

World key to the species of Pyrenulaceae and Trypetheliaceae

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The keys below treat all c. 750 species in the families Pyrenulaceae and Trypetheliaceae. They are a separate print of the keys published in this book:

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They are published separately here online so as to give access to a wide audience, also to those who do not buy the book.

General key to the families and some genera of tropical pyrenocarpous lichens

(specimens without ascospores or with only conidia can rarely be identified and are not keyed out; it is important to distinguish septation with thickened cell walls, called distosepta, from simple eusepta; also it is important to observe whether or not the hamathecium filaments = paraphyses are branched; in case one of these characters is not ascertained, try both alternatives)

Please note that **keys A to E** mainly contain Pyrenulaceae, and **keys F to Ω** are all Trypetheliaceae. The keys look similar to previously published keys, but differ in numerous points, notably additional species and the corrections of mistakes. Each key alternative is given a separate code (like K2b) for easy future reference. Updated known world distributions are indicated for each species.

1a Hamathecium filaments absent or slimy; algae dark green, verrucarioid; thallus usually microsquamulose. Verrucariaceae (corticolous: *Agonimia*, *Endocarpon*, *Placidium*, *Psoroglaena*)

1b Hamathecium filaments present; algae trentepohlioid, or sometimes absent. 2

2a Ascospores simple. 3

2b Ascospores septate. 5

3a Ascospores globose, >50 per ascus; pantropical (Brazil, Papua New Guinea, Solomon Islands). *Melanophloea pacifica* P. James & Vězda

3b Ascospores 1 to 8 per ascus. 4

4a Ascospores ornamented with warts or spines. *Monoblastia*

4b Ascospores not ornamented, with wide, shaped gelatinous sheath: pantropical, but rarely reported (Brazil, Papua New Guinea). *Papilionovela athallina* Aptroot

5a Hamathecium with unbranched paraphyses or hamathecium unclear. 6

5b Hamathecium with branched to anastomosing paraphysoids. 19

6a Ascospores brown. 7

6b Ascospores hyaline. 12

7a Ascospores remaining stuck in mass on top of the ascoma, mazaedioid. Pyrenulaceae (*Mazaediothecium*, *Pyrgillus*). **Key E**

7b Ascospores discharged. 8

8a Ascospores 1-septate. 9

8b Ascospores more than 1-septate. Pyrenulaceae. 11

9a Ascospores not ornamented, often thick-walled, distoseptate. Pyrenulaceae (*Clypeopyrenis*, *Distopyrenis*, *Granulopyrenis*, *Parapyrenis*). **Key D**

9b Ascospores ornamented, thin-walled. 10

10a Ascospores up to $20 \times 8 \mu\text{m}$, only in one species larger (up to $30 \times 10 \mu\text{m}$). *Pseudobogoriella*. **Key X**

10b Ascospores $20\text{--}50 \times 8\text{--}15 \mu\text{m}$. *Bogoriella*. **Key Q**

11a Ascospores transversely septate. Pyrenulaceae (mostly *Eopyrenula*, *Lithothelium*, *Pyrenula*). **Key B**

11b Ascospores (sub)muriform. Pyrenulaceae (mostly *Anthracotheicum*, *Pyrenula*). **Key A**

12a Ascospores >10 per ascus. *Thelopsis*

12b Ascospores 1 to 8 per ascus. 13

13a Hamathecium a pseudoparenchymatous tissue; ascomata usually in dense groups with common black cover. *Mycoporum*

13b Hamathecium consisting of filaments. 14

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- 14a Ascospores thick-walled, distoseptate, either with rather unclear septation or with filiform ascospores). Pyrenulaceae (*Celothelium*, *Lithothelium*). **Key C**
- 14b Ascospores thin-walled, euseptate. 15
- 15a Ascomata in thalline warts with black pulveraceous mass. *Phyllobathelium*
- 15b Ascomata not in thalline warts with black pulveraceous mass. 16
- 16a Thallus medulla bright yellow or orange. *Myeloconis*
- 16b Thallus medulla not bright yellow or orange. 17
- 17a Ascomata with periphyses in addition to paraphyses. *Topelia*
- 17b Ascomata without periphyses. 18
- 18a Ascomata adorned with setae formed of conglutinated hairs. *Trichothelium*
- 18b Ascomata usually not adorned, but if with setae, these not made of conglutinated hairs. *Porina*
- 19a Ascospores distoseptate, mostly thick-walled; when relatively thin-walled, either hyaline and with constrictions or brown and ornamented. Trypetheliaceae. 23
- 19b Ascospores thin-walled, euseptate. 20
- 20a Hamathecium filaments unbranched between the asci. 21
- 20b Hamathecium filaments branched. 22
- 21a Ascospores 1 to 3-septate. Monoblastiaceae (*Acrocordia*, *Anisomeridium*, *Megalotremis*, *Trypetheliopsis*)
- 22b Ascospores muriform. *Julella*
- 22a Ascospores hyaline, usually uniseriate in the ascus; conidia with gelatinous appendages. Strigulaceae (*Dichoporis*, *Flagellostrigula*, *Strigula*, *Swinscowia*)
- 22b Ascospores biseriate; conidia without appendages. Thelenellaceae (*Aspidothecium*, *Thelenella*)
- 23a Ascospores remaining hyaline. 24
- 23b Ascospores becoming brown. 50
- 24a Ascospores 1-septate. 25
- 24b Ascospores 3-septate to muriform. 26
- 25a Ascospores smooth-walled. *Constrictolumina*. **Key R**
- 25b Ascospores granular ornamented. *Macroconstrictolumina*. **Key T**

- 26a Thallus ecorticate, usually whitish or greyish. 27
26b Thallus distinctly corticate, olive-green to yellowish brown. 31
- 27a Hamathecium filaments basally thickened, branched but usually not anastomosing.
28
27b Hamathecium filaments thin, straight, branched and anastomosing to form a net-like
structure. 29
- 28a Ascospores smooth-walled. *Constrictolumina*. **Key R**
28b Ascospores granular ornamented. *Macroconstrictolumina*. **Key T**
- 29a Ascospores with diamond-shaped lumina. *Pseudopyrenula*. **Key Y**
29b Ascospores with almost rectangular lumina. 30
- 30a Ascospores transversely septate, or when muriform, ostiole apical. *Polymeridium*.
Key W
30b Ascospores muriform; ostioles lateral. *Dictyomeridium*. **Key S**
- 31a Ascospores transversely septate. 32
31b Ascospores muriform. 41
- 32a Ascospores very large with few (3–5) septa, typically over $100 \times 30 \mu\text{m}$ and up to
 $190 \times 60 \mu\text{m}$; septa and walls somewhat thickened but lumina not astrothelioid.
Architrypethelium. **Key G**
32b Ascospores when 3–5-septate very rarely exceeding $100 \times 30 \mu\text{m}$ and if so,
ascospores distinctly astrothelioid, with diamond-shaped lumina. 33
- 33a Ascospores with diamond-shaped lumina. 34
33b Ascospores with ellipsoid to lentiform or almost rectangular lumina. 38
- 34a Ascomata strongly prominent to sessile, completely exposed, pure black, somewhat
egg-shaped. *Nigrovothelium*. **Key V**
34b Ascomata immersed to erumpent or aggregate in erumpent to sessile pseudostromata.
Astrothelium. 35
- 35a Ascomata each with a separate, consistently apical ostiole. 36
35b Ascomata either with a separate, eccentric to lateral ostiole or several ascomata with
a fused ostiole which is then positioned apically relative to the ascomatal cluster
but with individual channels originating eccentric or lateral from each individual
ascoma or chamber. 37

- 36a Thallus and/or ascomata with external or internal, yellow to red pigment(s) (usually K+ red to purple) and/or with lichexanthone (then UV+ yellow). **Key H**
- 36b Pigments and lichexanthone absent. **Key I**
- 37a Thallus and/or ascomata with external or internal, yellow to red pigment(s) (usually K+ red to purple) and/or with lichexanthone (then UV+ yellow). **Key J**
- 37b Pigments and lichexanthone absent. **Key K**
- 38a Ascomata aggregate in prominent to sessile, brownish black pseudostromata; ascospores with thin septa and walls. *Bathelium*. **Key P**
- 38b Ascomata solitary to pseudostromatic but pseudostromata not as above; ascospores with slightly thickened septa. 39
- 39a Ascomata immersed to erumpent or rarely indistinctly pseudostromatic; pigments mostly absent. 40
- 39b Ascomata aggregate in distinct, prominent to sessile pseudostromata; internal and/or external pigments usually present. *Trypethelium*. **Key Z**
- 40a Thallus UV-negative. *Viridothelium*. **Key O**
- 40b Thallus UV+ yellow; Brazil. *Exiliseptum ocellatum* (Müll. Arg.) R.C. Harris
- 41a Ascospores with ellipsoid to lentiform or almost rectangular lumina. 42
- 41b Ascospores with diamond-shaped lumina. 45
- 42a Ascomata single. *Architrypethelium submuriforme* Aptroot
- 42b Ascomata aggregate. 43
- 43a Ascomata aggregate in prominent to sessile, brownish black pseudostromata. *Bathelium*. **Key P**
- 43b Ascomata in erumpent, whitish pseudostromata. 44
- 44a Thallus UV-negative: Panama. *Viridothelium tricolor* Lücking, M.P. Nelsen & N. Salazar
- 44b Thallus UV+ yellow; Brazil. *Trypethelium muriforme* Aptroot & M.F. Souza
- 45a Ascomata in prominent to sessile warts covered by a thick layer of yellow-orange or red pigment. *Marcelaria*. **Key U**
- 45b Ascomata immersed to erumpent, rarely prominent, usually covered by thallus, rarely with a thin layer of pigment pruina. 46

- 46a Ascomata aggregate in irregular, blackish pseudostromata; ascospores about 50×15 μm ; Thailand. *Architrypethelium murisporum* Luangsaph., Lumbsch & Sangvichien
- 46b Ascomata and ascospores not with the above combination of characters.
Astrothelium. 47
- 47a Ascomata each with a separate, consistently apical ostiole. 48
- 47b Ascomata either with a separate, eccentric to lateral ostiole or several ascomata with a fused ostiole which is then positioned apically relative to the ascomatal cluster but with individual channels originating eccentric or lateral from each individual ascoma or chamber. 49
- 48a Thallus and/or ascomata with external or internal, yellow to red pigment(s) (usually K+ red to purple) and/or with lichexanthone (then UV+ yellow). **Key L**
- 48b Pigments and lichexanthone absent. **Key M**
- 49a Thallus and/or ascomata with external or internal, yellow to red pigment(s) (usually K+ red to purple) and/or with lichexanthone (then UV+ yellow). **Key N**
- 49b Pigments and lichexanthone absent. **Key O**
- 50a Ascospores transversely septate. 51
- 50b Ascospores (sub-)muriform. 56
- 51a Ascospores with a basal euseptum and the basal cell pale, otherwise distoseptate and brown; neotropical. *Polypyrenula sexlocularis* (Müll. Arg.) D. Hawksw.
- 51a Ascospores septa all similar. 52
- 52a Ascospores large, usually over $100 \mu\text{m}$ long. 53
- 52b Ascospores small, under $50 \mu\text{m}$ long. 54
- 53a Ascospores 3-septate, $25\text{--}50 \mu\text{m}$ broad, about 3–4 times as long as broad.
Architrypethelium. **Key G**
- 53b Ascospores 11–15-septate, $25\text{--}30 \mu\text{m}$ broad, about 4–5 times as long as broad;
Colombia. *Astrothelium fuscosporum* Soto-Medino, Aptroot & Lücking
- 54a Ascospores drop-shaped, macrocephalic, with strongly thickened terminal walls and two narrow, rectangular lumina near the center; Azores. *Schummia angulata* (Aptroot & Schumm) Lücking, R. Miranda & Aptroot
- 54b Ascospores ellipsoid, not macrocephalic. 55
- 55a Ascospores up to $20 \times 8 \mu\text{m}$, only in one species larger (up to $30 \times 10 \mu\text{m}$).
Pseudobogoriella. **Key X**

55b Ascospores $20\text{--}50 \times 8\text{--}15\text{ }\mu\text{m}$. *Bogoriella*. **Key Q**

56a Ascospores small, under $50 \times 20\text{ }\mu\text{m}$, often with irregularly thickened endospore and halter-shaped lumina. *Bogoriella*. **Key Q**

56b Ascospores very large, $150\text{--}400 \times 50\text{--}140\text{ }\mu\text{m}$, with outer wall often breaking under pressure. *Aptrootia*. **Key F**

Key A. Mostly tropical corticolous pyrenocarpous lichens with simple paraphyses and brown, submuriform to muriform, distoseptate ascospores (mostly Pyrenulaceae: *Anthracothecium*, *Lithothelium* and *Pyrenula*)

A1a Young ascospores with eusepta only; mature ascospores with scarce endospore and edgy corners. *Anthracothecium*. 2

A1b Septation only or mostly distoseptate, with notably thick endospore layers, in particularly in the corners, and causing the locules to appear rounded. 6

A2a Ascomata simple. 3

A2b Ascomata mostly compound with a joint ostiole. 5

A3a Ostiole apical. 4

A3b Ostiole lateral; pantropical. *Anthracothecium australiense* (Müll. Arg.) Aptroot

A4a Ascospores 2–4/ascus; pantropical. *Anthracothecium macrosporum* (Hepp) Müll. Arg.

A4b Ascospores 6–8/ascus; pantropical. *Anthracothecium prasinum* (Eschw.) R.C. Harris

A5a Ascospores 1–2/ascus; pantropical. *Anthracothecium interlatens* (Nyl.) Aptroot

A5b Ascospores 6–8/ascus; australasian, possibly also african.

Anthracothecium gregale (C. Knight) Aptroot

A6a Ascospores strongly flattened (lozenge-shaped), with two rows of locules.
Sulcopyrenula. 7

A6b Ascospores not flattened, circular in transverse section. 11

A7a Thallus UV-negative. 8

A7b Thallus UV+ yellow. 9

A8a Hamathecium interspersed; neotropical. *Sulcopyrenula canellae-albae* (Fée) H. Harada

A8b Hamathecium not interspersed; pantropical. *Sulcopyrenula staurospora* (Tuck.) H. Harada

A9a Ascospores with 4 locules. 10

A9b Ascospores with 8 locules; Guyana. *Sulcopyrenula biseriata* Aptroot & Sipman

A10a Ascospores ellipsoidal, c. 2 times as long as wide; Brazil.

Sulcopyrenula cruciata Aptroot

A10b Ascospores nearly globose; neotropical. *Sulcopyrenula subglobosa* (Riddle)
Aptroot

A11a Ascospores submuriform, only one or a few of the median locules with longitudinal
septa. 12

A11b Ascospores muriform (when ascospores small, logically only few longitudinal
septa can be present; when in doubt, start with the first alternative). 25

A12a Ascomata usually fused or compound, when separate, ostioles lateral; ostioles
apical or lateral. 13

A12b Ascomata separate and simple; ostioles apical. 18

A13a Ascomata fused, in black, exposed groups with several ostioles; ascospores 15–22
µm long; australasian. *Lithothelium hieroglyphicum* Aptroot

A13b Ascomata compound, with several, usually flask-shaped chambers usually
immersed in the thallus and with a joint ostiole. 14

A14a Ascospores mostly less than 25 µm long. 15

A14b Ascospores mostly over 25 µm long. 17

A15a Thallus with pseudocyphellae; ascospores 15–19 µm long; Guyana. *Pyrenula*
infrastroidea Aptroot & Sipman

A15b Thallus without pseudocyphellae. 16

A16a Ascospores red-brown, 14–23 µm long; eastern palaeotropical (Australia to Japan).
Lithothelium nanosporum (C. Knight) Aptroot

A16b Ascospores grey-brown, 17–20(–25) µm long; neotropical. *Pyrenula subvariabilis*
Aptroot & Sipman

A17a Ascospores up to 32 µm long; australasian. *Pyrenula subumbilicata* (C. Knight)
Aptroot

A17b Ascospores 45–65 µm long; neotropical. *Pyrenula erumpens* R.C. Harris

A18a Ascospores 13–35(–40) µm long. 19

A18b Ascospores 34–72 µm long. 24

A19a Ascospores 13–17 µm long. 20

- A19b Ascospores 22–35(–40) μm long. 21
- A20a Ascospores with little endospore formation, lumina almost angular; on wood, pacific. *Pyrenographa irregularis* (Wehmeyer) R.C. Harris
- A20b Ascospores much thickened, with rounded lumina; Florida. *Distopyrenis submuriformis* R.C. Harris
- A21a Thallus probably without algae; temperate. *Requienella seminuda* (Pers.) Boise
- A21b Thallus superficial, with copious algae. 22
- A22a Ascospores 22–40 μm long; overmature ascospores with reddish content before shiveling; pantropical. *Pyrenula seminuda* (Müll. Arg.) Sipman & Aptroot
- A22b Ascospores 23–35 μm long; overmature spores all shrivelled. 23
- A23a Ascospores 23–35 μm long; hamathecium not inspersed; eastern palaeotropical. *Pyrenula gibberulosa* (Vain.) Aptroot
- A23b Ascospores 23–33 μm long; hamathecium inspersed; eastern palaeotropical (India). *Pyrenula darjeelingensis* Jagadeesh Ram & G.P. Sinha
- A24a Ascospores with pointed ends; hamathecium not inspersed; eastern palaeotropical (Australia to Japan). *Pyrenula subvariolosa* (C. Knight) Aptroot
- A24b Ascospores with rounded ends; hamathecium inspersed; neotropical. *Pyrenula novemseptata* Vain.
- A25a Ascomata and/or thallus or medulla with yellow, orange or red anthraquinone pigments; pigments K+ pink to purplish. 26
- A25b Anthraquinones absent; thallus K– or yellowish. 32
- A26a Thallus warts internally with soft orange medulla; Philippines. *Pyrenula endocrocea* Aptroot
- A26b Yellow, orange or red pigment on outside. 27
- A27a Ascomata and/or thallus red. 28
- A27b Ascomata and/or thallus yellow to orange. 30
- A28a Ostiole apical; hamathecium inspersed; neotropical. *Pyrenula cruentata* (Müll. Arg.) R.C. Harris
- A28b Ostiole lateral; hamathecium not inspersed. 29
- A29a Ascomata partly fused with joint ostioles; ascospores with up to 6 locules per segment; caribbean. *Pyrenula kermesina* R.C. Harris

A29b Ascomata solitary; ascospores with up to 2 locules per segment; pacific. *Pyrenula palmarum* (Krempelh.) R.C. Harris

A30a Ascospores 10–23 µm long, with 3 primary septa. 31

A30b Ascospores 23–35 µm long, with 5–7 primary septa; neotropical.

Pyrenula ochraceoflavens (Nyl.) R.C. Harris

A31a Thallus red-orange; ascospores 9–18 µm long; Brazil. *Pyrenula aurantiacorubra* Aptroot & M. Cáceres

A31b Thallus yellow to orange; ascospores 10–23 µm long; pantropical.

Pyrenula ochraceoflava (Nyl.) R.C. Harris

(with small ascospores with two layers of locules; pacific: *Pyrenula ochraceoflava* var. *pacifica* P.M. McCarthy)

A32a Ostioles lateral. 33

A32b Ostioles apical. 41

A33a Ascospores <70 µm long. 34

A33b Ascospores >70 µm long. 36

A34a Ascomata at least partly with more than one chamber and with joint ostiole. 35

A34b Ascomata all simple and single, with separate ostioles; ascospores 15–33 µm long; pantropical (El Salvador, India). *Pyrenula microspora* (Nagarkar & Patw.) Upreti

A35a Ascospores 25–45 µm long; pantropical. *Pyrenula astroidea* (Fée) R.C. Harris

A35b Ascospores 45–70 µm long; pantropical. *Pyrenula ravenelii* (Tuck.) R.C. Harris

A36a Ascospores 2/ascus, 135–200 µm long; pantropical. *Pyrenula lyoni* (Zahlbr.) Aptroot

A36b Ascospores 4–8/ascus. 37

A37a Ascospores 25–110 µm long. 38

A37b Ascospores 85–135 µm long. 40

A38a Ascospores 25–31 µm long; Guyana. *Pyrenula triangularis* Aptroot & Sipman

A38b Ascospores 50–110(–135) µm long. 39

A39a Ascospores 50–90 µm long; pantropical (El Salvador, India). *Pyrenula ceylonensis* (Ajay Singh & Upreti) Aptroot

A39b Ascospores 70–135 µm long; W. Europe, Madagascar & Macaronesia). *Pyrenula hibernica* (Nyl.) Aptroot

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- A40a Ascomata mostly with several chambers; pantropical. *Pyrenula schiffneri* (Zahlbr.) Aptroot
- A40b Ascomata often with single chamber; neotropical. *Pyrenula chilensis* (Fée) R.C. Harris
- A41a Ascospores <25 µm long. 42
- A41b Ascospores >25 µm long. 46
- A42a Hamathecium inspersed. 43
- A42b Hamathecium not inspersed. 44
- A43a Ascospores 13–18 µm long, with basal cilium; Mauritius. *Pyrenula muriciliata* Diederich & Ertz
- A43b Ascospores 20–25 µm long, without cilium; Borneo. *Pyrenula borneensis* Aptroot
- A44a Thallus UV+yellow; pantropical. *Pyrenula confinis* (Nyl.) R.C. Harris
- A44b Thallus UV-negative. 45
- A45a Ascospores 15–22 µm long; pantropical. *Pyrenula parvinuclea* (Meyen & Flot.) Aptroot
- A45b Ascospores 7–10 µm long; India. *Pyrenula nanospora* (Ajay Singh) Upreti
- A46a Old ascospores containing orange oil before shriveling; pantropical. *Pyrenula breutelii* (Müll. Arg.) Aptroot
- A46b Old ascospores without orange oil, directly shriveling. 47
- A47a Ascospores >80 µm long, mostly 2/ascus. 48
- A47b Ascospores <80 µm long, mostly 4–8/ascus. 53
- A48a Hamathecium inspersed, ascospores 90–200 µm long. 49
- A48b Hamathecium not inspersed. 50
- A49a Thallus UV+ yellow, with lichexanthone; neotropical. *Pyrenula xanthoglobulifera* Aptroot, Lücking & M. Cáceres
- A49b Thallus UV-negative, without lichexanthone; pantropical. *Pyrenula globifera* (Eschw.) Aptroot
- A50a Thallus without pseudocyphellae, ascospores 80–140(–155) µm long; pantropical. *Pyrenula platystoma* (Müll. Arg.) Aptroot
- A50b Thallus with pseudocyphellae. 51
- A51a Ascospores 80–180 µm long, 2–8/ascus. 52

- A51b Ascospores 205–350 µm long, 1/ascus; Guyana. *Pyrenula monospora* Aptroot & Sipman
- A52a Ascospores 80–110 µm long, 2–8/ascus; Hawaii. *Pyrenula neosandwicensis* Aptroot
- A52b Ascospores 115–180 µm long, 2/ascus; pantropical. *Pyrenula duplicans* (Nyl.) Aptroot
- A53a Hamathecium inspersed. 54
- A53b Hamathecium not inspersed. 55
- A54a Ascospores 2/ascus, 55–75 µm long; Brazil. *Pyrenula bisporea* Aptroot & M. Cáceres
- A54b Ascospores 8/ascus, 30–45 µm long; pantropical (India, Brazil). *Pyrenula sublaevigata* (Patw. & Makhija) Upreti
- A55a Locules relatively large and angular, with up to 6 between 2 primary septa; pantropical. *Pyrenula leucostoma* Ach.
- A55b. Locules mostly round, at least in the central part of the ascospore with more than 6 between 2 primary septa. 56
- A56a Ascospores <50 µm long. 57
- A56b Ascospores >50 µm long. 60
- A57a Ascospores 25–35 µm long; palaeotropical. *Pyrenula welwitschii* (Upreti & Ajay Singh) Aptroot
- A57b Ascospores >35 µm long. 58
- A58a Ascospores 11–15 µm wide; pantropical. *Pyrenula thelomorpha* Tuck.
- A58b Ascomata 14–22 µm wide. 59
- A59a Old ascospores containing colourless oil before shriveling; neotropical. *Pyrenula oleosa* R.C. Harris
- A59b Old ascospores without oil, directly shriveling when old; neotropical. *Pyrenula dissimulans* (Müll. Arg.) R.C. Harris
- A60a Ascomata deeply immersed in bark below the thallus, not visible, only ostioles visible; Brazil. *Pyrenula abditicarpa* Aptroot & M. Cáceres
- A60b Ascomata more-or-less exposed. 61
- A61a Ascospores with rounded ends; pantropical. *Pyrenula pyrenuloides* (Mont.) R.C. Harris

A61b Ascospores with pointed ends; pantropical. *Pyrenula papillifera* (Nyl.) Aptroot

Key B. Corticolous pyrenocarpous lichens with simple paraphyses and brown, transversely 3- or more septate distoseptate ascospores (mostly Pyrenulaceae: *Eopyrenula*, *Lithothelium* and *Pyrenula*)

B1a Ascospores 3-loculate. 2

B1b Ascospores 4- or more-loculate. 4

B2a Ascospore septation strongly asymmetrical; Madagascar. *Lacrymospora parasitica* Aptroot

B2b Ascospore septation symmetrical. 3

B3a Ascomata aggregated in grey to black pseudostromata; pantropical. *Pyrenula lineatostroma* Aptroot

B3b Ascomata dispersed, not stromatoid; Brazil. *Pyrenula biseptata* Aptroot & M. Cáceres

B4a Ascospores nearly only euseptate, locules rectangular, at most a bit rounded in the corners, end cells often paler than middle cells. 5

B4b Ascospores clearly distoseptate, locules more or less rounded or diamond-shaped. 17

B5a Ascospores more than 5 times as long as wide; South Africa. *Pyrenowilmsia wilmsiana* (Zahlbr.) Aptroot

B5b Ascospores less than 4 times as long as wide. 6

B6a Ascospores only 4-loculate; macroconidia 3-septate or unknown. 7

B6b Ascospores 4–8-loculate; macroconidia either 1–7-septate or unknown. 12

B7a Ascoma wall dense. 8

B7a Ascoma wall cellular. *Eopyrenula*. 10

B8a Ascospores smooth, 14–17 µm long; neotropical. *Pyrenula tenuisepta* R.C. Harris

B8b Ascospores verrucose, 30–47 µm long. *Bogoriella*. 9

B9a Ascomata at least partly fused with a more or less joint ostiole; Japan; pantropical. *Bogoriella collospora* (Vain.) Aptroot & Lücking

B9b Ascomata all single; Australasian; pantropical. *Bogoriella queenslandica* (Müll. Arg.) Aptroot & Lücking

- B10a Ascospores 4–5 µm wide; New world temperate. *Eopyrenula parvispora* R.C. Harris & Aptroot
B10b Ascospores 5.5–7.5 µm wide. 11
- B11a Ascospores mostly <15 µm long; Atlantic (W. Europe). *Eopyrenula avellanae* Coppins
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B54a Ascospores more than 4 times as long as wide; neotropical. 55

B54b Ascospores less than 4 times as long as wide. 56

B55a Ascospores more than 4 times as long as wide; hamathecium clear. *Pyrenula melanophthalma* (Mont.) Trevis.

B55b Ascospores 30–37 x 3–4 µm; thallus UV+ yellow instead of UV–; hamathecium interspersed with colourless oil globules. *Pyrenula musaespora* Aptroot & M. Cáceres

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B57b Ascospores without orange oil; thallus without pseudocyphellae; South Africa. *Pyrenula wilmsiana* Müll. Arg.

B58a Ascospores 29–35 µm long; hamathecium not interspersed; Australasian (Papua New Guinea). *Pyrenula sexluminata* Aptroot

B58b Ascospores 30–55 µm long; hamathecium interspersed; pantropical. *Pyrenula caracasana* Müll. Arg.

B59a Ascospores with a long tail at one end; Pacific (Mariana Islands). *Pyrenula flagellata* H. Harada

B59b Ascospores without tails. 60

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B61b Thallus with pseudocyphellae. 63

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B63a Ascospores 8–12-loculate; eastern palaeotropical (India). *Pyrenula subcylindrica* Jagadeesh Ram & Upreti

B63b Ascospores 12–18-loculate, 75–90 × 4.5–6.5 µm, gradually attenuated toward the ends; New Caledonia. *Pyrenula filiformis* Aptroot

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B64b Ascospores 53–70 μm long; Australasian (New Zealand), also neotropical?
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B75b Ascomata and thallus without external pigments. 97

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B77a Ascomata at least partly yellow; hamathecium not inspersed; neotropical and pacific (Panama, Costa Rica, Puerto Rico, Hawaii). *Pyrenula luteopruinosa* Etayo & Aptroot

B77b Ascomata or thallus orange or red; hamathecium inspersed. 78

B78a Ascomata red; thallus UV-negative; Australasian (Lord Howe Island). *Pyrenula howeana* Aptroot

B78b Thallus or ascomata orange, thallus UV+ yellow. 79

B79a Ascomata orange; ascospores 17–20 µm long; eastern palaeotropical (Korea). *Pyrenula sipmanii* Aptroot & K.H. Moon

B79b Thallus orange; ascospores 19–22 µm long; eastern palaeotropical (Thailand). *Pyrenula aurantiopileata* Aptroot

B80a Thallus yellow (in shade) to orange (in full light). 81

B80b Thallus and/or ascomata at least partly pink, red or lilac. 82

B81a Ascospores ca. 25–40 µm long, not plicate; found in mangrove; neotropical. *Pyrenula cerina* Eschw.

B81b Ascospores 55–65 µm long, longitudinally plicate; Chile. *Pyrenula plicata* Sipman & Aptroot

B82a Thallus and/or ascomata at least partly red. 83

B82b Thallus lilac; Brazil. *Pyrenula lilacina* C.O. Mendonça, Aptroot & M. Cáceres

B82c Thallus salmon pink; hamathecium inspersed; ascospores 24–27 × 13–16 µm; Brazil. *Pyrenula salmonea* Aptroot

B83a Hamathecium not inspersed. 84

B83b Hamathecium inspersed with colourless oil globules. 91

B84a Ascomata aggregated in pseudostromata. 85

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B85a Ascospores 15–18(–20) µm long. 86

B85b Ascospores 20–24 µm long; ascomata densely aggregated in well-delimited, bright red pseudostromata; Brazil. *Pyrenula sanguinea* Aptroot, M. Cáceres & Lücking

- B86a Ascomata covered by red thallus; Brazil. *Pyrenula cinnabarina* Aptroot, E.L. Lima & M. Cáceres
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- B89a Red colouration only in tissue around the ostiole; neotropical. *Pyrenula rubrostoma* R.C. Harris
B89b Red coloration extending over the thallus; Brazil. *Pyrenula rubronitidula* Aptroot & M. Cáceres
- B90a Thallus extensively carmine-red-stained; Brazil. *Pyrenula rubroacutispora* Aptroot
B90b Only ostioles of (immersed) ascomata red; Caribbean. *Pyrenula sanguineostiolata* Aptroot & Mercado Diaz
- B91a Ascomata aggregated in pseudostromata; ascospores 12–15 x 6–8µm; Brazil. *Pyrenula reginae* E.L. Lima, Aptroot & M. Cáceres
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- B94a Thallus orange-brown to red, ostioles black; Brazil. *Pyrenula rubromamillana* E.L. Lima, Aptroot & M. Cáceres
B94b Only ostioles pigmented, red; Brazil. *Pyrenula rubrostigma* Aptroot & M. Cáceres
- B95a Thallus dark reddish to orange-brown, K+ crimson; ascomata hemispherical, 0.4–0.7 mm diam.; eastern palaeotropical (Java). *Pyrenula rubrojavânica* Aptroot
B95b Thallus orange, K+ purple; ascomata low-conical, 0.7–1 mm diam.; Brazil. *Pyrenula aurantiacothallina* C.O. Mendonça, Aptroot & M. Cáceres

B96a Ascospores 25–29 x 10–12 µm; thallus with red spots or lines; ascomata immersed in thallus, 0.2–0.4 mm diam.; Caribbean. *Pyrenula sanguineomeandrata* Aptroot & Mercado Diaz

B96b Ascospores 27–35 µm long; thallus with red patches or completely red; ascomata erumpent, c. 0.4–0.8 mm diam.; pantropical. *Pyrenula cruenta* (Mont.) Vain.

B97a Ascomata mostly aggregated, with fused walls but with separate ostioles. 98

B97b Ascomata mostly simple, only aggregated as by chance when crowded (if difficult to decide, start with the first alternative). 112

B98a Old ascospores with red oil; Puerto Rico. *Pyrenula concastroma* R.C. Harris

B98b Old ascospores without red oil. 99

B99a Terminal locules directly against the exospore wall; Australasian (Papua New Guinea). *Pyrenula pyrenastrospora* Aptroot

B99b Terminal locules separated from the exospore wall by endospore thickening. 100

B100a Hamathecium interspersed with colourless oil globules. 101

B100b Hamathecium not interspersed. 103

B101a Ascospores 16–20 µm long. 102

B101b Ascospores 25–40 µm long; ostioles sometimes partly eccentric; pantropical. *Pyrenula minarum* Vain.

B102a Ascomata hemispherical, 0.3–0.5 mm diam.; ascospores 16–18 µm long; Brazil. *Pyrenula paraminarum* Aptroot & M. Cáceres

B102b Ascomata conical with flattened tip, 0.4–1.2 mm diam.; ascospores 17–20 µm long; Argentina. *Pyrenula inspersoleucotrypa* Aptroot, L.I. Ferraro & M. Cáceres

B103a Ascospores mostly <20 µm long. 104

B103b Ascospores mostly >21 µm long. 108

B104a Ascospores with dark bands between the locules; USA (Florida). *Pyrenula atrolaminata* R.C. Harris

B104b Ascospores without dark bands. 105

B105a Ascomata not in dense stromata but more loosely aggregated, the individual ascomata often well recognizable, conical, with distinct ostioles. 106

B105b Ascomata in dense, well delimited stromata, subglobose with indistinct, black ostioles. 107

- B106a Ascospores 11–13 x 3.5–5 µm; Brazil. *Pyrenula aggregataspistea* Aptroot & M. Cáceres
- B106b Ascospores 15–18(–22) µm long; Brazil. *Pyrenula infraleucotrypa* Aptroot & M. Cáceres
- B107a Ascospores mostly >15 µm long; ascomata in dense stromata; pantropical. *Pyrenula anomala* (Ach.) Vain.
- B107b Ascospores mostly <15 µm long; pantropical. *Pyrenula arthoniotheca* Upreti
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- B108b Ascospores mostly >25 µm long. 110
- B109a End locules elongated; Costa Rica. *Pyrenula subsoluta* (Müll. Arg.) Aptroot
- B109b All locules more or less rounded; eastern palaeotropical. *Pyrenula leucotrypa* (Nyl.) Upreti
- B110a Thallus with pseudocyphellae; neotropica. 111
- B110b Thallus without pseudocyphellae; eastern palaeotropical (Sri Lanka). *Pyrenula zeylanica* Upreti & Ajay Singh
- B111a Thallus with pseudocyphellae; Cuba. *Pyrenula wrightii* (Müll. Arg.) R.C. Harris
- B111b Thallus with pseudocyphellae, ascomata slightly fused, in groups of few ascomata which are hardly touching each other; Brazil. *Pyrenula diamantinensis* C.O. Mendonça, Aptroot & M. Cáceres
- B112a Thallus ecorticate, whitish. 113
- B112b Thallus corticate (may be difficult to observe in poor specimens; when in doubt try the first alternative first). 118
- B113a Thallus UV+yellow. 114
- B113b Thallus UV–. 115
- B114a Ascospores 18–21 µm long; pantropical. *Pyrenula cocoes* Müll. Arg.
- B114b Ascospores 14–17 µm long; Brazil. *Pyrenula xanthinspersa* Aptroot & M. Cáceres
- B115a Hamathecium inspersed; pantropical (Brazil, Philippines). *Pyrenula albohallina* Vain.
- B115b Hamathecium not inspersed. 116
- B116a Thallus white to grey, dull; ascomata <0.7 mm diam.; pantropical. *Pyrenula microcarpa* Müll. Arg.

- B116b Thallus cream to silvery or inapparent, smooth; temperate. 117
- B117a Ascospores <18 µm long; hamathecium K-negative; pycnidia present. Known from temperate regions on the northern hemisphere and reported from Chile, so probably cosmopolitan in temperate regions. *Pyrenula coryli* A. Massal.
- B117b Ascospores >18 µm long; hamathecium sometimes KOH+ blue (fleeting), pycnidia absent; temperate northern hemisphere. *Pyrenula laevigata* (Pers.) Arnold
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- B118b Old ascospores without orange oil. 120
- B119a Ascospores 25–35 µm long; pantropical. *Pyrenula bahiana* Malme
- B119b Ascospores (30–)35–51 µm long; eastern palaeotropical. *Pyrenula thailandica* Aptroot
- B120a Terminal locules all directly against the exospore wall (if anthraquinones present on thallus and/or ascomata, compare B75). 121
- B120b Terminal locules mostly (at least in mature ascospores) separated from the exospore wall by endospore thickening. 142
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- B121a Thallus UV+yellow. 122
- B121b Thallus UV-negative. 124
- B122a Hamathecium not inspersed; pantropical. *Pyrenula cocoes* Müll. Arg.
- B122b Hamathecium inspersed. 123
- B123a Thallus olivaceous with thick cortex; northern temperate. *Pyrenula pseudobufonia* (Rehm) R.C. Harris
- B123b Thallus pale grey, with thin cortex; neotropical (Guyana, Venezuela). *Pyrenula guyanensis* Sipman & Aptroot
- (*Pyrenula obvoluta* (Nyl.) R.C. Harris may be an older name, but in the lectotype the fertile warts are only 0.6–0.8 mm wide and details of hamathecium and ascospores are missing)
- B124a Hamathecium inspersed (in some cases only in the upper part). 125
- B124b Hamathecium not inspersed. 136
- B125a Ascospores with elongated end locules. 126
- B125b Ascospores with all locules more or less rounded to angular. 129

- B126a Ascospores 20–25 µm long; pantropical (compare also *Pyrenula acutalis* which is only inspersed in the upper part). *Pyrenula maravalensis* Vain.
B126b Ascospores >25 µm long. 127
- B127a Ascospores with attenuated, horn-like apices, (21–)25–29(–32) µm long; Brazil. *Pyrenula cornutispora* Aptroot & M. Cáceres
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- B128a Ascospores 26–30 µm long; Australasian (Papua New Guinea). *Pyrenula rinodinospora* Aptroot
B128b Ascospores 35–50 µm long; eastern palaeotropical (India). *Pyrenula kurzii* Ajay Singh & Upreti
- B129a Ascospores all <16 µm long; pantropical. *Pyrenula cayennensis* Müll. Arg.
B129b Ascospores partly >16 µm long. 130
- B130a Ascospores <40 µm long. 132
B130b Ascospores >40 µm long. 135
- B131a Ascospores partly >30 µm long. 132
B131b Ascospores all <30 µm long. 133
- B132a Ascospores with black granular material around the ends; Australasian (Papua New Guinea). *Pyrenula grossa* Aptroot
B132b Ascospores without black granular material; eastern palaeotropical (Borneo, Sri Lanka). *Pyrenula fulva* (Krempelh.) Müll. Arg.
- B133a Thallus with patches of orange brown colouration which are KOH+purple; known from temperate regions on the northern hemisphere and South Africa, so probably cosmopolitan. *Pyrenula occidentalis* (R.C. Harris) R.C. Harris
B133b Thallus without coloured, KOH+purple patches. 134
- B134a Hamathecium only inspersed in the upper part; neotropical. *Pyrenula acutalis* R.C. Harris
B134b Hamathecium totally inspersed; pantropical. *Pyrenula fetivica* (Krempelh.) Müll. Arg.
- B135a Ascospores 42–50 µm long, mostly straight; eastern palaeotropical (India). *Pyrenula subcamptospora* Upreti
B135b Ascospores 45–52 µm long, mostly curved; neotropical. *Pyrenula cryptostoma* (Nyl.) Müll. Arg.

B136a End locules elongated. 137

B136b All locules more-or-less rounded to angular. 139

B137a Ascospores 20–29 μm long; ascomata <0.7 mm diam. 138

B137b Ascospores 27–40 μm long; ascomata >0.7 mm diam.; pantropical. *Pyrenula vernicosa* (Krempelh.) Müll. Arg.

B138a Ascospores 20–29 μm long; ascomata 0.5–0.7 mm diam.; eastern palaeotropical. *Pyrenula finitima* Müll. Arg.

B138b Ascospores 20–29 μm long; ascomata <0.5 mm diam.; pantropical. *Pyrenula approximans* (Krempelh.) Müll. Arg.

B139a Ascomata >2 mm diam.; eastern palaeotropical (Philippines). *Pyrenula irosina* Vain.

B139b Ascomata <2 mm diam. 140

B140a Ascospores 11–13 μm long; palaeotropical (Seychelles). *Pyrenula infracongruens* Aptroot & Schumm

B140b Ascospores >13 μm long. 141

B141a Ascospores 14–16 μm long; eastern palaeotropical. *Pyrenula mastophoriza* (Nyl.) Zahlbr.

B141b Ascospores at least partly >16 μm long; pantropical. *Pyrenula nitidula* (Bres.) R.C. Harris

B142a Hamathecium inspersed. 143

B142b Hamathecium not inspersed. 162

B143a Hamathecium inspersed with coloured particles. 144

B143b Hamathecium inspersed with colourless oil globules. 146

B144a Hamathecium inspersed with orange, K-negative crystals; Sri Lanka. *Pyrenula multicolorata* Weerakoon & Aptroot

B144b Hamathecium inspersed with red or yellow oil globules. 145

B145a Hamathecium inspersed red; ascospores 13–16 μm long; Venezuela. *Pyrenula rubroinspersa* Aptroot & Sipman

B145b Hamathecium inspersed yellow; ascospores 29–35 μm long; Ecuador. *Pyrenula flavoinspersa* Aptroot & Sipman

- B146a Central ascospore locules elongated; Northern temperate. *Pyrenula subelliptica* (Tuck.) R.C. Harris
- B146b Central ascospore locules transversely lenticular to rounded. 147
- B147a Ascospores constricted at the central septum; little endospore thickening between the outer lumina and the wall; Costa Rica. *Pyrenula minae* Aptroot & Lücking
- B147b Ascospores not constricted, at most becoming constricted when postmature. 148
- B148a Ascomata mostly <0.7 mm diam. 149
- B148b Ascomata mostly >0.7 mm diam. 153
- B149a Ascospores 13–18 µm long; neotropical. *Pyrenula laetior* Müll. Arg.
- B149b Ascospores >18 µm long. 150
- B150a Ascospores about 18–25 µm long. 151
- B150b Ascospores >27 µm long. 152
- B151a Ascospores 18–20 µm long; thallus and ascomata without any anthraquinone; eastern palaeotropical (Singapore). *Pyrenula subglabrata* (Nyl.) Müll. Arg.
- B151b Ascospores 18–25 µm long; thallus and/or ascomata with patches of rusty anthraquinone; known from temperate regions on the northern hemisphere and South Africa, so probably cosmopolitan. *Pyrenula occidentalis* (R.C. Harris) R.C. Harris
- B152a Ascospores 25–31 µm long; thallus with pseudocyphellae; Brazil. *Pyrenula supralaetior* C.O. Mendonça, Aptroot & M. Cáceres
- B152b Ascospores 27–50 µm long; thallus without pseudocyphellae; eastern palaeotropical (India, Sri Lanka). *Pyrenula oculata* Ajay Singh & Upreti
- B153a Ascospores mostly 10–20 µm long. 154
- B153b Ascospores mostly >20 µm long. 156
- B154a Ascospores mostly 10–14 µm long, up to 4 µm wide; Brazil. *Pyrenula inframamillana* Aptroot & M. Cáceres
- B154b Ascospores mostly >15 µm long. 155
- B155a Ascospores mostly 14–17 µm long and about half as wide, biseriate in the ascus; pantropical. *Pyrenula castanea* (Eschw.) Müll. Arg.
- B155b Ascospores mostly 17–21 µm long and about one third as wide, uniseriate in the ascus; pantropical *Pyrenula mamillana* (Ach.) Trevis.
- B156a Ascospores <30 µm long. 157

- B156b Ascospores 30–45 µm long. 159
- B157a Ascoma chamber deeply immersed in the bark; only ostioles visible, often with red-brown pigment; Brazil. *Pyrenula celaticarpa* Aptroot & M. Cáceres
- B157b Ascomata erumpent, at least partially visible as black dots. 158
- B158a Ascospores rounded, uniseriate in the ascus; pantropical. *Pyrenula massariospora* (Starb.) R.C. Harris
- B158b Ascospores at least at one end pointed, biseriate in the ascus; neotropical. *Pyrenula acutalis* R.C. Harris
- B159a Ascomata conical, emergent. 160
- B159b Ascomata globose to hemiglobose. 161
- B160a Ascomata conical, emergent, sides spreading; eastern palaeotropical. *Pyrenula interducta* (Nyl.) Zahlbr.
- B160a Ascospores without black granular material, and with thin apical walls bulging at the spore tips; palaeotropical (Seychelles). *Pyrenula supracongruens* Aptroot & Schumm
- B161a Ascomata globose, immersed; neotropical. *Pyrenula mastophoroides* (Nyl.) Zahlbr.
- B161b Ascomata hemispherical, prominent; eastern palaeotropical. *Pyrenula ocellulata* Wijeyaratne, Lücking & Lumbsch
- B162a Thallus UV+ yellow (when material well preserved, sometimes only part of the thallus reacting). 163
- B162b Thallus UV-negative or greenish/whitish reflecting. 167
- B163a Ascospores mostly >24 µm long. 164
- B163b Ascospores mostly <24 µm long. 165
- B164a Ascospores 25–40 µm long, without black granules; Costa Rica (also reported from China). *Pyrenula andina* Aptroot
- B164b Ascospores 36–45 µm long, with black granules at the tips; temperate America. *Pyrenula caryae* R.C. Harris
- B165a Thallus brownish with thick cortex; ascomata not in distinct thallus warts. 166
- B165b Thallus whitish with thin cortex; ascomata immersed in distinct thallus warts; ascospores 15–22 µm long, ellipsoidal, not pointed; neotropical. *Pyrenula micromma* (Mont.) Trevis.

(*Pyrenula obvoluta* (Nyl.) R.C. Harris & Aptroot is most probably a separate species, characterized by not-pointed ascospores)

B166a Ascospores 9–11 µm long, ellipsoid; pantropical (Australia, Guyana). *Pyrenula xanthominuta* Aptroot

B166b Ascospores 14–21 µm long, fusiform, pointed; cosmopolitan. *Pyrenula dermatodes* (Borrer) Schaer.

(somewhat variable, especially in UV-reaction, but always with pointed ascospores and thallus at least partly covering the ascomata. *Pyrenula shirabeicola* Kurok. & S. Nakan. is probably a further synonym. The oldest name found for specimens that are not reacting with UV is *Pyrenula subtrahens* (Nyl.) Müll. Arg.)

B167a Ascospores mostly >25 µm long. 168

B167b Ascospores mostly <25 µm long. 181

B168a Ascospores 36–45 µm long, with or without black granules at the tips. 169

B168b Ascospores <40 µm long, without black granules at the tips. 170

B169a Ascospores 36–45 µm long, with black granules at the tips; temperate America. *Pyrenula caryae* R.C. Harris

B169b Ascospores 36–45 µm long, without black granules at the tips; pantropical. *Pyrenula subducta* (Nyl.) Müll. Arg.

B170a End locules elongated, ascospores 24–29 µm long; Virgin Islands. *Pyrenula expectata* R.C. Harris

B170b End locules not elongated. 171

B171a Growing on rock, ascospores with dark bands between the locules, 25–30 µm long; Brazil. *Pyrenula quarzitica* Aptroot

B171b Growing on bark, ascospores without dark bands. 172

B172a Ascomata mostly >0.7 mm diam. 173

B172b Ascomata mostly <0.7 mm diam. 176

(*Pyrenula lilacina* with lilac-colored thallus keys out here when the pigment is not observed)

B173a Thallus with pseudocyphellae; temperate regions of the old world. *Pyrenula macrospora* (Degel.) Coppins & P. James

B173b Thallus without pseudocyphellae. 174

- B174a Ascospores 27–32 µm long, when mature dark brown and constricted at the central septum instead of pale grey brown and constricted at the locules; Guyana. *Pyrenula minoides* Aptroot & Sipman
- B174b Ascospores pale greybrown and constricted at the locules. 175
- B175a Ascospores 24–29 µm long, thallus thick; eastern palaeotropical (Papua New Guinea, Juan Fernandez). *Pyrenula media* Aptroot
- B175b Ascospores 29–40 µm long, thallus thin; eastern palaeotropical. *Pyrenula complanata* (Mont.) Trevis.
- B176a Ascospores with diamond-shaped locules; temperate regions on both hemispheres. *Pyrenula chlorospila* (Nyl.) Arnold
- B176b Ascospores with somewhat rounded or quadrangular locules. 177
- B177a Ascospores with dark granules between the locules; temperate America and Japan. *Pyrenula macounii* R.C. Harris
- B177b Ascospores without dark bands. 178
- B178a Ascospores 32–42 µm long; temperate America and Japan. *Pyrenula punctella* (Nyl.) Trevis.
- B178b Ascospores mostly 25–37 µm long; tropical. 179
- B179a Central locules of ascospores much longer than wide; ascomata superficial, hemispherical; Guyana. *Pyrenula perfecta* Aptroot & Sipman
- B179b Central locules of ascospores not longer than wide. 180
- B180a Central locules much wider than long, ascomata conical, emergent, thallus without pseudocyphellae; pantropical. *Pyrenula mastophora* (Nyl.) Müll. Arg.
- B180b Central locules more-or-less rounded; ascomata somewhat rounded, often partly immersed in the thallus; thallus often with (generally sparse) pseudocyphellae; pantropical. *Pyrenula quassiicola* (Fée) Fée
- B181a Ascospores mostly 21–25 µm long. 182
- B181b Ascospores mostly <21 µm long. 189
- B182a Ascomata c. 3–4 mm diam.; Japan. *Pyrenula gigas* Zahlbr.
- B182b Ascomata <3 mm diam. 183
- B183a Ascomata with red, KOH+purple crystals inside. 184
- B183b Ascomata without red crystals. 185

- B184a Ascomata <0.5 mm diam.; temperate regions of Europe and Asia. *Pyrenula nitidella* (Flörke ex Schaer.) Müll. Arg.
- B184b Ascomata >0.5 mm diam.; temperate regions of Europe and Asia. *Pyrenula nitida* (Weigel) Ach.
- B185a Ascospores with angular diamond-shaped locules; temperate North and South America. *Pyrenula micheneri* R.C. Harris
- B185b Ascospores with rounded or quadrangular locules. 186
- B186a Ascospores with bands of dark granules between the locules, without much endospore thickening between the outer lumina and the wall; pantropical. *Pyrenula pyrgillospora* Aptroot
- B186b Ascospores without bands of dark granules. 187
- B187a Thallus with dense pseudocyphellae; postmature ascospores longitudinally plicate; Chile. *Pyrenula maritima* Sipman & Aptroot
- B187b Thallus without pseudocyphellae; ascospores not regularly plicate when postmature. 188
- B188a Ascospores with at least one pointed end; temperate northern hemisphere, extending to the tropics. *Pyrenula acutispora* Kalb & Hafellner
- B188b Ascospores with rounded ends; eastern palaeotropical (India). *Pyrenula submastophora* Ajay Singh & Upreti
- B189a Ascospores 7–10 µm long; Iran. *Pyrenula minutissima* Aptroot, Valadbeigi & Sipman
- B189b Ascospores >10 µm long. 190
- B190a Ascospores mostly <15 µm long. 191
- B190b Ascospores mostly >15 µm long. 195
- B191a Ascomata >0.7 mm diam.; pantropical. *Pyrenula atropurpurea* (Eschw.) Müll. Arg.
- B191b Ascomata <0.7 mm diam. 192
- B192a Ascospores 6–8 µm wide; pantropical. *Pyrenula brunnea* Fée
- B192b Ascospores 3–6 µm wide. 193
- B193a Ascospores 3.5–4.0 µm wide, rhomboidal; Brazil. *Pyrenula rhomboidea* Aptroot & M. Cáceres
- B193b Ascospores 4–6 µm wide. 194

- B194a Ascospores 4–6 µm wide; pantropical. *Pyrenula aspistea* (Ach.) Ach.
B194b Ascospores 5–6 µm wide; like *P. aspistea* but with immersed ascomata; Brazil. *Pyrenula minutispora* Aptroot & M. Cáceres
- B195a Thallus at least partly 0.3 mm thick. 196
B195b Thallus thinner. 197
- B196a Ascospores at least partly constricted at the septa; Australasian (Papua New Guinea). *Pyrenula montana* Aptroot
B196b Ascospores not constricted; neotropical (Puerto Rico, Brazil). *Pyrenula psoriformis* Zahlbr.
- B197a Ascomata >0.7 mm diam. 198
B197b Ascomata <0.7 mm diam. 201
- B198a Thallus with pseudocyphellae; New Zealand. *Pyrenula deliquescentis* (C. Knight) Müll. Arg.
B198b Thallus without pseudocyphellae. 199
- B199a Ascospores pale reddish brown instead of pale grey-brown; Brazil. *Pyrenula mattickiana* Sipman & Aptroot
B199b Ascospores pale grey-brown. 200
- B200a Locules rounded; eastern palaeotropical (India). *Pyrenula scutata* (Stirt.) Zahlbr.
B200b Locules angular; pantropical. *Pyrenula balia* (Krempelh.) R.C. Harris
- B201a Ascospores with distinct inner endospore layer around locules; neotropical (Florida, Louisiana). *Pyrenula rubrostoma* R.C. Harris
B201b Ascospores without extra endospore layers. 202
- B202a Ascospores with dark bands between the locules; North America and Asia. *Pyrenula confoederata* R.C. Harris
B202b Ascospores without dark bands. 203
- B203a Ascomata <0.4 mm diam.. 204
B203b Ascomata reaching >0.4 mm diam.; pantropical (UV-negative material of *Pyrenula dermatodes* keys out here as well; The oldest name found for such specimens that are not reacting with UV is *Pyrenula subtrahens* (Nyl.) Müll. Arg.). *Pyrenula aggregata* (Fée) Fée
- B204a Thallus pale grey, with thin cortex and filled with crystals, not oily or olivaceous; Brazil. *Pyrenula albonigra* Aptroot, D.S. Andrade & M. Cáceres

B204b Thallus olivaceous, oily. 205

B205a Ascospores 18–20 µm long; palaeotropical. *Pyrenula tristissima* Vain.

B205b Ascospores <18 µm long; neotropical. *Pyrenula minor* Fée

Key C. Pyrenocarpous lichens with simple paraphyses and septate, hyaline, distoseptate ascospores

(*Celothelium*, *Lithothelium*; temperate *Celothelium* species are not keyed out as they are dubious; all saxicolous *Lithothelium* species are keyed out here as well to make the treatment of all Pyrenulaceae complete, even if some of them have have brown ascospores)

C1a Ascospores filiform. *Celothelium*. 2

C1b Ascospores ellipsoid to fusiform. *Lithothelium*. 7

C2a Ascomata sideways fused. 3

C2b Ascomata solitary or with joined ostioles. 4

C3a Ascomata sideways grouped in dense, often linear, clusters; neotropical. *Celothelium cinchonarum* (Vain.) Vain.

C3b Ascomata in small groups; temperate. *Celothelium ischnobelum* (Nyl.) M.B. Aguirre

C4a Ostiole lateral to eccentric, fused or not. 5

C4b Ostiole apical, ascomata solitary. 6

C5a Ascomata less than 0.5 mm wide; neotropical. *Celothelium aciculiferum* (Nyl.) Vain.

C5b Ascomata over 0.5 mm wide; Korea. *Celothelium longisporum* K.H. Moon & Aptroot

(here also keys out from India: *Lithothelium filisporum* (Patw., Makhija & D. Rane) Kr.P. Singh & G.P. Sinha, which could well be a *Celothelium*)

C6a Without yellow pigment; neotropical. *Celothelium dominicanum* (Müll. Arg.) Aguirre

C6b With yellow pigmentation; Bermuda. *Celothelium lutescens* F. Berger & Aptroot

C7a Ascospores colourless. 8

C7b Ascospores red-brown to brown; on rock (species on bark are in keys A and B). 25

C8a Thallus on bark; ascospores 3-septate. 9

C8b Thallus on rock. 21

- C9a Ascospores 4/ascus; Thailand. *Lithothelium quadrisporum* Aptroot
C9b Ascospores mostly 8/ascus. 10
- C10a Ascomata with fused ostioles only or with fused ostioles and fused walls. 11
C10b Ascomata solitary. 14
- C11a Ascomata with fused ostioles only; thallus epiphloeodic, brownish to green; ascospores $12-15(-18) \times 4-6 \mu\text{m}$; pantropical. *Lithothelium obtectum* (Müll. Arg.) Aptroot
C11b Ascomata with fused ostioles and fused walls. 12
- C12a Thallus endophloeodic, brownish to grey; ascospores $18-23 \times (6-)7-10 \mu\text{m}$; pantropical. *Lithothelium illotum* (Vain.) Aptroot
C12b Thallus epiphloeodic, brownish to green. 13
- C13a Ascospores $18-23 \times (6-)8-11 \mu\text{m}$; neotropical. *Lithothelium paraguayense* Müll. Arg.
C13b Ascospores $16-18 \times 7-8 \mu\text{m}$; neotropical. *Lithothelium fugax* (Müll. Arg.) Aptroot
- C14a Thallus epiphloeodic, brownish green to greenish. 15
C14b Thallus endophloeodic, whitish to brownish grey. 17
- C15a Ascospores $10-12 \times 4-4.5 \mu\text{m}$; Florida. *Lithothelium microsporum* R.C. Harris
C15b Ascospores larger. 16
- C16a Ascospores $16-19 \times 5.5-6.5 \mu\text{m}$; South Africa. *Lithothelium almbornii* Aptroot
C16b Ascospores $27-37 \times 12-17 \mu\text{m}$; pantropical (Brazil, China). *Lithothelium grossum* Aptroot
- C17a Hymenium inspersed with oil droplets; ascospores $(9-)10-14(-17) \times (3-)4-5 \mu\text{m}$; Japan. *Lithothelium japonicum* H. Harada
C17b Hymenium not inspersed. 18
- C18a Terminal lumina much smaller than the central lumina. 19
C18b Terminal lumina only slightly smaller than the central lumina. 20
- C19a Ascospores $14-20(-24) \times 6-8(-12) \mu\text{m}$; pantropical. *Lithothelium hyalosporum* (Nyl.) Aptroot
C19b Ascospores $18-31 \times 10-20 \mu\text{m}$; Australia. *Lithothelium quiescens* P.M. McCarthy
- C20a Paraphyses simple; ascospores $18-23 \times (6-)7-10 \mu\text{m}$; pantropical. *Lithothelium illotum* (Vain.) Aptroot

- C20b Paraphyses branched and anastomosing; ascospores $17\text{--}25 \times 8.5\text{--}12 \mu\text{m}$; India. *Lithothelium insulare* Makhija & Adaw.
- C21a Ascospores 4–8-septate, $20\text{--}25(\text{--}30) \times 3\text{--}5.5(\text{--}6) \mu\text{m}$; Bahamas. *Lithothelium bahamense* Riddle
- C21b Ascospores 3-septate. 22
- C22a Ascomata with fused ostioles and fused walls; thallus endolithic. 23
- C22b Ascomata solitary; thallus at least partly epilithic. 24
- C23a Thallus violet-grey; hamathecium IKI+ blue to orange; asci with rounded ocular chamber; ascospores $13\text{--}17(\text{--}20) \times 3.5\text{--}5(\text{--}6) \mu\text{m}$; neotropical. *Lithothelium cubanum* Müll. Arg.
- C23b Thallus greenish grey; hamathecium IKI negative; asci with sagittiform ocular chamber; ascospores $16\text{--}19 \times 5\text{--}7 \mu\text{m}$; Falklands. *Lithothelium falklandicum* (Nyl.) Aptroot
- C24a Ostioles apical; asci without ocular chamber; ascospores $17\text{--}20 \times 6\text{--}8 \mu\text{m}$; Eurasian temperate. *Lithothelium triseptatum* (Nyl.) Aptroot
- C24b Ostioles lateral; asci with rounded ocular chamber; ascospores $15\text{--}18 \times 6\text{--}7 \mu\text{m}$; Hawaii. *Lithothelium hawaiiense* Aptroot
- C25a Ascospores ornamented with spines, $14\text{--}19 \times 6\text{--}7.5 \mu\text{m}$; China. *Lithothelium echinatum* Aptroot
- C25b Ascospores smooth. 26
- C26a Thallus epilithic, rimose to areolate; ascospores $18\text{--}28 \times 8\text{--}14 \mu\text{m}$; Australia. *Lithothelium austropacificum* P.M. McCarthy
- C26b Thallus endolithic; ascospores $20\text{--}26 \times 6\text{--}8 \mu\text{m}$. 27
- C27a Ascospore lumina all rounded: New Zealand. *Lithothelium australe* Aptroot & H. Mayrhofer
- C27b Ascospore lumina partly diamond-shaped and connected; Bermuda. *Lithothelium bermudense* F. Berger, LaGreca & Aptroot

Key D. Tropical pyrenocarpous lichens with simple paraphyses and 1-septate, distoseptate, brown ascospores (mostly Pyrenulaceae: *Clypeopyrenis*, *Distopyrenis*, *Granulopyrenis*, *Parapyrenis*)

(all are rare or rarely collected and rarely studied; at least the sequenced *Granulopyrenis* is basal in or sister to the Pyrenulaceae)

D1a ascomata conical, distinctly flattened, superficial, 0.6–1.2 mm diam.; ostioles apical, black, obconical; ascospores brown, biloculate, $6-8 \times 2-2.5 \mu\text{m}$, ellipsoidal; neotropical. *Clypeopyrenis microsperma* (Müll. Arg.) Aptroot

D1b Ascospores larger. 2

D2a Ascospores with double wall, with a layer of conspicuous granules inside.

Granulopyrenis. 3

D2b Ascospores without internal granules. 7

D3a Ascomata grouped under a stroma; Brazil. *Granulopyrenis nigrescens* (Müll. Arg.) R.C. Harris

D3b Ascomata single. 4

D4a Thallus not blackened around the ascocarps; ostiole apical, asci with rounded ocular chamber; South Africa. *Granulopyrenis macrocarpoides* (Zahlbr.) Aptroot

D4b Thallus blackened around the ascocarps. 5

D5a Ostiole lateral; asci with rounded ocular chamber; on bark; on driftwood; USA.

Granulopyrenis hymnothora Aptroot

D5b Ostiole apical to eccentric; asci without ocular chamber. 6

D6a Ostiole partly eccentric; Caribbean. *Granulopyrenis portoricensis* (Petrak) Y. Z. Wang, Aptroot & K. D. Hyde

D6b Ostiole apical; Hong Kong. *Granulopyrenis seawardii* Aptroot & Sipman

D7a Thallus lichenicolous; Papua New Guinea. *Parapyrenis lichenicola* Aptroot & Diederich

D7b Thallus not lichenicolous. 8

D8a Thallus on driftwood; Papua New Guinea. *Parapyrenis maritima* Aptroot

D8b Thallus on bark. 9

D9a Ascomata grouped under a stroma; neotropical (Brazil, Puerto Rico). *Distopyrenis composita* R.C. Harris

D9b Ascomata single. 10

D10a Thallus with violet tinge; Australia. *Distopyrenis violacea* Aptroot

D10b Thallus brownish or whitish. 11

- D11a Ascospores with elongated lumina. 12
D11b Ascospores with rounded or angular lumina. 13
- D12a hamathecium IKI + blue; ascocarps flattened, simple or aggregated; Bermuda.
Parapyrenis elongata Aptroot
D12b hamathecium IKI negative; ascocarps not flattened, simple; neotropical.
Parapyrenis guayaca (Fée) Aptroot
- D13a Ascospores with an euseptum within the septum. 14
D13b Ascospores only distoseptate with relatively small lumina. 15
- D14a Lumina angular; thallus whitish grey to invisible, not blackened around the
ascocarps; USA and Caribbean. *Distopyrenis americana* Aptroot
D14b Lumina rather rounded; thallus pinkish grey, blackened around the ascocarps;
Mexico and Caribbean. *Distopyrenis fuliginosa* Aptroot
- D15a Ascospores with large, rounded lumina; Australia. *Parapyrenis conica* Aptroot
D15b Ascospores with angular lumina, with much thickened endosporium formation,
thus lumina relatively small. 16
- D16a Ascomata flattened; Java. *Parapyrenis aurora* (Zahlbr.) Aptroot
D16b Ascomata conical; French Guiana. *Distopyrenis pachyspora* Aptroot

**Key E. Pyrenocarpous lichens with mazaedioid ascomata (Pyrenulaceae:
Mazaediothecium, *Pyrgillus*)**

- E1a Ascoma wall not carbonized; ascospores amassing in the large ostioles of the cup-
like ascomata, either 1-septate or cruciate submuriform. *Mazaediothecium*. 2
E1b Ascoma wall carbonized; ascospores amassing in a cup-like structure on top of the
closed ascomata, transversely 1-3-septate. *Pyrgillus*. 6
- E2a Ascomata red; Papua New Guinea. *Mazaediothecium rubiginosum* Aptroot
E2b Ascomata black. 3
- E3a Ascospores 1-septate. 4
E3b Ascospores cruciate submuriform. 5
- E4a Thallus corticate; photobiont trebouxoid; Brazil. *Mazaediothecium serendipiticum*
Aptroot

E4b Thallus not corticate; photobiont trentepohlioid; French Guiana. *Mazaediothecium uniseptatum* Aptroot

E5a Thallus UV+ yellow; neotropical. *Mazaediothecium album* Aptroot

E5b Thallus UV-negative; Malaysia. *Mazaediothecium mohamedii* H. Harada & Yoshik. Yamam.

E6a Ascospores 1-septate. 7

E6b Ascospores 3-septate. 9

E7a Mazaedium pruina golden-yellow; pantropical. *Pyrgillus indicus* (Kremp.) Aptroot

E7b Mazaedium pruina white. 8

E8a Ascospores with pale ends, red brown; Australia. *Pyrgillus fuscus* Aptroot

E8b Ascospores with dark ends, brown; pantropical. *Pyrgillus cubanus* Nyl.

E9a Thallus UV–; mazaedium pruina orange, KOH+ purple; ascospores $10\text{--}14 \times 5\text{--}7$ μm ; Cambodia and China. *Pyrgillus cambodiensis* Kashiw., K.H. Moon & Aptroot

E9b Thallus UV+ yellow, with lichexanthone. 10

E10a Mazaedium pruina white, KOH–; ascospores $10\text{--}13 \times 6.0\text{--}8.5$ μm ; pantropical. *Pyrgillus javanicus* (Mont. & Bosch) Nyl.

E10b Mazaedium pruina orange or red, KOH+ orange, reddish violet or violet. 11

E11a Mazaedium pruina red, KOH+ reddish violet, UV–; ascospores $15\text{--}20(\text{--}23) \times 7.5\text{--}10.0$ μm ; India. *Pyrgillus tibellii* Kr. P. Singh & Pushpi Singh

E11b Mazaedium pruina red but KOH+ violet or orange, UV+ red; ascospores $13.0\text{--}17.5 \times 5.0\text{--}7.5$ μm . 12

E12a Mazaedium pruina orange, KOH+ violet; ascospores $13\text{--}16 \times 6.0\text{--}7.5$ μm , c. 2 times as long as wide; Brazil. *Pyrgillus aurantiacus* Aptroot & M. Cáceres

E12b Mazaedium pruina red, KOH+ orange; ascospores $15.0\text{--}17.5 \times 5.0\text{--}6.5$ μm , c. 2.5–3 times as long as wide; Brazil. *Pyrgillus rufus* Aptroot & M. Cáceres

Key F. *Aptrootia* species

F1a Thallus on bark, corticate, green, bullate; ascospores ornamented; Eastern palaeotropical. *Aptrootia elatior* (Stirt.) Aptroot

F1b Thallus on soil and bryophytes, not corticate, grey, cartilaginous, smooth; ascospores smooth. 2

F2a Ascospores $170\text{--}230 \times 40\text{--}70 \mu\text{m}$; amphipacific (Costa Rica, Papua New Guinea, Solomon Islands). *Aptrootia terricola* (Aptroot) Lücking, L. Umaña & Chaves

F2b Ascospores $150\text{--}360(\text{--}400) \times 65\text{--}140 \mu\text{m}$; Australia. *Aptrootia robusta* (P.M. McCarthy & Kantvilas) Aptroot

Key G. *Architrypethelium* species with transversely septate ascospores

G1a Ascospores remaining hyaline 2

G1b Ascospores soon becoming brown 5

G2a Ascomata sessile, very large (up to 3 mm diam.); Brazil. *Architrypethelium grande* (Kremp.) Aptroot & Lücking

G2b Ascomata immersed or in erumpent prominent thallus warts, smaller (usually not exceeding 1 mm diam.). 3

G3a Ascomata completely immersed between bullate thallus warts; Brazil. *Architrypethelium lauropaluanum* Lücking, M.P. Nelsen & Marcelli

G3b Ascomata erumpent to prominent, partly thallus-covered. 4

G4a Thallus UV+ yellow; neotropical. *Architrypethelium hyalinum* Aptroot

G4b Thallus UV–; Bolivia. *Architrypethelium penuriixanthum* Flakus & Aptroot

G5a Ostiole eccentric; ascomata sometimes with fused ostioles; neotropical. *Architrypethelium nitens* (Fée) Aptroot

G5b Ostiole apical; ascomata solitary. 6

G6a Hamathecium inspersed; Colombia. *Architrypethelium columbianum* (Nyl.) Aptroot & Lücking

G6b Hamathecium clear; pantropical. *Architrypethelium uberinum* (Fée) Aptroot

Key H. *Astrothelium* species with ascospores transversely septate, ostiole apical, secondary substances present on thallus and/or ascoma

H1a Lichexanthone present; thallus and/or ascomata UV+ yellow; pigment(s) present or absent. 2

- H1b Lichexanthone absent; pigment(s) always present, thallus and ascomata usually K+ red to purple and UV+ orange or red. 21
- H2a Pigments present in thallus and/or ascomata; lichexanthone on thallus; ascomata pseudostromatic, in irregular black lines. 3
- H2b Pigments absent; lichexanthone on thallus and/or ascomata; ascomata variable. 4
- H3a Ascospores 3-septate, small (18–26 µm long); ascomata with external orange pigment, scattered laterally along pseudostromata; neotropical. *Astrothelium neogalbineum* (R.C. Harris) Aptroot & Lücking
- H3b Ascospores (3–)5-septate, large (90–115 µm long); ascomata with external purplish-red pigment, scattered laterally along pseudostromata; Brazil. *Astrothelium pictum* Aptroot
- H4c Ascospores 9–11-septate; Brazil. *Astrothelium pseudodermatodes* Aptroot
- H4a Ascospores 3–9-septate. 5
- H5a Ascospores 5–9-septate. 6
- H5b Ascospores 3-septate. 7
- H6a Lichexanthone on ascomata; ascomata solitary to irregularly confluent, erumpent, covered by thallus; eastern palaeotropical. *Astrothelium cinereorosellum* (Kremp.) Aptroot & Lücking
- H6b Lichexanthone on pseudostromata; ascomata distinctly pseudostromatic; Fiji. *Astrothelium fijiense* Lücking, Naksuwankul & Lumbsch
- H7a Hamathecium inspersed; ascospores small (15–30 µm long). 8
- H7b Hamathecium clear; ascospores small to medium-sized (15–70 µm long). 12
- H8a Lichexanthone on ascomata only, absent from thallus; ascomata solitary to irregularly confluent, largely immersed and covered by thallus; Brazil. *Astrothelium punctulatum* Malme
- H8b Lichexanthone on thallus and ascomata or on thallus only. 9
- H9a Lichexanthone on thallus only, absent from ascomata; ascomata solitary but dense; thallus gall-like; eastern palaeotropical. *Astrothelium grossoides* Aptroot & Lücking
- H9b Lichexanthone on thallus and ascomata; thallus not gall-like. 10
- H10a Ascomata pseudostromatic, immersed in prominent pseudostromata that are often partly covered by thallus; pantropical. *Astrothelium porosum* (Ach.) Aptroot & Lücking

- H10b Ascomata solitary, erumpent, whitish. 11
- H11a Ascospores 20–25 µm long; neotropical. *Astrothelium vulcanum* Aptroot
- H11b Ascospores 14–17 µm long; Brazil. *Astrothelium infravulcanum* Aptroot
- H12a Ascospores small (15–30 µm long). 13
- H12b Ascospores (small to) medium-sized (25–70 µm long). 18
- H13a Lichexanthone only on ascomata or ostiole. 14
- H13b Lichexanthone on thallus and ascomata. 15
- H14a Lichexanthone on ascomata only, absent from thallus; ascomata pseudostromatic, immersed in prominent pseudostromata covered by thallus; neotropical (Brazil and Bolivia). *Astrothelium stromatofluorescens* Aptroot & M. Cáceres
- H14b Lichexanthone only on ostioles; pseudostromata sessile, brownish; Brazil. *Astrothelium gyalostiolum* Aptroot
- H15a Ascomata solitary to irregularly confluent, erumpent, covered by thallus; pantropical. *Astrothelium pulcherrimum* (Fée) Aptroot & Lücking
- H15b Ascomata pseudostromatic, immersed in pseudostromata that are often partly covered by thallus. 16
- H16a Pseudostromata well-delimited, with whitish cover, prominent to sessile; neotropical. *Astrothelium leucosessile* Lücking, M.P. Nelsen & Aptroot
- H16b Pseudostromata not well-delimited, covered by thallus, erumpent to prominent; pantropical. 17
- H17a Hamathecium clear, and pseudostromata UV+ yellow. *Astrothelium phlyctaena* (Fée) Aptroot & Lücking
- H17b Hamathecium interspersed with oil droplets, and pseudostromata UV-. *Astrothelium luminothallinum* C. Zhang & S.H. Jiang
- H18a Ascospores under 40 µm long. 19
- H18b Ascospores over 45 µm long. 20
- H19a Ascospores 25–40 × 8–13 µm; thallus and thalline cover of ascomata UV+ yellow; pantropical. *Astrothelium pupula* (Ach.) Aptroot & Lücking
- H19b Ascospores 34–38 × 8.5–10.5 µm; only pseudocyphellae UV+ yellow; Brazil. *Astrothelium xanthopseudocyphellatum* Aptroot

- H20a Ascospores $60\text{--}70 \times 16\text{--}18 \mu\text{m}$; El Salvador. *Astrothelium megochroleucum* Aptroot
- H20b Ascospores $45\text{--}60 \times 19.5\text{--}22.5 \mu\text{m}$; Brazil. *Astrothelium miniannulare* Kalb & Aptroot
- H21a Ascospores 3-septate. 22
- H21b Ascospores 5–19-septate. 45
- H22a Ascospores medium-sized ($50\text{--}65 \mu\text{m}$ long); medulla (ascomata) with internal, redpigment; ascomata solitary to irregularly confluent, erumpent, covered by thallus; neotropical. *Astrothelium thelotremoides* (Nyl.) Aptroot & Lücking
- H22b Ascospores small to medium-sized ($15\text{--}50 \mu\text{m}$ long); pigment external or internal, yellow to red. 23
- H23a Hamathecium inspersed. 24
- H23b Hamathecium clear. 29
- H24a Hamathecium with red, K+ green pigment; Sri Lanka. *Astrothelium isohypocrellinum* Aptroot & Weerakoon
- H24b Hamathecium hyaline. 25
- H25a Ascomata with external, yellow to orange pigment mostly developed around the ostiolar area; ascomata solitary to irregularly confluent, erumpent, covered by thallus except for black ostiolar area. 26
- H25b Medulla (ascomata) with internal, red pigment; ascomata variable. 28
- H26a Ascomata with yellow pigment; ascomata diffusely pseudostromatic, pseudostromata forming irregular lines; El Salvador. *Astrothelium neoinspersum* Aptroot
- H26b Thallus and/or ascomata with orange pigment; ascomata solitary to irregularly confluent. 27
- H27a Both thallus and ascomata with abundant orange pigment; pantropical. *Astrothelium inspersaeneum* Aptroot & M. Cáceres
- H27b Only ascomata with sparse orange pigment; pantropical (Colombia and Papua New Guinea). *Astrothelium aenascens* Aptroot
- H28a Ascospores $20\text{--}30 \times 7\text{--}9 \mu\text{m}$; Brazil. *Astrothelium rubrocrystallinum* Aptroot & M. Cáceres
- H28b Ascospores $30\text{--}50 \times 14\text{--}16 \mu\text{m}$; neotropical. *Astrothelium buckii* (R.C. Harris) Aptroot & Lücking

- H29a Thallus and/or ascomata with external pigment(s). 30
H29b Medulla (ascomata) with internal pigment(s). 40
- H30a Ascomata with external, red pigment(s); Mexico. *Astrothelium coccineum* Córd.-Cháv., Aptroot & M. Cáceres
H30b Ascomata with external, yellow to orange pigment(s). 31
- H31a Thallus grey, barely lichenized; ascomata distinctly pseudostromatic, pseudostromata prominent to sessile, with orange cover strongly contrasting with thallus; Thailand. *Astrothelium aurantiacocinereum* Lücking, Naksuwankul & Lumbsch
H31b Thallus olive-green, distinctly lichenized; ascomata solitary or pseudostromatic, if pseudostromatic, then pseudostromata immersed to erumpent and in irregular, often reticulate lines. 32
- H32a Ascospores very small (16–18 µm long); ascomata pseudostromatic, immersed, pseudostromata in irregular, often reticulate lines, covered with pigment and contrasting with olive-green thallus; Brazil. *Astrothelium flavum* Aptroot & M. Cáceres
H32b Ascospores small (20–35 µm long). 33
- H33a Ascospores 20–25(–27) × 6–10 µm; ascomata solitary or pseudostromatic. 34
H33b Ascospores 25–35 × 10–12 µm; ascomata solitary to irregularly confluent, erumpent, covered by thallus. 38
- H34a Ascomata solitary to irregularly confluent; pigment on thallus and ascomata. 35
H34b Ascomata pseudostromatic, pseudostromata in irregular lines, covered with pigment and contrasting with olive-green thallus. 37
- H35a Thallus resembling bubbles of wax plus prothallus; Venezuela. *Astrothelium bullatothallinum* Aptroot & Sipman
H35b Thallus smooth. 36
- H36a Pigment orange to yellow; pantropical. *Astrothelium aeneum* (Eschw.) Aptroot & Lücking
H36b Pigment ochraceous; Brazil. *Astrothelium ochraceum* Aptroot
- H37a Thallus strongly bullate; Brazil. *Astrothelium flavostromatum* Aptroot & M. Cáceres
H37b Thallus smooth to uneven; neotropical. *Astrothelium kunzei* (Fée) Aptroot & Lücking

- H38a Pigment orange, abundant; neotropical (Brazil & Bolivia). *Astrothelium megaeneum* Flakus & Aptroot
H38b Pigment yellow, sparse. 39
- H39a Ostioles partly lateral and fused; pigment K+ purple; Bolivia. *Astrothelium pallidoflavum* Flakus & Aptroot
H39b Ostioles consistently apical; pigment K+ red; neotropical. *Astrothelium subcatervarium* (Malme) Aptroot & Lücking
- H40a Ascospores medium-sized ($30\text{--}50 \times 10\text{--}16\ \mu\text{m}$). 41
H40b Ascospores small ($15\text{--}30 \times 5\text{--}9\ \mu\text{m}$). 43
- H41a Medullary pigment red; neotropical. *Astrothelium cartilagineum* (Fée) Aptroot & Lücking
H41b Medullary pigment yellow. 42
- H42a Thallus bullate; Brazil. *Astrothelium endochryseum* (Vain.) Aptroot & Lücking
H42b Thallus smooth; Brazil. *Astrothelium laevithallinum* Lücking, M.P. Nelsen & Marcelli
- H43a Ascomata solitary to irregularly confluent, erumpent, covered by thallus; medullary pigment orange; Brazil. *Astrothelium aeneoides* Aptroot
H43b Ascomata pseudostromatic; pseudostromata blackish brown; medullary pigment (pale) yellow. 44
- H44a Medullary pigment K+ red; pantropical. *Astrothelium degenerans* (Vain.) Aptroot & Lücking
H44b Medullary pigment K-. 16; neotropical. *Astrothelium feei* (C.F.W. Meissn.) Aptroot & Lücking
- H45a Ascospores small to medium-sized ($15\text{--}45 \times 6\text{--}9\ \mu\text{m}$). 46
H45b Ascospores medium-sized to large ($50\text{--}150 \times 10\text{--}40\ \mu\text{m}$). 48
- H46a Medulla (ascomata) with internal, red pigment; ascospores 9–13-septate; ascomata pseudostromatic, exposed, forming irregular, reticulate lines or groups; India. *Astrothelium nigrorufum* (Makhija & Patw.) Aptroot & Lücking
H46b Medulla (ascomata) with internal, yellow to orange pigment; ascospores 5–9-septate. 47
- H47a Hamathecium inspersed; medullary pigment K+ red; ascomata pseudostromatic, pseudostromata erumpent to prominent, whitish; Papua New Guinea. *Astrothelium pseudodissimulium* Aptroot

- H47b Hamathecium clear; medullary pigment K+ purple; ascomata pseudostromatic, exposed, forming irregular, reticulate lines or groups; India. *Astrothelium dissimilum* (Makhija & Patw.) Aptroot & Lücking
- H48a Ascospores medium-sized (50–90 µm long). 49
- H48b Ascospores large (110–150 µm long). 50
- H49a Ascomata with scattered, external, pink pigment, solitary to irregularly confluent, immersed in large thallus verrucae; hamathecium inspersed; ascospores 50–65 × 10–17 µm; Brazil. *Astrothelium decemseptatum* Aptroot & M. Cáceres
- H49b Medulla (ascomata) with internal, yellow pigment; ascomata pseudostromatic, pseudostromata prominent, covered by thallus except black ostiolar areas; hamathecium clear; ascospores 55–90 × 13–28 µm; East Asia *Astrothelium luridum* (Zahlbr.) Aptroot & Lücking
- H50a Ascomata with scattered, external, pink pigment, solitary, immersed; ascospores 17–22 µm broad, 13–19-septate; Caribbean. *Astrothelium calosporum* (Müll. Arg.) Aptroot & Lücking
- H50b Ascomata with external and internal yellow pigment; ascospores 30–37 µm broad, 7–11-septate; neotropical. *Astrothelium rimosum* Aptroot

Key I. *Astrothelium* species with ascospores transversely septate, ostiole apical, secondary substances absent

- I1a Ascospores 3-septate. 2
- I1b Ascospores (3–)5–15-septate. 28
- I2a Ascospores small to medium-sized (15–45(–50) × 6–16 µm). 3
- I2b Ascospores medium-sized to large ((45–)50–120 × 15–35 µm). 22
- I3a Hamathecium inspersed. 4
- I3b Hamathecium clear. 7
- I4a Ascospores (25–)30–40 µm long; ascomata in irregular groups to pseudostromatic, pseudostromata erumpent, white, contrasting with olive-green thallus; pantropical. *Astrothelium perspersum* Aptroot & Ertz
- I4b Ascospores 15–25(–30) µm long. 5
- I5a Ascomata solitary. 6

- I5b Ascomata irregularly grouped to pseudostromatic, immersed to erumpent, mostly exposed, brown-black; pantropical. *Astrothelium scoria* (Fée) Aptroot & Lücking
- I6a Ascomata erumpent, with white cover; neotropical. *Astrothelium subscoria* Flakus & Aptroot
- I6b Ascomata erumpent to prominent, not white-covered, thallus bullate. *Astrothelium jiangxiense* C. Zhang & S.H. Jiang
- I7a Ascospores I+ violet. 8
- I7b Ascospores I-. 9
- I8a Ascomata solitary, immersed, covered by thallus except dark ostiolar area; pantropical. *Astrothelium infossum* (Nyl.) Aptroot & Lücking
- I8b Ascomata distinctly pseudostromatic, pseudostromata erumpent, brown-black, with pale ostiolar areas; neotropical. *Astrothelium infuscatulum* (Müll. Arg.) Aptroot & Lücking
- I9a Ascospores $15\text{--}28 \times 7\text{--}10\text{--}(12) \mu\text{m}$ (*Astrothelium nitidiusculum* complex). 10
- I9b Ascospores $26\text{--}46 \times (7\text{--})10\text{--}16 \mu\text{m}$. 17
- I10a Ascomata pseudostromatic; pseudostromata either prominent or contrasting with thallus in colour. 11
- I10b Ascomata solitary to irregularly confluent or grouped but not prominent or contrasting with thallus. 15
- I11a Pseudostromata prominent, partly covered by thallus and hence not strongly contrasting with thallus in colour; pantropical. *Astrothelium bicolor* (Taylor) Aptroot & Lücking
- I11b Pseudostromata immersed to erumpent and more or less leveled with thallus, often forming irregular to reticulate lines or groups, contrasting with thallus in colour (either dark or whitish). 12
- I12a Pseudostromata with whitish cover; neotropical. 13
- I12b Pseudostromata exposed, brown-black. 14
- I13a Pseudostromata with more ascomata; neotropical. *Astrothelium rufescens* (Müll. Arg.) Aptroot & Lücking
- I13b Pseudostromata with few ascomata; China. *Astrothelium subrufescens* C. Zhang & S.H. Jiang

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- I14a Pseudostromata forming distinct, compact groups laterally covered by thallus; neotropical. *Astrothelium subendochryseum* Lücking, M.P. Nelsen & Marcelli
- I14b Pseudostromata diffuse, exposed; neotropical. *Astrothelium nigratum* (Müll. Arg.) Aptroot & Lücking
- I15a Ascomata forming irregular groups, with rather broad, brown-black ostiolar area; eastern palaeotropical. *Astrothelium meiophorum* (Nyl.) Aptroot & Lücking
- I15b Ostiolar areas not broadly. 16
- I16a Ascomata covered by olive-green thallus; neotropical. *Astrothelium ceratinum* (Fée) Aptroot & Lücking
- I16b Ascomata with broadly white area surrounding the ostiole or entirely white; pantropical. *Astrothelium nitidiusculum* (Nyl.) Aptroot & Lücking
- I17a Ascospores $36\text{--}46 \times 14\text{--}16 \mu\text{m}$; ascomata solitary, erumpent, covered by thallus and with pale ring surrounding the dark ostiolar spot; pantropical, extending into temperate regions. *Astrothelium floridanum* Zahlbr. ex M. Choisy
- I17b Ascospores $26\text{--}39 \times 7\text{--}14 \mu\text{m}$; ascomata variable. 18
- I18a Ascomata pseudostromatic, pseudostromata exposed, immersed and leveled with thallus, forming irregular to reticulate lines or groups. 19
- I18b Ascomata solitary, covered by thallus. 21
- I19a Thallus consisting of globose verrucae with a thick hyaline cortex; Papua New Guinea. *Astrothelium diaphanocorticatum* Aptroot & Sipman
- I19b Thallus smooth to verrucose. 20
- I20a Ascospores $36\text{--}39 \mu\text{m}$ long; neotropical. *Astrothelium scoriiothelium* Aptroot & Lücking
- I20b Ascospores $29\text{--}33 \mu\text{m}$ long; Brazil. *Astrothelium disjunctum* Aptroot & M. Cáceres
- H21a Thallus and ascomata finely verrucose; ascomata immersed to erumpent, numerous and dense; neotropical. *Astrothelium papulosum* (Nyl.) Aptroot & Lücking
- H21b Thallus and ascomata smooth to uneven; ascomata erumpent to prominent, scattered; neotropical. *Astrothelium solitarium* Aptroot & M. Cáceres
- I22a Hamathecium inspersed. 23
- I22b Hamathecium clear. 25
- I23a Ascospores $45\text{--}62 \times 15\text{--}22 \mu\text{m}$; thallus uneven-bullate; ascomata solitary, erumpent, covered by thallus, with pale ring surrounding the dark ostiolar spot; Bolivia. *Astrothelium inspersotuberculosum* Flakus & Aptroot

- I23b Ascospores $85\text{--}120 \times 22\text{--}35\text{ }\mu\text{m}$; thallus and ascomata variable. 24
- I24a Ascospores $85\text{--}95 \times 22\text{--}25\text{ }\mu\text{m}$; thallus uneven-verrucose; ascomata solitary, prominent, exposed, with gently sloping sides; Vietnam. *Astrothelium clypeatum* Aptroot & Gueidan
- I24b Ascospores $100\text{--}120 \times 30\text{--}35\text{ }\mu\text{m}$; thallus uneven-verrucose; ascomata confluent, erumpent to prominent, exposed, with gently to steeply sloping sides; Guyana. *Astrothelium megatropicum* Aptroot
- I25a Ascomata prominent, completely exposed; Colombia. *Astrothelium phaeothelium* (Nyl.) Aptroot & Lücking
- I25b Ascomata immersed to erumpent, covered by thallus, with pale ring surrounding the dark ostiolar spot. 26
- I26a Thallus verrucose-papillose; ascomata solitary to irregularly confluent, prominent to sessile; Panama. *Astrothelium pseudannulare* Aptroot & Etayo
- I26b Thallus uneven to shallowly bullate. 27
- I27a Ascospores $48\text{--}65 \times 17\text{--}20\text{ }\mu\text{m}$; neotropical. *Astrothelium tuberculosum* (Vain.) Aptroot & Lücking
- I27b Ascospores $62\text{--}80 \times 20\text{--}25\text{ }\mu\text{m}$; neotropical. *Astrothelium annulare* (Fée) Aptroot & Lücking
- I28a Ascospores medium-sized ($29\text{--}59\text{--}(80) \times 8\text{--}17\text{ }\mu\text{m}$). 29
- I28b Ascospores large ($85\text{--}220 \times (8\text{--})20\text{--}45\text{ }\mu\text{m}$). 34
- I29a Hamathecium inspersed. 30
- I29b Hamathecium clear. 31
- I30a Ascospores $50\text{--}59\text{ }\mu\text{m}$ long; thallus verrucose-bullate; Papua New Guinea. *Astrothelium galligenum* (Aptroot) Aptroot & Lücking
- I30b Ascospores $40\text{--}49\text{ }\mu\text{m}$ long; thallus smooth to uneven; Sri Lanka. *Astrothelium nitidulum* Weerakoon & Aptroot
- I31a Ascomata at least mostly solitary. 32
- I31b Ascomata in irregular groups to pseudostromatic, groups or pseudostromata erumpent to prominent. 33
- I32a Ascomata solitary to irregularly confluent, immersed to erumpent, with erumpent part exposed, blackish; Malaysia. *Astrothelium tryptelizabethans* (Nyl.) Aptroot & Lücking

- I32b Ascomata solitary, immersed, not exposed; Brazil. *Astrothelium quintannulare* Aptroot
- I33a Pseudostromata whitish; eastern palaeotropical. *Astrothelium ubianense* (Vain.) Aptroot & Lücking
- I33b Pseudostromata brownish; Brazil. *Astrothelium pseudoplatystomum* (Makhija & Patw.) Aptroot & Lücking
- I34a Hamathecium inspersed. 35
- I34b Hamathecium. 40
- I35a Ascospores 9–15-septate, occasionally with a longitudinal septum in one or several cells. 36
- I35b Ascospores 5–9-septate, lacking longitudinal septa. 37
- I36a Ascospores 120–195 µm long; India. *Astrothelium macrosporum* (Makhija & Patw.) Aptroot & Lücking
- I36b Ascospores 75–100 µm long; Malaysia. *Astrothelium tanianum* Aptroot & Sipman
- I37a Ascospores 180–220 × 40–45 µm, 5–9-septate; ascomata grouped in large thallus verrucae; Angola. *Astrothelium pustulatum* (Vain.) Aptroot & Lücking
- I37b Ascospores 100–170 × 29–40 µm, 5-septate; ascomata variable. 38
- I38a Ascospores curved; ascomata grouped; Brazil. *Astrothelium curvisporum* Aptroot & M. Cáceres
- I38b Ascospores straight; ascomata solitary to irregularly confluent. 39
- I39a Ascomata solitary, prominent to sessile, covered by thallus except dark ostiolar area; neotropical (Brazil and Guyana). *Astrothelium sipmanii* Aptroot
- I39b Ascomata solitary to irregularly confluent, erumpent, upper part exposed; Colombia. *Astrothelium pseudomegalophthalmum* Aptroot
- I40a Ascospores 140–190 µm long, 11–19-septate; ascomata solitary to irregularly confluent. 41
- I40b Ascospores 85–120 µm long, 3–17-septate; ascomata irregularly grouped to pseudostromatic. 42
- I41a Thallus verrucose-bullate; ascomata erumpent to prominent, covered by thallus except broad, blackened ostiolar area; Uruguay. *Astrothelium basilicum* (Kremp.) Aptroot & Lücking
- I41b Thallus smooth; ascomata immersed, completely covered by thallus; Argentina. *Astrothelium spectabile* (Aptroot & L.I. Ferraro) Aptroot & Lücking

- I42a Ascospores 20–33 μm broad, 3–7-septate. 43
I42b Ascospores 8–16 μm broad, 9–17-septate; neotropical. *Astrothelium olivaceofuscum* (Zenker) Aptroot & Lücking
- I43a Thallus smooth to uneven; ascomata covered by thallus; Brazil. *Astrothelium trematum* Kalb & Aptroot
I43b Thallus verrucose-bullate; ascomata exposed, brown-black. 44
- I44a Thallus verrucose-bullate; Brazil. *Astrothelium megalophthalmum* (Müll. Arg.) Aptroot & Lücking
I44b Thallus squamulose; Brazil. *Astrothelium squamosum* Aptroot

Key J. *Astrothelium* species with ascospores transversely septate, ostiole lateral, secondary substances present on thallus and/or ascoma

- J1a Lichexanthone present; thallus and/or ascomata UV+ yellow; pigment(s) present or absent. 2
J1b Lichexanthone absent; pigment(s) always present, thallus and ascomata usually K+ red to purple and UV+ orange or red. 38
- J2a Pigments present on/in thallus and/or ascomata; lichexanthone on thallus only. 3
J2b Pigments absent; lichexanthone on thallus and/or ascomata. 10
- J3a Ascospores 9–11-septate, 50–75 \times 12–22 μm ; thallus with external, orange pigment (absent on ascomata); ascomata solitary to irregularly confluent, erumpent, covered by thallus except dark ostiolar area; Venezuela. *Astrothelium dicoloratum* Aptroot
J3b Ascospores 3-septate, 21–55 \times 7–23 μm ; ascomata with external, yellow-orange pigment (absent on thallus). 4
- J4a Hamathecium inspersed; ascospores 20–25 \times 9–11 μm ; groups of fused ascomata dispersed to irregularly confluent; Singapore. *Astrothelium inspersogalbineum* Aptroot & Weerakoon
J4b Hamathecium clear; ascospores variable in size. 5
- J5a Ascospores 21–28 \times 7–11 μm . 6
J5b Ascospores 28–55 \times 10–23 μm . 7

- J6a Ascomata pseudostromatic; pseudostromata prominent, containing one or several groups of fused ascomata, covered with orange pigment; pantropical.
Astrothelium macrocarpum (Fée) Aptroot & Lücking
- J6b Ascomata solitary to irregularly confluent, erumpent, containing a single group of fused ascomata; Thailand. *Astrothelium flavocoronatum* Luangsaph., Aptroot & Sangvichien
- J7a Ascospores $37\text{--}55 \times 15\text{--}23 \mu\text{m}$; ascomata pseudostromatic, pseudostromata erumpent, containing several groups of fused ascomata, covered with orange pigment; neotropical. *Astrothelium ochrothelium* (Nyl.) Müll. Arg.
- J7b Ascospores $28\text{--}35 \times 10\text{--}15 \mu\text{m}$. 8
- J8a Thallus strongly folded-bullate, whitish; groups of fused ascomata dispersed, immersed, with yellow-orange pigment around ostiolar area; pantropical.
Astrothelium versicolor Müll. Arg.
- J8b Thallus smooth to uneven, light olive-brown to olive-green; ascomata pseudostromatic. 9
- J9a Pseudostromata immersed to erumpent, containing several groups of fused ascomata, forming irregular to reticulate lines covered with yellow-orange pigment; Brazil.
Astrothelium aureomaculatum (Vain.) Aptroot & Lücking
- J9b Pseudostromata erumpent to prominent, each containing one group of fused ascomata, covered by orange pigment; New Caledonia. *Astrothelium grossum* Müll. Arg.
- J10a Ascospores 3-septate, rarely 3(–5)-septate. 11
- J10b Ascospores (3–)5–11-septate. 27
- J11a Ascospores small to medium-sized ($20\text{--}52 \times 6\text{--}17 \mu\text{m}$). 12
- J11b Ascospores medium-sized to large ($50\text{--}120 \times 17\text{--}40 \mu\text{m}$). 23
- J12a Ascospores $30\text{--}52 \times 10\text{--}17 \mu\text{m}$. 13
- J12b Ascospores $20\text{--}30 \times 6\text{--}11 \mu\text{m}$. 16
- J13a Hamathecium inspersion, inspersion dirty yellow-brown; lichexanthone on thallus and ascomata or ascomata only; ascomata pseudostromatic, pseudostromata prominent, containing one or several groups of fused ascomata. 14
- J13b Hamathecium clear; lichexanthone on thallus and ascomata; ascomata crowded or indistinctly pseudostromatic, pseudostromata immersed to erumpent, containing one or several groups of fused ascomata. 15

- J14a Lichexanthone on ascomata only; Brazil. *Astrothelium sordithecium* Lücking, M.P. Nelsen & Marcelli
- J14b Lichexanthone on thallus and ascomata; Brazil. *Astrothelium xanthosordithecium* Aptroot
- J15a Ascomata solitary or in dispersed, diffuse pseudostromata, conical with flattened top, whitish; neotropical. *Astrothelium leucothelium* Nyl.
- J15b Ascomata crowded, hemispherical to wart-shaped, covered by thallus; Malaysia. *Astrothelium chrysostomum* (Kremp.) Aptroot & Lücking
- J16a Lichexanthone on ascomata or only on ostiole or only on thallus. 17
- J16b Lichexanthone on thallus and ascomata; hamathecium inspersed or clear; ascospores 20–26 µm long. 21
- J17a Lichexanthone only on ostiole; hamathecium inspersed; Brazil. *Astrothelium eustominspersum* Aptroot & Oliveira-Junior
- J17b Lichexanthone on ascomata only; hamathecium clear or inspersed. 18
- J17c Lichexanthone on the thallus only; hamathecium inspersed. *Astrothelium subeustominspersum* C. Zhang & S.H. Jiang
- J18a Hamathecium inspersed; Brazil. *Astrothelium studerae* Aptroot & M. Cáceres
- J18b Hamathecium clear. 19
- J19a Hamathecium inspersed; ascomata diffusely pseudostromatic, erumpent, with whitish cover; Thailand. *Astrothelium neovariolosum* Luangsaph., Aptroot & Sangvichien
- J19b Hamathecium clear. 20
- J20a Groups of fused ascomata dispersed, immersed to erumpent; Brazil. *Astrothelium laevigatum* Müll. Arg.
- J20b Ascomata pseudostromatic, pseudostromata prominent, often whitish, containing one or several groups of fused ascomata; pantropical. *Astrothelium variolosum* (Ach.) Müll. Arg.
- J21a Ascomata diffusely pseudostromatic, pseudostromata erumpent, covered by thallus, containing one or several groups of fused ascomata; ascospores 20–25 µm; Brazil. *Astrothelium subinterjectum* Lücking, M.P. Nelsen & Jungbluth
- J21b Ascomata distinctly pseudostromatic, pseudostromata prominent, with white or grey cover contrasting with the olive-green thallus, containing one or several groups of fused ascomata. 22

- J22a Thallus with pseudocyphellae; pseudostromata grey; Brazil. *Astrothelium pseudocyphellatum* R.C. Harris
- J22b Thallus lacking pseudocyphellae; pseudostromata whitish; pantropical. *Astrothelium interjectum* R.C. Harris
- J23a Ascospores $100\text{--}130 \times 35\text{--}45 \mu\text{m}$; groups of fused ascomata dispersed to aggregate, immersed-erumpent, covered by thallus except for whitish ostiolar area; Venezuela. *Astrothelium ultralucens* Aptroot
- J23b Ascospores $50\text{--}75 \times 14\text{--}26 \mu\text{m}$. 24
- J24a Lichexanthone on thallus (and sometimes also on ascomata). 25
- J24a Lichexanthone not on thallus, only on ascomata. 26
- J25a Lichexanthone on thallus, not on ascomata; neotropical (Brazil and Venezuela). *Astrothelium leucoconicum* Nyl.
- J25b Lichexanthone on thallus and ascomata; Bolivia. *Astrothelium nigrocacuminum* Flakus, Kukwa & Aptroot
- J26a Ascomata distinctly pseudostromatic, pseudostromata erumpent, with white cover contrasting with the olive-green thallus, containing one or several groups of fused ascomata; ascospores $60\text{--}70 \times 17\text{--}20 \mu\text{m}$; Brazil. *Astrothelium sinuosum* Aptroot & Gumboski
- J26b Groups of fused ascomata dispersed, immersed, with broad, dark ostiolar area; ascospores $50\text{--}60 \times 14\text{--}17 \mu\text{m}$; Brazil. *Astrothelium obtectum* Lücking, M.P. Nelsen & Benatti
- J27a Ascospores small ($20\text{--}30 \times 6\text{--}11 \mu\text{m}$), 3–5-septate. 28
- J27b Ascospores medium-sized to large ($30\text{--}110 \times 11\text{--}25 \mu\text{m}$), 5–11-septate. 30
- J28a Lichexanthone on ostioles only; ascomata distinctly pseudostromatic, pseudostromata erumpent, with white cover contrasting with the olive-green thallus, containing one or several groups of fused ascomata; pantropical. *Astrothelium eustomum* (Mont.) Müll. Arg.
- J28b Lichexanthone on thallus and ascomata; ascomata variable. 29
- J29a Ascomata distinctly pseudostromatic, pseudostromata erumpent, with white cover contrasting with the olive-green thallus; Thailand. *Astrothelium neglectum* Luangsaph., Aptroot & Sangvichien
- J29b Ascomata indistinctly pseudostromatic, pseudostromata erumpent to prominent, covered by thallus; pantropical. *Astrothelium sexloculatum* Aptroot

- J30a Ascospores 30–55 μm long; ascomata with white cover contrasting with the olive green thallus, erumpent. 31
- J30b Ascospores 65–110 μm long; ascomata variable. 34
- J31a Hamathecium inspersed; ascomata dispersed to irregularly confluent; Thailand. *Astrothelium siamense* Luangsaph., Aptroot & Sangvichien
- J31b Hamathecium clear; ascomata distinctly pseudostromatic, containing several groups of fused ascomata. 32
- J32a Lichexanthone on thallus and ascomata; neotropical (Guyana and Venezuela). *Astrothelium septemseptatum* Aptroot
- J32b Lichexanthone on ascomata or ostiole only. 33
- J33a Lichexanthone on ascomata; Brazil. *Astrothelium octoseptatum* Aptroot & M. Cáceres
- J33b Lichexanthone on ostiole only; French Guiana. *Astrothelium macroeustomum* Aptroot & Sipman
- J34a Hamathecium inspersed; lichexanthone on thallus and ascomata; ascomata distinctly pseudostromatic, pseudostromata erumpent, with white cover contrasting with the olive-green thallus, each containing a single group of fused ascomata; Cuba. *Astrothelium diplocarpoides* Müll. Arg.
- J34b Hamathecium clear; lichexanthone on ascomata only; ascomata variable. 35
- J35a Ascospores 80–110 \times 17–25 μm , 5–7-septate; ascomata diffusely pseudostromatic, pseudostromata erumpent, covered by thallus, each containing a single group of fused ascomata; Brazil. *Astrothelium macrostomoides* Lücking, M.P. Nelsen & Benatti
- J35b Ascospores when transversely septate 65–85 \times 14–18 μm , 5–11-septate, submuriform when longer; ascomata variable. 36
- J36a Ascospores 5–7-septate; ascomata diffusely pseudostromatic, pseudostromata erumpent to prominent, covered by thallus, uneven-verrucose, each containing a single group of fused ascomata; French Guiana. *Astrothelium macrostomum* Aptroot
- J36b Ascospores 9–11-septate; ascomata distinctly pseudostromatic, pseudostromata immersed, with white cover contrasting with the olive-green thallus, containing one to several groups of fused ascomata. 37
- J37a Ascospores 65–70 \times 15–17 μm , transversely septate only; Brazil. *Astrothelium eumultiseptatum* Aptroot & M. Cáceres

- J38b Ascospores $90\text{--}110 \times 22\text{--}28 \mu\text{m}$, in part with longitudinal septa and becoming submuriform; neotropical. *Astrothelium diplocarpum* Nyl.
- J38a Ascospores 5–9-septate. 39
- J38b Ascospores 3-septate. 41
- J39a Ascospores 5-septate; ascomata diffusely pseudostromatic, pseudostromata with external pink pigment; Brazil. *Astrothelium bivelum* Aptroot & M. Cáceres
- J39b Ascospores 5–9-septate. 40
- J40a Ascospores 7–9-septate; only ostiole yellow pruinose; Brazil. *Astrothelium septoconicum* Aptroot
- J40b Ascospores 6–7-septate; pseudostromata with internal yellow pigment; Brazil. *Astrothelium introflavidum* Aptroot & M. Cáceres
- J41a Ascospores small ($20\text{--}30 \times 6\text{--}12 \mu\text{m}$). 42
- J41b Ascospores small to medium-sized ($30\text{--}65 \times 10\text{--}25 \mu\text{m}$). 47
- J42a Thallus and ascomata with orange pigment. 43
- J42b Pigment on ascomata only, yellow to orange. 44
- J43a Pseudostromata immersed to erumpent, whitish; Indonesia. *Astrothelium pseudoferrugineum* Aptroot
- J43b Pseudostromata erumpent to prominent, covered by thallus; Cuba. *Astrothelium ferrugineum* (Müll. Arg.) Aptroot & Lücking
- J44a Hamathecium inspersed; Sri Lanka. *Astrothelium inspersoconicum* Aptroot & Weerakoon
- J44b Hamathecium clear. 45
- J45a Pigment yellow, sparse; ostioles partly apical; ascomata solitary to irregularly confluent and fused, erumpent, covered by thallus; Bolivia. *Astrothelium pallidoflavum* Flakus & Aptroot
- J45b Pigment orange, distinct; ostioles consistently lateral and fused; ascomata pseudostromatic, erumpent to prominent, with orange cover, containing one to many of fused ascomata. 46
- J46a Ascomata with one or few fused ascomata; pantropical. *Astrothelium cinnamomeum* (Eschw.) Müll. Arg.
- J46b Ascomata pseudostromatic, with many groups of fused ascomata; Brazil. *Astrothelium stromatocinnamomeum* Aptroot

J47a Thallus yellow; ascospores $30\text{--}35 \times 10\text{--}12 \mu\text{m}$; Brazil. *Astrothelium croceum* Malme

J47b Thallus not cracked; ascospores $(30\text{--})35\text{--}65 \times (10\text{--})12\text{--}25 \mu\text{m}$. 48

J48a Ascospores $55\text{--}65 \times 15\text{--}25 \mu\text{m}$; pantropical. *Astrothelium ocellatum* Malme

J48b Ascospores $30\text{--}45 \times 10\text{--}17 \mu\text{m}$; pantropical. *Astrothelium scorioides* Nyl.

Key K. *Astrothelium* species with ascospores transversely septate, ostiole lateral, secondary substances absent

K1a Ascospores 3-septate. 2

K1b Ascospores $(3\text{--})5\text{--}23$ -septate. 21

K2a Ascospores medium-sized ($55\text{--}80 \times 15\text{--}25 \mu\text{m}$); thallus distinctly verrucose papillose. 3

K2b Ascospores small to medium-sized ($(12\text{--})20\text{--}45 \times (4\text{--})7\text{--}15 \mu\text{m}$); thallus variable. 4

K3a Ascospores medium-sized ($55\text{--}65 \times 15\text{--}19 \mu\text{m}$); thallus distinctly verrucose-papillose; ascomata immersed; Brazil. *Astrothelium simplex* Aptroot & S.M.A. Martins

K3b Ascospores $80\text{--}88 \times 32\text{--}36 \mu\text{m}$; ascomata prominent to sessile; Panama. *Astrothelium pseudannulare* Aptroot & Etayo

K4a Hamathecium inspersed. 5

K4b Hamathecium clear. 7

K5a Thallus covering the pseudostromata; Sri Lanka. *Astrothelium conjugatum* Weerakoon & Aptroot

K5b Thallus not covering the pseudostromata. 6

K6a Ascospores $20\text{--}25 \mu\text{m}$ long; ascomata diffusely pseudostromatic, pseudostromata prominent, laterally covered by thallus, with one to several groups of fused ascomata forming broad, flat, dark ostiolar areas often fused in lobate pattern; eastern palaeotropical. *Astrothelium straminicolor* (Nyl.) Aptroot & Lücking

K6b Ascospores $25\text{--}30 \mu\text{m}$ long; ascomata diffusely pseudostromatic, pseudostromata prominent, covered by thallus, with one to several groups of fused ascomata with dark, papilliform, always separate ostiolar areas; pantropical. *Astrothelium pyrenastrosulphureum* Aptroot & Lücking

K7a Ascospores $(12\text{--})20\text{--}27 \times (4\text{--})7\text{--}10 \mu\text{m}$. 8

K7b Ascospores $28\text{--}45 \times 10\text{--}15 \mu\text{m}$. 17

- K8a Ascospores $12\text{--}15 \times 4\text{--}5 \mu\text{m}$; ascomata diffusely pseudostromatic, pseudostromata prominent, laterally covered by thallus, with one to several groups of fused ascomata forming broad, flat, dark ostiolar areas often fused in lobate pattern; Cuba. *Astrothelium acrophaeum* Müll. Arg.
- K8b Ascospores $19\text{--}27 \times 7\text{--}10 \mu\text{m}$; thallus and ascomata variable (*Astrothelium crassum* complex). 9
- K9a Ostioles separate; ascomata aggregate in irregular groups or lines, immersed; neotropical. *Astrothelium scorizum* (Müll. Arg.) Aptroot & Lücking
- K9b Ostioles fused; fused ascomata dispersed to aggregate. 10
- K10a Thallus mottled olive-whitish, with irregular whitish areas or lines; ascomata usually developed on the whitish areas (but not covered by them). 11
- K10b Thallus uniformly olive-brown to olive-green, without whitish areas except when covering the ascomata. 13
- K11a Ascomata dispersed, conical, partially or fully covered by thallus; Malaysia. *Astrothelium peranceps* (Kremp.) Aptroot & Lücking
- K11b Ascomata dispersed to irregularly confluent, completely exposed. 12
- K12a Ascomata black, developed on distinct, white, irregular to reticulate lines; Brazil. *Astrothelium nigricans* Malme
- K12b Ascomata dark brown, emerging from thallus; neotropical. *Astrothelium nigrum* Aptroot & M. Cáceres
- K13a Ascomata aggregate in irregular groups bordered by a thin whitish line; thallus rather thick, uneven to irregularly folded; eastern palaeotropical. *Astrothelium subfuscum* Kremp.
- K13b Ascomata dispersed to irregularly confluent, exposed and brown or with whitish or (partial) thallus cover; thallus thin to thick but not folded. 14
- K14a Ascomata exposed and brown-black, conical; Brazil. *Astrothelium obscurum* Müll. Arg.
- K14b Ascomata at least with lateral thallus cover or with whitish rim or cover, lens-shaped to hemispherical. 15
- K15a Ascomata prominent, with basal thallus cover and upper part exposed; individual ascomata clearly discernible; Australia. *Astrothelium oligocarpum* (Müll. Arg.) Aptroot & Lücking
- K15b Ascomata erumpent to prominent, whitish or whitish rim; individual ascomata only visible as immersed chambers. 16

- K16a Ascomata with complete whitish cover including ostiolar area; thallus thin; Thailand. *Astrothelium subdissocians* (Nyl. ex Vain.) Aptroot & Lücking
- K16b Ascomata with whitish rim bordering a wide, dark ostiolar area; thallus thickened; pantropical. *Astrothelium crassum* (Fée) Aptroot
- K16c Ascomata irregularly grouped to pseudostromatic, pseudostromata usually white-covered and the thallus thin. *Astrothelium pseudocrassum* C. Zhang & S.H. Jiang
- K17a Thallus strongly verrucose-bullate; groups of fused ascomata dispersed, immersed, visible only by their dark, narrow ostiolar area; Brazil. *Astrothelium globosum* Aptroot & M. Cáceres
- K17b Thallus smooth to uneven; ascomata distinct, diffusely to distinctly pseudostromatic, pseudostromata covered with thallus. 18
- K18a Ascomata distinctly pseudostromatic, pseudostromata strongly prominent to sessile, uneven-verrucose, covered with thallus, with whitish ring around dark ostiolar zone, containing one or several groups of fused ascomata; pantropical. *Astrothelium fallax* Müll. Arg.
- K18b Ascomata diffusely pseudostromatic, pseudostromata erumpent to prominent, smooth to uneven, covered with thallus, containing several to many groups of fused ascomata. 19
- K19a Ascospores $35\text{--}45 \times 14\text{--}16 \mu\text{m}$; Brazil. *Astrothelium marcidum* (Fée) Aptroot & Lücking
- K19b Ascospores $28\text{--}33 \times 8\text{--}15 \mu\text{m}$. 20
- K20a Pseudostromata with distinctly separate, whitish ostiolar areas; ascospores $12\text{--}15 \mu\text{m}$ broad; Costa Rica. *Astrothelium intermedium* Aptroot & Lücking
- K20b Pseudostromata with upper part entirely whitish; ascospores $8\text{--}10 \mu\text{m}$ broad; Brazil. *Astrothelium pleiostomum* Redinger
- K21a Ascospores small and slender, 6–9-septate, $35\text{--}54 \times 7\text{--}10 \mu\text{m}$, curved; India. *Astrothelium himalayense* (Upreti & Aptroot) Aptroot & Schumm
- K21b Ascospores medium-sized ($45\text{--}80 \times 12\text{--}28 \mu\text{m}$). 22
- K21c Ascospores large ($80\text{--}130 \times 17\text{--}30 \mu\text{m}$). 29
- K22a Hamathecium inspersed. 23
- K22b Hamathecium clear. 24
- K23a Ascospores $45\text{--}55 \times 13\text{--}16 \mu\text{m}$, 7–9-septate; ascomata indistinctly pseudostromatic, pseudostromata erumpent to prominent, brownish; Venezuela. *Astrothelium tryptelioides* Aptroot

- K23b Ascospores $50\text{--}75 \times 14\text{--}22 \mu\text{m}$, 5-septate; ascomata diffusely pseudostromatic, pseudostromata erumpent, covered by thallus, containing one to several groups of fused ascomata; pantropical. *Astrothelium subclandestinum* Leight.
- K23c Ascomata in distinct, white pseudostromata; Vietnam. *Astrothelium decemloculare* Aptroot, Weerakoon & G. Vo
- K24a Ascospores 4–5-septate; groups of fused ascomata dispersed, erumpent, with whitish ring around dark ostiolar zone. 25
- K24b Ascospores 7–19-septate; ascomata variable. 26
- K25a Ascospores predominantly 4-septate, $45\text{--}55 \times 15\text{--}18 \mu\text{m}$; Brazil. *Astrothelium quatuorseptatum* Aptroot & M. Cáceres
- K25b Ascospores 5-septate, $50\text{--}75 \times 14\text{--}22 \mu\text{m}$; Brazil. *Astrothelium supraclandestinum* Aptroot & M. Cáceres
- K26a Ascospores 7-septate, $14\text{--}28 \mu\text{m}$ broad; ascomata pseudostromatic, pseudostromata immersed-erumpent, with whitish cover; neotropical (Brazil and Guyana). *Astrothelium zebrinum* Aptroot
- K26b Ascospores 9–19-septate, $12\text{--}17 \mu\text{m}$ broad. 27
- K27a Ascospores $45\text{--}55 \mu\text{m}$ long, consistently 9-septate; ascomata pseudostromatic, pseudostromata erumpent, with white cover contrasting with olive-green thallus, with several to many groups of fused ascomata; Brazil. *Astrothelium novemseptatum* Aptroot & M. Cáceres
- K27b Ascospores $60\text{--}80 \mu\text{m}$ long, 9–19-septate. 28
- K28a Ascospores $69\text{--}80 \mu\text{m}$ long, 11–15-septate; ascomata deeply immersed in groups; Brazil. *Astrothelium valsoides* Aptroot & M. Cáceres
- K28b Ascospores $60\text{--}80 \mu\text{m}$ long, 9–19-septate; groups of fused ascomata dispersed, erumpent, brown-black with whitish ring around base; eastern palaeotropical. *Astrothelium heterophorum* Nyl.
- K29a Ascospores I+ violet, occasionally with a longitudinal septum in one or several cells; thallus bullate-folded; groups of ascomata dispersed to irregularly confluent, immersed to erumpent, exposed and brown-black; Bolivia. *Astrothelium neodiplocarpum* Flakus, Kukwa & Aptroot
- K29b Ascospores I–, lacking longitudinal septa; groups of fused ascomata dispersed (or ostioles separate), mostly covered by thallus. 30
- K30a Hamathecium inspersed; groups of fused ascomata prominent, with broad white ostiolar area; ascospores 9–11-septate, $80\text{--}100 \mu\text{m}$ long; Thailand. *Astrothelium macrostiolum* Luangsaph., Aptroot & Sangvichien

- K30b Hamathecium clear; ascomata variable; ascospore septa variable, ascospores (90–)100–130 µm long. 31
- K31a Ascospores 5–7(–9)-septate. 32
- K31b Ascospores 9–23-septate. 33
- K32a Ascospore median septum not thickened; neotropical. *Astrothelium robustum* Müll. Arg.
- K32b Ascospore median septum thickened; Brazil. *Astrothelium fernandae* Aptroot
- K33b Ascospores 9–11-septate, median septum thickened; ostioles fused; Brazil. *Astrothelium medioincrassatum* Aptroot & M. Cáceres
- K33c Ascospores 11–23-septate. 34
- K34a Ascospores 11–15-septate; groups of fused ascomata erumpent; Brazil. *Astrothelium robustosporum* Aptroot & M. Cáceres
- K34b Ascospores 19–23-septate; groups of fused ascomata strongly prominent to sessile, with protruding, irregular ostioles; neotropical. *Astrothelium gigasporum* R.C. Harris

Key L. *Astrothelium* species with ascospores muriform, ostiole apical, secondary substances present on thallus and/or ascoma

- L1a Lichexanthone present; thallus and/or ascomata UV+ yellow; pigment(s) present or absent. 2
- L1b Lichexanthone absent; pigment(s) always present, thallus and ascomata usually K+ red to purple and UV+ orange or red. 14
- L2a Pigments present on/in thallus and/or ascomata; ascospores large, 70–160 × 15–32 µm. 3
- L2b Pigments absent; ascospores medium-sized to large, 40–160 × 15–40 µm. 6
- L3c Hamathecium inspersed; ascomata mostly solitary; lichexanthone only on thallus. Vietnam. *Astrothelium curcumarum* Aptroot, Weerakoon & G. Vo
- L3b Hamathecium clear. 4
- L4a Thallus and ascomata with external, yellow-orange, K+ purple pigment(s); lichexanthone on thallus only; ascomata distinctly pseudostromatic, pseudostromata erumpent to prominent, covered with orange pigment, sharply delimited and contrasting with thallus; Brazil. *Astrothelium flavoduplex* Aptroot & M. Cáceres

- L4b Ascomata or medulla with internal, red, K+ yellow-green pigment(s); lichexanthone on thallus and ascomata. 5
- L5a Ascospores I+ violet; ascomata solitary to irregularly confluent, erumpent to prominent, whitish around ostiole(s); Brazil. *Astrothelium sanguineoxanthum* Aptroot
- L5b Ascospores I–; ascomata distinctly pseudostromatic, pseudostromata erumpent to prominent, whitish, sharply delimited and contrasting with thallus; Bolivia. *Astrothelium elixii* Flakus & Aptroot
- L6a Hamathecium inspersed. 7
- L6b Hamathecium clear. 10
- L7a Ascospores (2–)4(–6) per ascus, 40–80 µm long; on rock; Brazil. *Astrothelium stramineum* (Malme) Aptroot & Lücking
- L7b Ascospores 8 per ascus. 8
- L8a Ascospores 65–71 µm long; Brazil. *Astrothelium rhinothallinum* Kalb & Aptroot
- L8b Ascospores 70–220 µm long. 9
- L9a Ascospores 70–120 × 18–24 µm; eastern palaeotropical. *Astrothelium meristosporoides* (P.M. McCarthy & Vongsheew.) Aptroot & Lücking
- L9b Ascospores 120–220 × 25–40 µm; eastern palaeotropical. *Astrothelium meristosporum* (Mont. & Bosch) Aptroot & Lücking
- L10a Ascospores 70–115 × 15–24 µm. 11
- L10b Ascospores 110–170 × 20–35 µm. 13
- L11a Lichexanthone on pseudostromata only; ascomata covered by thallus except for dark ostiolar area; neotropical (Brazil and Guyana). *Astrothelium corallinum* Aptroot
- L11b lichexanthone on thallus, sometimes also on ascomata. 12
- L12a Ascospores 70–90 × 18–20 µm, 8 per ascus; lichexanthone on thallus only; ascomata indistinctly pseudostromatic, pseudostromata erumpent, whitish, not sharply delimited; Guyana. *Astrothelium lucidothallinum* Aptroot
- L12b Ascospores 80–115 × 15–24 µm, 4 per ascus; lichexanthone on thallus and ascomata; ascomata distinctly pseudostromatic, pseudostromata erumpent to prominent, brown-black, sharply delimited; Brazil. *Astrothelium ochroleuroides* Aptroot & M. Cáceres

- L13a Ascomata pseudostromatic; pseudostromata erumpent, whitish; Bolivia.
Astrothelium variabile Flakus & Aptroot
- L13b Ascomata pseudostromatic; pseudostromata erumpent, brown-black; Brazil.
Astrothelium xanthosuperbum Aptroot & M. Cáceres
- L14a Ascospores medium-sized, 45–80 µm long. 15
- L14b Ascospores large over 80 µm long. 21
- L15a Ascospores 40–55 µm long. 16
- L15b Ascospores 60–80 µm long. 18
- L16a Ascomata with internal, yellow pigment; ascospores about 3–6 times as long as broad. 17
- L16b Thallus and ascomata with external, orange pigment and medulla (ascomata) additionally with internal, purple pigment; ascospores about twice as long as broad; Ecuador. *Astrothelium condoricum* Aptroot
- L17a Ascospores about 4–6 times as long as broad; Brazil. *Astrothelium lineatum* Aptroot & M. Cáceres
- L17b Ascospores about 3–4 times as long as broad; Brazil. *Astrothelium duplicatum* Aptroot & M. Cáceres
- L18a Ascomata with internal red pigment crystals; ostiolar area very broad and flat, black; Sierra Leone. *Astrothelium sierraleonense* (C.W. Dodge) Aptroot & Lücking
- L18b Pigment external; ostiolar area narrow, whitish. 19
- L19a Hamathecium inspersed; pigment on ascomata only; ascospores 20–30 µm broad; ascomata pseudostromatic, pseudostromata prominent, covered with orange pigment, sharply delimited from thallus; neotropical. *Astrothelium auratum* (R.C. Harris) Aptroot & Lücking
- L19b Hamathecium clear; pigment on thallus and ascomata; ascospores 12–25 µm broad; ascomata variable. 20
- L20a Ascomata pseudostromatic; pseudostromata erumpent, covered with orange pigment, sharply delimited; Brazil. *Astrothelium graphicum* Aptroot & S.M.A. Martins
- L20b Ascomata pseudostromatic; pseudostromata immersed, whitish, not sharply delimited; neotropical. *Astrothelium flavomaculatum* Aptroot
- L21a Ascomata with internal, red, K+ yellow-green pigment; ascospores I + violet; ascomata pseudostromatic, pseudostromata erumpent to prominent, brown-black,

- sharply delimited; Brazil. *Astrothelium sanguinarium* (Malme) Aptroot & Lücking
- L21b Thallus and/or ascomata with external or internal, yellow to orange, K+ purple pigment; ascospores I–; ascomata variable. 22
- L22a Pigment in medulla of pseudostromata only. 23
- L22b Pigment external on thallus and/or ascomata. 25
- L23a. Ascospores 8 per ascus, 90–105 × 26–36 µm; Malaysia. *Astrothelium deforme* (Fée) Aptroot & Lücking
- L23b Ascospores 2 or 4 per ascus. 24
- L24a Ascospores 2 per ascus, 110–130 × 30–35 µm; Guyana. *Astrothelium laurerospaerioides* Aptroot
- L24a Ascospores 4 per ascus, up to 330 × 40 µm; French Guiana. *Astrothelium cayennense* Aptroot & Sipman
- L25a Ascospores 8 per ascus, 20–25 µm broad; ascomata pseudostromatic, immersed to erumpent, covered with orange pigment, sharply delimited; Brazil. *Astrothelium mesoduplex* Aptroot & M. Cáceres
- L25b Ascospores 2–4 per ascus, 25–50 µm broad; ascomata variable. 26
- L26a Pigment on ascomata only, absent from thallus; ostiole in part lateral; Caribbean. *Astrothelium chrysoglyphum* (Vain.) Aptroot & Lücking
- L26b Pigment on thallus only, absent from ascomata; ostiole consistently apical; pantropical. *Astrothelium vezdae* (Makhija & Patw.) Aptroot & Lücking

Key M. *Astrothelium* species with ascospores muriform, ostiole apical, secondary substances absent

- M1a Hamathecium inspersed. 2
- M1b Hamathecium clear. 20
- M2a Ascospores small to medium-sized (30–60 × 11–20 µm). 3
- M2b Ascospores large (80–300 × 20–75 µm). 6
- M3a Ascomata aggregate into irregular groups or lines, immersed to erumpent, exposed, blackish; ascospores 35–50 × 12–18 µm; pantropical. *Astrothelium subdiscretum* (Nyl.) Aptroot & Lücking
- M3b Ascomata solitary or few aggregate, at least partly covered by thallus; ascospores variable. 4

- M4a Ascospores $32\text{--}45 \times 11\text{--}13 \mu\text{m}$; ascomata aggregate to pseudostromatic, pseudostromata prominent to sessile, covered by thallus; India. *Astrothelium pseudovariatum* (Upreti & Ajay Singh) Aptroot & Lücking
- M4b Ascospores $45\text{--}70 \times 13\text{--}20 \mu\text{m}$; ascomata solitary to aggregate, if aggregate then whitish. 5
- M5a Ascomata solitary, prominent, mostly exposed and brown-black; Brazil. *Astrothelium ambiguum* (Malme) Aptroot & Lücking
- M5b Ascomata solitary, erumpent, mostly covered by thallus except for dark ostiolar area; eastern palaeotropical. *Astrothelium indicum* (Upreti & Ajay Singh) Aptroot & Lücking
- M6a Ascospores 1–2 per ascus, $210\text{--}300 \mu\text{m}$ long. 7
- M6b Ascospores 4–8 per ascus, $80\text{--}200\text{--}(230) \mu\text{m}$ long. 8
- M6c Ascospores 4 per ascus, $240\text{--}260 \mu\text{m}$ long; Brazil. *Astrothelium flavogigasporum* Aptroot
- M7a Ascospores 1 per ascus, $240\text{--}300 \times 45\text{--}50 \mu\text{m}$, with thickened median septum; ascomata confluent to irregularly pseudostromatic, immersed-erumpent, with whitish cover around the blackish ostiole; Colombia. *Astrothelium colombiense* Aptroot
- M7b Ascospores 2 per ascus, $210\text{--}225 \times 30\text{--}35 \mu\text{m}$, without thickened median septum; ascomata solitary, prominent, mostly exposed and brown-black; eastern palaeotropical. *Astrothelium megaleium* (Kremp.) Aptroot & Lücking
- M8a Ascospores submuriform, with few longitudinal septa, $17\text{--}22 \mu\text{m}$ broad; ascomata solitary to irregularly confluent, immersed to erumpent, covered by thallus with broad whitish area around the dark ostiolar spot; India. *Astrothelium macrosporum* (Makhija & Patw.) Aptroot & Lücking
- M8b Ascospores distinctly muriform, $20\text{--}75 \mu\text{m}$ broad; ascomata variable. 9
- M9a Ascospores $80\text{--}140 \mu\text{m}$ long. 10
- M9b Ascospores $(125\text{--})140\text{--}230 \mu\text{m}$ long, most ascospores distinctly exceeding $140 \mu\text{m}$. 12
- M10a Ascospores 2–3 times as long as broad ($80\text{--}100\text{--}(125) \times 28\text{--}48 \mu\text{m}$), without thickened median septum; ascomata solitary, erumpent, laterally covered by thallus with ostiolar area exposed, black; neotropical. *Astrothelium effusum* (Aptroot & Sipman) Aptroot & Lücking
- M10b Ascospores 4–5 times as long as broad ($115\text{--}140 \times 25\text{--}33 \mu\text{m}$), with thickened median septum; ascomata variable. 11

- M11a Ascomata solitary, strongly prominent, completely covered by thallus; eastern palaeotropical. *Astrothelium aurantiacum* (Makhija & Patw.) Aptroot & Lücking
- M11b Ascomata solitary to irregularly confluent, immersed to erumpent, covered by thallus but with exposed, dark ostiolar area bordered by whitish rim; eastern palaeotropical. *Astrothelium sikkimense* (Makhija & Patw.) Aptroot & Lücking
- M12a Ascospores with thickened median septum. 13
- M12b Ascospores without thickened median septum. 17
- M13a Ascomata distinctly pseudostromatic, pseudostromata prominent to sessile, with whitish cover; thallus smooth to uneven; Indonesia. *Astrothelium alboverrucoides* Aptroot
- M13b Ascomata solitary; thallus variable. 14
- M14a Thallus smooth to uneven; ascomata prominent, exposed and blackish; pantropical. *Astrothelium flavomeristosporum* Aptroot
- M14b Thallus verrucose-papillose or bullate; ascomata immersed, covered by thallus. 15
- M15a Thallus coarsely bullate, gall-like; ascomata immersed in large thallus verrucae, completely covered by thallus; Philippines. *Astrothelium philippinense* Aptroot & Schumm
- M15b Thallus verrucose-papillose; ascomata variable but ostioles partly lateral. 16
- M16a Hamathecium orange; ascospores 26–34 µm broad; Papua New Guinea. *Astrothelium papillosum* (P.M. McCarthy) Aptroot & Lücking
- M16b Hamathecium uncoloured; ascospores 35–45 µm broad; Venezuela. *Astrothelium komposchii* Aptroot
- M17a Ascospores 135–165 µm long; thallus uneven-verrucose; ascomata solitary to irregularly confluent, erumpent, covered by thallus, uneven-verrucose; Brazil. *Astrothelium irregulare* (Müll. Arg.) Aptroot & Lücking
- M17b Ascospores (140–)165–230 µm long; thallus and ascomata variable. 18
- M18a Hamathecium yellow; thallus bullate; ascomata solitary, prominent, beaked; neotropical. *Astrothelium flavomegaspermum* Aptroot & Etayo
- M18b Hamathecium hyaline. 19
- M19a Thallus bullate; ascomata solitary to confluent, immersed in coarse thallus verrucae, covered by thallus, with yellowish ostiolar rim; Ecuador. *Astrothelium flavostiolum* Aptroot

- M19b Thallus smooth to uneven; ascomata solitary, prominent, covered by thallus except for dark ostiolar area usually bordered by a whitish rim; pantropical. *Astrothelium megaspermum* (Mont.) Aptroot & Lücking
- M20a Ascospores small ($30\text{--}60 \times 11\text{--}20\text{ }\mu\text{m}$). 21
- M20b Ascospores medium-sized to large ($60\text{--}280 \times (15\text{--})20\text{--}65\text{ }\mu\text{m}$). 22
- M21a Ascospores $30\text{--}45 \times 11\text{--}13\text{ }\mu\text{m}$; ascomata pseudostromatic, pseudostromata (strongly) prominent, covered by thallus except for ostioles; neotropical. *Astrothelium variatum* (Nyl.) Aptroot & Lücking
- M21b Ascospores $50\text{--}60 \times 15\text{--}20\text{ }\mu\text{m}$; ascomata solitary, prominent, covered by thallus; eastern palaeotropical. *Astrothelium keralense* (Upreti & Ajay Singh) Aptroot & Lücking
- M22a Ascospores $200\text{--}280 \times 50\text{--}65\text{ }\mu\text{m}$, 2 per ascus; ascomata irregularly grouped to diffusely pseudostromatic, pseudostromata erumpent, completely covered by thallus; neotropical. *Astrothelium gigantosporum* (Müll. Arg.) Aptroot & Lücking
- M22b Ascospores $70\text{--}195 \times 14\text{--}45\text{ }\mu\text{m}$, (2–)4–8 per ascus; ascomata variable. 23
- M23a Ascospores I+ blue. 24
- M23b Ascospores I-negative. 25
- M24a Ascospores I+ violet-blue, $125\text{--}170 \times 27\text{--}40\text{ }\mu\text{m}$; Bolivia. *Astrothelium amylosporum* Flakus & Aptroot
- M24b Ascospores I+ pale blue, $85\text{--}100 \times 20\text{--}24\text{ }\mu\text{m}$; Thailand. *Astrothelium palaeoexostemmatidis* Sipman & Aptroot
- M25a Ascospores with thickened median septum. 26
- M25b Ascospores without thickened median septum. 27
- M26a Ascospores 4 per ascus, $145\text{--}175 \times 30\text{--}35\text{ }\mu\text{m}$; thallus strongly bullate; ascomata solitary to irregularly confluent, immersed in bullate thallus warts and completely covered by thallus except for protruding ostiole; Brazil. *Astrothelium tetrasporum* Aptroot & M. Cáceres
- M26b Ascospores (6–)8 per ascus, $(85\text{--})100\text{--}170 \times 23\text{--}33\text{ }\mu\text{m}$; thallus smooth to uneven; ascomata solitary to diffusely pseudostromatic, prominent, whitish surrounding the black ostiolar area; India. *Astrothelium alboverrucum* (Makhija & Patw.) Aptroot & Lücking
- M27a Ascospores 1–4 per ascus. 28
- M27b Ascospores 8 per ascus. 31

- M28a Ascospores 1 per ascus, 125–148 μm long; Brazil. *Astrothelium unisporum* Aptroot & M. Cáceres
- M28b Ascospores 1–4 per ascus. 29
- M29a Ascomata distinctly pseudostromatic, pseudostromata erumpent to prominent, with white cover, sharply delimited from thallus; ascospores 80–140 \times 25–35 μm ; pantropical. *Astrothelium sphaerioides* (Müll. Arg.) Aptroot & Lücking
- M29b Ascomata irregularly confluent to diffusely pseudostromatic, erumpent to prominent, either fully exposed and brown-black or covered by olive-green thallus; ascospores 120–180(–200) \times 30–50(–60) μm . 30
- M30a Ascomata erumpent, fully exposed and brown-black; ascospores 120–175 \times 30–45 μm ; neotropical. *Astrothelium subdisjunctum* (Mont.) Aptroot & Lücking
- M30b Ascomata prominent, covered by thallus except dark ostiole bordered by a white rim, with one to several ascomata per thallus wart and ostioles often pointing in different directions; ascospores 160–180(–200) \times 40–50(–60) μm ; Central America. *Astrothelium nicaraguense* Lücking, M.P. Nelsen & T. Orozco
- M31a Ascospores 150–190 \times 40–45 μm ; ascomata solitary or few grouped, covered by thallus; neotropical (Brazil and Bolivia). *Astrothelium octosporoides* Aptroot & Lücking
- M31b Ascospores 60–150 \times 15–30 μm ; ascomata variable. 32
- M32a Ascomata solitary, immersed to erumpent, covered by thallus except for dark ostiolar area surrounded by irregular whitish rim; ascospores not exceeding 80 μm in length; neotropical. *Astrothelium exostemmatis* (Müll. Arg.) Aptroot & Lücking
- M32b Ascomata irregularly confluent to pseudostromatic, erumpent to prominent, fully exposed; ascospores usually exceeding 80 μm in length; Brazil. *Astrothelium chapadense* (Malme) Aptroot & Lücking

Key N. *Astrothelium* species with ascospores muriform, ostiole lateral, secondary substances present on thallus and/or ascoma

- N1a Lichexanthone present; thallus and/or ascomata UV+ yellow; pigment(s) present or absent. 2
- N1b Lichexanthone absent; pigment(s) always present, thallus and ascomata usually K+ red to purple and UV+ orange or red. 17
- N2a Hamathecium inspersed; ascomata with separate or fused ostioles. 3
- N2b Hamathecium clear; ascomata with fused ostioles. 6

- N3a Ascospores $80\text{--}115 \times 25\text{--}35\text{ }\mu\text{m}$, 4 per ascus; lichexanthone in medulla; ascomata with separate ostioles, immersed, covered by thallus; Ecuador. *Astrothelium lucidomedullatum* Aptroot
- N3b Ascospores $150\text{--}220 \times 40\text{--}65\text{ }\mu\text{m}$, 2 or 8 per ascus; lichexanthone external on thallus and/or ascomata. 4
- N4a Ascospores 8 per ascus, $40\text{--}50\text{ }\mu\text{m}$ broad; ascomata with separate ostioles,; lichexanthone on thallus and ascomata. 5
- N4b Ascospores 2 per ascus, $50\text{--}65\text{ }\mu\text{m}$ broad; ascomata with fused ostioles, groups of fused ascomata dispersed, covered by thallus except ostioles; lichexanthone on ascomata only; Brazil. *Astrothelium megalostomum* (Vain.) Aptroot & Lücking
- N5a Ascomata covered by thallus except for broad black ostiolar area; Bolivia. *Astrothelium carrascoense* Flakus, Kukwa & Aptroot
- N5b Ascomata with separate ostioles, covered by thallus, without black ostiolar area; Brazil. *Astrothelium aureoirregulare* Aptroot & Gumboski
- N6a Ascospores small ($35\text{--}45 \times 15\text{--}19\text{ }\mu\text{m}$). 7
- N6b Ascospores large ($85\text{--}250 \times 19\text{--}65\text{ }\mu\text{m}$). 8
- N7a Only ostiole UV+ yellow; fused ascomata pseudostromatic, pseudostromata erumpent, with white cover contrasting with olive-green thallus; Brazil. *Astrothelium eustomurale* Aptroot & M. Cáceres
- N7b Entire pseudostroma UV+ yellow; fused ascomata pseudostromatic, pseudostroma immersed, with white cover contrasting with olive-brown thallus; Guyana. *Astrothelium lucidostromum* Aptroot
- N8a Ascospores $150\text{--}250 \times 30\text{--}65\text{ }\mu\text{m}$, (1–)2 per ascus; ascomata with fused ostioles. 9
- N8b Ascospores $85\text{--}150 \times 19\text{--}45\text{ }\mu\text{m}$, 2 or 8 per ascus; ascomata variable. 12
- N9a Fused ascomata solitary, immersed and covered by thallus; lichexanthone on thallus and ascomata; neotropical. *Astrothelium sepultum* (Mont.) Aptroot & Lücking
- N9b Fused ascomata pseudostromatic, pseudostromata immersed, whitish and contrasting with olive-green thallus; thallus bullate-bumpy; lichexanthone on pseudostromata only. 10
- N10a Lichexanthone only on the thallus; pseudostroma with orange pigment; Brazil. *Astrothelium astrolucidum* Aptroot & M. Cáceres
- N10b Lichexanthone only on pseudostromata; pseudostromata without pigment. 11

- N11a Thallus dominated by finely and densely cracked pseudostromata, with thallus bumps dispersed; ascomata completely immersed in pseudostromata, hardly visible; Panama. *Astrothelium cryptolucens*
Lücking, M.P. Nelsen & N. Salazar
- N11b Thallus dominated by vegetative part forming large bumps separating the smooth pseudostromata; ascomata immersed to erumpent with the ostiolar area broadly exposed and black; neotropical. *Astrothelium norisianum* Lücking, M.P. Nelsen & Aptroot
- N12a Ascospores 85–130 µm long, 2 per ascus; lichexanthone internal in medulla; fused ascomata solitary to irregularly confluent, immersed to erumpent, covered by thallus except dark ostiolar area surrounded by irregular whitish rim; neotropical. *Astrothelium consimile* (Müll. Arg.) Aptroot & Lücking
- N12b Ascospores 100–150 µm long, 8 per ascus; lichexanthone external on ascomata; ascomata variable. 13
- N13a Ascospores 30–45 µm broad. 14
- N13b Ascospores 17–23 µm broad; ascomata variable. 15
- N14a Ascomata solitary; lichexanthone on pseudostromata; neotropical. *Astrothelium defossum* (Müll. Arg.) Aptroot & Lücking
- N14b Ascomata fused; lichexanthone only on ostiole; Brazil. *Astrothelium megeustomurale* M. Cáceres & Aptroot
- N15a Ascomata solitary, immersed to erumpent, covered by thallus except dark ostiolar area; thallus shallowly folded; Brazil. *Astrothelium octosporum* (Vain.) Aptroot & Lücking
- N15b Ascomata irregularly confluent to grouped, erumpent to prominent, completely covered by thallus; thallus smooth to uneven. 16
- N16a Ostioles visible as sessile, broadly white papillae; Brazil. *Astrothelium megeustomum* Aptroot & Fraga Jr.
- N16b Ostioles visible as minute, immersed dark pores; neotropical. *Astrothelium confluens* (Müll. Arg.) Aptroot & Lücking
- N17a Ascospores (small to) medium-sized (35–80 × 12–25 µm). 18
- N17b Ascospores large (75–200 × 22–50 µm). 20
- N18a pigment external on ascomata only, orange. 19
- N18b Ascomata pseudostromatic, pseudostromata immersed, whitish, forming irregular to reticulate lines, well delimited from thallus; pigment external on thallus only,

orange; French Guiana. *Astrothelium praetervisum* (Müll. Arg.) Aptroot & Lücking

N19a Ascomata pseudostromatic, with fused ostioles; Brazil. *Astrothelium muriconicum* Aptroot

N19b Ascomata solitary, immersed to erumpent, covered by thallus except dark ostiolar area surrounded by whitish rim; neotropical. *Astrothelium subaequans* Müll. Arg.

N20a Pigment orange, external on ascomata or internal in medulla. 21

N20b Pigment red, external on ascomata. 23

N21a Pigment internal in medulla of ascomata; neotropical. *Astrothelium amazonum* (R.C. Harris) Aptroot & Lücking

N21b Pigment external on ascomata. 22

N22a Ascospores $100\text{--}170 \times 30\text{--}40 \mu\text{m}$, regularly muriform; ascomata pseudostromatic, pseudostromata erumpent, with orange cover; Brazil. *Astrothelium carassense* Lücking, M.P. Nelsen & Marcelli

N22b Ascospores $90\text{--}110 \times 22\text{--}28 \mu\text{m}$, with few longitudinal septa, submuriform; ascomata solitary to irregularly grouped, covered by thallus except ostiole; neotropical. *Astrothelium diplocarpum* Nyl.

N23a Ascospores $100\text{--}130 \times 25\text{--}30 \mu\text{m}$, 8 per ascus; ascomata solitary, immersed to erumpent, irregularly bumpy with central red ostiole; neotropical. *Astrothelium purpurascens* (Müll. Arg.) Aptroot & Lücking

N23b Ascospores $150\text{--}200 \times 40\text{--}50 \mu\text{m}$, 2 per ascus; Brazil. *Astrothelium isabellinum* Eschw.

Key O. *Astrothelium* species with ascospores muriform, ostiole lateral, secondary substances absent

O1a Ascomata solitary, with separate ostioles. 2

O1b Ascomata fused, with joint ostioles. 18

O2a Hamathecium inspersed. 3

O2b Hamathecium clear. 11

O3a Ascospores $30\text{--}33 \times 9.5\text{--}10.5 \mu\text{m}$; Brazil. *Astrothelium quasimamillanum* Aptroot & C.O. Mendonça

O3b Ascospores $70\text{--}230 \times 20\text{--}55 \mu\text{m}$. 4

- O4a Ascospores $70\text{--}100 \times 20\text{--}35 \mu\text{m}$; thallus lacking pseudocyphellae. 5
- O4b Ascospores $(85\text{--})100\text{--}230 \times 25\text{--}55 \mu\text{m}$, if less than $100 \mu\text{m}$ then thallus with pseudocyphellae. 7
- O5a Ascospores curved, $74\text{--}90 \times 25\text{--}34 \mu\text{m}$; ascomata dispersed, immersed to erumpent and covered by thallus except ostioles; Brazil. *Astrothelium curvatum* Aptroot & M. Cáceres
- O5b Ascospores straight. 6
- O6a Ascospores 8 per ascus; thallus smooth to uneven; ascomata dispersed to irregularly confluent, immersed to erumpent, laterally covered by thallus but otherwise exposed and black, surrounded by irregular whitish rim; pantropical. *Astrothelium santessonii* (Letr.-Gal.) Aptroot & Lücking
- O6b Ascospores 2 per ascus; thallus verrucose-papillose; ascomata dispersed to irregularly confluent, sessile, covered by thallus except the strongly protruding ostiole; Costa Rica. *Astrothelium minicecidiogenum* Aptroot & Sipman
- O7a Ascospores $250\text{--}350 \times 40\text{--}60 \mu\text{m}$, 1 per ascus; thallus irregularly bullate-bumpy; ascomata solitary, immersed, hardly visible; Panama. *Astrothelium megacrypticum* Lücking, M.P. Nelsen & N. Salazar
- O7b Ascospores $85\text{--}230 \times 25\text{--}60 \mu\text{m}$, $(1\text{--})2\text{--}8$ per ascus; ascomata variable. 8
- O8a Ascospores 8 per ascus, $200\text{--}230 \times 30\text{--}40 \mu\text{m}$, about 6–7 times as long as broad; Brazil. *Astrothelium longisporum* Aptroot, J.R. Silva & M. Cáceres
- O8b Ascospores 1–2 per ascus. 9
- O9a Ascospores $170\text{--}340 \times 30\text{--}60 \mu\text{m}$, about 5–6 times as long as broad, 2 per ascus; neotropical. *Astrothelium puiggarii* (Müll. Arg.) Aptroot & Lücking
- O9b Ascospores $85\text{--}175 \times 25\text{--}55 \mu\text{m}$, about 2.5–4 times as long as broad. 10
- O10a Thallus with pseudocyphellae; ascomata laterally covered by thallus, with black ostiolar area surrounded by black rim; Bolivia. *Astrothelium pyrenuliforme* Flakus & Aptroot
- O10b Thallus lacking pseudocyphellae; ascomata solitary, exposed and pure black; Ecuador. *Astrothelium ecuadoriense* Aptroot
- O11a Ascospores $210\text{--}230 \mu\text{m}$ long, 1 per ascus; thallus irregularly verrucose; ascomata dispersed, immersed, hardly visible; São Tomé. *Astrothelium lugescens* (Nyl.) Aptroot & Lücking
- O11b Ascospores $70\text{--}200 \mu\text{m}$ long, $(1\text{--})2\text{--}8$ per ascus; ascomata variable. 12
- O12a Ascospores $70\text{--}130 \times 20\text{--}36 \mu\text{m}$. 13

- O12b Ascospores $120\text{--}200 \times 30\text{--}50\text{--}(60) \mu\text{m}$. 15
- O13a Ascospores 2 per ascus; ascomata irregularly confluent to pseudostromatic, immersed to erumpent, covered by thallus except black ostiolar area surrounded by irregular whitish rim; India. *Astrothelium andamanicum* (Makhija & Patw.) Aptroot & Lücking
- O13b Ascospores 4–8 per ascus; ascomata dispersed. 14
- O14a Ascospores with distinctly thickened median septum, 4–8 per ascus; thallus smooth to uneven; ascomata erumpent; pantropical. *Astrothelium tenue* (Aptroot) Aptroot & Lücking
- O14b Ascospores lacking thickened median septum, 4 per ascus; thallus gall-like, coarsely bullate to folded; ascomata solitary, immersed, visible only by the dark ostiolar area; Guyana. *Astrothelium guianense* Aptroot
- O15a Ascospores I+ violet; thallus strongly bullate; ascomata immersed in thallus warts, completely covered by thallus; Bolivia. *Astrothelium bullatum* Flakus & Aptroot
- O15b Ascospores I–. 16
- O16a Ascospores 8 per ascus; eastern palaeotropical. *Astrothelium superbum* (Fr.) Aptroot & Lücking
- O16b Ascospores 2–4 per ascus. 17
- O17a Ascomata usually single in thalline warts, warts up to 1 mm diam., with broad, diffusely grey-black ostiolar area; ostioles always eccentric; neotropical. *Astrothelium campylocartilagineum* Aptroot & Lücking
- O17b Ascomata 1–5 in thalline warts, warts up to 2 mm diam., with narrow, brown-black ostiolar area surrounded by a whitish rim; ostioles pointing in various directions including apical ones; Nicaragua. *Astrothelium nicaraguense* Lücking, M.P. Nelsen & T. Orozco
- O18a Ascospores small to medium-sized ($30\text{--}80 \times 16\text{--}26 \mu\text{m}$). 19
- O18b Ascospores large ($125\text{--}230 \times 28\text{--}80 \mu\text{m}$). 23
- O19a Hamathecium inspersed; ascospores $50\text{--}65 \mu\text{m}$ long; groups of fused ascomata irregularly confluent to pseudostromatic, immersed to erumpent, covered by thallus except black ostiolar area surrounded by irregular whitish rim; Brazil. *Astrothelium testudineum* Aptroot & M. Cáceres
- O19b Hamathecium clear; ascospores $30\text{--}52$ or $70\text{--}80 \mu\text{m}$ long. 20

- O20a Ascospores medium-sized ($70\text{--}80 \times 20\text{--}25\ \mu\text{m}$); thallus uneven-verrucose; groups of fused ascomata pseudostromatic, pseudostromata prominent, covered by thallus except for dark, papilliform ostiole; Brazil. *Astrothelium mediocrassum* Aptroot
- O20b Ascospores small ($30\text{--}52 \times 16\text{--}22\ \mu\text{m}$); thallus and ascomata variable. 21
- O21a Groups of fused ascomata hemispherical; Brazil. *Astrothelium citrisporum* Aptroot, Oliveira-Junior & M. Cáceres
- O21b Groups of fused ascomata immersed to erumpent. 22
- O22a Groups of fused ascomata pseudostromatic, pseudostromata immersed, with white cover, forming irregular to reticulate lines, contrasting with thallus; neotropical. *Astrothelium cinereum* (Müll. Arg.) Aptroot & Lücking
- O22b Groups of fused ascomata dispersed, immersed-erumpent, hardly visible; neotropical. *Astrothelium leioplacum* (Müll. Arg.) Aptroot & Lücking
- O23a Ascospores $215\text{--}230\ \mu\text{m}$ long, 1 per ascus; groups of fused ascomata dispersed, erumpent, completely covered by thallus; on rock; Brazil. *Astrothelium saxicola* (Malme) Aptroot & Lücking
- O23b Ascospores $125\text{--}200\ \mu\text{m}$ long, 8 per ascus. 24
- O24a Ascospores 2/ascus, with median thickening; hamathecium only inspersed above; Brazil. *Astrothelium dimidioinspersum* Aptroot & M. Cáceres
- O24b Ascospores 8/ascus, with or without median thickening. 25
- O25a Ascospores with median thickening; groups of fused ascomata dispersed, immersed, hardly visible; Brazil. *Astrothelium flavomurispurum* Aptroot & M. Cáceres
- O25b Ascospores lacking thickening; groups of fused ascomata dispersed to irregularly confluent, covered by thallus except whitish ostiolar area; neotropical. *Astrothelium cecidiogenum* (Aptroot & Lücking) Aptroot & Lücking

Key P. *Bathelium* species

- P1a Ascospores transversely septate. 2
- P1b Ascospores muriform. 7
- P2a Ascospores 13–17-septate, $65\text{--}105\ \mu\text{m}$ long; ostiolar area UV+ yellow, with lichexanthone; Bolivia. *Bathelium flavostiolum* Flakus & Aptroot
- P2b Ascospores 3–9-septate, $18\text{--}40\ \mu\text{m}$ long; UV–. 3
- P3a Ascospores 3(–5)-septate, $18\text{--}25(–30)\ \mu\text{m}$ long. 4

- P3b Ascospores 5–9-septate, 25–40 µm long. 6
- P4a Internal pseudostroma pigment yellow, K+ persistently yellow; ascomata distinctly pseudostromatic; USA. *Bathelium carolinianum* (Tuck.) R.C. Harris
- P4b Internal pseudostroma pigment yellow-orange to reddish brown, K+ orange-red or purple-violet; ascomata variable. 5
- P5a Internal pseudostroma pigment yellow-orange, K+ purple-violet; ascospores 18–21 × 6–7 µm long; ascomata pseudostromatic; South Africa. *Bathelium austroafricanum* (Zahlbr.) Aptroot & Lücking
- P5b Internal pseudostroma pigment reddish brown, K+ orange-red; ascospores 20–30 × 6–7 µm long; ascomata solitary to irregularly confluent; eastern palaeotropical. *Bathelium porinosporum* Lücking, M.P. Nelsen & Gueidan
- P6a Ostioles usually white-pruinose; ascospores 5–7-septate, 25–32 µm long; eastern palaeotropical. *Bathelium albidoporum* (Makhija & Patw.) R.C. Harris
- P6b Ostioles non-pruinose, black; ascospores 5–9-septate, 30–40 µm long; palaeotropical. *Bathelium nigroporum* (Makhija & Patw.) Aptroot & Lücking
- P7a Thallus and pseudostromata UV+ yellow, with lichexanthone. 8
- P7b Thallus and pseudostromata UV– or UV+ red when pigment is present, lichexanthone absent. 9
- P8a Hamathecium inspersed; Brazil. *Bathelium pruinolucens* Aptroot & Lücking
- P8b Hamathecium not inspersed; Bolivia and Brazil. *Bathelium pruinsum* Flakus, Kukwa & Aptroot
- P9a Internal pigment of pseudostromata dark red, K+ green. 10
- P9b Internal pigment of pseudostromata yellow-orange, K+ purple. 11
- P10a Pseudostromata erumpent, covered with orange pigment and with dark ostioles surrounded by paler rim; Bolivia and Brazil. *Bathelium mirabile* Flakus, Kukwa & Aptroot
- P10b Pseudostromata prominent to sessile, dark brown and with strongly contrasting, whitish ostiolar area; Bolivia. *Bathelium boliviense* Flakus & Aptroot
- P11a Ascospores 40–80 µm long. 12
- P11b Ascospores 100–200 µm long. 15
- P12a Hamathecium fully inspersed; Bolivia. *Bathelium inspersomastoideum* Flakus & Aptroot
- P12b Hamathecium clear except for ostiolar area. 13

P13a Ascospores (50–)60–80 µm long. *Bathelium mastoideum* Afzel. ex Ach.

P13b Ascospores 40–55 µm long. 14

P14a Thallus smooth to uneven; pantropical. *Bathelium madreporiforme* (Eschw.) Trevis.

P14b Thallus verrucose-bullate; pantropical. *Bathelium tuberculosum* (Makhija & Patw.)
R.C. Harris

P15a Ascospores 100–120 µm long; pantropical. *Bathelium lineare* (C.W. Dodge) R.C.
Harris

P15b Ascospores 130–200 µm long; Sierra Leone. *Bathelium sphaericum* (C.W. Dodge)
R.C. Harris

Key Q; pantropical. *Bogoriella* species

Q1a Ascospores becoming distinctly muriform, with thin eusepta and rectangular lumina.
2

Q1b Ascospores 1-septate to rarely 3-septate or submuriform, with thin eusepta or with
irregularly thickened endospore and distosepta. 4

Q2a Ascospores becoming thick-walled and with thickened
median septum, 28–45 µm long; Bolivia. *Bogoriella chiquitana* (Flakus, Kukwa &
Aptroot) Aptroot & Lücking

Q2b Ascospores remaining thin-walled, 20–35 µm long. 3

Q3a Ascospores 20–30 × 12–16 µm, about 1.5–2 times as long as broad; pantropical.
Bogoriella decipiens (Müll. Arg.) Aptroot & Lücking

Q3b Ascospores 20–35 × 7–10 µm, about 3–3.5 times as long as broad; China.
Bogoriella pandanicola (S.N. Zhang & K.D. Hyde) S.N. Zhang, Aptroot &
Lücking

Q4a Ascospores with irregularly thickened endospore and distosepta, 1-septate or rarely
3-septate to submuriform; lumina irregular to halter-shaped. 5

Q4b Ascospores with thin eusepta, 1-septate or rarely 3-septate; lumina rectangular. 8

Q5a Ascospores (1–)3-septate to appearing submuriform, 27–45 × 10–17 µm. 6

Q5b Ascospores 1-septate but cells with irregular endospore invaginations, 15–29 × 6–14
µm. 7

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- Q6a Ascospores mostly distinctly 3-septate, occasionally 1-septate or with additional longitudinal septa; pantropical. *Bogoriella queenslandica* (Müll. Arg.) Aptroot & Lücking
- Q6b Ascospores with one distinct, rather dark central septum and the two cells with irregular endospore invaginations giving them the appearance of a (sub-)muriform division; Brazil. *Bogoriella complexoluminata* Aptroot & Lücking
- Q7a Ostiole with red pigment; ascospores $23\text{--}29 \times 10\text{--}14 \mu\text{m}$, secondary endospore invaginations developing late; Hong Kong. *Bogoriella isthmospora* (Aptroot) Lücking, R. Miranda & Aptroot
- Q7b Ostiole lacking pigment; ascospores $15\text{--}18 \times 6\text{--}8 \mu\text{m}$, secondary endospore invaginations developing soon; Caribbean. *Bogoriella rubrostoma* (Aptroot) Aptroot & Lücking
- Q8a Ostiole apical. 9
- Q8b Ostiole lateral. 18
- Q9a Hamathecium inspersed. 10
- Q9b Hamathecium clear. 12
- Q10a Ascospores $24\text{--}27 \times 8\text{--}11 \mu\text{m}$; neotropical. *Bogoriella oleosa* (Aptroot) Aptroot & Schumm
- Q10b Ascospores $30\text{--}45 \times 10\text{--}15 \mu\text{m}$. 11
- Q11a Ascomata 0.5–0.7 mm diam; Venezuela. *Bogoriella xanthonica* (Komposch, Aptroot & Hafellner) Aptroot & Lücking
- Q11b Ascomata 0.7–1.1 mm diam; Venezuela. *Bogoriella macrocarpa* (Komposch, Aptroot & Hafellner) Aptroot & Lücking
- Q12a Ascospores becoming 3-septate; pantropical. *Bogoriella obovata* (Stirt.) Aptroot & Lücking
- Q12b Ascospores remaining 1-septate. 13
- Q13a Ascospores 28–40 μm long; Brazil. *Bogoriella megaspora* (Aptroot & M. Cáceres) Aptroot & Lücking
- Q13b Ascospores 17–27 μm long. 14
- Q14a Black prothallus line present. 15
- Q14b Black prothallus line absent. 16
- Q15a Asci 10–20 μm broad; eastern palaeotropical. *Bogoriella conothelena* (Nyl.) Aptroot & Lücking

Q15b Asci 20–30 µm broad; pantropical. *Bogoriella thelena* (Ach.) Aptroot & Lücking

Q16a Ascomata 0.8–1 mm diam., basally broadly expanded; pantropical. *Bogoriella confuens* (Müll. Arg.) Aptroot & Lücking

Q16b Ascomata 0.2–0.4 mm diam., basally barely or not expanded. 17

Q17a Ascomata conical; Brazil. *Bogoriella pachytheca* (Sacc. & P. Syd.) Aptroot & Lücking

Q17b Ascomata fattened; pantropical. *Bogoriella modesta* (Müll. Arg.) Aptroot & Lücking

Q18a Thallus UV-negative; Puerto Rico. *Bogoriella triangularis* (Aptroot) Aptroot & Lücking

Q18b Thallus UV+ yellow; Brazil. *Bogoriella xantholateralis* Aptroot

Key R. *Constrictolumina* species

R1a Ascospores $17\text{--}23 \times 5\text{--}8$ µm, 1–3-septate. 2

R1b Ascospores (20–)22–46 × 7–24 µm, 1-septate. 3

R2a Ascomata aggregate; neotropical. *Constrictolumina esenbeckiana* (Fée) Lücking, M.P. Nelsen & Aptroot

R2b Ascomata solitary; pa; Dominica; neotropical ntropical. *Constrictolumina cinchonae* (Ach.) Lücking, M.P. Nelsen & Aptroot

R3a Ascospores $40\text{--}46 \times 16\text{--}24$ µm. *Constrictolumina porospora* (Vain.) Lücking, M.P. Nelsen & Aptroot

R3b Ascospores $20\text{--}30 \times 7\text{--}16$ µm. 4

R4a Ascomata aggregate; ascospores 3-septate; neotropical. *Constrictolumina leucostoma* (Müll. Arg.) Lücking, M.P. Nelsen & Aptroot

R4b Ascomata solitary; ascospores 1(–3)-septate; pantropical. *Constrictolumina planorbis* (Ach.) Lücking, M.P. Nelsen & Aptroot

Key S. *Dictyomeridium* species

S1a Thallus UV+ yellow. 2

S1b Thallus UV–. 5

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- S2a Ascomata deeply immersed in the bark, ascospores 2 per ascus, $45\text{--}70 \times 17\text{--}25 \mu\text{m}$; Brazil. *Dictyomeridium immersum* (Aptroot, A.A. Menezes & M. Cáceres) Aptroot, M.P. Nelsen & Lücking
- S2b Ascomata erumpent, ascospores 8 per ascus. 3
- S3a Ascospores $25\text{--}35 \times 12\text{--}17 \mu\text{m}$; Bolivia. *Dictyomeridium lueckingii* Flakus & Aptroot
- S3b Ascospores over $35 \mu\text{m}$ long. 4
- S4a Ascospores $35\text{--}54 \times 12\text{--}19 \mu\text{m}$; pantropical. *Dictyomeridium proponens* (Nyl.) Aptroot, M.P. Nelsen & Lücking
- S4b Ascospores $55\text{--}75 \times 19\text{--}21 \mu\text{m}$; Brazil. *Dictyomeridium parapropionens* (Aptroot, M. Cáceres & E.L. Lima) Aptroot, M.P. Nelsen & Lücking
- S5a Ascospores $55\text{--}80 \times 17\text{--}25 \mu\text{m}$; eastern palaeotropical. *Dictyomeridium campylothelioides* (Aptroot & Sipman) Aptroot, M.P. Nelsen & Lücking
- S5b Ascospores under $55 \mu\text{m}$ long. 6
- S6a Ostiole with red, KOH+ green pigment inside, ascospores $33\text{--}55 \times 11\text{--}15 \mu\text{m}$; Brazil. *Dictyomeridium isohypocrellinum* (Xavier-Leite, M. Cáceres & Aptroot) Aptroot, M.P. Nelsen & Lücking
- S6b Ostiole without red pigment, ascospores $33\text{--}55 \times 12\text{--}21 \mu\text{m}$; pantropical. *Dictyomeridium amylosporum* (Vain.) Aptroot, M.P. Nelsen & Lücking

Key T. *Macroconstrictolumina* species

- T1a Ascospores $18\text{--}30 \times 7\text{--}10\text{--}12 \mu\text{m}$; pantropical. *Macroconstrictolumina lyrata* (R.C. Harris) Lücking, R. Miranda & Aptroot
- T1b Ascospores $30\text{--}48 \times 10\text{--}16\text{--}24 \mu\text{m}$. 2
- T2a Ostiole lateral; ascospores 1-septate; Brazil. *Macroconstrictolumina megalateralis* Aptroot
- T2b Ostiole apical; ascospores 1(–3)-septate. 3
- T3a Ascospores $27\text{--}37 \times 10\text{--}12 \mu\text{m}$, often 3-septate; pantropical. *Macroconstrictolumina majuscula* (Nyl.) Lücking, R. Miranda & Aptroot
- T3b Ascospores $40\text{--}50 \times 15\text{--}20 \mu\text{m}$, mostly 1-septate; pantropical. *Macroconstrictolumina malaccitula* (Nyl.) Lücking, R. Miranda & Aptroot

Key U. *Marcelaria* species

U1a Ascomata (and often thallus) bright red, UV–; hamathecium clear; ascospores 110–170 µm long, amyloid; Neotropics and African Palaeotropics. *Marcelaria purpurina* (Nyl.) Aptroot, Nelsen & Parnmen

U1b Ascomata (and often thallus) (orange-)yellow, UV+ yellow; hamathecium densely inspersed; ascospores 50–80 µm long, non-amyloid (rarely dextrinoid); eastern Palaeotropics. 2

U2a Thallus yellow-pruinose; ascospores 8 per ascus; ostiolar region narrow. *Marcelaria benguelensis* (Müll. Arg.) Aptroot, Nelsen & Parnmen

U2b Thallus non-pruinose; ascospores 2 per ascus; ostiolar region broad, flat. *Marcelaria cumingii* (Mont.) Aptroot, Nelsen & Parnmen

Key V. *Nigrovothelium* species

V1a Hamathecium inspersed; pantropical. *Nigrovothelium inspersotropicum* Aptroot & Diederich

V1b Hamathecium clear. 2

V2a Thallus smooth to uneven; pantropical. *Nigrovothelium tropicum* (Ach.) Lücking, M.P. Nelsen & Aptroot

V2b Thallus verrucose-bullate; India. *Nigrovothelium bullatum* Lücking, Upreti & Lumbsch

Key W. *Polymeridium* species

W1a Ascospores transversely septate. 2

W1b Ascospores submuriform to muriform. 49

W2a Ascospores regularly 3-septate. 3

W2b Ascospores irregularly (3–)4–17-septate. 28

W3a Thallus UV+ yellow, with lichexanthone. 4

W3b Thallus UV–, without substances or rarely with medullary pigments or pruina on ascomata. 14

W4a Hamathecium inspersed. 5

W4b Hamathecium clear. 7

W5a Ascospores $24\text{--}33 \times 6\text{--}10 \mu\text{m}$; pantropical. *Polymeridium subvirescens* (Nyl.) R.C. Harris

W5b Ascospores $17\text{--}23 \times 5\text{--}8 \mu\text{m}$. 6

W6a Ascospores $17\text{--}20 \times 5\text{--}7 \mu\text{m}$; pantropical. *Polymeridium pyrenuloides* (Müll. Arg.) Aptroot

W6b Ascospores $20\text{--}23 \times 6\text{--}8 \mu\text{m}$; pantropical. *Polymeridium albidovarians* Aptroot

W7a Ostioles eccentric, separate or fused; ascospores $24\text{--}33 \mu\text{m}$ long. 8

W7b Ostioles apical; ascospores variable. 9

W8a Ostioles fused; Venezuela. *Polymeridium pyrenastroides* R.C. Harris ex Aptroot

W8b Ostioles separate; neotropical. *Polymeridium stramineoatrum* (Vain.) Aptroot

W9a Ascospores IKI+ violet, $16\text{--}23 \times 5\text{--}7 \mu\text{m}$; Brazil. *Polymeridium amyloideum* R.C. Harris

W9b Ascospores IKI-. 10

W10a Ascospores $13\text{--}20 \times 4\text{--}6 \mu\text{m}$. 11

W10b Ascospores $19\text{--}33 \times 6\text{--}11 \mu\text{m}$. 12

W11a Ascospores $13\text{--}17 \mu\text{m}$ long; pantropical. *Polymeridium albopruinosum* (Makhija & Patw.) Aptroot

W11b Ascospores $16\text{--}20 \mu\text{m}$ long; pantropical. *Polymeridium bengoanum* (Vain.) Aptroot

W12a Ascomata mostly covered by thallus, with black ostioles bordered by white ring; ascospores relatively broad, $17\text{--}25 \times 7\text{--}11 \mu\text{m}$, c. 2.5 times as long as broad; Australia. *Polymeridium xanthoreagens* Aptroot

W12b Ascomata pure black; ascospores narrower, $20\text{--}33 \times 6\text{--}10 \mu\text{m}$, about 3 times as long. 13

W13a Ascospores $20\text{--}23 \times 6\text{--}8 \mu\text{m}$; Brazil. *Polymeridium albidoreagens* Aptroot, A.A. Menezes & M. Cáceres

W13b Ascospores $25\text{--}33 \times 7\text{--}10 \mu\text{m}$; pantropical. *Polymeridium catapastum* (Nyl.) R.C. Harris

W14a Hamathecium inspersed; ostioles apical. 15

W14b Hamathecium clear; ostioles variable. 20

W15a Ascospores $24\text{--}34 \mu\text{m}$ long; ascomata laterally covered by thallus. 16

- W15b Ascospores 12–24 μm long; ascomata variable. 17
- W16a Ascospores with rough wall, 26–34 μm long; blackish ostiolar area broad; eastern palaeotropical. *Polymeridium glaucostrum* (Vain.) R.C. Harris
- W16b Ascospores smooth, 24–30 μm long; blackish ostiolar area narrow; eastern palaeotropical. *Polymeridium suffusum* (Knight) Aptroot
- W17a Ascospores 12–20 \times 3–6 μm . 18
- W17b Ascospores 20–24 \times 5–10 μm . 19
- W18a Ascospores 12–16 μm long; neotropical. *Polymeridium contendens* (Nyl.) R.C. Harris
- W18b Ascospores 16–20 μm long; pantropical. *Polymeridium inspersum* Aptroot
- W19a Ascomata with ostioles bordered by white ring; ascospores relatively broad, 20–24 \times 7–10 μm , c. 2.5–3 times as long as broad; pantropical. *Polymeridium tribulationis* Aptroot
- W19b Ascomata pure black; ascospores narrower, 20–23 \times 5–7 μm , c. 3–4 times as long as broad; pantropical. *Polymeridium siamense* (Vain.) Aptroot
- W20a Ascomata with internal or external, yellow-orange or red pigment. 21
- W20b Ascomata without pigments. 22
- W21a Ascomata with internal, yellow-orange, K+ purple pigment; ascospores 30–34 \times 9–10 μm ; Brazil. *Polymeridium endocrocinum* R.C. Harris
- W21b Ascomata with external, red, K+ red pruina; ascospores 17–19 \times 4–5 μm ; Puerto Rico. *Polymeridium rhodopruinosum* Aptroot & Mercado Diaz
- W22a Ostioles lateral. 23
- W22b Ostioles apical. 24
- W23a Ascomata grouped with fused ostioles; ascospores 26–30 \times 8–10 μm ; Brazil. *Polymeridium biloculare* R.C. Harris
- W23b Ascomata solitary with separate ostioles; ascospores 30–35 \times 12–13 μm ; neotropical. *Polymeridium simulans* R.C. Harris
- W24a Ascospores 24–33 μm long; eastern palaeotropical. *Polymeridium catapastoides* Aptroot
- W24b Ascospores 11–27 μm long. 25
- W25a Ascospores 11–16 \times 3–6 μm ; pantropical. *Polymeridium microsporum* (Makhija & Patw.) Aptroot

W25b Ascospores longer. 26

W26a Ascospores (15–)16–20 × 5.0–7.5 µm; pantropical. *Polymeridium subcinereum* (Nyl.) R.C. Harris

W26b Ascospores 19–27 × 6–11 µm. 27

W27a Ostiole flat and with white ring; ascospores 19–27 × 6.5–11.0 µm; eastern palaeotropical.

Polymeridium sulphurescens (Müll. Arg.) R.C. Harris

W27b Ostiole not flat, black; ascospores (18–)20–23 × 6–8(–9) µm; pantropical. *Polymeridium albidum* (Müll. Arg.) R.C. Harris

W28a Thallus UV+ yellow, with lichexanthone. 29

W28b Thallus UV–, without substances. 38

W29a Hamathecium inspersed. 30

W29b Hamathecium clear. 33

W30a Hamathecium yellow. 31

W30b Hamathecium hyaline. 32

W31a Ascospores 5–7-septate, 32–37 × 10–13 µm; Brazil. *Polymeridium endoflavens* Aptroot, D.S. Andrade & M. Cáceres

W31b Ascospores 8–12-septate, 56–70 × 12–14 µm; Brazil. *Polymeridium longiflavens* Aptroot, Mendonça & M. Cáceres

W32a Ascospores 4–7-septate, 18–28 × 5–7 µm; pantropical. *Polymeridium multiseptatum* Aptroot, A.A. Menezes & M. Cáceres

W32b Ascospores 8–12-septate, 40–50 × 9–11 µm; neotropical. *Polymeridium chioneum* (Mont.) R.C.Harris

W33a Ascomata with lateral ostioles. 34

W33b Ascomata with apical ostioles. 36

W34a Ascomata solitary, ascospores 11–13-septate, 52–88 × 16–19 µm; Panama. *Polymeridium xanthopleurothecium* Aptroot & Etayo

W34b Ascomata grouped with lateral, fused ostioles. 35

W35a Ascospores 28–35 µm long; neotropical. *Polymeridium dithecium* R.C. Harris

W35b Ascospores 30–50 µm long; Bolivia. *Polymeridium xanthoexcentricum* Flakus & Aptroot

- W36a Ascospores (4–)5(–7)-septate, 19–26 μm long; neotropical. *Polymeridium multifforme* Aptroot
- W36b Ascospores 7–13-septate, 28–39 μm long. 37
- W37a Thallus corticate; Brazil. *Polymeridium corticatum* A.A. Menezes, M. Cáceres & Aptroot
- W37b Thallus ecorticate; neotropical. *Polymeridium alboflavescens* Aptroot
- W38a Hamathecium inspersed. 39
- W38b Hamathecium clear. 45
- W39a Hamathecium yellow. 40
- W39b Hamathecium hyaline. 41
- W40a Ascospores 8–12-septate, 40–55 \times 9–11 μm ; ostioles lateral; ; neotropical. *Polymeridium flavothecium* R.C. Harris
- W40b Ascospores 6–8-septate, 35–37 \times 7.5–8 μm ; ostioles apical; Sri Lanka. *Polymeridium fernandoi* Aptroot & Weerakoon
- W41a Ostioles lateral; ascospores 3–6-septate, 22–26 \times 7–9 μm ; India. *Polymeridium refertum* (Stirt.) Aptroot
- W41b Ostioles apical; ascospores variable. 42
- W42a Ascospores 4–7-septate. 43
- W42b Ascospores 7–12-septate. 44
- W43a Ascospores with rough wall, 7-septate, 30–33 \times 9–10 μm ; Venezuela. *Polymeridium neuwirthii* Aptroot
- W43b Ascospores smooth, (4–)5(–7)-septate, 18–28 \times 4–7 μm ; pantropical. *Polymeridium quinqueseptatum* (Nyl.) R.C. Harris
- W44a Ascospores 7–11-septate, 25–36 \times 5–9 μm ; pantropical. *Polymeridium pleiomerellum* (Müll. Arg.) R.C. Harris
- W44b Ascospores 8–12-septate, 40–50 \times 9–11 μm ; neotropical. *Polymeridium costaricense* Aptroot
- W45a Ostioles lateral. 46
- W45b Ostioles apical. 47
- W46a Ascospores 7–9-septate, 40–50 \times 8–9 μm ; neotropical. *Polymeridium neblinae* R.C. Harris

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- W46b Ascospores 9–13-septate, (35–)50–75 × 12–16 µm; pantropical. *Polymeridium pleurothecium* R.C. Harris
- W47a Ascospores 13–17-septate, 85–150 × 20–30 µm; Argentina. *Polymeridium bambusicola* Aptroot & L.I. Ferraro
- W47b Ascospores 4–11-septate, 21–39 × 5–9 µm. 48
- W48a Ascospores (4–)5(–7)-septate, 21–30 × 5–9 µm; pantropical. *Polymeridium jordanii* (C.W. Dodge) Aptroot
- W48b Ascospores 7–11-septate, (24–)28–39 × 6–9 µm; pantropical. *Polymeridium albocinereum* (Kremp.) R.C. Harris
- W49a Hamathecium inspersed, ascospores 18–20 × 6.0–7.5 µm; Philippines. *Polymeridium submuriforme* Aptroot
- W49b Hamathecium clear, ascospores 25–45 × 9–13 µm. 50
- W50a Ascospores 30–45 × 9–11 µm, submuriform, 3–4 times as long as broad; neotropical. *Polymeridium cinereonigricans* (Vain.) R.C. Harris
- W50b Ascospores 25–29 × 11–13 µm, muriform, 2.0–2.5 times as long as broad; Brazil. *Polymeridium julelloides* E.L. Lima, M. Cáceres & Aptroot

Key X. *Pseudobogoriella* species

- X1a Ostiole lateral; Australia. *Pseudobogoriella lateralis* (Sipman) Lücking, R. Miranda & Aptroot
- X1b Ostiole apical 2
- X2a Ascospores 24–28 µm long; pantropical. *Pseudobogoriella hemisphaerica* (Müll. Arg.) Lücking, R. Miranda & Aptroot
- X2b Ascospores 12–22 µm long. 3
- X3a Thallus foliicolous, subcuticular, distinctly lobed; New Zealand. *Pseudobogoriella striguloides* (Sérus. & Aptroot) Lücking, R. Miranda & Aptroot
- X3b Thallus corticolous, not lobed. 4
- X4a Excipulum with K+ red, dissolving pigment; pantropical. *Pseudobogoriella leuckertii* (D. Hawksw. & J.C. David) Lücking, R. Miranda & Aptroot
- X4b Excipulum lacking pigment. 5

- X5a Black prothallus line with numerous pycnidia present; pantropical. *Pseudobogoriella punctata* (Aptroot) Lücking, R. Miranda & Aptroot
- X5b Black prothallus line lacking pycnidia or absent. 6
- X6a Thallus besides ascomata with numerous black dots representing pycnidia. 7
- X6b Thallus lacking pycnidia. 8
- X7a Ascomata aggregate; ascospores $15\text{--}20 \times 6\text{--}9 \mu\text{m}$; neotropical. *Pseudobogoriella socialis* (Zahlbr.) Lücking, R. Miranda & Aptroot
- X7b Ascomata solitary; ascospores $11\text{--}17 \times 5\text{--}7 \mu\text{m}$; pantropical. *Pseudobogoriella fumosula* (Zahlbr.) Lücking, R. Miranda & Aptroot
- X8a Involucrellum broadly expanding basally to over 0.5 mm diam; pantropical. *Pseudobogoriella alata* (Groenh. ex Aptroot) Lücking, R. Miranda & Aptroot
- X8b Ascomata including basally slightly expanding involucrellum 0.2–0.5 mm diam. 9
- X9a Ascospores 12–16 μm long. 10
- X9b Ascospores 16–22 μm long. 12
- X10a Ascomata 03–05 mm diam; pantropical. *Pseudobogoriella subfallens* (Müll. Arg.) Lücking, R. Miranda & Aptroot
- X10b Ascomata 02–03 mm diam. 11
- X11a Ascospores 4–55 μm broad, 25–3 times as long as broad; involucrellum basally not expanding; pantropical. *Pseudobogoriella exigua* (Müll. Arg.) Lücking, R. Miranda & Aptroot
- X11b Ascospores 55–7 μm broad, 2–25 times as long as broad; involucrellum basally expanding; China. *Pseudobogoriella minutula* (Zahlbr.) Lücking, R. Miranda & Aptroot
- X12a Black prothallus line present. 13
- X12b Black prothallus line absent. 14
- X13a Ascomata conical, basally not expanded; neotropical. *Pseudobogoriella captiosa* (Müll. Arg.) Lücking, R. Miranda & Aptroot
- X13b Ascomata fattened, basally expanded; pantropical. *Pseudobogoriella miculiformis* (Müll. Arg.) Lücking, R. Miranda & Aptroot
- X14a Ascomata basally broadly expanded, fringe 50–100 μm Broad; pantropical. *Pseudobogoriella annonacea* (Müll. Arg.) Lücking, R. Miranda & Aptroot
- X14b Ascomata basally narrowly expanded, fringe 20–50 μm

Broad; pantropical. *Pseudobogoriella nonensis* (Stirt.) Lücking, R. Miranda & Aptroot

Key Y. *Pseudopyrenula* species

Y1a Thallus UV+ yellow, with lichexanthone. 2

Y1b Thallus UV-. 6

Y2a Hamathecium clear; ascospores $30\text{--}45 \times 8\text{--}11 \mu\text{m}$; Venezuela. *Pseudopyrenula cryptotheca* Komposch, Aptroot & Hafellner

Y2b Hamathecium inspersed with hyaline or yellow oil droplets; ascospores under $37 \mu\text{m}$ long. 3

Y3a Hamathecium inspersed with yellow oil droplets. 4

Y3b Hamathecium inspersed with hyaline oil droplets. 5

Y4a Ascospores $21\text{--}28 \times 6\text{--}9 \mu\text{m}$; neotropical. *Pseudopyrenula flavoreagens* Aptroot & M. Cáceres

Y4b Ascospores $26\text{--}36 \times 7\text{--}10 \mu\text{m}$; Bolivia. *Pseudopyrenula flavosuperans* Flakus & Aptroot

Y5a Ascospores $21\text{--}25 \times 6\text{--}9 \mu\text{m}$; neotropical. *Pseudopyrenula guianensis* Aptroot

Y5b Ascospores $30\text{--}35 \times 9\text{--}11 \mu\text{m}$; neotropical. *Pseudopyrenula superans* Müll. Arg.

Y6a Ascospores 5-septate, $16\text{--}21 \times 6\text{--}7 \mu\text{m}$; Venezuela. *Pseudopyrenula hexamera* Aptroot

Y6b Ascospores 3-septate. 7

Y7a Thallus corticate; ascospores $21\text{--}25 \times 6\text{--}9 \mu\text{m}$; Costa Rica. *Pseudopyrenula thallina* Lücking & Aptroot

Y7b Thallus not corticate. 8

Y8a Hamathecium inspersed with hyaline or yellow oil droplets. 9

Y8b Hamathecium clear (but ascospores may contain yellow oil). 19

Y9a Hamathecium inspersed with yellow oil droplets. 10

Y9b Hamathecium inspersed with hyaline oil droplets (but ascospores may contain yellow oil). 14

Y10a Ascospores $37\text{--}44 \times 10\text{--}12 \mu\text{m}$; neotropical. *Pseudopyrenula endoxantha* (Vain.) Zahlbr.

Y10b Ascospores under $35 \times 10 \mu\text{m}$. 11

- Y11a Ascospores $25\text{--}30 \times 7.5\text{--}8.5 \mu\text{m}$; pantropical. *Pseudopyrenula media* Aptroot & Diederich
Y11b Ascospores $13\text{--}25 \times 5.5\text{--}9 \mu\text{m}$. 12
- Y12a Ascospores $13\text{--}17 \times 5.5\text{--}6.5 \mu\text{m}$; Brazil. *Pseudopyrenula miniflavida* Aptroot & A.D. Nunes
Y12b Ascospores $18\text{--}25 \times 6\text{--}9 \mu\text{m}$. 13
- Y13a Ascospores $21\text{--}25 \times 6\text{--}9 \mu\text{m}$; hamathecium K+ deep yellow to reddish; pantropical. *Pseudopyrenula subgregaria* Müll. Arg.
Y13b Ascospores $18\text{--}22 \times 6\text{--}8 \mu\text{m}$; hamathecium K+ weakly purplish; Thailand. *Pseudopyrenula endoxanthoides* Vain.
- Y14a Ascoma wall with yellow, K+ red pigment; ascospores $21\text{--}32 \times 7\text{--}10 \mu\text{m}$; Brazil. *Pseudopyrenula cerei* Vain.
Y14b Ascoma wall without yellow pigment. 15
- Y15a Thallus saxicolous; ascospores $35\text{--}45 \times 11\text{--}13 \mu\text{m}$; Brazil. *Pseudopyrenula saxicola* Malme
Y15b Thallus corticolous; ascospores under $38 \mu\text{m}$ long. 16
- Y16a Ascospores $33\text{--}37 \times 10\text{--}12 \mu\text{m}$; neotropical. *Pseudopyrenula dubia* Vain.
Y16b Ascospores under $33 \mu\text{m}$ long. 17
- Y17a Ascospores $(24\text{--})26\text{--}32 \times 7\text{--}10 \mu\text{m}$; pantropical. *Pseudopyrenula diluta* (Fée) Müll. Arg.
Y17b Ascospores $21\text{--}25 \times 6\text{--}9 \mu\text{m}$. 18
- Y18a Ostioles eccentric; Cuba. *Pseudopyrenula cubana* (Müll. Arg.) Aptroot & Lücking
Y18b Ostioles apical; pantropical. *Pseudopyrenula subnudata* Müll. Arg.
- Y19a Thallus without algae, brownish, of bark colour. 20
Y19b Thallus with algae, whitish. 22
- Y20a Ascospores $45\text{--}55 \times 12\text{--}15 \mu\text{m}$; USA (Florida). *Pseudopyrenula staphyleae* (Petr.) Aptroot
Y20b Ascospores under $40 \mu\text{m}$ long. 21
- Y21a Ascospores $25\text{--}29 \times 7\text{--}9 \mu\text{m}$; Papua New Guinea. *Pseudopyrenula papuana* Aptroot

- Y21b Ascospores $30\text{--}39 \times 6\text{--}8 \mu\text{m}$; Papua New Guinea. *Pseudopyrenula serusiauxii* Aptroot
- Y22a Ascospores $12\text{--}18 \times 4\text{--}6 \mu\text{m}$; Tasmania. *Pseudopyrenula kantvilasii* (P.M. McCarthy) Aptroot, comb. nov. Mycobank no 841169; basionym: *Lithothelium kantvilasii* P.M. McCarthy, Telopea 18: 168, 2015. The description and illustration show several characters that are characteristic of the genus *Pseudopyrenula*, especially the presence of yellow oil in the ascospores, which is unknown from any other genus, but also the diamond-shaped lumina and the branched hamathecium filaments.
- Y22b Ascospores $26\text{--}35 \times 7\text{--}11 \mu\text{m}$. 23
- Y23a Ascospores $26\text{--}32 \times 7\text{--}10 \mu\text{m}$; neotropical. *Pseudopyrenula americana* Aptroot
- Y23b Ascospores $30\text{--}35 \times 9\text{--}11 \mu\text{m}$; Brazil. *Pseudopyrenula gelatinosa* Aptroot

Key *Z. Trypethelium* species

- Z1a Thallus, pseudostroma and/or ostioles UV+ yellow, with lichexanthone 2
- Z1b Thallus, pseudostroma and ostioles UV-. 9
- Z2a Thallus UV-, only pseudostroma and/or ostioles UV+ yellow 3
- Z2b Thallus and sometimes also pseudostroma UV+ yellow 4
- Z3a Pseudostroma UV+ yellow outside, with yellow pigment inside. *Trypethelium aureornatum* Aptroot
- Z3b Only ostioles UV+ yellow; Brazil. *Trypethelium xanthostiolornatum* Aptroot
- Z4a Hamathecium not inspersed. 5
- Z4b Hamathecium inspersed. 8
- Z5a Pseudostromata externally with orange pigment; Bolivia. *Trypethelium xanthoplatystomum* Flakus & Aptroot
- Z5b Pseudostromata internally with yellow pigment. 6
- Z6a Thallus and pseudostroma UV+ yellow; neotropical. *Trypethelium tolimense* Lücking, Moncada & M. Gut.
- Z6b Only thallus UV+ yellow; pseudostroma UV-. 7
- Z7a Ascospores muriform; Brazil. *Trypethelium muriforme* Aptroot & M.F. Souza
- Z7b Ascospores only transversely septate; Brazil. *Trypethelium endoflavum* Aptroot

- Z8a Pseudostromata lacking pigment, prominent; ascospores (65–)83–97 × 11–15 µm, 13–19-septate; *Brazil. Trypethelium regnellii* Malme
- Z8b Pseudostromata internally with yellow pigment; neotropical. *Trypethelium tolimense* Lücking, B. Mocada & M.C. Gut.
- Z9a Pseudostromata inside and/or outside with yellow or orange pigments (sometimes thin and not readily visible). 10
- Z9b Pseudostromata lacking pigments. 15
- Z10a Ostiolar areas very broad, disc-shaped or fused in lobate fashion; pigments usually sparse. 11
- Z10b Ostiolar areas narrow, visible as small dots; pigments conspicuous 13
- Z11a Ostiolar areas disc-shaped, uniformly brown-black, marginally with small, black papillae arranged in circular fashion. *Trypethelium krempelhuberi* Makhija & Patw.
- Z11b Ostiolar areas fused in lobate fashion, contrasting with a bordering whitish rim, without marginal papillae. 12
- Z12a Ostiolar area centrally with dark red pigment in addition to orange pigment bordering the ostiolar lobes; ostioles sometimes eccentric and fused; ascospores 65–100 µm long; neotropical. *Trypethelium astroideum* Flakus & Aptroot
- Z12b Ostiolar area only with bordering orange pigment; ostioles always apical; ascospores 55–75 µm long; pantropical. *Trypethelium platystomum* Mont.
- Z13a Pseudostromata immersed to erumpent; ascospores 37–42 µm long, 7–9-septate; Vietnam. *Trypethelium infraeluteriae* Aptroot & Gueidan
- Z13b Pseudostromata prominent to sessile; ascospores (37–)42–85 µm long, 9–17-septate. 14
- Z14a Pseudostromata inside and/or outside with yellow pigment; ascospores 37–52 × 8–11 µm, 9–13-septate; pantropical. *Trypethelium eluteriae* Spreng.
- Z14b Pseudostromata inside and/or outside with orange-yellow pigment; ascospores 60–85 × 11–12 µm, 13–16-septate; pantropical. *Trypethelium subeluteriae* Makhija & Patw.
- Z15a Pseudostromata immersed-erumpent, with ascomata clearly distinguished and individually protruding, brown-black. 16
- Z15b Pseudostromata erumpent to prominent, with ascomata completely immersed in the pseudostromata and not individually protruding, with whitish ostiolar spot or ostiolar area surrounded by irregular whitish to cream-coloured rim or pseudostromata entirely whitish. 17

- Z16a Thallus verrucose-rugose; individual ascomata with flattened top; ascospores $45\text{--}55 \times 6\text{--}8 \mu\text{m}$, 12–17-septate; palaeotropical. *Trypethelium plicatorimosum* Makhija & Patw.
- Z16b Thallus smooth to uneven; individual ascomata with convex top; ascospores $21\text{--}40 \times 9\text{--}15 \mu\text{m}$, 5–11-septate; pantropical. *Trypethelium inaequale* Fée
- Z17a Pseudostromata erumpent to prominent, entirely white or cream-coloured; hamathecium clear. 18
- Z17b Pseudostromata prominent to sessile, grey to black with contrasting, white ostiolar spots; hamathecium inspersed. 19
- Z18a Pseudostromata entirely white, with small, dark ostiolar spots; ascospores $30\text{--}60 \mu\text{m}$ long, 5–9(–13)-septate; palaeotropical. *Trypethelium epileucodes* Nyl.
- Z18b Pseudostromata cream-coloured, with larger, often angular-lobate ostiolar spots; ascospores $58\text{--}78 \mu\text{m}$ long, 9–15-septate; Brazil. *Trypethelium foveolatum* Müll. Arg.
- Z19a Pseudostromata sessile with constricted base, upper part black, sharply contrasting with white ostiolar spots; ascospores $80\text{--}110 \times 14\text{--}18 \mu\text{m}$, 13–19-septate; Africa. *Trypethelium sphaerocephalum* (Vain.) Zahlbr.
- Z19b Pseudostromata prominent to sessile, grey to black with contrasting, white ostiolar spots; hamathecium inspersed; neotropical. *Trypethelium ornatum* Müll. Arg.

Ω Key of . *Viridothelium* species

- Ω1a Ascospores muriform; thallus and ascomata strongly contrasting in colour, with thallus brownish and ascomata white with black ostiolar areas; neotropical. *Viridothelium tricolor* Lücking, M.P. Nelsen & N. Salazar
- Ω1b Ascospores transversely septate; thallus and ascomata not strongly contrasting in colour, more or less olive-green to yellowish brown with ascomata sometimes blackish. 2
- Ω2a Ascospores 5- or more septate. 3
- Ω2b Ascospores 3-septate. 10
- Ω3a Ostioles eccentric. 4
- Ω3b Ostioles apical. 6
- Ω4a Ascospores $75\text{--}98 \times 17\text{--}20 \mu\text{m}$, 15–19-septate; Solomon Islands. *Viridothelium solomonense* Aptroot

- Ω4b Ascospores $90\text{--}152 \times 22\text{--}33\text{ }\mu\text{m}$. 5
- Ω5a Ascospores $99\text{--}152 \times 26\text{--}33\text{ }\mu\text{m}$, (9–)15–17-septate; India. *Viridothelium megaspermum* (Makhija & Patw.) Aptroot & Lücking
- Ω5b Ascospores $90\text{--}100 \times 22\text{--}26\text{ }\mu\text{m}$, 15–21-septate; Fiji. *Viridothelium vonkonratii* Lücking, Naksuwankul & Lumbsch
- Ω6a Hamathecium inspersed; ascospores $60\text{--}75 \times 12\text{--}17\text{ }\mu\text{m}$, 12–14-septate; Papua New Guinea. *Viridothelium inspersum* Aptroot
- Ω6b Hamathecium clear. 7
- Ω7a Ascospores $90\text{--}150\text{ }\mu\text{m}$ long. 8
- Ω7b Ascospores $38\text{--}80\text{ }\mu\text{m}$ long. 9
- Ω8a Ascospores $90\text{--}105 \times 12\text{--}16\text{ }\mu\text{m}$, (9–)13–17-septate; eastern palaeotropical. *Viridothelium indutum* (Stirt.) Aptroot & Lücking
- Ω8b Ascospores $100\text{--}150 \times 18\text{--}23\text{ }\mu\text{m}$, 17–25-septate; Malaysia. *Viridothelium kinabaluense* Aptroot
- Ω9a Ascospores $38\text{--}52 \times 7\text{--}10\text{ }\mu\text{m}$; temperate America and Asia. *Viridothelium virens* (Tuck. ex Michener) Lücking, M.P. Nelsen & Aptroot
- Ω9b Ascospores $50\text{--}80 \times 8\text{--}15\text{ }\mu\text{m}$; temperate Asia. *Viridothelium cinereoglauescens* (Vain.) Lücking, M.P. Nelsen & Aptroot
- Ω10a Thallus and ascomata thinly furnished with orange pigment; Brazil. *Viridothelium leptoseptatum* Aptroot & M. Cáceres
- Ω10b Thallus and ascomata lacking pigment. 11
- Ω11a Ascomata mostly single, immersed to erumpent; Brazil. *Viridothelium sinuosogelatinosum* Aptroot & M. Cáceres
- Ω11b Ascomata in dense, raised groups; Brazil. *Viridothelium ustulatum* M. Cáceres & Aptroot