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Standard Paper

Identification key to the lichen species of the parmelioid clade in Kenya

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Abstract

Of the *c*. 900 lichen species known from Kenya, 178 belong to the parmelioid clade. Several of these parmelioid taxa require further revisionary studies. An identification key to the species of the parmelioid clade, based on updated nomenclature, is produced to support the practical work in collecting and selecting certain parmelioid lichens for further research. A new combination *Parmotrema nyasense* (C. W. Dodge) R. S. Egan comb. nov. in Egan *et al*., *Bibliotheca Lichenologica* **110**, 383 (2016) is published here by R. S. Egan.

Key words: East Africa, lichenized fungi, nomenclature, *Parmeliaceae*, species determination, taxonomy

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Introduction

East African fruticose and foliose lichens were studied in detail through the joint efforts of Dougal Swinscow and Hildur Krog in the 1970s and 1980s, resulting in a synthesis in 1988 (Swinscow & Krog 1988). The taxonomy and nomenclature of taxa treated in their identification book '*Macrolichens of East Africa*' have been significantly changed as a result of molecular genetic studies carried out during the last decades in several taxonomic groups, especially in the family *Parmeliaceae* (e.g. Blanco *et al*. 2004, 2006; Crespo *et al*. 2007, 2010, 2011; Divakar *et al*. 2010; Thell *et al*. 2012; Leavitt *et al*. 2018; Grewe *et al*. 2020). This species-rich lichen family is widely distributed in the Southern Hemisphere and its largest clade, the parmelioid clade, contains one tenth of the lichen species known worldwide (with *c*. 1800 spp. (Kirk *et al*. 2008; Thell *et al*. 2012)). The group is also rich in lichen secondary metabolites with various bioactive and other potential roles. However, the identification of these taxa is difficult since the only key to macrolichens of East Africa (Swinscow & Krog 1988) needs to be revised. In an attempt to update a considerable part of the key, we are concentrating on parmelioid taxa in Kenya. This family is not only rich in species, but also characterized by an enormous diversity in its lichen secondary metabolites (LSMs) (Divakar & Upreti 2005). Additionally, our knowledge of the various biological and other roles of these unique substances has also increased (Molnár & Farkas 2010; Nguyen *et al*. 2013; Petrova *et al*. 2021). However, little information is available regarding the application of LSMs in terms of their potential insecticidal and antiprotozoal activity (Muhoro & Farkas 2021). Since *Parmeliaceae* is largely found in the Southern Hemisphere with main distribution centres being in southern Africa, South America and Australia (Elix 1993), field collectors in these regions frequently meet representatives of this taxonomic group. In the case of Kenya, 178 of the *c*. 900 lichen species belong to the parmelioid clade (Krog & Swinscow 1987; Swinscow & Krog 1988; Hale 1990; Staiger & Kalb 1995; Alstrup & Aptroot 2005; Alstrup & Christensen 2006; Archer *et al*. 2009; Alstrup *et al*. 2010; Kirika *et al*. 2012, 2016*a*, *b*, *c*, 2017*a*, *b*, 2019; Lücking & Timdal 2016; Bjelland *et al*. 2017; Kantelinen *et al*. 2021; Kirika & Lumbsch 2021) .

Certain species of the parmelioid clade were investigated in our study to determine their potential insecticide role, the second author using his parasitological experience to carry out field and experimental studies on malaria vector mosquitoes. To aid further field collections of relatively frequent lichens, one of the main aims of this study was to prepare a practical key for identifying species of the parmelioid clade found in Kenya.

Materials and Methods

The list of parmelioid taxa in Kenya (see Supplementary Material, available online) was extracted from the species treated by Swinscow & Krog (1988). Additional species were added from recently published literature sources (Kirika *et al*. 2016*a*, *b*, *c*, 2017*a*, *b*, 2019). Altogether 178 species were listed belonging to the genera *Bulborrhizina* (1), *Bulbothrix* (9), *Canoparmelia* (9), *Cetrelia* (1), *Crespoa* (1), *Flavoparmelia* (4), *Flavopunctelia* (2), *Hypotrachyna* (37), *Melanelixia* (1), *Myelochroa* (1), *Parmelia* (2), *Parmelinella* (1), *Parmotrema* (64), *Pseudoparmelia* (2), *Punctelia* (9), *Relicina* (4), *Remototrachyna* (1) and *Xanthoparmelia* (29). In compiling the key to parmelioid lichen species of Kenya, the most important sources were the identification keys prepared by Swinscow & Krog (1988), Divakar & Upreti (2005) and Awasthi (2007). Several valuable works on various genera were also studied from the Neotropics (Adler 1992, 2014; Sipman *et al*. 2009; Canêz

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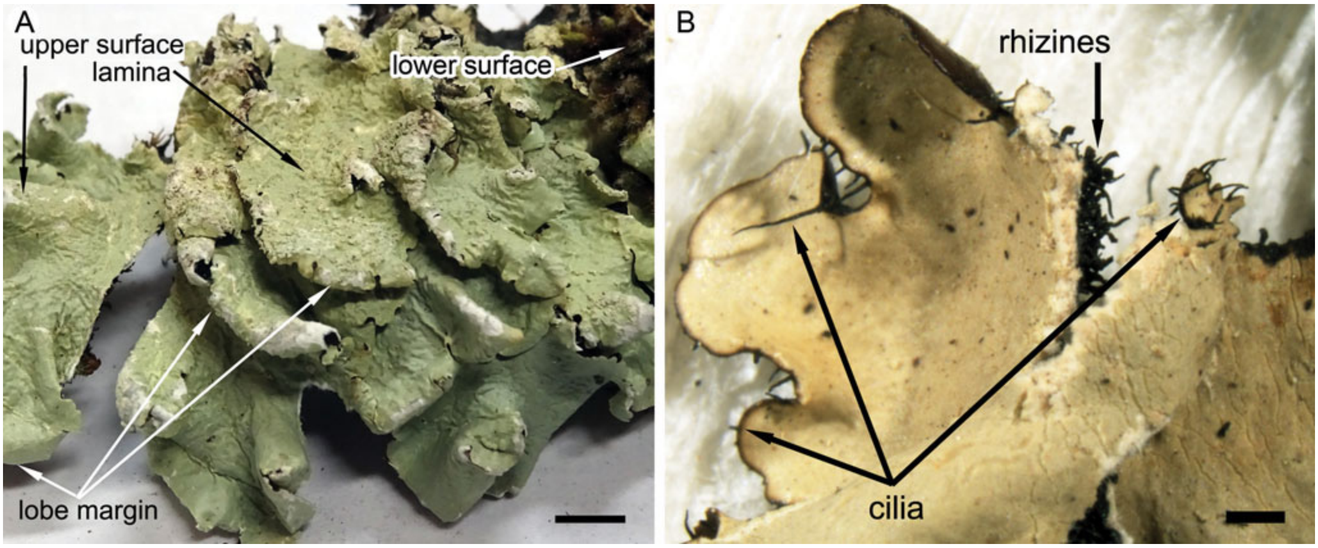

Fig. 1. Parts of a foliose thallus indicated by arrows. A, upper and lower surface, lamina, lobe margin (*Flavoparmelia caperata*, *A. M. Muhoro* 21/01). B, appendages on the thallus: cilia, rhizines (*Parmotrema ultralucens*, VBI 2217). Scales: A = 1 mm; B = 0.5 mm. In colour online.

& Marcelli 2010; Benatti 2012*a*, *b*, 2013, 2014; Kukwa *et al.* 2012; Divakar *et al.* 2013; Spielmann & Marcelli 2020), and Smith *et al.* (2009) was consulted for morphological details. Some of the important morphological characters are illustrated: lamina, lobe margin, lower and upper surface (Fig. 1A); cilia (Figs 1B & 2A); rhizines (Figs 1B, 2B & 3); isidia (Fig. 4); pseudocyphellae (Fig. 5A); soredia (Figs 5B & 6).

The dichotomous main key leads to species where the genus has only a small number of representatives (maximum 4 species), but otherwise to genera. Larger genera are treated separately after the main key. *Bulborrhizina* (1) is treated in the generic key (*Bulbothrix* s. lat.) together with *Bulbothrix* (9); *Canoparmelia* (9) and *Pseudoparmelia* (2) are also treated in the same key.

The key was tested using East African (mostly Tanzanian) herbarium specimens deposited in VBI (abbreviation according to Thiers (2022)) and recently collected samples. Fragments of parmelioid thalli were collected by the second author in Kenya in 2020 and 2021; localities are listed below. Morphology and anatomy were studied using a Nikon Eclipse/NiU compound microscope and a Nikon SMZ18 stereomicroscope. Micrographs were prepared using a Nikon Fi3 camera with NIS-Elements BR ML software. HPTLC analysis was carried out according to standard methods for analyzing lichen samples described by Arup *et al.* (1993) and Molnár & Farkas (2011).

Specimen details

Localities visited. **Kenya:** *Uasin Gishu County*: Eldoret in Sukunanga estate opposite Toyota Kenya *c.* 1.5 km from Sosiani River along Nakuru road, 0°29′32″N, 35°18′06″E, alt. 2129 m, from bark of trees, 2020, *A. M. Muhoro* 20/01. *Nyeri County*: at

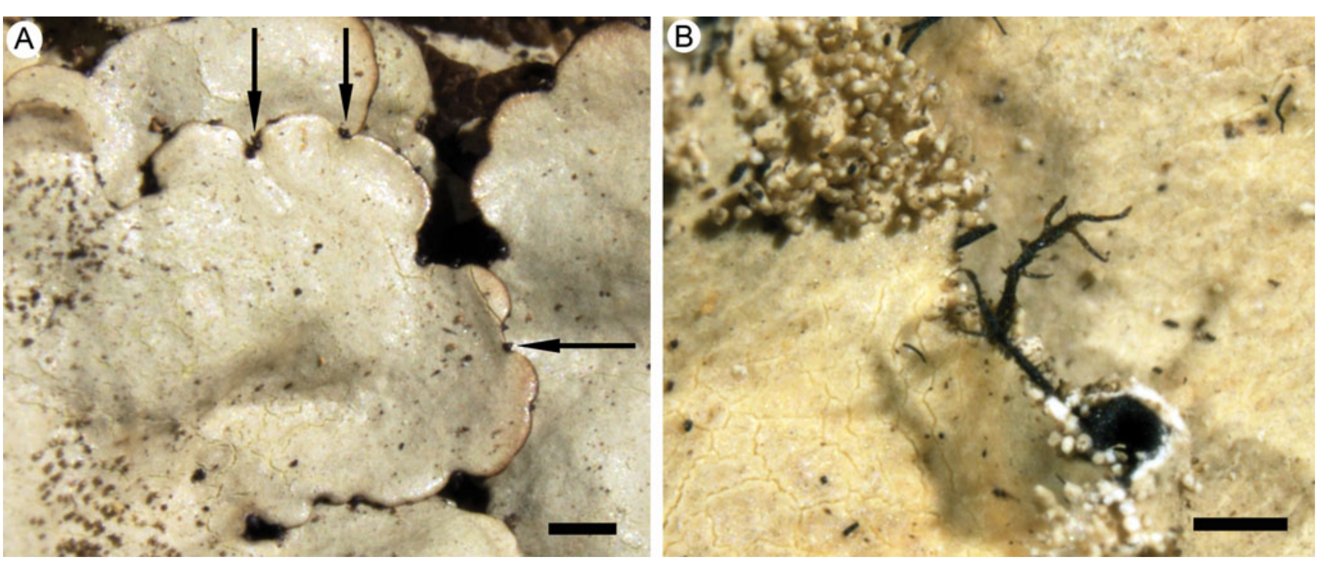

Fig. 2. Appendages on the thallus. A, bulbate cilia indicated by arrows (*Bulbothrix isidiza*, VBI 1691). B, branched rhizine (*Parmotrema ultralucens*, VBI 2217). Scales: A & B = 0.5 mm. In colour online.

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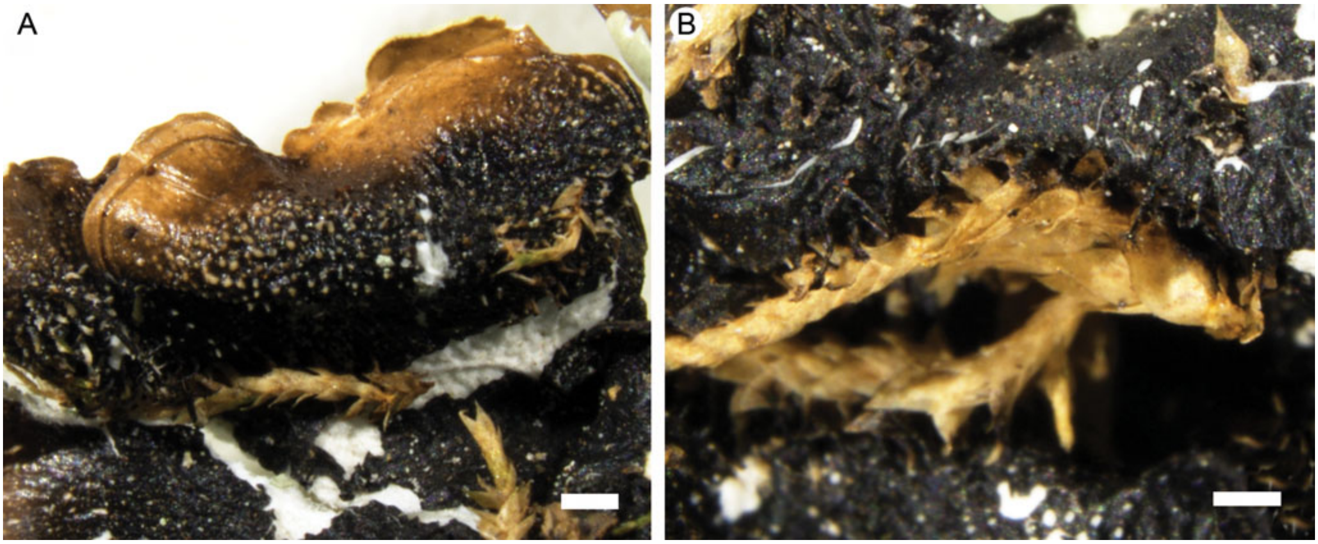

Fig. 3. Lower surface of the thallus (*Flavoparmelia caperata*, *A. M. Muhoro* 21/01). A, paler zone at the margin with pale rhizines. B, inner dark rhizines. Scales: A & B = 0.5 mm. In colour online.

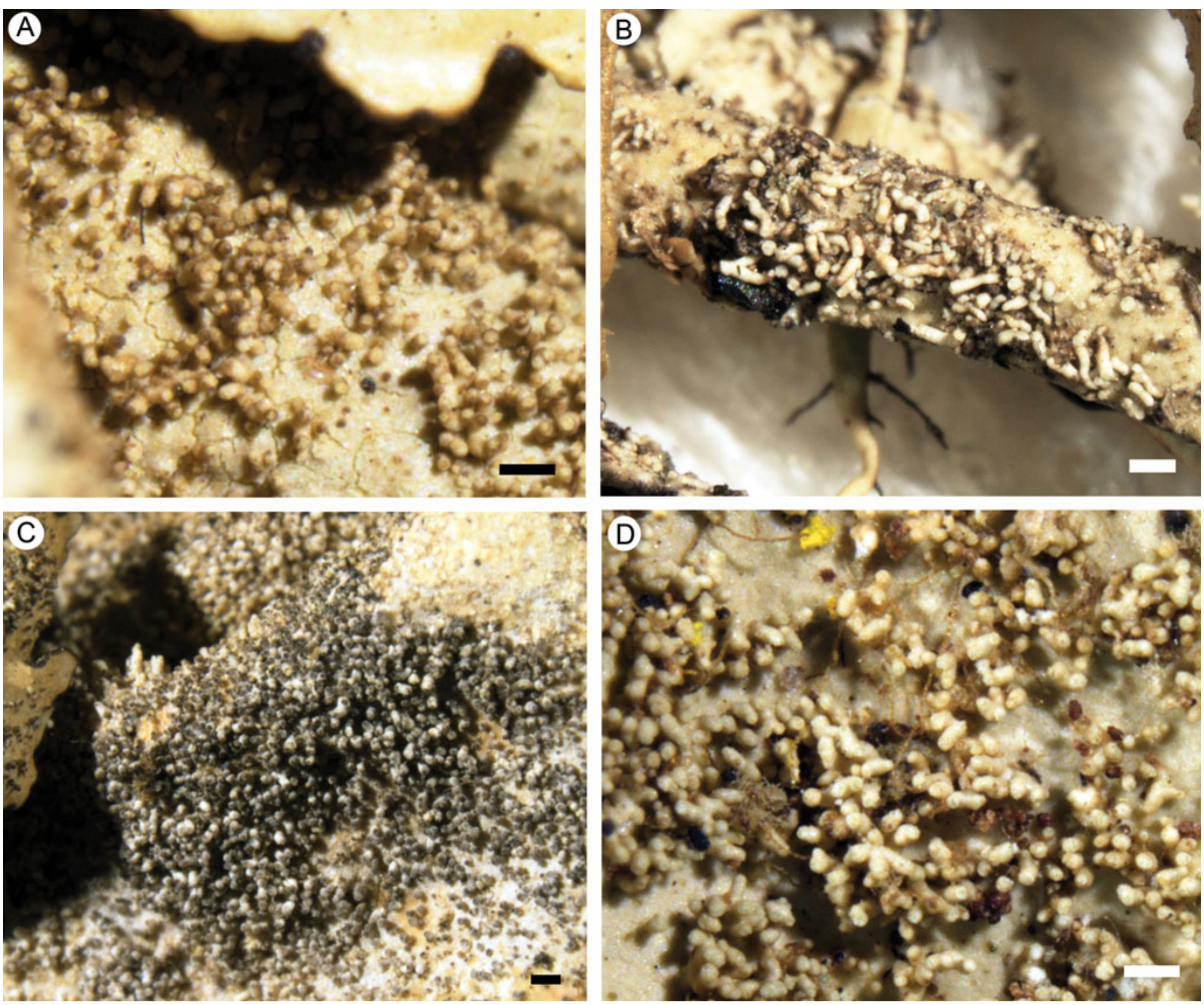

Fig. 4. Laminal isidia. A, semiglobular to cylindrical isidia often with brown tips, mostly simple (*Bulbothrix isidiza*, VBI 1691). B, cylindrical and claviform isidia (*Hypotrachyna vexans*, VBI 1741). C, cylindrical granular isidia with brown tips (*Parmelinella schimperiana*, VBI 2309). D, subglobose to cylindrical or inflated isidia, simple or branched (*Parmotrema tinctorum*, VBI 4917). Scales: A–D = 0.2 mm. In colour online.

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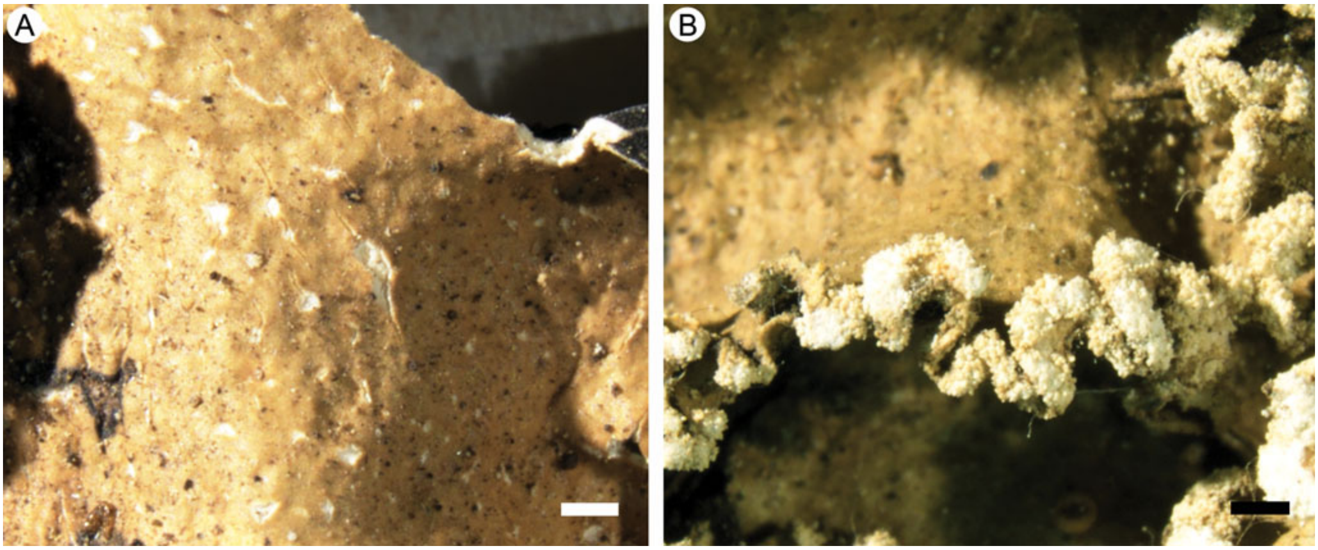

Fig. 5. Morphological details (*Flavopunctelia flaventior*, VBI 2321). A, laminal pseudocyphellae. B, marginal linear soralia. Scales: A & B = 0.5 mm. In colour online.

the foot of Mt Kenya, *c.* 1 km from Naro Moru entry gate to Kenya Wildlife Service in Gitinga Village, 0°10′25.84″S, 37° 9′3.40″E, alt. 2454 m, from bark, twigs and branches of trees in tropical rainforest, 2021, *A. M. Muhoro* 21/01, 21/02.

Specimens used for micrographs. *Bulbothrix isidiza* (Nyl.) Hale. **Tanzania:** *Morogoro Region*: Northern Uluguru Mts, near the town of Morogoro, valley leading S from Bigwa Mission to Lupanga peak, on E-facing slope, alt. 1100–1200 m, from bark of *Dahlbergia lactea* in dry rocky woodland, 1988, *T. Pócs* 88191/P (VBI 1691).

Canoparmelia texana (Tuck.) Elix & Hale (as *Pseudoparmelia texana* (Tuck.) Hale). **Tanzania:** *Arusha Region*: Ngorongoro Conservation Area, NE rim of Ngorongoro Crater, inner slope, NW of Oljoro Nyuki, alt. 2220 m, ramicolous in mature, mist affected, heavily grazed *Acacia lahai* stand, very rich in epiphytes, 1989, *T. Pócs, A. Kijazi, P. Murphy* 89011/PB, det. H. Krog, rev. E. Farkas (VBI 2308).

Flavopunctelia flaventior (Stirt.) Hale (as *Punctelia flaventior* (Stirt.) Krog). **Tanzania:** *Arusha Region*: Ngorongoro Conservation Area, NE rim of Ngorongoro Crater, inner slope, NW of Oljoro Nyuki, alt. 2220 m, ramicolous in mature, mist affected, heavily grazed *Acadia lahai* stand, very rich in epiphytes, 1989, *T. Pócs, A. Kijazi, P. Murphy* 89011/X, det. H. Krog, rev. E. Farkas (VBI 2321).

Hypotrachyna vexans (Zahlbr. ex W. L. Culb. & C. F. Culb.) Divakar *et al.* (as *Cetrariastrum vexans* (Zahlbr.) W. L. Culb. & C. F. Culb.). **Tanzania:** *Mbeya Region*: Southern Highlands, Poroto Mts, W of Isongole Village, SE of Ngozi Crater, alt. 2000 m, from bark of *Hagenia* sp. in montane rainforest, 1989, *T. Pócs, E. Farkas, H. Krog* 89128/H, det. H. Krog, rev. E. Farkas (VBI 1741).

Parmelinella schimperiana Kirika & Divakar (as *Pseudoparmelia wallichiana* (Taylor) Krog & Swinscow). **Tanzania:** *Arusha Region*: Mt Meru, W slope, on the ridge

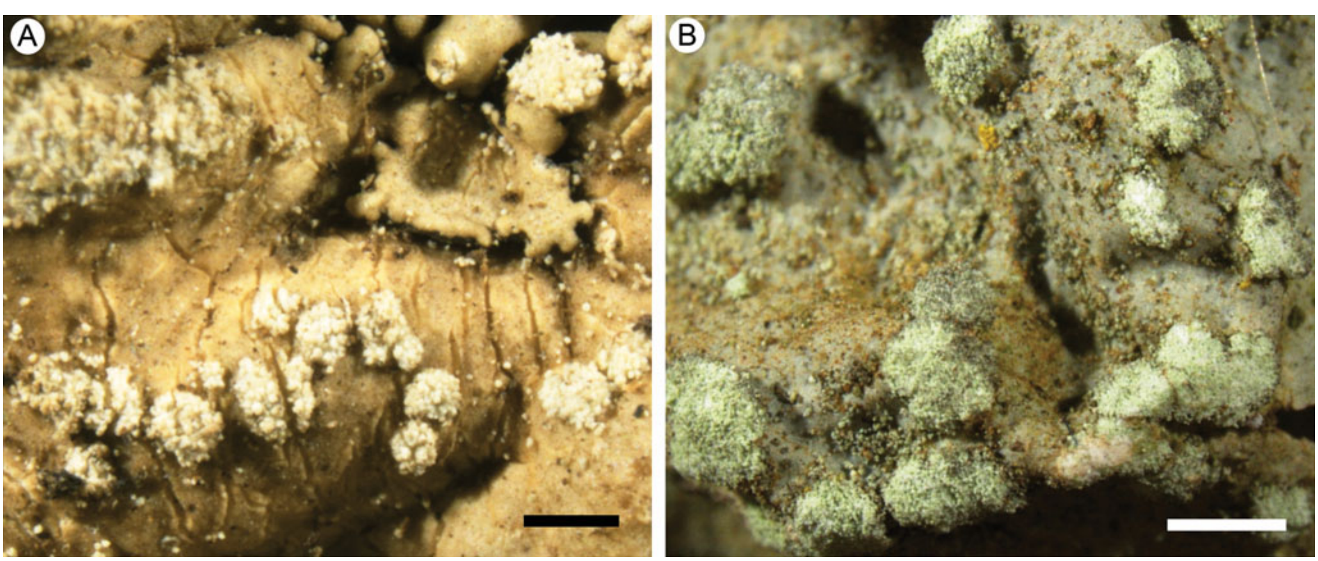

Fig. 6. Laminal punctiform soralia. A, *Canoparmelia texana* (VBI 2308). B, *Parmotrema* sp. (*A. M. Muhoro* 20/01). Scales: A = 0.5 mm; B = 1 mm. In colour online.

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above Laikinoi, alt. 2600 m, corticolous in *Juniperus-Podocarpus usambarensis* forest, 1988, *T. Pócs* & *Helsinki Univ. Bot. Dept.* 88296/L, det. H. Krog, rev. E. Farkas (VBI 2309).

Parmotrema tinctorum (Nyl.) Hale. **Tanzania:** *Tanga Region*: Lushoto District, West Usambara Mts, W slopes of Gonja Hill, 5 km E of Mgwashi Village, alt. 1600–1700 m, from bark in montane evergreen forest, 1988, *T. Pócs, H. Krog* 88205/LC, det. H. Krog (VBI 1741).

Parmotrema ultralucens (Krog) Hale. **Tanzania:** *Tanga Region*: Lushoto District, East Usambara Mts, Hunga stream valley, below Derema Village, alt. 840 m, rupicolous on granitic river-bed rocks, 1987, *K. Pócs* 87037/U, det. H. Krog (VBI 2217).

Key to species of the parmelioid clade in Kenya

Parmelioid species share the following characters within *Parmeliaceae*: photobiont green alga; foliose growth form, not umbilicate, thallus corticate above and below, adnate or loosely attached to substratum; presence of rhizines; medulla solid, grey, yellowish green or brownish; if present, fruiting body apothecium with thalline exciple; simple ascospores; laminal pycnidia.

Further keys lead to species of the genera *Bulborrhizina* (1) and *Bulbothrix* (9), *Canoparmelia* (9) and *Pseudoparmelia* (2), *Hypotrachyna* (37), *Parmotrema* (64), *Punctelia* (9) and *Xanthoparmelia* (29) and follow the main key.

1 Pseudocyphellae present, may occur on both sides 2
Pseudocyphellae absent, cortex continuous on both sides 8

2(1) Pseudocyphellae may occur on both upper and lower surfaces in the genus but this species has pseudocyphellae on upper surface only, together with granular and coralloid isidia on large wide lobes, lower side is black with black rhizines; cortex K+ yellow, atranorin; medulla K−, C−, KC+ pink, Pd−, alectoronic acid, α-collatolic acid . . . . . **Cetrelia braunsiana** (Müll. Arg.) W. L. Culb. & C. F. Culb.
Pseudocyphellae present on upper surface, thallus otherwise 3

3(2) Thallus grey; cortex K+ yellow, atranorin 4
Thallus yellow-green or brown; cortex K−, with or without usnic acid 6

4(3) Pseudocyphellae mostly linear effigurate, reticulate, seldom punctiform, lobes sublinear; medulla K+ red, Pd+ orange, salazinic acid 5
Pseudocyphellae punctiform to suborbicular, lobes rotund . . . . . **Punctelia** (9 species)

5(4) Pseudocyphellae linear effigurate, cylindrical isidia present with brown tips; lobes 1–3 mm wide, underside black; rhizines simple to bifurcate; lignicolous at *c.* 3000 m alt. . . . . . **Parmelia saxatilis** (L.) Ach.
Pseudocyphellae linear, reticulate, often developing into soredia; lobes 2–5 mm wide, underside black; rhizines simple to squarrose; saxicolous at 3500–4200 m alt. . . . . . **Parmelia sulcata** Taylor

6(3) Thallus olive to reddish brown; isidia present, cylindrical and punctiform soredia originate from pseudocyphellae, lower side brown to black with scattered simple rhizines; cortex without usnic acid, HNO_3−; medulla C+ red, lecanoric acid . . . . . **Melanelixia subaurifera** (Nyl.) O. Blanco *et al.*
Thallus yellow-green, pseudocyphellae punctiform to elongate; cortex with usnic acid; medulla C+ red, lecanoric acid . . . 7

7(6) Soredia present, soralia marginal linear or laminal punctiform; underside black, with a brown and glossy, broad, naked marginal zone; rhizines few, scattered, usually black but towards the margin pale brown or with white tips; apothecia common, with sorediate thalline exciple; ascospores long ellipsoid, 15–18 × 6–8 µm. . . . . **Flavopunctelia flaventior** (Stirt.) Hale
Soredia and isidia absent; underside black, glossy brown or white mottled in a broad marginal zone; rhizines short, inconspicuous; apothecia often numerous towards the centre of the thallus, with a pseudocyphellate thalline exciple; ascospores ellipsoid, 12–15 × 8–10 µm . . . . . **Flavopunctelia praesignis** (Nyl.) Hale

8(1) Thallus yellow, yellow-green or brown 9
Thallus grey 18

9(8) Thallus brown, grey-brown; upper cortex HNO_3+ blue-green, without usnic acid . . . . . **Xanthoparmelia** pr. p.
Thallus yellow, yellow-green, pale yellowish grey; upper cortex HNO_3−, with usnic acid 10

10(9) Bulbate cilia present at lobe margin, lobes pale yellow 11
Lobe margin without cilia, yellow-green to green (pale yellow in *Relicina abstrusa*) 14

11(10) Isidia absent 12
Cylindrical isidia present 13

12(11) Thallus yellow-green to green, with 1–2 mm wide sublinear, dichotomous lobes; underside black; cortex with usnic acid; medulla K+ yellow, C+ pale yellow to orange (unknown substance) and Pd+ deep orange (unknown substance,

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'echinocarpic acid'); apothecia laminal, thalline exciple pilose; ascospores subglobose, 6–8 × 3–5 µm . . . . **Relicina echinocarpa** (Kurok.) Hale

Lobes 3–6 mm wide, yellow-green to green, medulla pale yellow; apothecia laminal, thalline exciple crenate; ascospores subglobose, 8–10 × 7–8 µm; undetermined pigment and substances, ±atranorin (trace); corticolous at 1500–2200 m alt. . . . . **Relicina limbata** (Laurer) Hale

13(11) Lobes 1–2 mm wide, pale yellow, marginal cilia well developed, clearly bulbate; medulla white; apothecia absent in East African specimens; cortex, usnic acid; medulla K+ red, Pd+ orange, norstictic acid; corticolous in mangroves at 0–300 m alt. . . . . **Relicina abstrusa** (Vain.) Hale

Lobes 0.8–1.5 mm wide, bright yellow to yellow-green, ±eciliate; rhizines sometimes protruding beyond the lobe margins; medulla pigmented faintly yellow, especially near the upper cortex; apothecia common, up to 2 mm diam., thalline margin entire or crenate, disc flat; ascospores 8–10 × 4–6 µm; cortex, usnic acid; medulla Pd+ orange-red, protocetraric acid, ±fatty acid; corticolous on twigs and branches in mangroves, 0–500 m alt. . . . . **Relicina malaccensis** (Nyl.) Kirika *et al.*

14(10) Lobes rounded 15

Lobes elongated . . . . **Xanthoparmelia** pr. p.

15(14) Laminal soralia present 16

Laminal soralia absent, dactyls present or absent 17

16(15) Lobes 5–10 mm wide, imbricate in central parts, soralia starting from individual pustules but soon coalescing to cover larger areas; underside black with a fairly wide brown, naked marginal zone; rhizines simple, slender, dense or scattered, black, often tipped with white or brown; apothecia not seen in East African material; pycnoconidia weakly bifusiform, 5–6 µm long; cortex, usnic acid, ±atranorin (trace); medulla Pd+ orange-red, protocetraric acid, caperatic acid; corticolous at 1500–3600 m alt. . . . . **Flavoparmelia caperata** (L.) Hale

Lobes 1–5 mm wide, soralia punctiform, becoming confluent over larger areas; underside black, with a narrow, brown marginal zone; rhizines simple, black to brown, some tipped with white; apothecia and pycnidia not seen in material from Kenya; cortex, usnic acid; medulla K+ red, Pd+ orange, salazinic acid; corticolous, lignicolous, or saxicolous at 1100–2700 m alt. . . . . **Flavoparmelia soredians** (Nyl.) Hale

17(15) Lobes 1–2.5 mm wide, dactyls laminal, crowded in central parts of the thallus, mainly closed but occasionally becoming eroded or with a small perforation at the apex; underside velvety black to the margins; rhizines short, black; apothecia rare, up to 2 mm diam., with a thick, crenate thalline margin; spores 10–16 × 5–8 µm; pycnoconidia filiform, 10–12 µm long; cortex, usnic acid; medulla Pd+ orange-red, protocetraric acid; saxicolous at 1750 m alt. . . . . **Flavoparmelia pachydactyla** (Hale) Hale

Lobes 5–8 mm wide, without dactyls; underside black, with a narrow, brown, naked marginal zone; rhizines simple, black or tipped with white; apothecia not seen in East African material; pycnoconidia weakly bifusiform, 7–8 µm long; cortex, usnic acid, ±atranorin (trace); medulla Pd+ orange-red, protocetraric acid, caperatic acid; saxicolous at 3600 m alt. . . . . **Flavoparmelia rutidota** (Hook. f. & Taylor) Hale

18(8) Upper surface mostly maculate 19

Upper surface mostly emaculate 20

19(18) Lobes large, rotund, wider than 0.5 cm, upper cortex often reticulately cracked; maculae may occur… . . . . **Parmotrema** pr. p. (65 species)

Lobes narrower than 0.5 cm, rotund, subrotund or sublinear; emaculate species may occur . . . . **Canoparmelia** (9 species) and **Pseudoparmelia** (2 species)

20(18) Bulbate cilia present at lobe margin . . . . **Bulborrhizina** (1 species) and **Bulbothrix** (9)

Lobe margin without bulbate cilia 21

21(20) Lobes large, rotund, wider than 0.5 cm . . . . **Parmotrema** pr. p. (65 species)

Lobes narrower, rotund or elongated, narrower than 0.5 cm 22

22(21) Thallus with secalonic acid A yellow pigment 23

Thallus without secalonic acid A yellow pigment . . . . **Hypotrachyna** (37 species)

23(22) Medulla yellow to salmon pink, pigment K−; lobes sublinear to irregular, 3–5 mm wide, pale grey; rhizines mainly simple but a few branched, some growing out horizontally from the margins; pustular soralia and open dactyls laminally and submarginally situated; cortex K+ yellow, atranorin; medulla, triterpenoids, secalonic acid A . . . . **Myelochroa aurulenta** (Tuck.) Elix & Hale

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Medulla white; lobes irregularly to subirregularly branched, 3–8 mm wide, margins ciliate; upper surface grey, grey-green, usually pruinose; isidia cylindrical, mostly simple, also branched; lower surface black with brown papillate margins; rhizines black, simple, evenly distributed; apothecia 1–5 mm; ascospores 5–10 × 5–7.5 µm; pycnidia not seen in material from Kenya; cortex K+ yellow, UV−, secalonic acid A and atranorin; medulla K+ yellow turning red, C−, KC−, Pd+ orange-red, UV−, salazinic acid . . . . **Parmelinella schimperiana** Kirika & Divakar

Key to species of Bulborrhizina *Kurok. (1) and* Bulbothrix *Hale (9)*

Bulborrhizina: thallus pale straw-yellow, loosely adnate, divaricate, composed of linear lobes divided dichotomously, canaliculate below. Cortex with atranorin.

Bulbothrix: thallus grey, relatively small. Surface without pseudocyphellae, marginal cilia bulbate. Cortex with atranorin. Apothecia, isidia or phyllidia may occur.

1 Apothecia present or absent; soredia, isidia and phyllidia absent 2
Apothecia rare; isidia or phyllidia present 5

2(1) Underside pale 3
Underside black 4

3(2) Apothecia present; underside pale brown . . . . **Bulbothrix hypocraea** (Vain.) Hale
Apothecia absent; underside pale straw-yellow; medulla, salazinic acid (major), gyrophoric acid (minor) . . . . **Bulborrhizina africana** Kurok.

4(2) Ascospores 8–12 × 6–8 µm . . . . **Bulbothrix sensibilis** (Steiner & Zahlbr.) Hale
Ascospores 16–20 × 8–12 µm . . . . **Bulbothrix meizospora** (Nyl.) Hale

5(1) Underside pale brown 6
Underside dark brown to black 7

6(5) Upper surface faintly to distinctly maculate, cilia bulbate . . . . **Bulbothrix isidiza** (Nyl.) Hale
Upper surface emaculate, cilia reduced to bulbate nodules . . . . **Bulbothrix kenyana** Kirika *et al.*

7(5) Phyllidia numerous, cylindrical isidia absent . . . . **Bulbothrix suffixa** (Stirt.) Hale
Phyllidia rare or absent, cylindrical isidia present 8

8(7) Rhizines branched; medulla C+ rose, Pd−, gyrophoric acid . . . . **Bulbothrix goebelii** (Zenker) Hale
Rhizines simple; medulla C−, Pd+ orange 9

9(8) Apothecia ecoronate; K+ yellow turning red, salazinic acid present . . . . **Bulbothrix sublaevigatoides** (C. W. Dodge) Kirika *et al.*
Apothecia (rare) coronate; K+ red, norstictic acid present . . . . **Bulbothrix ventricosa** (Hale & Kurok.) Hale

Key to species of Canoparmelia *Elix & Hale (9) and* Pseudoparmelia *Lynge (2)*

Canoparmelia: lobes usually narrower than 5 mm, rotund or subrotund. Marginal cilia absent. Medulla white. Apothecia, soralia, isidia or dactyls may occur. Rhizines usually simple, often with white, frayed tips. Cortex usually emaculate, with atranorin and/or usnic acid. Corticolous.

Pseudoparmelia: lobes usually narrower than 5 mm, sublinear or irregularly incised. Marginal cilia absent. Medulla white or pigmented. Apothecia and isidia occur. Rhizines usually simple. Cortex shiny, emaculate, with atranorin. Saxicolous.

1 Thallus pale yellow to yellow-green . . . . **Canoparmelia ecaperata** (Müll. Arg.) Elix & Hale
Thallus pale grey to ash grey 2

2(1) Thallus saxicolous 3
Thallus corticolous 4

3(2) Medulla white, with salazinic acid (Pd+ orange-red, K+ red); lobes sublinear, 4–8(– 10) mm wide; isidia laminal, semiglobular or cylindrical, simple; underside black with a brown apical zone; apothecia laminal, thalline margin isidiate . . . . **Pseudoparmelia usambarensis** (J. Steiner & Zahlbr.) Krog & Swinscow
Medulla faintly pink, with perlatolic acid aggr., echinocarpic acid (Pd+ deep orange, K+ yellow, C+ yellow, KC+ salmon); lobes irregularly incised, 2–2.5–(3) mm wide, imbricate; isidia short, fairly coarse, cylindrical to claviform, simple or sparingly branched; underside black with a dark brown, naked marginal zone; apothecia rare, with crenate thalline margin . . . . **Pseudoparmelia singularis** Krog & Swinscow

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4(2) Soredia, isidia or dactyls present 5
Soredia, isidia or dactyls absent 9

5(4) Laminal, punctiform soralia present . . . . **Canoparmelia texana** (Tuck.) Elix & Hale
Isidia or dactyls present 6

6(5) Laminal dactyls with open tips present . . . . **Canoparmelia pustulescens** (Kurok.) Elix
Cylindrical isidia present 7

7(6) Upperside matt, emaculate, Pd+ orange-red (protocetraric acid) . . . . **Canoparmelia amazonica** (Nyl.) Elix & Hale
Upperside maculate, cracked and rugose, Pd−, containing perlatolic acid or divaricatic acid 8

8(7) Medulla with perlatolic acid . . . . **Canoparmelia caroliniana** (Nyl.) Elix & Hale
Medulla with divaricatic acid . . . . **Canoparmelia concrescens** (Vain.) Elix & Hale

9(4) Lobes 1–3 mm wide . . . . **Canoparmelia rodriguesiana** (Hue) Elix
Lobes 3–8 mm wide 10

10(9) Upperside maculate; medulla with divaricatic acid and an unknown substance (C+ pale pink, KC+ purple) . . . . **Canoparmelia nairobiensis** (J. Stein. & Zahlbr.) Elix & Hale
Upperside emaculate; medulla with protocetraric acid (Pd+ orange-red). . . . . **Canoparmelia somaliensis** (Müll. Arg.) Elix & Hale

Key to species of Hypotrachyna *(Vain.) Hale (37)*

Lobes pale grey or pale yellow above, black below, generally sublinear, sometimes irregularly incised. Rhizines black, sparingly to densely branched, the branching dichotomous or squarrose, often with unbranched rhizines immixed or dominating. Branched or unbranched rhizines or cilia may also be marginally situated. Apothecia sessile to substipitate, with imperforate disc. Pycnoconidia bifusiform.

1 Soredia, isidia and dactyls absent 2
Soredia, isidia or dactyls present 7

2(1) Medulla Pd+ orange → red 3
Medulla Pd− 4

3(2) Rhizines simple to sparingly branched; medulla K− (protocetraric acid); saxicolous species . . . . **Hypotrachyna fissicarpa** (Kurok.) Hale
Rhizines densely branched; medulla K+ red (salazinic acid); corticolous species . . . . . **Hypotrachyna sublaevigata** (Nyl.) Hale

4(2) Rhizines mainly simple; di-*O*-methylgyrophoric acid and related substances ('horrescens complex'[1]) present . . . . **Hypotrachyna damaziana** (Zahlbr.) Krog & Swinscow
Rhizines distinctly branched; chemistry otherwise 5

5(4) Medulla C+ rose (gyrophoric acid) . . . . **Hypotrachyna scytophylla** (Kurok.) Hale
Medulla C+ yellow-orange or C− 6

6(5) Rhizines moderately branched; medulla KC+ orange, barbatic acid, 4-*O*-demethylbarbatic acid and obtusatic acid . . . . **Hypotrachyna ducalis** (Jatta) Hale
Rhizines densely dichotomously branched; medulla KC+ orange, barbatic acid (major) obtusatic acid (minor) . . . . **Hypotrachyna kenyana** Kirika *et al.*

7(1) Thallus with isidia or closed dactyls 8
Thallus with soredia or open dactyls 16

8(7) Thallus with closed dactyls; substances in the lividic acid complex present . . . . **Hypotrachyna polydactyla** (Krog & Swinscow) T. H. Nash
Thallus with isidia; chemistry otherwise 9

[1]Throughout the key 'horrescens complex' refers to 3-methoxy-2,4-di-*O*-methylgyrophoric acid, 2,4-di-*O*-methylgyrophoric acid, gyrophoric acid, 5-*O*-methylhiascic acid, 4,5-di-*O*-methylhiascic acid, lecanoric acid, and 3-hydroxygyrophoric acids (Benatti 2012*b*).

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9(8) Medulla Pd+ orange 10
Medulla Pd− 11

10(9) Upper cortex yellow (usnic acid); medulla, norstictic and galbinic acids present . . . . **Hypotrachyna microblasta** (Vain.) Hale
Upper cortex grey (atranorin); medulla K+ red, Pd+ orange, salazinic acid, protolichesterinic acid present . . . . . **Hypotrachyna vexans** (Zahlbr. ex W. L. Culb. & C. F. Culb.) Divakar *et al.*

11(9) Isidia with conspicuous apical and lateral cilia, KC+ rose, 'horrescens complex' . . . . . **Hypotrachyna horrescens** (Taylor) Krog & Swinscow
Isidia without or with inconspicuous cilia 12

12(11) Medulla C+ rose (gyrophoric acid complex) 13
Medulla C+ yellow-orange or C− 15

13(12) Isidia in scattered submarginal and laminal groups; lobes 3–6 mm wide . . . . . **Hypotrachyna spathulata** (Kurok.) Krog & Swinscow
Isidia crowded, covering most of the thallus; lobe width various 14

14(13) Rhizines mainly simple; lobes short and 1–3 mm wide . . . . . **Hypotrachyna minarum** (Vain.) Krog & Swinscow
Rhizines frequently branched; lobes elongate and 2–3 mm wide (on twigs), or short and more than 5 mm wide (on tree trunks and rock) . . . . . **Hypotrachyna neodissecta** (Hale) Hale

15(12) Rhizines densely branched; medulla KC− (fatty acids) . . . . . **Hypotrachyna costaricensis** (Nyl.) Hale
Rhizines moderately branched; medulla KC+ orange, barbatic acid, KC+ yellow- orange, 4-*O*-demethylbarbatic acid, faint traces of obtusatic and norobtusatic acids . . . . . **Hypotrachyna orientalis** (Hale) Hale

16(7) Upper cortex yellow (usnic acid) 17
Upper cortex grey (usnic acid absent) 19

17(16) Soralia subapical, subcapitate, with abundant soredia, salazinic acid present 18
Soralia laminal, pustular, usually with sparse soredia . . . . . **Hypotrachyna meyeri** (Zahlbr.) Streim.

18(17) Norstictic acid present . . . . . **Hypotrachyna sinuosa** (Sm.) Hale
Norstictic acid absent . . . . . **Hypotrachyna meridionalis** Kirika *et al.*

19(16) Medulla pigmented yellow to salmon pink, pigment K−, barbatic and obtusatic acids present . . . . . **Hypotrachyna endochlora** (Leight.) Hale
Medulla white, at most pigmented ochraceous in patches, pigment K+ purple 20

20(19) Thallus with subapical soralia 21
Thallus with mainly laminal soralia, pustules, or open dactyls 30

21(20) Medulla Pd+ orange or red 22
Medulla Pd− 24

22(21) Medulla K− (fumarprotocetraric acid) except for pigmented areas, K+ purple . . . . **Hypotrachyna gondylophora** (Hale) Hale
Medulla K+ red (salazinic acid) 23

23(22) Soralia subcapitate; rhizines densely branched . . . . . **Hypotrachyna brevirhiza** (Kurok.) Hale
Soralia diffusely spreading; rhizines mainly simple . . . . . **Hypotrachyna swinscowii** (Hale) Krog & Swinscow

24(21) Medulla C+ rose or red 25
Medulla C+ yellow-orange or C− 28

25(24) Rhizines sparingly branched; gyrophoric acid present 26
Rhizines densely branched; soralia subcapitate; chemistry various 27

26(25) Soralia diffusely spreading, subapical; soredia green, powdery . . . . . **Hypotrachyna revoluta** (Flörke) Hale
Soralia subcapitate, subapically, marginally, or laminally situated in distal parts of the lobe; soredia coarsely granular . . . . . **Hypotrachyna catawbiensis** (Degel.) Divakar *et al.*

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27(25) Upper cortex often maculate; evernic and lecanoric acids present . . . . **Hypotrachyna rockii** (Zahlbr.) Hale
Upper cortex emaculate; anziaic acid present . . . . **Hypotrachyna producta** Hale

28(24) Upper cortex maculate; medulla KC+ orange with barbatic acid 29
Upper cortex emaculate; thallus 10 cm or more diam.; medulla KC+ red, alectoronic and α-collatolic acids present . . . . **Hypotrachyna densirhizinata** (Kurok.) Hale

29(28) K+ red, 4-*O*-demethylbarbatic acid and obtusatic acid (+) present . . . . **Hypotrachyna laevigata** (Sm.) Hale
K−, KC+ pale yellow, 4-*O*-demethylbarbatic acid absent, obtusatic acid (+) present . . . . **Hypotrachyna nyandaruaensis** Kirika *et al.*

30(20) Rhizines mainly simple; K+ purple pigment absent 31
Rhizines moderately branched; K+ purple pigment usually present 34

31(30) Thallus closely adnate; lobes less than 1.5 mm wide; with open dactyls, situated laminally, bursting open at maturity without the formation of soredia . . . . **Hypotrachyna spumosa** (Asah.) Krog & Swinscow
Thallus ±loosely attached; lobes more than 2 mm wide 32

32(31) Thallus sorediate; soralia laminal and marginal; soredia farinose; medulla Pd+ orange, salazinic acid, protolichesterinic acid . . . . **Hypotrachyna sorocheila** (Vain.) Divakar *et al.*
Thallus pustulate 33

33(32) Pustules in part subapical, in part laminal, without soredia; medulla C− or fleetingly pale pink, 'horrescens complex' present . . . . **Hypotrachyna subfatiscens** (Kurok.) Krog & Swinscow
Pustules laminal, often near the lobe margins, with soredia; medulla distinctly C+ rose, gyrophoric acid present . . . . **Hypotrachyna afrorevoluta** (Krog & Swinscow) Krog & Swinscow

34(30) Cortex K−, UV+ bright yellow (lichexanthone) . . . . **Hypotrachyna formosana** (Zahlbr.) Hale
Cortex K+ yellow, UV− (atranorin) 35

35(34) Medulla C+ blood red (unidentified substances) . . . . **Hypotrachyna leiophylla** (Kurok.) Hale
Medulla C− 36

36(35) Medulla Pd+ orange-red, UV− (protocetraric acid) . . . . **Hypotrachyna croceopustulata** (Kurok.) Hale
Medulla Pd+ pale yellow, UV+ bluish white (lividic acid complex) . . . . **Hypotrachyna immaculata** (Kurok.) Hale

Key to species of Parmotrema *Massal. (65)*

Lobes in most species widely rotund apically, pale grey or pale yellow above, pale to dark brown to black below, with brown, white, or mottled marginal zone. Marginal cilia present or absent. Rhizines unbranched or rarely bifurcate or squarrose, generally sparse or absent towards periphery of lobes, rarely dimorphous (in part long and coarse, in part short and slender). Apothecia substipitate to stipitate, disc perforate or imperforate. Pycnoconidia sublageniform or filiform.

1 Soralia, isidia, phyllidia and dactyls absent 2
Soralia, isidia, phyllidia, or dactyls present 35

2(1) Marginal cilia absent 3
Marginal cilia present 5

3(2) Apothecia imperforate; medulla C−, Pd+ orange-red (protocetraric acid) . . . . **Parmotrema zollingeri** (Hepp) Hale
Apothecia perforate; medulla C+ red, Pd− (lecanoric acid) 4

4(3) Thallus saxicolous, strongly attached; lobes less than 1 cm wide . . . . **Parmotrema soyauxii** (Müll. Arg.) Hale
Thallus normally corticolous, loosely attached; lobes more than 1 cm wide . . . . **Parmotrema andinum** (Müll. Arg.) Hale

5(2) Medulla pigmented pale yellow, ochraceous, or salmon pink, pigment K− 6
Medulla white, at most with patches of an ochraceous, K+ purple pigment near the lower cortex 7

6(5) Apothecia imperforate, with a dentate-ciliate thalline margin; medulla UV+ (undetermined substances); coastal species . . . . **Parmotrema pigmentiferum** (Krog & Swinscow) Krog & Swinscow
Apothecia perforate, with a smooth, eciliate thalline margin; medulla UV− (gyrophoric acid); upland species . . . . **Parmotrema subcoloratum** (Hale) Hale

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7(5) Upper cortex with a reticulate pattern of maculae and cracks; rhizines in part squarrose; salazinic acid present . . . . **Parmotrema cetratum** (Ach.) Hale
Upper cortex without a reticulate pattern of maculae and cracks; rhizines not squarrose; salazinic acid present or absent 8

8(7) Underside with a distinct, white marginal zone 9
Underside with a brown or mottled marginal zone 13

9(8) Apothecia perforate, medulla UV− 10
Apothecia mainly imperforate; medulla UV+ 12

10(9) Underside almost entirely white; medulla C−, KC− (protolichesterinic acid) . . . . . **Parmotrema leonis** Krog & Swinscow
Underside black in the centre, white peripherally; medullary reactions various 11

11(10) Lobe margins flat or revolute; medulla C+ red (lecanoric acid) . . . . . **Parmotrema hololobum** (Hale) Hale
Lobe margins ascending; medulla C− (norlobaridone and/or protolichesterinic acid) . . . . . **Parmotrema abessinicum** (Kremp.) Hale

12(9) Spores < 20 μm long; alectoronic acid present . . . . . **Parmotrema uberrimum** (Hue) Hale
Spores > 20 μm long; both alectoronic and α-collatolic acids present . . . . . **Parmotrema durumae** (Krog & Swinscow) Krog & Swinscow

13(8) Apothecia present 14
Apothecia absent 24

14(13) Spores > 20 μm long 15
Spores < 20 μm long 17

15(14) Upper cortex emaculate; apothecia imperforate . . . . . **Parmotrema durumae** (Krog & Swinscow) Krog & Swinscow
Upper cortex distinctly maculate; apothecia perforate or imperforate 16

16(15) Medulla UV+ (alectoronic acid, ±α-collatolic acid, ±gyrophoric acid) . . . . . **Parmotrema nilgherrense** (Nyl.) Hale
Medulla UV− (gyrophoric acid and/or norlobaridone, ±norstictic acid) . . . . . **Parmotrema eunetum** (Stirt.) Hale

17(14) Upper cortex distinctly maculate 18
Upper cortex emaculate or faintly maculate 20

18(17) Rhizines dimorphous; salazinic acid and norlobaridone present . . . . . **Parmotrema erubescens** (Stirt.) Krog & Swinscow
Rhizines uniform; chemical properties different 19

19(18) Underside brown; medulla Pd+ orange (stictic and norstictic acids); coast and coastal lowlands species . . . . . **Parmotrema aldabrense** (C. W. Dodge) Hale
Underside black in the centre, white, mottled, or brown peripherally; medulla Pd− (norlobaridone and/or protolichesterinic acid); upland species . . . . . **Parmotrema abessinicum** (Kremp.) Hale

20(17) Cortex Pd+ sulphur yellow near the apothecia (psoromic acid present); medulla C+ rose (gyrophoric acid) . . . . . **Parmotrema jacarandicola** (Krog & Swinscow) Krog & Swinscow
Cortex at most Pd+ pale yellow (psoromic acid absent); medulla C+ or C− 21

21(20) Medulla UV+ (alectoronic acid) . . . . . **Parmotrema maclayanum** (Müll. Arg.) Hale
Medulla UV− (alectoronic acid absent) 22

22(21) Thallus saxicolous; apothecia imperforate; medulla Pd+ orange-red (fumarprotocetraric acid) . . . . . **Parmotrema taitae** (Krog & Swinscow) Krog & Swinscow
Thallus normally corticolous; apothecia perforate; medulla Pd+ or Pd− (fumarprotocetraric acid absent) 23

23(22) Lobe margins flat or revolute; pycnoconidia filiform; medulla C+ red (lecanoric acid) . . . . . **Parmotrema hololobum** (Hale) Hale
Lobe margins ascending; pycnoconidia sublageniform; thalline exciple rarely ciliate; medulla C− (norlobaridone and/or protolichesterinic acid) . . . . . **Parmotrema abessinicum** (Kremp.) Hale

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24(13) Medulla Pd+ orange or red 25
Medulla Pd− (but cortex may be Pd+ sulphur yellow, see (32) *P. jacarandicola*) and upper cortex distinctly maculate . 29

25(24) Thallus saxicolous; fumarprotocetraric acid present . . . . . **Parmotrema taitae** (Krog & Swinscow) Krog & Swinscow
Thallus normally corticolous; fumarprotocetraric acid absent 26

26(25) Upper cortex distinctly maculate 27
Upper cortex emaculate or faintly maculate 31

27(26) Salazinic acid and norlobaridone present . . . . . **Parmotrema erubescens** (Stirt.) Krog & Swinscow
Salazinic acid absent, norlobaridone present or absent 28

28(27) Norstictic acid present in combination with gyrophoric acid and/or norlobaridone; montane forest species . . . . . **Parmotrema eunetum** (Stirt.) Hale
Norstictic acid present in combination with stictic acid; coastal species . . . . **Parmotrema aldabrense** (C. W. Dodge) Hale

29(24) Species of dry, well-lit lowland or upland habitats; medulla C− (norlobaridone and/or protolichesterinic acid) . . . . . **Parmotrema abessinicum** (Kremp.) Hale
Species of montane forests and the alpine zone 30

30(29) Medulla UV+ (alectoronic acid, ±α-collatolic acid, ±gyrophoric acid) . . . . . **Parmotrema nilgherrense** (Nyl.) Hale
Medulla UV− (gyrophoric acid and/or norlobaridone) . . . . . **Parmotrema eunetum** (Stirt.) Hale

31(26) Medulla C+ rose or red 32
Medulla C−; substances in the lividic acid complex absent; norlobaridone and/or protolichesterinic acid or alectoronic acid, ±α-collatolic acid present 33

32(31) Lecanoric acid present . . . . . **Parmotrema hololobum** (Hale) Hale
Gyrophoric acid present; pycnoconidia filiform; psoromic acid present in association with apothecia . . . . . **Parmotrema jacarandicola** (Krog & Swinscow) Krog & Swinscow

33(31) Medulla UV− (norlobaridone and/or protolichesterinic acid) . . . . . **Parmotrema abessinicum** (Kremp.) Hale
Medulla UV+ (alectoronic acid, ±α-collatolic acid) 34

34(33) Lobes mainly 1–2 cm wide; thallus corticolous or saxicolous; upland species above *c.* 1000 m altitude . . . . . **Parmotrema maclayanum** (Müll. Arg.) Hale
Lobes < 1 cm wide; thallus corticolous; coastal and lowland species below *c.* 1000 m altitude . . . . . **Parmotrema durumae** (Krog & Swinscow) Krog & Swinscow

35(1) Isidia (including sorediate isidia), phyllidia, or dactyls present 36
Isidia, phyllidia and dactyls absent; soralia present 50

36(35) Marginal cilia absent 37
Marginal cilia present 40

37(36) Medulla with protocetraric acid (Pd+ orange-red) and fatty acid, cortex with atranorin; lobes 1–2 mm wide, rounded, flat or convex; closed dactyls and crescent-shaped folds covering most of the thallus; upperside maculate; underside black to the margins; saxicolous . . . . . **Parmotrema zimbabwense** (Hale) Kirika *et al.*
Medulla Pd− 38

38(37) Thallus large, loosely attached to tree bark or rock; isidia cylindrical and granular, or dactyls present; medulla C+ red (lecanoric acid) . . . . . **Parmotrema tinctorum** (Nyl.) Hale
Thallus small, strongly attached to rock; only dactyls or coarse isidia present; medulla C+ or C− 39

39(38) Medulla C+ red (lecanoric acid) . . . . . **Parmotrema stuhlmannii** (C. W. Dodge) Krog & Swinscow
Medulla C− (physodic acid) . . . . . **Parmotrema tsavoense** (Krog & Swinscow) Krog & Swinscow

40(36) Thallus yellow-green (usnic acid present) . . . . .
Parmotrema nyasense (C. W. Dodge) R. S. Egan comb. nov. [MycoBank No.: MB 844542] basionym: *Parmelia nyasensis* C. W. Dodge, *Annals of the Missouri Botanical Garden* **46**, 126 (1959). The nomenclatural novelty in Egan *et al.*, *Bibliotheca Lichenologica* **110**, 383 (2016) is published here by R. S. Egan.
Thallus grey (usnic acid absent) 41

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41(40) Upper cortex with a reticulate pattern of maculae and cracks; rhizines in part squarrose . . . . **Parmotrema subisidiosum** (Müll. Arg.) Hale
Upper cortex without a reticulate pattern of maculae and cracks; rhizines not squarrose 42

42(41) Medulla pigmented pale to bright yellow or orange, pigment K− 43
Medulla white, at most with patches of an ochraceous, K+ purple pigment near the lower cortex; isidia cylindrical, submarginally or laminally situated 44

43(42) Medulla pigmented bright yellow to orange throughout; cylindrical isidia present; coastal species . . . . **Parmotrema sulphuratum** (Nees & Flotow) Hale
Medulla pigmented pale yellow, but sometimes inapparent; open dactyls present; lower montane forest species . . . . **Parmotrema cryptoxanthum** (des Abb.) Hale

44(42) Upperside distinctly maculate 45
Upperside emaculate or faintly maculate 46

45(44) Rhizines dimorphous; salazinic acid and norlobaridone present; upland species . . . . **Parmotrema subtinctorium** (Zahlbr.) Hale
Rhizines uniform; stictic and norstictic acids present; coastal species . . . . **Parmotrema kwalense** (Krog & Swinscow) Krog & Swinscow

46(44) Thallus coriaceous; isidia mainly laminal, never becoming sorediate 47
Thallus usually membranaceous; isidia mainly submarginal, often becoming sorediate-granular 48

47(46) Medulla C+ rose, Pd−, UV− (gyrophoric acid) . . . . . **Parmotrema pseudocrinitum** (Abbayes) Hale
Medulla C−, Pd+ orange, UV+ intensely yellow (salazinic acid, lichexanthone) . . . **Parmotrema ultralucens** (Krog) Hale

48(46) Upper cortex usually continuous; isidia rarely sorediate; medulla Pd+ orange (stictic acid) . . . . **Parmotrema crinitum** (Ach.) M. Choisy
Upper cortex fragile and flaking; isidia often sorediate; medulla Pd− 49

49(48) Medulla C+ rose, UV− (gyrophoric acid) . . . . . **Parmotrema lophogenum** (Abbayes) Hale
Medulla C−, UV+ (alectoronic acid) . . . . . **Parmotrema mellissii** (C. W. Dodge) Hale

50(35) Marginal cilia absent 51
Marginal cilia present 62

51(50) Saxicolous 52
Corticolous 55

52(51) Medulla Pd+ orange-red (protocetraric acid) . . . . . **Parmotrema pardii** (Krog & Swinscow) Krog & Swinscow
Medulla Pd− 53

53(52) Medulla C− (fatty acids) . . . . . **Parmotrema praesorediosum** (Nyl.) Hale
Medulla C+ red (lecanoric acid) 54

54(53) Thallus small, coriaceous, strongly attached; upper cortex emaculate, shiny . . . . . **Parmotrema defectum** (Hale) Hale
Thallus usually large, relatively thin, loosely attached; upper cortex faintly maculate, often matt . . . . **Parmotrema austrosinense** (Zahlbr.) Hale

55(51) Thallus yellow or yellowish grey (usnic acid present); medulla Pd+ orange-red (protocetraric acid) 56
Thallus pale grey (usnic acid absent); medulla Pd+ or Pd− 58

56(55) Thallus bright yellow to yellow-green; atranorin absent . . . **Parmotrema apricum** (Krog & Swinscow) Krog & Swinscow
Thallus yellowish grey; atranorin present 57

57(56) Echinocarpic acid and various unknowns present . . . . . **Parmotrema dilatatum** (Vain.) Hale
Echinocarpic acid and unknowns absent . . . . . **Parmotrema ravum** (Krog & Swinscow) Sérus.

58(55) Medulla C+ red (lecanoric acid) . . . . . **Parmotrema austrosinense** (Zahlbr.) Hale
Medulla C− 59

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59(58) Medulla Pd− (fatty acids) . . . . **Parmotrema praesorediosum** (Nyl.) Hale
Medulla Pd+ orange or red 60

60(59) Medulla K+ red (salazinic acid) . . . . **Parmotrema cristiferum** (Taylor) Hale
Medulla K+ pale brown (protocetraric acid) 61

61(60) Lobes 0.8–1.5(–2) cm wide, rarely sparingly ciliate, (cilia 0.2–0.5 mm long); upperside emaculate (or faintly maculate); soralia marginal and submarginal, soredia granular; apothecia laminal, substipitate, thalline exciple sorediate; pycnoconidia sublageniform . . . . **Parmotrema gardneri** (C. W. Dodge) Sérus.
Lobes 0.8–3 mm wide, eciliate; upperside maculate; soralia laminal, punctiform, more or less confluent in central parts; apothecia and pycnidia not seen in material from Kenya . . . . **Parmotrema epileucum** (Hale) Kirika *et al.*

62(50) Upper cortex fragile and flaking; soralia erupting in a pustular fashion 63
Upper cortex continuous; soralia rarely pustular 66

63(62) Medulla pigmented pale yellow; echinocarpic acid and fatty acids present . . . . . **Parmotrema cryptoxanthum** (Abbayes) Hale
Medulla white; chemistry otherwise 64

64(63) Medulla Pd+ orange, UV− (stictic acid) . . . . **Parmotrema bangii** (Vain.) Hale
Medulla Pd−, UV+ (alectoronic acid) 65

65(64) Soralia pustular, without isidia . . . . **Parmotrema rimulosum** (C. W. Dodge) Hale
Soralia not pustular, but occasionally interspersed with isidia . . . . **Parmotrema mellissii** (C. W. Dodge) Hale

66(62) Medulla pigmented (ochraceous yellow to salmon pink), K− 67
Medulla white, K− (or K+ purple, if patches of an ochraceous yellow pigment occur near the lower cortex) 68

67(66) Medulla C+ rose in upper parts (gyrophoric acid) . . . . **Parmotrema permutatum** (Stirt.) Hale
Medulla C− (fatty acids) . . . . **Parmotrema araucariarum** (Zahlbr.) Hale

68(66) Upper cortex with a reticulate pattern of maculae and cracks; rhizines in part squarrose . . . . **Parmotrema reticulatum** (Taylor) M. Choisy
Upper cortex lacking a reticulate pattern of maculae and cracks; rhizines not squarrose 69

69(68) Underside with a distinct, white marginal zone 70
Underside with a brown or mottled marginal zone 72

70(69) Lobes deeply divided, with sublinear laciniae; medulla K+ red, Pd+ orange (norstictic, galbinic and salazinic acids); coastal species . . . . **Parmotrema parahypoptorum** (W. L. Culb.) Hale
Lobes more or less rounded, sublinear laciniae absent; medulla K−, Pd−; inland species 71

71(70) Underside black in the centre, white peripherally; medulla UV− (norlobaridone and/or protolichesterinic acid) . . . . **Parmotrema hababianum** (Gyeln.) Hale
Underside almost entirely white; medulla UV+ (alectoronic acid) . . . . **Parmotrema louisianae** (Hale) Hale

72(69) Rhizines dimorphous, often extending to the margins 73
Rhizines uniform, rarely extending to the margins 74

73(72) Soralia marginal; medulla Pd+ orange, KC− (salazinic acid) or Pd−, KC+ red (norlobaridone) . . . . **Parmotrema subsumptum** (Nyl.) Hale
Soralia laminal; medulla Pd−, KC− (fatty acids) . . . . **Parmotrema pilosum** (Stizenb.) Krog & Swinscow

74(72) Upper cortex distinctly maculate 75
Upper cortex emaculate or faintly maculate 76

75(74) Medulla UV+ (alectoronic acid, ±α-collatolic acid, ±gyrophoric acid) . . . . **Parmotrema lobulascens** (J. Stein.) Hale
Medulla UV− (gyrophoric acid and/or norlobaridone, ±norstictic acid) . . . . **Parmotrema subschimperi** (Hale) Hale

76(74) Thallus saxicolous 77
Thallus normally corticolous 78

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77(76) Medulla UV+ (alectoronic acid) . . . . **Parmotrema poolii** (C. W. Dodge) Krog & Swinscow
Medulla UV−, Pd+ orange-red (fumarprotocetraric and protocetraric acids) . . . . **Parmotrema pseudograyanum** (Hale) Sérus.

78(76) Medulla Pd+ orange → red 79
Medulla Pd−; soralia Pd− or Pd+ yellow 83

79(78) Protocetraric acid present 80
Protocetraric acid absent 82

80(79) Medulla C+ rose, gyrophoric acid present . . . . **Parmotrema umbrosum** (Krog & Swinscow) Krog & Swinscow
Medulla C−, gyrophoric acid absent 81

81(80) Cilia well developed; medulla UV+ (alectoronic or α-collatolic acid) or UV− (protolichesterinic acid) . . . . **Parmotrema subarnoldii** (Abbayes) Hale
Cilia poorly developed, present only in the lobe axils; medulla UV− (±undetermined fatty acids) . . . . **Parmotrema gardneri** (C. W. Dodge) Sérus.

82(79) Stictic acid present . . . . **Parmotrema perlatum** (Huds.) M. Choisy
Salazinic acid present . . . . **Parmotrema cristiferum** (Taylor) Hale

83(78) Soralia Pd+ sulphur yellow (psoromic acid) . . . . **Parmotrema direagens** (Hale) Hale
Soralia Pd− or at most Pd+ pale yellow (psoromic acid absent) 84

84(83) Medulla UV+ (alectoronic acid) . . . . **Parmotrema poolii** (Dodge) Krog & Swinscow
Medulla UV− 85

85(84) Medulla C− (norlobaridone and/or protolichesterinic acid) . . . . **Parmotrema hababianum** (Gyeln.) Hale
Medulla C+ rose or red 86

86(85) Lecanoric acid present . . . . **Parmotrema cooperi** (Steiner & Zahlbr.) Sérus.
Gyrophoric acid present 87

87(86) Soralia often ciliate, soredia granular; fatty acids present . . . . **Parmotrema lophogenum** (Abbayes) Hale
Soralia eciliate, soredia farinose; fatty acids absent 88

88(87) Norlobaridone present . . . . **Parmotrema indicum** Hale
Norlobaridone absent . . . . **Parmotrema sancti-angelii** (Lynge) Hale

Key to the species of Punctelia *Krog (9)*

Upperside with laminal, punctiform pseudocyphellae. Rhizines simple. Medulla white except for an ochraceous, K+ purple pigment (skyrin) in some species. Apothecia with imperforate disc. Pycnoconidia unciform (rod-shaped with a single hook-shaped end), bifusiform, or filiform.

1 Soredia, isidia and phyllidia absent 2
Soredia, isidia, or phyllidia present 3

2(1) Underside pale brown; lecanoric acid present . . . . **Punctelia semansiana** (W. L. Culb. & C. F. Culb.) Krog
Underside black; gyrophoric acid present . . . . **Punctelia subpraesignis** (Nyl.) Krog

3(1) Isidia or phyllidia present, soredia absent 4
Isidia and phyllidia absent, soredia present 5

4(3) Thallus with low, papilliform or sparingly branched isidia with a dull surface; always on rock . . . . **Punctelia punctilla** (Hale) Krog
Thallus with coralloid isidia or phyllidia with a glossy cortex; underside pale brown; lecanoric acid present; commonly on trees . . . . **Punctelia rudecta** (Ach.) Krog

5(3) Medulla C+ rose or red, KC+ red 6
Medulla C−, KC− 8

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6(5) Underside pale brown; medulla C+ red (lecanoric acid) . . . . **Punctelia subrudecta** (Nyl.) Krog
Underside black; medulla C+ rose (gyrophoric acid) 7

7(6) Upperside predominantly grey; mainly corticolous; widespread . . . . **Punctelia borreri** (Sm.) Krog
Upperside with a pronounced brown marginal zone; saxicolous in upper montane-alpine region; rare . . . . **Punctelia stictica** (Duby) Krog

8(5) Underside pale brown; caperatic acid present . . . . **Punctelia neutralis** (Hale) Krog
Underside black; undetermined fatty acids present . . . . **Punctelia reddenda** (Stirt.) Krog

Key to species of Xanthoparmelia *(Vain.) Hale (29)*

Lobes irregularly incised, truncate, or rounded, separate to imbricate, 0.1–8 mm wide, marginal cilia absent. Upperside pale yellowish green or brown. Medulla white to ochraceous. Underside pale to dark brown or black, rhizinate to the margin or with a bare marginal zone (or rarely without rhizines). Rhizines simple, often with pale, frayed tips. With or without isidia, without soredia and pseudocyphellae. Apothecia adnate to substipitate, disc imperforate. Pycnoconidia shortly bifusiform.

Saxicolous, often in high elevations at several thousand metres.

1 Isidia absent 2
Isidia present 12

2(1) Underside brown 3
Underside black 5

3(2) Lobes usually wider than 2 mm; medulla with fumarprotocetraric and/or protocetraric acid 4
Lobes linear-elongate, almost completely terete, 0.5–1.5 mm wide; medulla with salazinic acid and norstictic acid (trace); cortex with usnic acid . . . . **Xanthoparmelia cylindriloba** M. D. E. Knox

4(3) Lobes imbricate, 0.8–4(–8) mm wide; medulla with fumarprotocetraric acid and associated substances; cortex with usnic acid . . . . **Xanthoparmelia phaeophana** (Stirt.) Hale
Lobes mainly adjacent, 2–4 mm wide; medulla with protocetraric acid; cortex with usnic acid . . . . **Xanthoparmelia austroafricana** (Stirt.) Hale

5(2) Thallus subcrustose, tightly adnate to the substratum; lobes 0.5–1 mm wide, reddish brown; norstictic acid present . . . . **Xanthoparmelia nakuruensis** (Essl.) O. Blanco *et al.*
Thallus foliose, loosely attached to the substratum 6

6(5) Upperside distinctly and evenly maculate, pale yellow; protocetraric acid present; lobes imbricate, ascending, repeatedly branched, sublinear, slightly convex, 0.5–1.5 mm wide; medulla with protocetraric acid, ±fatty acid; cortex with usnic acid; below *c.* 2500 m alt. . . . . **Xanthoparmelia hypoleia** (Nyl.) Hale
Upperside emaculate or at most maculate here and there; chemistry various, protocetraric acid absent; above *c.* 3000 m alt. 7

7(6) Salazinic acid present. 8
Salazinic acid absent. 9

8(7) Thallus pulvinate 10
Thallus not pulvinate, membranous, lobes sublinear, 2–4(–5) mm wide, contiguous to imbricate, emaculate, slightly to moderately rhizinate; cortex with usnic acid . . . . **Xanthoparmelia tasmanica** (Hook. f. & Taylor) Hale

9(7) Lobes up to 8 mm wide, white-maculate, rhizinate to the margins; cortex with usnic acid . . . . **Xanthoparmelia africana** Hale
Lobes 0.8–2 mm wide, black rimmed, emaculate, sparsely to moderately rhizinate; cortex with usnic acid . . . . **Xanthoparmelia salkiboensis** Hale

10(8) Lobes sublinear, secondary laciniae lacking, 2–4(–5) mm wide, contiguous to imbricate, emaculate, sparsely rhizinate; medulla with fumarprotocetraric acid and associated substances; cortex with usnic acid . . . . **Xanthoparmelia rogersii** Elix & J. Johnst.
Lobes 0.1–0.3 mm in the centre, peripherally 2–3(–4) mm wide, with a rhizine-free marginal zone at apices; medulla with different substances 11

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11(10) Medulla K+ red (norstictic acid); lobes plane or in part subterete, 0.1–2(–3) mm wide; cortex with usnic acid . . . . **Xanthoparmelia kiboensis** (C. W. Dodge) Krog & Swinscow
Medulla K− (fatty acids); lobes plane, 0.2–4 mm; cortex with usnic acid . . . . . **Xanthoparmelia atroventralis** (Hale) Hale

12(l) Thallus adnate to appressed; lobes adjacent, normally < 1.5 mm wide (however, *X. treurensis* and *X. verrucigera* with wider lobes key out here) 13
Thallus adnate to loosely attached; lobes often imbricate, normally > 1.5 mm wide (however, *X. endochrysea* with narrower lobes keys out here) 23

13(12) Underside black 14
Underside brown 19

14(13) Stictic acid present 15
Stictic acid absent 17

15(14) Lobes 0.2–0.8 mm wide, irregularly incised, with a narrow black margin; isidia globose, often bursting open, but not becoming sorediose; cortex with usnic acid . . . . **Xanthoparmelia congensis** (J. Steiner) Hale
Lobes wider than 1 mm, without black margin; isidia cylindrical 16

16(15) Lobes 1–3 mm wide, subirregular, contiguous to imbricate; verrucigeric acid present; cortex with usnic acid . . . . **Xanthoparmelia verrucigera** (Nyl.) Hale
Lobes 2–5 mm wide, sublinear, contiguous; verrucigeric acid absent; cortex with usnic acid . . . . **Xanthoparmelia treurensis** Hale *et al.*

17(14) Lobes sublinear, 1.8–4 mm wide, contiguous to densely imbricate, weakly white-maculate; isidia cylindrical, becoming dense and coralloid branched with age; salazinic acid present; cortex with usnic acid . . . . **Xanthoparmelia australasica** D. J. Galloway
Lobes 0.5–1.5 mm wide 18

18(17) Thallus moderately to closely adnate, medium to dark brown; lobes irregularly incised, more or less imbricate, (0.5–)1–1.5 mm wide; isidia cylindrical, rarely clavate, simple or branched; PQ-4 and related substances of the 'quintaria' type I; medulla K+ red, Pd+ pale yellow; cortex with usnic acid . . . . **Xanthoparmelia kenyana** (Essl.) O. Blanco *et al.*
Thallus adnate to appressed, pale yellow-green, darkening at the centre; lobes adjacent or somewhat overlapping, 0.7–1.3 mm, lobe ends irregularly incised; isida subglobose to shortly cylindrical, unbranched or rarely, sparingly branched; salazinic acid present; cortex with usnic acid . . . . **Xanthoparmelia diadeta** (Hale) Hale

19(13) Thallus yellowish grey or pale grey; cortex with atranorin 20
Thallus yellow-green; cortex with usnic acid 21

20(19) Lobes deeply divided; isidia usually darker than the thallus; apothecia often numerous, laminal, 1–2 mm diam.; pycnoconidia weakly bifusiform, 5–7 μm long; medulla with lecanoric acid (C+ red) . . . . **Xanthoparmelia annexa** (Kurok.) Elix
Lobes irregularly incised, often black rimmed, more or less imbricate; isidia concolorous with the thallus, sometimes darker grey; mature apothecia and pycnidia not seen in material from Kenya; medulla with norlobaridone (KC+ purple), loxodin . . . . **Xanthoparmelia subtortula** (Hale) Elix

21(19) Isidia coarse, dissolving into agglomerates of corticate granules; medulla K+ yellow, Pd+ yellow-orange, stictic acid aggr. . . . . **Xanthoparmelia glomerulata** Krog & Swinscow
Isidia cylindrical, slender 22

22(21) Medulla white, K−, Pd−, KC+ purple, norlobaridone . . . . **Xanthoparmelia amplexula** (Stirt.) Elix & Johnston
Medulla ochraceous, pigment K−; cortex with usnic acid; medulla with protocetraric acid, fumarprotocetraric acid (Pd+ orange-red) and two undetermined substances (trace amounts) . . . . **Xanthoparmelia krogiae** Hale & Elix

23(12) Underside black 24
Underside brown 26

24(23) Stictic acid present . . . . **Xanthoparmelia lusitana** (Nyl.) Krog
Stictic acid absent 25

25(24) Isidia uniformly cylindrical; medulla K− (fatty acids) . . . . **Xanthoparmelia meruensis** Krog & Swinscow
Isidia cylindrical, semiglobular, claviform, or spatulate-lobulate; medulla K+ red (salazinic acid) . . . . **Xanthoparmelia tinctina** (Maheu & A. Gillet) Hale

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26(23) Thallus adnate or tightly adnate on rock; medulla Pd+ pale orange 27
Thallus loosely attached; isidia mostly slender; medulla Pd+ yellow-orange or orange-red 28

27(26) Thallus tightly adnate, lobes 0.7–1.3 mm wide, moderately isidiate; hypoprotocetraric acid present . . . . . **Xanthoparmelia endochrysea** (Müll. Arg.) Hale
Thallus adnate, lobes 2–3 mm wide; isidia coarse; hypoprotocetraric acid present . . . . . **Xanthoparmelia weberi** (Hale) Hale

28(26) Medulla K+ pale brown, fumarprotocetraric acid present . . . . . **Xanthoparmelia subramigera** (Gyeln.) Hale
Medulla K+ red, salazinic acid present . . . . . **Xanthoparmelia mexicana** (Gyeln.) Hale

Discussion

The key obviously contains some species with only a preliminary taxonomic status. Several recent papers by Kirika *et al.* (Kirika *et al.* 2016*a*, *b*, *c*, 2017*a*, *b*, 2019) contain valuable novelties; these have been revealed by the application of molecular genetic methods on East African lichens which emphasizes the importance of studying further tropical collections to clarify unanswered questions. The most important changes were necessary to determine the status of *Pseudoparmelia* species, most of which were recombined as *Canoparmelia*, *Flavoparmelia*, *Parmelia*, *Parmotrema*, *Relicina* or *Xanthoparmelia*. *Parmotrema nyasense* (C. W. Dodge) R. S. Egan comb. nov. is formally recombined in this publication. Confirmation of this change by molecular genetic analysis is necessary as soon as fresh collections are available. A new combination for *Pseudoparmelia usambarensis* (J. Steiner & Zahlbr.) Krog & Swinscow was incorrectly cited in Index Fungorum Partnership (2022) as '*Parmotrema usambarense* (J. Steiner & Zahlbr.) Buaruang *et al.* [as '*usambarensis*'], *MycoKeys* **28** [actually **23**], 58 (2017)', and incorrectly listed in Buaruang *et al.* (2017) as '*Parmotrema usambarense* (J. Steiner & Zahlbr.) Krog & Swinscow, *Lichenologist* **19**, 424 (1987)', since this refers to the publication of *Pseudoparmelia usambarense* (J. Steiner & Zahlbr.) Krog & Swinscow, as maintained here in the newly presented key. Several other taxa may change their taxonomic status as a result of further research. Some species treated earlier as synonyms (e.g. *Pseudoparmelia caroliniana* (Nyl.) Hale and *P. concrescens* (Vain.) Hale) according to the chemical concept of Swinscow & Krog (1988) are independently added to the key (cf. Culberson 1993). The chemical variety (2) of *Flavoparmelia soredians sensu* Swinscow & Krog (1988) may represent smaller specimens of *F. caperata* with narrower lobes, or another species; it has therefore been omitted from the key. In other supposedly related species (e.g. the apotheciate *Parmotrema abessinicum* and the sorediate *P. hababianum*) with similar chemical compositions, different hypotheses may be reached. Several earlier literature sources (e.g. Hale 1974*a*, *b*, *c*, *d*; Elix *et al.* 1986; Kurokawa 1994) need to be restudied to revise or reinstate the various taxonomic concepts (Egan *et al.* 2016; Del-Prado *et al.* 2019; Diederich & Ertz 2020). Furthermore, the molecular genetic and regulatory background of the biosynthetic pathways must be better understood (cf. Singh *et al.* 2021) in order to explain chemotype diversity.

Some species indicated as *Hypotrachyna* sp. A and sp. B, *Neofuscelia* sp. A, *Parmotrema* sp. A and sp. B (Swinscow & Krog 1988) or certain species mentioned in other publications (e.g. Kirika *et al.* 2016*c*, 2019) as existing but not yet formally described, will no doubt increase the number of species in the near future, but further fieldwork will most certainly result in an increased number of newly described species.

Lichenologically, Kenya is one of the best studied countries in Africa. The search word 'Kenya' in the database '*Recent literature on lichens*' (Culberson *et al.* 2022) resulted in 79 papers out of 52 174, while 645 papers were found for 'tropical' (563) + 'tropics' (82) or 805 for 'Africa'. Thus *c.* 10% of publications from Africa originate from Kenyan material. However, discoveries of species new to science can be expected since tropical and African lichens are generally understudied.

Since our knowledge of lichenicolous fungi in East Africa is still limited (Farkas & Flakus 2016; Suija *et al.* 2018), research into possible host species is very important. The key presented here will support further field studies and the identification work that follows, and thus contribute to a better knowledge of both lichens and their lichenicolous fungi in Kenya and East Africa, as well as promote conservation studies and the practical use of bioactive lichen secondary metabolites.

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