40.

Pišút, I. 1981. Lišajníky Štátnej prírodnej rezervácie Rozsutec. In *Rozsutec Štátna prírodná rezervácia* (eds. Janík, M. & Štollmann, A.), pp. 409-419. Osveta, Martin.

Pišút, I. 1985. Die aktuelle Verbreitung einiger epiphytischen Flechten arten in der Slowakei I. *Zborn. Slov. nár. múz. Prír. Vedy*, 31: 3–26.

Pišút, I. 1992. Zaujímavejšie nálezy lišajníkov zo Slovenska [Interessantere Flechtenfunde aus der Slowakei]. *Bull. Slov. Bot. Spol.* (Bratislava) 14: 42–45.

Pišút, I. 1996. Zaujímavejšie nálezy lišajníkov zo Slovenska 3 [Interessantere Flechtenfunde aus der Slowakei 3]. *Bull. Slov. Bot. Spol.* (Bratislava) 18: 27–29.

Pišút, I. 1997. Application of some epiphytic lichens for environmental valorisation of mountain forests in Slovakia. *Biologia* (Bratislava) 52: 23–26.

Pišút, I. & Guttová, A. 1998. Lichenoflóra Národnej prírodnej rezervácie Rozsutec (Malá Fatra) po dvadsiatich piatich rokoch [Lichen flora of National nature reserve Rozsutec (Malá Fatra Mts) twenty five years later]. *Bull. Slov. Bot. Spol.* (Bratislava) 20 (in press).

Pišút, I., Lackovicová, A. & Lisická, E. 1996. A Second Checklist and Bibliography of Slovak Lichens. *Biologia* (Bratislava) 51/ Suppl. X: 1–78.

Servít, M. 1954. *Ceskoslovenské lišejníky celedi Verrucariaceae.* Nakl. CSAV, Praha. 249 pp.

Servít, M. & Cernohorský, Zd. 1935. Flechten aus Cechoslovakei. IV. Malá Fatra, Velká Fatra und Choc-Gruppe in Slowakei nebst Nachträgen. *Vestn. Král. Ceské Spolecn. Nauk*, Tr. Mat.-Prír. 1934: 1–34.

Suza, J. 1926. Lichenes Slovakiae II. Acta Bot. Bohem. 4–5: 3–20.

Suza, J. 1934. Lišejníky okolí Strecna nad Váhom (Malá Fatra na Slovensku). *Sborn. Muz. Slov. Spolocn.* 27–28: 235–242.

Suza, J. 1943. Meridionální vlivy v lišejníkové flore Západních Karpat [Meridionale Einflüsse in der Flechtenflora der Westkarpathen]. *Vestn. Král. Ceské Spolecn. Nauk*, Tr. Mat.-Prír. 1942: 1–47.

Suza, J. 1944. O povaze výskytu a rozšíøení nekterých epifytických lišejníkù v Karpatech [Zum Kenntnis des Vorkommens und der Verbreitung einiger Flechten – Epiphyten in den Karpathen]. *Vestn. Král. Ceské Spolecn. Nauk*, Tr. Mat.-Prír. 1943: 1–59.

Vêzda, A. 1958. Ceskoslovenské druhy rodu *Gyalecta* a *Pachyphiale* s klícem a prehledem evropských druhù. *Sborn. Vysoké Školy Zemed. Lesn.* Ser. C, 1: 21–56.

Vêzda, A. 1965a. *Lichenes selecti exsiccati editi ab Instituto botanico Academiae scientiarum Cechoslovacae, Prùhonice prope Pragam.* Fasc. XVII. (nos. 425–450). Brno. 7 pp.

Vêzda, A. 1965b. *Lichenes selecti exsiccati editi ab Instituto botanico Academiae scientiarum Cechoslovacae, Prùhonice prope Pragam.* Fasc. XVIII. (nos. 451–475). Brno. 7 pp.

Vêzda, A. 1970. Neue oder wenig bekannte Flechten in der Tschechoslowakei. I. *Folia Geobot. Phytotax.* 5: 307–337.

Vêzda, A. 1972. *Lichenes selecti exsiccati editi ab Instituto botanico Academiae scientiarum Cechoslovacae, Prùhonice prope Pragam.* Fasc. XLV. (nos. 1101–1125). Brno. 7 pp.

Vêzda, A. 1973. *Lichenes selecti exsiccati editi ab Instituto botanico Academiae scientiarum Cechoslovacae, Prùhonice prope Pragam.* Fasc. XLVI. (nos. 1126–1150). Brno. 7 pp.

Vêzda, A. 1978. Neue oder wenig bekannte Flechten in der Tschechoslowakei. II. *Folia Geobot. Phytotax.* 13: 397–420.

Folia Cryptog. Estonica, Fasc. 32: 75–79 (1998)

Red list of Estonian macrolichens

Tiina Randlane
Institute of Botany and Ecology, University of Tartu, 38 Lai St., EE2400 Tartu, Estonia

Abstract: A list comprising 110 endangered macrolichen species in Estonia is presented. The following threat categories have been applied: 0 – extinct or probably extinct (18 species), 1 – endangered (5), 2 – vulnerable (24), 3 – rare (41), 4 – care demanding (21), 5 – indeterminate (1).

Kokkuvõte: T. Randlane. Eesti suursamblike punane nimekiri.

Eesti ohustatud suursamblike nimekiri sisaldab 110 liiki. Kasutatud on järgmisi ohukategooriaid: 0 – hävinud või tõenäoliselt hävinud (18 liiki), 1– eriti ohustatud (5), 2 – ohualtid (24), 3 – haruldased (41), 4 – tähelepanu vajavad (21), 5 – määratlemata (1).

INTRODUCTION

According to our present knowledge the lichen flora of Estonia consists of about 800 species, out of which we have verified data about the distribution of 337 macrolichens. In addition, the occurence of more than 450 microlichen species is strongly suggested in our territory. The new checklist of Estonian lichen species will be completed at the end of this year as a result of a collective project. The revision of several microlichen genera has not been finished yet and, therefore, the inclusion of the microlichens into the red list is not considered to be scientifically justified at present.

The following red list is based on data presented in Trass & Randlane (1994) and on herbarium materials collected or identified later. Specimens cited are kept at the International Center for Environmental Biology (ICEB), or the Institute of Ecology (IE), both in Tallinn; in the herbaria of the Universities of Helsinki (H), Tartu (TU) or Uppsala (UPS). A few changes in the checklist of Estonian macrolichens since 1994 should be pointed out.

1. Several species that were earlier considered to be extinct from the modern lichen flora of Estonia (Trass & Randlane, 1994), are now treated as doubtfully recorded. These species are: *Bryoria bicolor* (Ehrh.) Nyl., *Collema auriforme* (With.) Coppins & J.R. Laundon, *Collema crispum* (Huds.) Weber, *Collema fluviatile* (Huds.) Steudel, *Dermatocarpon meiophyllizum* Vain., *Leptogium byssinum* (Hoffm.) Nyl., *Leptogium plicatile* (Ach.) Leight., *Melanelia elegantula* (Zahlbr.) Essl., *Parmotrema chinense* (Osbeck) Hale & Ahti, *Peltula euploca* (Ach.) Poelt, *Phaeophyscia constipata* (Norrl. & Nyl.) Moberg, *Physcia dimidiata* (Arnold) Nyl., *Physconia muscigena* (Ach.) Poelt, *Ramalina lacera* (With.) J.R. Laundon, *Umbilicaria grisea* Hoffm., *Umbilicaria proboscidea* (L.) Schrad., *Umbilicaria vellea* (L.) Hoffm., *Usnea articulata* (L.) Hoffm., *Usnea longissima* Ach., *Xanthoria elegans* (Link) Th. Fr. These taxa had been included in the flora based on information in old literature (Bruttan, 1870, 1889; Mereschkowsky, 1913; Räsänen, 1931). Unfortunately, we have not seen any herbarium specimens of them (possibly the specimens are not preserved) and cannot verify the identifications according to modern taxonomy. Still, we cannot convincingly exclude them either, as their occurrence in Estonia is chorologically possible. Therefore, a special category of species – doubtful (marked with ?) – is introduced now in all the lists and papers concerning the revision of Estonian lichens (see also Jüriado, 1998; Lõhmus, 1998; Suija, 1998). In the present treatment doubtful species are not included in the red list.

2. Five new species have been found during the last few years: *Bryoria furcellata* (Fr.) Brodo & D. Hawksw. (Randlane et al., 1997; ICEB, dup. in TU), *Dermatocarpon luridum* (With.) J.R. Laundon (TU), *Phaeophyscia chloantha* (Ach.) Moberg (Moberg, 1997; UPS, dup. in TU), *Ramalina elegans* (Bagl. & Carestia) Jatta (Skytén, 1993; H), *Solorina bispora* Nyl. (Moberg, 1997; UPS). One more species – *Ramalina capitata* (Ach.) Nyl. – must be added to the list, according to earlier literature data (Räsänen, 1931), as doubtful.

3. One species – *Usnea glauca* Mot. – is excluded from the list after re-determination (det. Pekka Halonen 1997 as *U. scabrata*).

4. Some species reported as extinct in Trass & Randlane (1994) have recently been found again: *Alectoria sarmentosa* (Ach.) Ach. (Martin & Martin, 1998; ICEB, dup. in TU), *Cladonia brevis* (Sandst.) Sandst. (TU), *Leptogium gelatinosum* (With.) J.R. Laundon (TU), *Melanelia hepatizon* (Ach.) A. Thell (Randlane et al. 1997; ICEB, IE, dup. in TU). Thus, these taxa are present in our contemporary lichen flora.

5. Three more species – *Nephroma helveticum* Ach., *Punctelia subrudecta* (Nyl.) Krog and *Umbilicaria hyperborea* (Ach.) Hoffm. – should be considered as extinct from Estonia, according to the latest data.

RED LIST OF ESTONIAN MACROLICHENS

The following threat categories have been applied:

0 – extinct or probably extinct,
1 – endangered,
2 – vulnerable,
3 – rare,
4 – care demanding,
5 – indeterminate.

Criteria for including the species and numeral data are presented in discussion. In nomenclature Trass & Randlane (1994) are mainly followed; changes in taxonomy or nomenclature compared to this are pointed out in brackets.

Alectoria sarmentosa (Ach.) Ach.	2
Anaptychia runcinata (With.) J.R. Laundon	3
Arctoparmelia incurva (Pers.) Hale	4
Bryoria chalybeiformis (L.) Brodo & D. Hawksw.	3
Bryoria furcellata (Fr.) Brodo & D. Hawksw.	4
Bryoria implexa (Hoffm.) Brodo & D. Hawksw. [incl. *B. osteola* (Gyeln.) Brodo & D. Hawksw., *B. pseudofuscescens* (Gyeln.) Brodo & D. Hawksw., *B. vrangiana* (Gyeln.) Brodo & D. Hawksw.]	4
Bryoria nadvornikiana (Gyeln.) Brodo & D. Hawksw.	2
Bryoria simplicior (Vain.) Brodo & D. Hawksw.	3
Caloplaca biatorina (A. Massal.) J. Steiner	3
Caloplaca flavescens (Huds.) J.R. Laundon	3
Caloplaca thallincola (Wedd.) Du Rietz	4
Caloplaca verruculifera (Vain.) Zahlbr.	3
Catapyrenium cinereum (Pers.) Körb.	3
Catapyrenium lachneum (Ach.) R. Sant. [syn. *Placidium lachneum* (Ach.) de Lesd.]	3
Catapyrenium pilosellum (Breuss) Breuss [syn. *Placidium pilosellum* Breuss]	3
Cetrelia olivetorum (Nyl.) W.L. Culb. & C.F. Culb. [incl. *C. cetrarioides* (Duby) W.L. Culb. & C.F. Culb.]	0
Cladonia brevis (Sandst.) Sandst.	2
Cladonia convoluta (Lam.) Anders	3
Cladonia decorticata (Flörke) Spreng.	4
Cladonia incrassata Flörke	2
Cladonia metacorallifera Asahina	3
Cladonia parasitica (Hoffm.) Hoffm.	2
Collema bachmanianum (Fink) Degel.	3
Collema limosum (Ach.) Ach.	3
Collema nigrescens (Huds.) DC.	0
Collema occultatum Bagl.	0
Collema parvum Degel.	3
Collema subnigrescens Degel.	0
Collema undulatum Flot.	3
Dermatocarpon arnoldianum Degel.	3
Dermatocarpon leptophyllum (Ach.) K.G.W. Lång	3
Dermatocarpon luridum (With.) J.R. Laundon	3
Endocarpon psorodeum (Nyl.) Blomb. & Forss.	2
Endocarpon pusillum Hedw.	2
Evernia divaricata (L.) Ach.	2
Evernia mesomorpha Nyl.	4
Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell	2
Flavoparmelia caperata (L.) Hale	0
Fulgensia fulgens (Sw.) Elenkin	3
Heterodermia speciosa (Wulfen) Trevis	0
Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt	0
Hypocenomyce anthracophila (Nyl.) P. James & Gotth. Schneid.	3
Hypocenomyce sorophora (Vain.) P. James & Poelt	3
Hypogymnia vittata (Ach.) Parrique	2
Lasallia pustulata (L.) Mérat	4
Lecanora achariana A.L. Sm.	3
Lempholemma isidiodes (Arnold) H. Magn.	3
Leptogium cyanescens (Rabenh.) Körb.	2
Leptogium gelatinosum (With.) J.R. Laundon	2
Leptogium rivulare (Ach.) Mont.	1
Leptogium schraderi (Bernh.) Nyl.	2
Leptogium subtile (Schrad.) Torss.	0
Leptogium tenuissimum (Dicks.) Körb.	4
Lobaria pulmonaria (L.) Hoffm.	4

Lobaria scrobiculata (Scop.) DC.	1
Melanelia commixta (Nyl.) A. Thell	3
Melanelia glabra (Schaer.) Essl.	2
Melanelia hepatizon (Ach.) A. Thell	3
Menegazzia terebrata (Hoffm.) A. Massal.	4
Multiclavula vernalis R.H. Petersen	2
Nephroma arcticum (L.) Torss.	0
Nephroma bellum (Spreng.) Tuck.	1
Nephroma helveticum Ach.	0
Nephroma isidiosum (Nyl.) Gyeln.	2
Nephroma laevigatum Ach.	2
Nephroma parile (Ach.) Ach.	4
Nephroma resupinatum (L.) Ach.	2
Pannaria leucophaea (Vahl) P.M. Jørg. [syn. *Fuscopannaria leucophaea* (Vahl) P.M. Jørg.]	2
Pannaria pezizoides (Weber.) Trevis.	2
Parmelia fraudans (Nyl.) Nyl.	3
Parmeliella triptophylla (Ach.) Müll. Arg.	2
Parmelina tiliacea (Hoffm.) Hale	4
Peltigera degenii Gyeln.	3
Peltigera elisabethae Gyeln.	0
Peltigera scabrosa Th. Fr.	3
Peltigera venosa (L.) Hoffm.	3
Phaeophyscia chloantha (Ach.) Moberg	0
Phaeophyscia endophoenicea (Harm.) Moberg	3
Physcia magnussonii Frey	3
Physcia semipinnata (J.F. Gmelin) Moberg	2
Pilophorus cereolus (Ach.) Th. Fr.	3
Punctelia subrudecta (Nyl.) Krog	0
Pycnothelia papillaria Dufour	4
Ramalina calicaris (L.) Fr.	2
Ramalina elegans (Bagl. & Carestia) Jatta	5
Ramalina siliquosa (Huds.) A.L. Sm.	3
Ramalina sinensis Jatta	4
Ramalina thrausta (Ach.) Nyl.	4
Solorina bispora Nyl.	3
Solorina saccata (L.) Ach.	4
Solorina spongiosa (Ach.) Anzi	4
Sphaerophorus globosus (Huds.) Vain.	1
Stereocaulon evolutum Graewe	0
Stereocaulon incrustatum Flörke	4
Stereocaulon vesuvianum Pers.	3
Toninia lobulata (Sommerf.) Lynge [syn. *Mycobilimbia lobulata* (Sommerf.) Hafellner]	0
Toninia verrucarioides (Nyl.) Timdal	3
Umbilicaria cinerascens (Arnold) Frey	3
Umbilicaria cylindrica (L.) Duby	3
Umbilicaria decussata (Vill.) Zahlbr.	3
Umbilicaria hyperborea (Ach.) Hoffm.	0
Usnea barbata (L.) F.H. Wigg.	0
Usnea diplotypus Vain.	3
Usnea glabrata (Ach.) Vain.	1
Usnea scabrata Nyl. (incl. *U. prostrata* Vain., *U. rugulosa* Vain., *U. sylvatica* Mot.)	4
Vulpicida tubulosa (Schaer.) J.-E. Mattsson & M.J. Lai	4
Xanthoria calcicola Oxner	4
Xanthoria fallax (Hepp) Arnold	2
Xanthoria lobulata (Flörke) Hellb. [syn. *Caloplaca lobulata* (Flörke) de Lesd.]	0
Xanthoria sorediata (Vain.) Poelt	3

DISCUSSION

The present red list of macrolichens was compiled as a part of a larger project "Red Data Book of Estonia. Threatened Fungi, Plants and Animals" (Lilleleht, in press) which hopefully will be published in 1998. Threat categories applied in this project were discussed on several meetings of the Nature Conservation Commission of the Estonian Academy of Sciences, consisting of representatives of different specialities. As a result, the desision was made to apply the categories that were already in use in the Red Data Books of neighbouring countries (Andrušaitis, 1996; Aronsson et al., 1995; Ingeloeg et al., 1993; Rassi et al., 1992), with minor changes.

This is the first officially recognised red list of Estonian lichens (available also in internet *http://www.ut.ee/lichens/red_list.html*), although some earlier publications also present relevant information: the list of 93 Estonian lichens in need of protection (Trass & Randlane, 1986) and the list of 38 extinct macrolichens in Estonia (Trass & Randlane, 1987). A list of 40 macrolichen species that should be enclosed in the Red Data Book of Estonia was printed in an encyclopaedic reference book a few years ago (Eesti A ja O, 1993).

The new list, based on latest verified data, includes 110 species, which comprises 33% of the total macrolichen flora known in Estonia at present. The distribution of taxa between the threat categories and the criteria for their including are as follows.

Category 0 – **extinct or probably extinct** – includes **18 species** (16 % of the total number of lichens in the red list). Herbarium material verifies earlier occurrence of all these species in Estonia; in addition, there are no new records since 1950. Several taxa of this category (e. g. *Hyperphyscia adglutinata, Nephroma helveticum, Umbilicaria hyperborea*) have been collected from the present territory of Tallinn (Nõmme, Rahumäe, Kopli, Lasnamäe) at the end of the last or at the beginning of this century. These habitats and localities have been certainly destroyed by now. Some species have earlier also been found in other towns (*Phaeophyscia chloantha* from Kunda – a small but heavily polluted town in norteastern Estonia; *Cetrelia olivetorum* and *Flavoparmelia caperata* from the closest vicinity of Tartu). A few extinct species are recorded from the islands of Saaremaa (Kuressaare, Orissaare, peninsula of Sõrve), Abruka (*Heterodermia speciosa*) or Muhu (*Toninia lobulata*).

Category 1 – **endangered** – includes **5 species** (5 %). All these species are very rare in Estonia (found only once after 1950) and seriously threatened to a certain extent. *Leptogium rivulare* is a rare species in the whole world, confined to the periodically inundated trees or occasionally rocks, on the banks of sluggish rivers and ponds in northern Europe and northeastern USA and Canada. It has disappeared from several localities in Sweden, Finland and Russia as well as in France, Canada and USA (Jørgensen & James, 1983; Jørgensen, 1994; Sierk, 1964). Only a few current localities are known, one of them in Estonia: Pärnumaa Co., Lihula, river Kasari, leg. H. Trass 1957, det. T. Randlane 1986, verified G. Degelius 1991 (Randlane, 1987). This is a lichen that strongly depends on changes of water level and is threatened by the destruction of such habitats. *Sphaerophorus globosus* is an arctic-alpine lichen growing in Estonia on its southern limit, inhabiting here open localities – alvars – on the Saaremaa Island. The general threat to alvars – becoming overgrown with bushes and trees as a result of ceased grazing – is dangerous to several rare lichens of that habitat, including *S. globosus*. *Lobaria scrobiculata, Nephroma bellum* and *Usnea glabrata* grow in old virgin forests and are mainly endangered by forestry.

Category 2 – **vulnerable** – includes **24 species** (22 %). Lichens belonging to this category are either quite rare or sparsely distributed in Estonia but certainly sensitive to the environmental changes and, therefore, they may fall into the previous category in the future. The major threats are various: destruction of very specialised habitats (*Cladonia parasitica, Pannaria pezizoides*), vulnerability due to growth on the very limit of distribution area (*Flavocetraria cucullata*), air pollution and cutting of forests (*Alectoria sarmentosa, Evernia divaricata, Ramalina calicaris*).

Category 3 – **rare** – includes **41 species** (37 %). All macrolichens that are recorded from one or two localities only (and which are not included in the first three categories) are treated as rare. The main threats are not identified, the taxa are considered endangered by the occasional destruction of localities.

Category 4 – **care demanding** – includes **21 species** (19 %). These taxa are distributed sparsely or even widely in Estonia but they are evidently sensitive to various factors and their decline has been observed during last decades.

Category 5 – **indeterminate** – comprises **1 species** (1 %) at present (*Ramalina elegans*). The distribution of this taxon in North Europe was described only recently (Skytén, 1993); its general distribution area and precise ecological demands are not clear yet.

The most important sites of endangered lichens in Estonia are: alvar communities, deciduous forests and wooded meadows, sandy dunes, calcareous or granite rocks (often on the seashore). Maintaining and undisturbing these habitats is the main strategy in protection of endangered lichens.

ACKNOWLEDGEMENTS

This research is a part of the project that was ordered and financed by the Ministry of Environment and the Foundation of Environment. The author is especially grateful to Hans Trass for the information and prolonged consultations during the last decades. All lichenologists in Tartu and Tallinn are thanked for discussions on the subject. Jan-Eric Mattsson is acknowledged for kindly revising the manuscript.

REFERENCES

Andrušaitis, G. (ed). 1996. *Latvijas sarkana gramata. I. Senes un kerpji* [*Red Data Book of Latvia. Vol. I. Fungi and lichens*]. Riga. 202 pp.

Aronsson, M., Hallingbäck, T. & Mattsson, J.-E. (eds.) 1995. *Rödlistade växter i Sverige 1995* [*Swedish Red Data Book of Plants 1995*]. ArtDatabanken, Uppsala. 272 pp.

Bruttan, A. 1870. Lichenen Est-, Liv- und Kurlands. *Arch. Naturk. Liv-, Ehst- u. Kurl.* Zweite Serie 7: 163–326.

Bruttan, A. 1889. Nachtrag zu den Lichenen Liv-, Est- und Kurlands. *Sitz.-ber. d. Nat.-forsch. Ges. bei der Univ. Dorpat* 8: 444–449.

Eesti A ja O. 1993. Eesti Entsüklopeedia Kirjastus, Tallinn.

Ingeloeg, T., Andersson, R. & Tjernberg, M. (eds.) 1993. *Red Data Book of the Baltic Region. I. Lists of threatened vascular plants and vertebrates.* Swedish Threatened Species Unit, Uppsala. 95 pp.

Jørgensen, P. M. 1994. Further notes on european taxa of the lichen genus *Leptogium*, with emphasis on the small species. *Lichenologist* 26: 1–29.

Jørgensen, P. M. & James, P. W. 1983. Studies on some *Leptogium* species of Western Europe. *Lichenologist* 15: 109–125.

Jüriado, I. 1998. Review of the *Lecanora subfusca* group in Estonia. *Folia Cryptog. Estonica* 32: 15–20.

Lilleleht, V. (ed.) 1998. Eesti Punane raamat. Ohustatud seened, taimed ja loomad [Red Data Book of Estonia. Threatened Fungi, Plants and Animals]. Tallinn (in press).

Lõhmus, P. 1998. List of Estonian *Caliciales*. *Folia Cryptog. Estonica* 32: 43–46.

Martin, L. & Martin, J. 1998. Epiphytic macrolichens in Estonian forests. *Folia Cryptog. Estonica* 32: 47–55.

Mereschkowski, K. 1913. *The checklist of lichens in the Baltic provinces* (in Russian). Kazan.

Moberg, R. 1997. *Phaeophyscia chloantha* and *Solorina bispora* new to Estonia. *Folia Cryptog. Estonica* 31: 36–37.

Randlane, T. 1987. *Leptogium rivulare* (Ach.) Mont. – a new rare lichen species in Estonia. *Folia Cryptog. Estonica* 25: 8–11.

Randlane, T., Jüriado, I., Martin, J., Martin, L., Nilson, E. & Temina, M. 1997. Lichens of Naissaar Island (Gulf of Finland, Estonia). *Folia Cryptog. Estonica* 31: 20–25.

Rassi, P., Kaipiainen, H., Mannerkoski, I. & Ståhls, G. 1992. Uhanalaisten eläinten ja kasvien seurantatoimikunnan mietintö [Report on the monitoring of threatened animals and plants in Finland]. *Komiteanmietintö 1991*, 30: 1–328.

Räsänen, V. 1931. *Die Flechten Estlands.* Helsinki. 163 pp.

Sierk, H. A. 1964. The genus *Leptogium* in North America North of Mexico. *Bryologist* 67: 245–317.

Skytén, R. 1993. *Ramalina elegans,* new to Sweden and Norway. *Graphis Scripta* 5: 93–95.

Suija, A. 1998. Lecideoid lichens from Estonia – an annotated checklist. *Folia Cryptog. Estonica* 32: 107–112.

Trass, H. & Randlane, T. 1986. Estonian lichens in need of protection (in Russian). *Folia Cryptog. Estonica* 21: 1–3.

Trass, H. & Randlane, T. 1987. Extinct macrolichens of Estonia. *Folia Cryptog. Estonica* 25: 1–7.

Trass, H. & Randlane, T. (eds) 1994. *Eesti suursamblikud.* Tartu. 399 pp.

Folia Cryptog. Estonica, Fasc. 32: 81–84 (1998)

Lichenological collections in TU

Andres Saag, Tiina Randlane & Ave Suija
Institute of Botany and Ecology, University of Tartu, 38 Lai St., EE2400 Tartu, Estonia

Abstract: Lichenological collections in TU include about 62 000 specimens. They are arranged into three main sections: Estonian herbarium (ca. 24 000 specimens), geographical collections (ca. 30 000 specimens) and a comparison herbarium (ca. 8 000 specimens). The specimen databasing has been started in the Estonian herbarium using the computer program BRAHMS. The genera, species of which have been databased already, are listed. Exsiccate materials and types that are located in TU are also listed.

Kokkuv›te: A. Saag, T. Randlane & A. Suija. Lihhenoloogilised kollektsioonid Tartu Ülikoolis.

Tartu Ülikooli (TU) lihhenoloogiline herbaarium sisaldab umbes 62 000 eksemplari. Samblike kollektsioon on jaotatud kolme ossa: Eesti samblike herbaarium (u. 24 000 eksemplari), geograafilised kogud (u. 30 000 eksemplari) ja võrdlusherbaarium (u. 8 000 eksemplari). Alustatud on Eesti samblike herbaareksemplaride andmebaasi loomist, kasutades programmi BRAHMS. Loetletud on andmebaasi juba sisestatud perekonnad. Samuti on esitatud meie herbaariumis paiknevate tüüpmaterjalide ja eksikaatide loendid.

INTRODUCTION

A thorough review revealing the present state of all herbaria of higher plants in Estonia (including private herbaria and collections of local museums and nature reserves) has been recently presented by Kukk (1997). Lichenological collections are much less popular and kept mainly in the research institutes. There are five intitutions in Estonia where scientific lichen herbaria are kept: International Center for Environmental Biology (ICEB), Institute of Ecology (IE), State Nature Museum (TAL), Tallinn Botanic Garden (TBA) – all four located in Tallinn – and University of Tartu (TU). Private lichenological collections are unusual in Estonia. The greatest private lichenological herbarium, founded in 1930s, belonged to Heinrich Aasamaa, a former lecturer of the University of Tartu. The conditions of these materials were unknown for decades. A few years ago it became evident that the collections, left in a farm near Tartu in the 1950s, had been destroyed. Heinrich Aasamaa, being over 80, started collecting lichens and preparing a herbarium again. All his present collections (including herbarium of higher plants of about 30 000 sheets) are kept at his home in Lasnamäe, Tallinn.

Lichenological herbarium of the Institute of Botany and Ecology, University of Tartu (TU) is the oldest and biggest of all those listed above. The different collections of this herbarium, and the curative work in TU are shortly characterized in the present paper.

RESULTS AND DISCUSSION

Lichenological collections in TU include about 62 000 specimens. There are three main sections:
Estonian herbarium – ca. 24 000 specimens
Geographical collections – ca. 30 000 specimens
Comparison herbarium (incl. exciccatae) – ca. 8 000 specimens.
All materials are arranged in the alphabetical order of genera – inside each section – and in the alphabetical order of species – inside the genera.

The Estonian herbarium of TU is the biggest collection of Estonian lichens in the world (about 24 000 specimens). Smaller collections of Estonian lichens are kept in other local herbaria as well – ICEB, IE, TAL, TBA – and to a lesser extent also in H, LD, RIG, S and UPS. Managing of Estonian herbarium has been our priority task during last four years. It has been re-arranged recently according to the modern taxonomy (accepting small genera of parmelioid, cetrarioid, lecideoid etc. lichens) in the course of verifying all specimens to compile the new checklist of Estonian lichens. Specimen databasing has been started using the computer program BRAHMS (Botanical Research And Herbarium Management System). The system was initially worked out by Denis Filer , Oxford Forestry Institute. Versions 3.3 and 3.4 have been applied for managing lichenological herbarium in TU. A module known as RDE (Rapid Data Entry), linked to BRAHMS, has been used to enter various information connected with the herbarium specimens. Configuration of RDE files has been edited according to our special needs of lichenological herbarium. Every file includes data about specimens of one species. Characters stored are the following for every specimen: collector and field number, number of the specimen in herbarium, additional collectors, genus, species, author(s), infraspecific taxa, date of collection, geographical locality, ecological group (based on substratum), longitude, latitude and altitude of the site of collection, local grid, herbarium name where the collection and its duplicates are kept, determiner and the date of identification, presence of fruiting bodies and parasymbionts, vitality, other ecological data, data of chemical and anatomical studies, other notes by the determiner (Saag, 1996). After importing all these data into BRAHMS, general specimen cataloguing, production of different categories of labels, citation lists of specimens, floristic checklists and other research proceedings become possible. Mapping program DMAP (Morton, 1997)has been used together with BRAHMS to produce distribution maps. At the moment, data of about 5000 lichen specimens of Estonia (materials of all species from genera *Acarospora, Adelolecia, Amandinea, Amygdalaria, Biatora, Buellia, Calicium, Carbonea, Cecidonia, Chaenotheca, Chaenothecopsis, Cyphelium, Diplotomma, Farnoldia, Fuscidea, Graphis, Ionaspis, Lecanora, Lecidea, Lecidella, Microcalicium, Mycocalicium, Miriquidica, Phaeocalicium, Placynthiella, Polysporina, Porpidia, Protoparmelia, Psilolechia, Pyrrhospora, Rimularia, Sagiolechia, Sarcogyne, Schaereria, Sclerophora, Sphaerophorus, Stenocybe, Tephromela, Thelomma, Trapelia, Trapeliopsis, Tremolecia, Rinodina*) have been entered into RDE and imported into BRAHMS. The majority of data have been entered into the database by Inga Jüriado, Piret Lõhmus, Mari Sarv and Ave Suija; the technical managing of the Estonian herbarium has mainly been carried out by Inga Jüriado.

The oldest lichen specimens in the Estonian herbarium date from the end of the last century. They were collected by Andreas Bruttan, altogether about 260 species, from Abruka, Aegviidu, Haaslava, Hiiumaa, Muhu, Saaremaa, Selja (Lääne-Virumaa), Tallinn, Tartu, Valga, Virtsu, Viru-Nigula. Part of his herbarium (179 sheets, with several species on each sheet, collected from the present territories of both Latvia and Estonia) are kept in RIG (Piterans, 1996). Other older collections of Estonian lichens in TU were raised by Paul Wasmuth (about 200 species), and by Konstantin Mereschkowski (only a few specimens preserved). Both persons worked during the first two decades of this century in Tallinn and its vicinity. Numerous materials (about 170 species) collected from Estonia (Abruka, Keila, Kunda, Lihula, Rakvere, Paldiski, Pärnu, Saaremaa, Tallinn, Tartu, Viljandi, Vilsandi, Väike-Maarja) by Veli Räsänen in 1927 and 1929, as well as some specimens collected by L. Kari, K. Linkola and E. Häyrén, are kept partly in TU and partly in H. Smaller collections of Hilja Lippmaa, Voldemar Reinthal, Jaak Ruubel, Gustav Vilbaste, that date mainly from the 1930s, are also deposited in this section. In the post-war period the biggest lichen collections have been raised by Hans Trass.

Geographical collections raised by the coworkers of our institute (altogether about 30 000 specimens) are arranged into some bigger geographical units:

I Extra-europian countries (mainly materials from Canada)
II Europian countries
  1. Foreign countries (mainly materials from Finland and Sweden)
  2. Former republics of the USSR (Latvia, Lithuania, European part of Russia)
III Caucasus (Azerbaijan, Georgia)
IV Central Asia (Kazakhstan, Kirghizia, Tadjikistan, Turkmenistan, Uzbekistan)
V Siberia
VI Lake Baical region
VII Russian Far East.

Two latter collections are the most numerous. Field works in the vicinity of the Lake Baical (Khamar-Daban Mountain Range in the Irkutsk Territory and Buryatian Autonomic Republic) were carried out in 1979–1982 by a group of students and reseachers (A. Pärn, K. Zobel, A. Roosma, T. Randlane etc.) led by Hans Trass. More than 1000 sample quadrats were analysed using air pollution monitoring methods and about 10 000 specimens were collected. This is the biggest geographical collection of lichens in TU. Herbarium of lichens from the Russian Far East consists of ca. 8 500 specimens, collected from the Chabarovsk and Primorje Territories, Peninsulas of Kamtchatka and Tshukotka, Wrangel Island – by H. Trass, A. Roosma, T. Randlane, S. Pärn-Eilart, V. Masing etc.

Comparison herbarium consists of ca. 8 000 specimens and has been maintained mainly by exchanging specimens with or receiving gifts from other herbaria. The following exsiccatae are represented in our collections rather numerously: Herbarium Lichenum Fenniae (1875, 1882) and Nylander & Norrlin, Herbarium Lichenum Fenniae (continued in 1921); Lichenotheca Fennica; Lichenes Fenniae Exsiccati; Plantae Graecenses (Lichenes); Lichenes Canadenses Exsiccati; Prof. C. Mereschkowsky. Lichenes Rossiae Exsiccati; V. P. Savicz. Lichenotheca Rossica; J. Suza: Lichenes Bohemoslovakiae; Reliquiae Suzaianae (Table 1). Several other exsiccate materials are represented in TU incompletely or in a few numbers only: Flora Exsiccata Austro-Hungarica; Flora Hungarica Exsiccata; J. A. Elix: Lichenes Australasici Exsiccati; Lichenes Americani Exsiccati; Lichenes Norvegiae Mediterranei Exsiccati; Syo Kurokawa: Lichenes Rariores et Critici Exsiccati; Reliquiae Tuckermanianae etc.

During the last few years our herbarium has been supplemented by a numerous and valuable collection of lichens from the southern hemisphere (Australia, New Zealand, Papua New Guinea, Antarctica, Argentina, Brasil, Chile) for which we are deeply indebted to our compatriot Dr Heinar Streimann, curator of the cryptogamic herbarium in Australian National Herbarium (CANB). These specimens have also been added to the comparison herbarium.

The following type materials are located in TU:
Asahinea culbersoniorum Trass – holotype
Cetrariopsis laii A. Thell & Randlane – holotype
Cetrelia orientalis Randlane & Saag – holotype
Cetrelia pseudocollata Randlane & Saag – holotype
Cetreliopsis papuae Randlane & Saag – isotype
Cladonia alinii Trass – holotype
Cladonia favillicola Trass – holotype
Cladonia trassii Ahti – isotype
Heterodermia intermedia Trass – holotype
Ramalina stevensiae Elix - isotype
Tuckneraria ahtii Randlane & Saag – isotype
Xanthoria oxneri S. Kondratyuk & Poelt – isotype

Table 1. Exsiccate materials in TU

Name of exsiccatae	
Series	Numbers present in TU
Lichenes Fenniae Exsiccati (Räsänen, Helsinki)	
Fasc. I	1–2, 4–5, 7–22, 25–50
Fasc. II	51–89, 98, 100
Fasc. III	101–113, 116–123, 125–150
Fasc. IV	151–164, 167–185, 190–192, 194, 197–200
Fasc. V	201–226, 229–240, 244–245, 250
Fasc. VI	251–266, 268, 270, 275–300
Fasc. VII	301–347, 349
Fasc. VIII	351–362, 364–367, 369, 385, 393–394
Fasc. IX	403
Fasc. X	462–477, 500
Fasc. XI	501–515, 517–550
Fasc. XV	701–734, 736–750
Fasc. XVI	751–784, 786–800
Fasc. XVII	801–835, 837–850
Fasc. XVIII	851–860, 862–885, 887–900
Fasc. XIX	901–907, 909–945, 947, 949
Fasc. XX	952–960, 963–981, 983–1000
Lichenotheca Fennica (Räsänen, Kuopio)	
Fasc. I	2, 4, 19, 20
Fasc. II	26–27, 39–43
Fasc. III	53, 64.
Fasc. IV	77–78, 81–83
Fasc. V	104, 121–122
Fasc. VI	126, 129–132, 147
Fasc. VII	153, 171–172
Fasc. VIII	181–183, 189–200
Fasc. IX	201, 225
Fasc. X	228–229, 232–233, 247–248
Fasc. XI	268–275
Fasc. XII	276–280, 291.
Fasc. XIII	301–325

Fasc. XIV	326–332, 334–350
Fasc. XV	351–361, 363–375
Fasc. XVI	376–400
Fasc. XVII	401–425
Fasc. XVIII	426–449
Fasc. XIX	451–459, 461–465, 467–472, 474
Fasc. XX	476–493, 496–497, 499–500
Fasc. XXI	501–519, 521–523
Fasc. XXII	526–550
Fasc. XXIII	551–572, 574–575
Fasc. XXIV	576–580, 582–586, 588–590, 592–600
Fasc. XXV	601–608, 610–620, 622–625
Fasc. XXVI	626–628, 630–636, 638–649
Fasc. XXVII	651–652, 654–675
Fasc. XXVIII	676–680, 682–700
Fasc. XXIX	701–712, 714–722, 724–725
Fasc. XXX	726–744, 746–749
Fasc. XXXI	751–773, 775
Fasc. XXXII	776–800
Fasc. XXXIII	801–822, 824–825
Fasc. XXXIV	826–828, 830–850
Fasc. XXXV	851–875
Fasc. XXXVI	876–890, 892–900
Fasc. XXXVII	901–925
Fasc. XXXVIII	926–950
Fasc. XXXIX	951–975
Fasc. XL	976–991, 993–1000
Fasc. XLI	1001–1025
Fasc. XLII	1027–1034, 1036–1049
Fasc. XLIII	1051–1075
Fasc. XLIV	1076–1100
Fasc. XLV	1101–1113, 1115–1125
Fasc. XLVI	1126–1150
Fasc. XLVII	1151–1163, 1165–1175
Fasc. XLVIII	1176–1200
Fasc. XLIX	1201–1203, 1206, 1209–1210, 1213, 1215, 1218, 1220–1225
Fasc. L	1226–1250
Fasc. LI	1251–1252, 1254, 1256–1273, 1275
Fasc. LII	1276–1289, 1291–1300

Herbarium Lichenum Fenniae

Fasc. II	51–59, 61–66, 68–100
Fasc. III	101–132, 134–150
Fasc. IV	151–160, 162–186, 188–200
Fasc. VI	252–273, 276–280, 282–300
Fasc. VII	301–317, 319, 321–328, 330–334, 336–350
Fasc. VIII	351–393, 395–400

Nylander & Norrlin, Herbarium Lichenum Fenniae
(continuatio)
451–502, 504–522, 524–566, 568–586, 588–736, 738–807

Plantae Graecenses. Lichenes
1–17, 20–43, 45–49, 51–60, 62–65, 200, 239, 250–288, 290–419, 421–447, 480

Lichenes Canadenses Exsiccati
1–6, 8–15, 17–18, 20–27, 29–227, 229–250

Prof. C. Mereschkowsky. Lichenes Rossiae exciccati
2–4, 6–8, 12–24, 27–29, 31, 33–35, 37–51, 53–55, 59, 62–63, 65–71, 73–74

V. P. Savicz. Lichenotheca Rossica

Decas III–XIII	21–70, 81–89, 91–109, 111–114, 116, 118–129

J. Suza: Lichenes Bohemoslovakiae
3, 6, 11, 37, 42, 45–50, 67–68, 71–72, 74, 76, 78–79, 86–87, 92–93, 97, 106–108, 110–114, 116, 118, 120, 126, 131, 135, 137–139, 143, 146, 148, 155–156, 158, 161, 164–165, 167, 169, 175, 179, 183, 193, 199, 205, 209, 214, 215, 222–223, 225, 227, 229–232, 234–236, 251, 254, 260, 262, 266, 270, 275–277, 285, 289–291, 294–296, 298–300

Reliquiae Suzaianae.
1–28, 30–62, 64–100

REFERENCES

Kukk, T. 1997. Eesti soontaimede herbaariumid – hetkeseis ja perspektiivid. *Rukkilill* 5: 4–17.

Morton, A. 1997. *DMAP for Windows*. Version 6.4.

Piterans, A. 1996. Lichenological herbaria of Latvia. In *Fungi and lichens in the Baltic region* (ed. Vimba, E.), pp. 76–77. Riga.

Saag, A. 1996. Usage of computer program BRAHMS in lichenological studies. In *Fungi and lichens in the Baltic region* (ed. Vimba, E.), pp. 78–79. Riga.

Folia Cryptog. Estonica, Fasc. 32: 85–96 (1998)

Time-space analyses of the British lichen flora, with particular reference to air quality surveys

Mark R. D. Seaward

Department of Environmental Science, University of Bradford, Bradford BD7 1DP, U.K.

Abstract: The spread of air pollution, particulary sulphur dioxide, throughout the British Isles and elsewhere over the past 200 years is accurately reflected by the decline of lichens. Lichens have proved highly versatile for monitoring not only rising but also decreasing levels of air pollution in general and, more recently, qualitative differences brought about by changes in energy policies, clean air legislation and agricultural practices. The use of lichens as biological monitors in air quality surveillance over wide geographical areas, where physicochemical equipment is often inadequate or indeed non-existent, is demonstrated through time-space analyses of distribution data derived from the British Lichen Society's Mapping Scheme.

Kokkuvõte: M. R. D. Seaward. Briti lihhenofloora aeg-ruumilised analüüsid, rõhuasetusega õhu kvaliteedi hinnangule.

Õhu saaste, eriti vääveldioksiidi levik kõikjal Briti saartel viimase 200 a. jooksul peegeldub samblike vähenemises. Samblikud on osutunud mitmekülgseteks indikaatoriteks, võimaldades täheldada mitte ainult õhu saastatuse tõusu ja langust üldjoontes, vaid ka viimasel ajal ilmnenud kvalitatiivseid erinevusi, mida põhjustavad muudatused energiapoliitikas ning põllumajanduses. Demonstreeritakse samblike kasutamist õhu kvaliteedi biomonitoridena samblike levikuandmete aeg-ruumiliste analüüside abil.

INTRODUCTION

The value of lichens as monitors of air pollution is undisputed and has captured the attention not only of lichenologists but also of biological and environmental scientists in general, as reflected by the endless flood of publications on this topic. This paper provides an historical review of the methodologies developed, and the different circumtances in which they have been employed, in order to monitor quantitative and qualitative changes in the British isles.

Although several early British botanists noted that lichens did not thrieve in polluted atmospheres (e.g. Borrer c. 1812 in Turner & Borrer, 1839; Grindon, 1859; Macmillan, 1861), it was the famous Finnish lichenologist William Nylander, at that time working in Paris, who suggested that lichens might be used as indicators of air quality: his studies in the Jardin du Luxembourg showed first the decline in (Nylander, 1866) and later the disapperance of (Nylander, 1896) its epiphytic flora. More than 90 years were to elapse before epiphytic lichens returned to the Jardin du Luxembourg (Seaward & Letrouit-Galinou, 1991).

British air pollution studies involving lichens in the second half of the 19th century and the first half of the 20th century, with few exceptions, were mainly concerned with casual observations on the impoversihment of urban floras or on the general decline in species over local areas (reviewed in Seaward, 1993). Such studies were instrumental in establishing baseline data which could be used later in time-space analyses. Hawksworth et al. (1973), for example, incorporated species data of earlier fieldwork in their reconstruction of the change in air quality in Epping Forest, near London, over the period 1784–1970; based on the nature and diversity of the epiphytic flora, and employing the scale devised by Hawksworth and Rose (1970), mean winter sulphur dioxide levels increased from less than 30 to 70–125 $\mu g/m^3$ over that time. Further studies by Hawksworth and McManus (1992) have shown a remarkable recovery of this flora consequent upon environmental amelioration. As well as their value in time-space analyses, such distribution studies made it possible for the first time to compare the severity, extent and pattern of air pollution between cities (Hawksworth, 1971, 1973; Laundon, 1973).

Several highly influential papers appeared in the 1950s which were to provide a springboard for the future development of lichen – air pollution studies. The first of these, by Jones (1952), contained details of lichen floras of tree boles at sites in England where air pollution levels were known. This made it possible for the first time to construct pollution monitoring scales based on the composition of the lichen flora. Based upon this rudimentary scale, many more sophisticated bioindicational scales were developed. Prior to this period, an 'air pollution hypothesis' had evolved to explain the paucity of lichens in urban areas and the gradual decline in the European lichen flora generally since the Industrial Revolution at the end of the 18th century. However, the constituents of air pollution responsible for these phenomena had not yet been determined; indeed, Jones (1952) and others had indicated smoke and/or soot deposition to be the main cause. Today, sulphur dioxide is recognized as being the major culprit affecting lichen vigour. However, other air pollutants are often implicated, and ever-changing environments, the exacerbatory/synergistic/buffering effects of two or more constituents of a complex pollution burden also affect lichen performance.

It was two publications in 1958 by the Dutch and Swedish scientists Barkman and Skye respectively which most influenced future research on lichens and air pollution in Britain and elsewhere. Since most field studies on this subject relied on the morphological nature and ecological performance of epiphytic lichens, Barkman's (1958) monumental treatise on the phytosociology and ecology proved of immense value in establishing protocols for description and measurement. Skye (1958) recognized sulphur dioxide to be the overriding factor affecting the lichen flora around an oil-shale works. This and his detailed investigation of the compostion and distribution of lichens in and around Stockholm (Skye 1968) provided models for a very large number of subsequent investigations. Casual observations of differences in the composition and numbers of species between lichen floras in polluted and unpolluted areas in earlier studies had been replaced by a simplistic zonal interpretation based on the concept of 'desert', 'struggle' and 'normal' devised by Sernander (1926), to be superseded in its turn, largely as a consequence of Skye's work, by more detailed zonal studies in the 1960s. Investigations in Britain at that time were centred on individual industrial plants, towns or cities, or on urban/industrial complexes, but regional and national studies were to follow with the establishment of the British Lichen Society's Distribution Maps Scheme which commenced in September 1963 (Hawksworth & Seaward, 1990); by applying Sernander's concept of 'desert' to these maps it has been possible to rank species susceptibility to air pollution (see below).

The key paper on zonal mapping was by Hawksworth and Rose (1970) who devised a qualitative scale using epiphytic lichens for the estimation of sulphur dioxide air pollution. Their scheme, designed for use in England and Wales, is based on simple phytosociological analyses which delineate zones equated with mean winter sulphur dioxide levels. This scale has stood the test of time, proving of immense value in air pollution monitoring throughout the British Isles, as well as forming the basis, often only requiring minor adaptation, for scales in Europe and elsewhere. It has been extensively used to monitor the extent or spread of air pollution, particulary sulphur dioxide; however, in areas experiencing reduced levels of, or qualitative changes in, pollution as a result of clean air legislation, it may be less effective (Seaward, 1987; Van Haluwyn & Lerond, 1988; Richardson, 1988). It should be noted that its biological scale is logarithmic in nature (Seaward, 1993, 1997): although major reductions in the sulphur dioxide level at the polluted end of the scale may have little or no effect on lichen species diversity, moving from a polluted to a less polluted situation exponentially increases the effect on the lichen vegetation, so that even a minor increase in sulphur dioxide would dramatically reduce species diversity.

The establishment of baseline data from zonal studies and transect work employing strict methodological protocols, regulary updated to provide valid data, is highly effective in time-space analyses aimed at demonstrating environmental changes, for good or ill, or in predictive interpretation through modelling (Henderson-Sellers & Seaward, 1979; Seaward, 1997).

AMELIORATING ENVIRONMENTS

The undoubted improvement in the lichen flora in many parts of the British Isles during recent years has been clearly demonstrated (Henderson-Sellers & Seaward, 1979; Seaward, 1980, 1993, 1997; Bates & Farmer, 1992; Rose & Hawksworth, 1981; Hawksworth & McManus, 1989). However, it is evident from the above works that the nature of a re-establishing lichen flora differs from that formerly wiped out by air pollution. From our knowledge of the behaviour of lichens subjected to sulphur dioxide air pollution, it has been possible to rank species according to their sensitivity to this pollutant, but variations in replacement assemblages will necessitate modifications to some bioindicational scales to account for these hierarchical changes.

The distribution of *Usnea* spp. in the British Isles illustrates the type of change which has occured since about 1800. This genus, at one time widespread and luxuriant, had over the course of the next 160 or more years almost entirely disappeared from a major area of England and

Table 1. Sensitivity to air pollution of selected species ranked according to scarcity in a prescribed region (1287 grid squares 10 km × 10 km) of Britain, the list commencing and finishing with the most and least sensitive species respectively

	% no. of squares from which sp. is absent (with ranking)		% change
	in Sept. 1992	in Nov. 1997	
Lobaria pulmonaria	96.04 (1)	95.80 (1)	- 0.24
Ramalina fraxinea	91.06 (2)	90.21 (2)	- 0.85
Thelotrema lepadinum	82.67 (3)	81.04 (3)	- 1.63
Lecanactis abietina	79.72 (4)	77.00 (4)	- 2.72
Parmelia perlata	77.78 (5)	71.48 (8)	- 6.30
Physcia aipolia	77.54 (6)	75.29 (5)	- 2.25
Graphis elegans	76.61 (7)	75.06 (6)	- 1.55
Ramalina fastigiata	74.90 (8)	72.96 (7)	- 1.94
Graphis scripta	73.89 (9)	71.41 (9)	- 2.48
Enterographa crassa	73.19 (10)	71.25 (10)	- 1.94
Pertusaria hymenea	71.95 (11)	70.40 (11)	- 1.55
Parmelia revoluta	69.77 (12)	64.96 (12)	- 4.81
Calicium viride	66.43 (13)	64.72 (13)	- 1.71
Lecidella elaeochroma	64.18 (14)	61.07 (14)	- 3.11
Usnea subfloridiana	62.08 (15)	54.31 (15)	- 7.67
Hypogymnia tubulosa	60.76 (16)	52.76 (16)	- 8.00
Parmelia subaurifera	54.86 (17)	41.10 (21)	- 13.76
Parmelia caperata	54.47 (18)	48.02 (18)	- 6.45
Platismatia glauca	53.61 (19)	50.04 (17)	- 3.57
Cliostomum griffithi	50.12 (20)	46.08 (19)	- 4.04
Lecanora chlarotera	48.41 (21)	42.89 (20)	- 5.52
Parmelia subrudecta	45.53 (22)	40.71 (22)	- 4.82
Ramalina farinacea	42.81 (23)	35.35 (24)	- 7.46
Parmelia glabratula	41.96 (24)	35.51 (23)	- 6.45
Evernia prunastri	41.86 (25)	23.00 (25)	- 8.86
Lecanora expallens	30.92 (26)	16.94 (27)	- 13.98
Buellia punctata	29.76 (27)	21.13 (26)	- 8.63
Hypogymnia physodes	21.06 (28)	15.31 (28)	- 5.75
Parmelia sulcata	20.05 (29)	12.12 (29)	- 7.93
Lecanora conizaeoides	1.24 (30)	0.85 (30)	- 0.39

Wales covering at least 68,000 km^2 (Fig. 1), and at least 6,000 km^2 of lowland Scotland, mainly as a result of the increase in atmospheric pollution. However, since the implementation of the Clean Air Acts of 1956 and 1968 in Britain, sulphur dioxide concentrations have declined dramatically in urban/industrial areas, with less dramatic reductions, or indeed occasional rises due to changes in pollutant dispersion techniques, in rural areas, so that much of Britain is now experiencing a more homogeneous distribution of this pollutant. The re-establishment of *Usnea* spp. (mainly *U. subfloridana*), ususally on *Fraxinus* and *Salix*, at numerous sites throughout the British Isles during recent years may largely reflect decreases in pollution levels. There is some evidence that *Ramalina farinacea*, *Evernia prunastri* and *Bryoria fuscescens* are exhibiting a similar response. It would appear, however, that the stability of these taxa of these sites is tenuous, since small thalli may only succeed in establishing themselves for one or two years. Nevertheless, it is now proving possible to monitor ameliorating environments on a relatively large scale through the use of lichen mapping (Fig. 1).

Table 1 has been assembled from detailed comparative studies of the distributions of selected lichen species within a prescribed region of 128,700 km^2 (Fig. 2): comparisons have been made between (a) field data derived from the British Lichen Society's Mapping Scheme up to May 1980, some of which were used in the preparation of the first volume of the *Lichen Atlas* (Seaward & Hitch, 1982) and (b) that derived from the current (November 1997) database to demonstrate the large-scale monitoring capabilities of lichens. These data show the strong correlation between a lichen's sensitivity to air pollution (mainly sulphur dioxide) and the area from which it had declined, as can be seen from the distributions of, for example, *Ramalina farinacea* (Fig. 3), *Usnea* spp. (Fig. 1) and *Parmelia perlata* (Fig. 4), their 'deserts' in c. 1970 extending over 45,000, 68,000 and 88,000 km^2 respectively. However, it is also clear that rankings (cf. Seaward, 1992, Table 1) are changing due to the different abilities of species to re-establish themselves in areas experiencing atmospheric ameloration. Hence, since the previous analysis undertaken less than five years ago, some species, *Lecanora expallens*, *Parmelia subaurifera*, *Evernia prunastri*, etc. (see Table 2) have a greater capacity to adapt to these new regimes.

Regional or 'blanket' pollution over wide areas has reduced lichen diversity, but has favoured expansion of a relatively small number of species formerly having narrower ecological requirements and more restricted distributions, such as *Parmeliopsis ambigua* (Fig. 5), *Scoliciosporum chlorococcum* (Fig. 6) and *Xanthoria polycarpa* (Fig. 7). Some species which are moderately tolerant of sulphur dioxide air pollution have been able to spread in areas where other species have been eliminated. *Parmelia laciniatula* and *P. elegantula*, first recorded in the British Isles as recently as 1933 and 1965 respectively, are two such species and detailed distributional studies show them to be on the increase due to both quantitative and qualitative changes in air pollution (Seaward, 1993).

'Acid rain' can affect lichens both directly or indirectly through the acidification of substrata. *Parmeliopsis ambigua* (Fig. 5), for example, which was formerly to be found mainly on decorticate conifer wood in Scotland, has, over the past few decades, undergone a remarkable expansion onto deciduous trees in moderately polluted areas throughout Britain (cf. Seaward, 1992, 1993), in response to increased bark acidification. The development of more oligotrophic epiphytic lichen floras, including such species as *Micarea nitschkeana* (Fig. 8), has been reported in the British Isles as a result of changes in the nature of pollutant emissions, but their present distribution is poorly understood; since many of the microlichens in these floras are difficult to determine, particulary in the field, their use as monitors of 'acid rain' will be limited. Furthermore, deposition of nitrates via acid rain, emanating from NO_x emissions, can produce a fertilization effect (see below), as yet little studied, which encourages numerous lichen species to flourish, at least over the short term.

Changes in the present lichen composition in many areas of the British Isles are often as much a reflection of increased eutrophication as a reduction in sulphur dioxide levels. Numerous species which are now spreading into suburbs are equally successful elsewhere but formerly had narrower ecological requirements and more restricted distributions. They are probably fa-

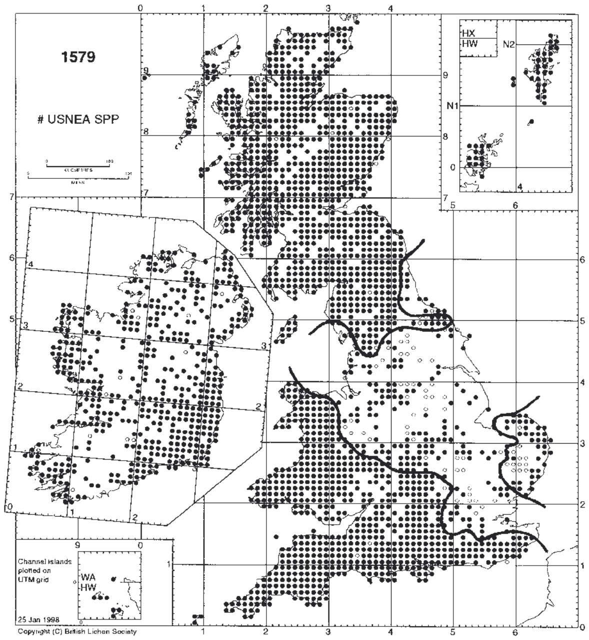


Fig. 1. Distribution of *Usnea* spp. in the British Isles (January 1998) to show its dissappearance from an area of c. 68, 000 km^2 during the period c. 1800-1970, and its subsequent re-establishment at numerous sites (in 150 recording units 10 km × 10 km) within that area; open dot = pre-1960 (usually 19th c.) records, filled dot = 1960 onwards records.

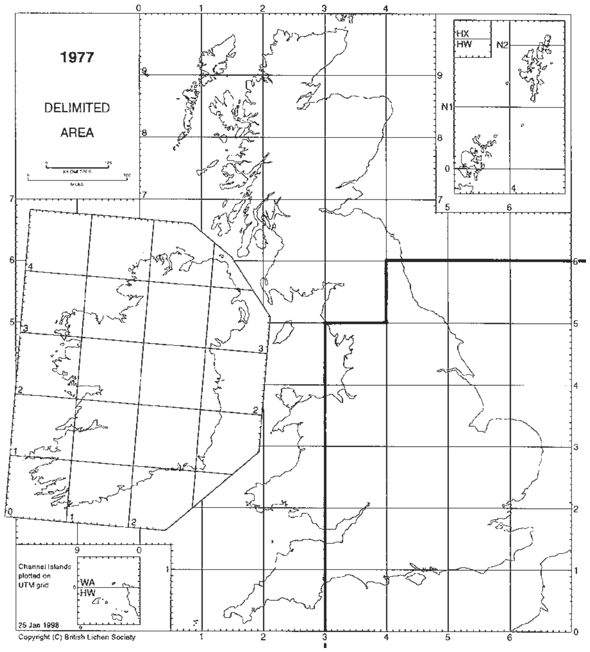


Fig. 2. Prescribed region of Britain (mainly England), much of which has been subjected to increasing air pollution over the past two centuries. The distributions of selected and potentially widespread species from this delimited area (1287 recording units 10 km × 10 km) have been ranked in Table 1 according to their susceptibility to air pollution, based on the number of recording units from which they are currently absent (i.e. lichen 'desert').

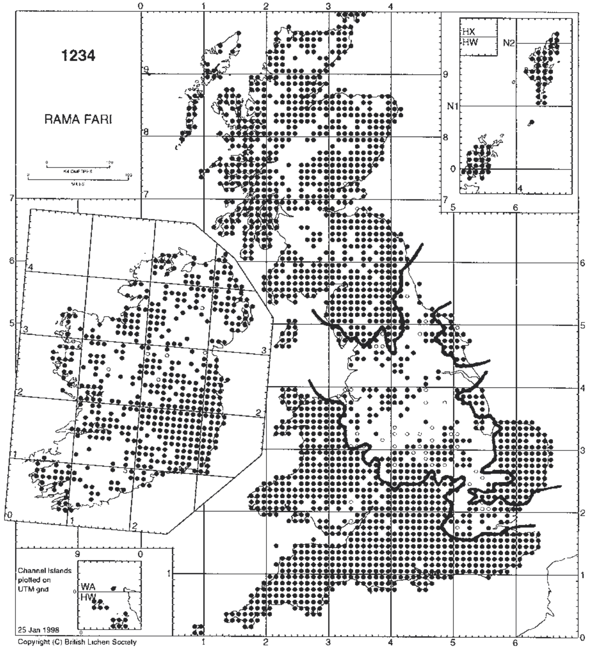


Fig. 3. Distribution of *Ramalina farinacea* in the British Isles (January 1998) to show its dissappearance from an area of c. 45, 000 km^2 during the period c. 1800-1970, and its subsequent re-establishment at numerous sites (in 173 recording units 10 km × 10 km) within that area (cf. Seaward & Hitch, 1982, map 140); open dot = pre-1960 (usually 19th c.) records, filled dot = 1960 onwards records.

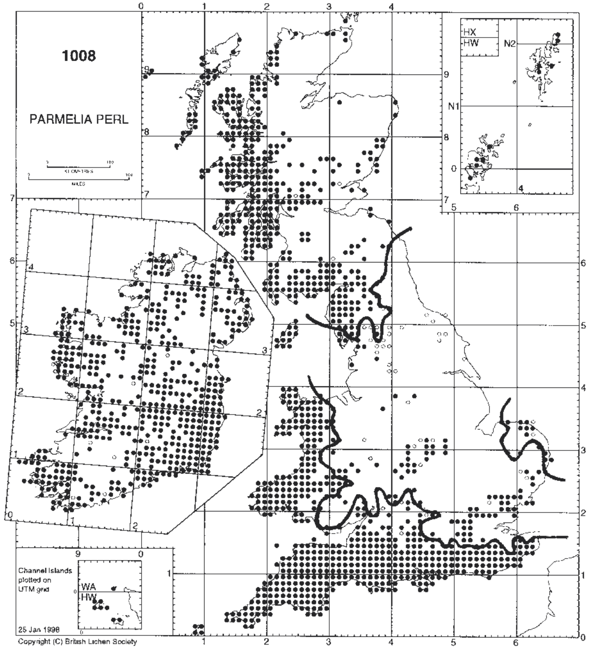


Fig. 4. Distribution of *Parmelia perlata* in the British Isles (January 1998) to show its dissappearance from an area of c. 88, 000 km^2 during the period c. 1800-1970, and its subsequent re-establishment at numerous sites (in 82 recording units 10 km × 10 km) within that area (cf. Seaward & Hitch, 1982, map 102); open dot = pre-1960 (usually 19th c.) records, filled dot = 1960 onwards records.

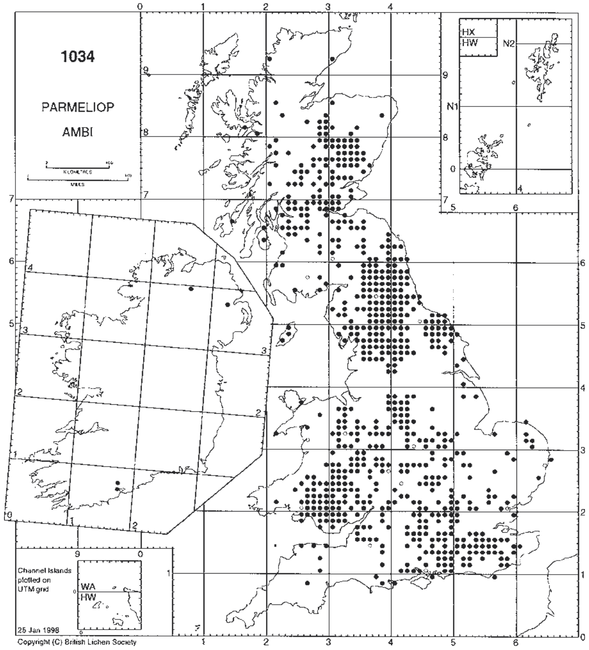
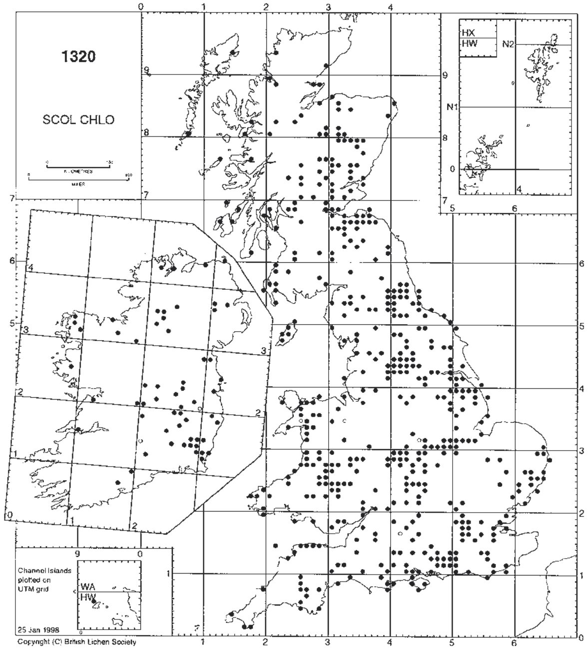


Fig. 5. Distribution of *Parmeliopsis ambigua* in the British Isles (January 1998) to show how it is extending its geographical range in response to increased bark acidification (to pH 3.0), at a rate of more than 11 recording units (10 km × 10 km) per annum over the past 15 years (cf. Seaward & Hitch, 1982, map 116; Seaward, 1992).



Figur 6. Distribution of *Scoliciosporum chlorococcum* in the British Isles (January 1998) to show its spread into both rural and suburban areas in response to changes in atmospheric pollution, being monitored at a rate of c. 26 recording units (10 km × 10 km) per annum over the past 9 years.

Table 2. Ranking of selected species (see Table 1) according to their ability to recolonize areas experiencing amelioration of air pollution within a prescribed region of Britain (see Fig. 2) over the period September 1992 and November 1997. *Lecanora conizaeoides*, with almost complete coverage of the area under study in September 1992, has been omitted from analysis

Species significantly extending their distribution by 7.0 % or more
Lecanora expallens
Parmelia subaurifera
Evernia prunastri
Buellia punctata
Hypogymnia tubulosa
Parmelia sulcata
Usnea subfloridiana
Ramalina farinacea
Species extending their distribution by 4.5 to 6.5 %
Parmelia caperata
Parmelia glabratula
Parmelia perlata
Hypogymnia physodes
Lecanora chlarotera
Parmelia subrudecta
Parmelia revoluta
Species extending their distribution by only 2.0 to 4.5 %
Cliostomum griffithii
Platismatia glauca
Lecidella elaeochroma
Lecanactis abietina
Graphis scripta
Physcia aipolia
Species scarcely extending their distribution
Ramalina fastigiata
Enterographa crassa
Calicium viride
Thelotrema lepadinum
Pertusaria hymenea
Graphis elegans
Ramalina fraxinea
Lobaria pulmonaria

voured by reduced competition, but urban and industrial (mainly alkaline) dusts, acid rain derived from NO_x emissions, soil fertilizers and other agrochemicals promote interesting lichen floras (Seaward, 1997). A fertilization effect on the lichen flora may manifest itself as a consequence of a reduction in the sulphur dioxide burden, but there are instances where this effect generated from factory emissions may ameliorate a local sulphur dioxide problem (Seaward, 1990).

The recent spread of some species into city suburbs and elsewhere may be promoted by windborne nutrient-enriched dusts (Seaward, 1997). By 1973, *Ramalina farinacea* had disappeared from c. 47,300 km^2 of England (Fig. 3), an area incorporating 457 of the 10 km × 10 km recording units (Seaward, 1992); since then, this taxon has been recorded from 78 of these units, showing its successful re-colonization not only of sites formerly experiencing sulphur dioxide levels of 60 μm/m^3 or more, but also those where barks of trees and shrubs have become moderately nutrient-enriched. The increasing occurrence of *Xanthoria polycarpa* throughout the British Isles (Fig. 9), where mean winter sulphur dioxide levels have fallen below 60 μg/m^3, is due in no small measure to agrochemicals which have promoted its growth even in the inner suburbs of most large towns and cities (Seaward, 1997). In 1980, it had been recorded from 580 recording units, and by 1991, it occurred in 869 (Seaward, 1992); in June 1993, this figure has risen to 966 (Seaward, 1993) and by November 1997 had reached 1249.

From an ever-present rich air spora, only a few species are capable of surviving the crucial stages of establishment, germination and development in polluted environments. Once established, such toxitolerant species are strongly competitive, with a high reproductive capacity and a tenacious hold on the substrata they colonize; they can create monovegetational cover, even when a reduction in air pollution level would presuppose reinvasion by formerly successful species. This is illustrated by the rise to dominance of *Lecanora conizaoides* throughout the British Isles, and much of Europe, over the past half century. It was first recorded in Britain in about 1860, since when its spread has been dramatic: by 1953, it occupied c. 121,800 km^2; by 1973, it occupied c. 185,300 km^2, and by 1997 this had extended to c. 207,900 km^2

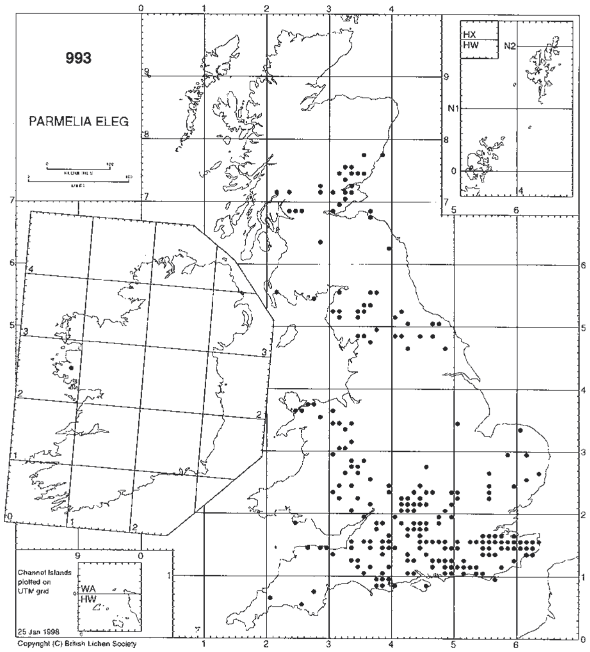


Fig. 7. Distribution of *Parmelia elegantula* in the British Isles (January 1998) to show how it is extending its geographical range, in response to qualitative changes in atmospheric pollution, at a rate of more than 4 recording units (10 km × 10 km) per annum over the past 15 years (cf. Seaward & Hitch, 1982, map 94).

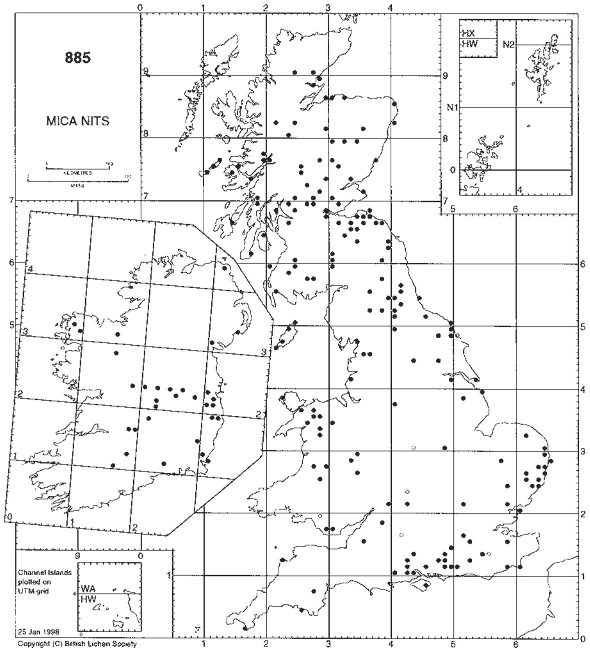


Fig. 8. Distribution of *Micarea nitschkeana* in the British Isles (January 1998) to show how it is extending its ecological amplitude and geographical range, probably in response to qualitative changes in atmospheric pollution, at a rate of c. 7 recording units (10 km × 10 km) per annum over the past 9 years; open dot = pre-1960 (usually 19th c.) records, filled dot = 1960 onwards records.

(Fig. 10). Air polluted environments provide an ideal milieu for the spread of this taxon, and even amelioration, resulting from the implementation of clean air policies, has not as yet broken its monopoly of substrata.

CONCLUDING REMARKS

Profitable lines of enquiry into determining the effects on lichens of the new air pollution regimes should include long-term field techniques involving stringent ecological and phytogeographical criteria. To a large extent, such studies have been made possible in the British Isles through a comprehensive ongoing programme of detailed lichen mapping carried out by members of the British Lichen Society since 1963. Although detailed lichen atlases (eg. Seaward & Hitch, 1982; Seaward, 1995 onwards) contribute significantly to the documentation of atmospheric regimes, mapping programmes must be supported by extensive field studies in a wide range of selected habitats in critical areas where more immediate changes can be scientifically diagnosed by means of bioindicational techniques complemented by adequate monitoring equipment. Intensive lichen monitoring is a necessary component of any programme aimed at effective long-term observation of air pollution.

There is a wealth of evidence to demonstrate the selective decline of lichen species over much wider areas during the past two centuries, mainly attributable to the rise in sulphur dioxide levels, although other pollutants and changing forestry and agricultural practices are also implicated. Lichen mapping is often a race against time, particulary in those areas where clean air legislation and changes in energy policies and industrial practices have been implemented: both qualitative changes in, and dramatic reductions in the level of, air pollution are reflected in the consequent reinvasion by lichens. At the same time, a less dramatic, but nevertheless significant, rise in pollution level over wide geographical areas due to changes in pollutant dispersion techniques has resulted in the loss of a number of lichen species, although others have been able to exploit/tolerate the new atmospheric regimes.

Lichens have been used as monitors of environmental conditions for many years. However, any successful use of lichen bioindicators must depend upon the rigorous definition of the monitoring scales adopted and a complete analysis of all the environmental parameters which affect their propagation, establishment and subsequent growth. The use of bioindicators has the obvious advantage of permitting long-term monitoring without widespread establishment and maintenance of costly and sophisticated equipment. Unfortunately, most of the existing bioindication scales rely on species diversity counts, or at least on a fairly detailed understanding of taxonomy, thereby making the techniques as difficult to employ as sophisticated measuring equipment. It is therefore a serious cause for concern that taxonomic skills are no longer considered an essential component of many biological educational programmes in Britain and elsewhere.

Physical and/or chemical surveys do not necessarily measure those air pollutants which are harmful to biological materials. On-site measuring devices are limited both in number and scope; furthermore, they are unevenly spread over a country, usually being concentrated in urban and industrial complexes (Seaward, 1993). Not only the implementation of a clean air policy resulted in widespread ‘blanket pollution’, but the location of industry and power stations away from cities has also added to the atmospheric burden over wide areas. The use of corroborative information derived from bioindication surveys to support the limited data available from rural sites is strongly recommended. It will never be completely possible to replace direct physical and chemical measurements of air pollutant concentrations by the use of bioindicators; nevertheless, both approaches are necessary for making detailed or large-scale surveys of the distribution of air pollutants, where the extensive use of technical equipment is costly or impractical.

DEDICATION

This paper is respectfully dedicated to Professor Hans Trass whose extensive ecological and phytogeographical studies of the Estonian lichen flora have made it possible to exploit fully their potential to monitor his country’s environment.

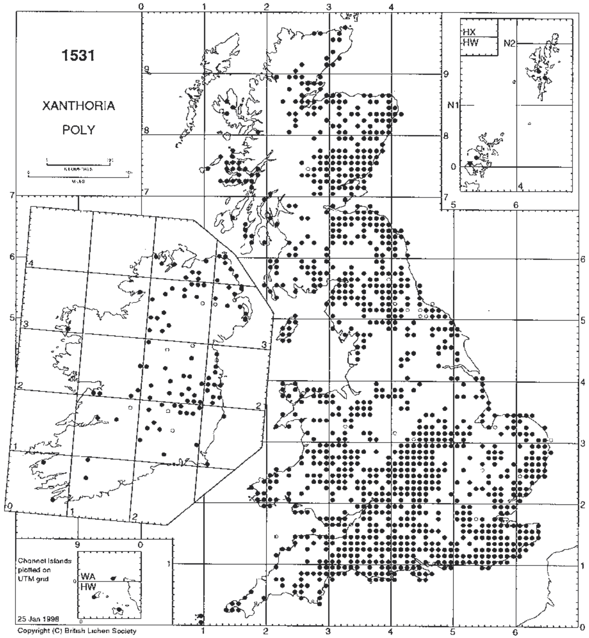


Fig. 9. Distribution of *Xanthoria polycarpa* in the British Isles (January 1998) to show how it is extending its geographical range, in response to nutrient-enrichment of bark via agrochemicals, alkaline dusts and acid rain from NO_3 emissions, at a rate of more than 40 recording units (10 km × 10 km) per annum over the past 15 years (cf. Seaward & Hitch, 1982, map 176; Seaward, 1992)); open dot = pre-1960 (usually 19th c.) records, filled dot = 1960 onwards records.

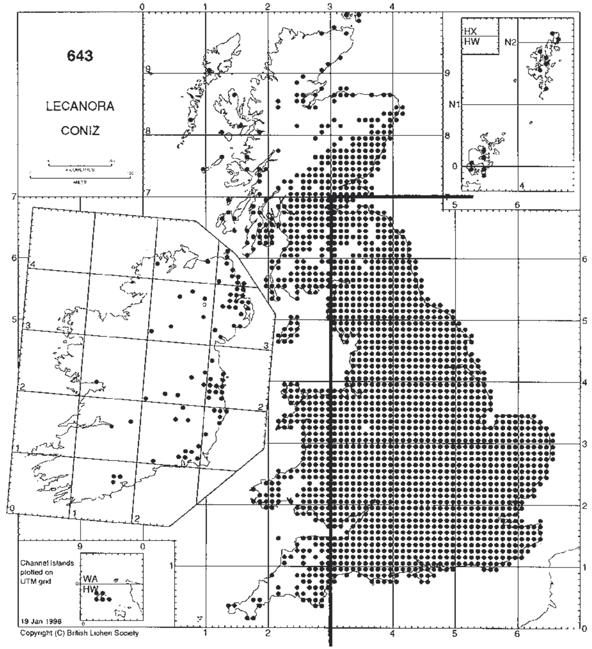


Fig. 10. Distribution of *Lecanora conizaeoides* in the British Isles (January 1998), being rarely encountered to the west and north of the grid lines indicated prior 1950.

REFERENCES

Barkmann, J. J. 1958. *Phytosociology and Ecology of Cryptogamic Epiphytes*. Van Gorcum, Assen.

Bates, J. W. & Farmer, A. W. (eds.) 1992. *Bryophytes and Lichens in a Changing Environment*. Claredon Press, Oxford.

Grindon, L. H. 1859. *The Manchester Flora*. White, London.

Hawksworth, D. L. 1971. Lichens as litmus for air pollution: a histrorical review. *Int. J. Environ. Studies* 1: 281–296.

Hawksworth, D. L. 1973. Mapping studies. In *Air Pollution and Lichens* (ed. Ferry, B. W., Baddeley, M. S. & Hawksworth, D. L.), pp. 38–76. Athlone Press, London.

Hawksworth, D. L. & McManus, P. M. 1989. Lichen recolonization in London under conditions of rapidly falling sulphur dioxide levels, and the concept pf zone skipping. *Bot. J. Linn. Soc.*. 100: 99–109.

Hawksworth, D. L. & McManus, P. M. 1992. Changes in the lichen flora on trees in Epping Forest through periods of increasing and then ameliorating sulphur dioxide air pollution. In *Epping Forest through the Eye of the Naturalist* (ed. Hanson, M. W.), pp. 92–101. Essex Field Club, London.

Hawksworth, D. L. & Rose, F. 1970. Qualitative scale for estimating sulphur dioxide air pollution in England and Wales using epiphytic lichens. *Nature, Lond.* 227: 145–148.

Hawksworth, D. L., Rose, F. & Coppins, B. J. 1973. Changes in the lichen flora of England and Wales attributable to pollution of the air by sulphur dioxide. In *Air Pollution and Lichens* (ed. Ferry, B. W., Baddeley, M. S. & Hawksworth, D. L.), pp. 330–367. Athlone Press, London.

Hawksworth, D. L. & Seaward, M. R. D. 1990. Twenty-five years of lichen mapping in Great Britain and Ireland. *Stuttg. Beitr. Naturk.,* ser. A (Biol.), (456): 5–10.

Henderson-Sellers, A. & Seaward, M. R. D. 1979. Monitoring lichen reinvasion of ameliorating environments. *Environ. Pollut.* 19: 207–213.

Jones, E. W. 1952. Some observations on the lichen flora of tree boles, with special reference to the effect of smoke. *Revue Bryol. Lichenol.* 21: 96–115.

Laundon, J. R. 1973. Urban lichen studies. In *Air Pollution and Lichens* (ed. Ferry, B. W., Baddeley, M. S. & Hawksworth, D. L.), pp. 109–123. Athlone Press, London.

MacMillan, H. 1861. *Footnotes from the Page of Nature or First Forms of Vegetation*. MacMillan, London.

Nylander, W. 1866. Les lichens du Jardin du Luxembourg. *Bull. Soc. Bot. Fr.* 13: 364–372.

Nylander, W. 1896. *Les Lichens des Environs de Paris*. Schmidt, Paris.

Richardson, D. H. S. 1988. Understanding the pollution sensitivity of lichens. *Bot. J. Linn. Soc.* 96: 31–43.

Rose, C. I. & Hawksworth, D.L. 1981. Lichen recolonization in London's cleaner air. *Nature, Lond.* 289: 289–292.

Seaward, M. R. D. 1980. The use of lichens as bioindicators of ameliorating environments. In *Bioindikation auf der Ebene der Individuen* (ed. Schubert, R. & Schuh, J.), pp. 17–23. Martin-Luther-Universität, Halle-Wittenberg.

Seaward, M. R. D. 1987. Effects of quantitative and qualitative changes in air pollution on the ecological and geographical performance of lichens. In *The Effects of Atmospheric Pollutants on Forests, Wetlands and Agricultural Ecosystems* (ed. Hutchinson, T. & Meema, K. M.), pp. 439–450. Springer Verlag, Berlin.

Seaward, M. R. D. 1990. The lichen flora of Teesside. *Naturalist* 115: 73–79.

Seaward, M. R. D. 1992. Large-scale air pollution monitoring using lichens. *GeoJournal* 28: 403–411.

Seaward, M. R. D. 1993. Lichens and sulphur dioxide air pollution: field studies. *Environ. Rev.* 1: 73–91.

Seaward, M. R. D. (ed.) 1995 onwards. *Lichen Atlas of the British Isles*. British Lichen Society, London.

Seaward, M. R. D. 1997. Urban deserts bloom: a lichen renaissance. In *New Species and Novel Aspects in Ecology and Physiology of Lichens* (ed. Kappen, L.). *Bibl. Lichenol.* 67: 297–309. Cramer, Berlin.

Seaward, M. R. D. & Hitch, J. B. (eds) 1982. *Atlas of the Lichens of the British Isles*. Vol. 1. Natural Environment Research Council, Cambridge.

Seaward, M. R. D. & Letrouit-Galinou, M. A. 1991. Lichen recolonization of trees in the Jardin du Luxembourg, Paris. *Lichenologist* 23: 181–186.

Sernander, R. 1926. *Stockholms Natur*. Almqvist & Wiksells, Uppsala.

Skye, E. 1958. Luftföroreningars inverkan pa busk- och bladlavfloran kring skifferoljeverket I Närkes Kvarntorp. *Svensk Bot. Tidskr.* 52: 133–190.

Skye, E. 1968. Lichens and air pollution. *Acta Phytogeogr. Suec.* 52: 1–123.

Turner, D. & Borrer, W. 1839. *Specimen of a Lichenographia Brittanica*. Privately printed, Yarmouth.

Van Haluwyn, C. & Lerond, M. 1988. Lichenosociologie et qualite de l'air: protocole operatoire et limites. *Cryptog., Bryol. Lichenol.* 9: 313–336.

Folia Cryptog. Estonica, Fasc. 32: 97–105 (1998)

Bryological comparisons between Australia and northern Europe

Heinar Streimann
Centre for Plant Biodiversity Research, Cryptogamic Herbarium, Australian National Herbarium,
Box 1600, Canberra, A.C.T., 2601, Australia

Abstract: Comparison and discussion on the similarities between the bryophyte floras of Australia and northern Europe – Denmark, Estonia, Finland, Iceland, Norway, Russia (NW) and Sweden – are made. Currently there are about 112 moss and 14 liverwort species that are common to both Australia and northern Europe, i.e. 10% and 3% respectively of the relevant Austalian floras. The majority of these species are restricted to Southeast Australia (including Tasmania). Of the 126 species compared 8 (2 liverwort) are cosmopolitan species, and 13 (1 liverwort) species may possibly be so; 12 species (all mosses) are recent introductions by man to Australia, and a further 9 are considered as possible introductions; 72 (6 liverwort) species are considered as bipolar disjunctive, including the recently confirmed *Scorpidium scorpioides*. Comments are also included on the Australian distribution and habitat preferences for many of these species.

Kokkuvõte: H. Streimann. Austraalia ja Põhja-Euroopa brüofloorade võrdlus.

Käsitletakse Austraalia ja Põhja-Euroopa (Taani, Eesti, Soome, Islandi, Norra, Loode-Venemaa ja Rootsi) brüofloorade sarnasust. 112 lehtsambla ja 14 helviksambla liiki (vastavalt 10% ja 3%) on ühised Austraaliale ja Põhja-Euroopale. enamus neist liikidest levib Kagu-Austraalias (k.a. Tasmaania). Ühistest liikidest 8 (2 helviksammalt) on kindlalt ja 13 (1 helviksammal) tõenäoliselt kosmopoliidid; 12 liiki (kõik lehtsamblad) on teadaolevalt ja 9 arvatavalt tulnuksamblad Austraaliasse; 72 (6 helviksammalt) on levikult bipolaarsed, sh. hiljuti tuvastatud *Scorpidium scorpioides*. Paljude liikide puhul tuuakse andmeid nende kasvukohtade ja leviku kohta Austraalias.

INTRODUCTION

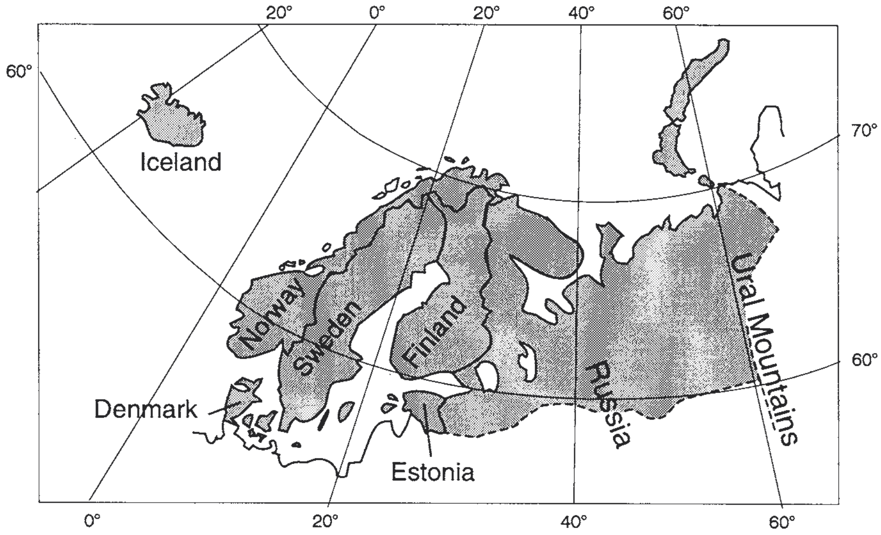
Very few studies have been undertaken to compare the bryophytes of the southern hemisphere to other regions of the world, mainly because of the lack of bryological information from the Australian region. Schofield investigated the bipolar mosses in the southern hemisphere, especially New Zealand (1974), while Piippo & Koponen (1997) investigated the affinities of the western Melanesian moss flora to Australia. The affinities of Asiatic and Australian liverwort floras were investigated by Piippo (1992).

This investigation was primarily initiated by numerous queries in discussions with northern European and Australian bryologists who were interested in the similarities of the bryoflora between the two regions. This work compares the similarities in the bryophyte floras of Australia and northern Europe, especially Scandinavia and northern European Russia (Fig. 1). Northern European Russia comprises the regions of European Arctic, Northwest and Northeast Russia and northern Ural Mountains (Ignatov & Afonina, 1992). Many of these similarities no doubt will apply also to other northern regions.

Many people, including plant botanists, are not aware of how widespread many cryptogams found in Australia are and they are surprised to learn that Australia shares many species with colder northern regions. The bryophyte relationships of tropical Australia with Southeast Asia, and temperate Victoria and Tasmania. with the *Nothofagus* forests of South America are easier to understand than relationships to the colder northern hemisphere.

The vegetation and climate differences between these two geographically distant areas are considerable. Although Australia has warm to hot arid to semi-arid regions, snow is a regular feature for part of the year in the sub-alpine regions of New South Wales, Victoria and Tasmania. Sub-alpine in this work refers to the shrub and herb dominated areas above the tree line.

The Australian vascular flora has adapted to the climatic extremes and generally poor soils which resulted in a distinctive vegetation. While vascular plant geographic distribution does not extend far from Australia, endemic species comprise 85% of the flora (Anon., 1996). Distribution of the moss flora is more widespread with only



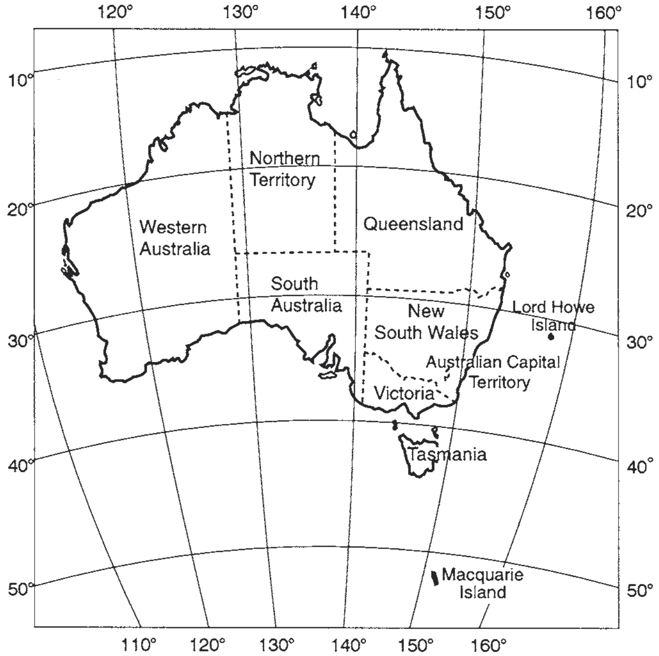


Fig. 1. Territories of compared bryophyte floras in northern Europe and Australia.

about 38 % endemism (Streimann & Curnow, 1989, with subsequent unpublished amendments due to revisions).

Vascular plant species diversity is greatest in Queensland (Hnatiuk, 1990) because of its *Nothofagus*, tropical to sub-tropical forests, monsoon scrub, arid western regions and the higher peaks which have a distinctive flora. However, New South Wales has the richest recorded bryophyte diversity because it also has sub-alpine vegetation and Lord Howe Island in the Pacific Ocean.

Bryophyte studies in Australia lag far behind those of the vascular flora. Exploration, though woefully inadequate, still reveals species previously unreported from Australia. Revisions will possibly decrease the number of endemic species, especially from tropical Australia as many of those species may prove to be geographical variations of widespread Southeast Asian species. The number of bryophyte species may remain stable or decrease. Some names may still be mis-applied in Australia e.g. *Bryoerythrophyllum recurvirostre*, *Pohlia bulbifera,* while some large groups e.g. *Bryum*, *Pottiaceae* and *Sphagnum* are still inadequately understood in Australia. Because of our limited knowledge of Australian (except possibly Tasmanian) cryptogams, the diversity and, geographic relationships have not been investigated fully.

This study is based mainly on data from Damsholt et al. (1969), Frisvoll et al. 1995, Hallingbäck & Söderström (1987), Ignatov & Afonina (1992), Ingerpuu et al. (1994), Jóhannsson (1983), Kannukene et al. (1997), Konstantinova et al. (1992), Koponen et al. (1977), Nyholm (1986, 1989, 1993) for northern Europe. For Australia Scott & Bradshaw (1986) and Streimann & Curnow (1989) were used. All Australian species of doubtful occurrence were ignored.

It must be borne in mind that the analyses of Australian bryophytes, and especially liverworts, are incomplete as most old collections lack adequate data and some recent collectors do not record habit and habitat data. Also many species and areas are still under collected and therefore their range, habitat preferences and distribution are not known with certainty.

Bryophyte numbers for the countries in this study are given in Table 1. The number of Australian moss species in common with the various European countries studied is much greater than was expected, but still represents only a small component of the Australian moss flora. However, when the number of species common with individual northern European countries or regions are compared they comprise 14–21% of moss flora and only 5–9% of the liverwort flora (Table 2).

Table 1. Numbers of bryophyte species in Australia and northern Europe

Country	Mosses	Liverworts
Australia	1150	436
Denmark	436	146
Estonia	405	116
Finland	591	226
Iceland	416	154
Norway	755	282
Russia (NW)	604	221
Sweden	753	266

Table 2. Percentage of the bryophyte flora of each northern European country also occurring in Australia

Country	Mosses (%)	Liverworts (%)
Denmark	21	8
Estonia	19	9
Finland	16	6
Iceland	14	6
Norway	15	5
Russia (NW)	15	6
Sweden	15	5

Most species (Table 3) in common with northern Europe are concentrated in the cooler moister habitats of Southeast Australia (including Tasmania) where sub-alpine regions occur, Kosciuszko National Park, and include areas such as the High Plains of Victoria and Highlands of New South Wales, Victoria and Tasmania.

Table 3. Number of moss species in Australian states common with northern Europe

State	Mosses
Queensland	28
New South Wales	78
Aust. Cap. Terr.	54
Victoria	75
Tasmania	74
Macquarie Is.	23
South Australia	47
Western Australia	30
Northern Territory	6

A further 35 moss and 16 liverwort genera are common to both regions, even though the species differ.

BIOGEOGRAPHICAL COMPARISONS OF MOSSES

The moss species common to Australia and northern Europe that have been analysed include cosmopolitan, disjunctive bipolar and introduced species. For these species, and the majority of the remaining species, comments are made on their Australian range and habitat preferences.

Cosmopolitan mosses

Such species generally thrive in disturbed or open areas and many follow man and his habitation. They are mostly hardy species. It is nearly impossible to ascertain if they were introduced prior to European settlement of Australia. Often there are various interpretations as to what constitutes a cosmopolitan species and an introduced species. Species can be spread unintentionally by birds, animals and man, and this can be considered as a natural function of plant migration. Species in Australia considered as cosmopolitan are: *Bryum argenteum*, *B. caespiticum*, *B. capillare*, *Funaria hygrometrica*, *Leptobryum pyriforme*, *Polytrichum juniperinum.*

Other species that may fit into this category are: *Amblystegium serpens, Aulacomnion palustre, Brachythecium plumosum, Bryum dichotomum, Ceratodon purpureus*, *Grimmia laevigata, G. pulvinata, Polytrichum commune, Schistidium apocarpum, Tortula muralis, T. papillosa* which is generally found in abundance on exotic trees and *Weissia controversa.*

Introduced species

Schofield (1974) lists 14 moss species introduced by man to New Zealand, the majority of which also occur in Australia. There are 9 species in Australia that are bipolar as well as introductions and they are generally considered in this section. The following 12 species are considered native to the northern hemisphere, but introduced to Australia: *Barbula unguiculata*, *Brachythecium albicans*, *B. mildeanum*, *Bryum radiculosum*, *B. rubens*, *Calliergonella cuspidata*, *Phascum cuspidatum*, *Pottia truncata*, *Pseudoscleropodium purum*, *Pterygoneurum ovatum*, *Rhytidiadelphus triquetrus*, *Tortula laevipila*.

Catcheside (1980) suggests that the following species may have also been introduced to Australia: *Acaulon mediterraneum*, *Aloina rigida*, *Amblystegium serpens*, *Barbula hornschuchiana*, *Brachythecium rutabulum*, *Kindbergia praelonga*, *Physcomitrium pyriforme*, *Pottia davalliana*, *Pottia starckeana*.

These introductions can be assumed to be the result of European settlement in Australia as the majority of collections were found in anthropogenic habitats or near to them. Further field studies are required to resolve their status.

Rhytidiadelphus triquetrus is a recent introduction to Australia and New Zealand (Dalton, 1997). It is extremely common in the wet, western Tasmania. This species aggressively invades lawns (especially golf courses), exposed waste land and roadsides where grass cutting apparently assists in dispersal.

Two Australasian species have taken the reverse track and have found the European environment suitable and reached the southern part of the study area. They are *Campylopus introflexus* (Denmark, Sweden, Norway) and *Orthodontium lineare* (Denmark, Sweden).

Bipolar disjunctive mosses

Du Rietz (1940) defined these taxa as “distributed both in the boreal and austral zone but absent from the tropical lowlands, with or without intermediate populations in tropical mountain areas". This definition was used by Schofield (1974) and has been followed here.

Schofield & Crum (1972) discussed disjunction in bryophytes and commented comprehensively on the various explanations that were offered for this distribution pattern. They mentioned only two species relevant to Australia, *Sanionia uncinata* and *Pseudoscleropodium purum*, and provided distribution maps.

Subsequently Schofield (1974) analysed the bipolar disjunctive mosses of New Zealand, but such studies have not been undertaken previously for Australian bryophytes. He included distribution maps for some species, of which *Aulacomnium palustre, Ceratodon purpureus, Climacium dendroides, Desmatodon heimii, Orthodontium lineare, Pottia truncata, Sanionia uncinata* and *Ulota phyllantha* are also found in Australia, but the latter not for New Zealand. Schofield (1974) listed *Plagiothecium denticulatum* (Hedw.) B.S.G., but most New Zealand and all Australian collections have proved to be *P. novae-zealandiae* Broth. (Ireland, 1992). Similarly *Mnium rostratum* Schrad. in Australasia proved to be *Plagiomnium novae-zealandiae* (Col.) T. Kop. (Koponen, 1981).

New Zealand bipolar mosses numbered 83 species (Schofield, 1974), but for Australia the number is about 66, of which the following have not been reported for New Zealand: *Bartramia halleriana, Bryum alpinum, B. creberrianum, Calliergon sarmentosum, Drepanocladus sendtneri, Meesia triquetra, Racomitrium heterostichum, R. sudeticum, Scorpidium scorpioides, Ulota phyllantha.*

An interesting distribution is that of *Climacium dendroides* which so far has been reported only from the Dargo High Plains in Victoria. It is not common there, but the two colonies found were in seepage areas and quite large. The only other southern hemisphere occurrence is in New Zealand. The recent discovery of *Scorpidium scorpioides* in Tasmania (Dalton et al., 1991) was unexpected as it does not occur in New Zealand. The species was common in continuous colonies around the perimeters of small, shallow alkaline ponds. It may prove to be more common than present reports suggest. It was not known from New Zealand when Schofield (1974) reported on the New Zealand bipolar mosses.

Bartramia halleriana, Conostonum tetragonum, Polytrichastum alpinum are absent from Denmark and Estonia because they are mountain species. *Bryum creberrimum,* which prefers basic substrates is absent from Estonia. *Pterygoneurum ovatum* is absent from Estonia, Finland and Iceland. *Bryum sauteri* is present in Norway and Iceland only, while *Grimmia laevigata* is reported only from Sweden and Denmark.

Species widespread in Australia

Widespread species are predominantly in the families *Bryaceae* or *Pottiaceae* and occur in open or disturbed areas. They include: *Aloina aloides* var. *ambigua, Barbula hornschuchiana, Bryum creberrimum, B. dichotomum, B. torquescens, Campylopus pyriformis, Grimmia pulvinata, Hedwigidium integrifolia, Pottia davalliana, Pterygoneurum ovatum, Tortula papillosa* and *Weissia controversa.* Of them *Grimmia pulvinata* and *Hedwigidium integrifolia* prefer drier granitic rocks at medium altitudes, generally in woodlands.

Physcomitrella patens occurs in moist areas of southern Australia and in northern Europe it occurs on mud or silt, but is absent from Iceland.

Cold climate and high altitude species

Australian regions where the climate would resemble that of northern Europe are the Australian Alps (New South Wales, Victoria), the highland areas of these two states plus Tasmania and Macquarie Island.

Tasmania. Tasmania has a cooler and moister climate than most of mainland Australia. This is reflected in the high number of species restricted to that state only in Australia, but also common with New Zealand. Species known only from Tasmania and occurring in northern Europe are: *Buxbaumia aphylla*, *Dicranella schreberiana*, *Fissidens adianthoides*, *Grimmia funalis*, *Kiaeria starkei*, *Polytrichum formosum*, *Racomitrium heterostichum*, *Rhytidiadelphus triquetrus*, *Scorpidium scorpidioides*, *Sphagnum compactum.*

Macquarie Island. *Ulota phyllantha* is the only species restricted to Macquarie Island where it forms compact cushions on rocks. It was reported (Seppelt, 1978) from a raised beach terrace and apparently it is salt tolerant.

Southeast Australian species that extend to Macquarie Island are: *Amblystegium serpens*, *Brachythecium rutabulum*, *B. salebrosum*, *Desmatodon heimii*, *Drepanocladus aduncus, Kindbergia praelonga*, *Orthodontium lineare*, *Sanionia uncinata*, *Schistidium apocarpum*, .

Widespread and common southern Australian species that are absent from humid tropical areas but extend to Macquarie Island are *Campylopus introflexus*, *Ceratodon purpureus*, *Grimmia laevigata* and *Hypnum cupressiforme*. This latter species is not common in Western Australia. Another common and widespread Australian species found on the Island is *Polytrichum juniperinum.*

High altitude species. The highest proportion of species which also occur in northern Europe reach their best development in the Australian Highlands and the alps, mostly preferring the moister areas. McVean and Weber were the first to collect widely in the Kosciuszko National Park. J.H. Willis included mosses amongst his plant studies on the Bogong High Plains of Victoria. In my continuing studies in the High Plains of Victoria several species have been found that are more common than previously reported (e.g. *Meesia triquetra* reported as rare by Scott & Stone, 1976). In Tasmania many of these species would occur at lower altitudes.

High altitude species that are confined to swampy or moist areas include: *Brachythecium rivulare*, *Bryum algovicum*, *B. muhlenbeckii*, *B. pseudotriquetrum*, *B. subapiculatum*, *B. tenuisetum*, *Calliergon sarmentosum*, *Calliergonella cuspidata*, *Campylium polygamum*, *Climacium dendroides*, *Drepanocladus aduncus*, *D. sendtneri*, *Leptodictyum riparium*, *Meesia triquetra*, *Pohlia bulbifera*, *P. cruda*, *Sanionia uncinata*, *Scorpidium scorpioides*, *Warnstorfia exannulata*, *W. fluitans.*

Pohlia nutans and *Pohlia wahlenbergii* can also occur at mid-elevations where they can withstand slightly drier conditions.

Mosses found predominantly on rocks or rock-faces include: *Distichium capillaceum*, *Fissidens adianthoides*, *Grimmia trichophylla*, *Orthotrichum rupestre*, *Racomitrium heterostichum*, *R. sudeticum*, *Schistidium rivulare*, *Tortula ruralis*.

Racomitrium lanuginosum is common in northern Europe. In Australia it is represented by the ssp. *pruinosum* Wils. It is scattered and moderately common in the sub-alpine regions, but rarely forming large continuous colonies. *Sanionia uncinata* is found in moister areas on the bases of treelets and shrub stems, on logs and along water course banks.

Other species

Some species barely manage to reach the European study area, possibly because they prefer the milder climates. Two species are found only in southern Sweden where they are not very common – *Acaulon mediterraneum* and *Pottia starckeana*. *Acaulon mediterraneum* occurs on lawns and river flats while the latter species is possibly introduced to Australia (Catcheside, 1980), being common in southern Australia on disturbed soil and in urban habitats. *Bryum torquescens* is rare in Denmark and southern Sweden while reasonably common in Australia on coastal sand dunes. *Pottia davalliana* which occurs in disturbed situations in southern Australia is not common in northern Europe, especially Estonia.

Aloina rigida is restricted to South Australia where it occurs on calcareous soils in dry disturbed habitats. Catcheside (1980) suspects that it may be introduced. In northern Europe it is found in Denmark, Estonia, Sweden and Norway, possibly in the warmer regions. An exclusively limestone moss in Australia, as in Europe, is *Orthotrichum cupulatum* which is restricted to mid-elevations in southeast Australia. *Encalypta vulgaris* occurs in drier southern Australia and is found on the ground, rocks and rock crevices, often also on limestone.

Bryum alpinum is known from one Victorian mountain locality from rocks (type unknown) in a creek while in Europe it prefers wet acid rocks. *B. dichotomum* occurs on clayey or silty soils, rocks, moist and sheltered areas and on disturbed soils in towns. *Hedwigia ciliata* prefers drier acid rocks and is common at mid-elevations in paddocks and *Eucalyptus* woodlands, while in Europe it is found on rocks in paddocks.

Several species that are found in both northern Europe and Australia occur in sub-tropical

Queensland. *Didymodon vinealis* and *Trichostomum brachydontium,* are found in the drier interior from southern Queensland to Western Australia. *Anoectangium aestivum* has been reported from eastern Victoria, Southeast New South Wales and from tropical coastal Queensland. Another species that reaches Queensland, and is reasonably common in moister Southeast Australia, is *Neckera pennata*. *Campylopus flexuosus* is restricted to northeast Queensland where it occurs above 760 m, but is more common on the higher mountains.

COMPARISONS OF LIVERWORTS

Fewer species (Table 1), and a smaller proportion of liverworts are common between the two study areas (Table 2). Of the 436 species found in Australia 26 genera extend into the northern European study area, with only 10 genera with 14 species common to the two regions.

Cosmopolitan species are not common in Australia with only 2 species considered cosmopolitan. *Lunularia cruciata* is common along water courses, generally in disturbed, manmade habitats, but also in various vegetation types that often dry out. *Ricciocarpus natans* is common on still lakes, especially those with bird populations (Scott, 1985). Schuster (1992) considers *Pallavicinia lyellii* to be sub-cosmopolitan being confined to temperate regions. In Australia it occurs in moister forested areas at lower elevations in Tasmania and Victoria.

Scott (1985) considered *Marchantia polymorpha* to be recently introduced, but CANB collections annotated by Bischler-Causse (1989) indicate that this species occurs in natural vegetation, as well as man made habitats between 600–1600 m in moister Southeast Australia.

Six species can be considered to be bipolar disjunctive and are confined to Southeast Australia and Tasmania. *Calopogeia sphagnicola* is confined to Tasmania. *Cephaloziella arctica is* found in a wide range of vegetation types, generally on burnt logs or soil, between 80–1400 m. *Lophocolea bidentata* ranges from *Eucalyptus* forests to sub-alpine heath, from near sea-level to 1520 m, and extends to grasslands on Macquarie Island. *Lophocolea minor* prefers moist, often calcareous rocks, in temperate forest and on semi-exposed ground at low to mid-altitudes. *Metzgeria furcata* is found in various forest types and commonly on road cuttings between 20–1600 m, and extends to grasslands on Macquarie Island. *Riccia sorocarpa* prefers soil and rocks in drier areas at lower elevations.

Two species are restricted to warmer, semi- to arid regions at lower altitudes. *Riccia cavernosa* occurs on clay or sand. *Riccia bifurca* is found generally in moister regions, often in towns while in northern Europe it occurs also at low to mid-altitudes.

Diplophyllum obtusifolium is confined to the sub-alpine areas where it occurs on rock ledges. *Metzgeria conjugata* is found in New South Wales and Tasmania, but no further data were available.

LIST OF BRYOPHYTES OCCURRING IN AUSTRALIA AND NORTHERN EUROPE

bipolar species
✸ introduced species
! cosmopolitan species

Mosses

	Acaulon mediterraneum Limpr.
	Aloina aloides (K.F. Schultz) Kindb.
	Aloina rigida (Hedw.) Limpr.
#	Amblystegium serpens (Hedw.) B.S.G.
#	Amblystegium varium (Hedw.) Lindb.
	Anoectangium aestivum (Hedw.) Mitt.
#	Aulacomnium palustre (Hedw.) Schwaegr.
	Barbula hornschuchiana K.F. Schultz
#✸	Barbula unguiculata Hedw.
#	Bartramia halleriana Hedw.
#✸	Brachythecium albicans (Hedw.) B.S.G.
✸	Brachythecium mildeanum (Schimp.) Schimp. ex Milde
#	Brachythecium plumosum (Hedw.) B.S.G.
	Brachythecium rivulare B.S.G.
#	Brachythecium rutabulum (Hedw.) B.S.G.
#	Brachythecium salebrosum (Web. & Mohr) B.S.G.
#	Bryoerythrophyllum recurvirostrum (Hedw.) Chen
#	Bryum algovicum Sendtn. ex C. Muell.
#	Bryum alpinum Huds. ex With.
!	Bryum argenteum Hedw.
!	Bryum caespiticium Hedw.
!	Bryum capillare Hedw.
#	Bryum creberrimum Tayl.

Bryum dichotomum Hedw.
Bryum intermedium (Brid.) Bland.
Bryum muhlenbeckii B.S.G.
Bryum pseudotriquetrum (Hedw.) Gaertn.
✸ Bryum radiculosum Brid.
#✸ Bryum rubens Mitt.
Bryum sauteri B.S.G.
Bryum subapiculatum Hampe
Bryum tenuisetum Limpr.
Bryum torquescens BB. & S.
Buxbaumia aphylla Hedw.
Calliergon sarmentosum (Wahlenb.) Kindb.
#✸ Calliergonella cuspidata (Hedw.) Loeske
Campylium polygamum (B.S.G.) J. Lange & C. Jens.
Campylopus flexuosus (Hedw.) Brid.
Campylopus introflexus (Hedw.) Brid.
Campylopus pyriformis (K.F. Schultz) Brid.
Ceratodon purpureus (Hedw.) Brid.
Climacium dendroides Web. & Mohr
Conostomum tetragonum (Hedw.) Lindb.
Desmatodon heimii (Hedw.) Mitt.
Dicranella schreberiana (Hedw.) Dix.
Dicranum scoparium Hedw.
Didymodon vinealis (Brid.) Zander
Distichium capillaceum (Hedw.) B.S.G.
Drepanocladus aduncus (Hedw.) Warnst.
Drepanocladus sendtneri (Schimp.) Warnst.
Encalypta vulgaris Hedw.
Eurhynchium speciosum (Brid.) Jur.
Fissidens adianthoides Hedw.
Fissidens bryoides Hedw.
! Funaria hygrometrica Hedw.
Funaria muehlenbergii Turn.
Grimmia laevigata (Brid.) Brid.
Grimmia pulvinata (Hedw.) Sm.
Grimmia trichophylla Grev.
Gymnostomum aeruginosum Sm.
Haplohymenium pseudotriste (C. Muell.) Broth.
Hedwigia ciliata (Hedw.) P. Beauv.
Hedwigidium integrifolium (P. Beauv.) Dix.
Hymenostylium recurvirostrum (Hedw.) Dix.
Hypnum cupressiforme Hedw.
Kiaeria starkei (Web. & Mohr) I. Hag.
Kindbergia praelonga (Hedw.) Ochyra
! Leptobryum pyriforme (Hedw.) Wils.
Leptodictyum riparium (Hedw.) Warnst.
Meesia triquetra (Richter) Ångstr.
Neckera pennata Hedw.
Orthodontium lineare Schwaegr.
Orthotrichum cupulatum Brid.
Orthotrichum rupestre Schleich. ex Schwaegr.
#✸ Phascum cuspidatum Hedw.
Physcomitrella patens (Hedw.) B. & S.
Physcomitrium pyriforme (Hedw.) Brid.
Pohlia bulbifera (Warnst.) Warnst.
#Pohlia cruda (Hedw.) Lindb.
Pohlia nutans (Hedw.) Lindb.
Pohlia wahlenbergii (Web. & Mohr) Andr.
Polytrichastrum alpinum (Hedw.) G.L. Sm.
Polytrichum commune Hedw.
Polytrichum formosum Hedw.
! Polytrichum juniperinum Hedw.
Polytrichum piliferum Hedw.
Pottia davalliana (Sm.) C. Jens.
Pottia starckeana (Hedw.) C. Muell.
#✸ Pottia truncata (Hedw.) B. & S.
#✸ Pseudoscleropodium purum (Hedw.) Fleisch.
#✸ Pterygoneurum ovatum (Hedw.) Dix.
Racomitrium heterostichum (Hedw.) Brid.
Racomitrium lanuginosum (Hedw.) Brid.
Racomitrium sudeticum (Funck) B. & S.
✸ Rhytidiadelphus triquetrus (Hedw.) Warnst.
Sanionia uncinata (Hedw.) Loeske
Schistidium apocarpum (Hedw.) B. & S.
Schistidium rivulare (Brid.) Podp.
Scorpidium scorpioides (Hedw.) Limpr.
Sphagnum compactum Lam. & DC.
Sphagnum cuspidatum Ehrh. ex Hoffm.
Sphagnum palustre L.
#✸ Tortula laevipila (Brid.) Schwaegr.
Tortula muralis Hedw.
Tortula papillosa Wils.
Tortula ruralis (Hedw.) Gaertn., Meyer & Schreb.
Trichostomum brachydontium Bruch
Ulota phyllantha Brid.
Warnstorfia exannulata (B.S.G.) Loeske
Warnstorfia fluitans (Hedw.) Loeske
Weissia controversa Hedw.
Weissia rutilans (Hedw.) Lindb.

Liverworts

Calypogeia sphagnicola (Arn. & Perss.) Warnst. & Loeske
Cephaloziella arctica Bryhn & Douin
Diplophyllum obtusifolium (Hook.) Dum.
Lophocolea bidentata (L.) Dum.
Lophocolea minor Nees
! Lunularia cruciata (L.) Lindb.
Marchantia polymorpha L.
Metzgeria conjugata Lindb.
Metzgeria furcata (L.) Dum.
Pallavicinia lyellii (Hook.) Carruth.
Riccia bifurca Hoffm.

Riccia cavernosa Hoffm.

\# Riccia sorocarpa Bisch.

! Ricciocarpus natans (L.) Corda

ACKNOWLEDGEMENTS

This study resulted from the kind invitation to contribute to the anniversary volume dedicated to Prof. Hans Trass. I had the good fortune to enjoy his company, on several visits to Estonia and discuss our mutual interests in lichens. Therefore I feel honoured to be able to pay my respects to his scholarship.

I am grateful to Drs E. Urmi (Zürich), J. Enroth (Helsinki) and A. Frisvoll (Trondheim) for assistance with publications and data. Sincerest thanks are also extended to Prof. W. Schofield (Vancouver), Dr H.P. Ramsay (Sydney) and M.Sc. N. Ingerpuu for comments suggesting improvements to the work. Dr R. Ochyra (KRAM) assisted with further information, while J. Johnston provided helpful editing assistance and suggestion to improve the content.

REFERENCES

Anon. 1996. *Australia state of the environment.* Dept Sport & Environ., Canberra.

Bischler-Causse, H. 1989. *Marchantia* L. The Asiatic and Oceanic taxa. *Bryophyt. Biblioth.* 38: 1–317.

Catcheside, D. G. 1980. *Mosses of South Australia.* Gov. Print., Adelaide. 364pp.

Dalton, P. J. 1997. *Rhytidiadelphus squarrosus* – an adventive species in western Tasmania. *Austral. Bryol. Newsletter* 36: 4–6.

Dalton, P. J., Seppelt, R. D. & Buchanan, A. M. 1991. An annotated checklist of Tasmanian mosses. In *Aspects of Tasmanian botany* (ed. Banks, M. R. et al.), pp. 15–32. Roy. Soc. Tasm., Hobart.

Damsholt, K., Holmen, K. & Warncke, E. 1969. A list of the bryophytes of Denmark. *Saert. Bot. Tidssk.* 65: 163–183.

Du Rietz, G. E. 1940. Problems of bipolar plant distribution. *Acta Phytogeogr. Suec.* 13: 215–282.

Frisvoll, A. A., Elvebakk, A., Flatberg, K. I. & Okland, R. H. 1995. *Sjekkliste over norske mosar. Vitskapleg og norsk namneverk* [Checklist of Norwegian bryophytes. Latin and Norwegian nomenclature]. Norsk institutt for naturforskning. Trondheim.

Hallingbäck, T. & Söderström, L. 1987. Sveriges mossor och deras svenska namnen kommenterad checklista [The bryophytes of Sweden, an annotated checklist with common names]. *Svensk Bot. Tidsk.* 81: 357–388.

Hnatiuk, R. J. 1990. Census of Australian Vascular Plants. *Austral. Fl & Fauna* 11: 1–650.

Ignatov, M. S. & Afonina, O. M. 1992. Check-list of mosses of the former USSR. *Arctoa* 1: 1–85.

Ingerpuu, N., Kalda, A., Kannukene, L., Krall, H., Leis, M. & Vellak, K. 1994. Eesti sammalde nimestik [List of the Estonian bryophytes]. *Abiks loodusev.* 94: 1–175.

Ireland, R. R. 1992. Studies of the genus *Plagiothecium* in Australia. *Bryologist* 95: 221–224.

Jóhannsson, B. 1983. A list of Icelandic bryophyte species. *Acta Nat. Islandica* 30: 1–29.

Kannukene, L., Ingerpuu, N., Vellak, K. & Leis, M. 1997. Additions and amendments to the list of Estonian bryophytes. *Folia Cryptog. Estonica* 31: 1–7.

Konstantinova, N. A., Potemkin, A. D. & Schljakov, R. N. 1992. Check-list of the Hepaticae and Anthocerotae of the former USSR. *Arctoa* 1: 87–127.

Koponen, T. 1981. A synopsis of Mniaceae (Bryophyta). VII. List of species and their distribution. *Ann. Bot. Fenn.* 18: 113–115.

Koponen, T., Isoviita, P. & Lammes, T. 1977. The bryophytes of Finland an annotated checklist. *Soc. pro Fauna & Fl. Fenn.* 6: 1-77.

Nyholm, E. 1986, 1989, 1993. *Illustrated moss flora of Nordic mosses.* Fasc 1: 1–72, Fasc. 2: 75–141, Fasc. 3: 145–244. Nordic Bryol. Soc.

Piippo, S. 1992. On the phytogeographical affinities of temperate and tropical asiatic and Australasiatic hepatics. *J. Hattori Bot. Lab.* 71: 1–35.

Piippo, S. & Koponen, T. 1997. On the phytogeographic biodiversity of western Melanesian mosses. *J. Hattori Bot. Lab.* 82: 191–201.

Schofield, W. B. 1974. Bipolar disjuntive mosses in the southern hemisphere, with particular reference to New Zealand. *J. Hattori Bot. Lab.* 38: 13–32.

Schofield, W. B. & Crum, H. A. 1972. Disjunctions in bryophytes. *Ann. Missouri Bot. Gard.* 59: 174–202.

Schuster, R. 1992. *The Hepaticae and Anthocerotae of North America, east of the hundreth meridian.* Vol. V. Field Museum, Chicago. 854 pp.

Scott, G. A. M. 1985. Southern Australian liverworts. *Austral. Fl. & Fauna 2:* 1–216.

Scott, G. A. M. & Bradshaw, J. A. 1986. Australian liverworts (Hepaticae): annotated list of binomials and check-list of published species with bibliography. *Brunonia* 8: 1–171.

Scott, G. A. M. & Stone, I. G. 1976. *The mosses of southern Australia.* Academic Press, London. 495 pp.

Seppelt, R. D. 1978. Studies on the bryoflora of Macquarie Island II. *Ulota phyllantha* Brid. *New Zealand J. Bot.* 16: 21–23.

Streimann, H. & Curnow, J. A. 1989. Catalogue of mosses of Australia and its external territories. *Aust. Fl. & Fauna* 10: 1–479.

Folia Cryptog. Estonica, Fasc. 32: 107–112 (1998)

Lecideoid lichens from Estonia – an annotated checklist

Ave Suija
Institute of Botany and Ecology, University of Tartu, 38 Lai St., EE2400 Tartu, Estonia

Abstract: 53 species, previously placed in the genus *Lecidea* are recognized in Estonia. Six of them – *Cecidonia umbonella* (Nyl.) Triebel & Rambold, *Lecidea plana* (J. Lahm) Nyl., *Lecidella scabra* (Taylor) Hertel & Leuckert, *Placynthiella dasaea* (Stirt.) Tønsberg, *Placynthiella oligotropha* (J.R. Laundon) Coppins & P. James and *Trapeliopsis pseudogranulosa* Coppins & P. James are new to the country.

Kokkuvõte: A. Suija. *Lecidea*-taolised kooriksamblikud Eestis.

Eesti lihhenoflooras on 53 varem perekonda *Lecidea* kuulunud liiki. Neist kuut – *Cecidonia umbonella* (Nyl.) Triebel & Rambold, *Lecidea plana* (J. Lahm) Nyl., *Lecidella scabra* (Taylor) Hertel & Leuckert, *Placynthiella dasaea* (Stirt.) Tønsberg, *Placynthiella oligotropha* (J.R. Laundon) Coppins & P. James and *Trapeliopsis pseudogranulosa* Coppins & P. James märgitakse esmakordselt.

INTRODUCTION

Since the last and the most complete checklist of Estonian lichens (Trass, 1970) until now, many important changes in lichen systematics have been taken place. For example, the catalogue by Trass contained 45 species in the genus *Lecidea*, while only four of them belong to the genus today. All other species have been placed into 15 different genera. The term "lecideoid lichens" was proposed by H. Hertel (1984) to unite all taxa previously treated in the genus *Lecidea*.

53 lecideoid lichen species representing 20 genera plus eight species with uncertain position are listed in the present paper. 43 species occur in the contemporary lichen flora of Estonia; six (*Amygdalaria panaeola*, *Adelolecia kolaensis*, *Fuscidea cyathoides*, *"Lecidea" hypopta*, "*L.*" *sphaerella*, *Trapelia coarctata*) are considered to be extinct (records only from before 1950). *Fuscidea lygaea*, *"Lecidea" albofuscescens*, *Lecidea sarcogynoides* and *Pyrrhospora cinnabarina* have been included in the checklist because of information in old literature (Bruttan, 1870; Mereschkowski, 1913; Räsänen, 1931; Trass, 1970), whereas there are no herbarium specimens. *Fuscidea kochiana*, *"Lecidea" fuscescens*, "*L.*" *fuliginosa*, "*L.*" *olivascens* and *Lecidella anomaloides* ought to be excluded from the checklist (Trass, 1970), as they appeared to be misidentifications. Six species – *Cecidonia umbonella*, *Lecidea plana*, *Lecidella scabra*, *Placynthiella dasaea*, *P. oligotropha* and *Trapeliopsis pseudogranulosa* are new for Estonia.

MATERIALS AND METHODS

This study was carried out in 1995–1997 and was based on the herbarium collections, kept in the University of Helsinki (H), International Center for Environmental Biology (ICEB) in Tallinn, Ecological Institute (IE) in Tallinn, University of Riga (RIG), Estonian Nature Museum (TAL), Tallinn Botanic Garden (TBA), the Institute of Botany and Ecology of the University of Tartu (TU) and Uppsala University (UPS). The references in literaure have also been taken into account: Bruttan (1870), Ekman et al. (1991), Mereschkowsky (1913), Moberg (1992), Räsänen (1931) and Trass (1967, 1970).

The morphological characters of taxa were examined using a stereo lens MBS-9, the anatomical characters using a light microscope MBI-3. Cross sections of fruitbodies were made by hand and then mounted in water, 10% KOH or Lugol's solution. The "spot tests" were made on the thallus or medulla using 10% KOH (K), sodium hypochlorite (C), p-phenylendiamine in ethanol (Pd) or Lugol's solution (I). Chemical analyses of secondary products of lichens were carried out according to standardized TLC methods described by Culberson & Kristinsson (1970) and Culberson (1972).

The following keys were used to identify the specimens: Foucard (1990), Gowan & Ahti (1993), Hertel (1995), Magnusson (1952b), Printzen (1995), Purvis et al. (1992), Tønsberg (1992), Vainio (1934) and Wirth (1995).

CHECKLIST OF TAXA

Genera and species are listed alphabetically. Nomenclature follows Santesson (1993), but recent changes are also taken into account. Species, the systematical position of which is uncertain, are marked with quotation marks (" "). Synonymes, which have been used in Estonian lichenological literature, are also included. New taxa for Estonia are given in **bold**, doubtful species are marked with a question mark (?), exctinct species with an asterisk (*).

* ADELOLECIA KOLAENSIS (Nyl.) Hertel & Rambold (syn. *Lecidea conferenda* Nyl.) – on siliceous rocks. Probably extinct in Estonia, only one collection known from the first part of century: Harjumaa Co., Kunda (58°29'N, 26°32'E), in the seashore, V. Räsänen, 14 June 1927 (H).

* AMYGDALARIA PANAEOLA (Ach.) Hertel & Brodo (syn. *Lecidea panaeola* Ach.) – on siliceous rocks. Probably extinct in Estonia, only one collection known from the last century: Saaremaa Co., Saaremaa Is., A. Bruttan, No.141 (RIG).

BIATORA CHRYSANTHA (Zahlbr.) Printzen (syn. *Lecidea epixanthoidiza* auct. non Nyl.) – on mosses. Very rare, only one record known: Läänemaa Co., at the ornithological field station at Puhtu (58°34'N, 23°35'E) (S) (Ekman et al., 1991).

BIATORA EFFLORESCENS (Hedl.) Erichsen [syn. *Lecidea epixanthoidiza* Nyl., *L. efflorescens* (Hedl.) Erichsen] – on the bark of coniferous trees. Rather rare: known from eight localities all over the country.

BIATORA HELVOLA Körb. [syn. *Lecidea helvola* (Körb.) Th. Fr.] – on the bark of coniferous trees, rarely on deciduous trees. Rather common: about 20 localities known in different parts of Estonia.

BIATORA OCELLIFORMIS (Nyl.) Arnold [syn. *Lecidea atroviridis* (Arnold) Th. Fr.] – on the bark of deciduous and coniferous trees. Rare: known from four localities. 1. Saaremaa Co., Saaremaa Is., Viidumäe Nature Reserve, sq. no.227 (58°16'N, 21°58'E), T. Randlane, 4541, 26 Aug. 1976 (TU); 2. Tartumaa Co., Vasula, Vasula forest (58°28'N, 26°40'E), E. Parmasto, 4539, 21 Nov. 1948 (TU); 3. Tartumaa Co., Tähtvere distr., sq. no.53 (58°25'N, 26°35'E), P. Pott, 4540, 10 July 1995 (TU); 4. Põlvamaa Co., near the Ahja River, Otten's mill (58°07'N, 27°03'E), H. Trass, 4542, 13 July 1990 (TU).

BIATORA VERNALIS (L.) Fr. [syn. *Lecidea vernalis* (L.) Ach.] – on the ground and on mosses. Rather rare: known from six scattered localities.

CARBONEA VITELLINARIA (Nyl.) Hertel [syn. *Lecidea vittelinaria* (Flörke) Körb.] – lichenicolous on the thallus of *Candellariella* sp. Rare: known from five localities in western and northern Estonia 1. Saaremaa Co., Harilaid (58°29'N, 21°51'E), H. Trass, 4479, 21 June 1959 (TU); 2. Läänemaa Co., Kaseküla alvar (58°38'N, 23°34'E), H. Trass, 4481, 4482, 10 Aug. 1991 (TU); 3. Harjumaa Co., Rammu Is. (59°34'N, 25°14'E), E. Nilson, July 1993 (IE); 4. Harjumaa Co., Rammu Is., T. Piin, No. 33(91), 1991 (TBA); 5. Harjumaa Co., Pedassaar Is. (59°31'N, 25°23'E), T. Piin, No.183(91), 1991 (TBA); 6. Harjumaa. Co., Tallinn, Nõmme (59°23'N, 24°42'E), J. Rubel No.116, June 1931 (TAL).

CECIDONIA UMBONELLA (Nyl.) Triebel & Rambold – lichenicolous on the thallus of *Lecidea lapicida* var. *lapicida*. Very rare, known from one locality: Saaremaa Co., Harilaid islet (58°29'N, 25°51'E), H. Trass, 4772, 22 June 1959 (TU).

FARNOLDIA JURANA (Schaer.) Hertel (syn. *Lecidea albosuffusa* Th. Fr., *L. jurana* Schaer.) – on calcareous substrata, particulary limestone. Rather rare: known from seven localities in coastal areas of northern and western Estonia.

FUSCIDEA ARBORICOLA Coppins & Tønsberg – on the bark of deciduous and coniferous trees. Rare, but possibly overlooked: known from three localities. 1. Ida-Virumaa Co., Soldina – Auvere (59°20'N, 28°00'E), T. Piin, 4587, 9 Aug. 1961 (TU); 2. Viljandimaa Co., Olustvere (58°30'N, 25°30'E), T. Piin, 4588, 11 Aug. 1963 (TU); 3. Raplamaa Co., Märjamaa distr., near Paluküla, sq. no.162, (58°52'N, 24°22'E), A. L. Sõmermaa, 4787, 18 Aug. 1967 (TU).

* FUSCIDEA CYATHOIDES (Ach.) V. Wirth & Vêzda [syn. *Lecidea cyathoides* (Ach.) Ach.] – on siliceous rocks. Probably extinct in Estonia, only one collection known from the last century: Saaremaa Co., A. Bruttan (RIG, TU).

? Fuscidea lygaea (Ach.) V. Wirth & Vêzda (syn. *Lecidea lygaea* Ach.) – Mereschkowski (1913) observed in Saaremaa, but the herbarium specimen has not been preserved.

Lecidea confluens (Weber) Ach. – on siliceous rocks. Rare: known from four localities in western Estonian islands. 1. Hiiumaa Co., Kassari, Sääre tirp (58°46'N, 22°48'E), T. Randlane, 4570 17 June 1984 (TU); 2. Saaremaa Co., Saaremaa Is., Viidumäe Nature Reserve, Viidumägi (58°18'N, 22°25'E), V. Räsänen, 4569, 30 July 1929 (TU, H); 3. Saaremaa Co., Saaremaa Is., Randvere (58°18'N, 22°24'E) H. Trass, 4755, 13 Aug. 1964 (TU); 4. Saaremaa Co., A. Bruttan No.141 (RIG).

This species has two chemotypes (Hertel 1995) – chemotype I (confluentic and stictic acid) and chemotype II (confluentic acid). Secondary chemistry of all above mentioned specimens was analysed and only chemotype II was detected.

Lecidea fuscoatra (L.) Ach. – on siliceous rocks. Rather common: more than 20 localities in northern and western Estonia known.

Lecidea lapicida (Ach.) Ach. – both varieties – var. *lapicida* and var. *pantherina* are found on siliceous rocks.

– var. lapicida. Rather rare: known from seven localities in western and northern Estonian islands.

– var. pantherina Ach. Rather common: known from 20 localities in western and northern Estonia.

Lecidea plana (J. Lahm) Nyl. – on siliceous rocks. Rare: known from three localities. 1. Hiiumaa Co., Tahkuna peninsula, H. Trass, 4745, 4748, 4751, 4 July 1959 (TU); 2. Põlvamaa Co., Värska (57°58'N, 27°38'E), Soe, 2248, 9 Sept. 1965 (TU); 3. Põlvamaa Co., Räpina, Pikaliiva sands, H. Trass, 4744, 8 July 1958 (TU).

? Lecidea sarcogynoides Körb. – on siliceous rocks. Bruttan (1870) has observed it in Saaremaa, but unfortunately the collection is not preserved.

Lecidea tessellata Flörke var. tessellata – on siliceous rocks. Rather rare: known from seven localities mainly in coastal areas of western and northern Estonia.

According to Hertel (1995), the species has two chemotypes – chemotype I (confluentic acid) and chemotype II (confluentic and norstictic acid). Three specimens were analysed and both chemotypes were detected. 1. Harjumaa Co., Tallinn, Kakumägi (59°27'N, 24°35'E), K. Mereschkowski, 4565, 1911 (TU) (chemotype I); 2. Saaremaa Co., Vahase islet (58°09'N, 22°29'E), H. Lippmaa, 4567, 24 Aug. 1937 (TU) (chemotype II); 3. Läänemaa Co., Lihula (58°41'N, 23°50'E), V. Räsänen, 4566, 3 Aug. 1927 (TU) (chemotype I).

? "Lecidea" albofuscescens Nyl. Trass (1967) has referred four localities for this species. Two specimens (Tartumaa Co., Meeksi and Harjumaa Co., Tallinn-Mustamäe) appeared to be misidentifications and the other two (Saaremaa Co., Randvere and Läänemaa Co., Tauksi Islet) samples are missing.

"Lecidea" albohyalina (Nyl.) Th. Fr. [syn. *Biatora albohyalina* (Nyl.) Bagl. & Car.] – on the bark of deciduous trees. Very rare, found only once: Läänemaa Co., near the Puhtu ornithological station (58°34'N, 23°33'E), R. Sundin No. 226a, 11–12 June 1989 (S) (Ekman et al. 1991).

"Lecidea" botryosa (Fr.) Th. Fr. (syn. *Biatora botryosa* Fr.) – on decaying wood. Rare: known from two localities in southern Estonia. 1. Jõgevamaa Co., Puurmani, Põltsamaa water-meadow (58°34'N, 26°18'E), H. Trass, 4316, 4317, 4318, 9 June 1958 (TU); 2. Viljandimaa Co., Tipu (58°21'N, 21°60'E), L. Martin, Aug. 1995 (ICEB).

"Lecidea" erythrophaea Flörke [syn. *Lecidea tenebricosa* (Ach.) Nyl.] – on the bark of deciduous trees and wood. Rare: known from three localities in northern and western Estonia. 1. Harjumaa Co., Tallinn, Mustamägi (59°24'N, 24°38'E), E. Parmasto, 4473, 20 Apr.1947 (TU); 2. locality unknown, A. Bruttan, 4319, (TU), 3. Läänemaa Co., near Puhtu ornithological station (58°34'N, 23°33'E), 11–12 June 1989 (S) (Ekman et al 1991); 4. Läänemaa Co., Kõinastu Islet (58°38'N, 23°02'E), 14 July 1989 (S) (Ekman et al., 1991).

* "Lecidea" hypopta Ach. [syn. *Lecanora hypopta* (Ach.) Vainio] – on wood. Probably extinct in Estonia, mentioned twice before 1950:

1. Locality unknown, J. Seim, 4723 (TU) 2. Harjumaa Co., Kunda, V. Räsänen (Räsänen, 1931).

"LECIDEA" NYLANDERI (Anzi) Th. Fr. – on the bark of *Pinus silvestris*. Rare, but possibly overlooked, known from three localities: 1. Raplamaa Co., Märjamaa distr., near Paluküla, sq. no.162 (58°52'N, 24°22'E), A. L. Sõmermaa, 4787, 18 Aug. 1967 (TU); 2. Saaremaa Co., Saaremaa Is., Odalätsi (58°28'N, 22°08'E), T. Randlane, 4528, 12 July 1989 (TU); 3. Saaremaa Co., Saaremaa Is., near Kuressaare (58°16'N, 22°28'E), A. Bruttan (RIG).

* "LECIDEA" SPHAERELLA Hedl. [syn. *Lecidea sylvana* (Körb.) Th. Fr.] – on the bark of decideous trees. Probably extinct in Estonia, the only collection dates from the end of the last century: Võrumaa Co., near the lake Pühajärve, A. Bruttan 4320 (TU).

"LECIDEA" TURGIDULA Fr. – on the bark of *Pinus silvestris*, rarely on wood. Common: more than 40 localities all over the country known.

LECIDELLA ELAEOCHROMA (Ach.) M. Choisy – on the bark of deciduous trees, especially on smooth-barked trees (*Alnus* sp., *Sorbus aucuparia* etc.), rarely on conifers and wood. Very common in all parts of Estonia.

LECIDELLA EUPHOREA (Flörke) Hertel [incl. *L. achristotera* (Nyl.) Hertel & Leuckert, *L. laureri* (Hepp) Körb.] – on the bark of deciduous trees, rarely on coniferous trees and wood. Very common in all parts of Estonia.

LECIDELLA SCABRA (Taylor) Hertel & Leuckert – on siliceous rock. Very rare: known from one locality: Saaremaa Co., Harilaid (58°29'N, 21°51'E), E. Nilson, Sept. 1993 (IE).

The specimen has both soralia (greenish, more or less discrete) and apothecia. The anatomy of fruitbodies is typical for the genus *Lecidella* (lax paraphyses, broad-ellipsoid spores etc.). This species is widespread in northern and central parts of Europe (Tønsberg, 1992; Wirth, 1995 etc.).

LECIDELLA STIGMATEA (Ach.) Hertel & Leuckert – on calcareous rocks, more rarely on siliceous rocks, grows both on natural and anthropogenous substrata. Common: more than 30 localities known, mainly in northern and western Estonia.

MIRIQUIDICA DEUSTA (Stenh.) Hertel & Rambold (syn. *Lecidea deustata* Zahlbr.) – on siliceous rocks. Very rare, only one locality known: Saaremaa Co., Saaremaa Is., Atla alvar (58°18'N, 21°54'E), H. Trass, 4501, 5 Aug. 1991 (TU).

The specimen contains lobaric acid.

PLACYNTHIELLA DASAEA (Stirt.) Tønsberg – on decaying wood. Very rare, but possibly overlooked, known from two localities: 1. Hiiumaa Co., Hanikatsi Islet (58°47'N, 23°02'E), T. Randlane, 4243, 9 June 1982 (TU); 2. Saaremaa Co., Saaremaa Is., Odalätsi (58°23'N, 22°09'E), T. Randlane, 4226, 12 July 1989 (TU).

PLACYNTHIELLA ICMALEA (Ach.) Coppins & P. James – on decaying wood, on plant debris, on bare ground. Very common: more than 50 localities known, mainly northern, western and southern Estonia.

PLACYNTHIELLA OLIGOTROPHA (J.R. Laundon) Coppins & P. James – on humus-rich ground (heathlands, cut-over areas, peat-bogs etc.). Rather common: known from 15 localities all over the country.

PLACYNTHIELLA ULIGINOSA (Schrad.) Coppins & P. James – on decaying wood, on plant debris, on humus-rich and sandy ground. Common: known from over 20 localities in western, northern and southern Estonia

PORPIDIA CINEREOATRA (Ach.) Hertel & Knoph (syn. *Lecidea cinereoatra* Ach.) – on siliceous rocks. Very rare: known from two localities. 1. Harjumaa Co., Pedassaar Is. (59°31'N, 25°23'E), T. Piin, 244(91), 1991 (TBA); 2. Saaremaa Co., Saaremaa Is., A. Bruttan, 4612 (TU).

PORPIDIA CRUSTULATA (Ach.) Hertel & Knoph [syn. *Lecidea crustulata* (Ach.) Spreng.] – on siliceous rocks, especially on pebbles. Common: known from 20 localities in northern, western and southeastern Estonia.

PORPIDIA MACROCARPA (DC.) Hertel & A.J. Schwab [syn. *Lecidea macrocarpa* (DC.) Steud., *L. nigrocruenta* Anzi] – on siliceous rocks. Rather rare: known from nine scattered localities.

PORPIDIA TUBERCULOSA (Sm.) Hertel & Knoph (syn. *Lecidea sorediza* Nyl.) – on siliceous rocks. Rare: known from three localities: 1. Harjumaa Co., Rammu Is. (59°34', 25°12'E), E. Nilson, July 1993 (IE); 2. Saaremaa Co., Saaremaa Is. Viidumäe Natural Reserve, Tornimägi, sq. no.182 (58°16'N, 22°08'E), T. Randlane, 4605, 18 Aug. 1976 (TU); 3. Saaremaa Co., Kõinastu Islet (58°38'N, 23°02'E), 15 June 1989 (LD) (Ekman et al., 1991).

Psilolechia lucida (Ach.) M. Choisy [syn. *Lecidea lucida* (Ach.) Ach.] – on rocks, on the roots, on the bark of *Pinus silvestris* etc. Grows preferably in shaded areas. Rare: known from five localities in southern and eastern Estonia. 1. Ida-Virumaa Co., Kauksi (58°59'N, 27°15'E), A. L. Sõmermaa, 4741, 9 Aug. 1966 (TU); 2. Tartumaa Co., Tartu (58°23'N, 26°44'E), A. Bruttan (RIG); 3. Tartumaa Co., Alam-Pedja Nature Reserve, Laeva distr., Karussaare, sq. no. 182/7 (58°26'N, 26°16'E), P. Lõhmus, 4742, 5 Okt. 1996 (TU); 4. Valgamaa Co., Kääriku (58°01'N, 26°24'E), H. Trass 4262 12 July 1964 (TU); 5. Viljandimaa Co., Tipu distr., sq. no. 27 (58°21'N, 25°06'E), P. Lõhmus, 4743, 28 July 1994 (TU).

? Pyrrhospora cinnabarina (Sommerf.) M. Choisy [syn. *Lecidea cinnabarina* Sommerf., *Protoblastenia cinnabarina* (Sommerf.) Räsänen]. Räsänen (1931) observed it in Lääne-Virumaa, Väike-Maarja (under the name *Protoblastenia cinnabarina*), but the herbarium specimen has not been preserved.

Pyrrhospora quernea (Dicks.) Körb. [syn. *Lecidea quernea* (Dicks.) Ach.] – on the bark of deciduous trees, rarely on the bark of coniferous trees. Rather rare: known from nine localities in western and central Estonia.

Ramboldia insidiosa (Th. Fr.) Hafellner (syn. *Lecidea insidiosa* Th. Fr.) – lichenicolous on the thallus of *Lecanora varia*. Rather rare: known from six localities mainly in western and northern Estonia.

Rimularia furvella (Nyl.) Hertel & Rambold – lichenicolous on various lichens on siliceous rocks. Rare: known from four localities: 1. Läänemaa Co., Kaseküla alvar (58°38'N, 23°34'E), H. Trass, 4729, 10 Aug. 1991 (TU); 2. Saaremaa Co., Saaremaa Is., Vilsandi Nature Reserve (58°23'N, 2150'E), T. Randlane, 4561, 21 June 1980 (TU); 3. Saaremaa Co., Saaremaa Is., Viidumäe Nature Reserve, on the border of sq. no. 17 and 164 (58°18'N, 22°06'E), T. Randlane, 2240 11 Aug. 1976 (TU); 4. Saaremaa Co., Abruka Is. (58°09'N, 22°31'E), R. Moberg (UPS).

Rimularia insularis (Nyl.) Rambold & Hertel [syn. *Lecidea insularis* (Nyl.) Rambold & Hertel, *L. intumescens* (Flörke) Nyl.] – lichenicolous on the thallus of *Lecanora rupicola*. Rather common: known from 12 localities mainly in western and northern Estonia.

Schaereria fuscocinerea (Nyl.) Clauzade & Roux [syn. *Lecidea griseoatra* (Hoffm.) Flot., *Schaereria tenebrosa* (Flot.) Hertel & Poelt] – on siliceous rocks. Rather rare: known from seven localities in western and northern Estonia.

* Trapelia coarctata (Sm.) M. Choisy [syn. *Lecidea coarctata* (Turner) Nyl.] – on siliceous rocks. Probably extinct in Estonia, collected only once in the last century: Saaremaa Co., Saaremaa Is., A. Bruttan, 4261 (TU).

Trapelia placodioides Coppins & P. James – on brick. Very rare, known from one locality: Läänemaa Co., Osmussaar Is. (59°18'N, 23°22'E), I. Jüriado, 4260, 29 July 1993 (TU).

Trapeliopsis flexuosa (Fr.) Coppins & P. James [syn. *Lecidea flexuosa* (Fr.) Nyl.] – on decaying wood (stumps, old roofs etc.) and on the ground. Common: more than 30 localities known in western, northern, central and southwestern Estonia.

Trapeliopsis granulosa (Hoffm.) Lumbsch (syn. *Lecidea granulosa* (Ehrh.) Ach.) – on humus-rich ground, on plant-debris, on mosses. Very common: more than 50 localities known all over Estonia.

Trapeliopsis pseudogranulosa Coppins & P. James – on peaty ground, on humid and shaded areas. Very rare, known from one locality: Tartumaa Co., Tähtvere, on the bank of a drainage ditch (58°24'N, 23°22'E), A. Suija, 4573, 4574, 12 June 1996 (TU).

Tremolecia atrata (Ach.) Hertel – on siliceous rocks, usually on stone pebbles. Rare: known from four localities in northern and western Estonia. 1. Harjumaa Co., Äksi Is. (59°36'N, 25°06'E), P. Põldmaa, 4503, 27 Aug. 1960 (TU); 2. Harjumaa Co., Rammu Is. (59°34', 25°12'E), T. Piin, No.58(91), 1991 (TBA); 3. Harjumaa Co., Naissaar Is. (58°34'N, 24°31'E), E. Nilson, Aug.1993 (IE); 4. Saaremaa Co., Saaremaa Is., Harilaid

(58°29’N, 21°51’E), E. Nilson, Sept.1993 (IE); 5. Saaremaa Co., Saaremaa Is., Harilaid, H. Trass, 4492, 6 Aug. 1991 (TU); 6. Saaremaa Co., Saaremaa Is., Harilaid, T. Randlane, 4493, 15 June 1984 (TU).

ACKNOWLEDGEMENTS

My sincere thanks are due to Ljudmilla Martin, Roland Moberg, Eva Nilson, Taimi Piin, Alfons Piterans, Tiina Randlane, Andres Saag, Marina Temina and Orvo Vitikainen. Prof. Dr. Hannes Hertel and Dr. Tør Tønsberg are thanked for identifying some of the specimens, Dr. G. Rambold for reviewing the manuscript.

This study is part of the project “Composition and analysis of Estonian lichen flora” and is financially supported by the Estonian Science Foundation (Grant No. 1297).

REFERENCES

Bruttan, A. 1870. Lichenen Est-, Liv- und Kurlands. *Arch. Naturk. Liv-, Ehst-, u. Kurl.* 7 : 163–326.

Culberson, C. F. 1972. Improved conditions and new data for the identification of lichen products by a standardized thin-layer chromatographic method. *J. Chromatogr.* 72 : 113–125.

Culberson, C. F. & Kristinsson, H. 1970. A standardized method for the identification of lichen products. *J. Chromatogr.* 46 : 85–93.

Ekman, S., Fröberg, L., Kärnefeldt, I., Sundin, R. & Thor, G. 1991. New or interesting lichens from Estonia. *Folia Cryptog. Estonica* 28: 1–32.

Foucard, T. 1990. *Svensk skorplavs flora.* Lund. 306 pp.

Gowan, S. P. & Ahti, T. 1993. Status of the lichen genus *Porpidia* in Eastern Fennoscandia. *Ann. Bot. Fenn.* 30 : 53–75.

Hertel, H. 1984. Über saxicole, lecideoide Flechten der Subantarktis. *Beih. Nova Hedwigia* 79 : 400–492.

Hertel, H. 1995. Schlüssel für die Arten der Flechtenfamilie *Lecideaceae* in Europa. *Bibl. Lichenol.* 58 : 137–180.

Magnusson, A. H. 1952b. Key to the species of *Lecidea* in Scandinavia and Finland. 2. Non-saxicolous species. *Svensk Bot. Tidskr.* 46 (3–4) : 313–323

Mereschkowski, K. 1913. *The checklist of lichens in the Baltic provinces* (in Russian). Kazan.

Moberg, R. 1991. New or interesting records of lichens from Estonia. *Folia Cryptog. Estonica* 29: 28–30.

Printzen, C. 1995. Die Flechtengattung *Biatora* in Europa. *Bibl. Lichenol.* 60 : 1–275.

Purvis, O. W., Coppins, B. J. Hawksworth, D. L., James, P. W., Moore, D. M. 1992. *The Lichen Flora of Great Britain and Ireland.* Natural History Museum Publications, London. 710 pp.

Räsänen, V. 1931. *Die Flechten Estlands I.* Helsinki. 163 pp.

Santesson, R. 1993. *The lichens and lichenicolous fungi of Sweden and Norway*. SPT-förlaget. Lund. 240 pp.

Trass, H. 1967. *Analysis of the lichen-flora of Estonia* (in Russian). Doctoral dissertation. Tartu State University.

Trass, H. 1970. The elements and deveopment of the lichen-flora of Estonia (in Russian). *Pap. Bot.* 9: 5–233.

Tønsberg, T. 1992. The sorediate and isidiate, corticolous crustose lichens in Norway. *Sommerfeltia* 14 : 1–331.

Vainio, E. A. 1934. Lichenographa Fennica IV. *Lecideales* II. *Acta Soc. Fauna Fl. Fenn.* 57 (2) : 1–506.

Wirth, V. 1995. *Flechtenflora.* Ulmer. 666 pp.

Folia Cryptog. Estonica, Fasc. 32: 113–122 (1998)

Phylogenetic relationships of some cetrarioid species in British Columbia with notes on *Tuckermannopsis*

Arne Thell
Department of Systematic Botany, Lund University, Östra Vallgatan 18–20, S-223 61 Lund, Sweden

Abstract: Phylogenetic relationships of seven cetrarioid lichens – *Ahtiana sphaerosporella, Esslingeriana idahoensis, Kaernefeltia merrillii, Tuckermannopsis americana, T. platyphylla, T. subalpina* and *Vulpicida canadensis* – occurring in British Columbia are analysed together with seven other cetrarioid species using parsimony analysis. The phylogenetic hypothesis based on ITS sequences suggest that ascus characters cannot be used as characters to distinguish genera within cetrarioid lichens but pycnoconidial shape is representative for larger groups. *Tuckermannopsis* as a polyphyletic genus is regarded as a key group for a better phylogenetic understanding of cetrarioid lichens.

Kokkuvõte: A. Thell. Mõnede tsetrarioidsete liikide fülogeneetilised seosed Briti Kolumbias, rõhuasetusega perekonnale *Tuckermannopsis*.

Analüüsitakse seitsme Briti Kolumbias (Kanada) esineva tsetrarioidse samblikuliigi – *Ahtiana sphaerosporella, Esslingeriana idahoensis, Kaernefeltia merrillii, Tuckermannopsis americana, T. platyphylla, T. subalpina* ja *Vulpicida canadensis* – omavahelisi fülogeneetilisi seoseid, samuti seoseid seitsme muu tsetrarioidse liigiga, kasutades parsimoonset analüüsi. ITS sekventsidel põhineva fülogeneetilise hüpoteesi kohaselt ei saa eoskoti tunnuseid kasutada tsetrarioidsete samblike perekondade eristamisel, kuid püknokoniidide kuju on sobiv tunnus suuremate rühmade eristamiseks. Polüfüleetilist perekonda *Tuckermannopsis* võib käsitleda kui võtmerühma tsetrarioidsete samblike fülogeneesi paremaks mõistmiseks.

INTRODUCTION

The lichen flora of British Columbia, acknowledged for its richness, comprises to 35 out of approximately 135 cetrarioid species in the latest world list (Goward et al., 1994; Randlane et al., 1997). In autumn 1996, I had the opportunity to collect fresh material of cetrarioid lichens in British Columbia. During a stay at the University of British Columbia, I started molecular work on the group. The internal transcribed spacer (ITS) regions of the mycobiont's nuclear ribosomal DNA (rDNA) gene appeared to be particularly suitable for comparing closely related species and genera. This gene has already been used in a study of populations of *Platismatia* s.l. and other cetrarioid species (Thell et al., 1998; Thell & Miao in prep.). Several sequences resulting from these studies (*Cetraria islandica, C. sepincola, Flavocetraria cucullata, Platismatia glauca, Tuckermannopsis chlorophylla* and *Vulpicida pinastri*) were selected for a comparison with new sequences from seven boreal to subalpine species from British Columbia (*Ahtiana sphaerosporella, Esslingeriana idahoensis, Kaernefeltia merrillii, Tuckermannopsis americana, T. platyphylla, T. subalpina* and *Vulpicida canadensis*). As part of a larger survey of the phylogeny of cetrarioid lichens, this investigation focuses mainly on the relationships of some species assigned to *Tuckermannopsis*.

The genus *Tuckermannopsis* was introduced by Gyelnik (1933), who distinguished it from *Nephromopsis* by the absence of pseudocyphellae on the lower surface. The generic name was not commonly used by lichenologists until it was reinstated by Lai (1981), who combined several taxa in *Tuckermannopsis*. Hale (in Egan, 1987), Weber (in Egan, 1991), Kurokawa (1991) and Kärnefelt et al. (1993) transferred additional taxa to the genus. Several of these taxa have recently been assigned to other genera, i. e. *Ahtiana, Allocetraria, Kaernefeltia, Melanelia* and *Vulpicida* (Mattson & Lai, 1993; Thell, 1995, Thell et al., 1995b, c; Thell & Goward, 1996). Currently, 11 taxa are assigned to *Tuckermannopsis* but still today the genus appears heterogeneous.

Cetrarioid lichens have been divided into three categories and may also include parmelioid genera (Kärnefelt et al., 1992). Two of these groups, centered around *Cetraria* s. str. and

Tuckermannopsis, included taxa almost exclusively with an origin in *Cetraria*. The third group contains taxa with asci of the *Melanelia* type which is present in the majority of the Parmeliaceae (Thell et al., 1995b).

MATERIAL AND METHODS

I. Selected material

The lichen samples used for the study and cited below were collected in British Columbia 1995–96 and are stored together with DNA isolations in the herbaria LD, TDI (TerraGen Diversity Inc.) and UBC.

Ahtiana sphaerosporella: Joffre Lake, Miao & Taylor, DNA#AT83 (TDI#211). *Esslingeriana idahoensis*: Clearwater, Goward TG-961354, DNA#AT145 (UBC); Goward TG-961348, DNA#AT146 (UBC). *Kaernefeltia merrillii*: Clearwater, Thell BC-9698, DNA#AT190; Whistler, Thell & Veer BC-9670, DNA#AT71 (LD). *Tuckermannopsis americana*: Joffre Lake, Miao & Taylor, DNA#AT82 (TDI#210); Wells Gray Park, Goward TG-961350 (UBC). *Tuckermannopsis platyphylla*: Whistler, Thell & Veer BC-9675, DNA#AT75 (LD); Kamloops, Thell & Veer BC-9643, DNA#AT43 (LD). *Tuckermannopsis subalpina*: Burke Mtn., Thell BC-9606, DNA#AT109 (LD). *Vulpicida canadensis*: Kamloops, Thell & Veer BC-96250, DNA#AT36 (LD); Jackson Flats, Miao, DNA#VM174 (TDI#146).

II. DNA preparation

The DNA was isolated following the procedure of Thell et al. (1998). Fragments were amplified with the primers ITS5 and ITS4 (White et al., 1990) using AmpliTaq DNA Polymerase (5 U/µl) according to the manufactorers protocol. All samples were PCR-amplified and agarose purified twice. A PCR was performed for 30 cycles with the following cycling conditions: denaturation at 94°C for 1 min., annealing at 48°C for 1 min., and extension at 72°C for 45 seconds. The second PCR differed from the first by an elevated annealing temperature of 53°C (Thell et al. 1998).

Both complementary strands were sequenced using Dye Terminator Cycle Sequencing Ready Reaction Kit (Perkin Elmer) according to the manufactorers instructions. ITS5, ITS4, ITS3 and ITS2 were used as sequencing primers (White et al., 1990). Cycle sequencing was carried out for 25 cycles with denaturation at 96°C for 10 seconds, annealing temperature at 50°C for 5 seconds, and extension at 60°C for 4 minutes. The DNA was cleaned through CENTRI-SEP columns (Princeton Separations, Inc.). Sequenced fragments were analysed using an ABI Prism 377 DNA automatic sequencer (Perkin Elmer).

III. Alignment and phylogenetic analysis

The ITS sequences were aligned with SeqApp/CAP 2, followed by a slight adjustment by hand (Table 1) and transferred to PAUP 3.0 (Gilbert, 1993; Huang, 1992). The consensus tree from 500 bootstrap replicates is presented. This tree was obtained using the branch and bound option (Fig. 1).

RESULTS

I. The sections of the ITS region and flanking parts

The amplified fragment of nuclear rDNA including the ITS region is about 560 base pairs long in cetrarioid lichens, and can be divided into five easily distinguished sections: The last part of the SSU rDNA gene (1) at the 5' end followed by the highly variable ITS 1 section (2), the conserved 5.8 S rDNA (3), the ITS 2 section (4), which is somewhat less variable than ITS 1, and, finally the 5'-end of the large conserved LSU rDNA gene (5). In the alignment, the five sections are recognized at the following sites (Table 1): 1: 1–33, 2: 34–223, 3: 224–381, 4: 382–536 and 5: 537–577. Group I introns of c. 220 nt length, which are excluded from the analyses, were found close to the end of the small subunit ribosomal DNA gene at position 1516 in four species (Gargas et al., 1995).

II. Variation in ITS1 and ITS2

The variation within and between species is restricted to the ITS 1 and ITS 2 regions, which are rapidly degraded during rRNA processing (between the bases 33 and 224 and 380–535). As in related investigations (Thell et al., 1998; Thell & Miao in prep.), a larger variation was found in the ITS 1 when compared with ITS 2.

In this study, infraspecific variation was found at 16 positions in the ITS 1 section but only at two in ITS 2 (Table 1).

III. The sequenced species and infraspecific variation

1. AHTIANA SPHAEROSPORELLA (Müll. Arg.) Goward. Only one specimen, which included a group I intron, was available for molecular studies from this species (DNA#AT83).
2. ESSLINGERIANA IDAHOENSIS (Essl.) Hale & M.J. Lai. Two samples (DNA#AT145, 146) from different localities in the same area had identical sequences.
3. KAERNEFELTIA MERRILLII (Tuck.) A. Thell & Goward. The two studied specimens (DNA#AT71, 190) were morphologically similar. Their sequences, however, differed at several positions: 113, 114, 146, 181 and 187 in the ITS 1 section, and at 456 and 527 in the ITS 2 section (Table 1).
4. TUCKERMANNOPSIS AMERICANA (Spreng.) Hale [syn. *Cetraria ciliaris* Ach. var. *halei* (W. L. Culb. & C. F. Culb.) Ahti]. The following sites were different in two sequenced specimens: 34, 99, 113, 136, 138, 143, 166, 201, 206 and 211. Group I introns were found in both sequences (DNA#AT82, 148).
5. TUCKERMANNOPSIS PLATYPHYLLA (Tuck.) Hale. The ITS region differed only at one position in both samples sequenced: 168 (Table 1). Group I introns were detected in both sequences (DNA#AT43, 75).
6. TUCKERMANNOPSIS SUBALPINA (Imshaug) Kärnefelt. A group I intron was detected in the single sample sequenced (DNA#AT109).
7. VULPICIDA CANADENSIS (Räsänen) J.-E. Mattsson & M.J. Lai. The two sequences (DNA#AT36 and DNA#VM174) were identical (Table 1).

DISCUSSION

Using *Platismatia* as the outgroup taxon, two main group where apparent in the ITS phylogeny (Fig. 1). One of these, supported by a bootstrap value of 71, includes *Cetraria islandica, C. sepincola, Vulpicida canadensis, V. pinastri* and *Tuckermannopsis subalpina.*

Vulpicida contains two distinct species groups. One group, containing the North American endemics *V. canadensis* and *V. viridis*, is characterized by citriform conidia and asci with less amyloid and smaller tholi. The other group, including four species, produces sublageniform conidia and asci showing a strong amyloid reaction in the tholus (Mattsson & Lai, 1993; Mattsson, 1993). These two groups, represented by one species each in the analysis appeared as a monophyletic genus.

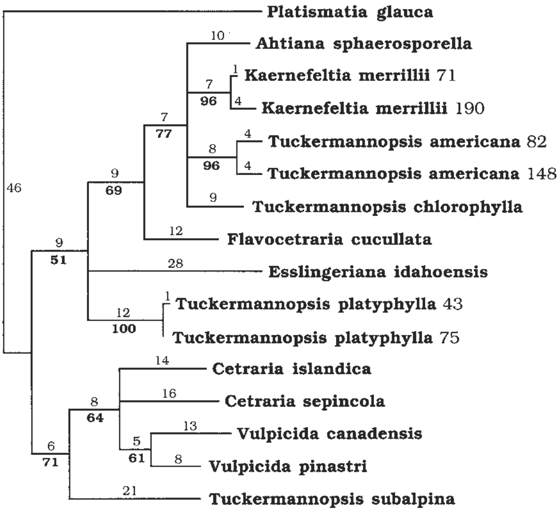


Fig. 1. The bootstrap consensus tree based on ITS sequences from Table 1. Tree length = 262, CI = 0.537, generated using the branch and bound option in PAUP 3.0. The numbers above or to the right of the branches are substitution numbers per branch. Branch lengths are proportional to the substitution numbers. Bootstrap percentages (from 500 replicates) are in bold face below the branches.

The two species of *Cetraria* included, *C. islandica* and *C. sepincola*, did not form a monophyletic group. This is not surprising because only *C. islandica* is considered as a *Cetraria* in a strict sense (Kärnefelt et al., 1993). *Cetraria sepincola* has asci of *Lecanora* type (*Melanelia* form) instead of *Cetraria* type (Thell et al., 1995b). However, more species related to *C. sepincola*, e.g. *C. fendleri* and *C. weberi*, need to be analysed before an alternative taxonomy might be considered. At least, a position in *Tuckermannopsis* for *C. sepincola*, as proposed by Hale (in Egan, 1987), is not supported by ITS data. *C. islandica* and *C. sepincola* are on a polytomous branching with *Vulpicida* (Fig. 1)

Table 1. ITS sequences of seven cetrarioid species from British Columbia. Sequences of *Esslingeriana idahoensis* and *Vulpicida canadensis* were identical within the species
* Infraspecific variation in *Kaernefeltia merrillii, Tuckermannopsis americana* and *T. platyphylla*

	10	20	30	40	50
A. sphaerosporella	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	AGGGGCTTCG
C. islandica	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	--GGGCTTCG
C. sepincola	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	--GGGCTTCG
E. idahoensis	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGGGAG	AGGGGCCTCG
F. cucullata	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	AGGGGCTTCG
K. merrillii 71	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTATCGAGAG	AGGGGCTTCG
	----------	----------	----------	----------	----------
K. merrillii 190	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTATCGAGAG	AGGGGCTTCG
P. glauca	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	--GGGC-TCG
T. americana 82	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTAATGAGAG	AGGGGCTTCG
	----------	----------	----------	---*------	----------
T. americana 148	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTATTGAGAG	AGGGGCTTCG
T. chlorophylla	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	AGGGGCTTC-
T. platyphylla 43	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	AGGGGCTTCG
	----------	----------	----------	----------	----------
T. platyphylla 75	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	AGGGGCTTCG
T. subalpina	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTATCGAGAA	GGGGGCTTCG
V. canadensis	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	AGGGGCTTCG
V. pinastri	GTTTCCGTAG	GTGAACCTGC	GGAAGGATCA	TTACTGAGAG	AGGGGCTTCG
	60	70	80	90	100
A. sphaerosporella	TGCTCCCGGG	GGCTTCGGCC	TCCAACTCTT	CACCCATTGT	CTACC-TACC
C. islandica	CGCTCCCGGG	GGCCTCGGCC	CCTAACTCTT	CACCCTTTGT	GTACC-AACC
C. sepincola	CGCTCCCGGG	GGTCTCGGCC	CCCAACTCTT	CACCCATTGA	CTACC-TACC
E. idahoensis	TGCTCCCGGG	GGTTTCGGCC	CCCAACTCTT	CACCCATTGT	CTACC-TACC
F. cucullata	CGCTCCCGGG	GGTTTCGGCC	TCTAGCTCTT	CACCCATTGT	CTACA-TACC
K. merrillii 71	TGCTCCCGGG	GGTTTCGGCC	TCCAACTCTT	CACCCATTGT	CTACC-TACC
	----------	----------	----------	----------	----------
K. merrillii 190	TGCTCCCGGG	GGTTTCGGCC	TCCAACTCTT	CACCCATTGT	CTACC-TACC
P. glauca	CGCCCCCGGG	GGCTCCGGCC	CCGGACTCTC	CACCCATTGC	GTACCG-ACC
T. americana 82	TGCTCCCGGG	GGCTTCGGCC	TCCAACTCTT	CACCCATTGT	CTACC-TACC
	----------	----------	----------	----------	--------*-
T. americana 148	TGCTCCCGGG	GGCTTCGGCC	TCCAACTCTT	CACCCATTGT	CTACC-TATC
T. chlorophylla	----------	GG--T---CC	-CCAACTCTT	CACCCATTGT	CCACC-TACC
T. platyphylla 43	CGCTCCCGGG	GGCTTCGGCC	CCTAACTCTT	CACCCATTGT	CTATC-TACC
	----------	----------	----------	----------	----------
T. platyphylla 75	CGCTCCCGGG	GGCTTCGGCC	CCTAACTCTT	CACCCATTGT	CTATC-TACC
T. subalpina	CGCTCCCGAG	GGCTTCGGCC	CTCAACTCTT	CACCCACTGT	ATACA-TACC
V. canadensis	CGCTCCCGGG	GGTCTCGGCC	CCCAACTCTT	CACCCATTGT	GTACCGTATC
V. pinastri	CGCTCCCGGG	GGTCTCGGCC	CCCAACTCTT	CACCCATTGT	GTACACTACC
	110	120	130	140	150
A. sphaerosporella	TATGTTGCTT	TGG-CGGGCC	TCGGGTACCA	CCCCGTGTCG	GCTTACCAG-
C. islandica	TCTGTTGCTT	TGG-CGGGTC	C-GAGGACC-	TCTCGCGCCG	-CCCACAGG-
C. sepincola	TTTGTTGCTT	TGG-CGGGCC	CCGAGGACC-	TCTCGCGCCG	-CGTACAGG-
E. idahoensis	TTTGTTGCTT	TGG-CGGGCC	ATGGGGCACG	TCCCGCGCCG	GCTTTCGTG-
F. cucullata	TTTGTTGCTT	TGG-CGGGCC	TCGGGCACCG	TCCCGTGTCG	ACTGACTGG-
K. merrillii 71	TATGTTGCTT	TGGGCGGGTC	TCGGGTACCA	TCCCGTGTCG	GCTTATCGG-
	----------	--**------	----------	----------	-----*----
K. merrillii 190	TATGTTGCTT	TGA-CGGGTC	TCGGGTACCA	TCCCGTGTCG	GCTTACCGG-
P. glauca	TTTGTTGCTT	TGG-CGGACC	CCGGGGTCTC	CCCCGCGCTG	GCTTCCTGGG
T. americana 82	TATGTTGCTT	TGA-CGGGCC	TCGGGTACCA	TCCCGCGTCG	GCTTACCGG-
	----------	--*-------	----------	-----*-*--	--*-------
T. americana 148	TATGTTGCTT	TGG-CGGGCC	TCGGGTACCA	TCCCGTGCCG	GCCTACCGG-
T. chlorophylla	TATGTTGCTT	TGG-CGGGCC	TCGGGTATCA	TCCCGTGTCG	GCTTACCGG-
T. platyphylla 43	TTTGTTGCTT	TGG-CGGGCC	TCGGGGACCA	TCCCGTGCCG	GCCTACTGG-
	----------	----------	----------	----------	----------
T. platyphylla 75	TTTGTTGCTT	TGG-CGGGCC	TCGGGGACCA	TCCCGTGCCG	GCCTACTGG-
T. subalpina	TTTGTTGCTT	TGG-CGGGCC	CTGAGGACT-	TCTCGCGCCG	GCAGACTTG-
V. canadensis	TTTGTTGCTT	TGG-CGGGCC	CTGAGGACC-	CCTCGCGCCG	-CTTACAAG-
V. pinastri	TTTGTTGCTT	TGG-CGGGCC	CCGAGGACT-	TCTCGCGCTG	-CCTACAGGG

Table 1 (continued)

	160	170	180	190	200
A. sphaerosporella	CCGGCGAGCG	CCCGCCAGAG	GCCCATTAAA	TTCTATTT-A	TTAGTGATGT
C. islandica	CCGGCGAGCG	CCCGCCAGAG	GCCCATTAAA	ATCTGCTT-A	TTAGTGATGT
C. sepincola	CCGGCGAGCG	CCCGCCAGAG	GCCCATTCAA	TTCTGTTT-A	TCAGTGATGT
E. idahoensis	CAGGCGAGCG	CCCGTCAGAG	GCTTATCAAA	CTCTATTA-A	TTAGTGATGT
F. cucullata	TCGGCGAGCG	CCCGTCAGAG	GCCAATCAAA	TTCTATTT-A	TCAGTGATGT
K. merrillii 71	TCGGCGAGCG	CCCGTCAGAG	GCCCATTAAA	TTCTGTTT-A	TCAGTGATGT
	----------	----------	----------	-*------*-	----------
K. merrillii 190	TCGGCGAGCG	CCCGTCAGAG	GCCCATTAAA	TCCTGTTTTA	TCAGTGATGT
P. glauca	CCGGCGAGCG	TCCGTCAGAG	GCCCATCAAA	TTCCATTT--	TCCACGCCGT
T. americana 82	TCGGCGAGCG	CCCGTCGGAG	GCCCATTAAA	TTCCGTTT-A	TCAGTGATGT
	----------	------*---	----------	----------	----------
T. americana 148	TCGGCGAGCG	CCCGTCAGAG	GCCCATTAAA	TTCCGTTT-A	TCAGTGATGT
T. chlorophylla	TCGGCGAGCG	CCCGTCAGAG	GCCCATTAAA	TTCTGTT-TA	TCAATGACGT
T. platyphylla 43	CCGGCGAGCG	CCCGCCAGGG	ACCAATCAAA	CTCTGTTT-A	TTAGTGAAGT
	----------	--------*-	----------	----------	----------
T. platyphylla 75	CCGGCGAGCG	CCCGCCAGAG	ACCAATCAAA	CTCTGTTT-A	TTAGTGAAGT
T. subalpina	CCTGCGAGCG	CCCGCTAGAG	GCCCACTATA	CTCTGTTT-A	TCAGTGATGT
V. canadensis	CCGGCGAGCG	CCCGCCAGAG	GCCCATTAAA	ATCTGTTT-A	TCAATGATGT
V. pinastri	-CGGCGAGCG	CCCGCCAGAG	GCCCATCAAA	ATCTGTTT-A	TCAATGGTGT
	210	220	230	240	250
A. sphaerosporella	CCGAGC-AAA	AACACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
C. islandica	CCGAGCGAAA	AACACAATAA	AT-AAAACTT	TCAACAACGG	ATCTCTTGGT
C. sepincola	CCGAGTGAAA	A-CACAATCA	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
E. idahoensis	CCGAGCCAAA	AATACAAT-A	GTAAAAACTT	TCAACAACGG	ATCTCTTGGT
F. cucullata	CCGAGC-AAA	AACGCAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
K. merrillii 71	CCGAGC-AAA	AACACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
	----------	----------	----------	----------	----------
K. merrillii 190	CCGAGC-AAA	AACACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
P. glauca	CAGAGTGAAA	A-CACAATCG	TT-AAAACTT	TCAACAACGG	ATCTCTTGGT
T. americana 82	CTGAGT-AAA	AACACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
	-*----*---	-*--------	----------	----------	----------
T. americana 148	CCGAGTCAAA	A-CACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
T. chlorophylla	CTGAGC-AAA	AACACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
T. platyphylla 43	CCGAGCAAAA	AACACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
	----------	----------	----------	----------	----------
T. platyphylla 75	CCGAGCAAAA	AACACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
T. subalpina	CCGAG-GAAA	AACACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
V. canadensis	CCGAGCGAAA	AACACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
V. pinastri	CCGAGCGAAA	A-CACAAT-A	ATCAAAACTT	TCAACAACGG	ATCTCTTGGT
	260	270	280	290	300
A. sphaerosporella	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAAT-GC
C. islandica	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
C. sepincola	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
E. idahoensis	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGT-AATTGC
F. cucullata	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
K. merrillii 71	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
	----------	----------	----------	----------	----------
K. merrillii 190	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
P. glauca	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAAGTAA	TGTGAATTGC
T. americana 82	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
	----------	----------	----------	----------	----------
T. americana 148	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
T. chlorophylla	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
T. platyphylla 43	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAAATAA	TGTGAATTGC
	----------	----------	----------	----------	----------
T. platyphylla 75	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAAATAA	TGTGAATTGC
T. subalpina	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
V. canadensis	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC
V. pinastri	TCCAGCATCG	ATGAAGAACG	CAGCGAAATG	CGATAACTAA	TGTGAATTGC

Table 1 (continued)

	310	320	330	340	350
A. sphaerosporella	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
C. islandica	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
C. sepincola	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
E. idahoensis	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
F. cucullata	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
K. merrillii 71	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
	----------	----------	----------	----------	----------
K. merrillii 190	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
P. glauca	AGAATTCAGT	GAATCATCGA	ATCTTTGAAC	GCACATTGCG	CCCCTCGGTA
T. americana 82	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
	----------	----------	----------	----------	----------
T. americana 148	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
T. chlorophylla	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
T. platyphylla 43	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
	----------	----------	----------	----------	----------
T. platyphylla 75	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
T. subalpina	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGCA
V. canadensis	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA
V. pinastri	AGAATTCAGT	GAATCATCGA	GTCTTTGAAC	GCACATTGCG	CCCCTCGGTA

	360	370	380	390	400
A. sphaerosporella	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TGCACCC-TT	CAAGCGTAGC
C. islandica	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TATACCCCT-	CAAGCGTAGC
C. sepincola	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TACACCCCT-	CAAGCGTAGC
E. idahoensis	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TACACCC-TT	CAAGCCTAGC
F. cucullata	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TACACCCCT-	CAAGCGTAGC
K. merrillii 71	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TACACCCCT-	CAAGCGTAGC
	----------	----------	----------	----------	----------
K. merrillii 190	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TACACCCCT-	CAAGCGTAGC
P. glauca	TTCCGGGGGG	CATGCCTGTC	CGAGCGTCAT	TACACCCCT-	CAAGCGTCGC
T. americana 82	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TGCACCCCT-	CAAGCGTAGC
	----------	----------	----------	----------	----------
T. americana 148	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TGCACCCCT-	CAAGCGTAGC
T. chlorophylla	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TGCACCTCT-	CAAGCGTAGC
T. platyphylla 43	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TACACCCCT-	CAAGCGTAGC
	----------	----------	----------	----------	----------
T. platyphylla 75	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TACACCCCT-	CAAGCGTAGC
T. subalpina	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TATACCCCT-	CAAGCGTAGC
V. canadensis	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TATACCC-TT	CAAGCGTAGC
V. pinastri	TTCCGGGGGG	CATGCCTGTT	CGAGCGTCAT	TATACCCCTT	CAAGCGTAGC

	410	420	430	440	450
A. sphaerosporella	TTGGTATTGG	GCC-TCGCCC	CCGCGGCGTG	CCTGAAAAAC	AGTGGCGGTC
C. islandica	TTGGTATTGG	GCC-TCGCCC	CCGTGGCGTG	CCCGAAAAGC	AGTGGCGGTC
C. sepincola	TTGGTATTGG	GCC-TCGCCC	CCGTGGCGTG	CCCGAAAAGC	AGTGGCGGTC
E. idahoensis	TTGGTATTGG	GCCCTCGCCC	CCGTGGCGTG	CCCGAAAATC	AGTGGCGGTC
F. cucullata	TTGGTATTGG	GCT-TCGCCC	CCGCGGCGTG	CCCGAAAAGC	AGTGGCGGTC
K. merrillii 71	TTGGTATTGG	GCC-TCGCCC	CCGCGGCGTG	CCCGAAAATC	AGTGGCGGTC
	----------	----------	----------	----------	----------
K. merrillii 190	TTGGTATTGG	GCC-TCGCCC	CCGCGGCGTG	CCCGAAAATC	AGTGGCGGTC
P. glauca	TTGGTCTTGG	ACG-TCGCCC	CCGCGGCGCG	CCCGAAAATC	AGTGGCGGTC
T. americana 82	TTGGTATTGG	GCC-TCGCCC	CCGCGGCGTG	CCCGAAAAGC	AGTGGCGGTC
	----------	----------	----------	----------	----------
T. americana 148	TTGGTATTGG	GCC-TCGCCC	CCGCGGCGTG	CCCGAAAAGC	AGTGGCGGTC
T. chlorophylla	TTGGTATTGG	GCC-TCGCCC	CCGCGGCGTG	CCCGAAAAGC	AGTGGCGGTC
T. platyphylla 43	TTGGTATTGG	GCC-TCGCCC	CCGTGGCGTG	CCCGAAAAGC	AGTGGCGGTC
	----------	----------	----------	----------	----------
T. platyphylla 75	TTGGTATTGG	GCC-TCGCCC	CCGTGGCGTG	CCCGAAAAGC	AGTGGCGGTC
T. subalpina	TTGGTATTGG	GCC-TCGCCC	CCGTGGCGTG	CCCGAAAAAC	AGTGGCGGTC
V. canadensis	TTGGTATTGG	GCC-TCGCCC	CCACGGCGTG	CCCGAAAAGC	AGTGGCGGTC
V. pinastri	TTGGTATTGG	GCC-TCGCCC	CCGTGGCGTG	CCCGAAAAGC	AGTGGCGGTC

Table 1 (continued)

	460	470	480	490	500
A. sphaerosporella	CGGTGCGACT	TTAAGCGTAG	TAAA-TCTCA	TCCCGCTTTG	AAAGTTCGCC
C. islandica	CGGGGTGACT	TTAAGCGTAG	TAAAATT--A	TCCCGCTTTG	AAAGTTCGCC
C. sepincola	CGTGGTGGCT	TCAAGCGTAG	TAAAAT--CA	TCCCGCTTTG	AAAGCTCGTC
E. idahoensis	CGTTGCGACT	TTAAGCGTAG	TAAATTTTCA	TCCCGCTTTG	AAAGTTAGCG
F. cucullata	CGGTGCGACT	TTAAGCGTAG	TAAA-TTTTA	TCCCGCTTTG	AAAGTTCGCC
K. merrillii 71	CGGTGCGACT	TTAAGCGTAG	TAAA-TTTCA	TCCCGCTTTG	AAAGTTCGCC
	------*---	----------	----------	----------	----------
K. merrillii 190	CGGTGCTACT	TTAAGCGTAG	TAAA-TTTCA	TCCCGCTTTG	AAAGTTCGCC
P. glauca	CGGTGCGACT	TTGCGTGTAG	TAAA-TTTC-	TCCCGCGTTG	AAAGTCCGCC
T. americana 82	CGGAGCGACT	TTAAGCGTAG	TAAA-TTCCA	TCCCGCTTTG	AAAGCTCGCC
	----------	----------	----------	----------	----------
T. americana 148	CGGAGCGACT	TTAAGCGTAG	TAAA-TTCCA	TCCCGCTTTG	AAAGCTCGCC
T. chlorophylla	CGGAGCGACT	TTAAGCGTAG	TAAA-TTTCA	TCCCGCTTTG	AAAGTTCGCC
T. platyphylla 43	CGGAGCGACT	TTAAGCGTAG	TAAAAT--CA	TCTCGCTTTG	AAAGTTCGCC
	----------	----------	----------	----------	----------
T. platyphylla 75	CGGAGCGACT	TTAAGCGTAG	TAAAAT--CA	TCTCGCTTTG	AAAGTTCGCC
T. subalpina	CGGTGCGACT	TTAAGCGTAG	TACAAT--CA	TCCCGCTTTG	AAAGTTCGCC
V. canadensis	CGGGGCGACT	TTGAGCGTAG	TAAAAT--CA	TCCCGCTTTG	AAAGCTCGCC
V. pinastri	CGGGGCGACT	TTAAGCGTAG	TAAAAT--CA	TCCCGCTTCG	AAAGTCCGCC

	510	520	530	540	550
A. sphaerosporella	CCGTGGCCGG	CCAGACAACC	CCGTT-ACTT	CA-ATAATTG	ACCTCGGATC
C. islandica	TCGTGGCCTG	CCAGATAACC	CCGTACAATT	CAAATCATTG	ACCTCGGATC
C. sepincola	TCGTGGCCGG	CCAGACAACC	CCATATCTTC	CATATCATTG	ACCTCGGATC
E. idahoensis	CCGTGACCGG	CCAGACAACC	CCATATATTT	--TATAATTG	ACCTCGGATC
F. cucullata	CCGTGGCTGG	CCAGACAACC	CCAT--ACTT	CA-ATAATTG	ACCTCGGATC
K. merrillii 71	CCGTGGCTGG	CCAGACAACC	CCATT-ACTT	CA-ATAATTG	ACCTCGGATC
	----------	----------	-------*--	----------	----------
K. merrillii 190	CCGTGGCTGG	CCAGACAACC	CCATT-ATTT	CA-ATAATTG	ACCTCGGATC
P. glauca	CCGCGGCCGG	CCAGACAACC	CCCAG-A-TT	CAAA-CATTG	ACCTCGGATC
T. americana 82	CCGTGGCCGG	CCAGACAACC	CCAGT--TTT	CA-ATAATTG	ACCTCGGATC
	----------	----------	----------	----------	----------
T. americana 148	CCGTGGCCGG	CCAGACAACC	CCAGT--TTT	CA-ATAATTG	ACCTCGGATC
T. chlorophylla	CCGCGGCCGG	CCAGACAACC	CCGTT-ACTT	CA-ATAATTG	ACCTCGGATC
T. platyphylla 43	CCGTGGCTTG	CCAGACAACC	CCATATATTT	CA-ATAATTG	ACCTCGGATC
	----------	----------	----------	----------	----------
T. platyphylla 75	CCGTGGCTTG	CCAGACAACC	CCATATATTT	CA-ATAATTG	ACCTCGGATC
T. subalpina	CCGTGGCCGG	CCAGACAACC	C-TTACATTT	CAAATCATTG	ACCTCGGATC
V. canadensis	TCGCGGCCGG	CCAGACAACC	CCATTCATTC	TATA-CATTG	ACCTCGGATC
V. pinastri	TCGCGGCCGG	CCAGACAACC	CCATACATTT	TAAA-CATTG	ACCTCGGATC

	560	570	580	590	600
A. sphaerosporella	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
C. islandica	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
C. sepincola	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
E. idahoensis	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
F. cucullata	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
K. merrillii 71	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
	----------	----------	-------		
K. merrillii 190	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
P. glauca	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
T. americana 82	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
	----------	----------	-------		
T. americana 148	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
T. chlorophylla	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
T. platyphylla 43	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
	----------	----------	-------		
T. platyphylla 75	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
T. subalpina	AGGTAGGGAT	ACCCGCTGAA	CTTAAGC		
V. canadensis	AGGTAGGAAT	ACCCGCTGAA	CTTAAGC		
V. pinastri	AGGTAGGAAT	ACCCGCTGAA	CTTAAGC		

and the ITS data suggests that *Vulpicida* and *Cetraria* s. str. are quite close. This is surprising considering the chemical differences.

Tuckermannopsis subalpina forms a basal clade in the first main group. Interestingly, Kärnefelt (1979) pointed out earlier that *Cetraria* species and *Masonhalea* are closely related to *Tuckermannopsis subalpina* (earlier *Cetraria subalpina*), but more recent studies on reproductive characters suggested a position in *Tuckermannopsis* for this species together with closely related *T. inermis* (Kärnefelt et al., 1993). However, both taxa belong to neither *Tuckermannopsis* nor *Cetraria*, as suggested by ITS data as well as by morphological characters: an one-layered cortex, spherical ascospores and asci with large axial bodies does not support a position in *Cetraria*, whereas the pycnocondial type – a long, narrow shape with sharp ends – differs from the dumbbell shape characteristic for the genus *Tuckermannopsis* (Kärnefelt, 1979; Kärnefelt et al., 1993).

The other main group of cetrarioid taxa includes *Ahtiana sphaerosporella, Kaernefeltia merrillii, Tuckermannopsis americana, T. chlorophylla, Flavocetraria cucullata*, the monotypic genus *Esslingeriana* and *Tuckermannopsis platyphylla.* This group is supported by a bootstrap value of 51 (Fig. 1).

Tuckermannopsis platyphylla has a characteristic appearance with large, almost *Umbilicaria*-like papillate and tuberculate lobes (Esslinger, 1973). *Tuckermannopsis orbata* is presumably the most closely related species but *T. platyphylla* may also be difficult to separate from broad-lobed specimens of *Kaernefeltia merrillii,* as well. The bootstrap consensus tree would support a new generic position for *T. platyphylla* (Fig. 1), but additional taxa have to be examined before an alternative systematic position is proposed.

Esslingeriana idahoensis, the rarest of the lichens represented here, is an example of a cetrarioid lichen with both laminal and marginal apothecia and pycnidia. Its morphology is very distinct, characterized by a foliose habit, a grey upper surface and large, dark pigmented cells in the lower cortex. Atranorin and endocrocin are distinct secondary compounds (Esslinger, 1971; Kärnefelt et al., 1992). The long branch of 28 steps agrees with an isolated position for this monotypic genus.

The genus *Flavocetraria* is characterized by asci of *Cetraria* type and the genus was earlier presumed to have close affinities with *Cetraria* s. str. (Kärnefelt et al., 1992). The unexpected position of *F. cucullata* presented here indicates that *Cetraria* is quite distinct from *Flavocetraria.* The pycnoconidia, however, are dumbbell shaped, a character shared with all taxa in this second main group of the bootstrap consensus tree (Fig. 1). Preliminary data suggest that *Flavocetraria cucullata* and *F. nivalis* group together as a monophyletic genus (Thell & Miao in prep.).

The sister group of *Flavocetraria cucullata* included British Columbian species in a polytomous branching (Fig. 1). One of these species is *Tuckermannopsis americana,* which is represented by two specimens on the tree. This taxon is indistinguishable from the type species, *T. ciliaris*, and sometimes recognized only at variety level, as *Cetraria ciliaris* Ach. var. *halei* (W. L. Culb. & C. F. Culb.) Ahti (in Brodo, 1984: 100; Goward et al., 1994). It is recognized by presence of alectoronic acid and occasionally by α-collatolic acid (Culberson & Culberson, 1967). Similar as for the chemical species of *Cetrelia*, the species status for this taxon is uncertain. The four species composing the *T. ciliaris* group, *T. americana, T. ciliaris, T. microphyllica* and *T. orbata*, are closely allied according to morphology and secondary chemistry (Culberson & Culberson, 1967).

The bootstrap consensus tree (Fig.1) suggests that if *Tuckermannopsis chlorophylla* with world-wide distribution and probably also the related eastern Asian *T. gilva* and *T. ulophyllodes* are also maintained in *Tuckermannopsis*, then the genera *Ahtiana* and *Kaernefeltia* have to be included as well. *Ahtiana sphaerosporella* is morphologically distinct form other groups and was originally distinguished from *Parmelia* as a monotypic genus – primarily on the basis of small and spherical ascospores (Goward, 1985), whereas *Ahtiana aurescens* and *A. pallidula* were transferred later from *Cetraria* (Thell et al., 1995a). *Ahtiana* is presumably most closely allied to the likewise yellow, Eastern Asian genus *Tuckneraria* which differs in the presence of cilia and pseudocyphellae (Randlane et al., 1994). The type species of *Tuckneraria* and *Allocetraria* must certainly be sequenced to obtain a more detailed picture of the evolution of the group.

Kaernefeltia was recently described and differs from other cetrarioid genera by its unique combination of characters (Thell & Goward, 1996). However, there is considerable morphological variation in the genus and the growth form of *Kaernefeltia merrillii* varies from broadly foliose to subfruticose. Unfortunately, suitable material for molecular studies was not available from the type species *K. californica*.

At present the data show that *Tuckermannopsis* is not only poorly delimited to members of other genera in the current circumscription but species assigned to *Tuckermannopsis* are polyphyletic according to the ITS data. Also, the status of several other genera is difficult to ascertain until more species assigned to *Tuckermannopsis* are sequenced. Even though this taxon is heterogeneous, it appears to be a key group for a better phylogenetic understanding of cetrarioid lichens. To improve the phylogenetic hypothesis, further cetrarioid genera also need to be compared with non-cetrarioid representatives from different segregates of the Parmeliaceae. This is especially important since gross morphology or chemistry are not supported as characters to separate larger units in neither parmelioid nor cetrarioid lichens (for chemistry compare with Poelt & Leuckert, 1993). As a consequence, generic rearrangements in cetrarioid lichens should be carried out with great care until a more detailed phylogeny is at hand.

ACKNOWLEDGEMENTS

I was delighted to contribute in this special volume in honour of Prof. Hans Trass, who has played an important role in the fruitful research coorperation between lichenologists in Tartu and Lund. My sincere thanks to Martin Grube, Vivian Miao, Tiina Randlane and Andres Saag for reading and commenting on the manuscript.

Fellowships covering expenses connected with this study were received from the Swedish Royal Academy of Sciences, Per-Erik Lindahls Foundation and from the European Comission, Human Capital and Mobility ”Large Scale Facility” contract no. ERBCHGECT940065 between the EU and the University of Helsinki, Department of Ecology and Systematics.

REFERENCES

Brodo, I. M. 1984. Lichenes Canadenses Exsiccati: Fascicle III. *Bryologist* 87: 97–111

Culberson, W. L. & Culberson, C. F. 1967. A new taxonomy for the *Cetraria ciliaris* group. *Bryologist* 70: 158–166.

Egan, R. S. 1987. A fifth checklist of the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. *Bryologist* 90: 77–173.

Egan, R. S. 1991. Changes to the ”fifth checklist of the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. *Bryologist* 94: 396–400.

Esslinger, T. L. 1971. *Cetraria idahoensis*, a new species of lichen endemic to western North America. *Bryologist* 74: 364–369.

Esslinger, T. L. 1973. Chemical and taxonomic studies on some corticolous members of the lichen genus *Cetraria* in western North America. *Mycologia* 65: 602–613.

Gargas, A., DePriest, P. T. & Taylor, J. W. 1995. Positions of multiple insertions in SSU rDNA of lichen-forming fungi. *Mol. Biol. Evol.* 12: 208–218.

Gilbert, D. 1993. *SeqApp, a biological sequence editor and analysis program.* Indiana University, Bloomington.

Goward, T. 1985. *Ahtiana*, a new lichen genus in the Parmeliaceae. *Bryologist* 88: 367–371.

Goward, T., McCune, B. & Meidinger, D. 1994. *The lichens of British Columbia. Illustrated keys. Part 1. Foliose and squamolose species.* Ministry of Forests Research Program. 181 pp.

Gyelnik, V. 1933. Lichenes varii novi critique. *Acta pro Fauna et Fl. Univ.* 2, 1 (5–6): 3–10.

Huang, X. 1992. A contig assembly program based on sensitive detection of fragment overlaps. *Genomics* 14: 18–25.

Kärnefelt, I. 1979. The brown fruticose species of *Cetraria*. *Opera Bot.* 46, 150 pp.

Kärnefelt, I., Mattsson, J.-E. & Thell, A. 1992. Evolution and phylogeny of cetrarioid lichens. *Pl. Syst. Evol.* 183: 113–160.

Kärnefelt, I., Mattsson, J.-E. & Thell, A. 1993. The lichen genera *Arctocetraria, Cetraria* and *Cetrariella* (Parmeliaceae) and their presumed evolutionary affinities. *Bryologist* 96: 394–404.

Kurokawa, S. 1991. Japanese species and genera of the Parmeliaceae. *J. Jap. Bot.* 66: 152–159.

Lai, M. J. 1981 [1980]. Studies on the cetrarioid lichens in Parmeliaceae of east Asia (1). *Quart. J. Taiwan Mus.* 33: 215–229.

Mattsson, J.-E. 1993. A monograph of the genus *Vulpicida. Opera Bot.* 119: 1–61.

Mattsson, J.-E. & Lai, M. J. 1993. *Vulpicida*, a new genus in Parmeliaceae (Lichenized Ascomycetes). *Mycotaxon* 49: 425–428.

Poelt, J. & Leuckert, C. 1993. Substitution and supplementary addition of secondary products in the evolution of lichenized Ascomycotina. *Bibl. Lichenol.* 53: 201–215.

Randlane, T., Saag, A., Thell, A. & Kärnefelt, I. 1994. The genus *Tuckneraria* Randlane & Thell – a new segregation in the family Parmeliaceae. *Acta Bot. Fenn.*150: 143–151.

Randlane, T., Saag, A. & Thell, A. 1997. A second updated world list of cetrarioid lichens. *Bryologist* 100: 109–122.

Thell, A. 1995. A new position of the *Cetraria commixta* group in *Melanelia* (Ascomycotina, Parmeliaceae). *Nova Hedwigia* 60: 407–422.

Thell, A., Berbee, M. & Miao, V. 1998. Phylogeny of the genus *Platismatia* based on rDNA ITS sequences (Lichenized Ascomycotina). *Crypto-gamie, Bryol.-Lichénol.* (in press)

Thell, A. & Goward, T. 1996. The new cetrarioid genus *Kaernefeltia* and related groups in the Parmeliaceae (Lichenized Ascomycotina). *Bryologist* 99: 125–136.

Thell A., Goward, T., Randlane, T., Kärnefelt, I & Saag, A. 1995a. A revision of the North American genus *Ahtiana* (Parmeliaceae). *Bryologist* 98:596–605.

Thell, A., Mattsson, J.-E. & Kärnefelt, I. 1995b. Lecanoralean ascus types in the lichenized families Alectoriaceae and Parmeliaceae. *Crypt. Bot.* 5: 120–127.

Thell A., Randlane, T., Kärnefelt, I., Gao, X. & Saag, A. 1995c. The lichen genus *Allocetraria* (Ascomycotina, Parmeliaceae). In *Flechten Follmann. Contributions to lichenology in honour of Gerhard Follmann* (eds Daniels, F. J. A., Schultz, M. & Peine, J.), pp. 353–370. University of Cologne, Germany.

White, T. J., Burns T., Lee, S. & Taylor, J. 1990. Amplification and direct sequencing of fungal ribosomal DNA genes for phylogenetics. In *PCR protocols: A guide to methods and applications* (eds Innis, M., Gelfand, J., Sninsky, J. & White, T.), pp. 315–322. Academic Press, Orlando, Florida.

Folia Cryptog. Estonica, Fasc. 32: 123–125 (1998)

16 lichens new to Estonia

Göran Thor & Anders Nordin
Department of Systematic Botany, Uppsala University, Villavägen 6, S-752 36 Uppsala, Sweden

Abstract: An investigation of three wooded meadows in Saaremaa and Läänemaa Counties and short visits at some other localities in 1991 resulted in the finding of 16 lichen species new to Estonia, *Buellia violaceofusca*, *Caloplaca herbidella*, *Cyphelium sessile*, *Fuscidea pusilla*, *Gyalecta truncigena*, *Lauderlindsaya acroglypta*, *Lecanora strobilina*, *Lepraria eburnea*, *Lepraria lobificans*, *Leptogium teretiusculum*, *Micarea peliocarpa*, *Ochrolechia subviridis*, *Opegrapha herbarum*, *O. sorediifera*, *Rinodina efflorescens* and *Ropalospora viridis*.

Kokkkuvõte: G. Thor ja A. Nordin. 16 Eestile uut samblikku.

Uurimistööde tulemusena kolmel Saaremaa ja Läänemaa puisniidul ning mõnedes teistes kasvukohtades 1991. a-l leiti 16 Eestile uut samblikuliiki: *Buellia violaceofusca*, *Caloplaca herbidella*, *Cyphelium sessile*, *Fuscidea pusilla*, *Gyalecta truncigena*, *Lauderlindsaya acroglypta*, *Lecanora strobilina*, *Lepraria eburnea*, *Lepraria lobificans*, *Leptogium teretiusculum*, *Micarea peliocarpa*, *Ochrolechia subviridis*, *Opegrapha herbarum*, *O. sorediifera*, *Rinodina efflorescens* ja*Ropalospora viridis*.

INTRODUCTION

In August 24–30, 1991 the lichen flora of three wooded meadows in Estonia was investigated, two of which were situated in the island of Saaremaa and one on the Estonian coast c. 30 km E of Saaremaa (Fig. 1, localities no. 1, 4, 5). Some additional localities were also shortly visited, including two in the vicinity of Tartu, where the excursion ended up (Fig. 1, localities 2, 3, 6, 7).

Traditionally managed wooded meadows in Sweden usually have a species rich lichen flora, including several red-listed species. This is mainly due to the continuity in tree growth in combination with the open forest structure, characteristic of traditional management practices. The red-listed species are mainly found on broad-leaved deciduous trees (Thor, 1998). Also the Estonian wooded meadows investigated proved to be species rich. Areas with wooded meadows (and wooded pastures) have decreased dramatically both in Sweden and Estonia and are now restricted to very small areas. The remaining wooded meadows and pastures consequently have high conservation values. The trend away from traditional management practices of such habitats, resulting in denser forest structure, has become a threat even in protected areas in Sweden. Practices such as pollarding is apparently positive to some lichens, e.g. *Caloplaca chrysophthalma* Degel., a red-listed species in Sweden (Thor, 1996). Pollarded trees, however, are rare in the Estonian wooded meadows investigated compared with those of Gotland, Sweden, also investigated by the authors (together with R. Sundin; Nordin et al., 1990, 1991, 1992, 1996). A few species found in the Estonian wooded meadows were not found in Gotland, e. g. *Physcia semipinnata* (J. F. Gmelin) Moberg (AN & GT 164, locality 4, on *Fraxinus excelsior*).

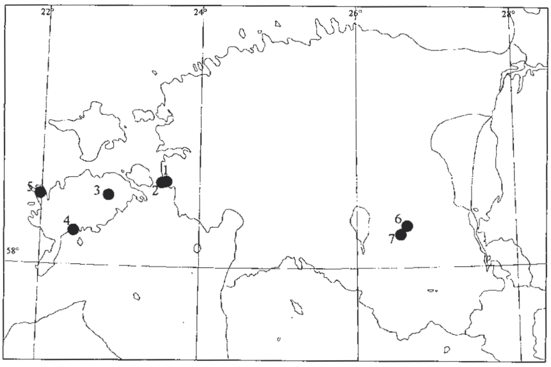


Fig. 1. Localities visited.

RESULTS

Altogether 12 species new to Estonia were found in the wooded meadows, six exclusively in Laelatu, two exclusively in Tagala, one exclusively in Loode, two in Laelatu and Tagala together, and one in the three of them. Four additional species new to Estonia were found at other localities specified below. At the same excursion *Cliostomum flavidulum* Hafellner & K. Kalb was collected and published as new to Estonia by Nordin et al. 1996 (as *Lecanora navarrensis* Etayo). One more lichen new to Estonia – *Phaeophyscia endophoenicea* (Harm.) Moberg – was collected in Tartumaa Co., Luke park. This finding has been published already in the macrolichen flora of Estonia (Trass & Randlane, 1994). Four of the species reported here are red-listed in Sweden, *Buellia violaceofusca* (Care demanding), *Cyphelium sessile* (Care demanding), *Gyalecta truncigena* (Vulnerable) and *Opegrapha sorediifera* (Vulnerable). The material will be deposited in UPS. For collections investigated by TLC the results are given together with the collection numbers. The numbers (1–7) refer to localities.

List of species new to Estonia

BUELLIA VIOLACEOFUSCA G. Thor & Muhr: 4 (no substances found by TLC, AN & GT 131). – On *Quercus robur*.

CALOPLACA HERBIDELLA (Hue) H. Magn.: 5 (AN & GT 216). – On *Quercus robur*.

CYPHELIUM SESSILE (Pers.) Trevis.: 4 (AN & GT 69; AN & GT 150). – On *Pertusaria coccodes* on *Fraxinus excelsior* (no. 150) and *Quercus robur* (no. 69).

FUSCIDEA PUSILLA Tønsberg: 1 (divaricatic acid, AN & GT 55), 5 (divaricatic acid, AN & GT 206). – On *Betula*.

GYALECTA TRUNCIGENA (Ach.) Hepp: 7 (AN & GT 280). – On *Quercus robur*.

LAUDERLINDSAYA ACROGLYPTA (Norman) R. Sant.: 1 (AN & GT 61), 5 (AN & GT 201). – On *Malus sylvestris* (no. 61) and *Tilia cordata* (no. 201); no perithecia found

LECANORA STROBILINA (Spreng.) Kieff.: 1 (usnic acid, zeorin, unidentified triterpen, AN & GT 57), 5 (usnic acid, zeorin, unidentified triterpen, AN & GT 207), 5 (usnic acid, zeorin, unidentified triterpen, AN & GT 237), 5 (usnic acid, zeorin, unidentified triterpen, AN & GT 277). – On *Betula* (no. 57, 207) and *Quercus robur* (237, 277).

LEPRARIA EBURNEA J.R. Laundon: 1 (alectorialic, barbatolic, protocetraric acids, AN & GT 37). – On *Fraxinus excelsior*.

LEPRARIA LOBIFICANS Nyl.: 2 (atranorin, stictic acid complex, zeorin, GT 10283), 4 (atranorin, stictic acid complex, zeorin, AN & GT 89), 8 (atranorin, stictic acid complex, zeorin, AN & GT 291). – On *Fraxinus excelsior* (10283), *Quercus robur* (no. 89) and *Tilia cordata* (no. 291).

LEPTOGIUM TERETIUSCULUM (Wallr.) Arnold: 1 (AN & GT 38). – On *Fraxinus excelsior*.

MICAREA PELIOCARPA (Anzi) Coppins & R. Sant.: 1 (AN & GT 53). – On *Betula*.

OCHROLECHIA SUBVIRIDIS (Hoeg) Erichsen: 3 (GT 10297). – On *Quercus robur*.

OPEGRAPHA HERBARUM Mont.: 1 (AN & GT 12). – On *Quercus robur*.

OPEGRAPHA SOREDIIFERA P. James: 5 (AN & GT 232). – On *Quercus robur*.

RINODINA EFFLORESCENS Malme: 1 (pannarin, AN & GT 31), 4 (pannarin, AN & GT 101), 5 (pannarin, AN & GT 211; pannarin, AN & GT 247). – On *Quercus robur* (no. 31, 101, 247) and *Betula* (211).

ROPALOSPORA VIRIDIS (Tønsberg) Tønsberg: 2 (perlatolic acid, GT 10280b). – On *Populus tremula*.

Localities

1. Läänemaa Co., Laelatu wooded meadow, 2 km E of Virtsu, 58°35'N, 23°35'E, 24–26 August 1991. Open, mowed wooded meadow dominated by *Quercus robur*.
2. Läänemaa Co., 2 km SSE of Virtsu, at the ornithological field station at Puhtu, 58°34'N, 23°33'E, 26 August 1991. Dense, old broadleaved deciduous forest at the Baltic sea.
3. Saaremaa Co., Ratla pasture, just SE of the road between Orissaare and Kuressare 30 km NE of Kuressare, 58°28'N, 22°51'E, 27 August 1991. Open pasture with scattered *Quercus robur*.
4. Saaremaa Co., Loode wooded meadow, 4 km W of Kuressare, just S of the road between Kuressare and Salme, 58°14'N, 22°25'E, 27–28 August 1991. Moowed wooded meadow (small parts mowed every year), dominated by *Fraxinus excelsior* and *Quercus robur*.
5. Saaremaa Co., Tagala wooded meadow, just W of Veere, 58°28'N, 21°59'E, 29–30 August 1991. Open, mowed wooded meadow with deciduous trees.

6. Tartumaa Co., 14 km SSW of Tartu, Unipiha park, 58°16'N, 26°37'E, 2 September 1991. Avenue and park with scattered broad-leaved deciduous trees.
7. Tartumaa Co., 16 km SSW of Tartu, Luke park, 58°14'N, 26°33'E, 2 September 1991. Overgrown park dominated by *Tilia cordata*.

ACKNOWLEDGEMENTS

We wish to thank H. Trass, T. Randlane, and A. Saag for their excellent organisation of the excursion and for assistance in the field. T. Randlane kindly informed us on which species were new to Estonia.

REFERENCES

Nordin, A., Sundin, R. & Thor, G. 1990. Lavinventering i ängen. *Rindi* 10: 35–36.

Nordin, A., Sundin, R. & Thor, G. 1991. *Lecanora strobilina* and *Polyblastia allobata* new to Sweden. *Graphis Scripta* 3: 50–51.

Nordin, A., Sundin, R. & Thor, G. 1992. *Bacidia caligans* and *Bacidina chloroticula* new to Sweden. *Graphis Scripta* 3: 134–137.

Nordin, A., Sundin, R. & Thor, G. 1996 [1995]. Two sorediate crustose lichens assigned to *Lecanora. Nord. J. Bot.* 15: 553–556.

Thor, G. 1996. The biology and distribution of three red listed lichens in Sweden. *Symb. Bot. Upsal.* 31: 3, 355–363.

Thor, G. 1998. Red-listed lichens in Sweden: habitats, threats, protection, and indicator value in boreal coniferous forests. *Biodiversity and Conservation* 7: 59–72.

Trass, H. & Randlane, T. (eds) 1994. *Eesti suursamblikud.* Tartu. 399 pp.

Folia Cryptog. Estonica, Fasc. 32: 127–133 (1998)

New and rare calicioid lichens and fungi from relict tertiary forests of Caucasus and the Crimea

Alexander N. Titov
Komarov Botanical Institute of the Russian Academy of Sciences, 2 Prof. Popov St., 197376 St. Petersburg, Russia

Abstract: 18 rare species of calicioid lichens and fungi are reported from tertiary forests of Caucasus and the Crimea. *Chaenothecopsis trassii* Titov is described as new. One new combination, *Chaenothecopsis jaczewskii* (Woronich.) Titov, is proposed. The habitat ecology and distribution of the species are presented.

Kokkuvõte: A. Titov. Uued ja haruldased kalitsioidsed samblikud ja seened Kaukaasia ja Krimmi reliktsetest tertsiaari metsadest.

Kaukaasia ja Krimmi reliktsetest tertsiaari metsadest loetletakse 18 haruldast kalitsioidset samblikku ja seent. Kirjeldatakse üks uus liik – *Chaenothecopsis trassii* Titov; esitatakse üks uus kombinatsioon – *Chaenothecopsis jaczewskii* (Woronich.) Titov. Käsitletakse liikide levikut ja nende kasvukohtade ökoloogiat.

INTRODUCTION

In accordance with Takhtadjan (1986) floristic division, Caucasus and the Crimea are situated on the boreal and tethyan subkingdoms of Holarctis. Although circumboreal elements dominate the flora of Caucasus and the Crimea, many relict islands of an ancient tertiary flora remain. There are two main centres of the tertiaty flora – the dry subtropical Hyrcanian forest and the wet subtropical forests of Colchis.

Relict Hyrcanian forests (the name originates from the ancient name of the Caspian Sea) form a separate province of the Irano-Turanion region, and occupy the northeastern slope of the Talysh range. The majority of forest-forming trees, such as *Acer vetulinum* Boiss., *Albizia julibrissin* Durazz., *Gleditschia caspia* Desf., *Parrotia persica* C.A.M., *Quercus castaneifolia* C.A.M., *Zelkova carpinifolia* (Pall.) C. Koch are endemics of the mesophilous tertiary forest.

The flora of the Colchian type (this name originates from the name of the territory in West Georgia – the lowlands of the river Rioni) form the Euxine province, and occurs in the western Caucasus – Adzharssk, Abkhassk and Krasnodar territories. In contrast to the Hyrcanian province, where conifers do not occur, the main forest-forming trees in the Euxine province are endemic conifers – *Abies nordmanniana* (Stev.) Spach and *Picea orientalis* (L.) Link – together with *Acer trautvetteri* Medw., *Carpinus betulus* L., *Fagus orientalis* Lipsky, *Pinus kochiana* Klotzsch ex C. Koch, *Quercus* spp., *Tilia begoniifolia* Stev.

The forests of the Crimea are mainly of a broad-leaved *Fagus-Quercus* type, and were included by Takhtadjan (1986) in a separate Crimean-Novorossijsk province. The flora of these forests is quite similar to that of the Colchian type.

During our field trips in Caucasus and the Crimea more than 50 species of calicioid lichens and fungi were found. In this paper only some rare, threatened, or earlier overlooked species are included.

All higher plants are named according to Czerepanov (1995), and lichens according to Santesson (1993).

MATERIAL AND METHODS

The material was collected from several localities in Caucasus and the Crimea by the author (Fig. 1) in the period from 1982–1993. The results are also based on herbarium material from LE, LEP and KW. For SEM, material was mounted on specimen stubs, air-dried and coated with gold. Estimates of the apothecium height, capitulum width, stalk width, ascus length, ascus width, spore length and spore width (for *Chaenothecopsis trassii*) are given in the following way: (min) a–b (max) – or for combinations of length and width: (min) a–b × c–d (max)– where a (and c) represent the arithmetic mean minus 1

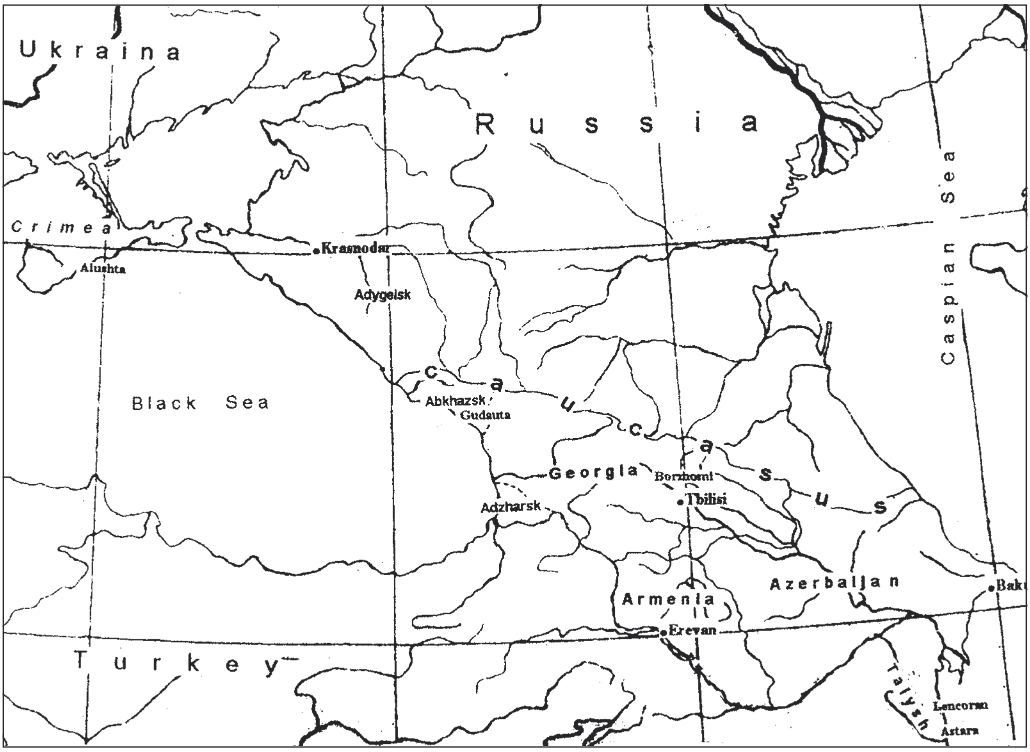


Fig. 1. The map of Caucasus and Crimea.

standard deviation and b (and d) the arithmetic mean plus 1 standard deviation. The extreme minimum (min) and maximum (max) values are given within parentheses.

THE SPECIES

CHAENOTHECA SERVITII Nadv., Fedde, Repert. 36: 308 (1934).

Caucasus. Russia, Krasnodar territory, Adygeisk autonomous region, Guzeripl, plateau Abago, alt. ca 1500 m, 1993 Titov 4528 (LE). On lignum of *Abies nordmanniana.*

C. servitii is known only from the type locality in Carpathians (Nadvornik, 1934). Here it is reported as a new for Russia and Caucasus.

CHAENOTHECA SUBROSCIDA (Eitner) Zahlbr., Cat. lich. univ. 578 (1922) – *Cyphelium subroscidum* Eitner, Jahrb. Schlesis. Ges. vaterl. Cult. 88: 53 (1911).

Caucasus. Georgia, Abkhazsk, Gudauta region, lake Ritza, alt. ca 900 m, 1988 Titov 1480, 1555 (LE). On bark and lignum of *Abies nordmanniana.*

C. subroscida occurs in Europe and North America, usually on bark of *Picea* (Tibell, 1980). In the former USSR it has not previously been found east of Estonia. It is here reported new to Asia.

CHAENOTHECOPSIS BREVIPES Tibell, Symb. Bot. Ups. 27(1): 119 (1987).

Caucasus. Russia, Krasnodar territory, Adygeisk autonomous region, Mezmaj, alt. ca 900 m, 1993 Titov 4543 (LE). On bark of *Acer trautvetteri.*

C. brevipes seems to be rare species, occuring on the thallus of *Arthonia* growing on bark of deciduous trees in shaded situations in cold temperate, wet forests. Originally described from New Zealand (Tibell, 1987), it has later been found only in a few localities in eastern North America (Selva, 1988), Russian Far East (Titov & Tibell, 1993) and Europe (Tibell & Ryman, 1995). It is here reported new to Caucasus.

CHAENOTHECOPSIS GOLUBKOVAE Tibell & Titov in Titov & Tibell, Nord. J. Bot. 13: 320 (1993).

Caucasus. Russia, Krasnodar territory, Adygeisk autonomous region, 2 km E of Kamyshanova polyana, alt. ca 1200 m, 1982 Titov 303 (type: LE; isotype: Tibell, Cal. Exs. 211); Guzeripl, plateau Abago, alt. ca 1500 m, 1993 Titov 4527 (LE). Georgia, Borzhomi region, Tadsrisi, alt. ca 1000 m, 1983 Titov 1460 (LE). On resin of *Abies nordmanniana* and *Picea orientalis*.

C. golubkovae occurs on bark of *Abies, Picea* and *Pinus* in open situations in temperate forests. It was found mainly in cracks of the bark where exudate had accumulated. It was recently included in a revision of resinicolous calicioid fungi (Tibell & Titov, 1995). *C. golubkovae* seems to be a rare species. It is known only from a few localities in Caucasus, Russian Far East (Titov & Tibell, 1993) and China (unpublished).

CHAENOTHECOPSIS HOSPITANS (Th. Fr.) Tibell, Nova Hedwigia 60: 202 (1995) – *Calicium hospitans* Th. Fr., Bot. Notiser: 40 (1865).

Caucasus. Georgia, Borzhomi region, Tadsrisi, alt. ca 1000 m, 1983 Titov 1351 (LE). On thallus of *Lecanora carpinea* (L.) Vain.

C. hospitans occurs as a parasite-parasymbiont on the thallus of *Lecanora carpinea* growing on deciduous trees, and also on *Haematomma ochroleucum* (Neck.) Laundon on shaded, siliceous rocks. It was previously known only from Central Europe and Scandinavia. New to Asia (Tibell & Ryman, 1995).

CHAENOTHECOPSIS JACZEVSKII (Woronich.) Titov, comb. nov. – *Protocalicium jaczevskii* Woronich., Travaux du Mus. Bot. 21 (1927): 103.

Caucasus. Georgia, Gori region, Licani, 1920, coll. N. N. Voronichin (holotype: LEP). On mycelium of *Hormiscium pinofilum* (Nees) Lind., growing on twigs of *Picea orientalis*.

Mycelium well developed, consisting of pale, irregular intervowen hyphae about 3 μm thick, mixed with the host mycelium. Algae not present in the substrate. Apothecia small, 0.2–0.4 mm high, on pale stalks. Capitulum ellipsoidal, black, 0.06–0.1 mm in diameter. Hymenium and hypothecium pale. Excipulum well-developed as a continuation of the outer part of the stalk, consisting of 4–5 layers of periclinally elongated cells, with a constricted margin. Stalks straight, 0.02–0.03 mm in diameter, consisting of loosely interwoven pale hyphae. Mature asci 55–70 × 4–5 μm, cylindrical, always with a canal in the apical thickening. Spores uni-

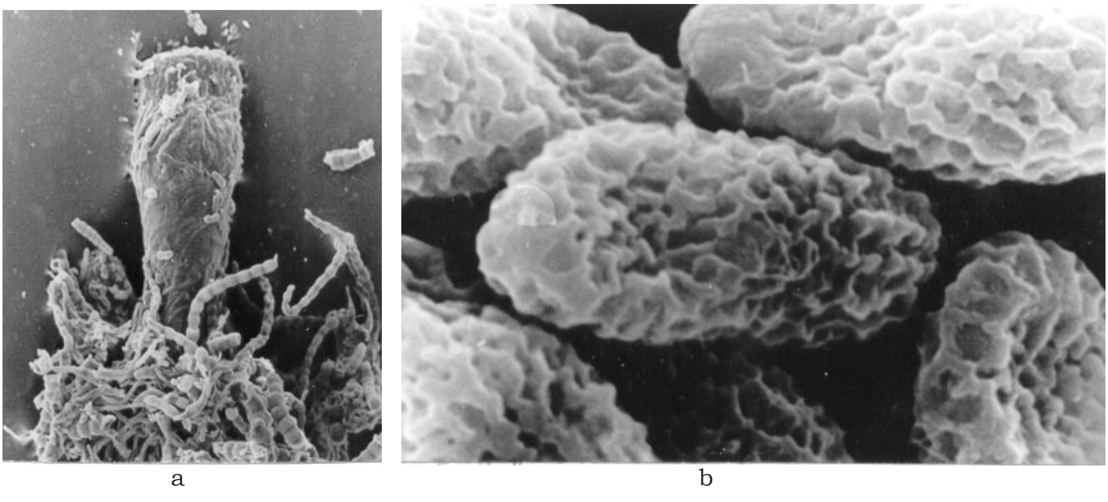

a b

Fig. 2. *Chaenothecopsis jaczevskii.* a – apothecium, assotiated with mycelium of *Hormiscium pinophilum*; b – spores.

seriately arranged in the asci, periclinally orientated, 1-septate, narrowly-ellipsoidal with rounded ends, pale-brown, 7–9 × 3–4 µm, with a well-developed, areolate ornamentation. All parts of the apothecium K-, H-, strongly swelling with K. Hymenium slightly blue-green with iodine (Fig. 2).

C. jaczevskii is characterized by its green in fresh material (Voronichin, 1927), well developed mycelium, small apothecia on pale stalks and ellipsoidal capitula, constricted excipulum margin and one-septate ornamented spores.

C. jaczevskii is known from one collection only and the material is rather scanty for suppling a good description, but this is evidently a distinctive species. In many respects it is quite different from other genera of calicioid fungi, and only placed in *Chaenothecopsis* tentatively, since the generic delimitations in *Mycocaliciaceae* are in need of reappraisal.

CHAENOTHECOPSIS OCHROLEUCA (Körb.) Tibell & K. Ryman, Nova Hedwigia 60: 208 (1995) – *Calicium ochroleucum* Körb., Parerga Lich.: 295 (1865).

Caucasus. Azerbaijan, Lencoran region, Belyasar, 1987 Titov, 1431, 1443, 1458 (LE). On thallus of *Haematomma ochroleucum* (Neck.) Laundon, growing on bark of *Fagus orientalis*. *C. ochroleuca* occurs on the bark of deciduous trees in humid situations in temperate forests. A rare species, *C. ochroleuca* is previously known from some localities of the northern Eurasia. Originally described from Germany (Koerber, 1865), it has also been reported from Central Europe (Nádvorník, 1934, 1942; Tibell & Ryman, 1995) and the Russian Far East (Titov & Tibell, 1993). New to Caucasus.

CHAENOTHECOPSIS TRASSII Titov sp. nov.

Apothecia parva, 0.23–0.32 mm alta, nigra, epruinosa. Excipulum brunneum, e hyphis periclinalibus constans, 4–6 µm crassum. Asci 28.9–40.7 × 3.4–4.2 µm, cylindrici vel anguste clavati. Sporae uniseptate, ellipsoideae, pallidae brunneae, laeves, 5.3–6.4 × 2.0–2.6 µm. Partes apotheciorum rubro-

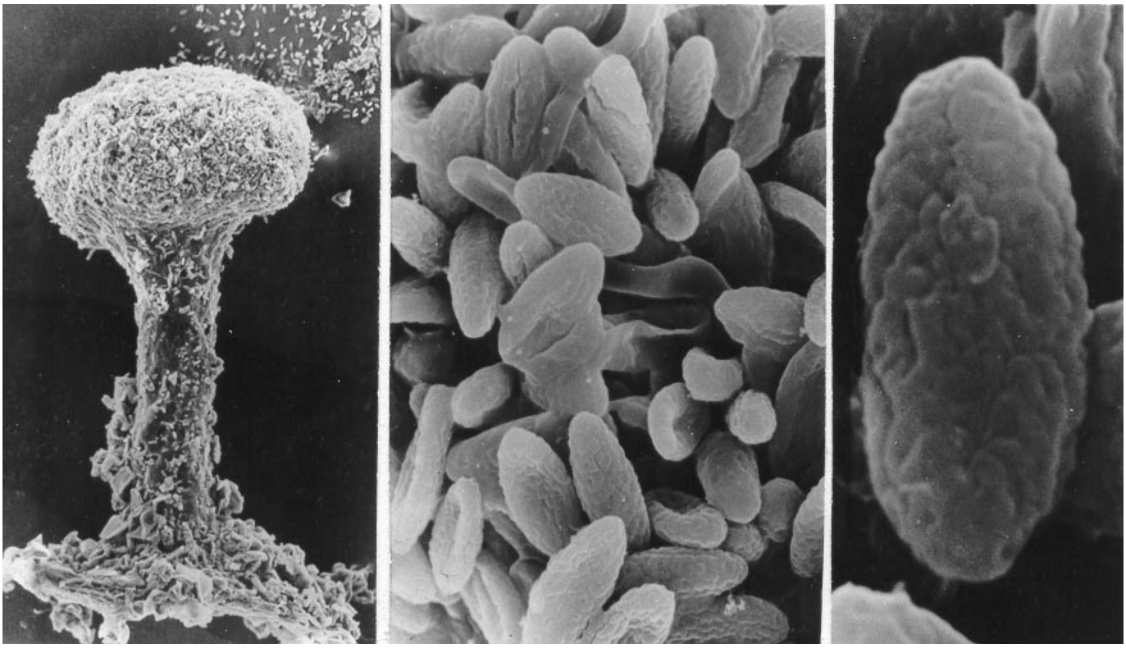


Fig. 3. *Chaenothecopsis trassii.* a – apothecium; b, c – spores.

pigmentataea K addito intense virescentes, ceterum H-, K-.

Apothecia associated with *Trentepohlia*, or no photobiont present. Apothecia small, (0.20)0.23–0.33(0.40) mm high, black. Capitulum subspherical to obconical and hemispherical, (0.10)0.12–0.20(0.25) mm in diameter. Epithecium brown, 2–4 µm thick. Hymenium and hypothecium pale. Excipulum well-developed as a continuation of the outer part of the stalk, consisting of 3–4 layers of periclinally elongated, 4–6 µm thick, brown cells. Stalks straight, 0.02–0.05 mm in diameter, consisting of interwoven periclinally arranged hyphae, which are pale and more loosely arranged in the central part and brown in outer part. Hymenium and more rarely hypothecium and inner part of stalk containing numerous red crystals. Asci (24.0)28.9–40.7(45.0) × (3.0)3.4–4.2(4.5) µm, cylindrical or narrowly clavate, with a thin canal in the apical thickening. Spores uni- or rarely biseriately arranged in the asci, periclinally or obliquely orientated, non-septate, ellipsoidal, pale-brown, (5.0)5.3–6.4(8.0) × (2.0)2.0–2.6(3.0) µm, smooth under the light microscope and weakly ornamented in SEM. All parts of the apothecium with red pigment turn aeruginose with K, but are H- (Fig. 3, a–c).

Caucasus. Azerbaijan, Lencoran region, Belyasar, 1987 Titov 1766 (Holotype: LE, isotype: UPS), Vyshnikesh, 1427 (LE). On bark of *Fagus orientalis*.

C. trassii is characterized by its small, short-stalked apothecia, the non-septate ellipsoidal spores, the ascocarp structure and by containing red crystals in hymenium, which yield a green reaction with K. *C. trassii* is rather similar to *C. rubescens*, which also has short-stalked apothecia which contain a red pigment, but it differs in having smaller, smooth spores and a different K reaction. *C. trassii* is also somewhat similar to *C. ochroleuca*, which has a K+ aeruginose reaction of the capitulum, but fusiform dark spores and often white pruinose stalks. *C. nana* and *C. amurensis* both have short-stalked apothecia and non-septate spores and could be mistaken for *C. trassii*, but differ in having a negative K reaction.

C. trassii is named in honour of Prof. H. Trass on the occasion of his 70th birthday for his invaluable contribution to the exploration of the Russian lichen flora.

CHAENOTHECOPSIS USSURIENSIS Titov, Nord. J. Bot. 13: 326 (1993).

Caucasus. Azerbaijan, Astara region, Sym, 1987 Titov 1435 (LE). On bark of *Quercus castaneifolia*.

C. ussuriensis is previously known only from the southern Far East of Russia and north-east of China, and seems to be a common and widely distributed but earlier overlooked species in relict *Pinus*-deciduous forests. The occurrence of this species in the Gyrcanian forest may indicate a connection between the tertiary forests of Caucasus and the Far East.

CHAENOTHECOPSIS VAINIOANA (Nádv.) Tibell, Publ. Herb. Univ. Upsal. 4: 5 (1979) – *Calicium vainioanum* Nádv., Preslia 18–19: 128 (1940).

The Crimea. Alushta region: mount Cziornaya, alt. ca 500 m, 1989 Titov 1900 (Tibell: Cal. exs. 217), 1940, 2000; cordon “Bukovsky, alt. ca 800 m., 1989 Titov 2101, 2162, 2168 (LE). On bark and lignum of *Acer campestre* L., *Fraxinus excelsior* L. and *Quercus robur* L.

C. vainioana is known only from Europe where it seems to be a rare species, occurring on trunks of old trees, usually *Quercus*, in open situations. New for the Crimea and Ukraine (Tibell, 1993).

CYBEBE GRACILENTA (Ach.) Tibell, Beih. Nova Hedw. 79: 666 (1984) – *Calicium gracilentum* Ach., Lich. Univ.: 243 (1810).

Caucasus. Russia: Krasnodar territory: Adygeisk autonomous region: 5 km north of Kamyshanova polyana, alt. ca. 1200 m., 1982 Titov 315 (Tibell: Cal. exs. 138), 494, 495; Guzeripl, plateau Abago, alt. ca 1500 m., 1993 Titov 4527 (LE). Azerbaijan, Astara region, Sym, 1987 Titov 1453 (LE), 1471 (Tibell: Cal. exs. 163). Georgia, Abhassk, Gudauta region, the lake Ritza, alt. ca 900 m., 1988 Titov 1760 (LE). On bark of *Acer trautvetteri, A. velutinum* and *Tilia begoniifolia.*

Cybebe gracilenta occurs on the bark and lignum of deciduous trees in humid and shaded situations in temperate forests. It is rare in Europe and North America. In Caucasus it was abundant in the localities mentioned above. New to Asia (Tibell, 1989).

Cyphelium karelicum (Vain.) Räsänen, Ann. Bot. Soc. Zool.-Bot. Fenn. 12: 188 (1939) – *Cyphelium lucidum* var. *karelicum* Vain., Acta Soc. F. Fl. Fenn. 57,1: 20 (1927).

Caucasus. Georgia, Abhassk, Gudauta region, the lake Ritza, alt. ca 900 m., 1988 Titov 1477, 1547, 1575, 1584 (LE). On bark of *Abies nordmanniana* and *Picea orientalis*.

C. karelicum is a rather rare species occurring in conifer forests of Europe, North America (Tibell, 1975) and the Siberian Arctic (Titov, 1984). New to Caucasus.

Cyphelium sessile (Pers.) Trevis., Flora 45: 3 (1862) – *Calicium sessile* Pers., Tent. disp. meth. fung.: 59 (1797).

The Crimea. Alushta region, cordon "Bukovsky", alt. ca 800 m, 1989 Titov 2155, 2169 (LE). On thallus of *Pertusaria* sp., growing on bark of *Fagus orientalis*.

C. sessile is known only from Europe where it is a rare species. Usually it occurs on bark of *Quercus* as a parasite-parasymbiont of *Pertusaria coccodes* (Ach.) Nyl. (Tibell, 1971). It is here reported new to the Ukraine.

Mycocalicium albonigrum (Nyl.) Tibell, Lichenologist 14: 238 (1982) – *Calicium albonigrum* Nyl., Syn. Lich.: 159 (1860).

The Crimea. Feodosia region, Lesnoe, alt. ca. 400 m, 1979, coll. Kopachevskaya (KW); Alushta region, cordon "Vesioly", alt. ca. 600 m, 1961, coll. Roms (KW), cordon "Bukovsky", alt. ca. 800 m, 1989 Titov 2801 (LE). On lignum *of Fagus orientalis*.

M. albonigrum occurs on lignum of trees in open situations. It is known from Australia, and North and South America (Tibell, 1987). *M. albonigrum* is quite similar to *M. subtile*, which is a very widely distributed species, but differs in having an excipulum formed by isodiametric cells. This species might have been overlooked since it is rather difficult to identify. It is here reported as new for Eurasia.

Pyrgidium montellicum (Beltr.) Tibell, Lichenologist 14: 239 (1982) – *Acolium montellicum*, Beltr. Lich. Bass.: 285 (1858).

Caucasus. Russia, Krasnodar territory, Adygeisk autonomous region, Kamyshanova polyana, alt. ca. 1200 m., 1982 Titov 302 (Tibell: Cal. exs. 195). Azerbaijan, Lencoran region, Belyasar, 1987 Titov 1433 (LE). On bark of *Acer pseudoplatanus* L. and *Carpinus betulus*.

P. montellicum occurs on bark and lignum in warm temperate to tropical forests. *P. montellicum* is a rare but widely distributed species, known only from rather few localities. Recorded from Italy, India, Costa Rica (Tibell, 1982a), Australia (Tibell, 1987) and Caucasus (Titov, 1990).

Sclerophora amabilis (Tibell), Tibell Beih. Nova Hedw. 79: 679 (1984) – *Coniocybe amabilis* Tibell, Publ. Herb. Univ. Upps. 10:6 (1982).

Caucasus. Georgia, Abhassk, Gudauta region, the lake Ritza, alt. ca. 900 m., 1988 Titov 1489 (LE). On decorticated trunks of *Hedera colchica* (Koch) Koch.

S. amabilis occurs on lignum and rarely bark of trees in shaded localities with high humidity. Originally described from New Zealand (Tibell, 1982b), *S. amabilis* was collected in the Russian Far East (Tibell, 1993), Sweden (Gustavsson, 1995), North America (Goward et al., 1996), and China (by the author, unpublished). Here it is reported as new for the Caucasus.

Sclerophora coniophaea (Norm.) J. Mattson & Middelb. in Middelb. & J. Mattson, Sommerfeltia 5: 61 (1987) – *Coniocybe coniophaea* Norm., K. Norske Vidensk.-Selsk. Skr. 5: 362 (1868).

Caucasus. Russia, Krasnodar territory, Adygeisk autonomous region, Guzeripl, plateau Abago, alt. ca 1500 m., 1993 Titov 4529 (LE). Georgia, Abhassk, Gudauta region, the lake Ritza, alt. ca. 900 m., 1988 Titov 1540 (LE). On bark of *Abies nordmanniana*.

S. coniophaea is known only from Europe and North America, where it is a rare species, occurring on trunks of old trees. Like most *Sclerophora* species, *S. coniophaea* is threatened by the disappearance of old-growth forests. It is here reported new to Asia.

Sclerophora peronella (Ach.) Tibell, Nova Hedw. Beih. 79; 679 (1989) – *Lichen peronellus* Ach., Lichenogr. suec. prodr.: 84 (1799).

Caucasus. Georgia, Abhassk, Gudauta region, the lake Ritza, alt. ca. 900 m., 1988 Titov 1494, 1572 (Tibell: Cal. exs. 171), 1762

(LE). On bark *of Acer trautvetteri, Fraxinus* sp.

S. peronella is known only from Europe, where it is a rare species, occurring on trunks of old trees. New for Asia (Tibell, 1989).

ACKNOWLEDGEMENTS

I wish to thank Dr Leif Tibell (Uppsala) for his help throughout this study, Prof. Nina S. Golubkova (St. Petersburg) for her support of the investigations of calicioid lichens and fungi in Russia, and Dr Sergej Krivorotov (Krasnodar) for organizing field trips in Caucasus.

REFERENCES

Czerepanov, S. K. 1995. *Plantae vasculares rossicae et civitatum collimitanearum.* S. Petropolis. 990 pp.

Goward, T., Breuss, O., Ryan, B., McCune, B., Sipman, H. & Scheidegger, C. 1996. Notes on the Lichens and Allied Fungi of British Columbia. III. *Bryologist* 99: 439–449.

Gustavsson, H.-E. 1995. The lichen flora on beech of Ödegärdet, Småland, SW Sweden. *Svensk Bot. Tidskr.* 89: 65–82.

Körber, G.W. 1865. *Parerga lichenologica.* Breslau.

Nádvorník, J. 1934. Calicieae-Studien aus der Tschechoslowakei. *Fedde, Repertorium* 36: 307–310.

Nádvorník, J. 1942. Systematische Ubersicht der mitteleuropäischen Arten der Flechtenfamilie Caliciaceae. *Stud. Bot. Cech.* 5: 6–46.

Santesson, R. 1993. *The lichens and lichenicolous fungi of Sweden and Norway.* Lund. 240 pp.

Selva, S. 1988. The Caliciales of Northern Maine. *Bryologist* 91: 2–17.

Takhtadjan, A. 1986. *Floristic regions of the world.* University of California press. Berkley, Los Angeles, London. 522 pp.

Tibell, L. 1971. The genus *Cyphelium* in Europe. *Svensk Bot. Tidskrift* 65: 157–158.

Tibell, L. 1975. The Caliciales of Boreal North America. *Symb. Bot. Upsal.* 21, 2: 1–128.

Tibell, L. 1980. The genus *Chaenotheca* in the northern hemisphere. *Symb. Bot. Upsal.* 23, 1: 1–65.

Tibell, L. 1982a. Caliciales of Costa Rica. *Lichenologist* 14, 4: 219–254.

Tibell, L. 1982b. Caliciales exsiccatae 3. *Publ. Herb. Univ. Upsal.* 10: 1–10.

Tibell, L. 1987. Australasian Caliciales. *Symb. Bot. Ups.* 27(1): 1–279.

Tibell, L. 1989. Caliciales exsiccatae 7. *Thunbergia* 8: 1–9.

Tibell, L. 1993. Caliciales exsiccatae 9. *Thunbergia* 18: 1–15.

Tibell, L. & Ryman, K. 1995. Revision of species of *Chaenothecopsis* with short stalks. *Nov. Hedw.* 60: 199–218.

Tibell, L. & Titov A. N. 1995. Species of *Chaenothecopsis* and *Mycocalicium* (Caliciales) on exudate. *Bryologist* 98,4: 550–560.

Titov, A. N. 1984. Lichenes Caliciales in parte boreali-occidentali planitiei Putoran (in Russian). *Novitates Syst. Plant. non Vasc.* 21: 179–183.

Titov, A. N. 1990. *Pyrgidium* Nyl. (Caliciales) – new genus in the flora of the USSR (in Russian). *Bot. J.* 75, 11: 1538–1539.

Titov, A. N. & Tibell L. 1993. *Chaenothecopsis* in the Russian Far East. *Nord. J. Bot.* 13: 313–329.

Voronichin, N. N. 1927. Materials to the flora of fungi of Caucasus (in Russian). *Travaux du Musee de l'cademie des Sciences de l'URSS*: 103–106.

Folia Cryptog. Estonica, Fasc. 32: 135–147 (1998)

Die Verbreitung der Gattungen *Anaptychia, Heterodermia, Hyperphyscia* und *Phaeophyscia (Physciaceae)* in Österreich

Von Roman Türk[1] und Walter Obermayer[2]
[1]Universität Salzburg, Institut für Pflanzenphysiologie, Hellbrunnerstraße 34, A-5020 Salzburg, Austria
[2]Universität Graz, Institut für Botanik, Holteigasse 6, A-8010 Graz, Austria

Summary: The distribution of the genus *Anaptychia*, *Heterodermia*, *Hyperphyscia* and *Phaeophyscia* (*Physciaceae*) in Austria is presented in form of grid maps. The patterns of distribution are explicable by the description of the ecological range of the treated species.

Kokkuvõte: Perekondade *Anaptychia*, *Heterodermia*, *Hyperphyscia* ja*Phaeophyscia* (*Physciaceae*) levik Austrias.

Perekondade *Anaptychia*, *Heterodermia*, *Hyperphyscia* ja*Phaeophyscia* (*Physciaceae*) levik Austrias on esitatud kaartidel. Vaadeldud liikide levikumustreid selgitatakse nende liikide ökoloogiliste nõudluste kirjeldamise abil.

EINLEITUNG

Die lobaten Gattungen *Anaptychia*, *Heterodermia*, *Hyperphyscia* und *Phaeophyscia* aus der Familie der Physciaceae sind hinsichtlich ihrer ökologischen Ansprüche und ihrer Verbreitung sehr unterschiedlich. Die Abgrenzung einiger Sippen ist zum Teil schwierig (vgl. Moberg, 1977; Hafellner et al., 1979). Nach Hafellner et al. (1979) sind z. B. die Gattungen *Anaptychia* und *Physconia* typisch nordhemisphärisch temperate Genera, *Heterodermia* tropisch-subtropische Breitgürtelelemente und *Hyperphyscia* ebenfalls tropisch-subtropisch mit einigen temperaten Ausläufern. Die Gattungen *Physcia* und *Phaeophyscia* wiederum haben eine sehr weite Verbreitung, die von der Arktis und der Antarktis bis in die Tropen reicht, auf einer Fülle von Substraten, sofern diese einen bestimmten Grad an Eutrophierung aufweisen. Die saxicolen Arten haben sehr unterschiedliche Ansprüche auf das Substrat, was den Säuregrad betrifft (vgl. Moberg, 1977).

Die Wuchsmöglichkeiten für Flechten sind in Österreich auf Grund der anstehenden Gesteine, der Substratvielfalt, der orographischen und klimatischen reichen Gliederung äußerst vielfältig und bieten Lebensraum für Flechten mit den unterschiedlichsten ökologischen Ansprüchen. Am Beispiel einiger Verterter aus der Familie der Physciaceae sollen die Verbreitungsmuster dargestellt und diskutiert werden.

DIE VERBREITUNG IN ÖSTERREICH

Die Literaturangaben über Funde in Österreich zwischen 1860 und 1993 sind aus Türk & Poelt (1993) zu entnehmen.

ANAPTYCHIA BRYORUM Poelt, syn.: *A. fusca* (Huds.) Vain. var. *stippea* auct. (Abb. 1)

Literatur: Türk & Poelt, 1993; Hafellner, 1993; Hofmann et al., 1995.

Anaptychia bryorum wächst zumeist an Steilflächen über Moosen und Pflanzenresten in der alpinen Stufe (Poelt & Vêzda, 1977). In Österreich bevorzugt sie sauren bis leicht kalkhaltigen Untergrund in den Zentralalpen, nur gelegentlich dringt sie in die Nördlichen Kalkalpen (Göllmassiv, Steinernes Meer, Hochkönig) vor.

ANAPTYCHIA CILIARIS (L.) Körb. (Abb. 2)

Literatur: Türk & Poelt, 1993; Geyer, 1985; Neuwirth & Türk, 1993; Pfefferkorn & Türk, 1993; Hafellner & Maurer, 1994; Hofmann et al., 1995; Baumgartner & Türk, 1996; Berger, 1996; Boom et al., 1996; Pfefferkorn, 1996; Pfefferkorn & Türk, 1997.

Diese formenreiche Art (vgl. Poelt & Vêzda, 1977) war mit ihren epiphytisch lebenden Vertretern früher weitaus häufiger als heute. In ihrem heutigen Hauptverbreitungsgebiet, im Mittelgebirge der Böhmischen Masse und im Alpenvorland, tritt sie meist nur in wenigblättrigen, deformierten Thalli auf. Normal wachsende Exemplare finden

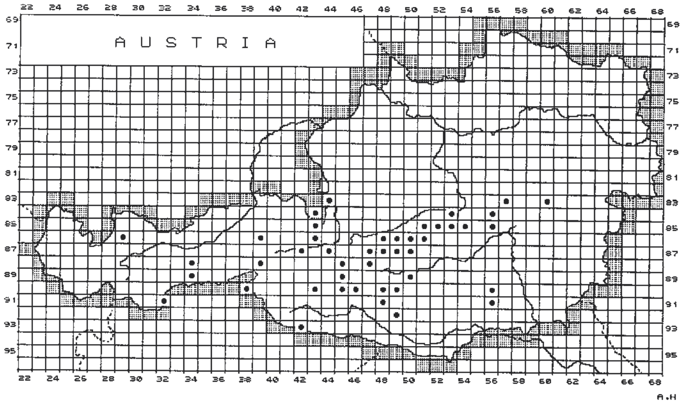


Abb. 1. Bisher bekannte Verbreitung von *Anaptychia bryorum* in Österreich.

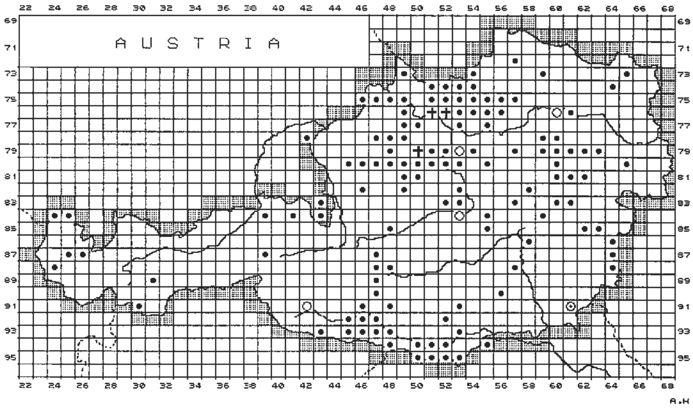


Abb. 2. Bisher bekannte Verbreitung von *Anaptychia ciliaris* in Österreich (Punkte: aktuelle Funde nach 1960; Kreuze: nachweislich ausgestorben; Kreis: Fund vor 1900; Kreis mit Punkt: Fund zwischen 1900–1950).

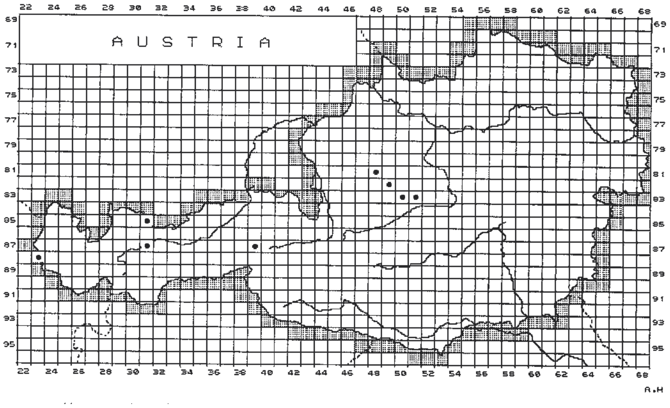


Abb. 3. Bisher bekannte, aktuelle Verbreitung von *Heterodermia obscurata* in Österreich.

sich in den Alpentälern und südlich des Alpenhauptkammes, wo sie sich auf einzelstehenden Bäumen in Viehweiden geradezu üppig entwickeln können. Als Substrat bevorzugt sie Laubbäume mit rauher, leicht gedüngter Borke in der niedermontanen bis hochmontanen Stufe.

HETERODERMIA OBSCURATA (Nyl.) Trevis. (Abb. 3)

Literatur: Türk & Poelt, 1993; Hofmann, 1993; 1994; Pfefferkorn, 1996; Türk, 1996; Pfefferkorn & Türk, 1997.

Heterodermia obscurata ist eine ozeanische Flechte, deren Hauptverbreitung in den ozeanischen Bereichen im Südwesten Europas (Küsten von Portugal, Spanien, Frankreich und Großbritannien) liegt (vgl. Schauer 1963). An niederschlagsreichen Orten mit gemäßigtem Temperaturregime findet sie sich auch in den Alpen ein, vornehmlich in einer Seehöhe zwischen 500 bis 700 Meter. Sie siedelt gern auf bachbegleitenden Weiden (*Salix* sp.) und Esche (*Fraxinus excelsior*). Der von Schauer (1963) angegebene Fund vom Langbathsee am Nordabfall des Höllengebriges in Oberösterreich konnte im Zuge neuerer Begehungen zwischen 1975 und 1996 nicht mehr bestätig werden. *Heterodermia obscurata* gehört zu den vom Aussterben bedrohten Arten in Österreich (Gefährdungsstufe 1).

HETERODERMIA SPECIOSA (Wulfen) Trevis. (Abb. 4)

Literatur: Türk & Poelt, 1993; Hofmann, 1993; Türk & Breuss, 1994; Rücker & Wittmann, 1995; Pfefferkorn, 1996; Türk, 1996; Pfefferkorn & Türk, 1997.

Heterodermia speciosa siedelt auf bemoosten Stämmen und auf Seitenästen von Laubbäumen (*Salix* sp., *Alnus incana*, *Acer pseudoplatanus*, *Fagus sylvatica* etc.), in extrem luftfeuchten Orten (enge Talschluchten, schattige Täler, Nähe von Wasserfällen) kommt sie auch auf Nadelbäumen vor. Als ozeanische Flechte bevorzugt sie Gebiete mit hohen Niederschlagsraten von der montanen (ab etwa 400 Meter) bis in die hochmontane (etwa 1400, im Extremfall 1600 Meter) Stufe. Sie fruchtet selten – und wenn, dann zumeist an bachnahen Stämmen und Ästen. Ein geschlossenes Verbreitungsgebiet weist sie in den Tälern der Nördlichen Kalkalpen auf, in den Zentralalpen tritt sie nur an sehr luftfeuchten Standorten auf. In den südlichen Kalkalpen bevorzugt sie die niederschlagsreichen Abschnitte der Karnischen Alpen und der Karawanken. Außerhalb der Alpen dürfte sie heute in Österreich ausgestorben sein. Über die Verbreitung in Europa siehe Schauer (1965).

HYPERPHYSCIA ADGLUTINATA (Flörke) H. Mayrhofer & Poelt, syn.: *Physciopsis a.* (Flörke) M. Choisy (Abb. 5)

Literatur: Türk & Poelt, 1993; Hafellner & Maurer, 1994; Türk et al., 1994; Hofmann et al., 1995; Obermayer, 1996.

Die tropische Gattung *Hyperphyscia* ist in Europa lediglich mit einer Art – *Hyperphyscia adglutinata* – vertreten. Diese Flechte ist wohl eine der kleinstwüchsigen Blattflechten unserer heimischen Flora. Ihr graugrün bis graubraun gefärbtes Lager liegt dem Substrat sehr eng an. Sie bevorzugt subneutrale bis staubimprägnierte Borke von freistehenden Laubbäumen (*Aesculus hippocastanum*, *Robinia pseudacacia*, *Tilia cordata*, *Populus* sp., *Juglans regia* u.a.) in wärmegetönten Lagen außerhalb der Alpen. In den Alpen folgt sie gelegentlich tiefer gelegenen Flußtälern. Sie bevorzugt die kolline (ab 180 Meter) bis niedermontane (ca. 700 Meter) Stufe. Aus Vorarlberg, Tirol und Kärnten liegen bisher keine Fundmeldungen vor. In Europa ist sie mitteleuropäisch-mediterran verbreitet.

PHAEOPHYSCIA CERNOHORSKYI (Nádv.) Essl., incl. *P. strigosa* (Poelt & Buschardt) Golubkova (Abb. 6)

Literatur: Türk & Poelt, 1993; Hofmann et al., 1995.

Phaeophyscia cernohorskyi bevorzugt ähnlich wie *Ph. insignis* südeponierte, trockenwarme Standorte. Neben ihrem gehäuften Auftreten in collinen bis submontanen Lagen des südöstlichen Alpenrandes stößt sie inneralpin (unter geeigneten kleinklimatischen Bedingungen) auch bis in hochmontane Lagen vor. Sie wächst überwiegend auf kalkhältigen Gesteinen oder darüberliegenden Moosen.

PHAEOPHYSCIA CHLOANTHA (Ach.) Moberg, syn.: *Physcia luganensis* Mereschk.; *Physciella chloantha* (Ach.) Essl. (Abb. 7)

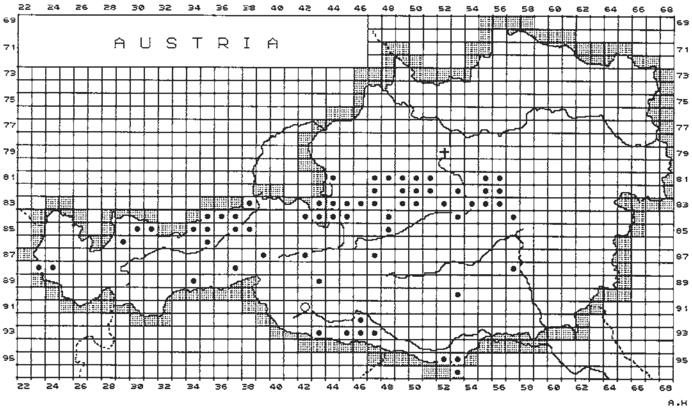


Abb. 4. Bisher bekannte Verbreitung von *Heterodermia speciosa* in Österreich (Kreuz: nachweiselich ausgestorben; Kreis: Fund vor 1900).

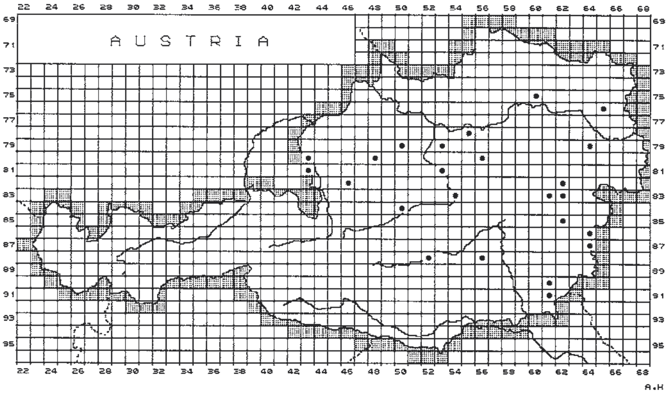


Abb. 5. Bisher bekannte Verbreitung von *Hyperphyscia adglutinata* in Österreich.

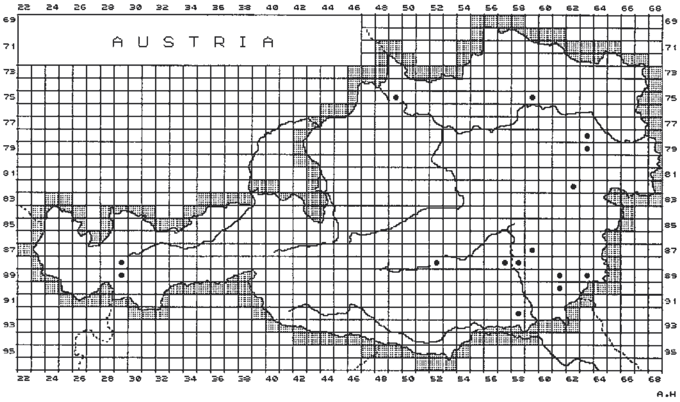


Abb. 6. Bisher bekannte Verbreitung von *Phaeophyscia cernohorskyi* in Österreich.

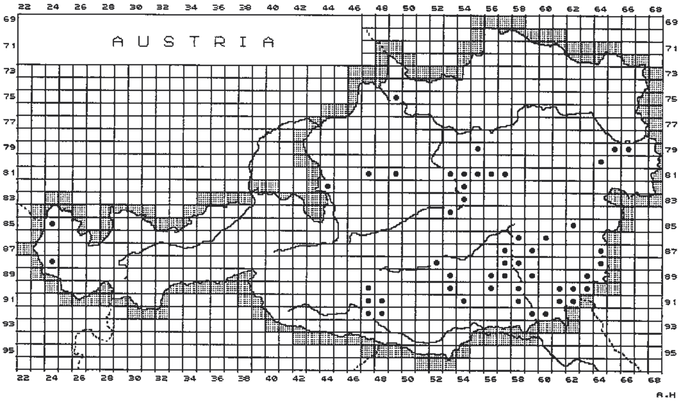


Abb. 7. Bisher bekannte Verbreitung von *Phaeophyscia chloantha* in Österreich.

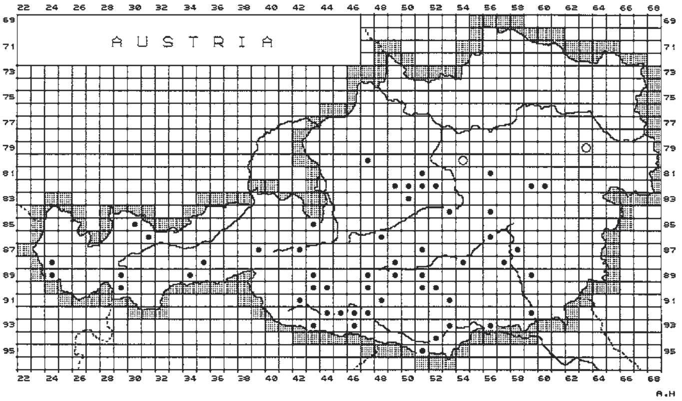


Abb. 8. Bisher bekannte Verbreitung von *Phaeophyscia ciliata* in Österreich (Kreis: Fund vor 1900).

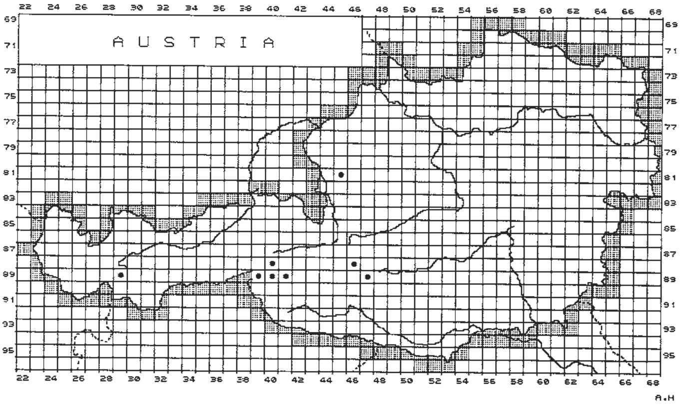


Abb. 9. Bisher bekannte Verbreitung von *Phaeophyscia constipata* in Österreich.

Literatur: Türk & Poelt, 1993; Obermayer, 1993; Hafellner & Maurer, 1994; Türk et al., 1994; Berger, 1996; Boom et al., 1996; Pfefferkorn, 1996; Pfefferkorn & Türk, 1997.

Phaeophyscia chloantha tritt in Österreich nur in geringer Abundanz auf, die aktuellen Funde betreffen zumeist nur einige wenige Exemplare. Sie wächst in kollinen bis submontanen, selten in montanen, wärmegtönten Lagen auf Laubbäumen mit nährstoffreicher Borke. Ihr höchst gelegener Fundpunkt liegt in 1000 Meter Höhe (Gaisberg bei Salzburg).

PHAEOPHYSCIA CILIATA (Hoffm.) Moberg, syn.: *Physcia c.* (Hoffm) Du Rietz (Abb. 8)

Literatur: Türk & Poelt, 1993; Hofmann, 1993; Obermayer, 1993; Türk & Breuss, 1994; Hofmann et al., 1995; Rücker & Wittmann, 1995; Boom et al., 1996; Pfefferkorn, 1996; Pfefferkorn & Türk, 1997.

Phaeophyscia ciliata hat hohe Ansprüche an die Feuchte, sie bevorzugt niederschlagsreiche Lagen von der montanen bis hochmontanen Stufe, wo sie auf Laubbäumen wächst. Gelegentlich wächst sie im Kronentrauf von Bäumen auch auf Holzzäunen. Ihr Vorkommen beschränkt sich in Österreich auf den Alpenraum.

PHAEOPHYSCIA CONSTIPATA (Norrl. & Nyl.) Moberg (Abb. 9)

Literatur: Türk & Poelt, 1993; Hofmann et al., 1995.

Phaeophyscia constipata ist eine der wenigen bodenbewohnenden Vertreter ihrer Gattung. Sie wächst auf sehr flachgründigen Kalk- und Dolomitböden, zumeist über Felsen, mit Moosen vergesellschaftet. Ihre Wuchsorte zeichnen sich durch einen hohen Strahlungsgenuß aus, weshalb sie in Österreich die regenarmen, inneralpinen Täler in hochmontanen Lagen bevorzugt. Lediglich in den Nördlichen Kalkalpen kommt sie auch in niederschlagsreicheren Regionen vor (Schober bei Thalgau, in 1300 msm). Sie gehört zu den Seltenheiten der heimischen Flechtenflora.

PHAEOPHYSCIA ENDOCOCCINA (Körb.) Moberg, incl. var. LITHOTODES Nyl. (Abb. 10)

Literatur: Türk & Poelt, 1993; Obermayer, 1993; Pils & Berger, 1995; Hofmann et al., 1995; Berger, 1996.

Diese Flechte siedelt bevorzugt auf nicht zu sauren, silikatischen Gesteinen. Hinsichtlich ihres Feuchtebedürfnisses scheint sie eine sehr weite ökologische Potenz zu haben: sie wächst in der amphibischen Zone klarerBäche, auf zeitweise überrieselten, stark geneigten Felsflächen oder auf überhängenden Felsflächen ohne jede Zufuhr von tropfbar flüssigem Wasser. Auch auf Moosen ist sie anzutreffen. In Österreich ist ihr Hauptverbreitungsgebiet in den Alpen, wo sie von der montanen bis in die alpine Stufe vorkommt. Außerhalb der Alpen ist sie sehr selten.

PHAEOPHYSCIA ENDOPHOENICEA (Harm.) Moberg (Abb. 11)

Literatur: Türk & Poelt, 1993; Hofmann, 1993; 1996; Neuwirth & Türk, 1993; Obermayer, 1993; Pfefferkorn & Türk, 1993; Berger & Türk, 1994; 1995; Hafellner & Maurer, 1994; Türk & Breuss, 1994; Türk et al., 1994; Rücker & Wittmann, 1995; Baumgartner & Türk, 1996; Boom et al., 1996; Hafellner et al., 1996; Pfefferkorn 1996.

Phaeophyscia endophoenicea sucht von vornherein feuchtere Habitate auf, die durch hohe Niederschläge oder große Nebelhäufigkeit ausgezeichnet sind. Zumeist wächst sie zwischen Moosen, was für ihre Wasserversorgung günstig ist. In Österreich kommt sie von der kollinenbis zur hochmontanen (höchster Fundpunkt in 1600 Meter) Stufe vor, sie meidet kalte Regionen, weshalb sie im Gebiet der Böhmischen Masse (Mühl und Waldviertel) nur an wärmebegünstigten Wuchsorten gedeiht.

PHAEOPHYSCIA HIRSUTA (Mereschk.) Essl. (Abb. 12)

Literatur: Türk & Poelt, 1993; Hofmann, 1993; Türk & Breuss, 1994; Boom et al., 1996.

Phaeophyscia hirsuta ist hauptsächlich südeuropäisch verbreitet, lediglich an warmen Standorten dringt sie bis in das südliche Mitteleuropa vor. Sie wächst auf der subneutralen bis schwach sauren Borke von Laubbäumen, die gelegentlich auch leicht eutrophiert sein kann und auf Gestein. Die Zentralalpen Österreichs meidet sie.

PHAEOPHYSCIA HISPIDULA (Ach.) Ess.(Abb. 13)
Literatur: Türk & Poelt, 1993; Berger, 1996; Hafellner, 1997.
Sie gehört zu den absoluten Seltenheiten der heimischen Flechtenflora. Diese offensichtlich tropisch-ozeanische Flechte kommt in den Bergwäldern des Mittelmeergebietes zerstreut vor (Poelt, 1969) und dringt nur an sehr trockenen, niederschlagsarmen Standorten in die Alpen vor. Außerhalb der Alpen wurde sie im Donautal aufgefunden.

PHAEOPHYSCIA INSIGNIS (Mereschk.) Moberg (Abb. 14)
Literatur: Türk & Poelt, 1993; Hafellner, 1997.
Die *Phaeophyscia orbicularis* sehr nahe stehende Sippe mit ihrem Verbreitungsschwerpunkt in Südeuropa ist in Österreich großteils auf wärmeexponiertere, colline bis montane Lagen beschränkt. Vereinzelt dringt sie auch bis in die montane Stufe vor. Phaeophyscia insignis siedelt zumeist an Allebäumen, geht aber auch auf (kalkstaubimprägnierte) Moose über.

PHAEOPHYSCIA KAIRAMOI (Vain.) Moberg (Abb. 15)
Literatur: Türk & Poelt, 1993; Hofmann, 1993; Hofmann et al., 1995.
Phaeophyscia kairamoi wächst sowohl epiphytisch auf Laubbäumen als auch auf bemoosten Kalkfelsen. Sie kommt von der montanen bis in die alpine Stufe vor. Hinsichtlich der Feuchteanprüche dürfte sie eine sehr weite Amplitude besitzen. In Österreich ist ihr Vorkommen auf die Alpen beschränkt.

PHAEOPHYSCIA LABRATA (Mereschk.) ined., syn.: *Physcia labrata* Mereschk. (Abb. 16)
Literatur: Türk & Poelt, 1993; Baumgartner & Türk, 1996.
Phaeophyscia labrata wächst auf der Borke von alten Laubbäumen in Bergwäldern. Ihre hohen Ansprüche auf Feuchtigkeit beschränkt ihr Vorkommen auf ozeanische Lagen (vgl. Schauer, 1965) in der montanen bis hochmontanen Stufe. Sie fehlt nördlich der Donau und in den kontinental geprägten östlichen Landschaften Österreichs.

PHAEOPHYSCIA NADVORNIKII (Frey & Poelt) N. S. Golubkova, syn.: *Physcia n.* Frey & Poelt (Abb. 17)
Literatur: Türk & Poelt, 1993; Türk, 1996.
Sie ist in Österreich sehr selten. Sie wächst auf Borke am Stamm und an Seitenästen von alten Laub- und Nadelbäumen sowie auf Felsen in sehr feuchten Lagen der montanen bis hochmontanen Stufe. Im Spritzbereich von Wasserfällen kann sie Massenbestände bilden (vgl. Schauer, 1965)

PHAEOPHYSCIA NIGRICANS (Flörke) Moberg (Abb. 18)
Literatur: Türk & Poelt, 1993; Hafellner, 1993; Obermayer, 1993; Hafellner & Maurer, 1994; Türk & Breuss, 1994; Türk et al., 1994; Berger & Türk, 1995; Boom et al., 1996.
Sie kommt in Österreich von der kollinen bis in die hochmontane Stufe (1600 msm) vor. Sie wächst auf eutrophierten, zumeist kalkhaltigen Gesteinsoberflächen, auf Mörtel, Beton und auchauf staubimprägnierten Baumborken am Stammgrund, wo sie leicht zu übersehen ist. Sie bevorzugt etwas trockenere, wärmegetönte Lagen. Im Voralpenland und in den Mittelgebirgen des Mühl- und Waldviertels tritt sie häufiger auf, in den Alpen ist sie selten.

PHAEOPHYSCIA ORBICULARIS (Neck.) Moberg, syn.: *Physcia virella* (Ach.) Flagey (Abb. 19)
Literatur: Türk & Poelt, 1993; Hofmann, 1993; 1994; Neuwirth & Türk, 1993; Obermayer, 1993; Pfefferkorn & Türk, 1993; Hafellner & Maurer, 1994; Türk & Breuss, 1994; Türk et al., 1994; Berger & Türk, 1995; Hofmann et al., 1995; Rücker & Wittmann, 1995; Baumgartner & Türk, 1996; Berger, 1996; Boom et al., 1996; Hafellner et al., 1996; Hafellner & Wittmann, 1996; Pfefferkorn, 1996; Türk, 1996.
Phaeophyscia orbicularis ist der häufigst auftretende Vertreter ihrer Gattung. Sie besiedelt alle möglichen Substrate, so sie genügend eutrophiert sind, seien es nun Baumborken oder Gesteinsoberflächen. Auf anthropogenen Substraten kann sie Massenbestände bilden, in Gebieten mit hohem Grad an Lufverunreinigungen ist sie oftmals der einzige Vertreter der Blattflechten. Sie kommt von der kollinen bis in die alpine Stufe vor, wo sie an gut gedüngten Plätzen über Pflanzenresten und auf Gesteinssubstraten wächst. Die leeren Grundfelder lassen vermuten, daß sie dort

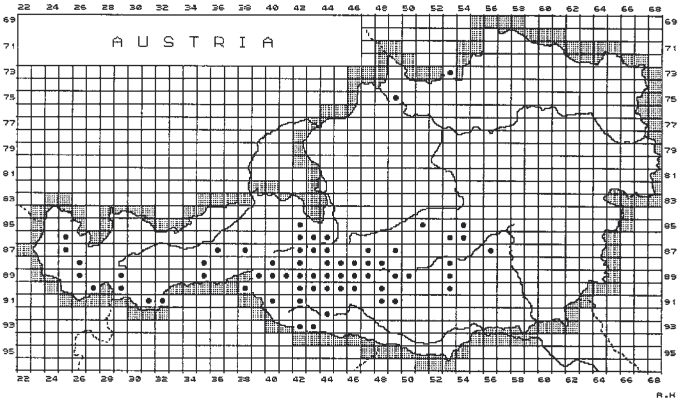


Abb. 10. Bisher bekannte Verbreitung von *Phaeophyscia endococcina* in Österreich.

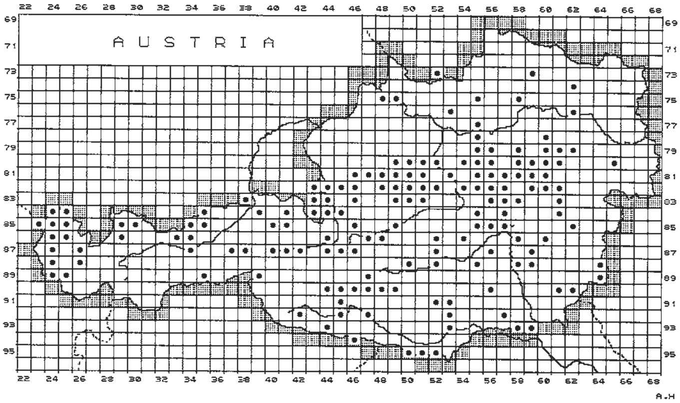


Abb. 11. Bisher bekannte Verbreitung von *Phaeophyscia endophoenicea* in Österreich.

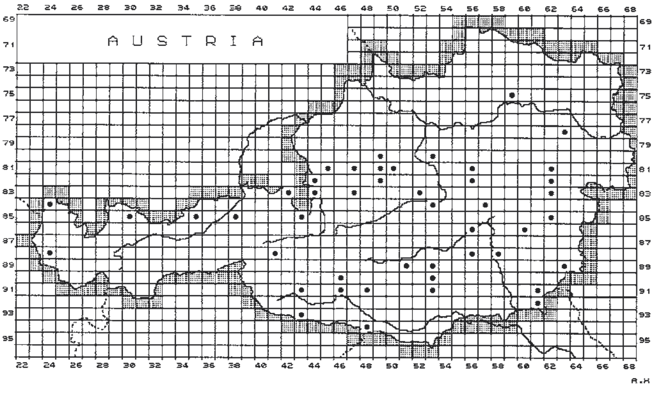


Abb. 12. Bisher bekannte Verbreitung von *Phaeophyscia hirsuta* in Österreich.

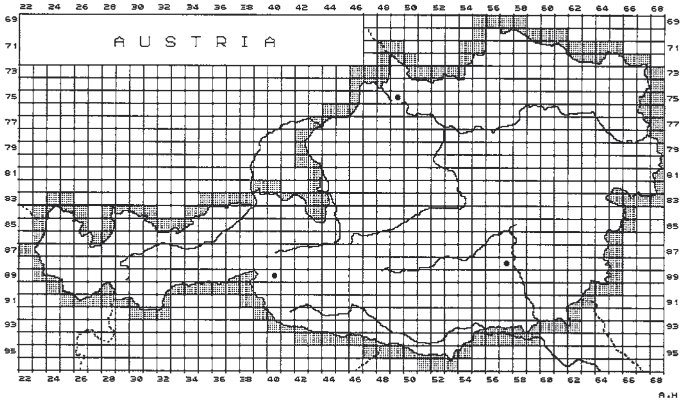


Abb. 13. Bisher bekannte Verbreitung von *Phaeophyscia hispidula* in Österreich.

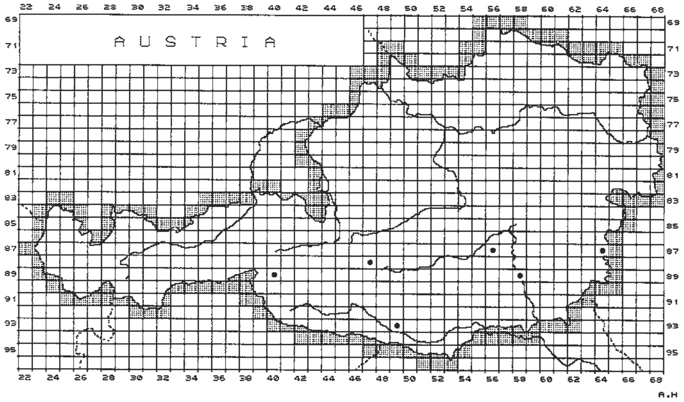


Abb. 14. Bisher bekannte Verbreitung von *Phaeophyscia insignis* in Österreich.

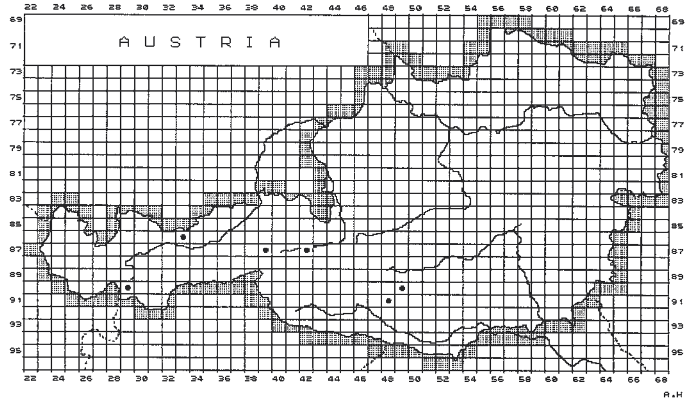


Abb. 15. Bisher bekannte Verbreitung von *Phaeophyscia kairamoi* in Österreich.

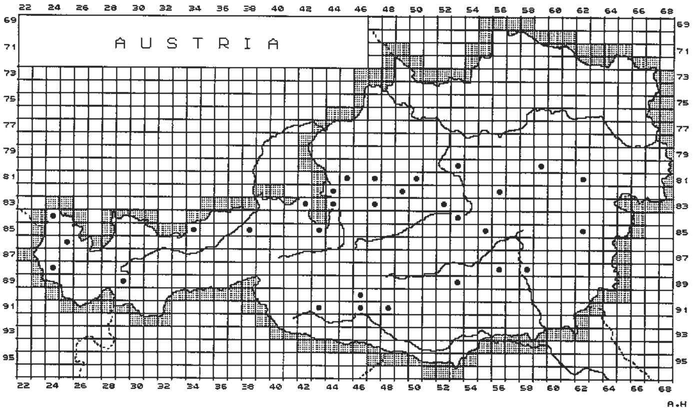


Abb. 16. Bisher bekannte Verbreitung von *Phaeophyscia labrata* in Österreich.

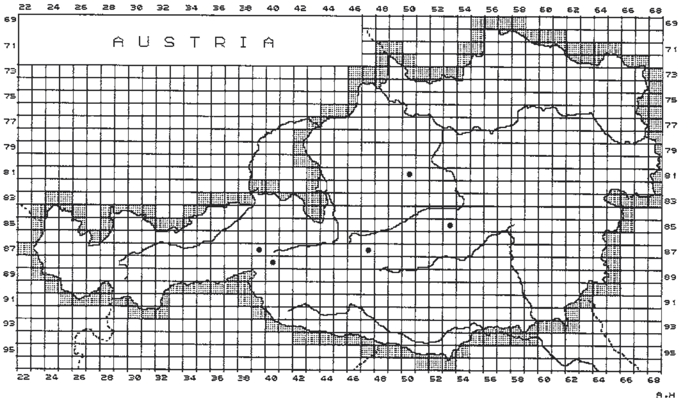


Abb. 17. Bisher bekannte Verbreitung von *Phaeophyscia nadvornikii* in Österreich.

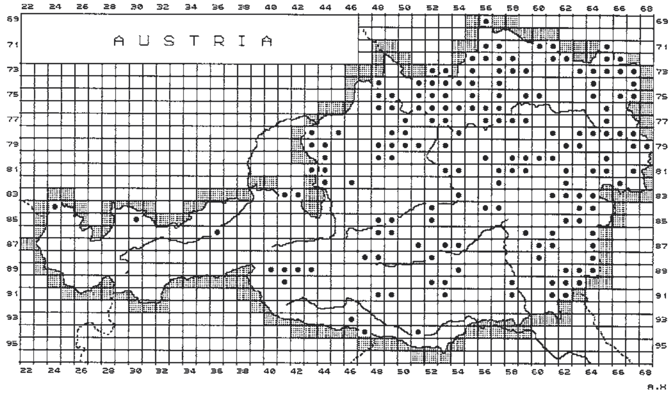


Abb. 18. Bisher bekannte Verbreitung von *Phaeophyscia nigricans* in Österreich.

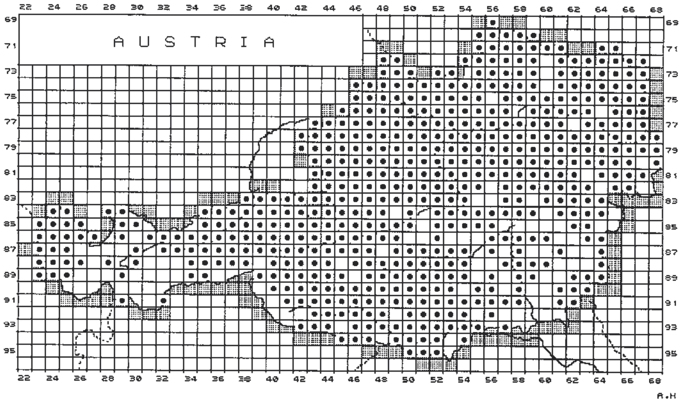


Abb. 19. Bisher bekannte Verbreitung von *Phaeophyscia orbicularis* in Österreich.

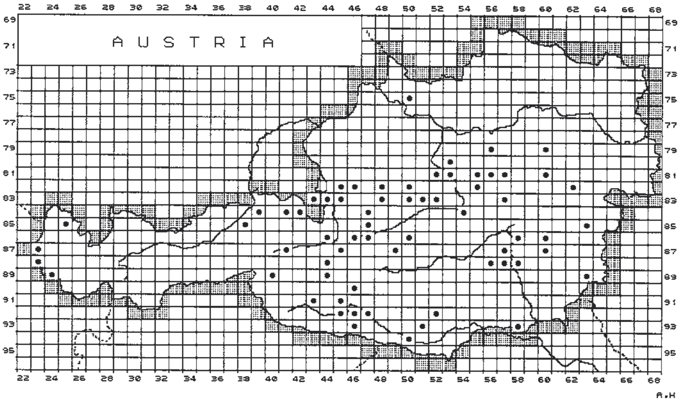


Abb. 20. Bisher bekannte Verbreitung von *Phaeophyscia pusilloides* in Österreich.

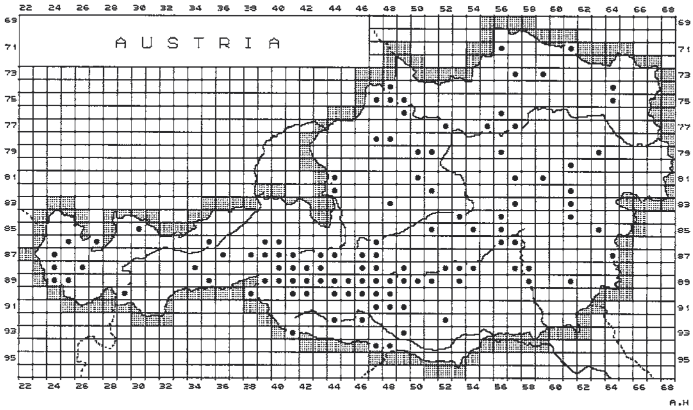


Abb. 21. Bisher bekannte Verbreitung von *Phaeophyscia sciastra* in Österreich.

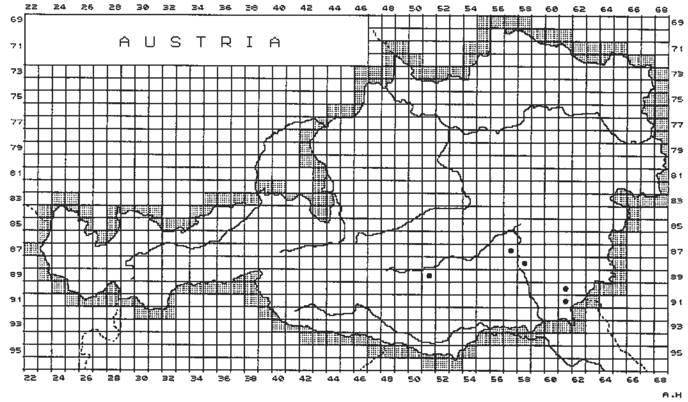


Abb. 22. Bisher bekannte Verbreitung von *Phaeophyscia stiriaca* in Österreich.

übersehen oder bisher noch nicht registriert wurde.

Phaeophyscia pusilloides (Zahlbr.) Essl. (Abb. 20)
Literatur: Türk & Poelt, 1993; Hofmann, 1993; Boom et al., 1996; Pfefferkorn, 1996; Pfefferkorn & Türk, 1997; Hafellner, 1997.
Phaeophyscia pusilloides ist eine typische Flechte alter, weitgehend naturnaher Waldbestände mit dem entsprechenden Bestandesklima in ozeanischg getönten Lagen. Zur Hauptsache ist sie in den Alpen von der montanen bis zur hochmontanen Stufe verbreitet, wo sie die Borke von Laubbäumen (*Acer pseudoplatanus*, *Fagus sylvatica*, *Fraxinus excelsior*, *Alnus incana*, *Salix* sp. etc.) besiedelt. Außerhalb der Alpen ist sie äußerst selten.

Phaeophyscia sciastra (Ach.) Moberg (Abb. 21)
Literatur: Türk & Poelt, 1993; Obermayer, 1993; Hafellner & Maurer, 1994; Türk & Breuss, 1994; Hafellner & Türk, 1995; Hofmann et al., 1995; Berger, 1996; Hafellner et al., 1996.
Phaeophyscia sciastra besiedelt eutrophierte Substrate wie Gesteinsoberflächen (Kalk und basiche Silikate), Holzschindeln, Dächer und Holzzäune. Äußerst selten tritt sie epiphytisch am staubimprägnierten Stammgrund von Laubbäumen auf. Im Gebirge wächst sie in höheren Lagen gern über gesteins- und holzbewohnenden Moosen. Diese morphologisch sehr variable Art kann leicht übersehen werden. Ein geschlossenes Verbreitungsgebiet in Österreich weist sie im Alpenraum auf, im übrigen Österreich tritt sie zerstreut auf.

Phaeophyscia stiriaca (Poelt) Clauzade & Roux (Abb. 22)
Literatur: Türk & Poelt, 1993.
Diese Flechte ist submediterran und mediterran verbreitet, an einigen wenigen Stellen dringt sie in die Steiermark vor. Sie wächst auf Boden, Gestein und über bodenbewohnenden Moosen.

DANK

Wir danken Herrn Professor Dr Josef Hafellner (Graz) für das Bereitstellen von Funddaten und Hinweise auf Literatur.

LITERATUR

Baumgartner, R. & Türk, R. 1996. Verbreitungsmuster epiphytischer Flechten im nördlichen Flachgau in bezug zur Hemerobie. *MGSL* 136: 329–366.

Berger, F. 1996. Neue und seltene Flechten und lichenicole Pilze aus Oberösterreich, Österreich II. *Herzogia* 12: 45–84.

Berger, F. & Türk, R. 1994. Zur Kenntnis der Flechten und flechtenbewohnenden Pilze von Oberösterreich und Salzburg IV. *Beitr. Naturk. Oberösterreichs.* 2: 161–173.

Berger, F. & Türk, R. 1995. Die Flechtenflora im unteren Rannatal. *Beitr. Naturk. Oberösterreichs* 3: 147–216.

Boom, v. d. .P. G., Breuss, O., Spier, L. & Brand, A. M. 1996. Beitrag zur Flechtenflora Kärntens (Ergebnisse der Feldtagung der Bryologischen und Lichenologischen Arbeitsgruppe der KNNV in Weißbriach 1994). *Linzer biol. Beitr.* 2: 619–654.

Geyer, M. 1985. *Hochdruck-Flüssigkeits-Chromato-graphie (HPLC) von Flechten-Sekundärstoffen.* Inauguraldissertation Universität Essen, 233 pp.

Hafellner, J. 1993. Seltene Flechten der Steiermark. *Mitt. naturwiss. Ver. Steiermark.* 123: 167–182.

Hafellner, J. 1997. Materialien zur Roten Liste gefährdeter Flechten Österreichs. *Fritschiana* 12: 3–31.

Hafellner, J. &. Maurer W. 1994. Weitere Flechtenfunde im südlichen Burgenland (Österreich). *Mitt. naturwiss. Ver. Steiermark* 124: 113–134.

Hafellner, J. &Türk, R. 1995. Über Funde lichenicoler Pilze und Flechten im Nationalpark Hohe Tauern (Kärntner Anteil, Österreich). *Carinthia* II 185/ 105: 599–635.

Hafellner, J. & Wittmann, H. 1996. *IAL3. Excursion 2: Alpine lichens of the central part of the Eastern Alps.* Excursion guide. Graz. 24 pp.

Hafellner, J., Türk, R. & Breuss, O. 1996. Zur Flechtenflora des Wechsel (Österreich). *Österr. Z. Pilzk.* 5: 211–231.

Hofmann, P. 1993. Die epiphytische Flechtenflora und -vegetation des östlichen Nordtirol unter Berücksichtigung immissionsökologischer Gesichtspunkte. *Bibl. Lichenol.* 51: 1–297.

Hofmann, P. 1994. Pollutant-related mapping of lichens in the area of Achenkirch. *Phyton* (Horn, Austria) *Special issue: „Achenkirch I“*, 34: 71–84.

Hofmann, P., Wittmann, H., Obermayer, W., Hafellner, J. & Poelt, J. 1995. Lichenologische Ergebnisse der BLAM-Exkursion 1991 ins Oberinntal (Nordtirol, Österreich). *Herzogia* 11: 225–237.

Moberg, R. 1977. The lichen genus *Physcia* and allied genera in Fennoscandia. *Symb. Bot. Ups.* 22:1.

Neuwirth. G. & Türk, R. 1993: Epiphytische Flechtengesellschaften im Innviertel (Oberösterreich). *Beitr. Naturk. Oberösterreichs* 1: 47–147.

Obermayer, W. 1993. Die Flechten der Seetaler Alpen (Steiermark, Österreich). *Mitt. naturwiss. Ver. Steiermark* 123: 91–166.

Obermayer, W. 1996. Lichenotheca Graecensis Fasc. 3 (Nos 41–60). *Fritschiana* 6: 1–8.

Pfefferkorn, V. 1996. Epiphytische Flechtenvereine in Vorarlberg (Österreich) unter besonderer Berücksichtigung der Hemerobie von Waldökosystemen. *Vorarlberger Naturschau* 1: 9–152.

Pfefferkorn, V. & Türk, R. 1993. Immissionsökologische Flechtenkartierung an vier Transekten im nördlichen Vorarlberg (Österreich). *Montfort* 45: 147–161.

Pfefferkorn, V. & Türk, R. 1997. Rote Liste der im Bundesland Vorarlberg aktuell gefährdeten Flechtenarten. *Vorarlberger Naturschau* 3: 217–229.

Pils, G. & Berger, H. 1995. Das Waldaisttal im Spiegel seiner Pflanzenwelt. In *Volksschule Reichenstein. Festschrift anläßlich der Eröffnungs- und Einweihungsfeier* (Hrsg. F. Mayr). 89–97.

Poelt, J. 1969. *Bestimmungsschlüssel europäischer Flechten.* Cramer, Lehre. 757 S.

Poelt, J. & Vêzda, A. 1977. *Bestimmungsschlüssel europäischer Flechten.* Ergänzungsheft I. Cramer, Vaduz. 258 S.

Rücker, Th. & Wittmann, H. 1995. Mykologisch-lichenologische Untersuchungen im Naturwaldreservat Kesselfall (Salzburg, Österreich) als Diskussionsbeitrag für Kryptogamenschutzkonzepte in Waldökosystemen. *Beih. Sydowia* 10: 168–191.

Schauer, Th. 1963. Einige Flechtenfunde aus den Alpen Bayerns. *Ber. Bayer. Bot. Ges.* 36.: 57–59.

Türk, R. 1996. Die Flechtenflora im Bereich der Krimmler Wasserfälle. *Wissenschaftliche Mitteilungen aus dem Nationalpark Hohe Tauern* 2: 18–30.

Türk, R. & Breuss, O. 1994. Flechten aus Niederösterreich I. – Steirisch-niederösterreichische Kalkalpen. *Verh. Zool.-Bot. Ges. Österreich* 131: 79–96.

Türk, R. &.Poelt, J. 1993. Bibliographie der Flechten und flechtenbewohnenden Pilze in Österreich. *Biosystematics and Ecology* 3: 1–168.

Türk, R., Wittmann, H., Roth, S. & Wögerer, I. 1994. Die Luftqualität im Stadtgebiet von Linz – Untersuchungen über den epiphytischen Flechtenbewuchs im Bezug zur Schadstoffbelastung. *Jahrb. Stadt Linz* 37–39: 457–490.

Folia Cryptog. Estonica, Fasc. 32: 149–152 (1998)

Biogeographical data on the lichen flora of Finland

Orvo Vitikainen
Botanical Museum (Mycology), P.O. Box 47, FIN-00014 University of Helsinki, Finland

Abstract: From data of the checklist of lichens and allied fungi of Finland, comprising 1624 taxa (1422 species of lichens, 120 species lichenicolous and 44 species allied non-lichenized fungi), examples of regional species richness and some other statistical values are presented on the basis of their occurrence in the traditional 21 biogeographical provinces. Ca. 10% of the taxa have been recorded in all provinces, but 22.6% are recorded only in one. Some 15.6% of the accepted taxa have their nomenclatural type from Finland.

Kokkuvõte: O. Vitikainen. Biogeograafilised andmed Soome lihhenofloora kohta.

Soome samblike ja neile lähedaste seente nimekirja põhjal , mis sisaldab 1624 taksonit (1422 liiki samblikke, 120 liiki parasümbiontseid seeni ning 44 liiki mittelihheniseerunud seeni), esitatakse näiteid regionaalsest liigirikkusest ning teisi statistilisi andmeid, mis põhinevad samblike levikul Soome 21 traditsioonilises biogeograafilises provintsis. Umbes 10% taksonitest on teada kõigist provintsidest, kuid 22.6% esinevad ainult ühes. 15.6%-l tunnustatud taksonitest pärineb nende nomenklatuurne tüüpmaterjal Soomest.

INTRODUCTION

One and a half century of lichen floristics in Finland has accumulated much information, both records in literature and materials in herbaria (see overview by Vitikainen, 1996). The spatial and temporal continuum of these studies, however, is rather tenuous when compared to the situation in countries such as Sweden and England. The lack of a national checklist of lichens of Finland for over one hundred years is one example of evident deficiencies. Even the recent checklist (Vitikainen et al., 1997) should rather be regarded as a stimulus for additional studies than a presentation of well-revised data. However, the information compiled for the list may be used for evaluating some aspects of the lichen flora and the status of its investigation, even if this treatment is not comparable in accuracy with the information on vascular plant flora of Finland given by Lahti and al. (1988), nor does it attempt to analyze the flora elements in the same degree as Trass (1970), for example.

RESULTS AND DISCUSSION

The Finnish checklist contains 1 624 "accepted" taxa, of which 1 458 are considered lichenized, comprising 1422 species as well as additional 15 subspecies and 21 varieties, and 166 either lichenicolous (120 species and 2 varieties) or allied (44 species) fungi, both latter categories being very poorly studied in Finland. In comparison, the checklist of the lichens of Sweden and Norway (Santesson, 1993) recognizes 2271 accepted species, and in the checklist of Great Britain and Ireland (Purvis et al., 1993) 1660 species with 61 additional infraspecific taxa are accepted. 395 of the lichenized species and 9 subspecies plus 11 varieties of the Finnish checklist are so called macrolichens. In comparison, in the recent macrolichen flora of Estonia 332 species are recognized (Trass & Randlane, 1994), but this area is much smaller and less variable geographically.

These Finnish figures, even if indicated as "accepted", still comprise several imperfectly known or critical taxa, many of which have been described from Finnish materials but not subjected to investigation by modern methods, and considerable changes and amendments of the list are anticipated with progressing taxonomical studies and checking of herbarium materials. For example, there was an increase of 261 species in ten years in the Swedish and Norwegian checklist, and almost one hundred species were added in 13 years to the list of the British Isles (see Santesson, 1993; Purvis et al., 1993).

Numbers of taxa in the biogeographical provinces

The numbers of taxa recorded in the 21 biogeographic provinces of Finland (Fig. 1) are presented in Table 1. It should be noted that a low number of provincial records, especially when compared with neighbouring provinces, often indicates less intensive research activity and not actual adverse conditions for lichen growth.

The provinces South Häme, Varsinais-Suomi and Uusimaa, with the highest numbers of recorded species – close or over 50 % of the total – are well-known as centres of activity since the early periods of lichen floristics in Finland; in addition, these areas also provide a richer range of habitats than the adjacent provinces.

The lowest figure, 193 recorded species for Ladoga Karelia, is explained by the situation that this area is only represented by a small and poorly studied corner of the traditional province, the main part belonging now to Russia. Other areas of less intensive recording than the average, e.g. South Karelia, South Savo, Middle and Oulu Ostrobothnia, Kittilä and Sompio Lapland, with ca. 400 species at most, include wide areas of rather monotonous and uniform oligotrophic boreal forest vegetation and nature with little geological variation and influence of cultivation but additional research will certainly increase the number of species. If the anomalous Ladoga Karelia is omitted, 574 taxa are present in each province on average, i.e the provinces Åland and North Savo represent the average number of taxa.

Patterns of species distribution

Finland, with its length of over 1 100 km from south to north, provides a gradient of several boreal vegetation zones, ranging from the hemiboreal zone in the three southernmost provinces to hemiarctic areas prevailing in Lapland. Some general observations of the species ranges along this transection can be made, though the limitations of the material should be remembered.

Not less than 24.5 % of the taxa are recorded only in one province, and even 11.8 % of the

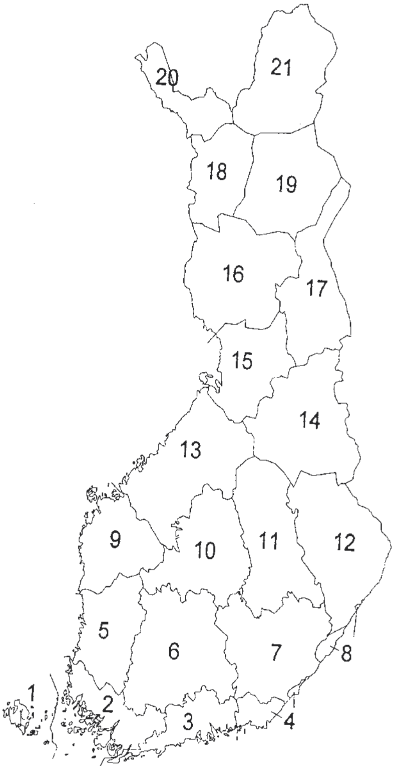


Fig. 1. The biogeographical provinces of Finland, their Finnish acronyms and names with their English equivalents used in the text.

1	A	Ahvenanmaa	Åland
2	V	Varsinais-Suomi	
3	U	Uusimaa	
4	EK	Etelä-Karjala	South Karelia
5	St	Satakunta	
6	EH	Etelä-Häme	South Häme
7	ES	Etelä-Savo	South Savo
8	LK	Laatokan Karjala	Ladoga Karelia
9	EP	Etelä-Pohjanmaa	South Ostrobothnia
10	PH	Pohjois-Häme	North Häme
11	PS	Pohjois-Savo	North Savo
12	PK	Pohjois-Karjala	North Karelia
13	PK	Keski-Pohjanmaa	Middle Ostrobothnia
14	Kn	Kainuu	
15	OP	Oulun Pohjanmaa	Oulu Ostrobothnia
16	PeP	Perä-Pohjanmaa	Outer Ostrobothnia
17	Ks	Koillismaa	
18	KiL	Kittilän Lappi	Kittilä Lapland
19	SoL	Sompion Lappi	Sompio Lapland
20	EnL	Enontekiön Lappi	Enontekiö Lapland
21	InL	Inarin Lappi	Inari Lapland

species are recorded in two provinces only. Only some 6.7 % of the total number of species have been recorded in all provinces, even if not in the same degree of abundance or frequency throughout the range. Such species include *Arctoparmelia centrifuga, Cetraria sepincola, Cladina arbuscula, C. stellaris, Evernia prunastri, Hypogymnia physodes, Parmelia saxatilis* and *Peltigera aphthosa*, among others. With exclusion of Ladoga Karelia the percentage of such widely occurring species is still close to 10 %. This relatively low figure is understandable bearing in mind those underexplored provinces discussed above.

Table 1. The numbers of taxa (A) in the biogeographical provinces of Finland, their percentage of the total (B), and percentage of taxa recorded in only one province (C)

Province		A	B %	C %
1	A	577	35.6	2.3
2	V	869	53.6	7.0
3	U	788	48.6	2.9
4	EK	385	23.8	–
5	St	599	37.0	1.0
6	EH	907	56.0	9.2
7	ES	492	30.4	0.6
8	LK	193	11.9	–
9	EP	460	28.4	0.2
10	PH	525	32.4	0.8
11	PS	571	35.2	1.8
12	PK	592	36.5	2.2
13	KP	405	25.0	0.3
14	Kn	533	32.9	1.9
15	OP	389	24.0	0.5
16	PeP	625	38.6	2.9
17	Ks	692	42.7	4.3
18	KiL	424	26.2	2.6
19	SoL	371	22.9	0.8
20	EnL	630	38.9	10.5
21	InL	638	39.4	6.3

Southern and western elements

Some 9 % of the total number of taxa are recorded only in the area comprising the three southwesternmost provinces Åland, Varsinais-Suomi and Uusimaa; for vascular plants the corresponding percentage is 15 (see Lahti et al., 1988). Species recorded in all of these three provinces include *Acrocordia gemmata, Caloplaca microthallina, Cladina ciliata, C. portentosa, Cladonia foliacea* and *Physcia leptalea*, for instance. South Karelia provides only five additional taxa to this "southern" or southwestern element.

A few marine species have their area extended along the coastal provinces of Gulf of Bothnia until Satakunta *(Ramalina siliquosa)* and South Ostrobothnia (so e.g. *Anaptychia ciliaris* var. *melanosticta and Physcia tenella* var. *marina)* or even to Outer Ostrobothnia like *Caloplaca scopularis*. A western pattern is represented also by *Cladonia strepsilis, Lecanora intumescens, Ramalina baltica* and *R. subfarinacea*, but these species extend their ranges farther off inland.

The reverse, an eastern distribution pattern is less obvious but may be seen in the ranges of e.g. *Hypocenomyce anthracophila, Menegazzia terebrata* and *Tuckermannopsis ciliaris*.

A major decrease in the number of "southern" species takes place in the inland province South Häme with its great number of "endemics", so that 18 % of the total number of taxa have not been recorded north of this province. A notable decline of 5.1 % after Outer Ostrobothnia and of 7.7 % after Koillismaa, with additional decrease in Kittilä and Sompio Lapland, results in that ca. 50 % of the species have not been recorded in the northernmost provinces Enontekiö and Inari Lapland.

The province Åland (A) shares some 91 % of its taxa with Varsinais-Suomi (V), whereas some 39,4 % of the taxa present in V have not been recorded from A. This may partly be explained by the different size and digressing natural conditions of these areas but is more likely due to the less intense of study of Åland lichens, which is also seen in the lower figure of taxa recorded in this province and the relatively high number of taxa recorded in V only.

Comparison of the records of Åland – representing the hemiboreal zone – with some other areas shows that this province shares 63 % of its taxa with Koillismaa, in the northern boreal zone, and 50 % of its species are also found in Enontekiö Lapland or some 52.5 % in Inari

Lapland, these two northernmost provinces representing orohemiarctic and even oroarctic areas. 46 % of the species found in Varsinais-Suomi are shared with Inari Lapland, respectively; however, the number of species shared by Varsinais-Suomi and Inari Lapland is higher than in the case of Åland because of the higher number of species found in Varsinais-Suomi.

Northern pattern of range

As to the “northern” element, species only recorded in the two northernmost provinces Enontekiö and Inari Lapland comprise 8 % of the total (19 % for vascular plants, see Lahti *et al.*, 1988). For example, *Dactylina ramulosa, Lecanora frustulosa, Solorina bispora* and *S. octospora* are known only in Enontekiö Lapland, and *Siphula ceratites* only in Inari Lapland, whereas *Lobaria linita, Rhizoplaca chrysophthalma, R. melanophthalma* and *Stereocaulon spathuliferum* have been recorded in both. 14 % of the lichens of Finland have not been found south of Koillismaa (15 % of vascular plants!). The respective figure for Middle Ostrobothnia – in the middle boreal zone – is 18.2 %, for South Ostrobothnia 23 %, and 1/3 of the taxa have their total recorded range in or north of South Häme.

Who described the Finnish lichens?

An attempt was made in the checklist to indicate, if the nomenclatural type of a taxon was known to be from a Finnish province. At least 257 accepted taxa (15.6 %) and 284 additional synonymous names have their type from Finland, these listings certainly not being complete. The highest numbers of types emerge in those biogeographical provinces, where floristic activity on lichens has been intensive, and display the areas of research by taxonomists like William Nylander, Edvard Vainio and Veli Räsänen: South Häme leading with 174 described taxa, of which 104 are “accepted”, then Uusimaa (59 v. 24 taxa, respectively), Varsinais-Suomi (43 v. 17), Inari Lapland (38 v. 22), Outer Ostrobothnia (31 v. 9), Enontekiö Lapland (30 v. 15) and Koillismaa (29 v. 24).

Not surprisingly, E. Acharius stands as the describing author of some 200 accepted taxa, but the most proliferous author proves to be W. Nylander (some 260 taxa plus about ten taxa validated by others but credited to Nylander). Next comes E. Vainio with about 100 taxa, then C. von Linné, who has named the epithet of 92 taxa, and Th. Fries, with 55 taxa. These five Nordic authors have described 43.7 % of the lichens and allied fungi of Finland.

REFERENCES

Lahti, T., Kurtto, A. & Väisänen, R. A. 1988. Floristic composition and regional species richness of vascular plants in Finland. *Ann. Bot. Fenn.* 25: 281–291.

Purvis, O., Coppins, B. J. & James, P. W. 1993. Checklist of lichens of Great Britain and Ireland. *Bull. British Lichen Soc. (Suppl.)* 72: 1–75.

Santesson, R. *The lichens and lichenicolous fungi of Sweden and Norway.* SBT-förlaget, Lund. 240 pp.

Trass, H. 1970. The elements and development of the lichen-flora of Estonia (in Russian). *Pap. Bot.* 9: 5–233.

Trass, H. & Randlane, T. (eds.) 1994. *Eesti suursamblikud.* Tartu. 399 pp.

Vitikainen, O. 1996. Lichen floristics in Finland. *Mem. Soc. Fauna Fl. Fenn.* 72: 213–218.

Vitikainen, O., Ahti, T., Kuusinen, M., Lommi, S. & Ulvinen, T. 1997. Checklist of lichens and allied fungi of Finland. *Norrlinia* 6: 1–123.

Folia Cryptog. Estonica, Fasc. 32: 153–159 (1998)

Lichens and lichenicolous fungi from the north of Pyasino lake,Taimyr peninsula, Siberia

Mikhail Zhurbenko
Lab. Systematics & Geography of Fungi, Komarov Botanical Institute of the Russian Academy of Sciences,
2 Prof. Popov St., 197376 St.-Petersburg, Russia

Abstract: A total of 152 species of lichens and 16 species of lichenicolous fungi is reported from the area of southern tundras north of Pyasino Lake on the Taimyr Peninsula. *Bachmanniomyces uncialicola*, *Bispora christiansenii*, *Epicladonia sandstedei*, and *Taeniolella pertusariicola* are new to Russia; *Acarospora nitrophila*, *Lecanora chlarotera*, *Pilophorus dovrensis*, and *Protoparmelia picea* are new to the Russian Arctic; *Buellia epigaea*, *Dactylospora attendenda*, *Lecanora leptacina*, *Pertusaria carneopallida*, *Polyblastia fuscoargillacea*, *Sagediopsis campsteriana*, and *Taeniolella beschiana* are new to the north of Central Siberia; *Amygdalaria elegantior*, *A. panaeola*, *Bacidia herbarum*, *Lecania cyrtella*, *Rinodina archaea*, and *R. lecideoides* are new to Taimyr.

Kokkuvõte: Mihhail Zhurbenko. Põhja pool Pjasino järve (Taimõri ps., Siber) kasvavad samblikud ja parasümbiontsed seened.

Taimõri poolsaarel Pjasino järvest põhja pool paikneva lõunatundra liikide nimekiri sisaldab 152 samblikuliiki ja 16 parasümbiontset seeneliiki. *Bachmanniomyces uncialicola*, *Bispora christiansenii*, *Epicladonia sandstedei* ja*Taeniolella pertusariicola* on uued liigid Venemaa floristilises nimestikus; *Acarospora nitrophila*, *Lecanora chlarotera*, *Pilophorus dovrensis* ja *Protoparmelia picea* on uued liigid Vene Arktikas; *Buellia epigaea*, *Dactylospora attendenda*, *Lecanora leptacina*, *Pertusaria carneopallida*, *Polyblastia fuscoargillacea*, *Sagediopsis campsteriana* ja *Taeniolella beschiana* on uued liigid Kesk-Siberi põhjaosas; *Amygdalaria elegantior*, *A. panaeola*, *Bacidia herbarum*, *Lecania cyrtella*, *Rinodina archaea* ja *R. lecideoides* on uued liigid Taimõri poolsaarel.

INTRODUCTION

Although about 38 local lichen floras have been studied from the Taimyr Peninsula and neighbouring islands (Zhurbenko 1996), lichens of its southern tundras have been heretofore much neglected. Lichens of southern tundras of Taimyr have been specially treated only by T. Piin (1984). There is also some information about dominant lichens from southern tundras in a few geobotanical papers (Avramchik, 1937; Alexandrova, 1937; Matveeva & Zanokha, 1986; Pospelova, 1974; Tyulina, 1937; Vinogradova, 1937). The present paper is a further contribution to the lichen flora of the area. It is a pleasure to include it in a festschrift of Prof. Hans Trass, an outstanding representative of Estonian lichenology, who has contributed much to the knowledge of Taimyr lichens.

From 16 till 24 July 1983, the author collected lichens near the field research station "Belyi Yar" of the Norilsk Far North Agricultural Research Institute (70°05'N, 87°43'E). The study area is located between the northern extremity of Pyasino Lake, west of the mouth of the Pyasina River and Ladanakh and Polovinnoe Lakes (Fig. 1). It is part of the northern Siberian Lowland. The landscape is hilly plain with numerous lakes and moraine deposits, like low crests and boulder fields. Altitudes range from 30 to 150 m. The region is situated within the zone of continuous permafrost and is influenced by the continental Siberian climate (Atlas of the Arctic, 1985). Mean annual temperature is approximately -12°C with the lowest mean monthly temperature approximately -30°C in January and the highest, +12°C in July. The daily mean is above freezing from the beginning of June up to the middle of September. Annual precipitation is about 300-400 mm. The dominant vegetation is classified as southern or shrub tundra (Chernov & Matveeva, 1979) and is characterized by closed shrub vegetation in upland tundras. Here and there vegetation cover includes areas of forest tundras with *Larix sibirica* Ledeb., typical tundras, meadows, and bogs. Frequently dominating species are *Alnus fruticosa* Rupr., *Betula nana* L., *Salix lanata* L., *S. reptans* Rupr., S. *pulchra* Cham., *S. glauca* L., *Dryas octopetala* L., *Vaccinium uliginosum* L., *V. vitisidaea* L., *Cassiope tetragona* (L.) D. Don, *Ledum decumbens* (Ait.) Lodd. ex Steud.,

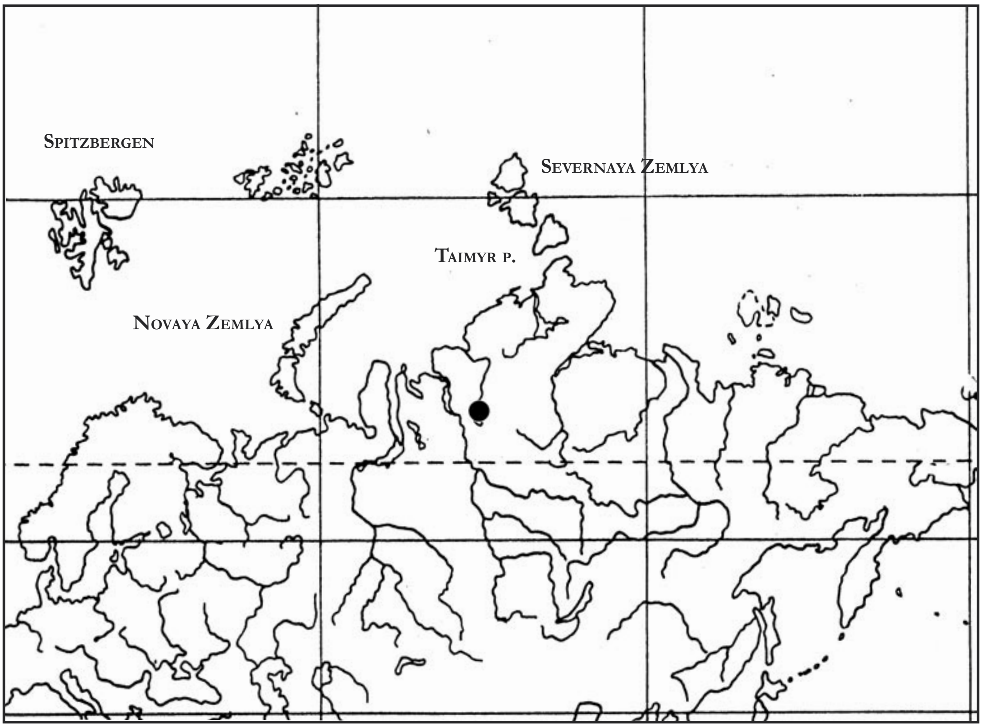


Fig. 1. Location of study area in Taimyr peninsula, Siberia.

Empetrum subholarcticum V. Vassil., *Salix polaris* Wahlenb., *Rubus chamaemorus* L., *Arctous alpina* (L.) Niedenzu, *Eriophorum vaginatum* L., *Hedysarum hedysaroides* (L.) Schinz & Thell. (Matveeva & Zanokha, 1986).

MATERIAL AND METHODS

Lichens were collected at 19 sample plots, representing the following nine habitat types (their numbers are cited in the list of taxa).

1 – exposed windswept areas of prominent convexities; spotty lichen-bryophyte-dwarf-shrub communities.
2 – slopes of terraces of Pyasino Lake in places with open boulder fields; shrubs (*Alnus fruticosa*, *Betula nana*), meadow tundras.
3 – slopes of moraine crests and lake terraces in places with boulder fields; lichen-bryophyte-dwarf-shrub communities.
4 – shore of Pyasino Lake; shrubs (*Alnus fruticosa*, *Betula nana*).
5 – plain and gentle slopes; tussock and spotty tundras.
6 – swampy plain with peat hillocks; lichen-dwarf-shrub-bryophyte communities.
7 – shores of lakes and streams with open sand and pebbles.
8 – lower slopes of lake depressions; willow shrubs.
9 – boulder beds on lower slopes of lake depressions.

Standard TLC methods were used for identification of some specimens of *Cladonia* and *Peltigera*. Voucher specimens are deposited in LE and H.

RESULTS AND DISCUSSION

The study resulted in a list of 152 species of lichens and 15 species of lichenicolous fungi which are representative for a typical local flora of southern tundras of Taimyr. All lichen species fall into wide-ranging circumpolar arctic-alpine, arcto-boreal, or boreal distributional categories.

The list is no doubt incomplete, for instance a nearby local flora from the vicinities of settlement Kresty Taimyrskie numbers 178 species just of epigaeic lichens (Piin, 1984).

Recently a few publications summarizing knowledge on lichens and lichenicolous fungi of the Russian Arctic have been published. Andreev et al. (1996) report 1069 species of lichens and nine species of lichenicolous fungi for the Russian Arctic as a whole. Zhurbenko & Santesson (1996) report 74 species of lichenicolous fungi for the Russian Arctic, and Zhurbenko (1996) reports 660 species of lichens and 61 species of lichenicolous fungi for the north of Central Siberia. To these lists we can now add 20 species. *Bachmanniomyces uncialicola*, *Bispora christiansenii*, *Epicladonia sandstedei*, and *Taeniolella pertusariicola* are new to Russia; *Acarospora nitrophila*, *Lecanora chlarotera*, *Pilophorus dovrensis*, and *Protoparmelia picea* are new to the Russian Arctic; *Buellia epigaea*, *Dactylospora attendenda*, *Lecanora leptacina*, *Pertusaria carneopallida*, *Polyblastia fuscoargillacea*, *Sagediopsis campsteriana*, and *Taeniolella beschiana* are new to the north of Central Siberia; *Amygdalaria elegantior*, *A. panaeola*, *Bacidia herbarum*, *Lecania cyrtella*, *Rinodina archaea*, and *R. lecideoides* are new to Taimyr. *Dactylospora purpurascens* is reported for the second time for Russia.

Annotated list of taxa

Annotations for the taxa include information on: substrate; incidental notes; habitat numbers, 1-9, in which the taxon occured; the number of different plots, at 19 sample plots, in which the taxon was noted (in parentheses). Lichenicolous fungi are marked with asterisks.

Acarospora nitrophila H. Magn. – on pebbles: 7 (1).

Alectoria nigricans (Ach.) Nyl. – over soil; common: 1, 2, 3 (4).

A. ochroleuca (Hoffm.) A. Massal. – over soil, also on driftwood; common: 1, 2, 3, 7 (6).

Amygdalaria elegantior (H. Magn.) Hertel & Brodo – on rock: 1 (1).

A. panaeola (Ach.) Hertel – on rock: 1 (1).

Arctocetraria nigricascens (Nyl.) Kärnefelt & A. Thell – on twigs of *Betula nana*: 4 (1).

Arctomia delicatula Th. Fr. – on bryophytes: 9 (1).

Asahinea chrysantha (Tuck.) W. L. Culb. & C. F. Culb. – on soil, also on rock: 1, 2, 3 (4).

*Bachmanniomyces uncialicola (Zopf) D. Hawksw. – on *Cladonia pyxidata* thallus: 5 (1).

Bacidia bagliettoana (A. Massal. & De Not.) Jatta – on decaying bark of *Salix glauca*: 7, 8 (2).

B. herbarum (Stizenb.) Arnold – on degenerating thallus of *Peltigera* sp.: 5 (1).

Baeomyces placophyllus Ach. – on soil: 1, 3 (2).

B. rufus (Huds.) Rebent. – on soil: 1, 2, 9 (4).

Biatora subduplex (Nyl.) Printzen – on bryophytes and plant remnants, on dead bark and naked lignum of *Salix glauca*; fairly common: 1, 3, 4, 7, 8, 9 (9).

*Bispora christiansenii D. Hawksw. – in apothecia of *Caloplaca* cf. *cerina*, and *Lecania cyrtella*: 4 (1). Conidia 0–1, septate, 5–10 × 5–6 μm.

Bryocaulon divergens (Ach.) Kärnefelt – over soil; common: 1, 2, 3, 6 (6).

Bryonora castanea (Hepp) Poelt – on bryophytes, soil and plant remnants; : 3, 9 (3).

Bryoria nitidula (Th. Fr.) Brodo & D. Hawksw. – over soil: 1, 3 (3).

Buellia epigaea (Pers.) Tuck. – on bryophyte: 9 (1).

B. insignis (Hepp) Th. Fr. – on bryophyte: 9 (1).

Caloplaca ammiospila (Ach.) H. Olivier – on bryophytes and bare driftwood: 1, 7 (2).

C. cerina (Ehrh. ex Hedw.) Th. Fr. – on bryophytes and plant remnants, including degenerating thallus of *Peltigera* sp., on dead bark of *Alnus fruticosa*; common: 1, 3, 4, 9 (5).

C. jungermanniae (Vahl) Th. Fr. – on bryophytes with earth: 7 (1).

C. tetraspora (Nyl.) H. Olivier – on bryophytes and plant remnants, including degenerating squamules of *Cladonia pyxidata*; common: 3, 7, 9 (4).

C. tiroliensis Zahlbr. – on dead bark of *Alnus fruticosa*: 4 (1).

C. tornoënsis H. Magn. – on saxicolous bryophytes: 3, 9 (2). Some specimens are distinguished for there large spore size: 20–23 × 7-8 μm, septum – 1–2 μm.

Candelariella placodizans (Nyl.) H. Magn. – on sandy soil: 1, 3 (2).

C. vitellina (Hoffm.) Müll. Arg. – on bryophytes, naked driftwood and rocks: 1, 3, 7, 9 (4).

*Carbonea vitellinaria (Nyl.) Hertel – on *Candelariella* cf. *vitellina* thallus: 1 (1).

Catapyrenium cinereum (Pers.) Körb. – on bryophyte: 7 (1).

Cetraria aculeata (Schreb.) Fr. – on soil: 1, 7 (3).

C. inermis (Nyl.) Krog – on *Betula nana* twigs: 8 (1).

C. islandica (L.) Ach. – on soil; abundant throughout the region: 1, 2, 3, 5, 6, 7, 8 (11).

C. laevigata Rass. – on soil; very common: 1, 2, 3, 5, 7, 8 (9).

C. odontella (Ach.) Ach. – on soil; common: 1, 2, 3, 7 (4).

Cetrariella delisei (Schaer.) Kärnefelt & A. Thell – on soil; common and locally abundant in humid sites: 3, 7, 9 (3).

Cladina arbuscula (Wallr.) Hale & W. L. Culb. s. lat. – on soil; very common: 1, 2, 3, 6, 7 (7).

C. rangiferina (L.) Nyl. – on soil; common: 1, 2, 3, 6 (6).

C. stellaris (Opiz) Brodo – on soil: 1, 3 (2).

C. stygia (Fr.) Ahti – on soil: 3 (Zhurbenko 8311) (1); rev. T. Ahti, 1992.

Cladonia acuminata (Ach.) Norrl. – on degenerating bryophytes: 7, 9 (2).

C. alaskana A. Evans – on soil: 1 (Zhurbenko 835), 3, 7 (Zhurbenko 8316) (3); rev. T. Ahti, 1993 (H, LE). The species previously thought to be restricted to Beringia, occurs sporadically at Taimyr and extends eastwards up to the Polar Ural (Ahti & Zhurbenko, 1994).

C. amaurocraea (Flörke) Schaer. – on soil, also on driftwood; very common: 1, 2, 3, 6, 7 (7).

C. bacilliformis (Nyl.) Glück – on soil: 5, 6 (2).

C. borealis S. Stenroos – on soil: 9 (Zhurbenko 837) (1); rev. T. Ahti, 1992.

C. cariosa (Ach.) Spreng. – on soil: 7 (1).

C. cervicornis (Ach.) Flot. ssp. verticillata (Hoffm.) Ahti – on soil: 1, 3 (Zhurbenko 8317) (2); rev. T. Ahti, 1992.

C. chlorophaea (Flörke ex Sommerf.) Spreng. – on rotting lignum of *Alnus fruticosa*: 5 (Zhurbenko 831) (1); rev. T. Ahti, 1992.

C. coccifera (L.) Willd. s. lat. – on soil; common: 1, 2, 3, 6, 9 (8).

C. cornuta (L.) Hoffm. – on soil and driftwood: 1, 7 (2).

C. cyanipes (Sommerf.) Nyl. – on soil: 5 (Zhurbenko 8313) (1); rev. T. Ahti 1992.

C. cf. ecmocyna Leight. – on soil: 1 (1).

C. fimbriata (L.) Fr. – on soil: 7 (Zhurbenko 832) (1); rev. T. Ahti, 1992.

C. gracilis ssp. elongata (Wulfen) Vain. – on soil: 3 (Zhurbenko 8315) (1); rev. T. Ahti, 1992. Common, but formerly misunderstood by the author.

C. macroceras (Delise) Hav. – on soil: 7 (Zhurbenko 8312), 8 (Zhurbenko 8310) (2); rev. T. Ahti, 1992. common, but formerly misunderstood by the author.

C. macrophylla (Schaer.) Stenh. – on sandy soil with silt: 9 (1).

C. pleurota (Flörke) Schaer. – on soil: 6 (1).

C. pocillum (Ach.) Grognot – on soil; very common: 1, 2, 3, 5, 7, 8, 9 (10).

C. pyxidata (L.) Hoffm. – on soil and bryophytes; very common: 1, 2, 3, 4, 5, 7, 8, 9 (11).

C. squamosa Hoffm. – on soil: 6 (1).

C. stricta (Nyl.) Nyl. – on soil: 9 (1).

C. symphycarpa (Flörke) Fr. – on soil: 7 (Zhurbenko 834) (1); rev. T. Ahti, 1992.

C. uncialis (L.) Weber ex Wigg. – on soil: 1, 2, 3 (4).

Dactylina arctica (M. J. Richardson) Nyl. – on soil; common: 1, 2, 5, 7, 8 (7).

D. ramulosa (Hook.) Tuck. – on soil: 2 (1). Studied specimens belong to P- chemical race.

*Dactylospora attendenda (Nyl.) Arnold – on *Pilophorus dovrensis* thallus: 5 (Zhurbenko 8395) (1); confirm. D. Triebel, 1997. Spores brown, (1–3-septate, 12–15.5 × 5–6 µm.

*D. deminuta – on *Biatora subduplex*, *Lecanora epibryon*, *Ochrolechia frigida*, and *Rinodina turfacea* thalli: 1, 2, 5 (3); confirm. D. Triebel, 1997. Spores brown with olive tinge, 3–7-septate, 15–22.5 × 5–6 µm.

*D. purpurascens Triebel – on *Amygdalaria panaeola* thallus: 3 (Zhurbenko 83138) (1). Spores 8–15 × 5-6 µm, epithecium K+ purpur.

*D. sp. – on *Cladonia pyxidata* thallus: 7 (Zhurbenko 8381) (1). Spores brown, 1-septate, 10.5–15 × 5–7 µm.

*Endococcus rugulosus Nyl. – on *Aspicilia* sp. thallus: 3 (1).

*Epicladonia sandstedei (Zopf) D. Hawksw. – forms galls on primary squamules of *Cladonia pyxidata*: 5 (Zhurbenko 8350) (1). Conidia hyaline, 1-septate, 10–12 × 3–4 µm.

*Epilichen scabrosus (Ach.) Clem. – on *Baeomyces placophyllus* thallus: 1 (1).

Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell – on soil, also on driftwood; very common: 1, 2, 5, 6, 7, 8 (9).

F. nivalis (L.) Kärnefelt & A. Thell – on soil; very common: 1, 2, 3, 5, 7, 8 (7). Specimen Zhurbenko 8374 has round soralia, representing a sorediate form of the species.

Hafellnera parasemella (Nyl.) Houmeau & Cl. Roux – on *Betula nana* twigs: 1, 2 (2).

HYPOGYMNIA AUSTERODES (Nyl.) Räsänen – on soil, also on rock: 1, 2 (2).

H. PHYSODES (L.) Nyl. – on soil: 1, 2, 3 (3).

JAPEWIA TORNOËNSIS (Nyl.) Tønsberg – on plant remnants: 1, 2 (2).

LECANIA CYRTELLA (Ach.) Th. Fr. – on dead bark of *Alnus fruticosa*: 4 (1). Apothecia 0.2–0.4 mm, hymenium K+ (violet), spores 7.5–13 × 2.5–3.5 µm, 0–1-septate.

LECANORA BOLIGERA (Norman ex Th. Fr.) Hedl. – on dead bark of *Alnus fruticosa*: 4 (1).

L. CHLAROTERA Nyl. – on dead bark of *Alnus fruticosa*: 4 (1).

L. EPIBRYON (Ach.) Ach. – on bryophytes and plant remnants, including dead parts of dwarf shrubs; common: 1, 2, 3, 5, 9 (6).

L. HAGENII (Ach.) Ach. var. SAXIFRAGAE (Anzi) R. Sant. – on degenerating bryophytes and peat: 1, 6 (2).

L. LEPTACINA Sommerf. – on degenerating bryophytes and peat: 1, 6 (2).

L. POLYTROPA (Ehrh. ex Hoffm.) Rabenh. – on pebbles and rocks: 3, 7 (2).

LECIDEA RAMULOSA Th. Fr. – on bryophytes: 7 (1).

LECIDELLA EUPHOREA (Flörke) Hertel – on bryophytes, plant remnants, dead bark of *Alnus fruticosa* and *Salix glauca*, and naked driftwood; common: 1, 2, 3, 4, 7, 8, 9 (7).

LECIOPHYSMA FINMARKICUM Th. Fr. – on degenerating bryophytes: 1 (1).

LEPRARIA NEGLECTA (Nyl.) Lettau – on saxicolous bryophytes: 3, 9 (2).

LOPADIUM CORALLOIDEUM (Nyl.) Lynge – on bryophytes and plant remnants: 2, 9 (2).

L. PEZIZOIDEUM (Ach.) Körb. – on bryophytes and plant remnants; common: 1, 2, 3, 6 (5).

MEGASPORA VERRUCOSA (Ach.) Hafellner & V. Wirth – on dead bryophytes: 3 (1).

MELANELIA DISJUNCTA (Erichsen) Essl. – on rock: 3 (1).

M. HEPATIZON (Ach.) A. Thell – on rock, also on peat: 1 (1).

M. PANNIFORMIS (Nyl.) Essl. – on rock and soil: 1, 3 (3).

M. SEPTENTRIONALIS (Lynge) Essl. – on bark of *Alnus fruticosa*: 4 (1).

M. SOREDIATA (Ach.) Goward & Ahti – on rocks: 3, 9 (2).

MYCOBILIMBIA BERENGERIANA (A. Massal.) Hafellner & V. Wirth – on sandy soil with plant remnants: 3, 9 (2).

M. CARNEOPALLIDA (Müll. Arg.) Printzen – on bryophyte; common: 5 (1).

M. HYPNORUM (Lib.) Kalb & Hafellner – on bryophytes: 5 (1).

M. LOBULATA (Sommerf.) Hafellner – on degenerating bryophytes with sandy soil: 5, 7 (2).

NEPHROMA EXPALLIDUM (Nyl.) Nyl. – on soil: 1 (1).

OCHROLECHIA ANDROGYNA (Hoffm.) Arnold – on bryophytes, plant remnants, also on bark of *Alnus fruticosa*; common: 1, 2, 5, 6, 9 (8).

O. FRIGIDA (Sw.) Lynge – on bryophytes and plant remnants; common: 1, 2, 3, 9 (6).

O. GRIMMIAE Lynge – on bryophytes and degenerating cushion of graminoid: 2 (1).

O. cf. INAEQUATULA (Nyl.) Zahlbr. – on bryophytes and lichens: 3 (2).

O. UPSALIENSIS (L.) A. Massal. – on bryophytes and dead parts of dwarf shrubs: 1, 2, 3 (3).

PANNARIA PEZIZOIDES (Weber) Trevis. – on soil: 8, 9 (2).

P. cf. PRAETERMISSA Nyl. – on soil: 2 (1).

PARMELIA FRAUDANS (Nyl.) Nyl. – on rock and soil: 3 (2).

P. OMPHALODES (L.) Ach. – on soil: 1, 2, 3 (4).

PARMELIOPSIS AMBIGUA (Wulfen) Nyl. – on bark of *Alnus fruticosa*: 4 (1).

P. HYPEROPTA (Ach.) Arnold. – on bark of *Alnus fruticosa* and *Salix* sp.: 4, 8 (2).

PELTIGERA APHTHOSA (L.) Willd. – on soil; common: 1, 5, 8, 9 (5).

P. CANINA (L.) Willd. – on soil: 1, 5, 7 (3).

P. DIDACTYLA (With.) J. R. Laundon – on soil: 1, 5 (2).

P. LEPIDOPHORA (Nyl.) Bitter – on soil: 5 (1).

P. LEUCOPHLEBIA (Nyl.) Gyeln. – on soil: 5, 8 (2).

P. NECKERI Hepp ex Müll. Arg. – on soil: 1 (Zhurbenko 8333), 7 (Zhurbenko 8328), 8 (Zhurbenko 8326) (3); rev. O. Vitikainen, 1993.

P. RUFESCENS (Weiss) Humb. – on soil; common: 1, 3, 5, 7 (6).

PERTUSARIA BRYONTHA (Ach.) Nyl. – on bryophytes; common: 1, 2, 3, 5 (6).

P. CARNEOPALLIDA – on bark of *Alnus fruticosa* and *Salix glauca*: 4, 8 (2); rev. I. I. Makarova, 1997.

P. CORIACEA (Th. Fr.) Th. Fr. – on bryophytes and dead parts of dwarf shrubs: 1, 2, 3 (3).

P. DACTYLINA (Ach.) Nyl. – on bryophytes; rather common: 1, 2, 3 (4).

P. GEMINIPARA (Th. Fr.) C. Knight – on bryophytes, also on plant remnants with sand above rock: 3, 9 (2).

P. GLOMERATA (Ach.) Schaer. – on degenerating bryophytes with sandy soil: 1 (1).

P. PANYRGA (Ach.) A. Massal. – on bryophytes, partly with sandy soil, also on dead parts of dwarf shrubs; common: 1, 2, 3 (4).

Phaeocalicium compressulum (Nyl. ex Szatala) A. F. W. Schmidt – on bark of *Alnus fruticosa*; sparse: 4 (1).

*Phaeosporobolus alpinus R. Sant., Alstrup & D. Hawksw. – on *Ochrolechia androgyna*, *O. frigida*, and *Pertusaria coriacea* thalli; frequently: 1, 2, 3 (3). One of the most common and noticeable lichenicolous fungi in the Siberian Arctic.

Pilophorus dovrensis (Nyl.) Timdal, Hertel & Rambold – on sandy soil: 5 (1).

Placynthiella uliginosa (Schrad.) Coppins & P. James – on bryophytes, also on dead bark of *Alnus fruticosa*: 1, 4 (2).

Polyblastia fuscoargillacea Anzi – on rock: 7 (1).

P. sendtneri Kremp. – on plant remnants with sandy soil: 7 (1).

Polychidium muscicola (Sw.) Gray – on plant remnants with sandy soil: 3 (1).

Porpidia flavocaerulescens (Hornem.) Hertel & A. J. Schwab in Hertel, Syn. *P. flavicunda* (Ach.) Gowan – on rock: 3 (1).

Protoparmelia picea auct. – on rock: 1 (1).

Psoroma hypnorum (Vahl) Gray – on bryophytes and plant remnants: 1, 5 (3).

Rhizocarpon hochstetteri (Körb.) Vain. – on pebbles: 7 (1).

Rinodina archaea (Ach.) Arnold – on naked driftwood: 7 (1).

R. lecideoides (Nyl.) Kernst. –on dead bark of *Salix glauca*: 8 (1).

R. mniaraea (Ach.) Körb. var. mniaraea – on bryophytes and plant remnants: 2, 9 (2).

R. mniaraea var. cinnamomea Th. Fr. – on bryophytes and plant remnants: 3, 9 (2).

R. olivaceobrunnea C. W. Dodge & G. E. Baker – on bryophytes and plant remnants (dead parts of dwarf shrubs etc.); common: 1, 2, 5, 7 (5).

R. turfacea (Wahlenb.) Körb. – on bryophytes and plant remnants; common: 1, 2, 3, 5 (6).

Psoroma hypnorum (Vahl) Gray – on soil: 1, 5 (4).

*Sagediopsis campsteriana (Linds.) D. Hawksw. & R. Sant – on *Ochrolechia* cf. *androgyna* thallus: 3 (1).

Solorina saccata (L.) Ach. – on sandy soil with plant remnants: 1, 5 (2).

S. spongiosa (Ach.) Anzi – on sandy soil with plant remnants: 1, 5, 7, 8 (4).

*Sphaerellothecium araneosum (Rehm ex Arnold) Zopf – on *Cladonia pocillum* and *Ochrolechia frigida* thalli: 2, 9 (2).

*S. minutum Hafellner – on *Sphaerophorus fragilis* and *S. globosus* thalli; common: 1, 2 (2).

Sphaerophorus fragilis (L.) Pers. – on soil; 1 (1).

S. globosus (Huds.) Vain. – on soil; common: 1, 2, 3, 6 (6).

Stereocaulon alpinum Laurer – on soil; abundant throughout the region: 1, 2, 3, 5, 7, 8, 9 (13).

S. botryosum Ach. – on rock: 3 (2).

S. glareosum (Savicz) H. Magn. – on sandy soil, often with silt: 7, 9 (2).

S. cf. paschale (L.) Hoffm. – on soil: 2 (1).

S. rivulorum H. Magn. – on sandy soil; common: 2, 3, 7, 9 (7).

*Stigmidium peltideae (Vain.) R. Sant. – on *Peltigera leucophlebia* thallus: 1 (1).

*Taeniolella beschiana Diederich – on *Cladonia* sp. primary squamules: 3 (Zhurbenko 83143) (1).

*T. pertusariicola D. Hawksw. & H. Mayrhofer – on *Pertusaria carneopallida*, mainly on apothecia, also on thallus: 2 (Zhurbenko 83127) (1).

Thamnolia vermicularis (Sw.) Schaer. var. vermicularis – on soil; common: 1, 2, 5, 7, 8 (6).

T. vermicularis var. subuliformis (Ehrh.) Schaer. – on soil; common: 1, 2, 3, 5, 8 (6).

Toninia squalida (Ach.) A. Massal. – on bryophytes with sandy soil: 3 (1).

Tuckermannopsis sepincola (Ehrh.) Hale – on bark of *Alnus fruticosa*, *Betula nana*, and *Salix* spp.: 2, 4, 8 (3).

Umbilicaria deusta (L.) Baumg. – on rocks: 3, 9 (2).

U. proboscidea (L.) Schrad. – on rocks: 1, 3 (2).

U. torrefacta (Lightf.) Schrad. – on rock: 1 (1).

Vulpicida pinastri (Scop.) J.-E. Mattsson & M. J. Lai. – on bark of *Alnus fruticosa* and *Salix* spp., also on soil and bryophytes: 1, 3, 4. 5, 8 (5).

ACKNOWLEDGEMENTS

Thanks are due to Prof. Dr Boris N. Norin and Mr. Lembit Kitsing, the leaders of the Polar Expedition of the Komarov Botanical Institute, for the opportunity to collect lichens at Taimyr. The help of Prof. Dr Teuvo Ahti, Dr Orvo Vitikainen, Dr Dagmar Triebel and Dr Irina I. Makarova in the revision of some taxa is gratefully acknowledged. The preparation of this paper has been financially supported by the Russian Fund for Basic Researches (RFBR grant no 97-04-48358). The study is part of the project (NTP of Russia) "Complex studies of the oceans and seas of the Arctic and Antarctic". English has been kindly revised by Dr Barbara Murray.

REFERENCES

Ahti, T. & Zhurbenko, M. P. 1994. Distribution of *Cladonia alaskana* in Asia. *Graphis Scripta* 6: 11-14.

Alexandrova, V. D. 1937. The tundra in the right shore of Popigay River (in Russian). *Trudy Arktich. Inst.*, Leningrad. 63: 181-206.

Andreev, M., Kotlov, Y., Makarova, I. 1996. Checklist of lichens and lichenicolous fungi of the Russian Arctic. *Bryologist.* 99 (2): 137-169.

Atlas of the Arctic (ed. Treshnikov, A. F.) (in Russian, English summary). 1985. GUGK, Moscow. 203 pp.

Avramtchik, M. N. 1937. Geobotanical and range characteristics of the district of Dudypta River (in Russian). *Trudy Arktich. Inst.*, Leningrad. 63: 47-81.

Chernov, Yu. I. & Matveeva, N. V. 1979. Patterns of the zonal distribution of communities in Taimyr (in Russian). In *Arctic tundras and polar deserts of Taimyr* (eds. Alexandrova, V. D. & Matveeva, N. V.), pp. 166-200. Nauka, Leningrad.

Matveeva, N. V. & Zanokha, L. L. 1986. Vegatation of southern tundras in western Taimyr (in Russian). In *Southern tundras of Taimyr* (eds. Chernov, Y. I. & Matveeva, N. V.), pp. 5-67. Nauka, Leningrad.

Piin, T. 1984. Flora and distribution of terricolous lichens in the southern tundra of Taimyr (in Russian, English summary). In *Flora and groupings of lower plants in natural and anthropo-genous extreme environment conditions* (ed. Martin, J. L.), pp. 134-172. Acad. Sci. Eston. SSR, Tallinn.

Pospelova, E. B. 1974.Structure and spatial distribution of phytomass in main plant communities of station "Agapa" (in Russian). In *Soil and production of plant communities* (ed. Kovda, V. A.), Part 2, pp. 48-66. Moscow State University, Moscow.

Tyulina, L. N. 1937. Forest vegetation of the Khatanga district along its north boundary (in Russian). *Trudy Arktich. Inst.*, Leningrad. 63: 83-180.

Vinogradova, A. N. 1937. Geobotanical outline of the reindeer ranges along the Piassina River (in Russian). *Trudy Arktich. Inst.*, Leningrad. 63: 5-45.

Zhurbenko, M. P. 1996. Lichens and lichenicolous fungi of the northern Krasnoyarsk Territory, Central Siberia. *Mycotaxon.* 58: 185-232.

Zhurbenko, M. P. & Santesson, R. 1996. Lichenicolous fungi from the Russian arctic. *Herzogia.* 12: 147-161.