

Philippine Lichens with Bulbate Cilia – *Bulbothrix* and *Relicina* (Parmeliaceae)

Paulina Bawingan^{1,2*}, Mechell Lardizaval¹, and John Elix³

¹School of Natural Sciences, Saint Louis University, Baguio City 2600 Philippines

²Biology Department, Tagum Doctors College, Tagum City 8100 Philippines

³Research School of Chemistry, Australian National University, Canberra, Australia

This paper presents a taxonomic treatment of *Bulbothrix* and *Relicina* lichens (Ascomycota, Parmeliaceae) collected in the Philippines, two genera characterized by the presence of bulbate cilia. A total of five species of *Bulbothrix* and fifteen species of *Relicina* were identified, with one new record for each genus. The Philippines is a major center of diversity for *Relicina*.

Keywords: coronate apothecia, lichenic acid crystals, parmelioid lichen, retrorse cilia, Hale

INTRODUCTION

The genera *Relicina* (Hale & Kurok.) Hale and *Bulbothrix* Hale belong to Parmeliaceae, one of the largest families of lichenized fungi. Both are segregates of *Parmelia* Ach. *s. lat.* According to Hale (1975, 1976), both genera have their centers of distribution in tropical regions – in South America and southern Africa for *Bulbothrix* and Southeast Asia for *Relicina*. Despite the high degree of endemism of *Relicina* in the Philippines, no species were among the many lichens described by Vainio (1909).

Species of *Bulbothrix* and *Relicina* are small foliose lichens known for their simple, furcate, or branched bulbate cilia. *Bulbothrix* thallus is distinguished for its gray to gray-green upper cortex (due to cortical atranorin); *Relicina* has pale green to yellow-green upper cortex (due to the cortical usnic acid). The upper cortex is plectenchymatous with a pored epicortex and the cell walls contain isolichenan (Hale 1975, 1976). Thalli of both genera can have a maculate or emaculate upper cortex and may or may not produce isidia, soredia, and lobules. Pseudocyphellae are absent from all species of both genera. The lower surface varies from pale tan to

black and the rhizines and cilia may be simple, sparsely, or densely branched. Both genera have apothecia that may be coronate (with black bulbils adorning the rim of the thalline exciple; Figure 1E) or ecoronate; the discs are imperforate, ranging from concave to flat and sometimes even convex. Some species of both genera have retrorse cilia *i.e.*, having rhizinae in the thalline exciple (Figure 1F). The unicellular ascospores can be ovoid, ellipsoid, or bicornute (Figure 1K–L) – 5.0–21.0 × 4.0–12.0 μm in *Bulbothrix* (Benatti 2014) and 3.0–12.0 × 2.0–6.0 μm in *Relicina* (Elix 1996). Both lichen genera commonly have pycnidia; the conidia may be bifusiform or bacilliform, 5–9 × 1 μm in *Bulbothrix* (Hale 1976) and 5–10 × 0.7–1 μm in *Relicina* (Hale 1975).

Despite these shared morpho-anatomic features, the two genera differ in ecological requirements, geographic distribution, and chemical profile, so Hale (1976) suggested that it was unlikely that there was any significant gene exchange in the past. A phylogenetic examination of the parmelioid lichens confirmed the lack of any close evolutionary relationship between *Bulbothrix* and *Relicina* (Crespo *et al.* 2010). In this study, *Bulbothrix* nests within the *Parmelina* clade albeit manifesting paraphyletic grouping; *Relicina* is polyphyletic in the *Parmelia* clade (Kirka *et al.* 2017).

*Corresponding Author: pbawingan@gmail.com

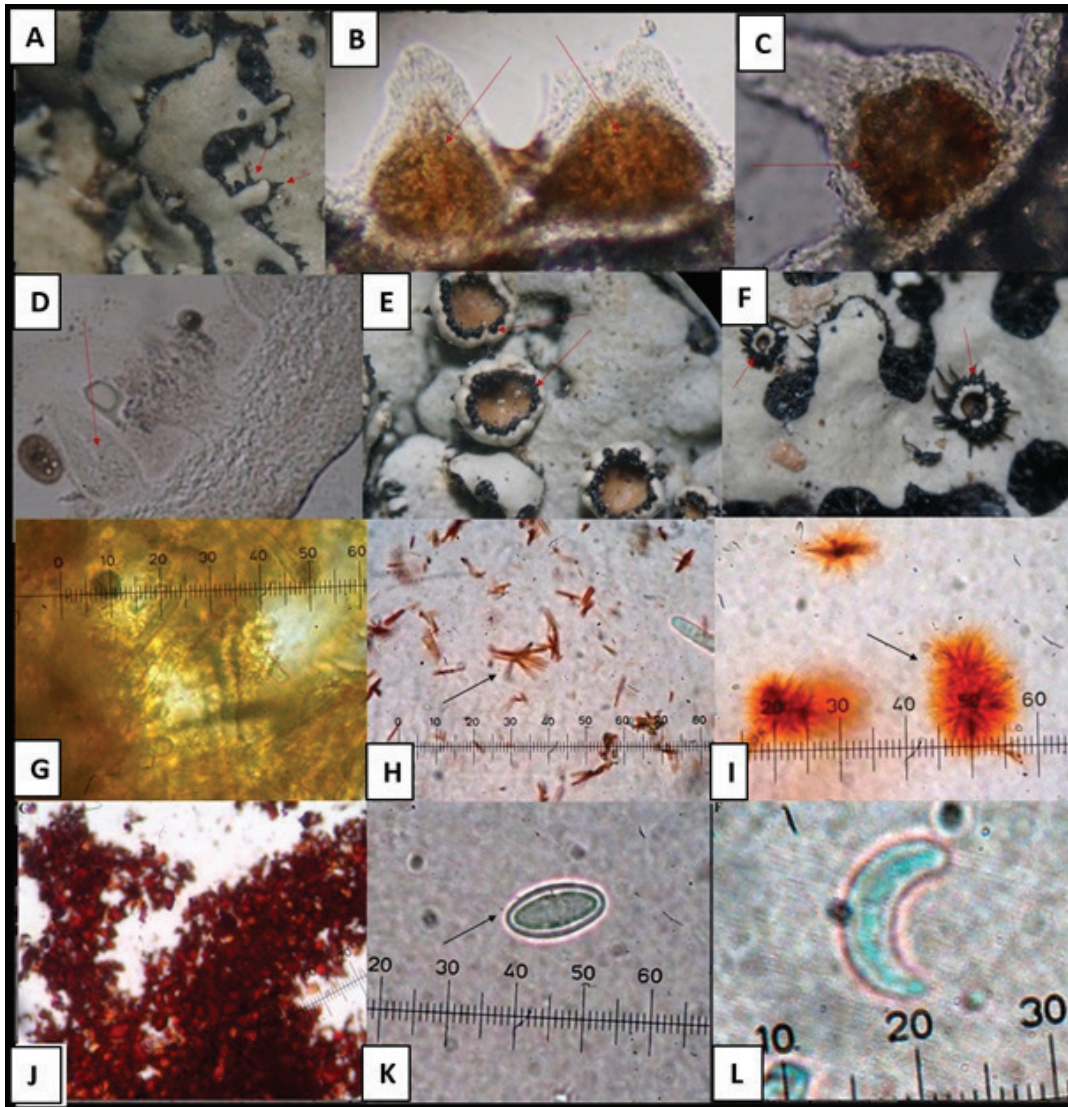


Figure 1. Observed features of the lichens: [A] thallus lobules and lacinulae with bulbate cilia (pointed); [B, C] results of clearing technique to verify if cilia are truly bulbate for *Bulbothrix isidiza* and *Relicina viridescens*, respectively; [D] result if the cilia is not really bulbate, as in *Parmelinella wallichiana*; [E] coronate apothecium in *Relicina relicinula*; [F] retrorsc cilia in *Relicina subabstrusa*; [G–, K+] yellow (yellow effusion observed under the microscope indicating presence of stictic acid); [H–, K+] yellow to red, crystals of norstictic acid observed under the microscope (100x), in *Relicina subabstrusa*; [I–, K+] yellow to red, salazinic acid crystals under the microscope (100x), in *Bulbothrix isidiza*; [J] shows formation of brick-red crystals upon the addition of P-reagent in *Relicina dentata*; we believe these crystals to be protocetraric acid; [K] ovoid or ellipsoid spore in *R. subabstrusa*; [L] bicornute spore in *R. precircumnodata*.

This paper continues our taxonomic accounts of the Parmeliaceae in the Philippines (Bawingan *et al.* 2017). The present paper not only lists the specimens that we have collected and identified but also includes other relevant material reported from the Philippines by other lichenologists.

MATERIALS AND METHODS

Collection Sites

Most of the collections studied are from the provinces in the Cordillera Region, Ilocos Province, Nueva Vizcaya, and Isabela. The lichen collections are deposited at the Father Braeckman Museum of Natural History herbarium, Saint Louis University, Baguio City. The specimen vouchers are given designations like

SLU-L02529 – in which SLU stands for Saint Louis University followed by the specimen number L-02529, L standing for lichen. We also studied some collections from Mindanao deposited at the Central Mindanao University herbarium. Unfortunately, there are no deposits of specimens belonging to these two genera at the Philippine National Herbarium. We are unable to study deposits in herbaria outside the Philippines; hence, we based our inclusion of other *Bulbothrix* species on the review and evaluation done by Benatti (2012, 2013, 2014) on the genus. We based our inclusion of other *Relicina* species on the monographs done by Hale (1975) and Elix (1996) and other literature (Elix 1998, Sipman *et al.* 2013).

Identification of the Lichens

The presence of true bulbate cilia in our specimens was confirmed by applying the clearing technique used by Benatti (2011) and observing the results under an Olympus compound microscope (Figure 1A–D). Other morphological features were evaluated using Meiji and Omni stereomicroscopes. For chemotaxonomy, we employed the spot tests on the medulla using solutions of 10% aqueous potassium hydroxide solution (K), *para*-phenylenediamine (P), and sodium hypochlorite (C) – as described by Hale (1983). A color change K⁺ yellow indicates the presence of stictic acid; K⁺ yellow then red indicates the presence of norstictic acid or salazinic acid; C⁺ red or KC⁺ rose pink indicates the presence of gyrophoric acid; and P⁺ yellow to red or orange indicates presence of norstictic, stictic, salazinic, or protocetraric acids (Elix 2014). In addition, thin sections of the thallus were placed on a glass slide and treated with a drop of a reagent (K or P) to observe color reactions and the formation of crystals under the compound microscope (Benatti 2012, Lucking 2009). Under the microscope, a K⁺ yellow solution without crystallization indicates the presence of stictic acid; the formation of long reddish needle-shaped crystals with a stellate formation indicates the presence of salazinic acid; norstictic acid crystals are shorter with no star-like formation (Figure 1G–I). A P⁺ test with the formation of red to deep red granules indicates the presence of protocetraric acid (Figure 1J). To confirm the identity of the lichen acids present, we applied thin layer chromatography (TLC) using solvents A and C adopting the method described by Elix and Ernst-Russell (1993) and Orange *et al.* (2001).

Based on all these characters, the lichens were identified by applying several taxonomic keys (Benatti 2013, 2014; Benatti and Elix 2012; Elix 1996, 1998; Hale 1975, 1976; Michlig and Benatti 2015) Photographs of morphological features and TLC results were forwarded to M. Benatti for verification.

Based on actual observations of collected species and on characteristics given by references for those species not studied by the authors, we prepared a key to the identification of Philippine *Bulbothrix* and *Relicina*. Descriptions of the studied species are our personal observations and some from literature sources. Cited references contain the full description of the other species.

RESULTS AND DISCUSSION

We have listed five species of *Bulbothrix* from the Philippines, four of which were recorded by Hale (1976). We excluded *Bulbothrix subinflata* (Hale) Hale because this species was shown to have non-bulbate but basally enlarged cilia by Benatti and Marcelli (2010), and was thus transferred to *Parmelinopsis*. *Bulbothrix laevigatula* (Nyl.) Hale [identified as *Parmelia hookeri* Taylor by Vainio (1909)] is also excluded as the Philippine material examined by Benatti (2014) had a different chemistry. In addition, *Bulbothrix goebelii* (Zenker) Hale is not included due to Hale's misinterpretation of this species and its synonyms (Benatti and Elix 2012). *Bulbothrix subdissecta* (Nyl.) Hale formerly considered a synonym of *B. goebelii* by Hale has since been resurrected as a distinct species (Benatti and Elix 2012). We have also identified *Bulbothrix viridescens* (Lyngby) Hale, a new record for the Philippines. Previously this species was only known from South America.

We have listed a total of fifteen species of *Relicina*, 13 of which were recorded by Hale (1975). Of these, we have collected and studied only five species ourselves: *Relicina planiuscula* (Kurok.) Hale, *R. precircumnodata* Hale, *R. relicinula* (Mull. Arg.) Hale, *R. subabstrusa* (Gyeln.) Hale, and *R. dentata* Elix (a new record for the Philippines).

Bulbothrix is uncommon in the Philippines while *Relicina* is more abundant. We collected *Bulbothrix* and *Relicina* in trunks and branches of conifers. According to Hale (1975), *Relicina* spp. tend to colonize the canopy branches of dipterocarps and other trees in lowland forests and the trunks and branches of conifers in higher altitude areas (Hale 1975). Hale mentioned that most of his collections were obtained from branches of felled dipterocarps in lumberyards. With rampant deforestation in many areas of the Philippines, these *Relicina* species may be endangered or already extinct.

Genus *Bulbothrix*

Bulbothrix isidiza (Nyl.) Hale, *Phytologia* 28: 480 (1974) [MB#341602] (Figure 2A)

= *Parmelia isidiza* Nyl., *Bull. Soc. Brot.* 3: 130 (1884).

Specimens examined: Sitio Pula, Ifugao, 16°56.251'N,

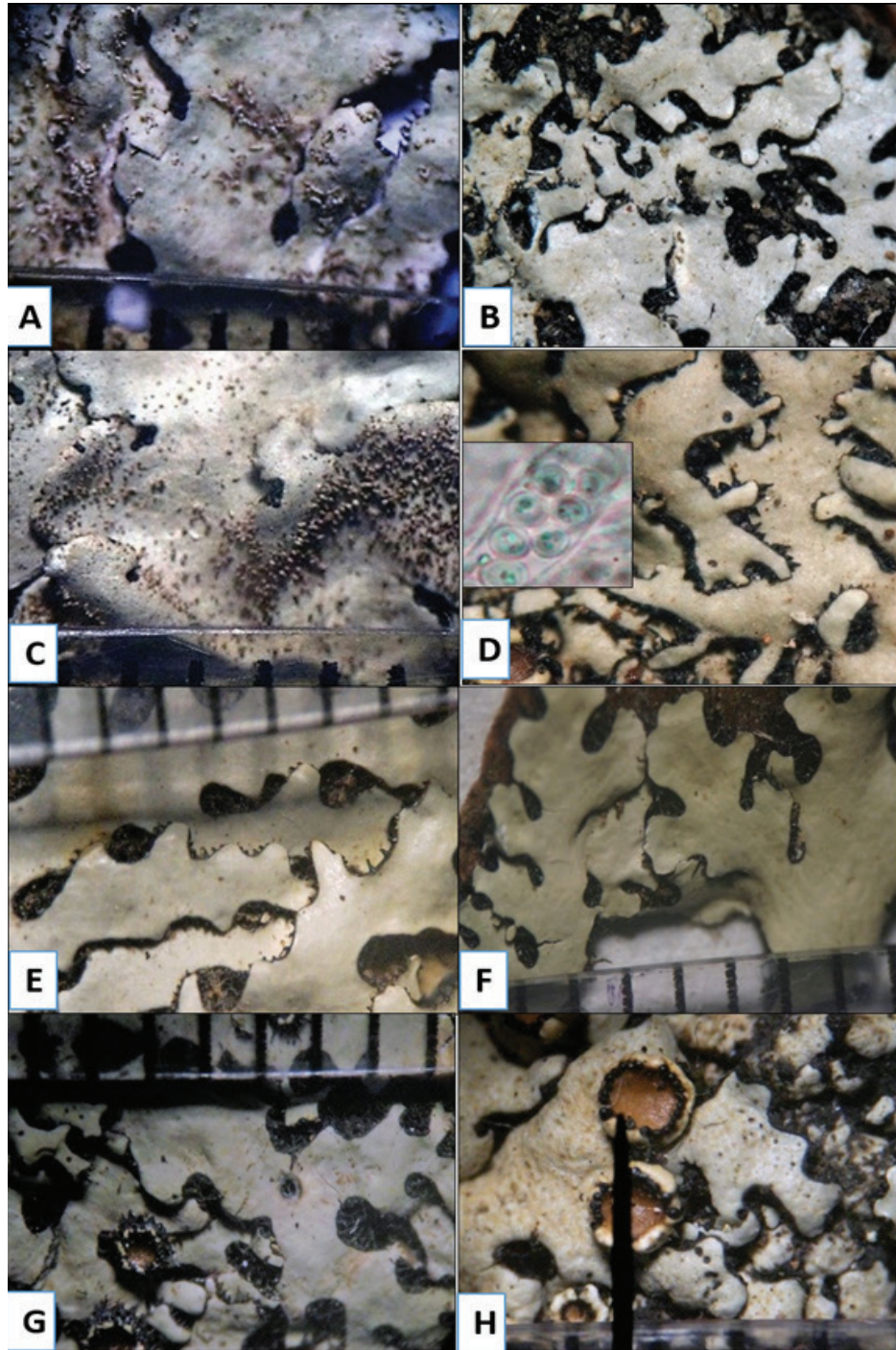


Figure 2. Lichens studied: [A] *Bulbothrix isidiza*; [B] *B. subdissecta*; [C] *B. tabacina*; [D] *B. viridescens*, inset: ascus with ascospores; [E] *Relicina dentata*; [F] *R. planiuscula*; [G] *R. relicinula*; and [H] *R. subabstrusa*. Note: all photos taken under a stereomicroscope (20X), camera zoomed at 1.5x, shown measurement in mm scale.

121°03.469'E, 1387 m, *R. Doplah* (SLU-L02529); Imugan, Nueva Vizcaya 16°9'32"N, 120°54'13"E, 1000 m, *A. Tabaquero* (SLU-L02530); Wangal, La Trinidad, Benguet, 16°28'12.3"N, 120°33'41.7"E, 1289 m, *M. Lardizaval* (SLU-L02528); Caliking, Atok, Benguet, 16°31'3.5"N,

120°41'4.8"E, 1506 m, *M. Lardizaval* (SLU-L02819); Mt. Pao, Adams, Ilocos Norte, 18°27'1.5"N, 120°53'36.1"E, 395 m, *P. Bawingan* (SLU-L02540); Sinto, Bauko, 16°51'41.8"N, 120°52'25.5"E, 2128 m, *M. Lardizaval* & *P. Bawingan* (SLU-L01195).

Other specimens (Hale 1976): Benguet, Degelius.

Remark: This lichen is found in almost all continents except Antarctica and Europe (Michlig and Benatti 2015).

Features: Thallus mineral gray to greenish-gray, moderately to loosely attached, lobes sublinear, irregularly branched, contiguous to slightly imbricate, with rounded apices; margin entire to crenate; cilia scarce, distributed mainly in lobe axils and in margin incisions, simple, inflated; soredia and pustules absent, isidia abundant, simple to branched; medulla white; lower surface brown, moderately rhizinate, rhizines simple, black or brown. A few immature apothecia were observed in one specimen; pycnidia absent. Spot test: cortex K⁺ yellow, UV⁻; medulla K⁺ yellow to dark red, C⁻, KC⁻, P⁺ yellow or pale orange. Major acids: atranorin, salazinic, and consalazinic acids.

***Bulbothrix pigmentacea* (Hale) Hale, Phytologia 28(5): 480 (1974) [MB#341607]**
= *Parmelia pigmentacea* Hale, 1968.

Remarks: Type collected from Pagbilao, Sierra Madre, Luzon, Philippines, *M. E. Hale* 26895 (US, holotype). We did not find any specimen, but this species was treated by Hale (1976) and Benatti (2013). It is characterized by emaculate upper cortex, abundant cilia with branched apices, simple isidia without pycnidia, a black lower cortex with black or brown margins, abundant and branched rhizines, and by the presence of a K⁻ reddish pigment in the medulla, lower cortex, and rhizines. The medulla of this species sometimes tests weakly + for K and KC, which indicates probability of containing small concentrations of gyrophoric acid.

***Bulbothrix subdissecta* (Nyl.) Hale, Phytologia 28(5): 481 (1974) [MB#341615] (Figure 2B)**
= *Parmelia subdissecta* Nyl. (1883)

Specimen examined: Mt. Mabol, Adams, Ilocos Norte, 18°27'22.0"N, 120°54'42.5"E, 348 m, *P. Bawingan* (SLU-L01755).

Other specimens: Tublay, Benguet (BM 000764837); Mt. Province, *M. Hale & J. Banaag* 25829 (US); Pagbilao, Quezon Province (preserved specimen at Lund Botanical Museum, identifier LD1186449); Chuan Logging area, Sierra Madre, ca. 15 km E of Pagbilao, Quezon Province, *M. E. Hale, Ellsworth, & J. Banaag* 26915 (US);

Features: Thallus submembranaceous, lobes contiguous to slightly imbricate, adnate, apices plane, truncate to subtruncate, marginal lacinules observed; cilia black, apices initially simple becoming branching; soredia and pustules absent, isidia frequent, laminal to rarely marginal, eciliate; medulla white; lower surface black,

densely rhizinate. No apothecia or pycnidia observed. Spot tests: cortex K⁺ yellow; medulla K⁻, C⁺ rose pink, KC⁺ rose to reddish rose, P⁻. Major acids: atranorin; medullary gyrophoric, lecanoric, lobaric, and oxolobaric acids (Benatti and Elix 2012).

Remarks: *B. subdissecta* was previously cited by Hale as one of the synonyms of *B. goebelli*, a species containing mainly lobaric acid and not forming isidia.

***Bulbothrix tabacina* (Mont. & Bosch) Hale, Phytologia 28(5): 48 [MB#341619] (Figure 2C)**

Specimens examined: Mt. Kabuyao, Benguet, 16°20'4.9"N, 120°33'40.8"E, 2260 m, *G. Negritto & J. Lachica* (SLU-L00078); Wright Park, Baguio City, 16°25'0"N, 120°36'0". 1540 m, *W. Leyson* (SLU-L01749); Tagaytay City, Cavite, 14°06'N, 120°56'E, 634 m, *P. Bawingan & R. Bawingan* (SLU-L02543); Mt. Kalatungba, Bukidnon, *A. Azuelo* (CMU 12-11) (SLU-L02821); Pula, Asipulo, Ifugao, 16°41.4'32"N, 120°4.9'23"E, 798 m, *M. Balabag* (SLU-L02825).

Other specimens (Hale 1976): Leyte, *Edano* 16051, 16053; Agusan, *Hale* 25052.

Features: Thallus gray-green, moderately attached to the substrate, lobes sublinear, irregularly branched, 1–5 mm wide, contiguous to slightly imbricate, with rounded apices; margin entire to slightly crenate, simple bulbate cilia distributed along the margins, mainly in lobe axils; soredia and pustules absent, isidia simple to sparsely branched, apices concolorous with the thallus; medulla white; lower surface black, moderately rhizinate, rhizines simple, black. Only a single immature apothecium observed in one specimen; pycnidia not observed. Spot tests: cortex K⁺ yellow, UV⁻; medulla K⁺ yellow turning red, C⁻, KC⁻, P⁺ yellow UV⁻. Major acids: atranorin, salazinic, and consalazinic acids.

****Bulbothrix viridescens* (Lyngé) Hale, Phytologia 28(5): 481 (1974) [MB#34162] (Figure 2D)**

Specimen examined: Mt. Mabol, Adams, Ilocos Norte, 18°27'13.3"N, 120°54'46.5"E, 436 m, *P. Bawingan* (SLU-L02542).

Features: Thallus gray-green, adnate, with narrow laciniae 0.5–1.5 mm wide, isidia, pustules or soredia absent; cilia simple, with or without apices; medulla white; lower surface black, rhizines predominantly simple. Apothecia common, coronate, containing rounded ascospores, 4.5–5.8 x 4.0–5.0 μm [4.5–6.0 x 4.0–5.0 μm in Benatti (2013)]. Spot tests: K⁻, C⁻, KC⁻, P⁻; only atranorin detected by TLC; no fatty acids observed.

Genus *Relicina*

***Relicina abstrusa* (Vainio) Hale, Phytologia 28(5): 484 (1974) [MB#343536]**

= *Parmelia abstrusa* Vain., Acta Societatis pro Fauna et Flora Fennica 7(1): 64 (1890)

Specimens (Hale 1975): Mountain, *M. E. Hale* 25769, 25818, 25828, 25881, 25888; Cagayan, *M. E. Hale* 25625, 25645, 25674, 25675, 25734; Negros Occidental, *M. E. Hale* 26432.

Other specimen: Mt. Mantalingahan, Palawan, 900 m, *H. Sipman & B. Tan* 29956

Notes: This species is distinguished by the simple cylindrical isidia, the black lower surface, coronate apothecia, and the only isidiate species to contain norstictic acid and connorstictic acid as the major medullary substances (Elix 1996).

***Relicina amphithrix* Hale, Smithsonian**

Contributions to Botany 26: 19 [MB#343538]

Specimens (Hale 1975): Luzon, Mountain Prov., *M. E. Hale* 25824 & *J. Banaag*; Agusan Prov., *M. E. Hale* 24454, 24481, 25064 & *J. Banaag*; Florida logging area, ca. 30 km SE of Butuan City, ca. 200 m, *M. E. Hale* 25191 & *J. Banaag*; Surigao del Sur Prov., *M. E. Hale* 24674 & *J. Banaag*; Negros, Negros Occidental Prov., *M. E. Hale* 24437, 26420, 26445, 26480, 26522, 26569, 26630, 26654 & *J. Banaag*.

Notes: This species is distinguished by the diminutive thallus, narrow adnate lobes (less than 1 mm wide) with cylindrical isidia, often with procumbent, lobulate isidia and the presence of medullary echinocarpic and conechinocarpic acids (Elix 1996).

***Relicina circumnodata* (Nyl.) Hale, Phytologia 28:**

484 (1974) [MB#343539]

= *Parmelia circumnodata* Nyl. in W. Nylander & J. M. M. Crombie, J. Linn. Soc. Bot. 20: 51 (1883).

Specimens (Hale 1975): Luzon, Cagayan Prov., *M. E. Hale* 24410, 25736 & *J. Banaag*; Quezon Prov., *M. E. Hale* 26878, 26879, 26887, 26900, 26920, 26923, 26925, 26928, 26934 & *J. Banaag*; Quezon National Park, ca. 300 m, *M. E. Hale* 26980 & *J. Banaag*; Mountain Prov., *M. E. Hale* 25787, 25802, 25810, 25820, 25841, 25873, 25902 & *J. Banaag*; Negros Occidental Prov., *M. E. Hale* 26421, 26433, 26474, 26500, 26517, 26561, 26572, 26580, 26599, 26631, 26633, 26651, 26652 & *J. Banaag*.

Notes: This species can be recognized by the cylindrical isidia, coronate apothecia, bicornute spores, pale lower surface with agglutinated rhizines, and the medullary protocetraric acid (Elix 1996).

***Relicina connivens* (Kurok.) Hale, Phytologia 28(5): 484 (1974) [MB#343540]**

= *Parmelia connivens* Kurok. in M. E. Hale & S. Kurokawa, Contr. U.S. Natl. Herb. 36: 142 (1964).

Specimens (Hale 1975): Negros Occidental, *M. E. Hale* 26457, 26709, 26626a; Agusan, *M. E. Hale* 25025, 25034, and 25044.

Notes: This species is distinguished by the broad lobes, the lack of vegetative propagules, the black lower surface and the unusual butlerin derivatives (butlerin A, B, C, and D) (Elix *et al.* 1995; Elix 1996).

****Relicina dentata* Elix, Bibliotheca Lichenologica 62: 55 (1996) [MB#415487] (Figure 2E)**

Specimens examined: Mt. Mabolo, Adams, Ilocos Norte, 18°27'18.7"N, 120°54'46.1" E, 436 m, 120°54'45.4"E, 367 m, (SLU-L01751); 18°26'50.6"N, 120°54'58.4"E, 394 m, (SLU-L01754).

Remark: This lichen was previously known from Australia (Elix 1996).

Features: Thallus adnate, yellow-green; lobes contiguous, sublinear-elongate and subdichotomously branched, lacking lobules and isidia; bulbate cilia moderately dense to sparse, black; medulla white; lower surface pale tan to brown; rhizines moderately dense, coarse, simple or occasionally dichotomously branched, dark brown to black. Apothecia common, adnate to substipitate, disk shallowly concave to flat, cinnamon-brown, thalline exciple ecoronate or rarely subcoronate; no pycnidia or conidia observed in our specimen. Spot tests: Cortex K–; medulla K– or K+ pale brown, C–, KC–, P+ orange. Major acids: usnic acid and protocetraric acid (major), atranorin (trace).

***Relicina malesiana* (Hale) Hale, Phytologia 28: 484 (1974) [MB#343549]**

= *Parmelia malesiana* Hale, J. Jap. Bot. 40: 203 (1965).

Remark: Type collected from Agusan Province, Mindanao, Philippines, Florida logging area, about 30 km SE of Butuan City, *M. E. Hale* 25370 (US).

Notes: *R. malesiana* has a brown-black lower surface and develops thin, shiny, blackening rhizines with squarrose branching, with fumarprotocetraric acid as major medullary constituent and traces of succinprotocetraric acid (Hale 1975, Elix 1996).

***Relicina palmata* Elix, Bibliotheca Lichenologica 62: 83 (1996) [MB#415489]**

Specimen: Sorsogon Prov., Irosin, 330–490 m, Nov. 1915, *A. D. E. Elmer* 15105b, 16194 (B). This was

earlier determined as *Relicina relicinula* (MA) Hale by H. Sipman in 1987 (BGBM 2016).

Remark: The type specimen was obtained from Sri Lanka, Sabaragamuwa Prov., Ratnapura District, logging area in Gilimale Forest Reserve, E of Gilimale, 160 m, on branches, *M. E. Hale* 46337, 12 Feb. 1976 [US!-holotype].

Notes: This species is distinguished by the diminutive thallus, narrow adnate lobes (less than 1 mm wide) with procumbent, palmately branched lobulae and the presence of medullary echinocarpic and conechinocarpic acids (Elix 1996).

***Relicina planiuscula* (Kurok.) Hale, Phytologia 28: 484 (1974) [MB#343550] (Figure 2F)**

= *Parmelia planiuscula* Kurok., in M. E. Hale & S. Kurokawa, Contr. U.S. Natl. Herb. 36: 144 (1964).

Specimen examined: Mt. Ugo, Benguet, *P. Bawingan* (SLU-L00585); Banaue Park, Banaue, Ifugao, 16°54'38"N, 121°3'15"E, 1500 m, *R. Doplah* (SLU-L02509).

Other specimens (Hale 1975): Mountain, Hale 26088, 26089, 26102, 26113, 26117, 26173, 26195, 26806.

Features: Thallus adnate, lobes contiguous, imbricate, sublinear-elongate, dichotomously or subdichotomously branched, bulbate cilia moderately dense, usually with tips; upper surface pale yellow-green, flat to convex, isidiate; isidia sparse to moderately dense, simple, cylindrical, short; a specimen observed had lobules; medulla white; lower surface black, rhizines moderately dense, simple, black. No apothecia or pycnidia observed. Elix (1996) described the apothecia as adnate, 1–2 mm wide; disc shallowly concave, cinnamon-brown to dark brown; thalline exciple ecoronate, ascospores broadly ellipsoidal to subglobose. Spot tests: cortex K–; medulla K+ yellow, C+ faint yellow-orange, P+ yellow; major acids: echinocarpic and conechinocarpic acids.

***Relicina precircumnodata* Hale, Smithsonian**

Contributions to Botany 26: 25 (1975) [MB#343551]

Remark: Type specimen collected from Agusan Province, Mindanao, Tungao Logging Area, 40 km SE of Butuan City, *M. E. Hale* 25044a (US).

Specimen examined: Mt. Mabol, Adams, Ilocos Norte, 18°27'13.3"N, 120°54'46.5"E, 436 m, *P. Bawingan* (SLU-L01752).

Other specimens (Hale 1975): Luzon: Cagayan Prov., *M. E. Hale* 24418 & *J. Banaag*; Mountain Prov., *M. E. Hale* 25826 & *J. Banaag*.

Features: Thallus coriaceous, adnate, lobes contiguous to separate, imbricate, sublinear, dichotomously to subdichotomously branched, 1–2 mm wide, lacking

lobules; cilia dense, globose, black; upper surface ±convex, dull, smooth or rugulose, emaculate, without isidia; medulla white. Lower surface pale tan; primary rhizines moderately dense, scattered; secondary rhizines developing from the primary rhizines or lower surface, richly branched or agglutinated, ivory to pale tan. Apothecia common, 1–2 mm wide, adnate; disc ±flat to shallowly concave, pale brown to brown; thalline exciple crenate, coronate, basally retrorsely rhizinate. Ascospores bicornute, eight per ascus. No pycnidia observed. Spot test: medulla K–, C–, KC–, P+red. Major acids: usnic and protocetraric.

***Relicina ramosissima* (Kurok.) Hale, Phytologia 28: 485 (1974) [MB#343552]**

= *Parmelia ramosissima* Kurok., in M. E. Hale & S. Kurokawa, Contr. U.S. Natl. Herb. 36: 145 (1964).

Specimen (Hale 1975): Agusan, *M. E. Hale* 25245, 25360.

Notes: *R. ramosissima* have linear-elongate, dichotomously branched lobes, elobulate, bulbate cilia dense, gradually inflated to globose, becoming apically branched, lack isidia, coronate apothecia, retrorsely rhizinate at base, ellipsoid to subglobose spores, and have a pale lower surface with agglutinated rhizines; contains medullary succinprotocetraric (major) and fumarprotocetraric (minor) acids (Hale 1975, Elix 1996).

***Relicina relicinula* (Mull. Arg.) Hale, Smithsonian**

Contr. Bot. 26: 27 (1975) [MB#283842] (Figure 2G)

= *Parmelia relicinula* Mull. Arg., Flora 65: 317 (1882).

= *Parmelia relicina* Fr., Syst. Orb. Veg. 1: 283 (1825).

Specimen examined: Battad, Ifugao, 16°55.537'N, 121°07.609'E, 1234 m, *R. Doplah* (SLU-L02531).

Other specimens (Hale, 1975): Mountain, *M. E. Hale* 25849, 25871; Cagayan, *M. E. Hale* 24402, 24416, 25604, 25638, 25652, 25657, 25658, 25737; Cavite, *M. E. Hale* 26836; Sorsogon, *Elmer* 16031; Agusan, *M. E. Hale* 24996, 25011, 25659; Surigao del Sur, *M. E. Hale* 24641, 24698, 24700; Zamboanga del Sur, *M. E. Hale* 24521, 24704, 24709, 24733, 24738, 24748, 24807, 24826, 24827, 24861, 25159, 25313.

Features: Thallus tightly adnate, 2–6 cm wide, lobes sublinear to separate, sublinear-elongate, not imbricate, dichotomously branched, 0.3–1.5 mm wide, usually with marginal lobules; bulbate cilia dense, conspicuous, strongly inflated to globose, 0.05–0.1 mm long, sometimes apically branched; upper surface yellow-green, flat, shiny, smooth, emaculate to faintly maculate, lacking isidia; medulla white; lower surface jet black, rhizines dense, simple or sparingly branched, black. Apothecia common,

adnate, to 1 mm wide, disc more or less flat, pale brown to brown, thalline exciple coronate, retrorsely rhizinate at the base; ascospores broadly ellipsoidal; pycnidia immersed, conidia bifusiform. Spot tests: cortex K⁻; medulla K⁻, C⁻, KC⁻, P⁻; major acids: usnic acid and relicinulinic acid B, with traces of atranorin.

***Relicina samoensis* (Zahlbr.) Hale, Phytologia 28: 485 (1974) [MB#343554]**

= *Parmelia samoensis* Zahlbr., in Reehinger, Denkschr. math.-naturw. Classe Kais. Akad. Wiss. Wien, 81: 272 (1907).

Specimen (Hale 1976): Quezon, *M. E. Hale* 26955 (US).

Notes: This species is distinguished by the diminutive thalli with adnate, stellate lobes, broad lobe axils, absence of vegetative propagules, and only lichen with coronate apothecia that has medullary echinocarpic acid (Hale 1975, Elix 1996)

***Relicina schizospatha* (Kurok.) Hale, Phytologia 28: 485 (1974) [MB#343555]**

= *Parmelia schizospatha* Kurok., in M. E. Hale & S. Kurokawa, Contr. U.S. Natl. Herb. 36: 146 (1964).

Specimen (Hale 1976): Bukidnon, *Sulit* 14806 (US).

Notes: This species is distinguished by the dense marginal and laminal lobules (±isidia), bulbate cilia not conspicuous, the black lower surface, the thin, fragile cortex, the subcoronate apothecia with scattered bulbae and medullary echinocarpic acid (Elix 1996, Hale 1975).

***Relicina subabstrusa* (Gyeln.) Hale, Phytologia 28: 485 (1974) [MB#343556] (Figure 2H)**

= *Parmelia subabstrusa* Gyeln., *Repert. Spec. Nov. Regni Veg.* 29: 288 (1931).

= *Parmelia abstrusa* f. *laevigata* Lynge, *Arkiv Bot.* 13: 147 (1914).

Specimens examined: Mt. Mabol, Adams, Ilocos Norte, 18°27'16.9"N, 120°54'45.9"E, 352 m, *P. Bawingan* (SLU-L01753); Asipulo, Ifugao, 16°42'6.0"N, 121°4.3"E, 352 m, *R. Doplak* (SLU-02822).

Other specimens (Hale 1976): Mountain, *M. E. Hale* 25760, 25762, 25772, 25581, 25797, 25800, 25801, 25812, 25817, 25838, 25858, 25863, 25879, 25898, 25901, 25802a, 25913, 26506 (US); Cagayan, *M. E. Hale* 25608, 25654, 25661, 25751 (US); Cavite, *M. E. Hale* 26811, 26828 (US); Negros Occidental, *M. E. Hale* 26427, 26444, 26449, 26473, 26494, 26494a, 26510, 26519, 26564, 26581, 26626, 26632, 26693, 26696 (US); Agusan, *M. E. Hale* 24460, 24474, 24984, 25003, 25014,

25029, 25033, 25048 (US); Basilan, *M. E. Hale* 24935, 24949, 25141, 25333 (US).

Further specimen: Mantalingahan slope, Palawan, 900 m, *Sipman & Tan* 29956 (B).

Features: Thallus adnate, 4–8 cm wide, lobes linear-elongate, dichotomously to subdichotomously branched; bulbate cilia dense, conspicuous, strongly inflated, to 1 mm long; upper surface yellow-green, flat to weakly convex, smooth, emaculate, without isidia; medulla white; lower surface black, rhizines dense, simple or sparingly branched, black. Apothecia abundant, adnate, thalline exciple markedly coronate, retrorsely rhizinate at base; disc more or less flat or shallowly concave, cinnamon-brown; ascospores ellipsoidal, eight per ascus; pycnidia common, punctiform. Spot tests: cortex K⁻; medulla K⁺ yellow-red, C⁻, P⁺ orange; major acids: usnic and norstictic acid (major); Elix (1996) also mentioned the presence of connorstictic acid (minor/trace), ±hyposalazinic acid (trace), and ±accessory diffractaic acid (major).

***Relicina sublanea* (Kurok.) Hale, Phytologia 28: 485 (1975) [MB#343558]**

= *Parmelia sublanea* Kurok., in M. E. Hale & S. Kurokawa, Contr. U.S. Natl. Herb. 36: 146 (1964).

Specimens (Hale 1975): Negros Occidental, *M. E. Hale* 26459, 26578, 26650, 26657 (US); Surigao del Sur, *M. E. Hale* 24635, 24655; Zamboanga del Sur, *M. E. Hale* 24793, 23310 (US); Basilan, *M. E. Hale* 24920, 24922 (US).

Notes: This lichen closely resembles *R. ramosissima* as both species lack isidia, have ecoronate apothecia, and pale surface with agglutinated rhizines, but *R. sublanea* has significantly larger spores and with medullary protocetraric acid (Elix 1996, Hale 1975).

ACKNOWLEDGMENTS

We sincerely thank Saint Louis University for the research grant and Michel Navarro Benatti of the Instituto de Botanica, São Paulo, Brazil for his comments to improve the manuscript and for verifying the identification of the lichens.

REFERENCES

- BAWINGAN PA, LARDIZAVAL MP, ROSUMAN PF, FAJARDO WT, AZUELO A, ELIX JA, HUR J-A. 2017. Philippine species of *Parmotrema* (Ascomycota, Parmeliaceae). *Philipp J Sci* 146(2): 145–158.

- BENATTI MN. 2011. A simple clearing technique to aid in the recognition of cilia and rhizinae structure in the Parmeliaceae. *Opuscula Philolichenum* 9: 2–25.
- BENATTI MN. 2012. A review of the genus *Bulbothrix* Hale: The species with medullary norstictic and protocetraric acids. *MycKeys* 2: 1–28. Doi: 10.3897/mycokeys.2.2522.
- BENATTI MN. 2013. A review of the genus *Bulbothrix* Hale: The species with medullary fatty acids or without medullary substances. *Mycosphere* 4(2): 303–331. Doi 10.5943.
- BENATTI MN. 2014. A review of the genus *Bulbothrix* Hale: The isidiate, lacinulate, sorediate and postulate species with medullary gyrophoric, lecanoric and lobaric acids together with a world key for the genus. *Opuscula Philolichenum* 13: 122–154.
- BENATTI MN, ELIX JA. 2012. The true identity of *Bulbothrix goebelii* (Zenker) Hale and the reestablishment of some of its synonyms as accepted species. *The Lichenologist* 44: 813–826.
- BENATTI MN, MARCELLI MP. 2010. Four Parmeliaceae species excluded from *Bulbothrix*. *Mycotaxon* 111: 387–401.
- [BGBM] Botanic Garden and Botanical Museum Berlin-Dahlem. 2016. Lichen Herbarium Berlin. Occurrence dataset (<https://doi.org/10.15468/gmyyyu>) accessed via GBIF.org (<https://www.gbif.org/occurrence/1212039352>) on 2019 Mar 29.
- CRESPO A, KAUFF F, DIVAKAR P, PRADO R, ORTEGA SP, DE PAZ GA, FERENCOVA Z, BLANCO O, ROCA-VALIENTE B, NUÑEZ-ZAPATA, CUBAS P, ARGÜELLO A, ELIX J, ESSLINGER T, HAWKSWORTH D, MILLANES AM, MOLINA MC, WEDIN M, AHTI T, APTROOT A. 2010. Phylogenetic generic classification of parmelioid lichens (Parmeliaceae, Ascomycota) based on molecular, morphological and chemical evidence. *Taxon* 59(6): 1735–1753.
- ELIX JA. 1996. A Revision of the Lichen Genus *Relicina*. *Bibliotheca Lichenologica* 62: 1–149.
- ELIX JA. 1998. A new species and revised key to the genus *Relicina* (Ascomycotina, Parmeliaceae). *Mycotaxon* 69: 129–136.
- ELIX JA. 2014. A catalogue of standardized chromatographic data and biosynthetic relationships for lichen substances, 3rd Ed. Canberra: Australian National University. Retrieved from <http://www.cpbr.gov.au/abrs/lichenlist/Chem%20Cat%203.pdf>
- ELIX JA, ERNST-RUSSELL KD. 1993. A Catalogue of Standardized Thin Layer Chromatographic Data and Biosynthetic Relationships for Lichen Substances, 2nd Ed. Canberra: Australian National University.
- ELIX JA, GAUL KL, HOCKLESS DCR, WARDLAW JH. 1995. Structure determination of butlerins A, B and C – three new lichen pterphenyls. *Australian Journal of Chemistry* 48: 1049–1053.
- HALE ME. 1975. A Monograph of the Lichen Genus *Relicina* (Parmeliaceae). *Smithsonian Contributions to Botany* 26: 1–32. doi: 10.5479/si.0081024X.26
- HALE ME. 1976. A Monograph of the Lichen Genus *Bulbothrix* Hale (Parmeliaceae). *Smithsonian Contributions to Botany* 33: 1–60.
- HALE ME. 1983. *How to Know the Lichens*, 2nd Ed. Dubuque, IA: Wm. C. Brown.
- KIRKAPA, DIVAKAR PK, LEAVITT SD, BUARUANG K, CRESPO A, MUGAMBI G, GATHERI G, LUMBSCH HT. 2017. The genus *Relicinopsis* is nested within *Relicina* (Parmeliaceae, Ascomycota). *The Lichenologist* 49(3): 189–197.
- LUCKING R. 2009. The taxonomy of the genus *Graphis sensu* Staiger (Ascomycota: Ostropales: Graphidaceae). *The Lichenologist* 41(4): 319–362.
- MICHLIG A, BENATTI M. 2015. Revision of the genus *Bulbothrix* (Parmeliaceae, lichenized Ascomycota) in NE Argentina, with a key to the species. *Cryptogamie* 36(2): 177–192. doi/10.7872/crym/v36.iss2.2015.177
- ORANGE A, JAMES PW, WHITE FJ. 2001. *Microchemical methods for the identification of lichens*. British Lichen Society. 101p.
- SIPMAN HJ, DIEDERICH P, APTROOT A. 2013. New lichen records and a catalogue of lichens from Palawan Island, The Philippines. *Philipp J Sci* 142: 199–210.
- VAINIO EA. 1909. *Lichenes Insularum Philippinarum I*. *Philipp J Sci* 4(5): 651–662.

APPENDIX

Key to Philippine Species of *Bulbothrix* and *Relicina*

1a	Upper surface gray-green to gray, K+ (with atranorin)	2 (<i>Bulbothrix</i>)
1b	Upper surface yellow-green, K- (with usnic acid)	6 (<i>Relicina</i>)
2a	Thallus isidiate, variable medullary substances	3
2b	Thallus not isidiate, without any medullary substances	<i>B. viridescens</i>
3a	Lower cortex with reddish spots, very narrow sublinear lacinae, up to 3.5 cm diam., presents an unidentified pigment, and may react faintly C+ rose	<i>B. pigmentacea</i>
3b	Lower cortex without reddish spots	4
4a	Medulla K-, C+ rose pink, P- lecanoric acid	<i>B. subdissecta</i>
4b	Medulla K+ yellow then red, C-, P+ yellow salazinic acid	5
5a	Lower surface pale brown throughout	<i>B. isidiza</i>
5b	Lower surface black with pale to dark brown marginal zone	<i>B. tabacina</i>
6a	Thallus isidiate	7
6b	Thallus not isidiate	11
7a	Secondary rhizines present, densely branched, and agglutinated	<i>R. circumnodata</i>
7b	Secondary rhizines absent; all rhizines simple	8
8a	Isidia becoming lobulate	<i>R. schizospatha</i>
8b	Isidia globose or cylindrical	9
9a	Medulla K+ yellow to red	<i>R. abstrusa</i>
9b	Medulla K- or K+ pale yellow	10
10a	Lobes very narrow, 0.3–1.0 mm, medulla K-	<i>R. amphithrix</i>
10b	Lobes broader, 1.0–1.3 mm, medulla K+ yellow	<i>R. planiuscula</i>
11a	Lower surface pale tan to brown	12
11b	Lower surface black	15
12a	Apothecia coronate	<i>R. precircumnodata</i>
12b	Apothecia ecoronate	13
13a	Rhizines not dimorphous, simple or occasionally branched, spores 4–6 x 2.5–4 µm.....	<i>R. dentata</i>
13b	Rhizines dimorphous; secondary rhizines dense, richly-branched, and agglutinated	14
14a	K-, KC+ red, spores 2 x 3 µm	<i>R. ramosissima</i>
14b	K- or K+ pale brown, KC-, spores 4–5 x 7–9 µm	<i>R. sublanea</i>
15a	Medulla P-	16
15b	Medulla P+ yellow, orange, or red.....	17
16a	Apothecia coronate	<i>R. relicinula</i>
16b	Apothecia ecoronate	<i>R. connivens</i>
17a	Apothecia ecoronate, P+ brick red	<i>R. malesiana</i>
17b	Apothecia coronate, P+ orange to orange-red	18
18a	Medulla K-, lobulate, lobulae palmately branched	<i>R. palmata</i>
18b	Medulla K+, elobulate	19
19a	Medulla K+ yellow to red, C-, P+ orange, with norstictic acid.....	<i>R. subabstrusa</i>
19b	Medulla K+ yellow, C+ pale orange, P+ yellow-orange, without norstictic acid	<i>R. samoensis</i>