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Research

Three overlooked species of *Bacidia* from insular Laurimacaronesia

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We discuss the taxonomy of three species of *Bacidia* occurring in insular Laurimacaronesia. Two of them, *B. amylothelia* (Vain.) Vain. and *B. endoleucoides* (Nyl.) Zahlbr., which were previously described from Angola and Madeira, respectively, are found here to belong in *Bacidia s. str.* (Ramalinaceae). Modern descriptions and illustrations are provided for the first time. *Bacidia amylothelia* is similar to *B. areolata* Gerasimova & A. Beck, *B. campalea* (Tuck.) S. Ekman & Kalb, *B. fusconigrescens* (Nyl.) Zahlbr., *B. heteroloma* (Vain.) Zahlbr., *B. millegrana* (Taylor) Zahlbr. and *B. suffusa* (Fr.) A. Schneid. and is reported here from the Canary Islands. *Bacidia endoleucoides* is most likely to be confused with *B. absistens* (Nyl.) Arnold, *B. friesiana* (Hepp) Körb., *B. salazarensis* B. de Lesd. and *B. caesiovirens* S. Ekman & Holien and was found to be widely distributed in the Canary Islands and Azores in addition to Madeira. The third species, *Bacidia deludens* S. Ekman, Tønsberg & van den Boom, is described here as new to science. *Bacidia deludens* is characterised by a greyish, crustose thallus with whitish soralia, pale apothecia with crystals in the hymenium and proper exciple, acicular ascospores with 3–19 septa, and the production of fumarprotocetraric acid as the consistently present major substance. It is described here from the Canary Islands and Madeira. Although conservatively treated here in *Bacidia*, we argue that it is likely to belong in the Malmideaceae. An identification key to all known species of *Bacidia* s. str. in insular Macaronesia is provided.

Keywords: *Bacidia*, determination key, Malmideaceae, new species, Ramalinaceae

Introduction

During ongoing investigations of the lichen flora of Macaronesia (van den Boom and Magain 2020 and references therein), the junior author came across three *Bacidia*-like species. Further studies of that material as well as a number of types of previously published names indicated that two of them belong in *Bacidia* s. str. (Ramalinaceae) and correspond to the named but poorly understood species *B. amylothelia* (Vain.) Vain. and *B. endoleucoides* (Nyl.) Zahlbr. We provide here the first modern descriptions and illustrations of these species and provide an identification key to all currently known members of *Bacidia* s. str. in insular Laurimacaronesia. The third species posed more of

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an enigma, displaying superficial similarities with *Bacidia* s. str. in the acicular ascospores (Ekman 1996, Kistenich et al. 2018). However, it finally became clear from ascus studies that similarities with the Ramalinaceae were only superficial and that the third species represents an undescribed species that is likely to belong in the Malmideaceae. It is described here but provisionally placed in the genus *Bacidia* as *B. deludens*.

Material and methods

Microscopic characters were investigated either in a 10% aqueous solution of KOH (ascospores, paraphyses) or in pure water (all other characters). The nomenclature and identification of apothecial and pycnidial pigments follow Meyer and Printzen (2000). Descriptions are based on the cited Macaronesian material only. Colour reactions of pigments were observed in K (a 10% aqueous solution of KOH), N (a 35% aqueous solution of HNO_3) and a 15% aqueous solution of HCl. Measurements of quantitative characters are given either as 'minimum value – maximum value' or 'minimum value – arithmetic mean value – maximum value (s = sample standard deviation, n = sample size)'. Asci were stained with a 0.3% w/w aqueous solution of IKI for the study of tholus structures. Lichen substances were screened using high performance thin layer chromatography (HPTLC) according to Arup et al. (1993) in system A (*Bacidia amylothelia*, *B. endoleucoides*) or thin layer chromatography (TLC) according to Orange et al. (2010) in system A, B and C (*Bacidia deludens*). Coordinates are provided as latitude-longitude in the WGS84 reference system, either as decimal degrees or degrees + decimal minutes.

Taxonomy

Bacidia amylothelia (Vain.) Vainio (1926, p. 18), MB377918 (Fig. 1)

Basionym: *Lecidea laurocerasi* var. *amylothelia* Vainio (1901, p. 420), MB607922.

Type: Angola, Cuanza Norte: Golunga Alta, hab. in truncos juniores in sylvis prope Sange, undated, F. Welwitsch: Iter Angolense 184 (BM 001096042–holotype, seen by SE).

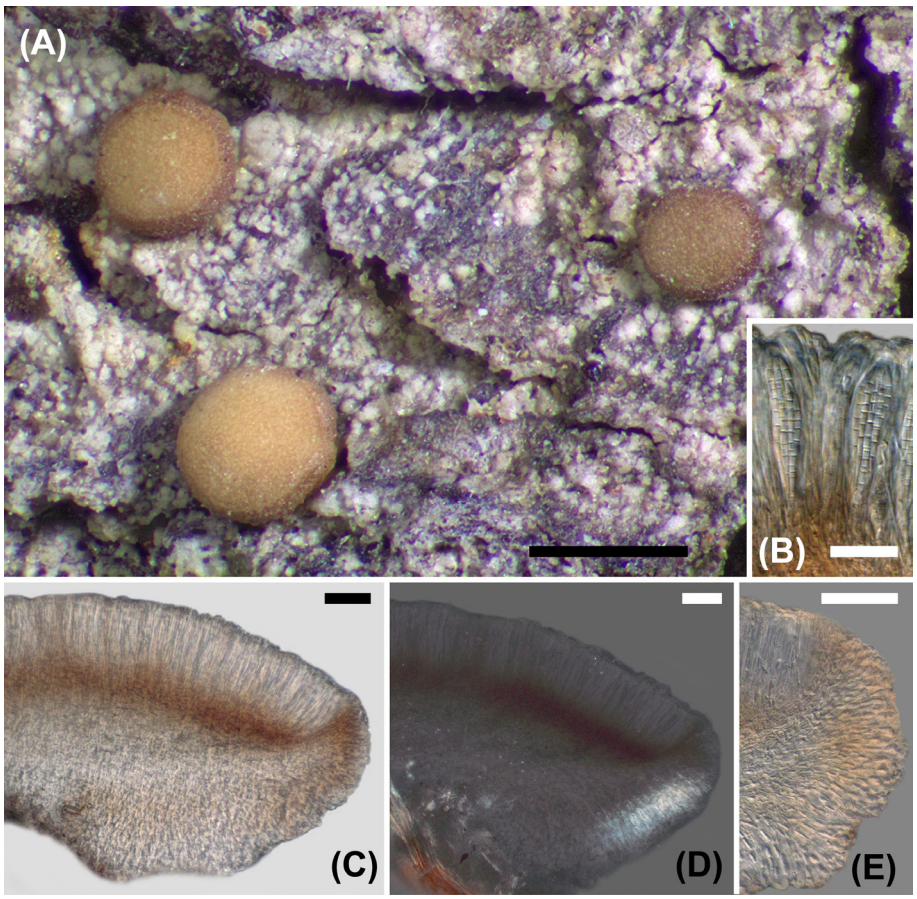

Figure 1. *Bacidia amylothelia*. (A) Thallus with apothecia. (B) part of hymenium showing asci with ascospores, (C) section through apothecium in bright-field showing pigmentation, (D) section through apothecium in polarized light showing minute crystals appearing as white shine in proper exciple, (E) section through proper exciple, showing enlarged cell lumina of terminal excipular hyphae. (A–E): van den Boom 45747. Scales: 0.5 mm (A), 25 µm (B), 50 µm (C–E).

Nomenclature

When Vainio (1901) described *Lecidea laurocerasi* var. *amylothelia*, he cited the Welwitsch gathering Iter Angolense 184, which may be represented by duplicates in other herbaria. However, the preface by George Murray in Hiern (1896, p. v–vi) makes it clear that the entire catalogue project dealing with the Welwitsch collections, to which Vainio contributed the lichens, is based on the specimens housed in BM. There is no type material in Vainio's lichen herbarium at TUR. Consequently, the name appears to be based on the single specimen in BM, which we refer to as the holotype.

Description

Thallus crustose, thin to medium thick, almost white to light greenish grey, ranging from discontinuous, of scattered, ± convex and often slightly effigurate areoles, to continuous, ± cracked, with warted surface. Prothallus lacking or present, forming thin black lines in competition with other lichens. Photobiont a member of Trebouxiophyceae, unicellular, cells globose or short-ellipsoidal, 4.5–11.0 µm long.

Apothecia biatorine, 0.4–0.6–1.0 mm diam. (s = 0.1, n = 20), at first flat, becoming more or less convex with age. Disc pale brownish yellow to beige to grey-brown, with ± thin, white pruina. Margin concolorous with disc or slightly paler or darker, distinct, slightly raised above disc in young apothecia, soon level with the disc, persistent or becoming excluded in convex apothecia, ± with white pruina, particularly close to the disc. Proper exciple 49–56–61 µm wide (s = 5, n = 10), in lower part with numerous and diffusely distributed, short-bacilliform, tiny (ca 1 µm long) crystals that are soluble in K, ± diffusely brown-orange (K+ intensifying) along edge and sometimes also in inner part closest to hypothecium, otherwise ± unpigmented; excipular hyphae dichotomously branched, in inner part of exciple with long and narrow lumina (0.8–1.3 µm wide) and very thick and gelatinized walls; terminal 5–6 cells with cell lumina gradually larger towards the edge, up to 8 µm wide. Hypothecium ± brown-orange (K+ intensifying). Hymenium 66–73–81 µm tall (s = 5, n = 10), colourless except for very pale orange to pale brown-orange (K+ intensifying) epihymenium with crystals (soluble in KOH). Paraphyses 1.2–1.7–2.0 µm wide in mid-hymenium (s = 0.3, n = 20), unbranched or moderately branched in upper part; apices ± clavate, 2.0–3.4–5.1 µm wide (s = 0.9, n = 20), without pigment. Asci clavate; young spore mass forming a bluntly and broadly conical ocular chamber; tholus staining dark blue in I with a paler blue, narrowly conical axial body, the zone closest to the axial body concolorous with rest of the tholus. Ascospores 8 per ascus, colourless, without perispore or ornamentation, acicular, straight or shallowly helical, straight or somewhat coiled in young asci, 39–47–57 µm long (s = 4, n = 20), 2.3–3.0–3.1 µm wide (s = 0.2, n = 20), 12.5–15.8–24.7 times as long as wide (s = 2.5, n = 20), with 3.0–7.5–13.0 septa (s = 2.2, n = 20).

Conidiomata not seen.

Chemistry and pigmentation

Thallus without acetone-soluble lichen substances or with atranorin in trace amounts, K–, C–, KC–, PD–. Rubella-orange in proper exciple, hypothecium and epihymenium.

Distribution and habitat

Bacidia amylothelia was described from northwestern Angola by Vainio (1901) and is reported here as new to insular Laurimacaronesia, where it is known from the two Canary Islands Tenerife and La Palma. It has also been reported from South Africa by Vainio (1926), but we were unable to locate that material. As the species was originally discovered on 'young trees', it might turn out to be weedy and substantially overlooked in at least the Old World tropics and subtropics. Two Tenerife collections are from the phorophyte *Laurus novocanariensis*, growing on branches. One La Palma collection was found on a trunk of a small *Laurus* tree (9 cm diam.) and one on a medium-sized trunk of *Ocotea foetens*.

Remarks

Bacidia amylothelia is a member of *Bacidia* in a strict sense on account of the heavily gelatinized excipular cells with long and narrow cell lumina (Kistenich et al. 2018). It can be identified by its distinctly orange-brown hypothecium, superficial white pruina, presence of minute crystals predominantly in the lower part of the exciple near the edge, no radiating clusters of large crystals in the proper exciple, and an indistinctly delimited 5–6-layer zone of enlarged cell lumina along the excipular edge. Apothecia in the Macaronesian specimens are, however, on average somewhat paler than in the type material, although apothecial colour in the holotype varies from grey-brown to orange-brown to purplish black. Similar and possibly closely related species include *B. areolata* Gerasimova & A. Beck (colourless or pale yellow hypothecium, no crystals or radiating crystal clusters in the proper exciple, distinct 3–4-layer zone of enlarged cell lumina along excipular edge; Gerasimova et al. 2018), *B. millegrana* (Taylor) Zahlbr. (colourless or pale yellow hypothecium, no crystals or radiating crystal clusters in the proper exciple, distinct 2-layer zone of enlarged cell lumina along excipular edge; Ekman 1996, p. 69), *B. suffusa* (Fr.) A. Schneid. (yellowish hypothecium, usually radiating crystal clusters in the proper exciple, distinct 4–6-layer zone of enlarged cell lumina along excipular edge; Ekman 1996, p. 108–109), *B. fusconigrescens* (Nyl.) Zahlbr. (similar to *B. suffusa* but with minute crystals evenly distributed throughout proper exciple; Ekman 1996, p. 69), *B. campalea* (Tuck.) S. Ekman & Kalb (brown-orange to brown hypothecium, proper exciple with large crystal clusters in lower part and with evenly dispersed and minute crystals in upper part, cell lumina along excipular edge as in *B. amylothelia*; Ekman 1996, p. 68–69), as well as *B. heteroloma* (Vain.) Zahlbr., which is known only from the Angolan type material and is characterized by the pale brown hypothecium, evenly distributed minute crystals in the proper exciple, and absence of enlarged cell lumina along the excipular edge (based on observations in the syntypes BM 001107917 and BM 001107919 by SE).

Additional specimens examined

Canary Islands, Tenerife, Las Montanas de Anaga, SW of Chamorga, E of Las Piedras, small open areas along trail from start at road TF 123, through a small mirador to end of trail, laurisilva with E- to N-exposed vertical outcrops, 28°33'63''N, 16°10'11''W, elev. 780 m a.s.l., 02 Mar 2011, P. & B. van den Boom 45747, 45759 (herb. van den Boom). La Palma, 3.5 km WSW of Los Sauces, Los Tilos, laurisilva, narrow cleft with path along N facing volcanic outcrops, between tunnel and mirador, 28°47'10''N, 17°48'60''W, elev. 750 m a.s.l., 27 Oct 2012, P. & B. van den Boom 48327 (herb. van den Boom). La Palma, N of Santa Cruz, W of La Galga, Cubo de La Galga, laurisilva in big valley with steep shaded volcanic outcrops, 28°45'60''N, 17°47'00''W, elev. 650 m a.s.l., 31 Oct 2012, P. & B. van den Boom 48664 (herb. van den Boom).

Bacidia endoleucoides (Nyl.) Zahlbruckner (1926, p. 193), MB378074 (Fig. 2)

Basionym: *Lecidea endoleucoides* Nyl. in von Krempelhuber (1868, p. 234), MB390568.

Type: Portugal. Madeira, 1867, A. da Costa de Paiva s.n. [= Barão de Castelo de Paiva] (H-NYL 17072–syntype, seen by SE).

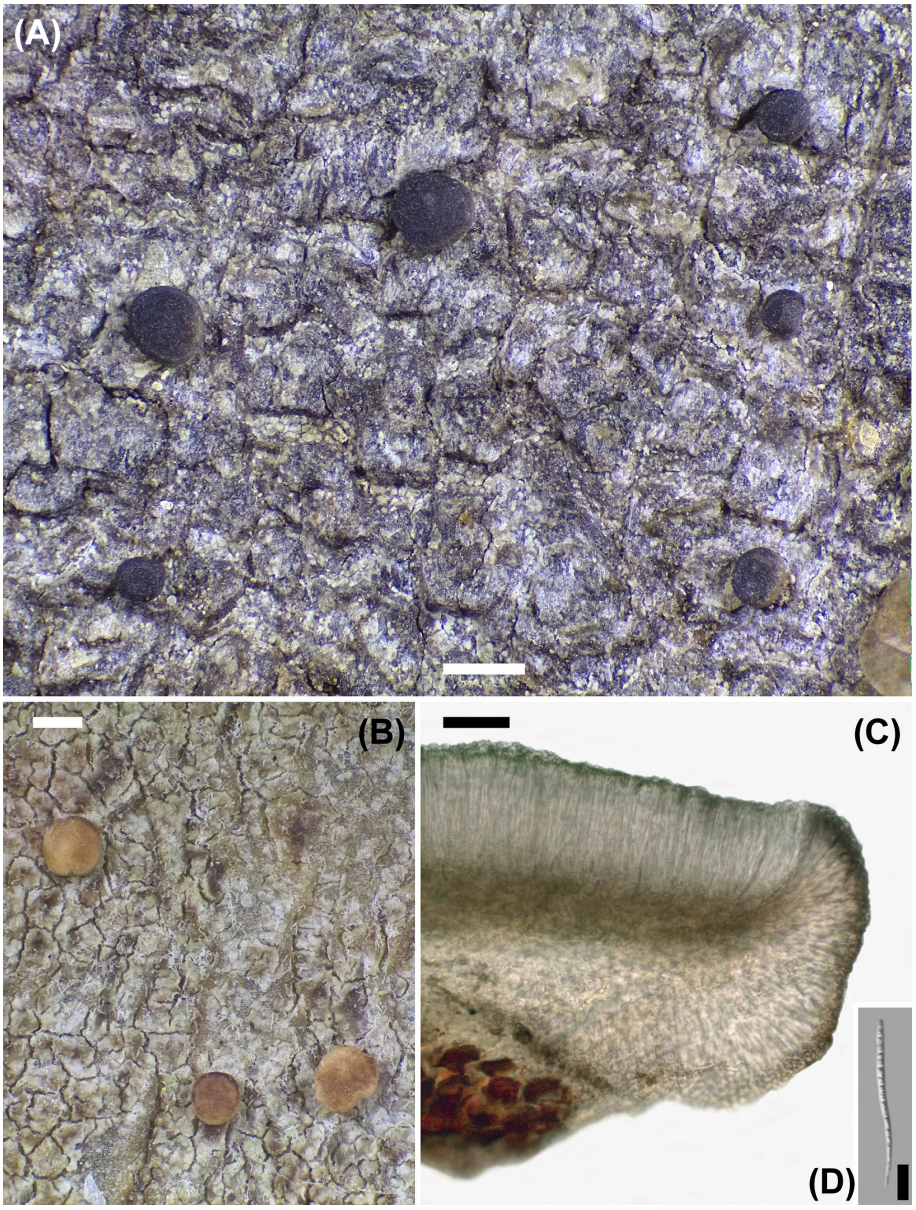

Figure 2. *Bacidia endoleucoides*. (A) Thallus and apothecia in normally pigmented specimen, (B) Thallus with partially pigment-deficient apothecia, (C) Section through apothecium, (D) Ascospore. (A, C, D): van den Boom 48374; (B): van den Boom 48513. Scales: 0.5 mm (A, B), 50 µm (C), 10 µm (D).

Nomenclature

Species described as new in von Krempelhuber (1868) are all suffixed 'Nyl. spec. nov.', and in the text there is a reference to a letter from Nylander (either as 'Nyl. in litt.' or 'Nyl. l. c.'). We interpret this to mean that the descriptions were worded by Nylander in this letter and used by von Krempelhuber. Therefore, we cite the basionym as 'Nyl. in Kremp.' as opposed to 'Nyl. ex Kremp', which would have been correct if descriptions were worded by von Krempelhuber (ICN Art. 46.5). Krempelhuber (1868) describes how the relatively small Madeiran lichen collection by Costa de Paiva was sent to Germany and made available to him. There are no duplicates or other gatherings of *Lecidea endoleucoides* in M (where the Madeiran Costa de Paiva lichen collection is housed) and the only specimen appears to have been sent to Nylander. However, as Nylander was living in Paris at the time, the specimen may have been divided and a duplicate may be present in PC (which did not respond to a request for material). Therefore, we refer to the material in H-NYL as a syntype for the time being.

Description

Thallus crustose, thin, almost white to light grey, ranging from discontinuous, of scattered, convex areoles, to continuous, cracked or areolate and with a warted surface. Prothallus lacking. Photobiont a member of Trebouxiophyceae, unicellular, cells globose or short-ellipsoidal, 4.5–9.5 µm long.

Apothecia biatorine, 0.3–0.4–0.7 mm diam. (s = 0.1, n = 40), at first flat, becoming more or less convex with age. Disc mostly bluish grey to bluish black, sometimes entirely or partially paler, ± beige to purplish brown. Margin in upper part concolorous with disc or paler, paler in lower part, distinct, slightly raised above disc in young apothecia, soon level with disc, becoming excluded in convex apothecia. Proper exciple 37–53–71 µm wide (s = 7, n = 20), without crystals, blue-green (K+ intensifying) in uppermost part close to the hymenium (except in pigment deficient apothecia), ± brown (K+ purplish) along the edge, colourless inside or with pale brownish yellow pigment (K–) extending from the hypothecium; excipular hyphae dichotomously branched, with long and narrow lumina (0.6–1.0 µm wide) and very thick and gelatinized walls; terminal 1–2 cells with cell lumina larger, up to 5 µm wide. Hypothecium ± brownish yellow (K–) in upper part, colourless below. Hymenium 68–76–85 µm tall (s = 5, n = 20), colourless except for blue-green (K+ intensifying) epihymenium without crystals. Paraphyses 0.9–1.3–1.6 µm wide in mid-hymenium (s = 0.2, n = 40), unbranched or moderately branched in upper part; apices ± narrowly clavate or not at all thickened, 1.2–2.7–5.4 µm wide (s = 0.9, n = 40), sometimes with a diffuse external hood of blue-green pigment. Asci clavate; young spore mass forming a bluntly and broadly conical ocular chamber; tholus staining dark blue in I with a paler blue, narrowly conical axial body, the zone closest to the axial body concolorous with rest of the tholus or slightly darker. Ascospores 8 per ascus, colourless, without perispore or ornamentation, acicular, straight or shallowly helical, straight or somewhat coiled in young asci, 40–53–70 µm long (s = 6, n = 40), 2.3–2.8–3.6 µm wide (s = 0.3, n = 40), 14.0–19.2–25.3 times as long as wide (s = 2.5, n = 40), with 3–7.3–11 septa (s = 1.8, n = 40).

Conidiomata not seen.

Chemistry and pigmentation

Thallus without acetone-soluble lichen substances or with atranorin in trace amounts, K–, C–, KC–, PD–. Bagliettoana-green in epihymenium and uppermost part of proper exciple. Laurocerasi-brown along excipular edge. Arceutina-yellow in hypothecium.

Distribution and habitat

Bacidia endoleucoides was described from Madeira and has so far never been reported from anywhere else (Carvalho et al. 2008). It appears to be quite widespread in insular Macaronesia, as we have seen specimens from the Canary Islands (Tenerife and La Palma) and the Azores (São Jorge), in addition to Madeira. In addition, we have recently come across a few specimens from South Hampshire in southernmost England, previously identified as *B. friesiana*, suggesting that *B. endoleucoides* may have a wider distribution in coastal Europe. In the Macaronesian sites studied by us, *B. endoleucoides* inhabits smooth as well as rough bark of trees and shrubs. It seems to prefer light conditions in laurisilva as well as habitats shaped by human activity (e.g. forest edges in the cultural landscape). Known phorophytes include *Apollonias barbujana*, *Laurus novocanariensis*, *Ocotea foetens* and *Prunus lusitancia*.

Remarks

Bacidia endoleucoides is a member of *Bacidia* in a strict sense on account of the heavily gelatinized excipular cells with long and narrow cell lumina (Kistenich et al. 2018). Apart from the original and quite vague diagnosis and brief mentions in checklists (Tavares 1952, Hafellner 1992, 1995), this species has not been discussed in the literature and no modern description is available. *Bacidia endoleucoides* can be confused with *B. absistens* (Nyl.) Arnold, *B. friesiana* (Hepp) Körb., *B. salazarensis* B. de Lesd. and *B. caesiovirens* S. Ekman & Holien. Forms of *Bacidia absistens* with a blue-green epihymenium are similar to *B. endoleucoides* and are primarily distinguished by the paler hypothecium and abundance of minute crystals throughout the proper exciple (Ekman 1996, Coppins and Aptroot 2009). *Bacidia friesiana*, unlike *B. endoleucoides*, has a hyaline or pale straw hypothecium, wider and less gelatinized excipular hyphae, as well as a thallus that becomes minutely granular (own observations, accurate descriptions lacking, the one by Wirth et al. 2013 coming closest). We have not come across any correctly identified material of *B. friesiana* from Macaronesia. *B. salazarensis*, a widespread tropical species, can be separated from *B. endoleucoides* by the colourless or pale straw hypothecium, warmer red-brown proper exciple, and most ascospores being 7–13 times as long as wide (Ekman 2004). *Bacidia caesiovirens*, a European oceanic species not known from Macaronesia, can be recognized

by its pale yellowish hypothecium and granular thallus with blue-green pigment (Ekman and Holien 1995). In addition, there is a seemingly undescribed species of *Bacidia* occurring in Macaronesia with which *B. endoleucoides* can be confused. It is mentioned and briefly characterized in the comments to the identification key below (as *B.* aff. *salazarensis*).

Additional specimens examined

Azores, São Jorge, NW of Velas, WNW of Rosais, trail to Farol dos Rosais, near Cha do Areeiro, small forest with *Erica* and *Pittosporum* and stones of walls, 38°44'82''N, 28°17'92''W, elev. 290 m a.s.l., 07 Sep 2017, P. & B. van den Boom 57182 (herb. van den Boom). Madeira, Ribeiro Frio, along Levada do Furado, 32°73'67.0''N, 16°88'59.6''W, elev. 600 m a.s.l., 22 Jan 1999, S. Ekman 3521 (UPS L-945335). S of Ilha, 32°80'18.1''N, 16°91'41.3''W, elev. 600 m a.s.l., 20 Jan 1999, S. Ekman 3485 (UPS L-945301). 0.9 km NW of Ribeiro Frio, Balcões, 32°74'06''N, 16°89'19''W, elev. 890 m a.s.l., 10 Jan 2008, L. Tibell (UPS L-173341). Canary Islands, Tenerife (NW), N of Santiago del Teide, Bco. de Cuevas Megras o del Agu, path from Erjos to Los Silos, central part, near the houses of Las Cuevas Negras, laurisilva, with *Erica arborea*, *Laurus novocanariensis* and *Apollonias barbujana*, outcrops and walls of stones, 28°20'53''N, 16°48'61''W, elev. 590 m a.s.l., 15 May 2007, P. & B. van den Boom 37940 (herb. van den Boom). La Palma, 3.5 km WSW of Los Sauces, Los Tilos, laurisilva, narrow cleft with path along N facing volcanic outcrops, between tunnel and mirador, 28°47'10''N, 17°48'60''W, elev. 750 m a.s.l., 27 Oct 2012, P. & B. van den Boom 48374, 48382 (herb. van den Boom). La Palma, 3.5 km WSW of Los Sauces, Los Tilos, laurisilva, steep trail from visitor centre to mirador de las Barandas, 28°47'70''N, 17°47'0''W, elev. 750 m a.s.l., 29 Oct 2012, P. & B. van den Boom 48513 (herb. van den Boom). La Palma, N of Santa Cruz, W of La Galga, Cubo de La Galga, laurisilva in big valley with shaded steep volcanic outcrops, 28°45'60''N, 17°47'00''W, elev. 650 m a.s.l., 31 Oct 2012, P. & B. van den Boom 48570 (herb. van den Boom). Great Britain, England, south Hampshire (V.C. 11), Hants, Roydon, Mill Copse, 50°79'36.0''N, 01°54'62.9''W, 10 May 1998, N. A. Sanderson 206 (UPS L-984795); New Forest, Mark Ash Wood, Pond Hill, 50°86'42.4''N, 01°65'36.7''W, 21 Jan 2005, N. A. Sanderson 850 (UPS L-984796); New Forest, Busketts Wood, Great Stubby Hat, 50°89'47.5''N, 01°56'72.0''W, 27 Sep 2016, N. A. Sanderson 2207 (UPS L-984798).

Bacidia deludens S. Ekman, Tønsberg & van den Boom sp. nov. (Fig. 3, 4)

MycoBank: MB836877

Thallus crustose, greyish, with whitish, circular to ellipsoidal soralia, producing fumarprotocetraric acid as consistently present major substance. Photobiont a Trebouxiophyceae, unicellular, small. Apothecia biatorine, ± convex when mature, pale with a margin that often becomes ± brown on the outside, internally with no or small amounts of pigment but with crystals near the edges. Ascus mostly more or less *Micarea*-type. Ascospores acicular, up to 90 µm long, with 3–19 septa.

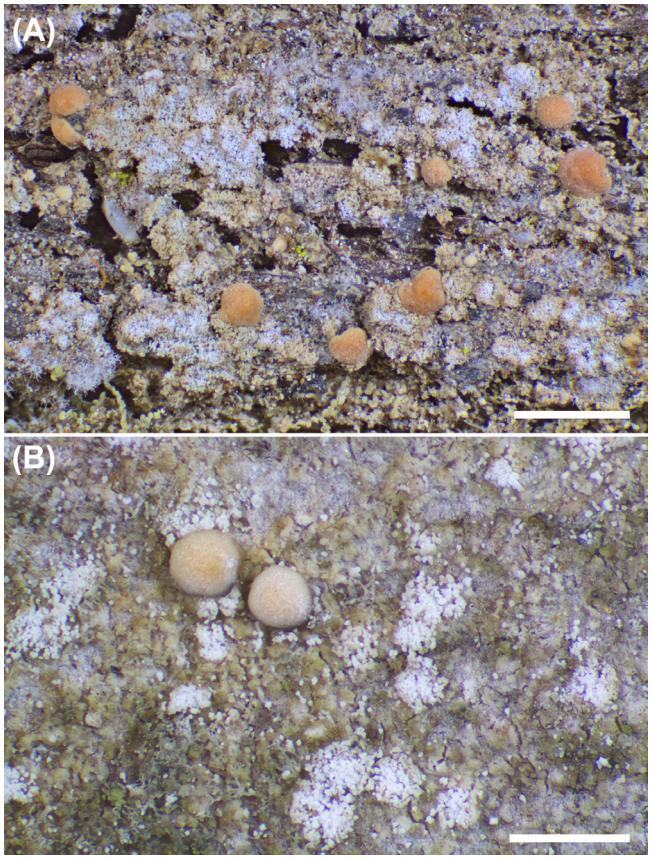

Figure 3. *Bacidia deludens* sp. nov. (A, B) Sorediate thallus with apothecia. Note younger and paler apothecia with dark-pigmented outer rim in (B) (A): van den Boom 37646 (holotype); (B): van den Boom 47804. Scales: 0.5 mm (A, B).

Type: Spain, Tenerife, N of Santiago del Teide, 1.5 km WSW of Erjos, path to Las Portelas, laurisilva, path in forest, rather shaded, with mainly *Laurus novocanariensis* and *Erica arborea*, on *Erica arborea*, 28°19'70''N, 16°48'70''W, elev. 1000 m a.s.l., 8 May 2007, P. & B. van den Boom 37646 (UPS L-972106–holotype, herb. van den Boom–isotype, BG–isotype).

Etymology

The epithet *deludens* means 'deceiving', the present active participle of *deludo*, and refers to the fact that, morphologically, *B. deludens* may be taken for a member of the Ramalinaceae even though it is a member of another family.

Description

Thallus crustose, thin, yellow-grey to pale brown-grey, sorediate, composed of scattered, irregular, convex areoles that coalesce to form a continuous and ± cracked crust with smooth or rough surface, on furrowed bark forming small, indeterminate patches of areoles up to 0.08 mm diam. with rough surface, on smooth bark usually well delimited, to 20 mm

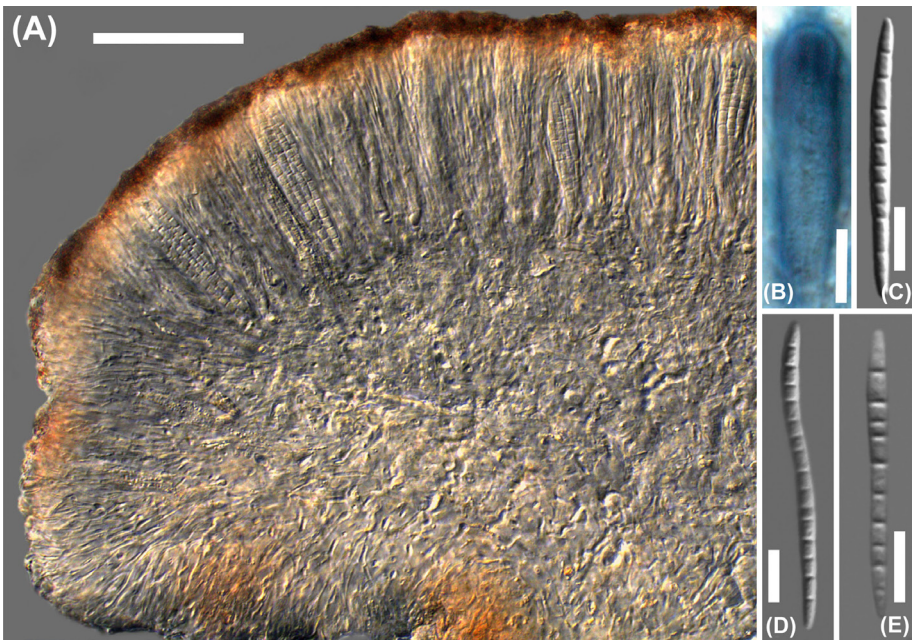

Figure 4. *Bacidia deludens* sp. nov. (A) Section through apothecium. Note that the epihymenial layer that appears brown is actually a dense, colourless and mostly opaque layer of crystals. (B) Ascus stained with 0.3% IKI in water (after pretreatment with 10% KOH). Note darker tube-like structure in apex. (C–E) Ascospores. (A, C–E): van den Boom 45954; (B): van den Boom 47804. Scales: 50 µm (A), 10 µm (B–E).

diam., areolate (areoles up to 0.16 mm diam.) or more often continuous, then cracked but with otherwise ± smooth surface. Soralia ± tinged pale brownish in outer part, whitish in the centre where soredia have been shed, on furrowed bark efflorescent, irregularly rounded or (following the ridges of the bark) ellipsoidal, flat to convex, to 0.8 mm when elongate; on smooth bark bursting through the thallus, mostly rounded and to 0.5 mm diam., flat and level with the surrounding thallus, often forming a ± vertical, discontinuous rim along the edge of the soralia. Soredia globose to ellipsoidal, 20–28–41 µm long (s = 7, n = 50). Prothallus, when present, blackish, particularly prominent where several specimens form a mosaic. Photobiont a member of Trebouxiophyceae, unicellular, cells globose or short-ellipsoidal, 5–8 µm long.

Apothecia biatorine, 0.2–0.4–0.8 mm diam. (s = 0.2, n = 30), at first flat, soon becoming more or less convex. *Disc* pale yellow, pale pink or pale beige. *Margin* in upper part concolorous with disc or paler or darker, particularly outer part sometimes dark brown, level with disc in young apothecia, becoming excluded in convex apothecia. Proper exciple 34–46–56 µm wide (s = 8, n = 15), with a layer of minute crystals (≤ 1 µm long) along the edge (soluble in K, insoluble in N), colourless to very pale orange (K–), sometimes with brown-orange (K–) in diffuse and ± wide zone along edge; excipular hyphae dichotomously branched, ± radiating, with long and narrow lumina (ca 1 µm wide) and very thick and gelatinized walls; terminal cell lumina not expanded. Hypothecium colourless. Hymenium 44–61–73 µm tall (s = 9, n = 15), colourless or with pale yellowish (K–) epihymenium containing a thick layer of minute crystals (same as in proper exciple). Paraphyses 1.2–1.3–1.5 µm wide in mid-hymenium (s = 0.1, n = 30), abundantly branched; apices narrowly clavate or not at all thickened, 1.2–1.7–2.3 µm wide (s = 0.3, n = 30), without pigment. Asci clavate; young spore mass forming an indistinct ocular chamber; axial body when stained with IKI (in some asci) narrowly conical and not reaching all through d-layer, or (in most asci) cylindrical and reaching all through d-layer, the zone closest to the axial body darker than rest of tholus, forming a thick, dark tube in asci with a cylindrical axial body (approximately *Micarea*-type sensu Hafellner 1984). Ascospores 8 per ascus, colourless, without perispore or ornamentation, acicular, straight or slightly curved or very shallowly helical, straight or somewhat coiled in young asci, 31–51–90 µm long (s = 13, n = 30), 2.6–3.1–3.6 µm wide (s = 0.2, n = 30), 10.0–16.5–29.0 times as long as wide (s = 4.5, n = 30), with 3–11.3–19 septa (s = 4.0, n = 30), not constricted at septa.

Conidiomata pycnidia, rare, globose, 30–50 µm diam., semi-immersed, unilocular, with blue-green (K+ intensifying, N+ purple) pigment around ostiole. Conidia 1-celled, long-ellipsoidal, 4–6 µm long and ca 1.2 µm wide, formed terminally from cylindrical, 1.2–1.5 µm wide conidiophores.

Chemistry and pigmentation

Thallus with fumarprotocetraric acid (major), protocetraric acid (trace) and ± two unidentified substances (faint traces), K–, C–, KC–, PD+ bright orange-red. Apothecia without lichen substances in any detectable amounts. Small amounts of an unidentified, yellowish or pale orange (K–) pigment (Arceutina-yellow or perhaps Rubella-orange) in minute

quantities in proper exciple, hypothecium and hymenium. Bagliettoana-green in pycnidial wall around ostiole.

Distribution and habitat

Bacidia deludens is currently known from the Canary Islands (Tenerife and La Gomera) as well as Madeira at altitudes between 600 and 1200 m a.s.l. We have observed it on bark of *Erica*, *Vaccinium*, an unidentified shrub in laurisilva and on *Cupressus* in a mixed forest. Localities vary from disturbed and poor in lichens to fairly species-rich. In the type locality, where *B. deludens* inhabits bark of *Erica*, accompanying microlichens include *Byssoloma marginatum*, *Coenogonium luteum*, *Endohyalina ericina*, *Fellhaneropsis vezdae*, *Jamesiella anastomosans*, *Micarea alabastrites*, *M. doliiformis*, *M. pycnidiophora*, *Porina coralloidea* and *Scoliciosporum pruinosum*. One specimen lacks apothecia, which opens the possibility that *B. deludens* may occur as an overlooked 'sterile, sorediate crust' in insular Laurimacaronesia.

Remarks

In a fertile state, *B. deludens* may remind of a member of *Bacidia*, *Bacidina* or *Toniniopsis* on account of the combination of acicular and transversely septate ascospores, biatorine apothecia and the Trebouxiophyceae photobiont (Kistenich et al. 2018). The prominent, whitish or pale brownish soralia, combined with the somewhat *Cliostomum*-like apothecia with sparse amounts of pigment and presence of minute crystals only along the edge of the proper exciple is unprecedented in the Ramalinaceae, however. In a sterile state, on the other hand, *Bacidia deludens* bears a superficial resemblance to *Biatora britannica* Printzen et al., *B. efflorescens* (Hedl.) Räsänen and *Lecanora jamesii* J. R. Laundon, in which argopsin is dominant in the two first and atranorin, usnic acid and 2-*O*-methylsulphurellin is usually present in the latter (Tønsberg 1992, Lumbsch et al. 1995, Printzen et al. 2001).

Bacidia deludens does not fit in any known genus in the Ramalinaceae. The ascus structure instead suggests affinities to the Malmideaceae or Pilocarpaceae. Based on the well developed and strongly gelatinized proper exciple with radiating hyphae, lack of constrictions at the ascospore septa and the abundance of crystals in the hymenium, we suggest that *B. deludens* is a member of the Malmideaceae. Among the genera currently classified in the Malmideaceae (Spribille et al. 2020, Wijayawardene et al. 2020), *Malmidea*, *Sprucidea* and *Zhurbenkoa* possess mainly non-septate ascospores and a brown hypothecium, *Malmidea* also having halonate ascospores, *Sprucidea* producing sporodochia and *Zhurbenkoa* having a parasitic life-style on other lichens (Kalb et al. 2011, Cáceres et al. 2017, Flakus et al. 2019). *Puttea* includes species with non-septate ascospores, minute apothecia with a poorly developed proper exciple, and (when pigmented) brown pigment caps on the terminal cells of the excipular hyphae (Dillman et al. 2012). Ascomata are unknown in *Cheiromycina* and *Savoronala*, which are instead recognised by their prominent sporodochia (Ertz et al. 2013, Muggia et al. 2017). Ascospores with up to 3 septa are known in *Crustospathula* and *Kalbionora*, but *Crustospathula* is also characterised by stalked soralia, *Kalbionora* by a brown hypothecium, and both genera by a variety of lichen substances not involving fumarprotocetraric acid (Kalb et al. 2012, Sodamuk et al. 2017). All genera except *Malmidea* currently include 1–4 species, while *Malmidea* has 52 species (Wijayawardene et al. 2020). The circumscription and generic classification of the Malmideaceae is poorly known and it has been suggested that several additional taxa may belong in that family, e.g. the genus *Porpidinia* as well as couple of species formerly referred to *Phyllopsora* in the Ramalinaceae or the large and distantly related *Lecidea*, the type of which belongs in the Lecideaceae (Breuss and Lücking 2015, Kistenich et al. 2018, 2019, Palice et al. 2018, Flakus et al. 2019). At the moment, we see three options to classify our new species: 1) a new genus in the Malmideaceae could have been erected. We do not favour this option, partly because the genus to which our species belongs may turn out to be already described but misclassified in another family, partly because we would prematurely create a monotypic genus based on fragmentary data in a phylogenetically and taxonomically poorly known family. In the latter case, typification of the genus may turn out to be suboptimal if several species are later shown to belong to the genus. 2) We could have provisionally recognised the species in an already described genus classified in the Malmideaceae. As outlined above, all currently recognised genera are morphologically homogeneous and match poorly with our species. The two genera *Crustospathula* and *Kalbionora* may seem as the least bad alternatives because of the presence of 3-septate ascospores, but our species deviates substantially from these genera in characters outlined above. Adding our species to any of the genera would extend the morphological variation and make the genus problematic to characterise, which is why we decided to avoid this option. 3) The third option, which we settled for, is to provisionally classify our new species in the genus *Bacidia* awaiting a reasonable overview of the phylogeny and classification of the Malmideaceae. *Bacidia* has historically been the home to basically all crustose lichens with a chlorococcoid photobiont, biatorine apothecia and ascospores with three or more transverse but no longitudinal septa (Ekman 1996). Most of those species are not congeneric with the type species *B. rosella* (Pers.) De Not., but a more natural classification was recently proposed (Kistenich et al. 2018). Provisionally accepting another species not congeneric with the type in an already heterogeneous assemblage is in line with recent history and would minimally impact the endeavour to achieve a monophyletic *Bacidia*. In addition, there is precedent for provisionally treating species as members of historically heterogeneous genera awaiting phylogenetic and taxonomic clarification, recent examples being, e.g. *Lecidea coriacea* Holien & Palice (Holien et al. 2016), *Bacidia gullah-geechee* Lendemer (Lendemer 2018), *Bacidia pruinata* Fryday (Fryday 2019) and *Lecidea streveleri* T. Sprib. (Spribille et al. 2020). The latter was explicitly placed in the Malmideaceae, yet described in *Lecidea* for the same reason we described our species in *Bacidia*.

Additional specimens examined (paratypes)
Madeira, Ribeiro Frio, at the head of Levada do Furado, 32°73'52.5''N, 16°88'59.0''W, elev. 600 m a.s.l., 22 Jan 1999, S. Ekman 3520 (UPS L-945318, sterile). NW of Funchal, road (ER228) from Ribeira Brava to São Vicente, ca 1 km N of Boca da Encumeada, trail PR22 'Vereda do Chao dos Louros', laurisilva, 32°45'50''N, 17°01'10''W, elev. 880 m a.s.l., 30 Apr 2012, P. & B. van den Boom 47804 (herb. van den Boom). S of Santiago, S of Redondo, Pico das Pedras, picnic area at the edge of a mixed forest, scattered trees, including *Camellia* and conifer trees such as *Cupressus*, 32°46'66''N, 16°53'85''W, elev. 880 m a.s.l., 09 Apr 2019, P. & B. van den Boom 58422 (herb. van den Boom). Canary Islands, Tenerife, N of Santiago del Teide, 1.5 km WSW of Erjos, path to Las Portelas, laurisilva, path in forest, rather shaded, with mainly *Laurus novocanariensis* and *Erica arborea*, 28°19'70''N, 16°48'70''W, elev. 1000 m a.s.l., 08 May 2007, P. & B. van den Boom 37594, 37641 (herb. van den Boom). La Gomera, NE of Valle Gran Rey, NE of Arure, Garajonay N. P., S of road TF-713, trail from Montaña de los Mamantiales to Raso de Don Pedro, laurisilva, 28°08'88''N, 17°17'55''W, elev. 1185 m a.s.l., 31 Aug 2011, P. & B. van den Boom 45954 (herb. van den Boom).

A provisional key to Bacidia sensu stricto in insular Laurimacaronesia

The circumscription of *Bacidia* s. str. used for this key follows Kistenich et al. (2018), which means that we include members of the Ramalinaceae with 'acicular ascospores, pycnidia with filiform and curved conidia, and a proper exciple consisting of furcate hyphae with very thin cell lumina and thick, heavily gelatinized cell walls (terminal cells sometimes excepted)'. We include species listed as members of *Bacidia* from the area by Hafellner (1995, 1999, 2005, 2008), Carvalho et al. (2008), Aptroot et al. (2010), Hernández Padrón and Pérez-Vargas (2010), Breuss (2018) and van den Boom and Alvarado (2019) with the following exceptions: *Bacidia acclinoides* (Nyl.) Zahlbr, *B. flavida* (Hepp) Tav. and *B. fritzei* (Stein) Zahlbr. are highly unlikely to belong in *Bacidia* s. str. according to their original descriptions, although we have not seen the types of these names. *Bacidia albonigricans* (Nyl.) Zahlbr. is a member of the Arthoniales according to studies of type material (M0101870, seen by SE). *Bacidia auerswaldii* (Stizenb.) Mig. belongs in *Scutula* as *S. effusa* (Rabenh.) Kistenich et al. (Kistenich et al. 2018). *Bacidia arnoldiana* Körb., *B. caligans* (Nyl.) A.L. Sm., *B. delicata* (Leight.) Coppins, *B. egenula* (Nyl.) Arnold, *B. inundata* (Fr.) Körb. and *B. phacodes* Körb. all belong in *Bacidina*; Wirth et al. 2013). *Bacidia friesiana* (Hepp) Körb. is probably incorrectly reported for Macaronesia, as all investigated specimens have turned out to be misidentifications of *B. endoleucoides* or *B. heterochroa*. *Bacidia incompta* (Borrer) Anzi belongs in *Bellicidia* (Kistenich et al. 2018). *Bacidia propinqua* (Hepp) Arnold belongs in *Bilimbia* (Ekman 1996, although not conspecific with *Bilimbia sabuletorum* (Schreb.) Arnold as stated there). *Bacidia scopulicola* (Nyl.) A.L. Sm. probably represents misidentifications of *B. sipmanii* (Brand et al. 2009). *Bacidia subacerina* Vain. is a synonym of *B. laurocerasi* (Delise ex Duby) Zahlbr. (Ekman 1996). *Bacidia subilludens* (Harm.) Zahlbr. is a member of *Bactrospora* according to studies of type material (DUKE-169907, seen by SE). *Bacidia bagliettoana* (A. Massal. & De Not.) Jatta and *B. subincompta* belong in *Toniniopsis* (Kistenich et al. 2018). *Bacidia trachona* (Ach.) Lettau and *B. viridifarinosa* Coppins & P. James belong in *Aquacidia* in the Pilocarpaceae (Aptroot et al. 2018). The newly described *Bacidia deludens* is included in the key even though it does not belong to *Bacidia* (nor Ramalinaceae).

The species referred to in the key as *Bacidia* aff. *salazarensis* is most likely not that species but an undescribed one. Like *B. salazarensis*, it contains red-brown pigment in the exciple and green pigment in the epihymenium. However, whereas true *B. salazarensis* has straight and quite stout ascospores like *B. heterochroa* (Müll. Arg.) Zahlbr. (Ekman 2004), *B.* aff. *salazarensis* has long and helically twisted ascospores like *B. laurocerasi*. In addition, it has modest amounts of crystals in the exciple unlike *B. salazarensis*, *B. heterochroa* and *B. laurocerasi*. It is known for sure only from two relatively small specimens (UPS L-945301 and as an immixture in a specimen of *B. endoleucoides* cited above, UPS L-945335).

For the use of this key, one should study thin sections of the darkest apothecia available. To be able to observe specific hues, it is recommended to use a light microscope with strong light (daylight temperature) and keep the condenser aperture as open as possible (maximum 1/3 closed). In ordinary light (bright-field), crystals may be mistaken for brown pigmentation. Crystals are best studied between two crossed polarization filters.

1 Thallus with distinct, circular or ellipsoidal, whitish or pale brownish soralia. Uppermost part of hymenium and uppermost part of proper exciple with a continuous layer of crystals……*B. deludens*
1 Thallus without soralia. Uppermost part of hymenium and uppermost part of proper exciple mostly without a continuous layer of crystals……2
2 Apothecial sections at least in K with green hues in epihymenium and/or proper exciple of at least the darkest apothecia……3
2 Apothecial sections in K without green hues, unpigmented or with orange to purplish brown pigmentation……5
3 Epihymenium purple (or sometimes green) in water, turning green in K; proper exciple densely and evenly set with minute crystals……*B. absistens*
3 Epihymenium at least partly green in water; proper exciple without or with modest amounts of crystals……4
4 Epihymenium purely blue-green, intensifying in K; without crystals in proper exciple……*B. endoleucoides*
4 Epihymenium with a mixture of blue-green and red-brown pigment (intensifying and turning purplish, respectively); proper exciple with modest amounts of minute crystals……*B.* aff. *salazarensis*
5 Darkest apothecia orange, bronze-brown or pale brown to orange-brown to red-brown to black; epihymenium, hypothecium, and/or inner part of proper exciple with yellow, orange or brown pigment……6

5 Darkest apothecia ± pink to pale pink-orange; epihymenium, hypothecium and inner part of proper exciple unpigmented or with tiny amounts of yellowish pigment (although sometimes with crystals that may appear brownish in bright-field microscopy)……14
6 Hypothecium brown-orange to dark brown, conspicuously K+ purple-red……*B. polychroa*
6 Hypothecium pale yellowish to dark brown (K–, K+ intensifying or K+ purplish), never conspicuously K+ purple-red……7
7 Apothecia with thin white pruina and/or at least epihymenium with crystals……8
7 Apothecia without pruina and epihymenium without crystals……9
8 Hypothecium and interior of proper exciple evenly dark brown, K–; habit similar to *Lecidella elaeochroma*……
……*B. canariensis*
8 Hypothecium ± brown-orange, K+ intensifying; interior of proper exciple mostly pale but often somewhat brown-orange near hypothecium; habit otherwise……
……...*B. amylothelia*
9 Epihymenium in water with red-brown, K+ purplish pigment in distinct layer……10
9 Epihymenium brown-yellow (K–), ± orange (K± intensifying) or unpigmented……..11
10 Red-brown pigment forming distinct hoods in the walls of the paraphysis apices……*B. heterochroa*
10 Red-brown pigment present as irregular grains or dissolved in the gelatinous matrix surrounding the paraphyses, not forming distinct hoods……*B. laurocerasi*
11 Epihymenium with pigment in distinct layer, brown-yellow, K–……..*B. arceutina*
11 Epihymenium unpigmented or vaguely and diffusely pigmented, pigment not in a distinct layer……12
12 Thallus granular……*B. rubella*
12 Thallus smooth or ± warted continuous, never granular……13
13 Spores distinctly helically twisted; on bark (*Erica*)……
……*B. sigmospora*
13 Spores straight or slightly curved; on rock……
……...*B. sipmanii*
14 Ascospores bacilliform to fusiform; epihymenium without crystals……*B. paramedialis*
14 Ascospores acicular; epihymenium with crystals……
……15
15 Ascospores > 65 µm long, with up to 15 septa; proper exciple thick, laterally > 80 µm wide, composed of narrow, not distinctly radiating cell lumina with gelatinized walls thicker than the lumina; epihymenial crystals forming sharply delimited layer……...*B. rosella*
15 Ascospores ≤ 60 µm, with up to 7 septa; proper exciple thinner, laterally < 80 µm wide, in outer part composed of stout, distinctly radiating cell lumina with gelatinized walls thinner than the lumina; epihymenial crystal layer diffuse, extending downwards between paraphyses……
……*B. thyrrenica*

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Author contributions

Stefan Ekman: Conceptualization (supporting); Data curation (supporting); Formal analysis (lead); Investigation (lead); Methodology (lead); Project administration (equal); Resources (equal); Validation (equal); Visualization (lead); Writing – original draft (lead); Writing – review and editing (lead). **Tor Tønsberg**: Conceptualization (supporting); Data curation (supporting); Formal analysis (lead); Investigation (supporting); Methodology (supporting); Project administration (equal); Resources (equal); Validation (equal); Visualization (supporting); Writing – original draft (supporting); Writing – review and editing (supporting). **Pieter P. G. van den Boom**: Conceptualization (lead); Data curation (lead); Formal analysis (supporting); Investigation (lead); Methodology (supporting); Project administration (equal); Resources (equal); Validation (equal); Visualization (supporting); Writing – original draft (supporting); Writing – review and editing (supporting).

References

Aptroot, A. et al. 2010. Lista dos líquenes e fungos liquenícolas (Fungi). – In: Borges, P. A. V. (ed.), Listagem dos organismos terrestres e marinhos dos Açores. Principia, pp. 59–79.

Aptroot, A. et al. 2018. *Aquacidia*, a new genus to accommodate a group of skiophilous temperate *Bacidia* species that belong in the Pilocarpaceae (lichenized ascomycetes). – Gorteria 40: 11–14.

Arup, U. et al. 1993. High performance thin layer chromatography (HPTLC), an improved technique for screening lichen substances. – Lichenologist 25: 61–71.

Brand, M. et al. 2009. Further data on the lichen genus *Bacidia s.l.* in the Canary Islands and western Europe, with descriptions of two new species. – Bibl. Lichenol. 99: 81–92.

Breuss, O. 2018. Neue und bemerkenswerte Flechtenfunde von den Azoren (Insel São Miguel). – Herzogia 31: 430–435.

Breuss, O. and Lücking, R. 2015. Three new lichen species from Nicaragua, with keys to the known species of *Eugeniella* and *Malmidea*. – Lichenologist 47: 9–20.

Cáceres, M. E. da S. et al. 2017. *Sprucidea*, a further new genus of rain forest lichens in the family Malmideaceae (Ascomycota). – Bryologist 120: 202–211.

Carvalho, P. et al. 2008. Lista dos líquenes e fungos liquenícolas (Fungi). – In: Borges, P. A. V. et al. (eds), Listagem dos fungos, flora e fauna terrestres dos arquipélagos da Madeira e Selvagens. Direcção Regional do Ambiente da Madeira and Universidade dos Açores, pp. 105–122.

Coppins, B. J. and Aptroot, A. 2009. *Bacidia* De Not. (1846). – In: Smith, C. W. et al. (eds), The lichens of Great Britain and Ireland. Nat. Hist. Mus. Publ., pp. 189–207.

Dillman, K. L. et al. 2012. New records, range extensions and nomenclatural innovations for lichens and lichenicolous fungi from Alaska, USA. – Herzogia 25: 177–210.

Ekman, S. 1996. The corticolous and lignicolous species of *Bacidia* and *Bacidina* in North America. – Opera Bot. 127: 1–148.
Ekman, S. 2004. *Bacidia*. – In: Nash, T. H. (eds), Lichen flora of the Greater Sonoran Desert region, Vol. 2. Lichens Unlimited, pp. 18–28.
Ekman, S. and Holien, H. 1995. *Bacidia caesiovirens*, a new lichen species from western Europe. – Lichenologist 27: 91–98.
Ertz, D. et al. 2013. Savoronala, a new genus of Malmideaceae (Lecanorales) from Madagascar with stipes producing sporodochia. – Mycol. Prog. 12: 645–656.
Flakus, A. et al. 2019. A new genus, *Zhurbenkoa*, and a novel nutritional mode revealed in the family Malmideaceae (Lecanoromycetes, Ascomycota). – Mycologia 111: 593–611.
Fryday, A. M. 2019. Eleven new species of crustose lichenized fungi from the Falkland Islands (Islas Malvinas). – Lichenologist 51: 235–267.
Gerasimova, J. V. et al. 2018. Four new species of *Bacidia s.s.* (Ramalinaceae, Lecanorales) in the Russian Far East. – Lichenologist 50: 603–625.
Hafellner, J. 1984. Studien in Richtung einer natürlicheren Gliederung der Sammelfamilien Lecanoraceae und Lecideaceae. – Nova Hedwigia, Beihefte 79: 241–371.
Hafellner, J. 1992. A new checklist of lichenized and lichenicolous fungi of the Madeira archipelago. – Inst. für Botanik, Karl-Franzens-Universität.
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.
Hafellner, J. 1999. Additions and corrections to the checklist and bibliography of lichens and lichenicolous fungi of insular Laurimacaronesia. I. – Fritschiana 17: 1–26.
Hafellner, J. 2005. Additions and corrections to the checklist and bibliography of lichens and lichenicolous fungi of insular Laurimacaronesia. III. – Fritschiana 50: 1–13.
Hafellner, J. 2008. Additions and corrections to the checklist and bibliography of lichens and lichenicolous fungi of insular Laurimacaronesia. IV. – Fritschiana 64: 1–28.
Hernández Padrón, C. and Pérez-Vargas, I. 2010. Lichenes, lichenicolous fungi. – In: Arechacaleta, M. et al. (eds), Lista de especies silvestres de Canarias. Hongos, plantas y animales terrestres. 2009. Gobernio de Canarias, pp. 71–105.
Hiern, W. P. 1896. Catalogue of the African plants collected by Dr. Friedrich Welwitsch in 1853–1861, Vol. 1, part 1 Dicotyledons. – British Museum (Natural History).
Holien, H. et al. 2016. *Lecidea coriacea* sp. nov., a lichen species from oldgrowth boreal and montane forests in Europe and North America. – Herzogia 29: 412–420.
Kalb, K. et al. 2011. The phylogenetic position of *Malmidea*, a new genus for the *Lecidea piperis*- and *Lecanora granifera*-groups (Lecanorales, Malmideaceae), inferred from nuclear and mitochondrial ribosomal DNA sequences, with special reference to Thai species. – Bibl. Lichenol. 106: 143–168.
Kalb, K. et al. 2012. New or otherwise interesting lichens. VI, including a lichenicolous fungus. – Phytotaxa 42: 35–47.
Kistenich, S. et al. 2018. Molecular systematics and character evolution in the lichen family Ramalinaceae (Ascomycota: Lecanorales). – Taxon 67: 871–904.
Kistenich, S. et al. 2019. Towards an integrative taxonomy of *Phyllopsora* (Ramalinaceae). – Lichenologist 51: 323–392.
Krempelhuber, A. von 1868. Prodromus Lichenographiae Insulae Maderae. – Flora 51: 221–224, 230–235.
Lendemer, J. C. 2018. *Bacidia gullahgeechee* (Bacidiaceae, Lecanoromycetes) an unusual new species potentially endemic to the globally unique Ashepoo-Combahee-Edisto River Basin of southeastern North America. – Bryologist 121: 536–546.
Lumbsch, H. et al. 1995. A revision of the usnic acid containing taxa belonging to *Lecanora* sensu stricto (Lecanorales: lichenized Ascomycotina). – Bryologist 98: 561–577.
Meyer, B. and Printzen, C. 2000. Proposal for a standardized nomenclature and characterization of insoluble lichen pigments. – Lichenologist 32: 571–583.
Muggia, L. et al. 2017. Molecular analyses uncover the phylogenetic placement of the lichenized hyphomycetous genus *Cheiromycina*. – Mycologia 109: 588–600.
Orange, A. et al. 2010. Microchemical methods for the identification of lichens, 2nd edn. – British Lichen Society.
Palice, A. et al. 2018. New remarkable records and range extensions in the central European lichen biota. – Herzogia 31: 518.
Printzen, C. et al. 2001. *Biatora britannica* sp. nov. and the occurrence of *Biatora efflorescens* in the British Isles. – Lichenologist 33: 181–187.
Sodamuk, M. et al. 2017. *Kalbionora palaeotropica*, a new genus and species from coastal forests in Southeast Asia and Australia (Malmideaceae, Ascomycota). – MycoKeys 22: 15–25.
Spribille, T. et al. 2020. Lichens and associated fungi from Glacier Bay National Park, Alaska. – Lichenologist 52: 61–181.
Tavares, C. N. 1952. Contributions to the lichen flora of Macaronesia. I – Lichens from Madeira. – Port. Acta Biol. Ser. B 3: 308–391.
Tønsberg, T. 1992. The sorediate and isidiate, corticolous, crustose lichens in Norway. – Sommerfeltia 14: 1–331.
Vainio, E. A. 1901. Lichenes. – In: Anonymous (ed.), Catalogue of the African plants collected by Dr. Friedrich Welwitsch in 1853–1861, Vol. 2, part 2 Cryptogamia. British Museum (Natural History), pp 396–463.
Vainio, E. A. 1926. Lichenes Africani novi. – Ann. Univ. Fenn. Aboensis Ser. A 2: 1–33.
van den Boom, P. P. G. and Alvarado, P. 2019. Lichens and lichenicolous fungi of Faial (Azores, Portugal) with descriptions of three new species. – Herzogia 32: 421–437.
van den Boom, P. P. G. and Magain, N. 2020. Three new lichen species from Macaronesia belonging in Ramalinaceae, with the description of a new genus. – Plant Fungal Syst. 65: 167–175.
Wijayawardene, N. N. et al. 2020. Outline of Fungi and fungus-like taxa. – Mycosphere 11: 1060–1456.
Wirth, V. et al. 2013. Die Flechten Deutschlands. – Eugen Ulmer.
Zahlbruckner, A. 1926. Catalogus lichenum universalis, Vol. 4. – Gebrüder Borntraeger, pp. 161–320.