



NOTE

Contribution to the knowledge of the Lichen Mycota of Myanmar (I) twenty species newly recorded from Southern Myanmar

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ABSTRACT: Specimens of lichens collected from southern Myanmar including Tanintharyi and Yangon Regions were examined. As the result of taxonomic examinations, the following 20 species were identified: *Astrothelium macrocarpum*, *Bulbothrix subscortea*, *Coccocarpia erythroxyli*, *C. palmicola*, *Cruentotrema thailandicum*, *Dirinaria aegialita*, *D. consimilis*, *Dyplolabia afzelii*, *Flakea papillata*, *Glyphis cicatricosa*, *Graphis* cf. *caesiella*, *G. desquamescens*, *G. supracola*, *Malmidea bakeri*, *Physcia undulata*, *Pyrenula mamillana*, *Pyxine dactyloschmidtii*, *Sarcographa labyrinthica*, *Trypethelium eluteriae*, and *Zwackhia prosodea*. All of them, except the two species of *Coccocarpia*, are new records for Myanmar. The ITS rDNA sequences were successfully obtained from 17 samples for 14 species. The BLAST identities for Myanmar collections with the same species in GenBank range from 89 to 100%.

KEY WORDS: BLAST, distribution, inventory, ITS rDNA, lichenized fungi, Southeast Asia, taxonomy.

INTRODUCTION

Myanmar is considered to hold important and irreplaceable biodiversity that is part of the Indo-Burma Biodiversity Hotspot. Habitats range from the mangrove forests and coral reefs of the Andaman Islands in the south to the snow-capped peaks of Mt. Kakaboradzi (5,881 m) in the north, the highest mountain in Southeast Asia (Mittermeier *et al.*, 2004; Tanaka *et al.*, 2018). Despite much attention paid to the investigation and conservation of plant and animal biodiversity (Tordoff *et al.*, 2011), the lichen mycota has been poorly studied so far. Only 10 species and one variety of lichens were reported before the present study: i.e., *Bulbothrix* cf. *tabacina* (Mont. & Bosch) Hale, *Coccocarpia erythroxyli* (Spreng.) Swinscow & Krog, *C. palmicola* (Spreng.) Arv. & D.J. Galloway, *Dirinaria picta* (Sw.) Clem. & Shear, *Gyronactis asiatica* Ertz & Tehler, *Leptogium trichophorum* Müll. Arg., *L. trichophorum* var. *fuliginosum* Müll. Arg., *Melaspilea heterocarpa* (Fée) Müll. Arg., *Parmotrema sulphuratum* (Nees & Flot.) Hale, *Pyrenula laevigata* (Pers.) Arnold, and *Rhizocarpon subalboatrum* (Nyl.) Müll. Arg. (Nylander and Crombie, 1883; Müller, 1889; Arvidsson, 1982; Ertz *et al.*, 2015).

As part of the international cooperative project "Biological Inventory with special attention to Myanmar" organized by the National Museum of Nature and Science, Japan and the Forest Department, Ministry of Natural Resources and Environmental Conservation, Myanmar, the authors have since 2017 studied the lichen

mycota of Myanmar.

This paper contributes to the knowledge of the lichen mycota of Myanmar. ITS rDNA sequences were generated from DNA extracted from identified specimens.

MATERIALS AND METHODS

Field surveys in Tanintharyi and Yangon Regions in Myanmar were carried out from 16 to 25 January 2017. A total of 159 specimens was collected. Twenty-five specimens are identified to species level and are reported in this study, while the remaining specimens are still under examination. All specimens are housed in the herbarium of the National Museum of Nature and Science, Japan (TNS), with some duplicates in the herbaria of the Forest Research Institute, Myanmar (RAF) and National Taiwan University, Taiwan (TAI).

Morphological observations were made using a dissecting microscope (Olympus SZX16) and a differential interference contrast microscope (Olympus BX51). Anatomical examinations were made on hand cut sections mounted in water. Ascospore measurements are given as (minimum–) range including mean \pm standard deviation (–maximum) (n = number of measurements).

Chemical substances of lichens were examined using thin layer chromatography (TLC) (Culberson and Johnson, 1982). Solvent system B' (hexane: methyl tert-butyl ether: formic acid, 140: 72: 18) was used for all TLC analyses.

DNA extraction followed a modified CTAB protocol (Hosaka, 2009).



Table 1. Identified taxa from the southern part of Myanmar and the BLAST results of the ITS rDNA sequence

| Taxa | Voucher | GenBank accession number for ITS rDNA | BLAST results with GenBank sequences. Identity; score; e-value (accession number, species) of the top 3 sequences (maximum) of related taxa are shown. |
|----------------------------------|-----------------------|---------------------------------------|---|
| <i>Astrothelium macrocarpum</i> | Y. Ohmura 12285 | LC573990 | 527/533 (99%), 948, 0.0 (LC127382, <i>Astrothelium macrocarpum</i>) 527/533 (99%), 948, 0.0 (LC127383, <i>Astrothelium macrocarpum</i>) 520/525 (99%), 941, 0.0 (LC127384, <i>Astrothelium macrocarpum</i>) |
| | Y. Ohmura 12392 | LC573991 | 783/793 (99%), 1406, 0.0 (LC127382, <i>Astrothelium macrocarpum</i>) 783/793 (99%), 1406, 0.0 (LC127383, <i>Astrothelium macrocarpum</i>) 786/800 (98%), 1397, 0.0 (AB759880, <i>Astrothelium macrocarpum</i>) |
| <i>Bulbothrix subscortea</i> | Y. Ohmura 12397 | LC573992 | 527/527 (100%), 974, 0.0 (KM249896, <i>Bulbothrix subscortea</i>) 526/526 (100%), 972, 0.0 (KM249904, <i>Bulbothrix subscortea</i>) 527/528 (99%), 968, 0.0 (KM249907, <i>Bulbothrix subscortea</i>) |
| | Y. Ohmura 12398 | LC573993 | 526/527 (99%), 968, 0.0 (KM249896, <i>Bulbothrix subscortea</i>) 525/526 (99%), 966, 0.0 (KM249904, <i>Bulbothrix subscortea</i>) 526/528 (99%), 963, 0.0 (KM249907, <i>Bulbothrix subscortea</i>) |
| <i>Coccocarpia erythroxyli</i> | Y. Ohmura 12336 | LC573994 | 726/744 (98%), 1267, 0.0 (KT947056, <i>Coccocarpia erythroxyli</i>) 724/744 (97%), 1256, 0.0 (KT947055, <i>Coccocarpia erythroxyli</i>) 718/743 (97%), 1218, 0.0 (KT947060, <i>Coccocarpia palmicola</i>) |
| <i>Coccocarpia palmicola</i> | Y. Ohmura 12408 | LC573995 | 724/725 (99%), 1334, 0.0 (KT947060, <i>Coccocarpia palmicola</i>) 709/743 (95%), 1162, 0.0 (KT947056, <i>Coccocarpia erythroxyli</i>) 707/743 (95%), 1151, 0.0 (KT947055, <i>Coccocarpia erythroxyli</i>) |
| <i>Cruentotrema thailandicum</i> | Y. Ohmura 12327 | LC573996 | 483/545 (89%), 652, 0.0 (KP012902, <i>Dyplolabia afzelii</i>) 366/428 (86%), 425, 2e-114 (KR017123, <i>Fissurina insidiosa</i>) |
| <i>Dirinaria aegialita</i> | Y. Ohmura 12281 | LC573997 | 532/533 (99%), 979, 0.0 (MK028196, <i>Dirinaria aegialita</i>) 531/533 (99%), 972, 0.0 (MK028169, <i>Dirinaria aegialita</i>) 531/533 (99%), 972, 0.0 (MK028168, <i>Dirinaria aegialita</i>) |
| | Y. Ohmura 12396 | LC573998 | 621/628 (99%), 1118, 0.0 (AB764068, <i>Dirinaria aegialita</i>) 552/560 (99%), 987, 0.0 (LC516424, <i>Dirinaria consimilis</i>) 532/538 (99%), 959, 0.0 (MK028174, <i>Dirinaria picta</i>) |
| <i>Dyplolabia afzelii</i> | Y. Ohmura 12324 | N/A | N/A |
| | Y. Ohmura 12411 | LC573999 | 530/546 (97%), 911, 0.0 (KP012902, <i>Dyplolabia afzelii</i>) 334/375 (89%), 484, 2e-132 (MK503256, <i>Dyplolabia afzelii</i>) |
| <i>Flakea papillata</i> | Y. Ohmura 12329 | LC574000 | 726/815 (89%), 994, 0.0 (KT232210, <i>Flakea papillata</i>) |
| <i>Glyphis cicatricosa</i> | Y. Ohmura 12294 | N/A | N/A |
| <i>Graphis cf. caesiella</i> | Y. Ohmura 12268 | N/A | N/A |
| | Y. Ohmura 12337 | N/A | N/A |
| <i>Graphis desquamescens</i> | Y. Ohmura 12268 pr.p. | N/A | N/A |
| <i>Graphis supracola</i> | Y. Ohmura 12268 pr.p. | N/A | N/A |
| <i>Malmidea bakeri</i> | Y. Ohmura 12366 | LC574001 | 606/624 (97%), 1051, 0.0 (MK499341, <i>Malmidea subaurigera</i>) |
| | Y. Ohmura 12404 | LC574002 | 605/623 (97%), 1050, 0.0 (MK499341, <i>Malmidea subaurigera</i>) |
| <i>Phycia undulata</i> | Y. Ohmura 12300 | LC574003 | 507/507 (100%), 937, 0.0 (MK028207, <i>Phycia undulata</i>) 507/507 (100%), 937, 0.0 (MK028206, <i>Phycia undulata</i>) |
| | Y. Ohmura 12413 | LC574004 | 898/916 (98%), 1589, 0.0 (KT820154, <i>Pyrenula massariospora</i>) 845/925 (91%), 1245, 0.0 (KT820150, <i>Pyrenula mamillana</i>) 825/908 (91%), 1201, 0.0 (KT820149, <i>Pyrenula mamillana</i>) |
| <i>Pyxine dactyloschmidtii</i> | Y. Ohmura 12276 | LC574005 | 488/489 (99%), 898, 0.0 (MK028211, <i>Pyxine retirugella</i>) 487/489 (99%), 891, 0.0 (MK028217, <i>Pyxine retirugella</i>) 487/489 (99%), 891, 0.0 (MK028216, <i>Pyxine retirugella</i>) |
| | Y. Ohmura 12399 | LC574006 | 410/488 (84%), 444, 3e-120 (KC592266, <i>Leiorreuma sericeum</i>) 338/389 (87%), 420, 5e-113 (KC592265, <i>Leiorreuma sericeum</i>) 329/381 (86%), 394, 3e-105 (NR_120278, <i>Halegrapha chimaera</i>) |
| | Y. Ohmura 12400 | N/A | N/A |
| <i>Trypethelium eluteriae</i> | Y. Ohmura 12270 | N/A | N/A |
| <i>Zwackhia prosodea</i> | Y. Ohmura 12388 | N/A | N/A |



For DNA amplification, 10 µL of PCR mix contained 1 µL genomic DNA extraction, 0.25 µL of each primer (10 pmol/µL) and 5 µL Emerald-Amp PCR Master Mix (TaKaRa Bio Inc.). PCR amplification of the ITS rDNA region (including ITS1, 5.8S rDNA and ITS2) was performed using the primer set of ITS1F (Gardes and Bruns, 1993) as the 5' primer and LR1 (Vilgalys and Hester, 1990) as the 3' primer. PCR cycling conditions were 94°C (3 min), followed by 11 cycles of 95°C (30 sec), 62°C to 52°C (30 sec) with annealing temperatures lowered by 1°C between cycles, and 72°C (1 min), followed by 30 cycles at 52°C annealing temperature and a final extension at 72°C (7 min). Sequencing was done on an ABI Prism 3130x genetic analyzer (Applied Biosystems) using the BigDye Terminator ver. 3.1 Cycle Sequencing Kit according to the manufacturer's instructions.

The obtained sequences were analyzed using the GenBank BLAST search (blastn). Default settings for the blastn option were used.

Voucher information and GenBank accession numbers for the obtained ITS rDNA sequences are shown in Table 1.

RESULTS AND DISCUSSION

Astrothelium macrocarpum (Fée) Aptroot & Lücking, *Lichenologist* 48: 867. 2016.

Figs. 1A & 1B

For a detailed description and synonyms, see Aptroot and Lücking (2016). Ascospore size for the Myanmar collections is (15.7–)19.1–21.9(–22.9) × (5.4–)7.0–8.2(–9.1) µm (n = 53). Perispore is 2.1–6.5 µm thick.

Chemistry: Parietin.

Remarks: Ascospore size of the Myanmar collection is slightly smaller than the reported size (21–28 × 7–11 µm) in Aptroot and Lücking (2016). Because their ranges partially overlap, this study treats the difference as intraspecific variation.

Astrothelium macrocarpum resembles *Trypethelium eluteriae* Spreng. in having an olive-green to yellow crustose thallus and yellow pseudostromata. However, it is readily distinguished from the latter species by erumpent pseudostromata with flattened top and 3-septate ascospores.

In addition to the morphological and chemical conformity, the BLAST results show high identities (98–99%) with *A. macrocarpum* sequences in GenBank (Table 1).

Distribution: Pantropical. Asia (Borneo, India, Singapore, Sri Lanka, and Thailand), Oceania (Australia and Papua New Guinea), North and South Americas (Brazil, Colombia, Costa Rica, Cuba, French Guiana, Guyana, Panama, USA, and Venezuela), and Africa (Gabon and South Africa) (Aptroot and Lücking, 2016). New to Myanmar.

Specimens examined: MYANMAR. Tanintharyi Region:

Pha Chaung Inn Beach, Kanbauk Village, Yephyu Township, N14°30'37", E97°56'44", on bark of Fabaceae, elev. 0 m, 18 January 2017, *Y. Ohmura* 12285 (TNS, RAF, TAI); Migyanughlaung, Tanintharyi Nature Reserve, Yephyu Township, N14°40'18", E98°08'16", on bark of broad-leaf tree, elev. 35 m, 23 January 2017, *Y. Ohmura* 12392 (TNS, RAF, TAI).

Bulbothrix subscortea (Asahina) Marcelli & Benatti, *Mycosphere* 3: 48. 2012.

Fig. 1C

For detailed descriptions, see Benatti (2012) and Zhang *et al.* (2014).

Chemistry: Atranorin and salazinic acid.

Remarks: In addition to the morphological and chemical conformity, the BLAST results show high identities (99–100%) with *B. subscortea* sequences in GenBank (Table 1).

Distribution: Tropical to subtropical regions of Asia (Cambodia, China, India, Japan, Nepal, and Taiwan) (Zhang *et al.*, 2014). New to Myanmar.

Specimens examined: MYANMAR. Tanintharyi Region:

Migyanughlaung, Tanintharyi Nature Reserve, Yephyu Township, N14°40'18", E98°08'16", on bark of *Areca catechu*, elev. 35 m, 23 January 2017, *Y. Ohmura* 12397 (TNS, RAF, TAI), *Y. Ohmura* 12398 (TNS, RAF).

Coccocarpia erythroxyli (Spreng.) Swinscow & Krog, *Norweg. J. Bot.* 23: 256. 1976.

Fig. 1D

For a detailed description and synonyms, see Arvidsson (1982).

Chemistry: No lichen substance was detected by TLC.

Remarks: In addition to the morphological and chemical conformity, the BLAST results show high identity (98%) with *C. erythroxyli* (the first hit) sequence in GenBank (Table 1).

Distribution: Tropical to temperate regions of Asia, Oceania, North and South Americas, Europe, and Africa (Arvidsson, 1982).

Specimen examined: MYANMAR. Tanintharyi Region:

Kanbauk Village, Yephyu Township, N14°35'14", E98°03'06", on bark of broad-leaf tree, elev. 25 m, 20 January 2017, *Y. Ohmura* 12336 (TNS, RAF).

Coccocarpia palmicola (Spreng.) Arv. & D.J. Galloway, *Bot. Not.* 132: 242. 1979.

Fig. 1E

For a detailed description and synonyms, see Arvidsson (1982).

Chemistry: No lichen substance was detected by TLC.

Remarks: In addition to the morphological and chemical conformity, the BLAST results show high identity (99%) with *C. palmicola* sequence in GenBank (Table 1).

Distribution: Tropical to warm-temperate regions of Asia, Oceania, North and South Americas, and Africa (Arvidsson, 1982).



Specimen examined: MYANMAR. Tanintharyi Region: Migyanughlaung, Tanintharyi Nature Reserve, Yephyu Township, N14°40'18", E98°08'16", on bark of *Areca catechu*, elev. 35 m, 23 January 2017, *Y. Ohmura 12408* (TNS, RAF).

Cruentotrema thailandicum Rivas Plata, Papong & Lumbsch, *Fungal Divers.* 52: 119. 2012.

Figs. 1F & 1G

For a detailed description, see Rivas Plata *et al.* (2012). Ascospore size for the Myanmar collections is (15.1–)17.0–20.6(–23.6) × (5.9–)6.5–7.5(–8.1) μm (n=39). Perispore is 1.4–2.6 μm thick.

Chemistry: Red pigments (R_f classes 1, 2–3).

Remarks: This species resembles *C. lirelliforme* J. Kalb, Polyiam & K. Kalb that has lirelliform ascomata, while *C. thailandicum* has angular-rounded ascomata (Kalb *et al.*, 2016). The specimen from Myanmar has both lirelliform and angular-rounded ascomata. However, the ascospore size of the specimen from Myanmar agrees with *C. thailandicum* (15–25 × 7–10 μm), while *C. lirelliforme* has longer ascospores (20–30 × 7–10 μm) (Rivas Plata *et al.*, 2012; Kalb *et al.*, 2016). Since both species were described on few specimens collected at the respective type localities, further taxonomic research including additional collections is needed to examine their relationship.

The BLAST results show less than 89% identity with Graphidaceae sequences in GenBank although an e-value with *Dyplolabia afzelii* shows 0.0 (Table 1). The low homology results were due to the fact that ITS rDNA sequences of *Cruentotrema* species are not registered in GenBank.

Distribution: Asia (Thailand) (Rivas Plata *et al.*, 2012). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Padauk-kon Chaung, Thet Kae Kawt Compartment, Tanintharyi Nature Reserve, Yephyu Township, N14°23'19", E98°11'05", on bark of broad-leaf tree, elev. 40 m, 19 January 2017, *Y. Ohmura 12327* (TNS, RAF).

Dirinaria aegialita (Afzel. ex Ach.) B.J. Moore, *Bryologist* 71: 248. 1968.

Fig. 1H

For a detailed description and synonymy, see Elix (2009).

Chemistry: Atranorin, divaricatic acid and terpenes.

Remarks: In addition to the morphological and chemical conformity, the BLAST results show high identity (99%) with *D. aegialita* sequences in GenBank (Table 1).

Distribution: Tropical to warm-temperate regions of Asia, Oceania, North and South Americas, and Africa (Elix, 2009). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Pha Chaung Inn Beach, Kanbauk Village, Yephyu Township, N14°30'37", E97°56'44", on bark of Fabaceae, elev. 0 m, 18 January 2017, *Y. Ohmura 12281* (TNS, RAF, TAD).

Dirinaria consimilis (Stirt.) D.D. Awasthi, *J. Indian Bot. Soc.* 49: 135. 1970.

Fig. 1I

For a detailed description, see Elix (2009). For synonymy, see Kashiwadani (1979).

Chemistry: Atranorin, sekikaic acid and terpenes.

Remarks: The BLAST results show 99% identity with *D. aegialita* (the first hit), 99% with *D. consimilis* (the second hit) and 99% with *D. picta* (the third hit) sequences in GenBank (Table 1). The presence of sekikaic acid in the Myanmar collection confirmed the identification as *D. consimilis*. The other two species contain divaricatic acid.

Distribution: Tropical to warm-temperate regions of Asia, Oceania and Africa (Elix, 2009). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Migyanughlaung, Tanintharyi Nature Reserve, Yephyu Township, N14°40'18", E98°08'16", on bark of *Areca catechu*, elev. 35 m, 23 January 2017, *Y. Ohmura 12396* (TNS, RAF).

Dyplolabia afzelii (Ach.) A. Massal., *Neagen. Lich.*: 6. 1854.

Figs. 1J & 1K

For a detailed description, see Archer (2006). Ascospore size for the Myanmar collections is (14.9–)15.6–18.0(–20.2) × (6.1–)6.9–8.3(–9.2) μm (n=63).

Chemistry: Lecanoric acid.

Remarks: In addition to the morphological and chemical conformity, the BLAST result shows high identity (97%, the first hit) with *D. afzelii* sequence in GenBank (Table 1). The low identity (89%) with the second sequence of this species is due to the many ambiguous sites and short read of the sequence (MK503256).

Distribution: Pantropical. Asia (Cambodia, China, India, Indonesia, Malaysia, the Philippines, Singapore, Sri Lanka, Thailand, and Vietnam), Oceania (Australia and Papua New Guinea), North and South Americas (Bermuda, Bolivia, Brazil, Colombia, Cuba, Dominica, French Guiana, Guyana, Mexico, Peru, Suriname, U.S.A., and Venezuela), and Africa (Cameroon and Kenya) (Staiger, 2002; Archer, 2006; Singh and Singh, 2010; Moon *et al.*, 2015; Buaruang *et al.*, 2017). New to Myanmar.

Specimens examined: MYANMAR. Tanintharyi Region: Padauk-kon Chaung, Thet Kae Kawt Compartment, Tanintharyi Nature Reserve, Yephyu Township, N14°23'19", E98°11'05", on bark of *Ficus elastica*, elev. 40 m, 19 January 2017, *Y. Ohmura 12324* (TNS, RAF, TAD); Migyanughlaung, Tanintharyi Nature Reserve, Yephyu Township, N14°41'09", E98°08'59", on bark of *Anacardium occidentale*, elev. 60 m, 23 January 2017, *Y. Ohmura 12411* (TNS, RAF).

Flakea papillata O.E. Erikss., *Syst. Ascom.* 11: 14. 1992.

Fig. 1L

For a detailed description, see Perlmutter (2006).

Chemistry: No lichen substance was detected by TLC. Thor and Kashiwadani (1996) reported zeorin and two other triterpenoids from Japanese collections.

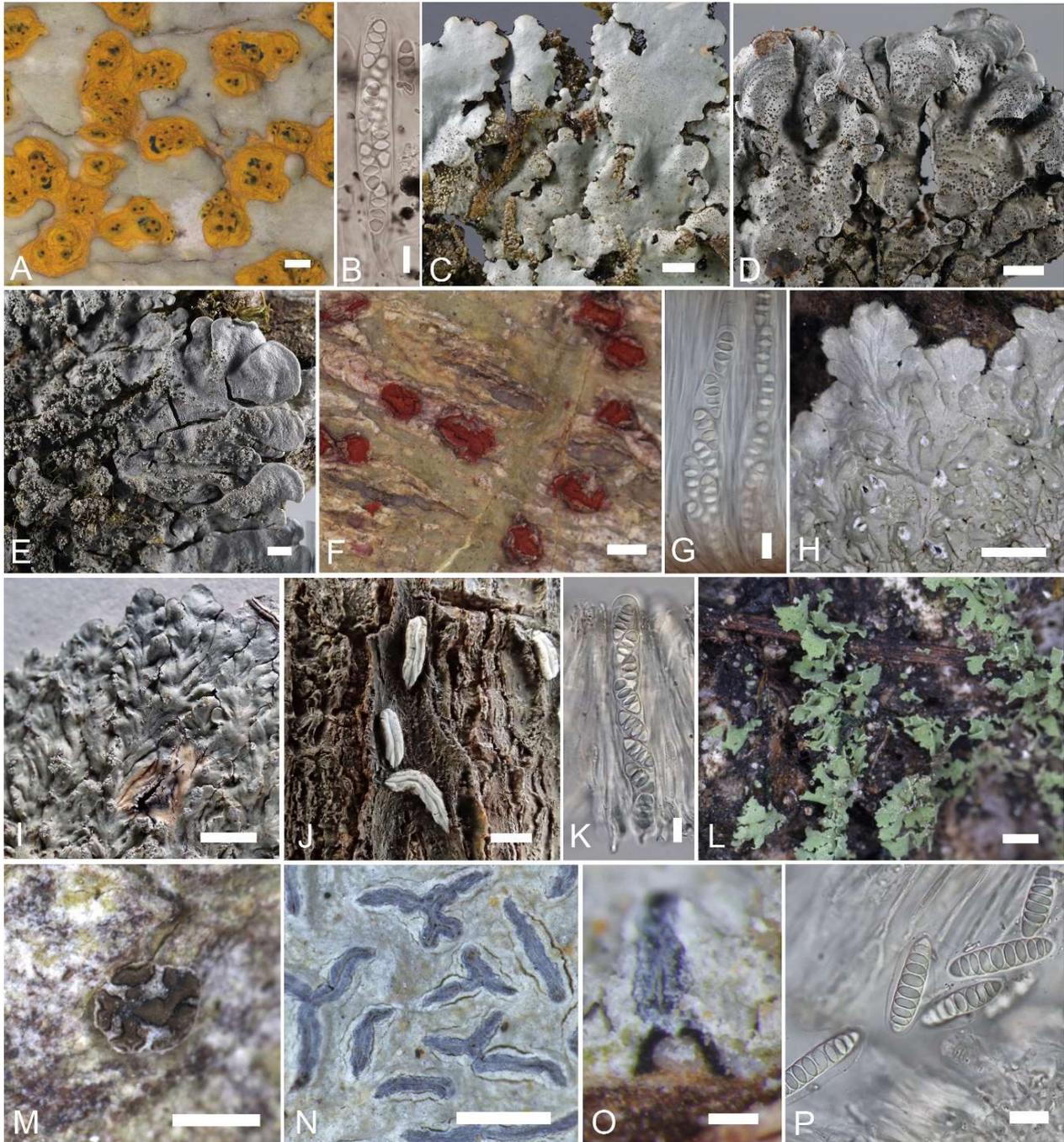


Fig. 1. Lichens collected from southern Myanmar. **A–B.** *Astrothelium macrocarpum* (Y. Ohmura 12285, TNS) (A: ascomata; B: ascospores). **C.** *Bulbothrix subscortea* (Y. Ohmura 12397, TNS). **D.** *Coccocarpia erythroxyli* (Y. Ohmura 12336, TNS). **E.** *Coccocarpia palmicola* (Y. Ohmura 12408, TNS). **F–G.** *Cruentotrema thailandicum* (Y. Ohmura 12327, TNS) (F: ascomata; G: ascospores). **H.** *Dirinaia aegialita* (Y. Ohmura 12281, TNS). **I.** *D. consimilis* (Y. Ohmura 12396, TNS). **J–K.** *Dyplolabia afzelii* (Y. Ohmura 12411, TNS) (J: ascomata; K: ascospores). **L.** *Flakea papillata* (Y. Ohmura 12329, TNS). **M.** *Glyphis cicatricosa* (Y. Ohmura 12294, TNS). **N–P.** *Graphis* cf. *caesiella* (Y. Ohmura 12268, TNS) (N: ascomata; O: vertical section of ascoma; P: ascospores). Scales: A, L, M, N = 0.5 mm; B, G, K, P = 10 μ m; C, E, F, J = 1 mm; D, H, I = 2 mm; O = 0.1 mm.

Remarks: This species is known as a strictly sterile taxon characterized by flake-like thalli of narrowly arranged, irregularly wrinkled, small bluish-green lobes that are not or only little incised. Molecular phylogenetic analysis confirmed it to belong to Verrucariaceae

(Muggia *et al.*, 2009). The BLAST result shows only 89% identity with *F. papillata* (KT232210, U.S.A. sample) sequence in GenBank (Table 1). The low identity of the BLAST result indicates that *F. papillata* is a heterogeneous sterile taxon with low morphological



differentiation. The differences observed in thallus chemistry (Thor and Kashiwadani, 1996) might be a possible taxonomic feature to distinguish taxa within *F. papillata* s. lat. Further study of this taxon is needed with respect to morphological, chemical, and molecular phylogenetic data.

Distribution: Pantropical. Asia (Japan and Thailand), Oceania (Australia and Fiji), North and South Americas (Argentina, Brazil, Cuba, Paraguay, Peru, and U.S.A.), and Africa (Kenya) (Thor and Kashiwadani, 1996; Perlmutter, 2006; Cáceres, 2007; Buaruang *et al.*, 2017). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Padauk-kon Chaung, Thet Kae Kawt Compartment, Tanintharyi Nature Reserve, Yephyu Township, N14°23'19", E98°11'05", on rock, elev. 40 m, 19 January 2017, *Y. Ohmura 12329* (TNS, RAF, TAI).

Glyphis cicatricosa Ach., Syn. Meth. Lich.: 107. 1814.

Fig. 1M

For a detailed description and synonyms, see Archer (2009). Because the collected material was very poor, anatomical measurements could not be performed.

Distribution: Tropical to warm-temperate regions of Asia, Oceania, and North and South Americas (Archer, 2009). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Forest Department Office of Tanintharyi Region, Dawei (Tavoy), N14°04'28", E98°11'44", on bark of tree branch, elev. 15 m, 17 January 2017, *Y. Ohmura 12294* (TNS).

Graphis cf. *caesiella* Vain., Acta Soc. Fauna Fl. Fenn. 7(2): 122. 1890.

Figs. 1N–P

For a detailed description and synonymy, see Archer (2009). Ascospore size for the Myanmar collection is (19.9–)22.8–30.8(–35.0) × (6.0–)6.4–7.2(–7.5) μm (n=19). Perispore is 1.3–3.8 μm thick. The number of septa is 6–9.

Chemistry: Norstictic acid (major), salazinic acid (minor), and protocetraric acid (trace).

Remarks: According to Lücking (2009), the *Graphis caesiella* aggregate consists of at least four species with similar morphology but different chemistry: *G. bakeri* (salazinic), *G. caesiella* (norstictic), *G. dendrogramma* (stictic), and *G. supracola* (protocetraric). The morphology of the Myanmar collection agrees with *G. caesiella*, but the chemistry does not fit to the current circumscription of the species (it should contain only norstictic acid). The Myanmar collection could be a new chemotype for *G. caesiella* or a new species but further study is needed to clarify the taxonomic position in relation with these four taxa based on morphological, chemical and molecular phylogenetical analyses. Because of this taxonomic problem, this study treats the Myanmar collection as *G. cf. caesiella*. See also remarks of *G. supracola* below.

Distribution: For *G. caesiella*, tropical to subtropical regions of Asia (Japan and Thailand), Oceania (Australia,

Norfolk Island, Lord Howe Island, and Vanuatu), North and South Americas (Brazil and Costa Rica), and Africa (the Seychelles) (Archer, 2009; Buaruang *et al.*, 2017; Ohmura and Kashiwadani, 2018). New to Myanmar.

Specimen examined: MYANMAR. Yangon Region: Bogyoke Park, Kandawgyi Lake, N16°47'47", E96°09'56", on bark of *Azadirachta indica*, elev. 20 m, 16 January 2017, *Y. Ohmura 12268* (TNS, RAF).

Graphis desquamescens (Fée) Zahlbr., Denkschr. Kaiserl. Akad. Wiss. Wien, Math.-Naturwiss. Kl. 83: 108. 1909.

Figs. 2A–D

For a detailed description, see Archer (2009). Ascospore size for the Myanmar collection is (19.3–)24.2–36.0(–45.3) × (4.6–)6.1–8.3(–9.6) μm (n=31). The number of septa is 7–9.

Chemistry: Norstictic acid.

Distribution: Tropical to warm-temperate regions of Asia (China, Japan and Taiwan), Oceania (Australia and New Zealand), and North and South Americas (Brazil, Mexico and U.S.A.) (Nakanishi, 1966; Archer, 2009). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Kanbauk Village, Yephyu Township, N14°35'14", E98°03'06", on bark of broad-leaf tree, elev. 25 m, 20 January 2017, *Y. Ohmura 12337* (TNS, RAF).

Graphis supracola A.W. Archer, Aust. Syst. Bot. 14: 267. 2001.

Fig. 2E–G

For a detailed description, see Archer (2009). Ascospore size for the Myanmar collection is (23.1–)24.6–35.8(–42.8) × (6.5–)6.8–7.8(–8.5) μm (n=20). Perispore is 1.5–3.1 μm thick. The number of septa is 7–9(–10).

Chemistry: Protocetraric acid.

Remarks: This collection was found after TLC examinations of several spots on the specimen of *G. cf. caesiella*. These species grew side by side and the boarder of colonies is not distinctly recognized. See also remarks of *G. cf. caesiella* above.

Distribution: Pantropical (Lücking *et al.*, 2009). Asia (Cambodia and Thailand), Oceania (Australia), North and South Americas (Brazil, Columbia and USA), and Africa (Cameroon) (Archer, 2012; Joshi *et al.*, 2016). New to Myanmar.

Specimen examined: MYANMAR. Yangon Region: Bogyoke Park, Kandawgyi Lake, N16°47'47", E96°09'56", on bark of *Azadirachta indica*, elev. 20 m, 16 January 2017, *Y. Ohmura 12268 pr.p.* (TNS).

Malmidea bakeri (Vain.) Kalb, Rivas Plata & Lumbsch, Biblioth. Lichenol. 106: 154. 2011.

Figs. 2H & 2I

For a detailed description, see Kalb *et al.* (2011). Ascospore size for the Myanmar collections is (10.2–)11.1–14.1(–16.0) × (4.3–)5.3–7.1(–8.4) μm (n=30).

Chemistry: Atranorin.

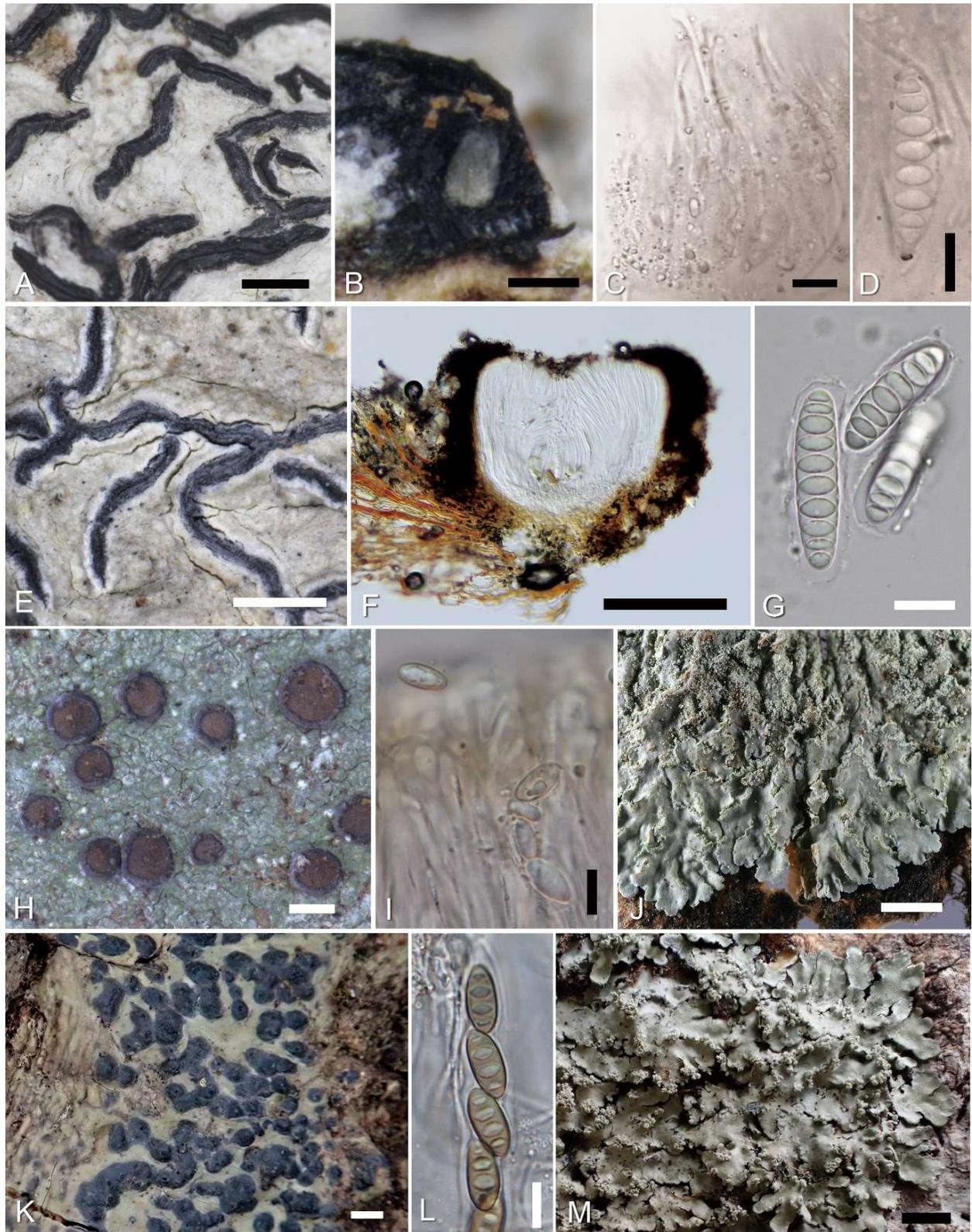


Fig. 2. Lichens collected from southern Myanmar. **A–D.** *Graphis desquamescens* (Y. Ohmura 12337, TNS) (A: ascomata; B: vertical section of ascoma; C: interspersed hymenium; D: ascospore). **E–G.** *Graphis supracola* (Y. Ohmura 12268 pr.p., TNS). **H–I.** *Malmidea bakeri* [H: ascomata and thallus (Y. Ohmura 12404, TNS); I: ascospores (Y. Ohmura 12366, TNS)]. **J.** *Physcia undulata* (Y. Ohmura 12300, TNS). **K–L.** *Pyrenula mamillana* (Y. Ohmura 12413, TNS) (K: ascomata; L: ascospores in ascus). **M.** *Pyxine dactyloschmidtii* (Y. Ohmura 12276, TNS). Scales: A, E, H = 0.5 mm; B, F = 0.1 mm; C, D, G, I, L = 10 μ m; J = 2 mm; K, M = 1 mm.



Remarks: This species is known to be close to *M. subaurigera* (Vain.) Kalb, Rivas Plata & Lumbsch, but the latter species has larger ascospores (17–21 × 9–13 µm) and an orange-yellow medulla (Kalb *et al.*, 2011). The BLAST results show 97% identity with *M. subaurigera* sequence in GenBank (Table 1). ITS rDNA sequences of *M. bakeri* were not registered in GenBank before this study.

Distribution: Tropical to subtropical regions of Asia (India, the Philippines and Thailand) (Kalb *et al.*, 2011; Gupta and Sinha, 2016).

Specimens examined: MYANMAR. Tanintharyi Region: Tanintharyi Nature Reserve, Yephyu Township, N14°44'18", E98°13'42", on bark of broad-leaf tree, elev. 160 m, 21 January 2017, *Y. Ohmura 12366* (TNS, RAF); Migyanuglaung, Tanintharyi Nature Reserve, Yephyu Township, N14°40'18", E98°08'16", on bark of *Areca catechu*, elev. 35 m, 23 January 2017, *Y. Ohmura 12404* (TNS, RAF).

Physcia undulata Moberg, Nordic J. Bot. 6: 861. 1986.

Fig. 2J

For a detailed description, see Moberg (2001).

Chemistry: Atranorin, zeorin and other terpenes.

Remarks: In addition to the morphological and chemical conformity, the BLAST results show high identity (100%) with *P. undulata* sequences in GenBank (Table 1).

Distribution: Pantropical. Asia (India and Thailand), Oceania (Australia and New Zealand), North and South Americas (Argentina, Brazil, Chile, Colombia, Costa Rica, and Ecuador), and Africa (Kenya and South Africa) (Moberg, 1990, 2001; Singh and Sinha, 2010; Buaruang *et al.*, 2017). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Kanbauk Village, Yephyu Township, N14°35'32", E98°03'28", on bark of *Moringa oleifera*, elev. 35 m, 19 January 2017, *Y. Ohmura 12300* (TNS, RAF, TAI).

Pyrenula mamillana (Ach.) Trevis., Consp. Verruc.: 13. 1860.

Figs. 2K & 2L

For detailed descriptions and synonyms, see Aptroot (2009, 2012). Ascospore size for the Myanmar collection is (14.9–)16.0–18.8(–19.6) × (5.4–)6.1–7.1(–7.5) µm (n=40). Perispore is 0.8–1.0 µm thick.

Chemistry: No lichen substance was detected by TLC.

Remarks: This species resembles *Pyrenula massariospora* (Starbäck) R.C. Harris, but the ascospore size is smaller (mostly <21 µm) than in the latter (mostly >20 µm) (Aptroot, 2012).

The BLAST results show 98% identity with *P. massariospora* (the first hits) and 91% identity with *P. mamillana* (the second and third hits) sequences in GenBank but the e-values are 0.0 in all cases (Table 1). Morphological features especially ascospore size of the Myanmar collection are consistent with the description of *P. mamillana*.

Distribution: Pantropical. Asia (India, Japan, the Philippines, Sri Lanka, and Thailand), Oceania

(Australia and Papua New Guinea), and South America (Brazil, Colombia, Costa Rica, and Guyanas) (Aptroot, 2009; Kashiwadani *et al.*, 2009; Singh and Sinha, 2010; Flakus *et al.*, 2013; Buaruang *et al.*, 2017). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Migyanuglaung, Tanintharyi Nature Reserve, Yephyu Township, N14°41'09", E98°08'59", on bark of *Mangifera indica*, elev. 60 m, 23 January 2017, *Y. Ohmura 12413* (TNS, RAF).

Pyxine dactyloschmidtii Kalb & Mongkolsuk, Phytotaxa 59: 44. 2012.

Fig. 2M

For a detailed description, see Mongkolsuk *et al.* (2012).

Chemistry: Atranorin, testacein and terpenes (R_f classes 4–5, 5, 5–6, 6).

Remarks: This species is morphologically similar to *P. retirugella* Nyl. and *P. boonpragobiana* Kalb & Mongkolsuk. However, *P. dactyloschmidtii* is easily distinguished from these species by the absence of norstictic acid (Mongkolsuk *et al.*, 2012).

The BLAST results show high identity (99%) with *P. retirugella* sequences in GenBank (Table 1). However, the ITS rDNA sequences for *P. dactyloschmidtii* were not registered in GenBank before this study. Taxonomic revision with regard to the presence or absence of norstictic acid is needed for *P. retirugella* and *P. dactyloschmidtii* because of the close identity of their ITS DNA sequences.

Distribution: Asia (India and Thailand) (Mongkolsuk *et al.*, 2012; Zachariah *et al.*, 2019). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Pha Chaung Inn Beach, Kanbauk Village, Yephyu Township, N14°30'37", E97°56'44", on bark of broad-leaf tree, elev. 0 m, 18 January 2017, *Y. Ohmura 12276* (TNS, RAF, TAI).

Sarcographa labyrinthica (Ach.) Müll. Arg., Mém. Soc. Phys. Genève 29(8): 62. 1887.

Figs. 3A & 3B

For detailed descriptions and synonyms, see Staiger (2002) and Archer (2009). Ascospore size for the Myanmar collections is (13.8–)16.8–23.4(–26.6) × (5.3–)6.3–8.1(–9.3) µm (n=51).

Chemistry: Norstictic, stictic and constictic acids.

Remarks: The BLAST results show less than 87% identity with Graphidaceae sequences in GenBank (Table 1). The low homology results were due to the fact that ITS rDNA sequences of *Sarcographa* species were not registered in the GenBank.

Distribution: Pantropical. Asia (India, Indonesia, Malaysia, the Philippines, Sri Lanka, and Thailand), Oceania (Australia, New Zealand and Norfolk Island), North and South Americas (Brazil, Mexico and U.S.A.), Africa, and Europe (Archer, 2009; Singh and Sinha, 2010). New to Myanmar.

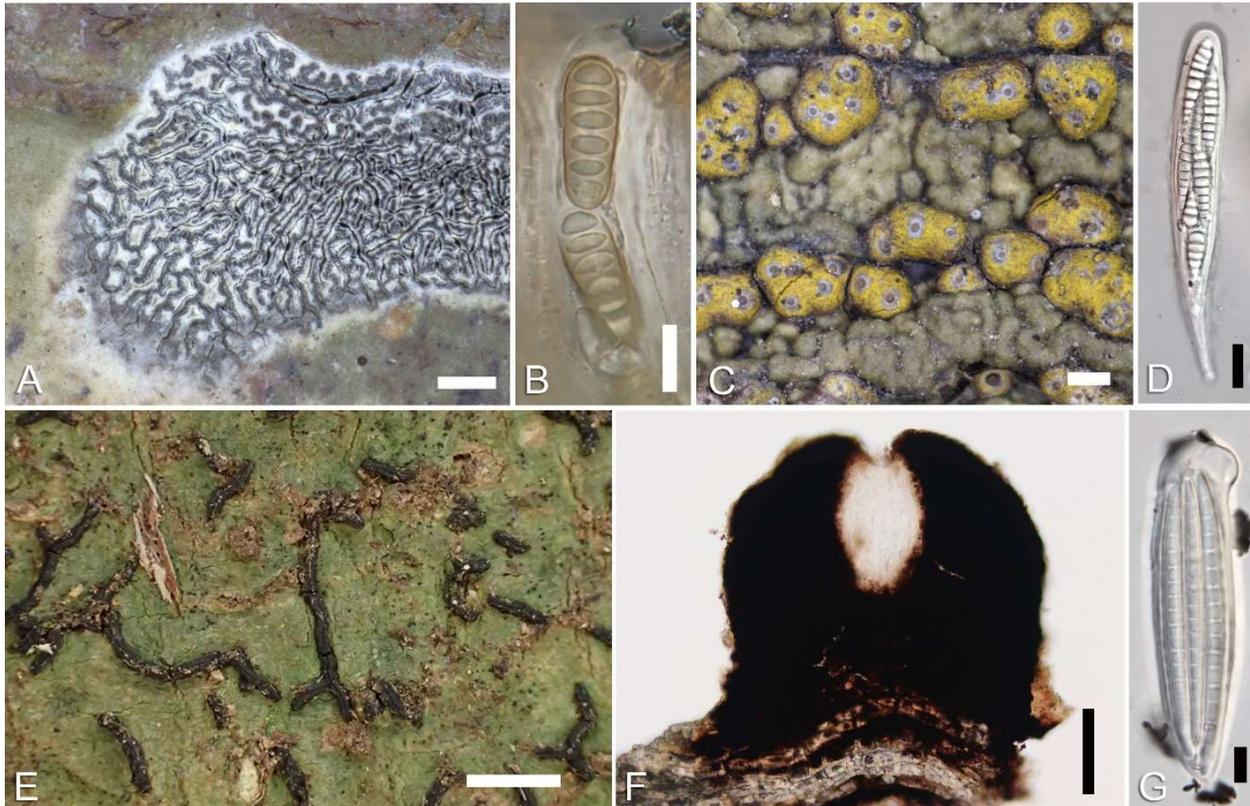


Fig. 3. Lichens collected from southern Myanmar. **A–B.** *Sarcographa labyrinthica* (Y. Ohmura 12399, TNS) (A: ascomata on pseudostroma; B: ascospores in ascus). **C–D.** *Trypethelium eluteriae* (Y. Ohmura 12270, TNS) (C: ascomata; D: ascospores in ascus). **E–G.** *Zwackhia prosodea* (Y. Ohmura 12388, TNS) (E: ascomata; F: vertical section of ascoma; G: ascospores in ascus). Scales: A, C = 0.5 mm; B, G = 10 μ m; D = 20 μ m; E = 2 mm; F = 0.1 mm.

Specimens examined: MYANMAR. Tanintharyi Region: Migyanughlaung, Tanintharyi Nature Reserve, Yephyu Township, N14°40'18", E98°08'16", on bark of broad-leaf tree; elev. 35 m, 23 January 2017, Y. Ohmura 12399 (TNS, RAF, TAI); Migyanughlaung, Tanintharyi Nature Reserve, Yephyu Township, N14°40'18", E98°08'16", on bark of broad-leaf tree, elev. 35 m, 23 January 2017, Y. Ohmura 12400 (TNS, RAF).

Trypethelium eluteriae Spreng., Anleit. Kenntn. Gew. 3: 351. 1804.

Figs. 3C & 3D

For a detailed description and synonyms, see Aptroot and Lücking (2016). Ascospore size for the Myanmar collection is (36.6–)41.1–54.1(–60.9) \times (6.8–)7.8–9.6(–10.5) μ m (n=61). Perispore is 1.4–3.9 μ m thick. The number of septa is 9–14.

Chemistry: Parietin.

Remarks: This species somewhat resembles *Astrothelium macrocarpum*, but *T. eluteriae* is readily distinguished by the morphology of pseudostromata and ascospores (see the paragraph on *A. macrocarpum*).

Distribution: Pantropical. Asia (Cambodia, China, Hong Kong, India, Indonesia, Japan, Java, the Philippines, Sri Lanka, Taiwan, Thailand, and Vietnam), Oceania (Australia, New Caledonia and Papua New Guinea), North and South Americas (Brazil, Columbia,

Costa Rica, Cuba, El Salvador, French Guiana, Galapagos, Guadeloupe, Guatemala, Mexico, Paraguay, Surinam, U.S.A., and Venezuela), and Africa (Gambia, Tanzania and Seychelles) (Aptroot and Lücking, 2016). New to Myanmar.

Specimen examined: MYANMAR. Yangon Region: Bogyoke Park, Kandawgyi Lake, N16°47'47", E96°09'56", on bark of *Mimusops* sp., elev. 20 m, 16 January 2017, Y. Ohmura 12270 (TNS, RAF).

Zwackhia prosodea (Afzel.) Ertz, Bull. Soc. Naturalistes Luxemb. 113: 106. 2012.

Figs. 3E–G

For a detailed description, see Pentecost and James (2009, as '*Opegrapha prosodea*'). For synonymy, see Hafellner (2008). Ascospore size for the Myanmar collection is (60.8–)66.9–85.1(–95.4) \times (4.1–)4.9–6.9(–7.7) μ m (n=26). Perispore is 0.9–2.3 μ m thick. The number of septa is 12–15. Excipulum of ascoma is 109–169 μ m wide laterally and 98–221 μ m at the base.

Chemistry: No lichen substance was detected by TLC.

Remarks: This species resembles *Z. robusta* (Vain.) Ertz and *Z. viridis* (Ach.) Poetsch & Schied. However, *Z. prosodea* is distinguished from *Z. robusta* by the absence of confluent acid and from *Z. viridis* by the larger ascomata (1–3 mm against 0.4–1 mm for *Z. viridis*) and



ascospores [50–80 µm against 25–60(–75) µm for *Z. viridis*] (Ertz, 2009). But not only these ascospore sizes but also those of the Myanmar collection widely overlapped. Whereas, the size of ascoma exipulum for the Myanmar collection is much thicker (109–169 µm wide laterally and 98–221 µm at the base) than those of *Z. viridis* [25–50 µm wide laterally and 15–80 µm at the base according to Ertz (2009)], and the size fits to *Z. prosodea* (105–200 µm at the base; Joseph *et al.*, 2018).

Distribution: Tropical to subtropical regions of Asia (China, India, Taiwan, and Thailand), Oceania (Australia), North America, Europe (Azores, Madeira and U.K.), and Africa (Macaronesia) (Tavares, 1952; Wei, 1991; Aptroot and Rodrigues, 2005; Pentecost and James, 2009; Aptroot *et al.*, 2010; Singh and Sinha, 2010; Buaruang *et al.*, 2017). New to Myanmar.

Specimen examined: MYANMAR. Tanintharyi Region: Tanintharyi Nature Reserve, Yephyu Township, N14°44'12", E98°11'30", on bark of broad-leaf tree, elev. 270 m, 22 January 2017, *Y. Ohmura 12388* (TNS, RAF, TAI).

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