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Lecidea phaeophysata: a new saxicolous lichen species from western and southern Europe with a key to saxicolous lecideoid lichens present on Atlantic coasts

Alan M. FRYDAY and Pieter P. G. VAN DEN BOOM

Abstract: The new lichen species *Lecidea phaeophysata* is described from rocks close to the coast in Italy, Portugal, France and Ireland. Distinguishing features include *Porpidia*-type asci and simple paraphyses that are fuscous brown pigmented in their upper section. Its systematic position is discussed but is unclear as molecular data are lacking (all collections are *c.* 20 years old). Therefore, we chose to describe the species in a broadly-circumscribed *Lecidea* rather than erecting a new monotypic genus. A key to saxicolous lecideoid lichens present on Atlantic coasts in Europe is also provided.

Key words: *Bryobilimbia*, coastal habitat, *Lecideaceae*, *Porpidia*-type ascus, taxonomy

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Introduction

The lichen biota of Western Europe is probably better studied and understood than any other region worldwide but collections of apparently undescribed species still occur with surprising regularity (e.g. Fryday & Coppins 2012; van den Boom *et al.* 2017). Among these are five collections of a novel saxicolous species, made between 1993 and 2001 in maritime areas of the Atlantic and Mediterranean coasts from north-west Italy to western Ireland. The new species could easily be mistaken in the field for a species of *Porpidia* Körb. but it is microscopically very distinctive because it possesses simple paraphyses that are pigmented in the upper 10–25 µm. As this combination of characters is unique, we also suspect that these collections represent a distinct lineage. However, as molecular data are lacking, we chose not to erect a new genus but instead to describe them in a broadly-circumscribed *Lecidea*.

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Materials and Methods

This study was based on specimens collected by the second author and by Maarten Brand (Leiden, the Netherlands). They were compared with specimens held in the herbarium of Michigan State University (MSC). Apothecial characteristics were examined by light microscopy on hand-cut sections mounted in water, 10% KOH (K), 50% HNO_3 (N), 15% HCl (H) or Lugol's reagent (0·15% aqueous IKI). The ascus structure was studied in IKI, both without and after pretreatment with K. Measurements of ascospores and paraphyses were made in K. Ascospore measurements are given in the format (lowest observed–) arithmetic mean ± standard deviation (–highest observed). Mean values are presented in bold.

The Species

Lecidea phaeophysata Fryday, van den Boom & M. Brand sp. nov.

MycoBank No.: MB 828933

Characterized by the *Porpidia*-type asci, narrow ellipsoid ascospores and simple paraphyses with the upper 10–25 µm pigmented.

Type: Italy, Liguria, Sestri Levante, S. Anna, *c.* 0·2 km from sea, near path to Roman bridges, 44°17′N, 9°22′E, 10 m, sandstone, of steep side (*sic*), in open *Pinus* woodland, 21 July 1993, *M. Brand* 30100 (L—holotype; hb. Brand, hb. v. d. Boom—isotypes).

(Fig. 1)

Thallus effuse, up to 5 cm diam., chasmolithic or thin diffuse, pale greenish when

fresh, creamish to brown in the herbarium; medulla I–. *Photobiont* chlorococcoid; cells 9–12 µm diam.

Apothecia (Fig. 1A–C) abundant, sessile, lecideine, *c.* 0·6–1·1 mm diam., black with plane, matt disc and slightly raised shiny margin, constricted below, especially in mature apothecia; proper margin 0·07–0·10 mm wide, prominent when young, occasionally becoming excluded in old apothecia. Only fuscous brown pigments present internally (Fig. 1D); pigment little changed in K or N although slightly paler in K and more orange-brown in N. *Excipulum* (Fig. 1E) well developed, *c.* 60–70 µm wide, cupular, continuous below the hypothecium, composed of parallel, radiating hyphae *c.* 5–6 µm wide with brown extracellular granules; cortical cells 7–10 µm diam. *Hymenium* 55–65 µm tall, paraphyses (Fig. 1F) *c.* 2·0–2·5 µm wide at the base and apex, thinning somewhat to *c.* 1·5–2·0 µm wide in mid-hymenium, unbranched, septate, cells *c.* 10 µm long, occasionally constricted at the septum, not capitate or strongly conglutinated, upper 10–25 µm pigmented fuscous brown, pigment sometimes extending all the way down to the hypothecium. *Asci* cylindrical, 35–50 × 10–12 µm, *Porpidia*-type (Fig. 1G, H), amyloid tube not reaching all the way to the apex in immature asci (Fig. 1G). *Ascospores* hyaline, ellipsoid, (11–)**14·33** ± 1·67(–18) × (4·0–)**4·79** ± 0·50(–5·5) µm (n = 12), perispore absent. *Hypothecium* brown, *c.* 100 µm tall; dark below composed of randomly-orientated hyphae, becoming paler with increasingly vertically-orientated hyphae towards the hymenium; hyphal pigment the same as that of the upper paraphyses.

Conidiomata uncommon, seen on only one collection (*Brand* 38356), flat, brown, 0·6–0·8 mm diam., sometimes with a gaping ostiole; conidia filiform, curved *c.* 14–16 × 0·5–0·6 µm.

Chemistry. K–, C–, KC–, Pd–, UV+ yellow (?carotenoids); thallus too scant for TLC.

Etymology. The name is derived from the dark pigmentation of the upper part of the paraphyses.

Distribution and ecology. The new species is widely distributed on the Atlantic coast of Western Europe from Ireland to Portugal, with one locality in Southern Europe on the Mediterranean coast in NW Italy (Fig. 2). It is found on siliceous rock in maritime areas mainly on or near the coast, on N-sloping overhanging acidic rocks, with only the Irish collection (*Brand* 40679) being more than 2 km from the sea, on an overhang near the entrance of a cave. The type specimen locality is situated on steep sandstone. In other areas it has possibly been overlooked, being mistaken for a species of *Porpidia* or other lecideoid species. However, it can be distinguished from these in the field by its apothecia having a narrow base which leaves the margins and much of the underside free of the substratum.

No other lichens are present on the type collection but there are saxicolous species associated with the other collections including: *Micarea botryoides* (Nyl.) Coppins, *Micarea prasina* Fr. s. lat. and *Gyrographa gyrocarpa* (Flotow) Ertz & Tehler (Ireland); and *Amandinea pelidna* (Ach.) Fryday & L. Arcadia, *Cliostomum tenerum* (Nyl.) Coppins & S. Ekman, *Dirina* cf. *fallax* De Not., *Lecanora praepostera* Nyl., *L. subcarnea* (Lilj.) Ach. and *Roccellographa circumscripta* (Taylor) Ertz & Tehler (France). The collection from Portugal is from the small rocky hill of São Bartolomeu, where van den Boom (2006) recorded 228 species on a wide range of substrata, including acidic rock.

Additional specimens examined. **France:** *Brittany*: Département du Mobihan, Ile de Groix, 4 km W of Port Tudy, Beg-Melen, just E of semaphore, 47°39·2′N, 3° 30′W, 40 m, mica-schist rock, high cliff above sea (exp. N), vertical to overhanging face, 1999, *A. M. Brand* 38356 (hb. Brand); Département d'Ille-et-Vilaine, 8 km ENE of St Malo, Pointe du Meings, N-side, 48°42·1′N, 1°55·8′W, gneiss rocks of headland, N-sloping rocks, 28 April, 1999, *A. M. Brand* 38864 (hb. Brand, hb. v. d. Boom).—**Ireland:** *Galway*: Connemara, Twelve Pins, S slope of Muckanaght, near saddle to Benbrack, 53° 31·5′N, 9°51·4′W, 350 m, mica-schist rocks on N-exposed slope, overhang near entrance of cave, 2000, *A. M. Brand* 40679 (hb. Brand, hb. v. d. Boom).—**Portugal:** *Leiria*: 2·7 km E of Nazaré, São Bartolomeu, small rocky hill, 39°35·4′N, 9°3·7′W, 100 m, W-exposed rocky slope along *Pinus pinaster* forest, steep rock face and boulders, 2001, *P. & B. van den Boom* 27778 (hb. v. d. Boom).

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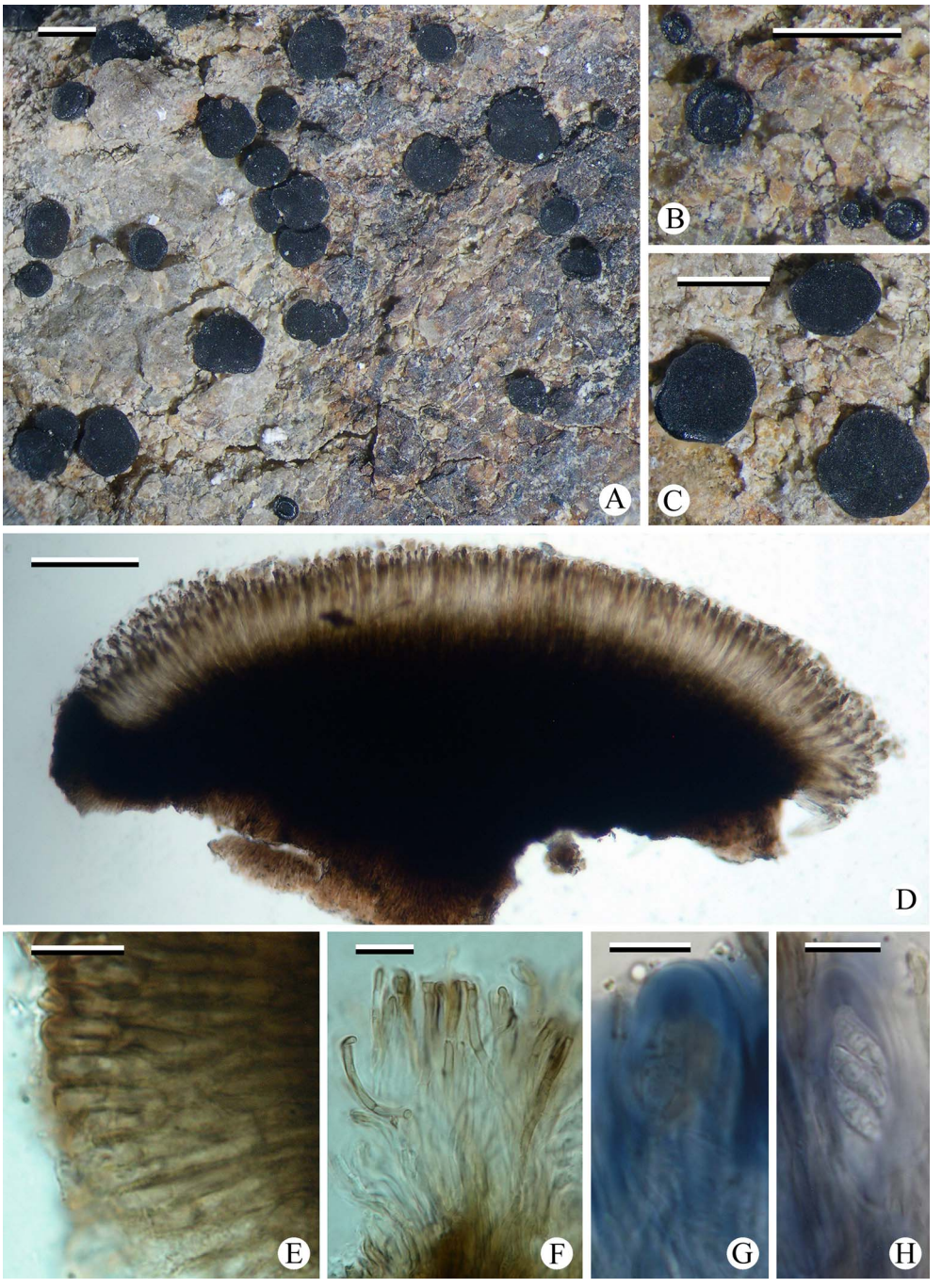

FIG. 1. *Lecidea phaeophysata* (*Brand* 30100—holotype). A, general view of thallus and apothecia; B, immature apothecia; C, mature apothecia; D, section through apothecium (in H_2O); E, section through exciple (in H_2O); F, paraphyses (in H_2O); G, immature ascus (in IKI); H, mature ascus (in H_2O). Scales: A–C = 1 mm; D = 100 μm; E = 20 μm; F–H = 10 μm. In colour online.

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FIG. 2. Map of Europe showing localities of collections of *Lecidea phaeophysata*.

Discussion

The combination of *Porpidia*-type asci and simple, non-captitate paraphyses with the upper section having a fuscous brown pigment appear to be unique to the new species. The *Porpidia*-type asci suggest a placement in the *Lecideaceae* but *Lecidea phaeophysata* does not fit comfortably in any described genus of that family. Clearly it does not belong to *Lecidea* Ach. s. str. because of the ascus type, and the genus *Porpidia* Körb. differs in having richly branched and anastomosing paraphyses; *Farnoldia* Hertel also differs in its carbonaceous exciple and capitate paraphyses. *Bryobilimbia* Fryday *et al.*, which also has *Porpidia*-type asci and ± simple, non-capitate paraphyses, is superficially similar and we initially planned to describe our new species in that genus. However, closer inspection revealed a number of significant differences between our new species and species of that genus. In particular, the epihymenial region of the paraphyses of *Bryobilimbia* is dilute brown or unpigmented which contrasts strongly with the pigmentation of the paraphyses in *L. phaeophysata* that regularly extends 10–25 µm into the hymenium, and often the entire length of the paraphysis through to the hypothecium is pigmented (Fig. 1F). In addition, the exciple of *Bryobilimbia* species is less strongly pigmented than the hypothecium and the excipular hyphae are much wider (6–10 µm) than those of *L. phaeophysata*. The pigment present in the exciple and hypothecium of *Bryobilimbia* species is reddish brown and K+ orange (?Superba-brown) and is clearly different from the fuscous brown pigment in our new species. The only Northern Hemisphere species of *Bryobilimbia* that commonly

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occurs on rocks, *B. ahlesii* (Körb.) Fryday *et al.,* is readily distinguished from the new species, even in the field, by its brown apothecial disc (especially when wet), a consequence of the dilute brown or unpigmented epihymenium, and is further distinguished microscopically by its broader ascospores ((5–)6–7(–9) µm; Aptroot *et al.* 2009). Also similar to *L. phaeophysata* is *Clauzadea* Hafellner & Bellem. but species of that genus occur on limestone, have branched and anastomosing paraphyses and the same reddish brown (K+ orange-brown) pigment as *Bryobilimbia*. Other genera with *Porpidia*-type asci that are similar to *Bryobilimbia* (*Lecidea berengeriana* group, *Lecidoma* Gotth. *et al.*, *Romjularia* Timdal) are all terricolous or bryicolous species and also differ in the pigmentation of their paraphyses (Fryday *et al.* 2014).

In the key to lichens of siliceous rocky shores (Fletcher 1975), *Lecidea phaeophysata* would key out as *Porpidia crustulata* (Ach.) Hertel & Knoph but it differs from that species, macroscopically, by the larger apothecia (typically 0·3–0·8 mm diam. in *P. crustulata*; Fryday *et al.* 2009) with a constricted base and, microscopically, by the simple paraphyses with pigmented upper section and the fuscous brown rather than red-brown pigment.

Between 1875 and 1878, Charles Larbalestier collected lichens extensively in Connemara (Mitchell 1998), including the area where one of the collections of *L. phaeophysata* (*Brand* 40679) was made. Nylander described numerous new species of *Lecidea* from these collections (see References in Mitchell (1998)) but perusal of 18 of these publications (including 10 containing species collected by Larbalestier and others containing species collected by Carroll or Hitchins) revealed nothing that could be an earlier name for *L. phaeophysata*. Nylander had a very wide concept of *Lecidea* that included species with septate spores and many of these taxa are now referred to other genera (e.g. *Bacidia*, *Buellia*, *Catillaria*, *Lecania*, *Micarea*, etc.) whereas others had already been reduced to synonymy with different species or the descriptions included characters (e.g. hyaline hypothecium, smaller or larger ascospores) that were incompatible with *L. phaeophysata*. The only species that could possibly have been an earlier name for *L. phaeophysata* was *L. valentior* Nyl., but that name has already been shown to be a synonym of *Bryobilimbia ahlesii* (Meyer 2002). The lectotype of *L. valentior* in H-Nyl was checked and this determination found to be correct.

The pigment present in *L. phaeophysata* appears most similar to Arnoldiana-brown (Meyer & Printzen 2000) but that pigment is reddish brown in water and changes between reddish brown at low pH and dark brown at high pH after pretreatment with either K or N. The pigment in *L. phaeophysata* is fuscous brown in water and changes little at low pH and high pH after pretreatment with K (somewhat lighter at low pH), although it does also change between reddish brown at low pH and dark brown at high pH after pretreatment with N.

Keys to saxicolous lecideoid lichens present on European Atlantic coasts

To aid identification of our new species and assist in separating it from other lecideoid species, we are providing keys to lichens that occur in the same or similar habitat. These keys include those lichen taxa with lecideine apothecia and either simple or septate spores, but exclude species of *Teloschistaceae*.

The decision as to which species to include was based on those species included in the keys of Fletcher (1975) and on our own field experience. Measurements of apothecia, ascospores etc. are mostly taken from Smith *et al.* (2009).

Ascospores simple ..... Key A
Ascospores septate ..... Key B

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Key A: saxicolous species with non-septate ascospores

1 Thallus C+ red (gyrophoric acid) or C+ orange (xanthones) 2
Thallus C− 11

2(1) Thallus C+ red, white, light to dark grey, or brown 3
Thallus C+ orange, yellow-green (*Lecidella* spp.) 9

3(2) Apothecia black 4
Apothecia brown (*Trapelia* and *Trapeliopsis* spp.) 7

4(3) Thallus shiny, with an epinecral layer; apothecia adnate to sessile; paraphyses ± simple 5
Thallus matt, without an epinecral layer; apothecia innate; paraphyses branched and anastomosing 6

5(4) Thallus grey ..... **Lecidea grisella**
Thallus brown ..... **Lecidea fuscoatra**

6(4) Thallus white; cephalodia present ..... **Amygdalaria pelobotryon**
Thallus dark grey; cephalodia absent ..... **Schaereria fuscocinerea**

7(3) Thallus thin, continuous ..... **Trapelia coarctata***
Thallus thicker, placodioid or subsquamulose 8

* The genus *Trapelia* in Europe was recently revised (Orange 2018) but as the distributions of the species segregated in that work are currently unclear, we treat only the species in their traditional circumscription.

8(7) Thallus white, placodioid, usually terricolous; apothecia rare ..... **Trapeliopsis wallrothii**
Thallus brown-grey, subsquamulose, usually saxicolous; apothecia frequent; ascospores 15–26 × 7–12 µm ..... **Trapelia glebulosa**

9(2) Thallus sorediate ..... **Lecidella scabra**
Thallus not sorediate 10

10(9) Thallus of corticate granules ..... **Lecidella asema**
Thallus of blastidia ..... **Lecidella meiococca**

11(1) Thallus K+ red or Pd+ red or yellow 12
Thallus K+ yellow or K−, Pd− 15

12(11) Thallus K+ red (red crystals in section; norstictic acid) 13
Thallus K−, Pd+ bright yellow or red 14

13(12) Apothecia ±pruinose; paraphyses simple; ascospores non-halonate ..... **Lecidea lactea**
Apothecia pruinose; paraphyses branched and anastomosing; ascospores halonate ..... **Porpidia platycarpoides**

14(12) Thallus shades of brown, Pd+ red (fumarprotocetraric acid); apothecia brown, sessile; ascospores bean-shaped ..... **Fuscidea cyathoides**
Thallus white, Pd+ bright yellow (psoromic acid); apothecia black, ±immersed; ascospores ellipsoid ..... **Lecidea phaeops**

15(11) Thallus rust red 16
Thallus white or grey or green, if reddish only patchily due to oxidization 17

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16(15) Thallus composed of bullate areoles; apothecia becoming sessile .. **Lecidea silacea**
Thallus of flat areoles; apothecia innate ..... **Tremolecia atrata**

17(15) Medulla I+ violet 18
Medulla I– 22

18(17) Thallus with tuberculate soralia ..... **Porpidia tuberculosa**
Thallus lacking soralia 19

19(18) Ascospores narrow ellipsoid, <4 μm wide 20
Ascospores broad ellipsoid, >5 μm wide 21

20(19) Exciple C+ red (2′-*O*-methylanziaic acid) ..... **Lecidea diducens**
Exciple C– ..... **Lecidea auriculata**

21(19) Apothecia innate; paraphyses branched and anastomosing; confluentic acid present (K+ oil droplets in section) ..... **Porpidia speirea**
Apothecia sessile; paraphyses simple; stictic acid present (K+ yellow solution in section) ..... **Lecidea lapicida**

22(17) Asci multi-spored, >100 ascospores per ascus; apothecia red-brown, blue-grey pruinose ..... **Sarcogyne regularis**
Ascospores 8 per ascus 23

23(22) Epihymenium K+ crimson; apothecia orange or red (*Protoblastenia* sp.); on calcareous rocks 24
Epihymenium not K+ crimson; apothecia black or brown; on calcareous or acidic rocks 26

24(23) Thallus distinctly epilithic, often cracked ..... **Protoblastenia rupestris**
Thallus endolithic to weakly epilithic 25

25(24) Apothecia immersed to semi-immersed in the rock, small, 0·2–0·5 mm, concave, plane or weakly convex. ..... **Protoblastenia incrustans**
Apothecia sessile, large, 0·4–1·6 mm, convex to strongly convex .. **Protoblastenia calva**

26(23) Apothecia rare; pycnidia frequent 27
Apothecia frequent 28

27(26) Pycnidia stalked; over bryophytes in shaded areas ..... **Micarea botryoides**
Pycnidia sessile; on rock ..... **Herteliana gagei**

28(26) Thallus composed of green goniocysts ..... **Micarea prasina** agg.
Thallus not composed of green goniocysts 29

29(28) Paraphyses lax in K (*Lecidella* spp.) 30
Paraphyses ±conglutinate 31

30(29) Hypothecium brown; thallus well developed, white ..... **Lecidella carpathica**
Hypothecium hyaline; thallus poorly developed or endolithic, greyish ..... **Lecidella stigmatea**

31(29) Ascospores large, >70 μm long, < 8 per ascus; red pigment present below apothecia ..... **Mycoblastus sanguinarius**
Ascospores smaller, 8 per ascus; red pigment absent 32

32(31) Hypothecium hyaline 33
Hypothecium pigmented 36

33(32) Thallus whitish 34
Thallus dark grey or greenish yellow 35

34(33) Apothecia angular with thin proper margin; paraphyses ±simple..... ..... **Lecidea lithophila**
Apothecia rounded with thicker proper margin; paraphyses branched ..... **Miriquidica leucophaea**

35(33) Thallus dark grey ..... **Fuscidea lygaea**
Thallus greenish yellow ..... **Lecanora sulphurea**

36(32) Hymenium with red, K+ purple pigment ..... **Lecidea sarcogynoides**
Hymenium ±hyaline 37

37(36) Apothecia <0·5 mm, hymenium <50 µm (*Micarea* spp.) 38
Apothecia >0·5 mm, hymenium >50 µm 39

38(37) Thallus epilithic, grey; apothecia usually with distinct proper margin .... **Micarea erratica**
Thallus ± endolithic; apothecia globose, proper margin ±absent ....**Micarea lutulata**

39(37) Paraphyses simple, upper 20 µm pigmented ..... **Lecidea phaeophysata**
Paraphyses branched and anastomosing 40

40(39) On ±calcareous substrata; hypothecium paler than exciple, only brown pigments internally 41
On siliceous substrata; hypothecium and exciple concolorous, greenish pigments often present internally (*Porpidia* spp.) 43

41(40) Apothecia immersed in the substratum ..... **Clauzadea metzleri**
Apothecia sessile 42

42(41) Hymenium usually with violet (K+ blue) granules; ascospores often 1-septate .... **Bryobilimbia hypnorum**
Hymenium lacking violet (K+ blue) granules; ascospores never septate ..... **Clauzadea monticola**

43(40) Exciple with hyaline medulla, excipular hyphae 2–3 µm wide 44
Exciple pigmented throughout, excipular hyphae wider 45

44(43) Epihymenium bright blue; thallus lacking lichen substances; not sorediate .... **Porpidia hydrophila**
Epihymenium olivaceous or brown; thallus containing 2′-*O*-methylsuperphyllinic acid; often sorediate ..... **Porpidia rugosa**

45(43) Exciple medulla pale brown, less pigmented than cortex; paraphyses richly branched and anastomosing; stictic acid or no substances present 46
Exciple ±uniformly dark; paraphyses sparingly branched and anastomosing; confluentic acid or methyl 2-*O*-methylmicrophillinate present 47

46(45) Proper margin thin and barely raised, <0·08 mm wide; mature apothecia <1·5 mm diam.; thallus epilithic, thin ..... **Porpidia crustulata**
Proper margin thick and raised, >0·1 mm wide; mature apothecia >1·5 mm diam.; exciple pale to mid brown internally; thallus ± endolithic .... **Porpidia macrocarpa**

47(45) Thallus containing confluentic acid (K+ oil droplets in section) ..... **Porpidia cinereoatra**
Thallus containing methyl 2′-*O*-methylmicrophillinate (K–) 48

48(47) Apothecia innate ..... **Porpidia contraponenda**
Apothecia sessile ..... **Porpidia irrigua**

Key B: saxicolous species with septate ascospores and brown to black apothecia

1 Ascospores hyaline 2
Ascospores brown 22

2(1) Ascospores 1-septate 3
Ascospores 3- or more septate or muriform 11

3(2) Apothecia marginate, sessile 4
Apothecia immarginate, immersed ..... **Arthonia meridionalis**

4(3) Medulla I+ violet 5
Medulla I– 6

5(4) Thallus brown with a grey-violet tinge, C+ red; apothecia up to 1 mm diam.; epihymenium K– ..... **Rhizocarpon richardii**
Thallus dark brown with a faint grey or pink tinge, C–; apothecia up to 0·7 mm diam.; epihymenium K+ purple-red ..... **Rhizocarpon polycarpum**

6(4) Apothecia 0·4–0·8 mm diam. 7
Apothecia 0·2–0·4 mm diam. 8

7(6) Thallus epilithic on siliceous rock; ascospores elongate-ellipsoid, 10–15 × 3–5 μm; hypothecium pale ..... **Tylothallia biformigera**
Thallus endolithic on limestone; ascospores ellipsoid, 9·5–12·5 × 4·0–5·5 μm; hypothecium reddish brown ..... **Toninia athallina**

8(6) Hypothecium hyaline 9
Hypothecium dark brown 10

9(8) Apothecia 0·1–0·2 mm diam., excipulum green-black throughout; on siliceous rock ..... **Catillaria atomarioides**
Apothecia 0·1–0·4 mm diam., excipulum pale at inner part; on limestone ..... **Catillaria lenticularis**

10(8) Ascospores (7·5–)9·0–12·0(–15·0) × 2·5–4·0 μm ..... **Catillaria chalybeia**
Ascospores 15–18 × 7·0–8·5 μm ..... **Rhizocarpon infernulum**

11(2) Ascospores with only transverse septa 12
Ascospores muriform 21

12(11) Ascospores 10–17-septate, 60–95 × 3–4 μm ..... **Bactrospora patellarioides**
Ascospores 3–7-septate; <60 μm long 13

13(12) Apothecia marginate; ascospores 3-septate; thallus pale grey to pale brown, squamulose ..... **Toniniopsis aromatica**
Apothecia immarginate or margin soon excluded; ascospores 3–7-septate 14

14(13) Apothecia immarginate; ascospores 3–5-septate; thallus brown with faint mauve tinge ..... **Arthonia phaeobaea**

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Apothecia margin present in young apothecia but soon excluded; thallus without faint mauve tinge 15

15(14) Ascospores 3-septate; thallus crustose ..... **Toniniopsis mesoidea**
Ascospores 3–7-septate; thallus crustose or squamulose 16

16(15) Apothecia brown 17
Apothecia black 19

17(16) Ascospores needle-shaped, spirally twisted ..... **Scoliciosporum umbrinum**
Ascospores ellipsoid 18

18(17) Thallus irregularly granular-warted; apothecia common; ascospores 1–3(–5)-septate, narrowly fusiform, 14–28 × 2–3 μm ..... **Lecania cuprea**
Thallus of rounded, flattened or coralloid granules; apothecia rare; ascospores 3–7-septate, bacilliform, 30–38 × 1·5–2·0 μm ..... **Bacidia scopulicula**

19(16) Thallus black, minutely squamulose; prothallus dark bluish to black; ascospores 1–3-septate ..... **Placynthium nigrum**
Thallus not black, squamulose; prothallus not visible 20

20(19) Thallus yellow-brown, C+ orange; paraphyses ±conglutinated **Toninia thiopsora**
Thallus brown-grey, C–; paraphyses ±lax ..... **Toninia squalida**

21(11) Thallus white; apothecia up to 1 mm diam.; epihymenium olive brown; ascospores usually >35 μm long ..... **Rhizocarpon petraeum**
Thallus grey to brown; apothecia 0·4–0·6 mm diam.; epihymenium olive green; ascospores <30 μm long ..... **Rhizocarpon reductum**

22(1) Thallus placodioid with marginal lobes 0·5–1·0 mm wide 23
Thallus crustose or without marginate lobes 24

23(22) Thallus with small marginal lobes, up to 0·5 mm wide; apothecia immersed, often with a white pruina; ascospores rugulate, 8–12 × 5–8 μm ..... **Dimelaena radiata**
Thallus with marginal lobes *c.* 1 mm wide; apothecia sessile, epruinose ..... **Diploicia canescens**

24(22) Ascospores submuriform to muriform 25
Ascospores 1-septate 27

25(24) Thallus green; ascospores muriform ..... **Rhizocarpon geographicum**
Thallus white or grey; ascospores submuriform, with a few longitudinal septa (*Diplotomma* spp.) 26

26(25) Thallus K+ red (red crystals in section) ..... **Diplotomma chlorophaeum**
Thallus K– ..... **Diplotomma alboatrum**

27(24) Ascospores double-walled, walls variously thickened 28
Ascospore wall of uniform thickness 33

28(27) Ascospores *Physconia*-type 29
Ascospores of different type 31

29(28) Thallus rimose, whitish to brown; ascospores 10–15 × 6·5–8·5 µm ..... **Amandinea pelidna**
Thallus areolate to bullate to bullate-subsquamulose 30

30(29) Conidia filiform, 15–30 µm long; thallus areolate to bullate, pale to dark brown ..... **Amandinea coniops**
Conidia bacilliform, 5–6 µm long; thallus flat, bullate to bullate-subsquamulose, whitish to ochraceous ..... **Buellia dispersa**

31(28) Ascospores *Mischoblastia*-type ..... **Rinodina oxydata**
Ascospores of different type 32

32(31) Thallus C+ red; ascospores between *Physcia* and *Milvina*-type ..... **Rinodina luridescens**
Thallus C–; ascospores *Pachysporaria*-type ..... **Rinodina beccariana** var. **lavicola**

33(27) Apothecia immersed 34
Apothecia adnate to sessile 35

34(33) Thallus K+ red (norstictic acid); ascospores 12–18 × 6–10(–12) µm ..... **Buellia aethalea**
Thallus K+ yellow (atranorin); ascospores 10–13 × 5·0–7·0(–8·5) µm ..... **Buellia stellulata**

35(33) Thallus K+ red, C+ red or C+ orange 36
Thallus K– or K+ yellow and C– 39

36(35) Thallus K+ red (norstictic acid) 37
Thallus K– or K+ yellow (different chemistry) 38

37(36) Thallus containing xanthones (UV+ orange); conidia 6–7 × 1·0–1·2 µm ..... **Buellia indissimilis**
Thallus without xanthones (UV–, but with atranorin); conidia 9–13 × 0·8–1·0 µm ..... **Buellia subdisciformis**

38(36) Thallus rimose cracked, yellow-grey, C+ red, UV– (gyrophoric acid) ..... **Buellia saxorum**
Thallus areolate, white to pale yellow-grey, C+ orange, UV+ orange (xanthones) ... **Buellia ocellata**

39(35) Hymenium inspersed with oil droplets ..... **Buellia leptoclinoides**
Hymenium clear 40

40(39) Thallus delimited by a dark fimbriate prothallus, K+ sordid yellow-brown, KC+ brownish orange or KC+ briefly pinkish ..... **Buellia tesserata**
Thallus not delimited by a dark fimbriate prothallus; thalline reactions different ... 41

41(40) Conidia bacilliform, up to 8 µm long 42
Conidia filiform, up to 30 µm long ..... **Amandinea punctata**

42(41) Thallus forming rosettes, well delimited by a pale prothallus; apothecia adnate, rarely sessile, up to 0·5 mm diam; conidia 2·5–4·0 × 1·0–1·5 µm . **Buellia caloplacivora**
Thallus not forming rosettes; apothecia cryptolecanorine to adnate, up to 0·7 mm diam.; conidia 4–6 × 1 µm ..... **Buellia spuria**

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