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Graphidaceae from Sabah (NE Borneo), including eight new species

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Abstract. *Graphidaceae* is one of the largest families of lichenized fungi, with over 2,300 species in 80 genera known and about 3,600 species predicted. The Eastern Paleotropics constitute one of the hotspots of *Graphidaceae* diversity, including many potentially unknown species awaiting discovery. The Malaysian state of Sabah in NE-Borneo is home to some of the oldest continuously forested areas in SE-Asia, but only a few recent studies sampled *Graphidaceae*, particularly in the remaining pockets of lowland Dipterocarp forests. As part of two larger field trips in 2012 and 2013, hundreds of specimens of mostly epiphytic *Graphidaceae* were collected. The identification of 115 collections thus far has resulted in 52 species, all of which represent new records for this region, including eight species new to science in eight different genera (*Allographa*, *Astrochapsa*, *Byssotrema*, *Diorygma*, *Melanotrema*, *Ocellularia*, *Platythecium*, *Sarcographa*), as well as new records for the Eastern Paleotropics, Malaysia, and Borneo. Most of the new species were found in old growth forests, and very few in selectively logged forests, highlighting the importance of effective conservation by strict protection of the remnants of unlogged stands for the highly threatened lowland Dipterocarp forests in SE-Asia.

Key words: *Acanthothecis*, *Heiomasia*, muriform

Introduction

Graphidaceae is one of two megadiverse, lichenized families in the *Ascomycota*, with currently more than 2,300 species in approximately 80 genera (Lücking et al. 2017; Joshi et al. 2018; Kalb et al. 2018; Pereira et al. 2018; Herrera-Campos et al. 2019; Weerakoon et al. 2019; Miranda-González et al. 2020; Feuerstein et al. 2022a, b; Aptroot et al. 2023, 2024). The family is widespread in tropical to mild temperate forests around the globe, and about 3,600 species have been predicted to exist (Lücking et al. 2014).

Tropical Asia is one of the hotspots of *Graphidaceae* diversity, including many potentially unknown species awaiting discovery (Lücking et al. 2014). Sabah, a Malaysian province in the northern portion of Borneo, belongs to grid 38 in the study by Lücking et al. (2014), for which 96 species of *Graphidaceae* were known at the time, but 457 species were predicted. In order to close this knowledge gap, provisionally identified *Graphidaceae* from two larger, separate collecting periods in lowland rain forest in the Malaysian part of Borneo in 2012 and 2013 were re-examined. The first collections were made in the framework of a study to assemble standardized data on epiphytic lichen-rich vegetation in three areas with different levels of disturbance (Thüs et al. 2021). Two of these areas represent little or undisturbed rain forest (Maliau Basin Conservation Area, Danum Valley Conservation Area). The third area represents mostly secondary forest patches that are included in the research project on the Stability of Altered Forest Ecosystems (SAFE; Ewers et al. 2011). During a second visit to the Maliau Conservation area in 2013, additional areas at higher elevations in the Maliau Conservation Area in the transition zone between Dipterocarp- and *Agathis*-dominated forests were visited.

The two field visits resulted in a large amount of *Graphidaceae*, with preliminary identifications by the first author amounting to approximately 20 genera. Subsequent studies revealed eight species of *Graphidaceae* new to science, representing eight different genera, which are formally described, illustrated and discussed here. Examination of 115 specimens in the present study resulted in the identification of 52 additional species, all of which constitute new records for this region.

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Material and methods

Specimens were examined in the laboratories of the Natural History Museum in London, the Field Museum in Chicago, the Stuttgart State Museum of Natural History, and the Botanischer Garten und Botanisches Museum Berlin, using OLYMPUS SZX7, LEICA MS5, LEICA Zoom 2000, and MOTIC K400 dissecting microscopes, and OLYMPUS BX50 with DIC, ZEISS Axioscop 2, and VISTA VISION VWR V036 compound microscopes, in part connected to NIKON Coolpix E995, JENOPTIC ProgRes C3 and C5 digital microscope cameras. Specimens are kept in BORH and BM, with some duplicates also at B, STU and F. Specimens from the 2012 survey consist of a one letter area code ("S" = SAFE-project area, "D" = Danum Conservation Area, "M" = Maliau Conservation Area), followed by the plot number within the respective area, and the tree number within the plot. The procedure for plot and tree selection, recording of occurrences and detailed information on associated lichens in each plot can be found in Thüs (2021). Samples found within a plot, but not part of the randomized sampling design on the chosen trees, are indicated by the code oQ (= "out of quadrats"). Samples with the letter area code only were collected within one of the three principal areas, but not from within the randomly selected plot sites. Additional collections from a subsequent exploratory visit to Sabah in February 2013 are indicated by the prefix letter "L". Anatomical measurements refer to specimens mounted in water; for iodine reactions, we used FLUKA 62650 Lugol solution. Due to the small size of most of the samples, we employed thin layer chromatography (TLC), using solvent C only (Orange et al. 2010), at the Natural History Museum in London and the Field Museum in Chicago.

Results

A total of 52 species were identified in the material, based on 115 collections identified to species level (Table 1). Among these are eight species new to science, described below, and several new records for the province of Sabah, the island of Borneo, Malaysia, and the Eastern Paleotropics, respectively (Table 1). The eight new species represent eight different genera, indicating that the sampling has not yet been exhaustive with regard to *Graphidaceae*. Besides the new species described below, the following combination is proposed: *Graphis radicicola* (A.W. Archer) Weerakoon & Lücking, comb. nov. [MycoBank MB 864755]; Basionym: *Graphina radicicola* A.W. Archer, Mycotaxon 77: 169. 2001; *Hemithecium radicicola* (A.W. Archer) A.W. Archer, Telopea 11(1): 75. 2005.

Acanthotrema brasilianum (Hale) Frisch, Biblioth. Lichenol. 92: 78. 2006. (Fig. 1A, B)

This is a chiefly neotropical species, also known from tropical Africa (Frisch 2006), that was recently for the first time reported from tropical Asia, specifically Thailand (Poengsungnoen et al. 2022). This appears to be only the second record for the Eastern Paleotropics. In spite of careful study, we could not find any differences between the Sabah material and selected specimens from the Neotropics.

Specimens examined. MALAYSIA. Sabah, Maliau Conservation Area, plot site M7, 4.7486°N, 116.9731°E, alt. 306 m, in lowland oldgrowth Dipterocarp Forest, Oct. 2012, H. Thüs, P. Wolseley & C. Vairappan M.7.Q.4 (BORH, BM, B, F); ibid., plot site M8, 4.7461°N, 116.9701°E, alt. 257 m, Oct. 2012, H. Thüs, P. Wolseley & C. Vairappan M.8.4.1 (BORH, BM, B, F).

Allographa malaysiana Weerakoon, Wolseley, Vairappan, Thüs & Lücking, sp. nov. (Fig. 1C–F)

MycoBank MB 864748

Diagnosis. Differing from *Allographa salacinilabiata* in the coarsely verrucose thallus and the robust, irregular lirellae.

Type: Malaysia, Sabah: Maliau Conservation Area, trail from "Agathis-Camp" to "Nepenthes-camp", 116.8900°E, 4.7000°N, alt ~600–1,000 m, *Agathis*-rich old growth forest on steep slope, Feb. 2013, H. Thüs & C. Vairappan L355 (BORH – holotype; BM, B – isotypes).

Etymology. Referring to the origin of the type material.

Description. Thallus corticolous, epiperidermal, up to 7 cm diam., continuous, light yellowish to greenish grey, coarsely verrucose-rimose; prothallus not observed. Thallus in section 200–300 µm thick, with prosoplectenchymatous cortex, 10–20 µm thick, photobiont layer, 30–50 µm thick, and massive medulla, 150–200 µm thick, nubilous with numerous small, reddish-brown crystals. Ascomata (rounded to) elongate to lirellate, often irregularly bent, unbranched to irregularly branched, erumpent, (1–)3–10 mm long, 1–1.5 mm broad, 0.3–0.5 mm high; disc immersed, somewhat gaping but laterally covered by the margin, reddish brown, thinly white-pruinose; labia entire to irregularly striate in places, apically exposed, yellowish white, laterally covered by thick, irregular, verrucose thalline margin. Excipulum prosoplectenchymatous, boat-shaped and closed below the hymenium, 30–50 µm broad, orange-brown; periphysoids absent; hypothecium 20–30 µm high, hyaline to greyish. Hymenium 180–230 µm high, clear, with conspicuous lateral flanks being much lower (70–100 µm) and sterile; paraphyses unbranched, apically smooth. Asci 120–140 × 20–25 µm, oblong. Ascospores 1(–2) per ascus, richly muriform, 150–200 × 35–50 µm, oblong, with rather thin septa and rectangular lumina, hyaline, I+ violet-blue.

Secondary chemistry. Salazinic acid.

Distribution and ecology. So far only known from the type locality, on bark of tree trunks in *Agathis*-rich old growth forest.

Remarks. This species would previously have been placed in the genus *Hemithecium*, on account of the corticate thallus, the uncarbonized ascomata, and the apically smooth paraphyses (Staiger 2002). However, it has been shown that species of *Hemithecium* either belong in the genus *Graphis* or the recently reinstated segregate *Allographa* (Rivas Plata et al. 2011; Lücking & Kalb 2018). Within the former species of *Hemithecium*, now

Table 1. Additional species (besides those mentioned or described below) of *Graphidaceae* found in the studied material from Sabah (primary vouchers all at BORH).

Name of taxa	Locality	Date	Collector	Field-Sample Code	Lat. (°N)	Long. (°E)	Elevation (m)
Allographa balbisii (Fée) Lücking & Kalb	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.D.oQ.4	4.7062	117.5839	238
Astrochapsa mastersonii (Rivas Plata, Lumbsch & Lücking) Parnmen, Lücking & Lumbsch	Maliau Basin	Oct. 2012	H. Thüs & C. Vairappan	M052	4.7446	116.9708	250
Astrochapsa zahlbruckneri (Redinger) Parnmen, Lücking & Lumbsch	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan	D.1.11.2 D.5.4.1	4.9644 4.9662	117.7960 117.7981	238 252
Carbacanthographis marcescens (Fée) Staiger & Kalb	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.5.3.oQ	4.7450	116.9780	232
	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan	D.3.3.2 D.4.8.1	4.9660 4.9702	117.7887 117.7975	277 257
	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs & C. Vairappan	M.6.10.1 M051	4.7505 4.7446	116.9669 116.9708	413 250
Clandestinotrema protoalbum (Hale) Rivas Plata, Lücking & Lumbsch	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan	M.1.10.1 M.5.1.2	4.7446 4.7450	116.9707 116.9781	250 232
Diorygma macgregorii (Vain.) Kalb, Staiger & Elix	Danum Valley	Sept. 2012	H. Thüs & C. Vairappan	D050	4.9644	117.7960	238
	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan	S.F.6.4 S.F.9.3	4.6987 4.6987	117.5346 117.5346	270 270
Diorygma pruinosum (Eschw.) Kalb, Staiger & Elix	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.M.1	4.6748	117.5782	165
Dyplolabia afzelii (Ach.) A. Massal.	SAFE project Area	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan	S.P.13 S.P.22b S.P.23	4.6748 4.6748 4.6748	117.5782 117.5782 117.5782	165 165 165
Fissurina dumastii Fée	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.3.9.4	4.7476	116.9675	344
Fissurina furfuracea (Leight.) A.W. Archer	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.3.oQ.2	4.7476	116.9675	344
Graphis radicicola (A.W. Archer) Weerakoon & Lücking, comb. nov.	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.5.1.oQb	4.9662	117.7981	252
Leucodecton compunctum (Ach.) A. Massal.	Danum Valley	Sept/Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.2.6.4	4.9649	117.7932	232
Myriotrema album Fée	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.2.1.1	4.9649	117.7932	232
	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs & C. Vairappan H. Thüs & C. Vairappan H. Thüs & C. Vairappan H. Thüs & C. Vairappan H. Thüs & C. Vairappan H. Thüs & C. Vairappan H. Thüs & C. Vairappan	M.4.5.1 M074 M096 M097 M099 M134 M137 M138	4.7456 4.7446 4.7446 4.7446 4.7446 4.7446 4.7446 4.7446	116.9714 116.9707 116.9707 116.9707 116.9707 116.9707 116.9707 116.9707	265 250 250 250 250 250 250 250
Myriotrema eminens (Hale) Hale	Maliau Basin	Oct. 2012	H. Thüs & C. Vairappan	M035	4.7446	116.9707	250
Myriotrema subconforme (Nyl.) Hale	Danum Valley	Sept/Oct. 2012	H. Thüs & C. Vairappan	D009	4.9644	11.7796	238
	Sabah, Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan H. Thüs & C. Vairappan	M.1.7.2 M.2.8.1 M.4.11.2 M.8.2.1 M126	4.7446 4.7454 4.7457 4.7461 4.7446	116.9707 116.9748 116.9714 116.9701 116.9707	250 249 265 257 250

Table 1. Continued.

Name of taxa	Locality	Date	Collector	Field-Sample Code	Lat. (°N)	Long. (°E)	Elevation (m)
Ocellularia allosporoides (Nyl.) Patw. & Kulk.	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.7.12.1	4.7486	116.9731	306
			H. Thüs, P. Wolseley & C. Vairappan	M.8.2.3	4.7460	116.9701	257
			H. Thüs & C. Vairappan	M033	4.7446	116.9707	250
	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.VJR.4.1	???	???	???
			H. Thüs, P. Wolseley & C. Vairappan	S.VJR.11.5	???	???	???
			H. Thüs, P. Wolseley & C. Vairappan	S.D.8.1	4.7061	117.5839	362
Ocellularia andamanica (Nyl.) Tat. Matsumoto & Deguchi	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.3.4.2	4.7476	116.9675	344
Ocellularia ascidioidea Hale	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.5.5.5	4.7450	116.9781	232
Ocellularia cavata (Ach.) Müll. Arg.	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.4.4.oQ	4.7457	116.9714	265
Ocellularia cinereoglaucescens (Vain.) Zahlbr.	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.5.10.2	4.9662	117.7981	252
	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.7.oQ.9	4.7486	116.9731	306
Ocellularia exigua Müll. Arg.	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.3.2.8	4.7476	116.9675	344
	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.4.8.1	4.9702	117.7975	257
Ocellularia henatomma (Ach.) Müll. Arg.	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.A.3.oQ	4.7043	117.6471	400
Ocellularia interponenda (Nyl.) Hale	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.A.3.2	4.7043	117.6471	400
	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.B.12.4	4.7276	117.6145	376
	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.1.6.8	4.9644	117.796	238
			H. Thüs & C. Vairappan	D018	4.9644	117.796	238
Ocellularia massalongoi (Mont.) Hale	Danum Valley	Septt. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.1.6.7	4.9644	117.796	238
			H. Thüs, P. Wolseley & C. Vairappan	D.5.7.1	4.9662	117.798	252
			H. Thüs & C. Vairappan	D019	4.9644	117.796	238
	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.3.9. oQ	4.7476	116.9675	344
			H. Thüs, P. Wolseley & C. Vairappan	M.6.10.3	4.7505	116.9669	413
			H. Thüs, P. Wolseley & C. Vairappan	M.7.12.2	4.7486	116.9731	306
			H. Thüs, P. Wolseley & C. Vairappan	M.8.oQ	4.7461	116.9701	257
			H. Thüs & C. Vairappan	M061	4.7446	116.9707	250
	SAFE project Area	Sept. 2013	H. Thüs, P. Wolseley & C. Vairappan	S.B.12.5	4.7276	117.6144	376
Ocellularia persimilis (Kremp.) Müll. Arg.	Maliau Basin	Oct. 2012	H. Thüs & C. Vairappan	M048	4.7446	116.9707	250
			H. Thüs & C. Vairappan	M060	4.7446	116.9707	250
Ocellularia pseudopapillata Papong, Mangold & Lücking	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.7.12.3	4.7486	116.9731	306
			H. Thüs & C. Vairappan	M059	4.7446	116.9707	250
	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.VJR.4.3	???	???	???
Ocellularia rongklaensis (Homchant. & Coppins) Lücking	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.5.7.2	4.9662	117.7981	252
	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.3.1.1	4.7476	116.9675	344
Ocellularia rotundifumosa Naksuwankul, Lücking & Lumbsch	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.2.1.3	4.9649	117.7932	232
			H. Thüs, P. Wolseley & C. Vairappan	D.8.3.2	4.9719	117.8017	231
	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.B.11.4	4.7276	117.6144	376

Ocellularia rugosothallina Lücking, Lumbsch & Parnmen	SAFE project Area	Sept.2010	H. Thüs & C. Vairappan	W075a	4.6749	117.5782	165
Ocellularia sublaeviusculoides Rivas Plata, Sipman & Lücking	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.1.1.1	4.7446	116.9707	250
Ocellularia subleucina Homchant. & Coppins	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan	M.4.8.1a	4.7457	116.9714	265
Ocellularia subsimilis (Hale) Hale	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.5.10.oQ	4.9662	117.7981	252
	Maliau Basin	Oct. 2012	H. Thüs & C. Vairappan	M086	4.7446	116.9707	250
Ocellularia violacea Räsänen	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.4.1.1	4.9702	117.7975	257
Ocellularia viridipallens Müll. Arg.	Maliau Basin	Oct. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan	M.1.3.oQ M.4.8.oQ.1 M.7.oQ.9	4.7446 4.7457 4.7486	116.9707 116.9714 116.9731	250 265 306
	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan H. Thüs, P. Wolseley & C. Vairappan	D.6.3.2 D.8.8.8	4.9651 4.9720	117.7981 117.8017	251 231
	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.VJR.2.2	???	???	???
Platythecium leiogramma (Nyl.) Staiger	Maliau Basin	Feb. 2013	H. Thüs & C. Vairappan	L283-3	4.7000	116.8900	600–1000
	Maliau Basin	Feb. 2013	H. Thüs & C. Vairappan	L224	4.7000	116.8900	600–1000
Sarcographa heteroclita (Mont.) Zahlbr.	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.P.oQ	4.6748	117.5782	166
	Maliau Basin	Oct. 2012	H. Thüs & C. Vairappan	M055	4.7446	116.9707	250
Sarcographa labyrinthica (Ach.) Müll. Arg.	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.P.3	4.6748	117.5782	166
Sarcographa oculata Müll. Arg.	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.P.7	4.6748	117.5782	166
Sarcographa ramificans (Kremp.) Staiger	Danum Valley	Sept. 2012	H. Thüs & C. Vairappan H. Thüs & C. Vairappan	D028 D049	4.9644 4.9644	117.7960 117.7960	238 238
	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.P.19	4.6748	117.5782	166
Stegobolus berkeleyanus Mont.	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.1.11.oQ	4.9644	117.7960	238
	Maliau Basin	Oct. 2012	H. Thüs & C. Vairappan	M128	4.7446	116.9707	250
	SAFE project Area	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	S.A.2.1	4.7042	117.6471	400
	Danum Valley	Sept. 2012	H. Thüs, P. Wolseley & C. Vairappan	D.6.2.1	4.9651	117.7981	251
Thecaria montagnei (Bosch) Staiger	Maliau Basin	Oct. 2012	H. Thüs & C. Vairappan	M021	4.7446	116.9707	250

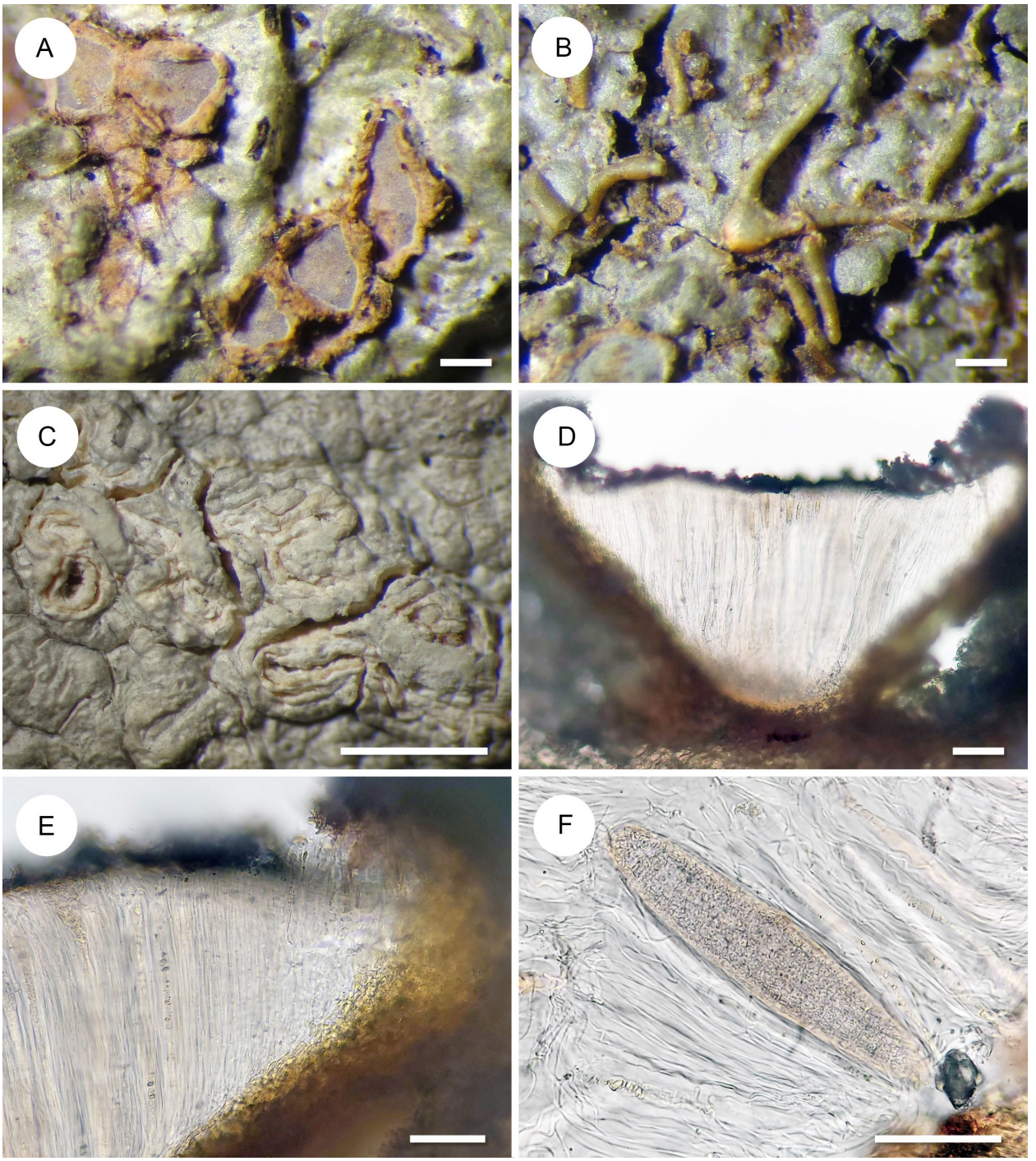

Figure 1. A, B – *Acanthotrema brasilianum* (H. Thüs, P. Wolseley & C. Vairappan M.7.oQ.4), thallus with apothecia and isidia; C–F – *Allographa malaysiana* (H. Thüs & C. Vairappan L355); C – thallus with lirellae; D, E – section through lirella, in E enlarged to show lateral paraphyses and excipulum; F – ascus with ascospore. Scales: A, B = 1 mm; C = 5 mm; D–F = 50 µm.

placed in either *Graphis* or *Allographa*, *A. salacinilabiata* (Patw. & C.R. Kulk.) Lücking & Kalb [≡ *Hemithecium salacinilabiatum* (Patw. & C.R. Kulk.) Chitale & Makhija] comes closest, agreeing in ascospore size and chemistry, but that species has a different thallus morphology (thinly verrucose) and much more delicate, regularly lirellate ascomata with smooth thalline margin.

The anatomy of the ascomata would also suggest the genus *Diorygma* (Kalb et al. 2004; Lücking & Rivas Plata 2008). The most similar species in that genus being *D. verrucirimosum* B.O. Sharma & Makhija (Sharma & Makhija 2009), which agrees in the verrucose-rimose thallus, but it differs in the absence of distinct labia, in the smaller ascospores, and in the presence of norstictic acid in addition to salazinic acid. A few species in the superficially similar genus *Acanthothecis* (Staiger & Kalb 1999; Staiger 2002) produce salazinic acid, but differ in the apically spinulose paraphyses or periphysoids and also have smaller ascospores.

Astrochapsa sorediata Weerakoon, Wolseley, Vairappan, Thüs & Lücking, sp. nov. (Fig. 2A–C)

MycoBank MB 864747

Diagnosis: Differing from *Astrochapsa astroidea* in the submuriform ascospores and the formation of soredia.

Type: Malaysia, Sabah: Danum Valley Conservation Area., plot site D7, 4.9701°N, 117.7928°E, alt. 297 m, in lowland old growth Dipterocarp Forest, Sept. 2012, H. Thüs, P. Wolseley & C. Vairappan D.7.7.1 (BORH – holotype; BM – isotype).

Etymology. The epithet refers to the sorediate thallus, an unusual trait in the genus *Astrochapsa*.

Description. Thallus corticolous, more or less endoperidermal, up to 5 cm diam., continuous, dark olive to olive-brown, smooth uneven, following the contours of the bark, sorediate; soralia numerous, but dispersed, maculiform, regularly rounded, 0.3–0.5 mm diam., whitish and contrasting with the surrounding thallus; prothallus not observed. Thallus in section 20–30 µm thick, with indistinct cortex and endoperidermal photobiont layer, 15–25 µm thick. Ascomata angular-rounded, erumpent, distinctly chroodiscoid, 0.5–1.5 mm diam., 0.15–0.2 mm high; disc more or less exposed, flesh-colored, densely, but finely white-pruinose and hence appearing light grey; margin formed by 4–8 triangular, recurved lobes composed of the fused proper and thalline margin, brown. Excipulum paraplectenchymatous, 20–30 µm broad, yellowish; periphysoids present lateral of the hymenium, 10–15 µm long, hyaline; hypothecium 10–20 µm high,

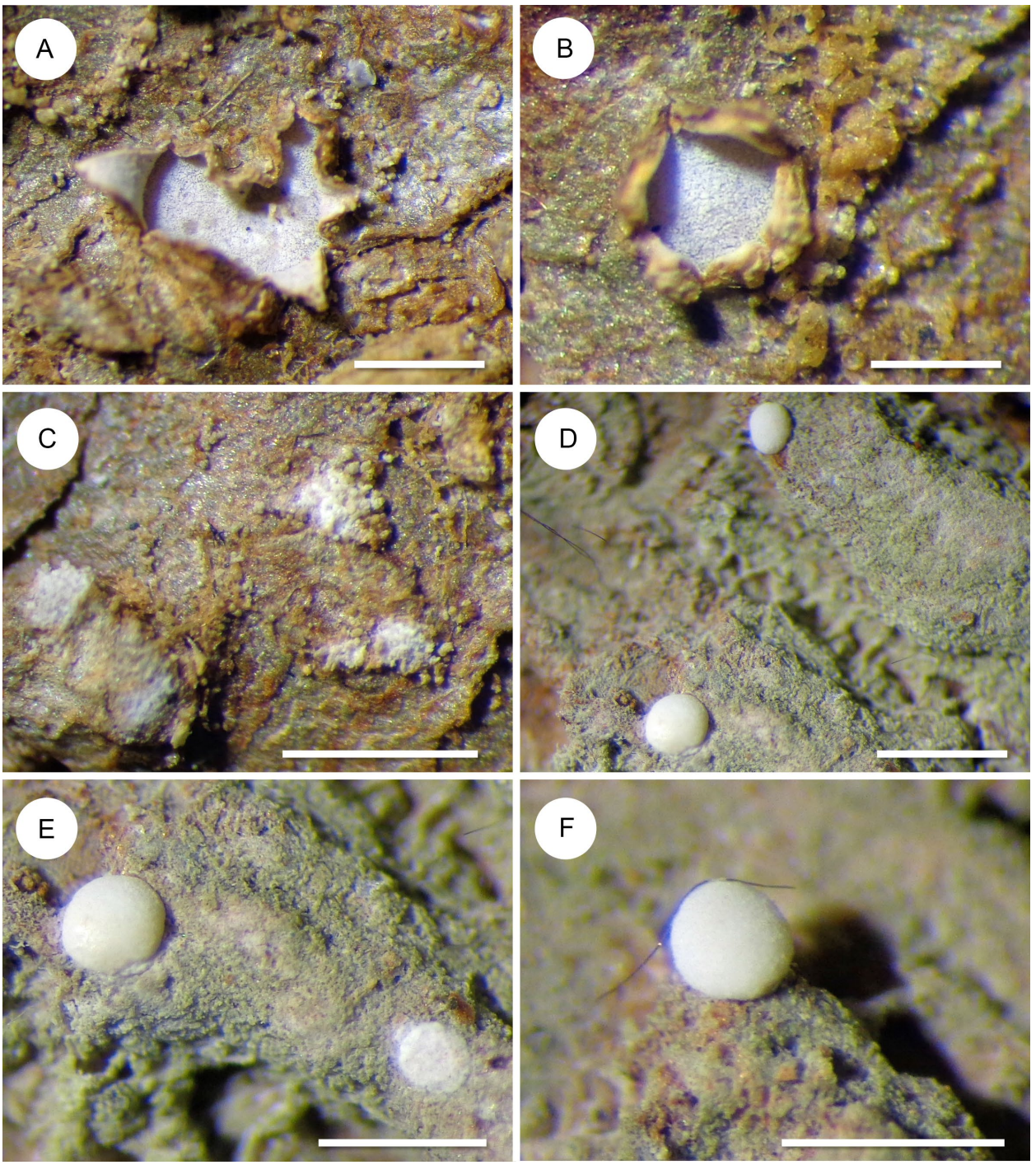

Figure 2. A–C – *Astrochapsa sorediata* (H. Thüs, P. Wolseley & C. Vairappan D.7.7.1), thallus with apothecia (A, B) and soredia (C). D–F, *Heiomasia annamariae* (H. Thüs, P. Wolseley & C. Vairappan M.5.OQ), thallus with schizidia. Scale = 1 mm.

hyaline. Hymenium 80–90 µm high, clear; paraphyses unbranched, apically smooth. Asci 50–60 × 15–20 µm, oblong-fusiform. Ascospores 8 per ascus, submuriform with 3–5 transverse and 0–1 longitudinal septum per segment, 12–18 × 7–9 µm, ellipsoid to fusiform, with slightly thickened septa and more or less rectangular lumina, hyaline, I–.

Secondary chemistry. No substances detected by TLC.

Distribution and ecology. Occurring on all aspects of an unidentified, smooth-barked tree with 1.28 m girth in old growth lowland Diperocarp forest.

Remarks. This is the first sorediate species in the genus *Astrochapsa*. Other species currently placed in *Chapsa* s.lat. with soralia differ in their amyloid, transversely septate ascospores, with the exception of *C. wijeyaratniana* Weerakoon, Lumbsch & Lücking, which has similar ascospores as in the new species, but differs in the apothecia having thick margins and a thick, coarse white pruina (Weerakoon et al. 2012). Morphologically, the new species agrees well with the generic type of *Astrochapsa*, *A. astroidea* (Berk. & Broome) Parnmen, Lücking & Lumbsch, except for the presence of soralia and the submuriform ascospores. Similar ascospores are known from *A. alstrupii* (Frisch) Parnmen, Lücking & Lumbsch, in which the ascospores are much longer, and *A. submuralis* E.L. Lima, Lücking & M. Cáceres, which differs by the thickly pruinose apothecia; both also lack soralia (Rivas Plata et al. 2010; Parnmen et al. 2012; Lima et al. 2016).

Byssotrema defectum Weerakoon, Wolseley, Vairappan, Thüs & Lücking, sp. nov. (Fig. 3)

MycoBank MB 864749

Diagnosis: Differing from *Byssotrema mirabile* in the non-carbonized ascomata furnished with an orange pigment and in the lack of secondary compounds in the thallus.

Type: Malaysia, Sabah: Maliau Conservation Area, tree canopy walk on the northern bank of Maliau river, close to Belian Camp, 116.9729°E, 4.7433°N, alt. ~220–230 m, on trunk of old *Koompassia* tree, Oct. 2012, H. Thüs & C. Vairappan M062 (BORH – holotype; BM, B, F – isotypes).

Etymology. The epithet refers to the absence of carbonization and secondary compounds in the thallus, as compared to the type species.

Description. Thallus corticolous, epiperidermal, up to 7 cm diam., continuous, light green-grey, uneven to shallowly verrucose, glossy; prothallus not observed. Thallus in section 60–80 µm thick, with thick, prosoplectenchymatous cortex, 20–30 µm thick, photobiont layer, 30–40 µm thick, and indistinct medulla. Ascomata rounded, erumpent to prominent with steeply sloping sides, 0.3–0.5 mm diam., 0.15–0.2 mm high; disc immersed, flesh-colored to salmon-colored, largely covered by a narrow pore 0.1–0.2 mm diam.; proper margin forming a broad, irregular, interrupted, orange rim around the pore, thalline margin almost complete, entire, light greenish grey to whitish, smooth. Excipulum prosoplectenchymatous, 25–40 µm broad, in inner part orange, in outer part hyaline, laterally covered by orange, amorphous periderm layer and corticate thallus layer; columella absent; periphysoids absent, but upper inner part of the excipulum above the hymenium with densely arranged, conglutinate, parallel hyphae resembling periphysoids or fibrils; hypothecium 10–15 µm high, hyaline. Hymenium 90–100 µm high, strongly inspersed and appearing sordid grey; paraphyses unbranched, smooth. Asci 90–100 × 20–25 µm, oblong-fusiform. Ascospores 8 per ascus, 7–11-septate (rarely with an occasional longitudinal septum), 24–32 × 8–10 µm, oblong, with thickened septa and lens-shaped lumina, hyaline, I+ violet-blue.

Secondary chemistry. No substances detected by TLC, but excipulum with orange anthraquinone pigment, K+ dark red.

Distribution and ecology. So far only known from the type locality; on an old veteran tree (*Koompassia* sp.) with *Diorygma roseum*, in remnant of old growth forest with moderately disturbed understorey, close to a river in the Maliau Conservation Area (Sabah/Malaysia).

Remarks. This new species is most similar to *Myriotrema muluense* Homchant. & Coppins (Homchantara & Coppins 2002), which agrees in the ascoma morphology and the inspersed hymenium, but the new species differs in the much larger ascospores, the stronger inspersion of the hymenium which makes the asci difficult to discern, and the orange-pigmented excipulum forming a visibly colored rim around the pore. The periderm of the bark substrate in the type material is bright orange, which made us suspect that the pigmentation of the ascomata is caused by the periderm, but the excipular pigment is clearly located in the inner excipulum away from the periderm and does not visibly react with K in microscopic sections (but becomes darker red under the stereomicroscope), whereas the periderm with K causes a deep yellow efflux. The new species is here included in the recently described genus *Byssotrema* due to the broad pore furnished with fibrils, but differs from the type species, *B. mirabile* M. Cáceres, Aptroot & Lücking (Cáceres et al. 2014), in the uncarbonized, pigmented excipulum and in the chemistry. The genus *Myriochapsa* is also similar, but differs in the fissured-lobulate apothecial margin lacking fibrils (Parnmen et al. 2013).

Diorygma roseum Weerakoon, Wolseley, Vairappan, Thüs & Lücking, sp. nov. (Fig. 4)

MycoBank MB 864750

Diagnosis: Differing from *Diorygma junghuhnii* in the deeply pink-red, very long lirellae.

Type: Malaysia, Sabah: Maliau Conservation Area, tree canopy walks on the northern bank of Maliau river, close to Belian Camp, 116.9729°E, 4.7433°N, alt. ~220–230 m, on trunk of old *Koompassia* tree, Oct. 2012, H. Thüs & C. Vairappan M029 (BORH – holotype; BM, B – isotypes).

Etymology. The epithet refers to the pink-red lirellae.

Description. Thallus corticolous, epiperidermal, up to 10 cm diam., continuous, very light green-grey to almost

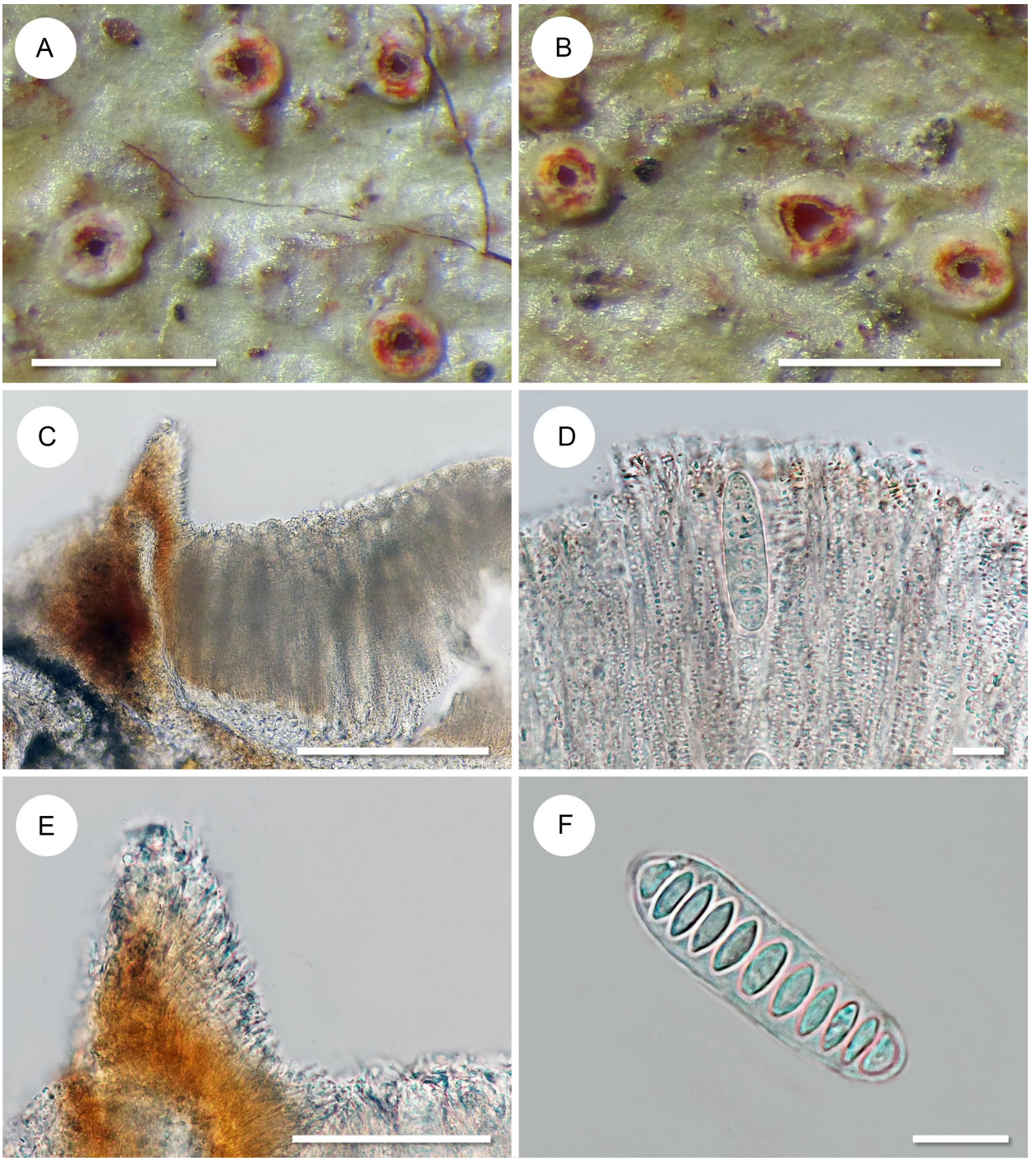

Figure 3. *Byssotrema defectum* (H. Thüs & C. Vairappan M62). A, B – thallus with apothecia; C, E – section through apothecium showing inspersed hymenium and excipulum with perpendicular, short fibrils in upper portion (in E enlarged); D – part of inspersed hymenium with ascospore; F – ascospore. Scales: A, B = 1 mm; C = 100 µm; D, F = 10 µm, E = 50 µm.

whitish, opaque, smooth to uneven; prothallus not observed. Thallus in section 50–80 µm thick, ecorticate, with photobiont layer, 30–60 µm thick, and indistinct medulla, photobiont layer encrusted with numerous small crystals. Ascomata lirellate, irregularly branched, erumpent, 5–15 mm long, 0.4–0.6 mm broad, 0.2–0.25 mm high; disc concealed to slightly gaping, grey-brown, white-pruinose; labia thick, entire, covered by a deeply pink-red pigment. Excipulum prosoplectenchymatous, 50–100 µm broad, rather dark brown, apically with a layer of red crystals; periphysoids absent; hypothecium 20–30 µm high, yellowish. Hymenium 130–150 µm high, clear; paraphyses mostly unbranched, in lateral parts of the hymenium branched and anastomosing, smooth. Asci 120–140 × 30–40 µm, oblong-fusiform. Ascospores 1–2 per ascus, muriform, 70–100 × 20–30 µm, oblong-ellipsoid, with thin septa and rectangular lumina, hyaline, I+ violet-blue.

Secondary chemistry. Norstictic acid and unidentified pink-red pigment visible in Thin Layer Chromatography; medulla P+ orange, K+ yellow turning orange and then red, microscopic section with K+ yellow efflux forming large, red, needle-shaped crystals; pigment on labia K+ dark violet.

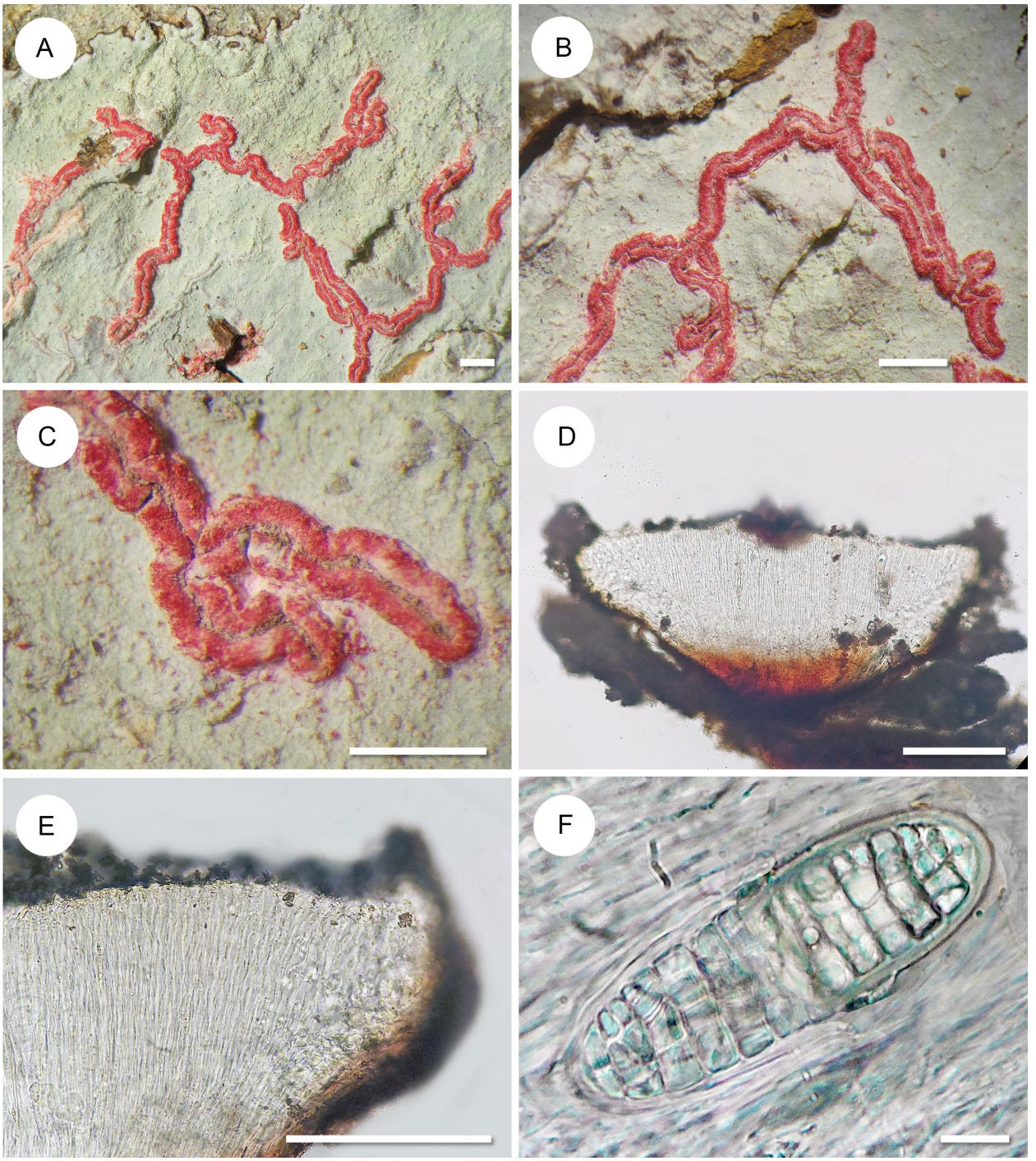

Figure 4. *Diorygma roseum* (H. Thüs & C. Vairappan M029). A–C – thallus with lirellae, in C enlarged; D, E – section through liralle, in E enlarged to show lateral paraphyses; F – ascospore. Scales: A–C = 1 mm; D, E = 100 µm; F = 10 µm.

Distribution and ecology. So far only known from the type locality; on an old veteran tree (*Koompassia* sp.) with *Byssotrema defectum*, in remnant of old growth forest with moderately disturbed understorey, close to a river in the Maliau Conservation Area (Sabah/Malaysia).

Remarks. This new species is characterized by the uniquely colored, pink-red lirellae. Apparently, it is the first species in the genus featuring prominent pigmentation (Kalb et al. 2004; Feuerstein et al. 2014), and the nature of the pigment appears to be different from any pigment in other species in *Graphidaceae*. Except for the pigment, the new species somewhat resembles *Diorygma junghuhnii* (Mont. & Bosch) Kalb, Staiger & Elix (Kalb et al. 2004) in ascoma anatomy, ascospores, and chemistry, but the latter also has shorter lirellae with a more exposed disc.

Heiomasia annamariae Kalb, Archive for Lichenology 15: 7. 2020. (Fig. 2D–F)

Description. (Based on material from Sabah). Thallus corticolous, epiperidermal, up to 5 cm diam., continuous, light green, opaque, minutely farinose, furnished with numerous schizidia; schizidia sessile on low thalline warts, disc- to lens-shaped (often slightly convex) or sometimes

flabellate when attached laterally, 0.3–0.5(–0.6) mm diam., more or less white; prothallus not observed. Thallus in section 50–70 µm thick, ecorticate, with photobiont layer, 30–60 µm thick, and indistinct medulla, photobiont layer encrusted with numerous small crystals; schizidia in section 60–60 µm thick, with a thin, irregular cortex, dispersed clusters of algal cells directly below the cortex, and a thick medulla. Ascomata not observed.

Secondary chemistry. Stictic acid and satellite substances visible with TLC; medulla P+ orange, K+ yellow turning orange, microscopic section with K+ persistently yellow efflux.

Remarks. This species was recently described from Sarawak (Kalb 2020). It is similar to other paleotropical species of the genus, *Heiomasia siamenis*, *H. sipmanii* and *H. pallescens* in the morphology of the schizidia, but these species all lack stictic acids.

Distribution and ecology. Our collections are the first records for Sabah. We found it in lowland rainforest of the Maliau Basin Conservation Area on smooth barked buttresses of dipterocarp trees (*Shorea johorensis*). Although this species is locally rather frequent on smooth bark in old growth forests in Maliau, it was not found in similar forest types in Danum.

Specimens examined. MALAYSIA. Sabah, Maliau Conservation Area, plot site M7, 4.7486°N, 116.9731°E, alt. 200–400 m, in lowland oldgrowth Dipterocarp Forest, Oct. 2012, H. Thüs, P. Wolseley & C. Vairappan M.7.oQ.7 (BORH, BM, B); plot site M5, 4.7450°N, 116.9781°E, alt. 306 m, Sept. 2012, H. Thüs, P. Wolseley & C. Vairappan M.5.oQ (BORH, BM, B, F).

Melanotrema cryptosticticum Weerakoon, Wolseley, Vairappan, Thüs & Lücking, sp. nov. (Fig. 5)

MycoBank MB 864751

Diagnosis: Differing from *Melanotrema platystomum* in the cryptostictic acid chemistry.

Type: Malaysia, Sabah: Danum Valley Conservation Area, in lowland old growth Dipterocarp Forest, plot site D4, 4.9702°N, 117.7975°E, alt. 257 m, Sept. 2012, H. Thüs, P. Wolseley & C. Vairappan D.4.12.2 (BORH – holotype; BM, B – isotypes).

Etymology. The epithet refers to the unusual chemistry.

Description. Thallus corticolous, epiperidermal, up to 5 cm diam., continuous, grey, uneven, opaque; prothallus not observed. Thallus in section 50–80 µm thick, with loose cortex, 7–15 µm thick, photobiont layer, 40–70 µm thick, and indistinct medulla, photobiont layer with numerous small crystals. Ascomata rounded to angular, erumpent, 0.5–0.8 mm diam., 0.25–0.35 mm high; disc more or less exposed, immersed, partially covered by a broad pore 0.3–0.5 mm diam. completely filled by broad, white-pruinose columella; proper margin indistinct, thalline margin complete, entire to fissured, grey. Excipulum completely carbonized, 30–50 µm broad, jet-black, laterally covered by distinct, orange-brown periderm layer and thin thallus layer; columella present, broad-stump-shaped, up to 550 µm broad, fully carbonized; periphysoids absent; hypothecium 10–15 µm high, hyaline. Hymenium developed as narrow ring between excipulum and columella, 90–100 µm high, clear; paraphyses unbranched, smooth. Asci 90–100 × 10–12 µm, fusiform. Ascospores 8 per ascus, 5–10-septate, occasionally becoming submuriform with a longitudinal septum in 1–2 cells, 12–17 × 5–6 µm, ellipsoid, with thickened septa and lens-shaped lumina, hyaline, I+ violet-blue.

Secondary chemistry. Cryptostictic acid visible with TLC; microscopic section with K+ faintly but persistently yellow outflux.

Distribution and ecology. Only known from lowland rainforest in the Danum valley conservation area on the buttress of a large emergent dipterocarp tree, *Shorea parvifolia*, with over 6 m girth.

Remarks. This new species is placed in the genus *Melanotrema* (Frisch & Kalb 2006) because of the loosely corticate, thin, grey thallus, the fully carbonized ascomata with broad, stump-shaped columella, and the unusual chemistry. So far, no other species among thelotremoid *Graphidaceae* is known with cryptostictic acid as major substance, although this compound occurs regularly in many species as minor or trace accessory compound together with stictic acid (Staiger 2002; Frisch & Kalb 2006). The species is otherwise most similar to *M. lynceodes* and *M. platystomum*.

Ocellularia maliauensis Weerakoon, Wolseley, Vairappan, Thüs & Lücking, sp. nov. (Fig. 6)

MycoBank MB 864752

Diagnosis: Differing from other species of *Ocellularia* with inspersed hymenium and small, transversely septate ascospores in the presence of an unknown chemical compound.

Type: Malaysia, Sabah: Maliau Conservation Area, plot site M5, 4.7450°N, 116.9781°E, alt. 232 m, in lowland oldgrowth Dipterocarp Forest, Sept. 2012, H. Thüs, P. Wolseley & C. Vairappan M.5.4.3 (BORH – holotype; BM, B – isotypes).

Etymology. Referring to the type locality.

Description. Thallus corticolous, epiperidermal, up to 10 cm diam., continuous, light greenish grey, uneven to shallowly verrucose, slightly glossy; prothallus not observed. Thallus in section 70–100 µm thick, with thick, prosoplectenchymatous cortex, 20–30 µm thick, photobiont layer, 30–40 µm thick, and medulla, 20–30 µm thick. Ascomata rounded, erumpent, 0.6–0.8 mm diam., 0.2–0.25 mm high; disc immersed, largely covered by a narrow pore 0.2–0.3 mm diam. partially filled by grey-pruinose to white-tipped columella often connected to the lateral margin; proper margin indistinct, forming a thin, whitish rim around the pore, thalline margin almost complete, entire, light greenish grey, smooth. Excipulum prosoplectenchymatous, apically carbonized, 10–20 µm broad, in upper half black, in lower half orange-brown, laterally covered by distinct, orange-brown, amorphous periderm layer and corticate thallus layer; columella present, finger-like to plug-shaped, 100–150 µm broad, carbonized; periphysoids absent; hypothecium 10–15 µm high, hyaline. Hymenium 50–60 µm high, strongly inspersed and

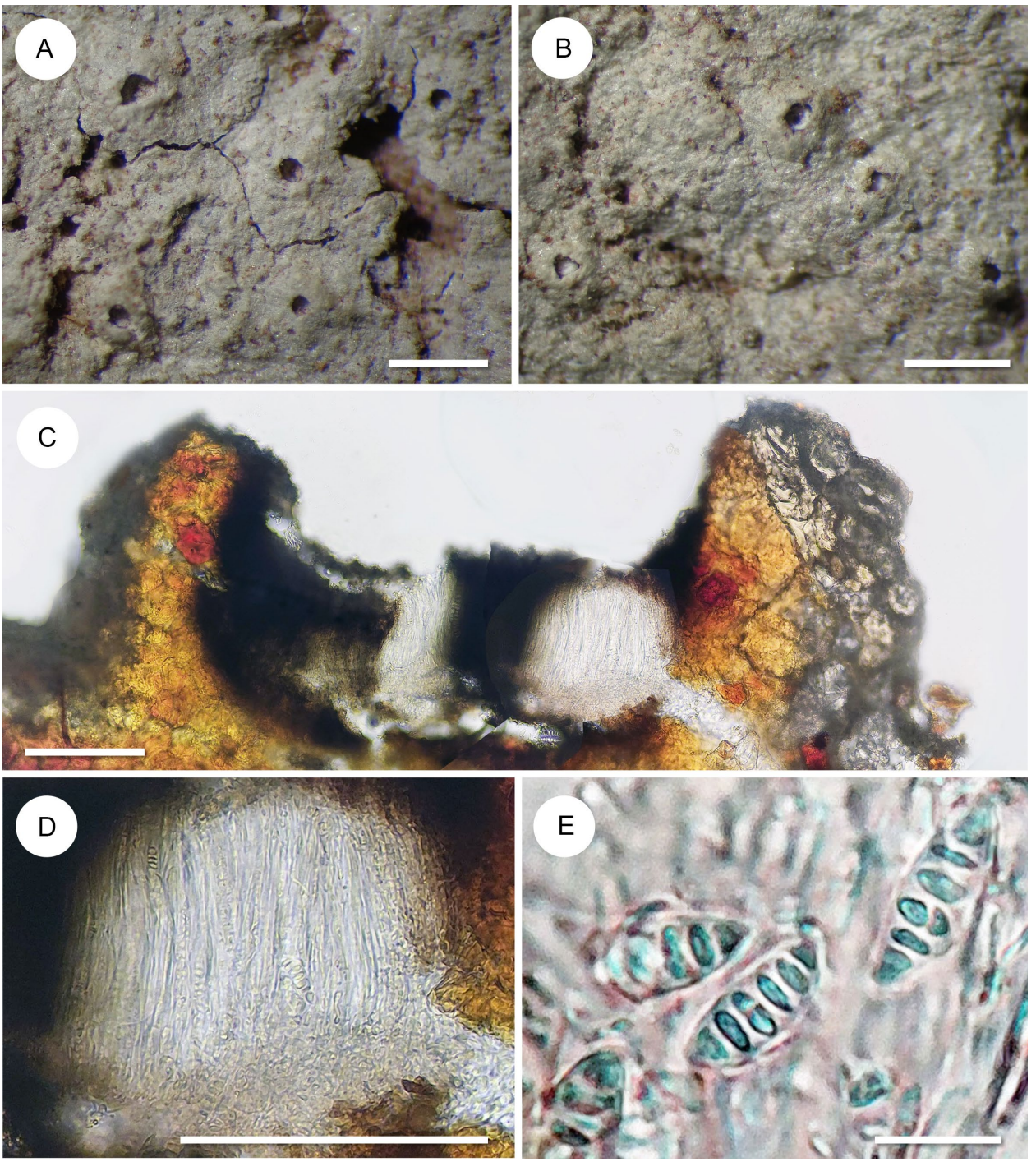

Figure 5. *Melanotrema cryptosticticum* (H. Thüs, P. Wolseley & C. Vairappan D.4.12.2). A, B – thallus with apothecia; C, D – section through apothecium with central columella, in D enlarged; E – ascospores. Scales: A, B = 1 mm; C, D = 100 µm; E = 10 µm.

appearing sordid grey; paraphyses unbranched, smooth. Asci 50–60 × 8–10 µm, oblong. Ascospores 8 per ascus, (3–)5-septate, 12–17 × 5–6 µm, ellipsoid, with thickened septa and lens-shaped lumina, hyaline, I+ violet-blue.

Secondary chemistry. Unknown substance forming a yellow spot at Rf = 18 in solvent C after charring; medulla P– yellow, K–, microscopic section K–.

Distribution and ecology. Thus far known from the type location, abundant on all aspects of young trunk of *Euphorbia malacensis* in comparatively open area of the forest following tree fall nearby.

Remarks. This new species is characterized by the strongly inspersed hymenium and the peculiar, unknown substance revealed by TLC. There are several species in *Ocellularia* sharing the inspersed hymenium and ascospore type, such as *O. fumosa* (Ach.) Müll. Arg. or *O. rotundifumosa* Naksuwankul, Lücking & Lumbsch, but in all these species the hymenium is finely inspersed, with a good view of the hamathecium and asci. In the present species, the strongly inspersed hymenium makes the paraphyses and asci almost invisible. The unknown substance is different from anything previously reported in the family; the spot characteristics are very similar to those of isonotatic and subnotatic acid which, however,

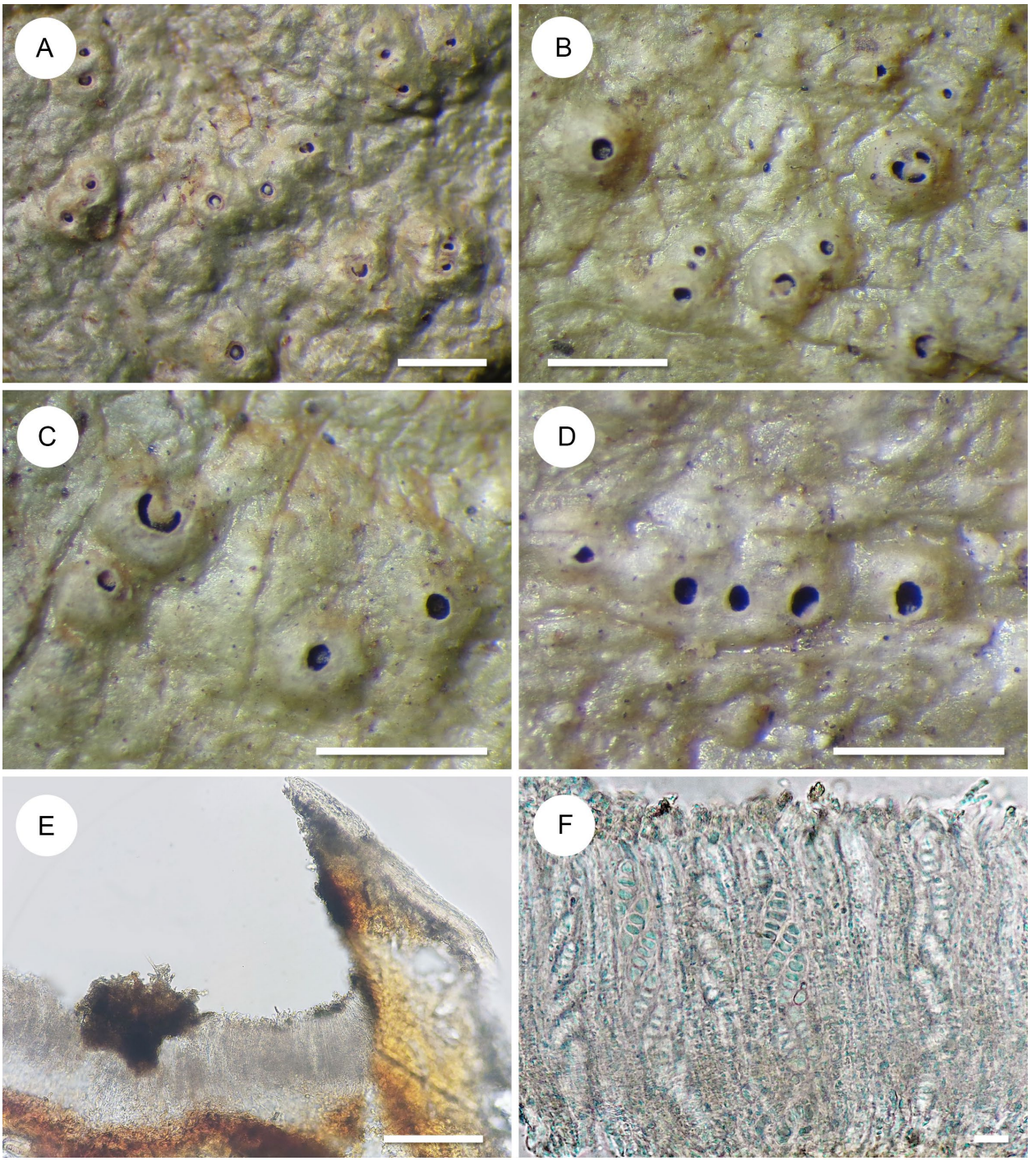

Figure 6. *Ocellularia maliauensis* (H. Thüs, P. Wolseley & C. Vairappan M.5.4.3). A–D – thallus with apothecia; E – section through apothecium with central columella; F – inspersed hymenium with asci and ascospores. Scales: A–D = 1 mm; E = 100 µm; F = 10 µm.

have different Rf values. Stictic acid is found in a similar position, but forms a more ellipsoid, yellow-orange spot and in microscopic section produces a K+ yellow efflux.

Platythecium saxicola Thüs, Weerakoon, Wolseley, Vairappan & Lücking, sp. nov. (Fig. 7)

MycoBank MB 864753

Diagnosis: Similar to other *Platythecium* species with saxicolous growth and brown ascospores, but differing from all other species in this genus by I-negative ascospores, bacilliform instead of filiform conidia, an acetone-insoluble, K+ orange metabolite, and the formation of large quantities of transparent crystals in the thallus.

Type: Malaysia, Sabah: Stability-of-Altered-Forests-Experiment (SAFE)-project area, 4.6748°N, 117.5782°E, alt. ~170 m, lowland secondary forest on logged previous *Dipterocarpaceae* dominated site, on wet siliceous rocks on a riverbank, H. Thüs & C. Vairappan s.n. (BORH – holotype; BM [BM00108880], STU [SMNS-STU-F-0009821], B – isotypes).

Etymology. The species epithet refers to its growth on rocks.

Description. Thallus saxicolous, epilithic, individual thalli more than 10 cm in diameter, forming a continuous smooth and glossy crust with light grey color. Prothallus white and fimbriate. Thallus in section up to 600 µm thick,

with colorless, prosoplectenchymatous cortex, 10–15 µm thick, photobiont layer, 150–160 µm thick, and yellowish to light brown medulla, 200–400 µm thick. Ascomata lirellate, scattered or in star-like clusters, unbranched to scarcely or sometimes stellately branched, 2–3 mm long, 0.3–0.35 mm broad, 0.15–0.19 mm high; disc immersed, black, thinly white-pruinose; labia entire, thin, apically exposed, separated from the surrounding thallus by a thin crack. Excipulum prosoplectenchymatous, boat-shaped and closed below the hymenium, 15–25 µm broad, brown; periphysoids absent; hypothecium 45–65 µm high, hyaline, with yellowish-brown pigmentation, pigmentation extending also in the lowermost part of the hymenium. Hymenium 110–130 µm high, clear; paraphyses unbranched, ~1.5 µm wide, apically smooth. Asci app. 60 × 9 µm, oblong-fusiform. Ascospores 4–8 per ascus, 3-septate to submuriform when fully mature, 11–13–16 × 6–8 µm (n = 20), oblong when 3-septate, mostly barrel-shaped when submuriform, with rather thick septa, brown, I–. Pycnidia immersed in the thallus, globose, 0.13 mm in diameter, with brown wall. Conidia bacilliform, ~4–5 × 1.5–2 µm.

Secondary chemistry. Without acetone soluble metabolites visible in HPTLC, but a colorless substance which immediately turns orange upon application of KOH,

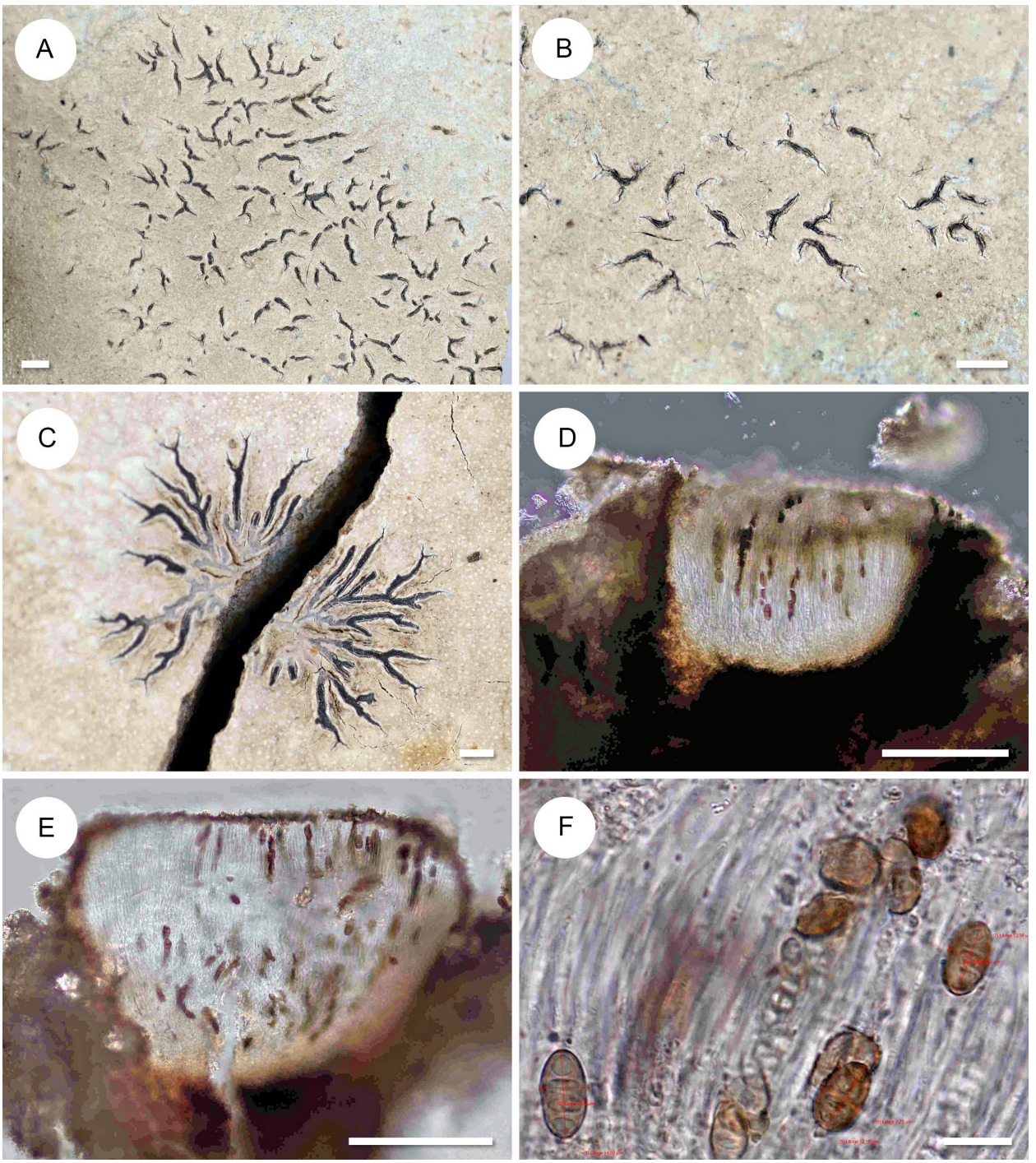

Figure 7. *Platythecium saxicola* (holotype). A–C – thallus with lirellae; D, E – section through lirellae; F – ascospores. Scales: A–C = 1 mm; D, E = 100 µm; F = 10 µm.

located throughout the thallus except the cortex, and with highest concentrations in the medulla. Furthermore, the thallus contains large transparent crystals of unknown composition.

Distribution and ecology. Only known from the type locality, where it grows on half-shaded, wet and iron rich siliceous rocks on the banks of a small river, temporarily inundated during high rainfall periods.

Remarks. The generic affiliation of this new taxon is preliminary, but we have so far found no better solution. The overall impression is that of a *Platythecium*, and species of this genus often form extensive thalli on rock, some producing brown ascospores (Staiger 2002). However, there are also substantial differences to other species of *Platythecium*, most notably the I-negative ascospores, the bacilliform instead of filiform conidia, an acetone-insoluble, K+ orange metabolite, and the formation of large quantities of transparent crystals in the thallus. Most similar in *Platythecium* is *P. serpentinellum* (Nyl.) Staiger, described as corticolous from Colombia. It is similar with the brown ascospores with similar size and septation and the formation of large crystal clusters in the thallus, but differs in the absence of secondary compounds (Staiger 2002).

Given the brown, I-negative ascospores, the genus *Phaeographis* is another option, especially the *P. intricans* group, which has a non-inspersed hymenium. Species with small, (sub-)muriform ascospores in this group include *P. leiogrammodes* (Kremp.) Müll. Arg., with norstictic acid; *P. epruinosa* (Redinger) Staiger, with stictic acid and much larger ascospores (22–35 × 11–13 µm); *P. alcicornis* Redinger, with stictic and norstictic acids and larger ascospores (15–30 × 6–10 µm); and *P. asteroides* (Fink) Lendemer, lacking secondary compounds and with much larger ascospores (25–40 × 10–15 µm).

Sarcographa aptrootiana Weerakoon, Wolseley, Vairappan, Thüs & Lücking, sp. nov. (Fig. 8)

MycoBank MB 864754

Diagnosis: Differing from other species of *Sarcographa*, particularly the morphologically similar *S. heteroclita*, in the comparatively large, muriform ascospores.

Type: Malaysia, Sabah: Danum Valley Conservation Area, 4.9702°N, 117.7975°E, alt. 238 m, on fallen Fagaceous tree in lowland old growth Dipterocarp Forest, Sept. 2012, H. Thüs, P. Wolseley & C. Vairappan D026 (BM [BM001104208] – holotype!, BORH – isotype).

Etymology. We dedicate this rather unusual new species to our esteemed colleague and friend, André Aptroot, for his numerous and invaluable contributions to the knowledge of tropical lichens, on the occasion of his 65th birthday earlier this year.

Description. Thallus corticolous, epiperidermal, up to 5 cm diam., continuous, olive-green, uneven, opaque to slightly glossy; prothallus not observed. Thallus in section 50–80 µm thick, with prosoplectenchymatous cortex, 10–15 µm thick, photobiont layer, 20–30 µm thick, and irregular medulla, 20–40 µm thick. Ascomata in distinctly pseudostromatic, well delimited clusters, pseudostromata prominent to sessile (then slightly constricted basally), 3–6 mm long,1–1.5(–2.5) mm broad, 0.3–0.4 mm high, with thickened, whitish margins; individual ascomata lirelliform, but strongly and irregularly to stellately branched and subdivided by whitish bridges into angular, isodiametric partial discs about 0.1–0.2 mm across, dark greyish brown, but thinly white-pruinose; proper margin indistinct; no thalline margin developed around the pseudostromata. Excipulum rather thinly developed between the individual ascomata, partly carbonized, 10–20 µm broad; hypothecium massive, up to 300 µm high, strongly carbonized; lateral tissue of the pseudostromata densely filled with small, greyish crystals giving it a nubilous appearance. Hymenium 100–120 µm high, strongly inspersed; paraphyses unbranched, smooth. Asci 90–100 × 25–35 µm, oblong. Ascospores (4–)8 per ascus, muriform, 60–70 × 15–18 µm, oblong, ellipsoid, with thickened septa and rounded lumina, for a long time hyaline, but finally brownish, I+ violet-blue.

Secondary chemistry. Stictic and constictic acids detected by TLC; thallus in section with K+ persistently yellow efflux.

Distribution and ecology. So far only known from the type location, where it grows on tree bark in the rain forest understory.

Remarks. *Sarcographa* is a mid-sized genus with approximately 40 species known (Staiger 2002; Cáceres 2007; Cáceres et al. 2012; Singh & Sinha 2015; Diederich et al. 2017; Luch & Lücking 2018; Lima et al. 2019). Thus far, all known species have transversely septate, often small ascospores, with the exception of *S. glyphiza* (Nyl.) Kr.P. Singh & G.P. Sinha, which produces small, submuriform ascospores. While the distinct pseudostromata, the strongly inspersed hymenium, and the chemistry of the new species fit the *Sarcographa* morphodeme well, the pseudostromata being similar to those of the widespread *S. heteroclita* (Mont.) Zahlbr., the rather large, muriform ascospores add a new dimension to the variation of species currently ascribed to this genus. The ascospores of the new species are about three times as long and wide as those of *S. glyphiza* and the latter also differs in the densely clustered lirellae which lack transverse divisions. In the available material, we observed that the ascospores of the new species remain hyaline for a long time and only become brownish with age, whereas in most other species of the genus, the ascospores are distinctly brown at maturity.

Discussion

The Malaysian state of Sabah in the Northeastern part of Borneo has received limited attention by lichenologists, who so far have mostly focussed on Mt Kinabalu (Sipman 1993; Paukow et al. 2017). Visits to other parts of the country targeted mostly large foliose and fruticose taxa (e.g., Wolseley 1991) or foliicolous lichens (Shapuan et al. 2019), and only a few records from Maliau Basin (Din et al. 2008). However, lowland tropical forests support

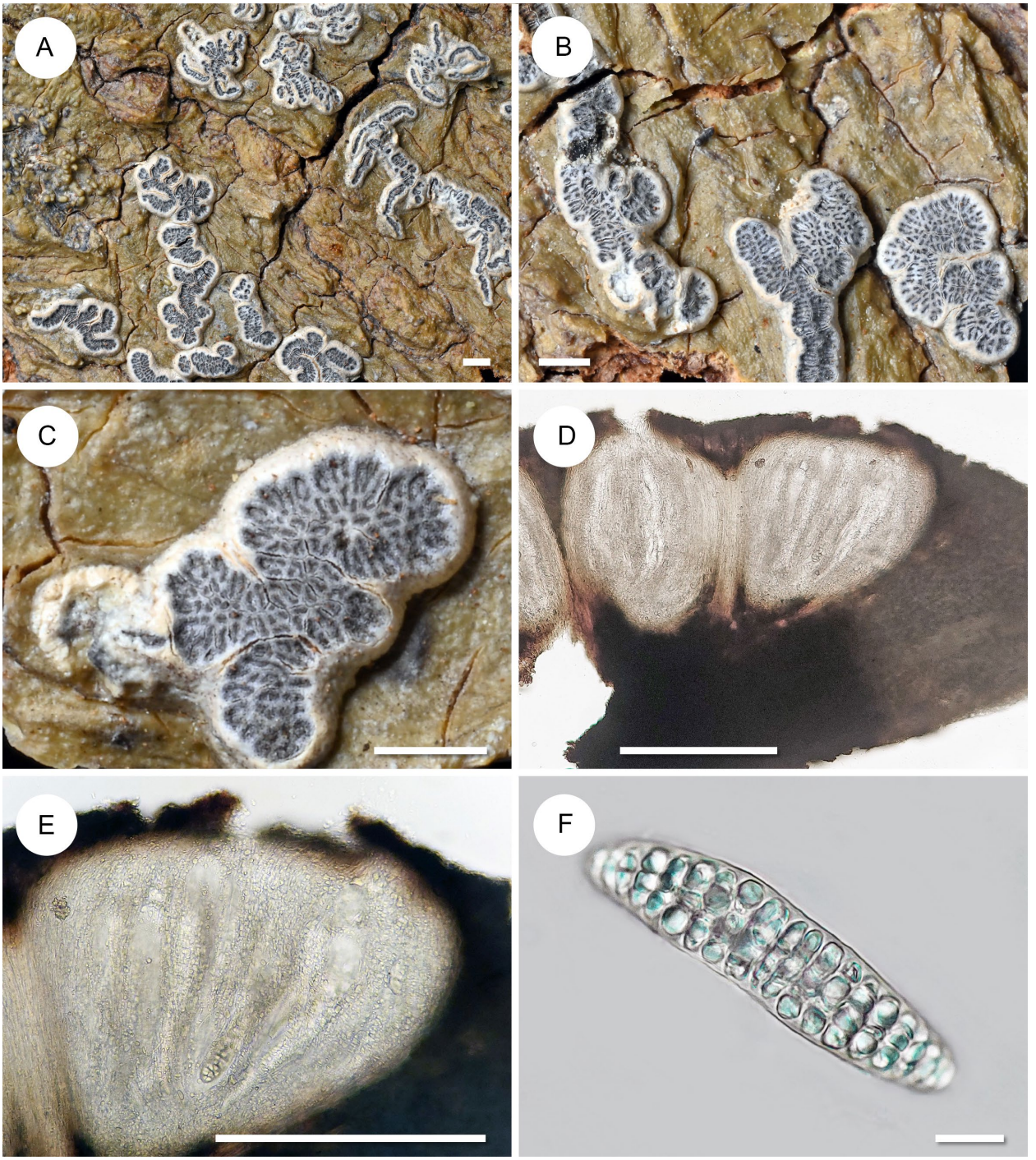

Figure 8. *Sarcographa aptrootiana* (holotype). A–C – thallus with pseudostromata, in C enlarged; D, E – section through pseudostroma, in E enlarged; F – ascospore. Scales: A–C = 1 mm; D, E = 100 µm; F = 10 µm.

a huge diversity of crustose corticolous species, much of which is undescribed or may be represented by type material in scattered 19th C herbaria.

Between 1996 and 2001, preliminary work in logged and unlogged lowland forests of Peninsular Malaysia, Sabah, and Kalimantan, highlighted the importance of *Graphidaceae* and its contribution to the high species diversity in undisturbed forests (Wolseley et al. 2007). In the 21st century, interest in tropical diversity has resulted in a steep increase in the description of new taxa in the region; for instance, from the small city state of Singapore, 11 new species were described (Sipman 2003; Weerakoon et al. 2015).

The discovery of eight new species among the material collected in our visits to Sabah in 2012 and 2013 is therefore not surprising. It is remarkable, however, that most of the new species appear to be restricted to old growth forests and were not encountered in the more or less disturbed plots of the SAFE project, not even in the so-called "Virgin Forest Reserve", which despite its reserve status has already lost most of the standing old *Dipterocarpaceae* trees due to historic selective logging. While this plot was still rather similar to true old growth sites based on a functional traits approach for ordinating disturbed and undisturbed plot data (Thüs et al. 2021), the results presented here indicate that the

occurrence of rare *Graphidaceae* species appears to be a more sensitive indicator for the demonstrable difference in disturbance levels between the "Virgin Forest Reserve" and larger old growth forest areas with a near natural representation of old and vital standing *Dipterocarpaceae* trees. Although most of the new species described here are able to grow on rather small trees, the forest conditions apparently are so altered by the selective logging of the timber trees that many sensitive lichens have disappeared.

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