Karstenia 50: 59–72, 2010

Ascomycetes and anamorphic fungi growing on Plagiochila (Hepaticae) in Finland

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MARSH, T., DÖBBELER, P., HUHTINEN, S. & STENROOS, S. 2010: Ascomycetes and anamorphic fungi growing on Plagiochila (Hepaticae) in Finland. – Karstenia 50: 59–72. Helsinki. ISSN 0453-3402.

Over 400 Finnish herbarium specimens of the hepatics *Plagiochila asplenioides* and the closely related *P. porelloides* were screened for the presence of fungi. The screening yielded ca. 200 recordings of bryicolous species belonging to the ascomycete genera *Bryomyces, Dactylospora, Epibryon, Lichenopeltella, Octosporella, Pleostigma,* and the anamorphic genus *Epicoccum.* With the exception of *Epibryon plagiochilae*, the species are new to Finland. They are described and illustrated. Their morphology, taxonomy and ecology are discussed and their distribution in Finland is mapped. A key is given to all known bryicolous fungi found on *P. asplenioides* (incl. *P. porelloides*).

Keywords: Ascomycetes, bryicolous fungi, hepaticolous fungi, *Plagiochila asplenioides, P. porelloides*

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Introduction

The presence of fungi on bryophytes may be more apparent to bryologists than mycologists, as mosses and hepatics host a wide range of fungi, some of which are common and easily visible under the stereo microscope. However, perhaps due to the lack of communication between researches of these different fields bryicolous fungi have been seriously overlooked. The first account of pyrenomycetes and fungi imperfecti occuring on the gametophytes and sporophytes of mosses and hepatics was presented by Racovitza (1959). Döbbeler (1978) continued the work by describing and keying 62 new and 61 previously known species of ascomycetes mainly on the haploid stage of bryophytes. A brief literature review of the gametophyte-inhabiting fungi has been compiled by Felix (1988).

Up to date, the total number of bryicolous ascomycetes described is ca. 350 species (Döbbeler 2002). They belong to more than 90 genera and at least ten orders, including Arthoniales, Dothideales, Helotiales, Hypocreales, Lecanorales, Microthyriales, Ostropales, Pezizales, Sordariales, and Verrucariales, some taxa remaining *incertae sedis*. Bryicolous fungi are by no means chance companions of their partners: there are several obligately bryicolous ascomycete genera which suggests that the relationship between the fungus and its host may have an ancient origin. Davey & Currah (2006) have provided a litera-

ture review of interactions between mosses and fungi. These interactions range from pathogenic to commensalistic, biotrophic parasitism by the fungus-partner probably being the most common (Döbbeler 2002).

A bryicolous lifestyle requires several morphological and physiological adaptations of the fungus, including the minute size of the fruit bodies, the ability to produce them all year round, specialized infection structures of the hyphae, and adaptations for reducing water-loss. The fruit bodies are not formed randomly on the host, but at species-specific microsites, reflecting the ecology of the fungus. Thorough summaries on the diversity and microniche utilization of bryicolous ascomycetes can be found in Döbbeler (1997, 2002).

Presently, about 300–400 species of mosses and hepatics have been proved to host bryicolous ascomycetes (Felix 1988). Just a handful of bryophyte species have been screened systematically for microfungi (e.g., Döbbeler 1981b, 1998, 2003, 2006, 2007, Laukka 2005, Lesonen 2006, Marsh 2005). These numbers constitute only the tiniest fraction of potential hosts, 18 000 estimated species of mosses and hepatics (Schofield 1985), that are all likely to harbor fungal associates.

The host species ***Plagiochila asplenioides*** and ***P. porelloides***

The hepatic genus *Plagiochila* (Dumort.) Dumort. is one of the largest genera of hepatics, with an estimated number of 400–450 species (So & Grolle 2000) and over 2500 taxa published (Inoue 1989). Members of the genus occur worldwide, but the species diversity is greatest in the humid tropics, where *Plagiochila* is one of the most common bryophytes (Inoue 1984). *Plagiochila* is characterized by general robustness and alternate, succubously inserted, often decurrent leaves (Damsholt 2002).

In Finland the only representatives of the genus are *P. asplenioides* (L.) Dumort. and *P. porelloides* (Torrey ex Nees) Lindenb. Species restrictions within the *P. asplenioides* -complex have been discussed controversially. Schuster (1980) and Damsholt (2002) regarded *P. porelloides* as a subspecies of *P. asplenioides*, whereas Paton (1999) and Schumacker & Váňa (2000) accepted two species. Both taxa are common and abundant in Finland. *P. asplenioides* prefers herb-rich forest floors and moist depressions. *P. porelloides* can be found on bases and crevices of shady silicate boulders, sometimes by brooks or on dead wood in shady forests.

Table 1. Ascomycetes previously recorded on *Plagiochila asplenioides* s.l.

Name	**Reference**
Belonioscyphella hypnorum (Syd. & P. Syd.) Höhn.	Döbbeler 1986a
Bryomyces hemisphaericus Döbbeler	Döbbeler 1978
Bryorella erumpens Döbbeler	Döbbeler 1978
Dactylospora heimerlii (Zukal) Döbbeler & Triebel	Döbbeler & Triebel 1985
Epibryon endocarpum Döbbeler	Döbbeler 1980a
Epibryon muscicola (Racov.) Döbbeler	Racovitza 1959, Döbbeler 1978
Epibryon plagiochilae (Gonz. Frag.) Döbbeler	Racovitza 1959, Döbbeler 1978
Epicoccum plagiochilae Racov.	Racovitza 1959, Döbbeler 1986b
Nectria racovitzae Döbbeler	Döbbeler 1978
Nectria salisburgensis Döbbeler & Poelt	Döbbeler 1978
Octosporella jungermanniarum (P. Crouan & H. Crouan) Döbbeler	Corner 1929, Döbbeler 1978
Phoma plagiochilae Racov.	Racovitza 1959, Döbbeler 1981a
Pleostigma jungermanniicola (C. Massal.) Kirschst.	Racovitza 1959

Thirteen species of bryicolous fungi have previously been recorded in association with *P. asplenioides* and/or *P. porelloides* (Table 1). It has not always come clear, especially from older literature, which of the two *Plagiochila* -species has been in question, therefore all associated species referred from literature have been grouped collectively under *P. asplenioides* s.l.

Material and methods

The study is based mainly on dry herbarium material from the bryological collections of the Botanical Museums of Turku (TUR) and Oulu (OULU). The laboratory work was carried out during the year 2004. The search for fruit bodies requires wetting the herbarium specimens of *Plagiochila* thoroughly under flowing tap water. Rehydration of the material restores the size of the ascomata, facilitates the handling of the hepatic, which is fragile and brittle when dry and removes some of the debris from the gametopyte. Each specimen of *Plagiochila* was subsequently screened, one shoot at a time, under an Olympus SZX9 stereo microscope, both from the dorsal and ventral sides of the leaves and around the stem. The handling of the hepatic was done with utmost care, so that it could be returned to the herbarium in good condition. The search for ascomata is facilitated by the knowledge of their species-specific microniches on the host (Döbbeler 2002). Shoots containing ascomata were separated from the original specimen for further investigation.

Morphological structures of the ascomata were studied using squash mounts. The mounts were observed with an Olympus BX40 light microscope. Spores, asci, paraphyses or pseudoparaphyses, wall structure, hairs or other features of the ascoma were observed and measured. Growth pattern of mycelia was observed from leaf preparates. A drawing tubus, attached to the microscope, was used to make illustrations of the structures. Congo Red (CR) was used as standard staining liquid to make structures more clearly visible. Iodine reactions were tested with Melzer's Reagent (MLZ) and Lugol's solution (IKI). Cotton blue (CB) was used to stain the hyphae in leaf preparates. All measurements originate from rehydrated herbarium material stained with Congo Red.

The genera in which the collected ascomycete species are positioned are presented shortly, followed by species descriptions, distribution map in Finland, and comments. Species descriptions one to eight are of those species, which were encountered during this study (Table 2), and their descriptions are based on personal observations and measurements. The descriptions of the rest of the species are abbreviated from relevant literature. The latter have been reported from *Plagiochila*, but have not yet been recorded from Finland. The maps provided present a picture of collections in the past and present, rather than reflect the true distribution of the species.

Results

About half of the *Plagiochila* -specimens examined hosted bryicolous ascomycetes belonging to eight different species (Table 2). Only *Epibryon plagiochilae* (Gonz. Frag.) Döbbeler was previously known from Finland. *Bryomyces hemisphaericus* Döbbeler, *Dactylospora heimerlii* (Zukal) Döbbeler & Triebel, *Epicoccum plagiochilae* Racov., *Lichenopeltella alpestris* (Sacc.) P.M. Kirk & Minter, *Octosporella jungermanniarum* (P. Crouan & H. Crouan) Döbbeler, and *Pleostigma jungermanniicola* (C. Massal.) Kirschst. are reported as new to Finland. One previously undescribed species of *Epibryon* is characterized.

Table 2. Ascomycetes found in this study and number of infected specimens

	P. asplenioides / ca. 200 studied	*P. porelloides* / ca. 200 studied
Bryomyces hemisphaericus	–	2
Dactylospora heimerlii	–	6
Epibryon plagiochilae	97	8
Epibryon sp.	–	6
Epicoccum plagiochilae	1	2
Lichenopeltella alpestris	35	6
Octosporella jungermanniarum	5	1
Pleostigma jungermanniicola	8	22

Key to all species recorded on *Plagiochila asplenioides* s.l.

1. Anamorphic, with conidiomata or pycnidia 2
   – Teleomorphic, with ascomata 3

2. Conidiomata superficial, conidia two-celled, dark brown ..... **5.** *Epicoccum plagiochilae*
   – Pycnidia within the leaf tissue, conidia one-celled, colourless ..... **15.** *Phoma plagiochilae*

3. Ascomata catathecioid, excipular cells arranged in rows ..... **6.** *Lichenopeltella alpestris*
   – Ascomata not catathecioid 4

4. Ascomata singly within individual host cells ..... **11.** *Epibryon endocarpum*
   – Ascomata not within individual host cells 5

5. Ascoma black, sphaerical, with hairs 6
   – Not with this character combination 8

6. Spores four-celled ..... **12.** *Epibryon muscicola*
   – Spores two-celled 7

7. Ascomata 50–100 µm diam, scattered on upper leaf surface, hairs horizontal or more often curved downward ..... **3.** *Epibryon plagiochilae*
   – Ascomata 40–70 µm diam, growing in leaf axils, hairs horizontal or pointed upwards ..... **4.** *Epibryon* sp.

8. Ascomata perithecioid, glabrous 9
   – Ascomata either hairy and perithecioid or apothecioid and glabrous 11

9. Spores muriform ..... **8.** *Pleostigma jungermanniicola*
   – Spores two-celled 10

10. Ascomata superficial, spores ca.13–16 × 6–7 µm ..... **1.** *Bryomyces hemisphaericus*
    – Ascomata immersed, spores. ca. 9–11 × 3–3.5 µm ..... **10.** *Bryorella erumpens*

11. Ascomata perithecioid, hairy 12
    – Ascomata apothecioid, without hairs 14

12. Spores without septa ..... **7.** *Octosporella jungermanniarum*
    – Spores septate 13

13. Spores 25–35 × 6–7 µm ..... **13.** *Nectria racovitzae*
    – Spores 6.5–8.5 × 1.5–2 µm ..... **14.** *Nectria salisburgensis*

14. Apothecia brownish, with a distinct margin, spores 13–20 × 5–8 µm, usually one-septate, biotrophic parasite ..... **2.** *Dactylospora heimerlii*
    – Apothecia reddish, disc flat, spores 33–40 × 7–8.5 µm, usually three-septate, necrotrophic parasite ..... **9.** *Belonioscyphella hypnorum*

1. *Bryomyces hemisphaericus* – Fig. 5, 8

Ascomata 50–120 µm diam, superficial, often gregariously but not merging, semiglobose to rarely globose, black, glabrous. *Ostiole* 10–18 µm diam, circular, not easily visible. *Excipulum* composed from 3–5 layers of isodiametric, very thick-walled brownish cells. *Asci* 28–45 × 17–22 µm, 8-spored, bitunicate, ovoid to slightly clavate, foot short or absent, MLZ–. *Spores* 13–16(–17) × (5–)6–7 µm, ellipsoid, hyaline or light-brown, smooth-walled, two-celled, strongly constricted at the septum, upper half nearly semiglobose, each cell commonly containing one large or several small oil droplets, one or both cells with a 3 µm long, hyaline appendage. *Paraphyses* absent. *Hyphae* brown, conspicuous, cells 4–10(–15) × 3–6 µm, ellipsoid in cross-section, thick-walled. The hyphae follow the hosts cell walls superficially, occasionally pegging the hosts cell wall with haustoria. In the vicinity of the ascomata, the hyphae form dense, stroma-like cushions.

Specimens studied: **FINLAND. Etelä-Häme.** Ruovesi, Helvetinjärvi, on *P. porelloides,* 29.VI.1939 *Söyrinki* (TUR). Tampere, Teisko, Männistö, on *P. porelloides*, 3.VIII.1967 *Laine* (TUR).

The genus *Bryomyces* Döbbeler contains 12 taxa found on hepatics and mosses. It is characterized by medium-sized, glabrous ascomata, absence of iodine reaction, and two-celled spores. Typical growth of mycelia and haustoria make it possible to identify the genus even when the ascomata are absent (Döbbeler 1978). While some of the species in this genus are reported to be widespread and fairly easy to identify, some of them may be quite difficult to distinguish (Döbbeler 2003). The ascomata of *B. hemisphaericus* were located in the lower part of infected plants, either on the dorsal side of the leaf or on the stem. The fruit body formation does not seem to be strictly localized; instead the fungus seems to colonize distinct areas of the plant with several ascomata forming in each other's vicinity. A heavy infection might even be visible in the field, since the leaves of the host plant may be covered in masses of black hyphae.

2. *Dactylospora heimerlii* – Fig. 7, 9

Apothecia rounded, 110–270(–400) µm diam, light brown to rarely black, urceolate to shortly stalked, concave when young, later disc even, with a distinct margin. *Ectal excipulum* composed of isodiametric, thick-walled cells, 13 µm diam, often with a rounded lumen. *Asci* (42–)50–80(–90) × (10–)11–15 µm, clavate, eight-spored (rarely 4–7 spores), thickened at the apex, IKI stains the outer wall blue, especially apically, KOH-pretreatment deepens the apical staining. *Spores* hyaline, rarely brownish when mature, (12–)13–20(–21) × (4–)5–8(–8.5) µm, ellipsoid to elongate-ellipsoid, usually slightly asymmetrically one-septate, rarely with 2–4 septa, smooth. *Paraphyses* branching. *Hyphae* hyaline, up to 1,5 µm diam, ramifying, growing between host cells, especially in cell corners, and outer layer of stem.

Specimens studied: **FINLAND. Varsinais-Suomi.** Länsi-Turunmaa, Parainen, on *P. porelloides,* 20.VII.2004 *Marsh* (TUR). **Uusimaa.** Helsinki, Töölönpuisto, on *P. porelloides,* 24.X.1884 *Lindberg* (TUR). Sipoo, Pickala, on *Jungermannia leiantha,* 23.V.3009 *Syrjänen, Niemi & Savola* (TUR). **Etelä-Häme.** Orivesi, Yliskylä, on *P. porelloides,* 6.VIII.1962 *Laine* (TUR). Ruovesi, Kukonpohja, on *P. porelloides,* 13.VI.1978 *Söyrinki* (TUR, OULU). **Pohjois-Häme.** Virrat, lowest lake of Toriseva, on *P. porelloides,* 22.VI.1948 *Söyrinki* (TUR, OULU). **Oulun Pohjanmaa.** Kiiminki, Isohalmeenmaa, on *P. porelloides,* 10.VII.1984 *Väre* (TUR).

Dactylospora Körb. is a widely distributed genus of ascomycetes with ca. 49 species (Kirk et al. 2008), most of which are lichenicolous but may also be found on hepatics, fungi, herbaceous plant material or dead wood. The morphological features of *Dactylopora* include asci with an amyloid, apical cap and a gelatinized, IKI+ outer layer (Hafellner 1979). *Dactylospora heimerlii* is reported as new to Finland. The apothecia found in this study were located mainly in the leaf axils or the perianths of *P. porelloides.* They occurred both in the healthy green parts and the decaying, lower parts of the stem. *D. heimerlii* has previously been recorded from nine hosts all belonging to different genera in the Jungermanniales (Döbbeler & Triebel 1985), most of which occur in Finland.

3. *Epibryon plagiochilae* – Fig. 2, 10

Ascomata superficial, gregariously or dispersed, very rarely merged, 50–100 µm diam, semiglobose, usually with hairs, brown to black. *Ostiole* 7–13 µm diam, visible under the microscope as

a clear circular spot. *Hairs* located in the upper third of the ascoma, usually sparse, horizontal, often bending towards the substratum, 20–55(–70) × 3–4 µm, dark-brown to blackish, one-celled, hairs may also be short or lacking. *Excipulum* composed of light-brown, thin-walled cells, ca. 6 µm diam, cells surrounding the ostiole 2–4 µm diam, isodiametric, thick-walled, brown. *Asci* (20–)24–40 × 7–12 µm, eight-spored, bitunicate, from ellipsoid to cylindrical, foot short, hymenial gel red in IKI. *Spores* biseriate or irregularly biseriate, (8.5–)9–10(–16.5) × 2.5–3(–4) µm, ellipsoid, smooth, two-celled, not constricted at the septum, lower cell slightly smaller, may have single guttules. *Hyphae* light-brown, cells 1–2 µm diam, thin-walled. The hyphae grow superficially on the anticlinal host cell walls, occasionally perforating some cells and filling them with mycelia which has short, 4–7 µm thick ovoid to ellipsoid cells. Hyphae may be seen abundantly in the vicinity of ascomata.

Selected specimens studied (all on P. asplenioides): **FINLAND. Varsinais-Suomi.** Karjalohja, Puujärvi, 24.IX.1979 *Laine* (TUR). **Uusimaa.** Espoo, Röylä, 7.X.1962 *Isoviita* (TUR). **Etelä-Häme.** Ruovesi, Hyytiälä, 21.VI.1943 *Söyrinki* (TUR, OULU). **Pohjois-Häme.** Konginkangas, Pyyrinlahti, 10.X.1964 *Isoviita* (TUR). **Kainuu.** Sotkamo, Laaka, 24.IX.1996 *Ulvinen* (TUR, OULU).

The genus *Epibryon* Döbbeler accommodates ca. 45 species according to current knowledge and is the largest genus of bryicolous ascomycetes, with also a few lichenicolous representatives. However, it is not considered as a natural group, but rather a collection of species sufficiently similar in appearance to be placed in the same genus (Döbbeler 1997). The ascomata in this genus are globose or semiglobose, 30–120(–200) µm diam. Most species grow on the surface of their host, although some grow immersed in their substratum, intracellularly, or in some cases between the lamellae of Polytrichales. A typical feature of the genus is that the hymenial gel stains red in IKI. *Epibryon* species are widespread and common on a great variety of mosses and hepatics. They prefer hosts that belong to Jungermanniales and Polytrichaceae. Most representatives of the genus are biotrophic parasites, which rarely harm their host even though ascomata may sometimes be abundant.

Epibryon plagiochilae shows a strong preference for the dorsal leaf border of its host hepatic, although ascomata can also occur on the stem or on female bracts and perianths. The species has previously been thought to be specific to *P. asplenioides* and *P. porelloides,* occurrence on *P. porelloides* being significantly lower. However, there have been recent observations of *E. plagiochilae* also occurring on *Plagiochila britannica* (Bosanquet 2007). This observation would be in accordance with the cytological evidence that suggests that *P. britannica* has originated from *P. asplenioides* and *P. porelloides* via allopolyploidy (Newton 1986). In all, 105 specimens were found from the ca. 400 studied collections. The distribution follows that of the host hepatic. *E. plagiochilae* was recorded from the following regions: Ahvenanmaa, Varsinais-Suomi, Uusimaa, Satakunta, Etelä-Häme, Pohjois-Häme, Etelä-Savo, Etelä-Karjala, Pohjois-Savo, Keski-Pohjanmaa, Oulun Pohjanmaa, and Kainuu.

4. *Epibryon* sp. – Fig. 11

An additional *Epibryon* species which was encountered during the research is briefly characterized here. As mentioned above, *Epibryon* species are among the most often encountered fungi on bryophytes. However, their species delimitation is challenging, and knowledge of their morphological variation and host selection is still limited. The material found was scarce, and the differences to other *Epibryon species* are minimal, therefore official species description shall be omitted.

Ascomata superficial, single, rarely merged, 40–70 µm diam, semiglobose, with hairs, brown to blackish. *Ostiole* circular, not easily visible. *Hairs* (15–)20–30 × 2–3 µm, usually abundant, ca. 60–100 on each perithecium, black to brown, single-celled. *Excipulum* composed of isodiametric, brown cells, 3.5–5 µm diam. *Asci* eight-spored, cylindrical, curved, bitunicate. *Spores* irregularly in ascus, 9–13 × 3–5 µm, ellipsoid or slightly allantoid, hyaline, two-celled, constricted at septum.

Specimens studied (all on P. porelloides): **FINLAND. Varsinais-Suomi.** Länsi-Turunmaa, Parainen, Kirjala, 20.VII.2004 *Marsh* (TUR). **Etelä-Häme.** Ruovesi, Kukonpohja, 13.VI.1978 *Söyrinki* (TUR). Tampere, 20.VIII.1913 *Helaakoski* (TUR, OULU). **Pohjois-Häme.** Toivakka, Huikko, 30.X.1971 *Ohenoja 25* (TUR, OULU).

Pohjois-Savo. Rautalampi, Hoikankylä, 30.VIII.1982 *Fagerstén 5128* (TUR, OULU). **Kainuu.** Paltamo, Mieslahti, 20.VI.1927 *Metsävainio* (TUR, OULU).

The species was placed in the genus *Epibryon* based on the bitunicate asci, hyaline, two-celled spores, and the general appearance of the ascoma. The iodine reaction was not analysed. The spores are somewhat constricted at the septum, while spores of *E. plagiochilae* are not. The most prominent differences are in the general habitus and the microhabitat. *Epibryon* sp. has more and shorter hairs than *E. plagiochilae. Epibryon* sp. is found in the leaf axils, whereas *E. plagiochilae* shows a strong preference for the dorsal edge of the leaf area never appearing in the axils.

5. *Epicoccum plagiochilae* – Fig. 3, 12

Conidioma superficial, 60–200(–250) µm diam, circular to oval, brown to blackish. *Conidiophores* unbranched. *Conidia* two-celled, 14–18(–19) µm, brown to blackish, upper cell globose, 10–14 µm, verrucose, the lower cell less verrucose. *Hyphae* superficial, (2.5–)3–4(–5) µm thick, dark brown, ramifying, partly following the anticlinal host cell walls, on both sides of the host leaf, sometimes even covering the stem. *Appressoria* ellipsoid, 7–13(–15) × 3–6 µm, dark brown, usually located between host cells. *Haustoria* intracellular 2.5 – 3 µm thick, threadlike, hyaline.

Specimens studied: **FINLAND. Uusimaa.** Helsinki, Degerö, on *P. porelloides,* 25.IX.1910 *Huumonen* (TUR, OULU). **Etelä-Karjala.** Miehikkälä, parish village, on *P. asplenioides,* 9.IX.1967 *Fagerström* (TUR, OULU). **Pohjois-Savo.** Kuopio, Neulamäki, on *P. porelloides,* 11.VI.1909 *Huumonen* (TUR, OULU).

Epicoccum Link. is a widespread, anamorphic hyphomycete, belonging to the family Pleosporaceae. Approximately 100 species have been described up to date (Kirk et al. 2008). *E. plagiochilae* is reported as new to Finland. It appears to be rare, though easy to identify when present.

6. *Lichenopeltella alpestris* – Fig. 6, 13

Ascomata superficial, (40–)50–70(–100) µm diam, 20–25 µm high, catathecioid, conical, dark brown, consisting of one layer. The lower cells are thin-walled, greyish, the upper are dark-brown, angular cells, 2–3 µm diam. *Ostiole* circular, 5–8 µm diam, surrounded by thick-walled, dark-brown, up to 5 µm high papillae, which from above look like hollow, rounded cells. *Asci* 30–35 × 10–13 µm, eight-spored, bitunicate, fissitunicate in discharge, ellipsoid. *Spores* irregularly grouped in the ascus, 8.5–11 × 2.5–3 µm, ellipsoid, hyaline, smooth, with a single median septum, not constricted at the septum, with four large oil droplets, with 1–3 very thin, medial appendages.

Selected specimens studied: **FINLAND. Varsinais-Suomi.** Länsi-Turunmaa, Parainen, on *P. asplenioides,* 20.VII.2004 *Marsh* (TUR). Raisio, Perno, on *P. asplenioides*, 18.VIII.1962 *Laine* (TUR). Turku, Halinen, on *P. asplenioides*, 29.VIII.2004 *Marsh* (TUR, two collections). **RUSSIA. Sortavala District.** Sortavala, Kirjavalahti, on *P. porelloides*, 13.VII.1927 *Parvela* (TUR, OULU).

The members of the genus *Lichenopeltella* Höhn. have charasteristic, catathecioid ascomata which resemble a shield. The majority of the species in the genus are lichenicolous, with the exception of a few bryicolous representatives and some species occurring on dying or dead vascular plants. Approximately 40 binomials have been reported in the genus (Kirk et al. 2008). No monograph has yet been prepared of the genus, although Aptroot et al. (1997) have presented a key for 26 species and Spooner & Kirk (1990) for 10 British species.

The ascomata of this common species occur superficially on the leaves and stems of *P. asplenioides* and *P. porelloides*, with the majority of the findings on *P. asplenioides. L. alpestris* is the second most frequent fungus found on *Plagiochila* in Finnish material. The ascomata are typically situated on the ventral side of the leaf, quite close to the stem. Most frequently the ascomata can be found on the lower, dying, brown parts, but also on the upper, green parts of the host. They easily remain unobserved due to the tiny size and inconspicuous colouring. Only one observation of a *Lichenopeltella* growing on a hepatic has been made before. *Lichenopeltella cetrariicola* (Nyl.) R. Sant. has been reported from *Lophozia barbata* (Schmidel) Dumort. (Racovitza 1959), though its main host is the lichen *Cetraria islandica* (L.) Ach. Laukka (2005) has recorded *L. palustris* (J.P. Ellis) P.M. Kirk & Minter on *Sphagnum capillifolium* (Ehrh.) Hedw. and *S. magellanicum* Brid. *P. asplenioides* and *P. porelloides* are here reported as new hosts to *Lichenopeltella.*

The species was originally described from *Carex* leaves (Saccardo 1880). We follow Racovitza's (1959) interpretation that the species can also grow on bryophytes. Especially noteworthy are the roundish papillae around the ostiole, which can also be seen in Racovitza's plate. Free spores are illustrated as somewhat pointed, whereas those drawn inside the asci look identical to present material.

7. *Octosporella jungermanniarum* – Fig. 4, 14

Ascomata single, superficial, (250–)300–450(–560) × 200–400 µm diam, ovoid to cylindrical, rounded at the apex and base, hairy, bright yellow to orange when dry, less colourful when rehydrated, white in old herbarium specimens. *Ostiole* circular, small, not easily seen. *Hairs* up to 200(–500) µm long, 9–15 µm wide at the base, tapering evenly to the apex, straight and stiff or bended and tangled, hyaline, thick-walled, rarely branched or septate. *Asci* 110–160 × (19–)21–27(–37) µm, usually eight-spored, unitunicate, narrowly ellipsoid, club- or clavate-shaped, rounded at the tip, MLZ–. *Spores* irregularly biseriate, 28–40(– 48) × (10–)12–14(–16.5) µm, elongate ellipsoid, tapering towards the apex, hyaline, smooth, aseptate, with three large oil droplets, the middle one bigger than the others. *Paraphyses* 2–4 µm thick, ramifying, septate, yellowish, guttules inside. *Hyphae* 5–10 µm thick, hyaline, septate, forming an irregular, net-like structure on the surface of the host leaf. The hyphae give rise to lateral branches which consist of a stalk and a terminal appressorium. The shape of the stalk and appressorium resemble distinctly the neck and the head of a goose. Each appressorium produces a thread-like haustorium, which penetrates the host cell wall.

Specimens studied: **FINLAND. Varsinais-Suomi.** Salo, Suomusjärvi, on *P. asplenioides,* 9.IX.1954 *Mäkinen* (TUR). **Etelä-Häme.** Hämeenlinna, Vanaja, on *P. asplenioides,* 6.IX.1963 *Hakulinen* (two specimens, TUR, OULU). Jämsänkoski, Myllymäki, on *P.asplenioides,* 7.XI.2000 *Eurola* (TUR, OULU). **Oulun Pohjanmaa.** Pudasjärvi, Korpinen, on *P. porelloides,* 14.VI.2000 Ulvinen (TUR, OULU). **Perä-Pohjanmaa.** Rovaniemi, NE corner of Pisavaara Strict Nature Reserve, on *P. asplenioides,* 21.VIII.1989 *Ulvinen* (TUR, OULU).

The genus *Octosporella* Döbbeler consists of eight species obligately parasitic on hepatics, some of which were originally placed in the genera *Nectria* (Fr.) Fr. or *Pseudonectria* Seaver (Döbbeler 1980b), some being added subsequently. Characteristic features of the genus are perithecia-like ascomata and thin-walled, operculate asci, appressoria and intracellular haustoria. The modified shape of apothecia might be a response to xerophily. Yao et al. (2006) have compiled a key to the genus. Ascomata occur singularly and are often located inconspicuously on the ventral side of the host leaf. *Octosporella jungermanniarum* catches the eye when fresh with its bright orange colouring, whilst herbarium material loses its colour quickly. It is reported as new to Finland.

8. *Pleostigma jungermanniicola* – Fig. 1, 15

Ascomata superficial, singly or rarely two together, 90–215 µm diam, globose to ovate, glabrous. *Ostiole* circular, neck occasionally elongated. *Excipulum* pseudoparenchymatic, composed of 6–8 rows of isodiametric cells, with walls thickening towards the excipulum. *Asci* 75 × 30 µm, eight-spored, bitunicate, elongate to ellipsoid, very thick-walled and rounded at the tip. *Spores* biseriately or irregularly grouped in the ascus, (18–)20–27(–30) × (7–)10–11(–12) µm, ellipsoid to elongated, brown to black, muriform, with 6–8 transverse and 1–2 longitudinal septa, not constricted. *Hyphae* superficial or under host cuticula, intracellular at the site of ascoma formation, 2.5–3 µm wide, septate, ramifying, hyaline to light brown.

Selected specimens studied: **FINLAND. Etelä-Häme.** Korpilahti, Oittila, on *P. porelloides,* 25.VI.1916 *Siintola* (TUR, OULU). Ruovesi, Visuvesi, on *P. asplenioides,* 23.VII.1948 *Söyrinki* (TUR, OULU). Ruovesi, Visuvesi, on *P. asplenioides,* 26.VIII.1946 *Söyrinki* (TUR, OULU). **Oulun Pohjanmaa.** Kiiminki, limestone area by the old Kuusamo road, on *P. porelloides,* 12.IX.1962 *Ulvinen* (TUR, OULU). Kiiminki, Murtoinsaaret, on *P. asplenioides,* 5.IX.1968 *Ulvinen* (TUR, OULU). Muhos, Muhosperä, on *P. porelloides,* 17.V.1962 *Ohenoja 17a* (TUR, OULU).

The genus *Pleostigma* Kirschst. accommodates nine species of ascomycetes with black, globose to semiglobose ascomata and muriform spores. These species occur on various substrates.The ascomata of *P. jungermanniicola* form in succession in every other leaf axil of *P. asplenioides* s.l. As the growth of the fungus follows the growth of the host liverwort, the ascomata form a

zig-zag pattern on the stem, the size of the ascomata decreasing towards the apex of the host. On other hosts the perithecia may appear irregularly on the leaves or on the stem (Racovitza 1959). In addition to *P. jungermanniicola,* some other axil-dwelling, globose and glabrous ascomata have also been described from hosts belonging to Jungermanniales, including *Pleosphaerella haploziae* Racov., *P. lophoziae* Racov., and *Pleospora hepaticola* Walt. Watson. The ascomata of these related species also have a parenchymately built excipulum, bitunicate asci and brown, muriform spores. The reasons for this apparent similarity is still quite unclear. Both Döbbeler (1978, 2002) and Racovitza (1959) treated *Pleospora hepaticola* and *Pleostigma jungermanniicola* as different species, whereas Henderson (1972) proposed that *P. hepaticola* described by Watson (1914) is, in fact, *P. jungermanniicola.* These species are thought to be widespread and fairly common, but poorly studied (Döbbeler 1978). The scantiness of useful morphological characters of these minute organisms also accounts for the confusion.

Thirty records of *P. jungermannicola* were made from the regions of Varsinais-Suomi, Satakunta, Uusimaa, Pohjois-Karjala, Etelä-Häme, Pohjois-Häme, Oulun Pohjanmaa and Kainuu. Some of the known hosts are common and widespread in Finland, and probably would yield new records if examined.

Abbreviated species descriptions for additional species known from *P. asplenioides* s.l.

9. *Belonioscyphella hypnorum*

Apothecia up to 700–(1000) µm high, (150–) 200–450(–600) µm diam, scattered, usually on the stem, hymenium flat, reddish when fresh, without hairs, stalk 75–150(–260) µm thick, often curved. *Asci* 140–210 × 14–19 µm, unitunicate, thick-walled, clavate, 8-spored. *Spores* (27–)33–40(–45) × (6–)7–8.5(–9.5) µm, elongate-ellipsoid, hyaline, with 3 (sometimes 4–6) septa, not strongly constricted, bipolarly asymmetric. Apical cells at the other or both ends of the ascospore produce phialide-bearing hyphae as they germinate. *Phialides* 6–10 × 2.5–3 µm, phialospores single-celled, hyaline, ca. 2 µm diam, widely ellipsoid. (Abbreviated from Döbbeler 1986a). Only once recorded on different mosses and *P. asplenioides* by Racovitza (1960).

10. *Bryorella erumpens*

Ascomata 50–75 µm diam, glabrous, slightly conical, lower part immersed in the substratum. *Ostiole* circular, 6–11 µm diam. *Asci* 26–34 × 7–8 µm, bitunicate, from cylindrical to ellipsoid, eight-spored. *Spores* 9–11 × 3–3.5 µm, ellipsoid, two-celled with one or two oil-bodies in each cell, hyaline, slightly constricted at septum. (Abbreviated from Döbbeler 1978).

11. *Epibryon endocarpum*

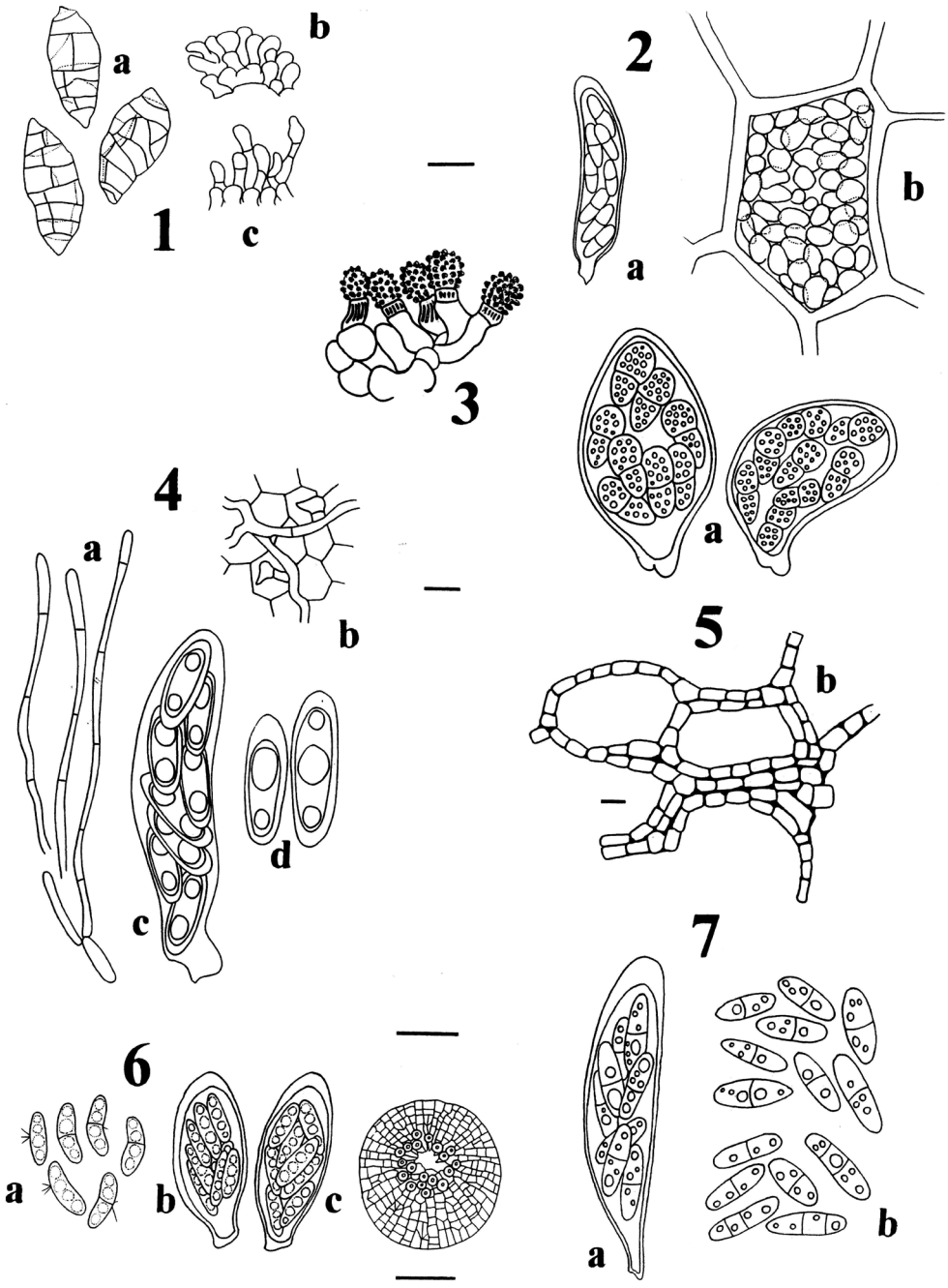
Ascomata solitarily within individual host leaf cells, (22–)25–35(–44) µm diam, 22–32(–40) µm high, perforating the host cell with an elongated, papilla-like neck. *Ostiole* 7–10 µm diam. *Asci* 11–15(–17) × 5–6 µm, bitunicate, ellipsoid, eight-spored. *Spores* 7–8(–8.5) × ca. 2 µm. two-celled, slightly or not constricted at septum. (Abbreviated from Döbbeler 1980a).

12. *Epibryon muscicola*

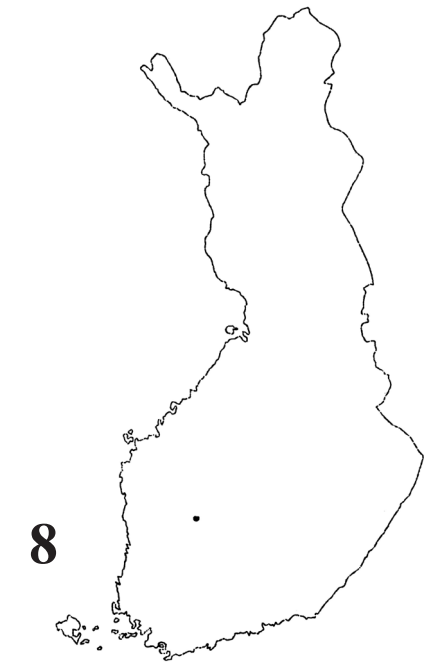
Ascomata 90–200 µm × 55–145 µm diam, pear-shaped, superficial, brown. *Ostiole* 17–25,5 µm in diam, protruding. *Hairs* 30–85 × 4–6 µm, dark brown, septate. *Asci* 45–90 × 12–18 µm, ellipsoid, eight-spored. *Spores* 12–28 × 6–8 µm, ellipsoid, four-celled, hyaline, not constricted at septa. *Hyphae* 2–4.5 µm in diam, light brown, superficial and intracellular. (Abbreviated from Racovitza 1959).

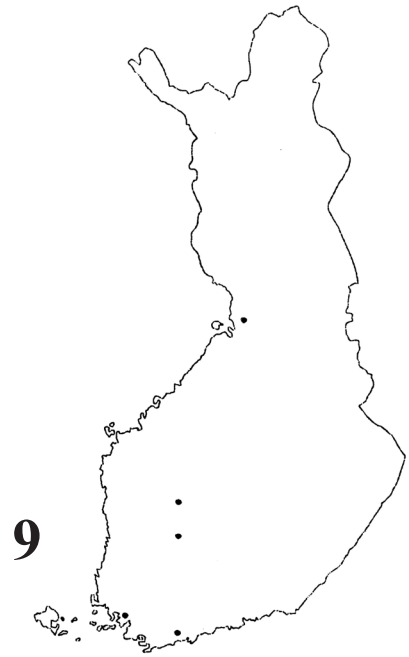
13. *Nectria racovitzae*

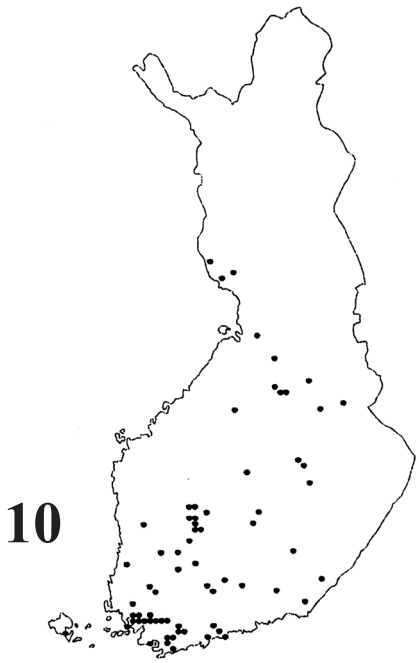
Ascomata 180–320 µm diam, spherical, from pale to bright orange, superficially, singly or sparsely aggregated. *Ostiole* small, not visible. *Hairs* 70 × 6(–10) µm, white, septate. *Asci* 60–85(–92) × 11–16 µm, cylindrical to narrowly ellipsoid, eight-spored. *Spores* (22–)25–35(–40) × (5.5–)6–7 µm, ellipsoid, two-celled, hyaline, slightly or not constricted, often with 2 large oil-bodies in each cell. (Abbreviated from Döbbeler 1978).

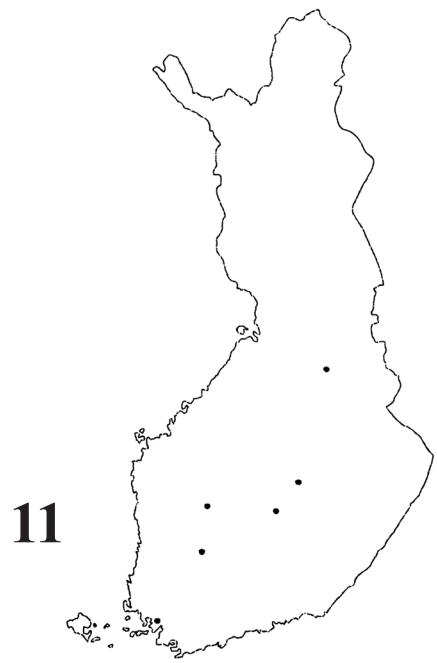


Figs. 1-7. Fungi on *Plagiochila* spp. 1) *Pleostigma jungermanniicola* – a = spores, b = excipulum, c = detail around ostiole. 2) *Epibryon plagiochilae* – a = ascus, b = host cell filled with mycelium. 3) *Epicoccum plagiochilae* conidiomata. 4) *Octosporella jungermanniarum* – a = paraphyses, b = hyphae with appressoria, c = immature ascus, d = mature spores. 5) *Bryomyces hemisphaericus* – a = mature asci, b = mycelium. 6) *Lichenopeltella alpestris* – a = spores, b = mature asci, c = ascoma. 7) *Dactylospora heimerlii* – a = mature ascus, b = spores, lower somewhat more rare. – Scales 10 µm, for ascoma 20 µm.

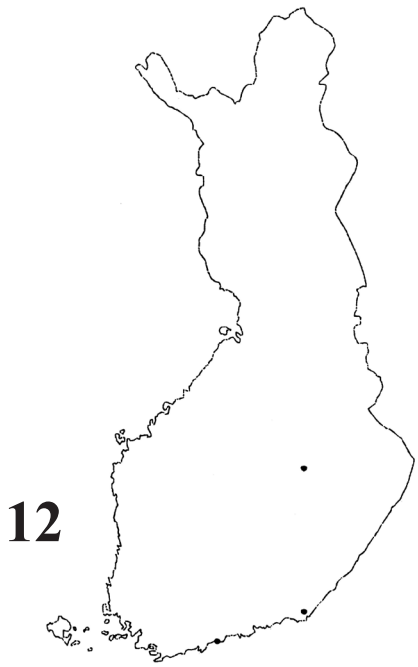


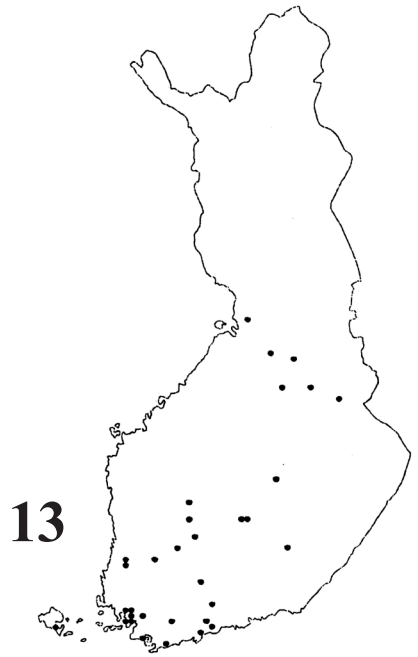


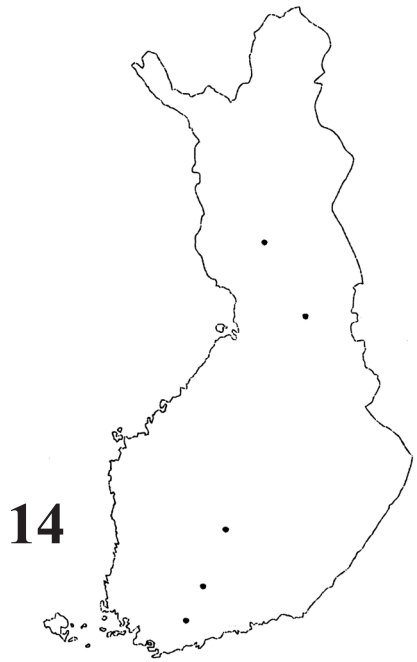


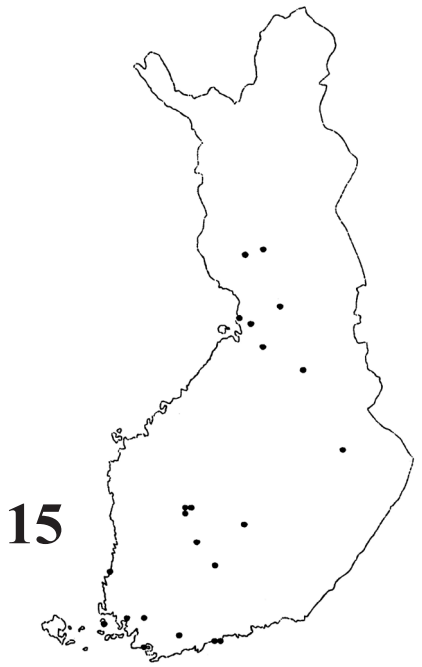


Figs 8-11. Distribution maps for fungi on *Plagiochila* spp. in Finland. 8) *Bryomyces hemisphaericus*. 9) *Dactylospora heimerlii*. 10) *Epibryon plagiochilae*. 11) *Epibryon* sp.









Figs 12-15. Distribution maps for fungi on *Plagiochila* spp. in Finland. 12) *Epicoccum plagiochilae*. 13) *Lichenopeltella alpestris*. 14) *Octosporella jungermanniarum*. 15) *Pleostigma jungermanniicola*.

14. *Nectria salisburgensis*

Ascomata 85–115 × 70–90 µm, densely covered by hairs, globose to pyriform, colourless, superficial. *Ostiole* inconspicuous. *Hairs* up to 40(–65) × 1.5–2.5 µm, thick-walled. *Asci* 18–28 × 4–5 µm, cylindrical, eight-spored. *Spores* (6–) 6.5–8.5 × 1.5–2 µm, narrowly ellipsoid to rod-shaped, two-celled, hyaline. *Hyphae* 1.5–3 µm diam, irregularly growing over and within the host cells. (Abbreviated from Döbbeler 1978). *Nectria salisburgensis* (syn. *N. hirta*) has been reported from decaying parts of *P. porelloides*. It is known only from the type collection.

15. *Phoma plagiochilae*

Pycnidia variable, (15–)20–45(–55) µm diam, glabrous, lower part immersed in host cell. *Ostiole* circular, 5(–6) µm diam, on the dorsal side of the leaf. *Conidia* elongate, hyaline, single-celled, 3.5–4.5(–5) × ca. 1 µm. *Hyphae* variable, brown, 1.5–2.5 µm diam. (Abbreviated from Döbbeler 1981a).

Discussion

Bryicolous ascomycetes are especially rewarding for studies concentrating on a single substrate. Even a regionally restricted floristic approach, as presented here, is interesting to carry out, and most likely rewards the researcher with pleasant surprises, such as new records for the area or country, new host species, and even previously undescribed species.

The pros for choosing herbarium specimens as research material are that the material is abundant, easy to obtain and collected from a geographically large area. As the material studied shows, bryicolous ascomycetes can be found and identified even from material collected a hundred years ago. The cons are that the mosses collected in herbaria are likely to be biased towards healthy and vigorous individuals, whereas a person interested in collecting bryicolous ascomycetes should not overlook poorly growing or atypical moss or hepatic material. As Döbbeler (1997) points out, necrotrophic species of bryicolous ascomycetes are certainly underrepresented in bryological collections for the reason stated above.

There are two main reasons to assume that bryicolous fungi are much more common than records indicate. Firstly, we have observed that mosses and hepatics are virtually never free of hyphal infections, but as for most ascomycete species, the identification is based on the fertile structures, which may or may not be present. Secondly, the distribution of infections in cushions or mats of mosses and hepatics is patchy, and the selection of host plants collected for microscopic investigation must be done randomly, since most of bryicolous ascomycetes escape even the highest magnification of hand-lenses used in the field. It is obvious, that the vast majority of bryicolous ascomycetes still wait to be discovered and bryophytes remain as an Eldorado for mycologists.

Acknowledgements: This work was supported by the Ministry of the Environment, Finland, as a part of the research program of deficiently known and threatened forest species (PUTTE). The curator of the herbarium OULU is warmly thanked for the loans. Jouni Issakainen and Tomi Laukka are thanked for useful comments on the manuscript.

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