

## 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, 2016a, b, c, 2017a, 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.

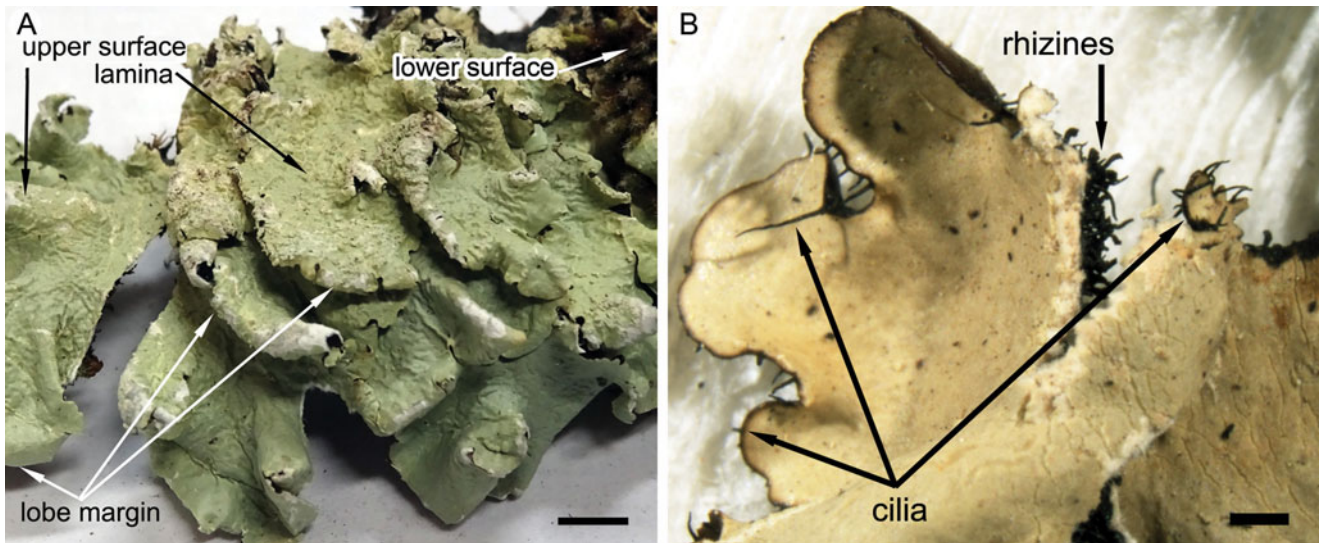
### Materials and Methods

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.* 2016a, b, c, 2017a, 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; Canëz

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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 2012a, 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).

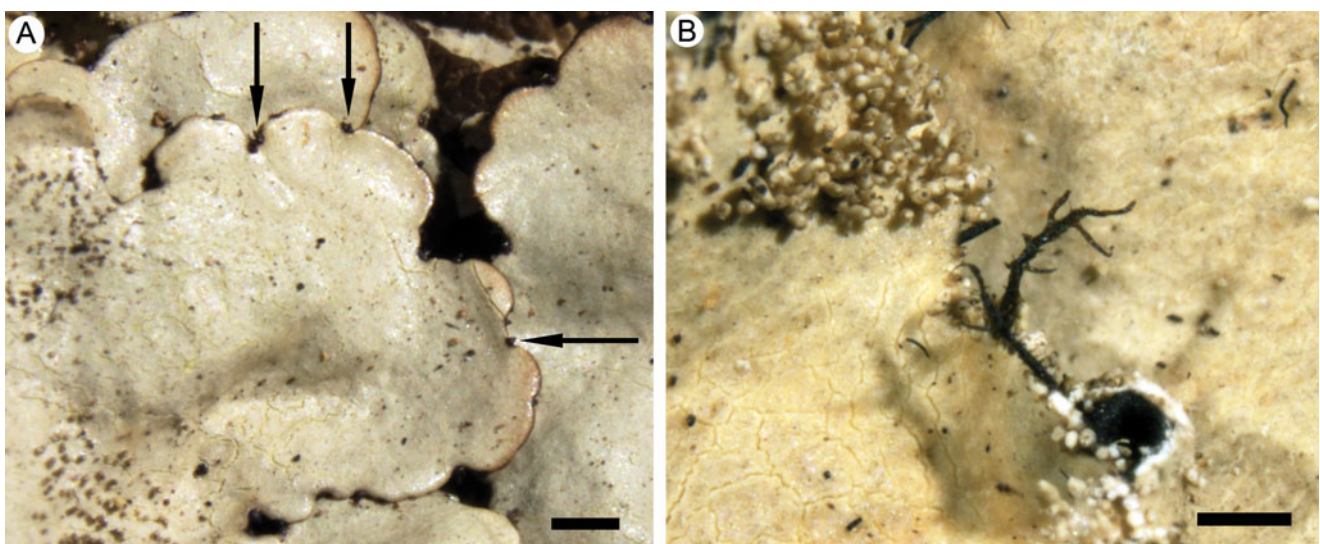
The dichotomous main key leads to species where the genus has only a small number of representatives (maximum 4 species), but otherwise to genera. Larger genera are treated separately after the main key. *Bulborrhizina* (1) is treated in the generic key (*Bulbothrix* s. lat.) together with *Bulbothrix*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

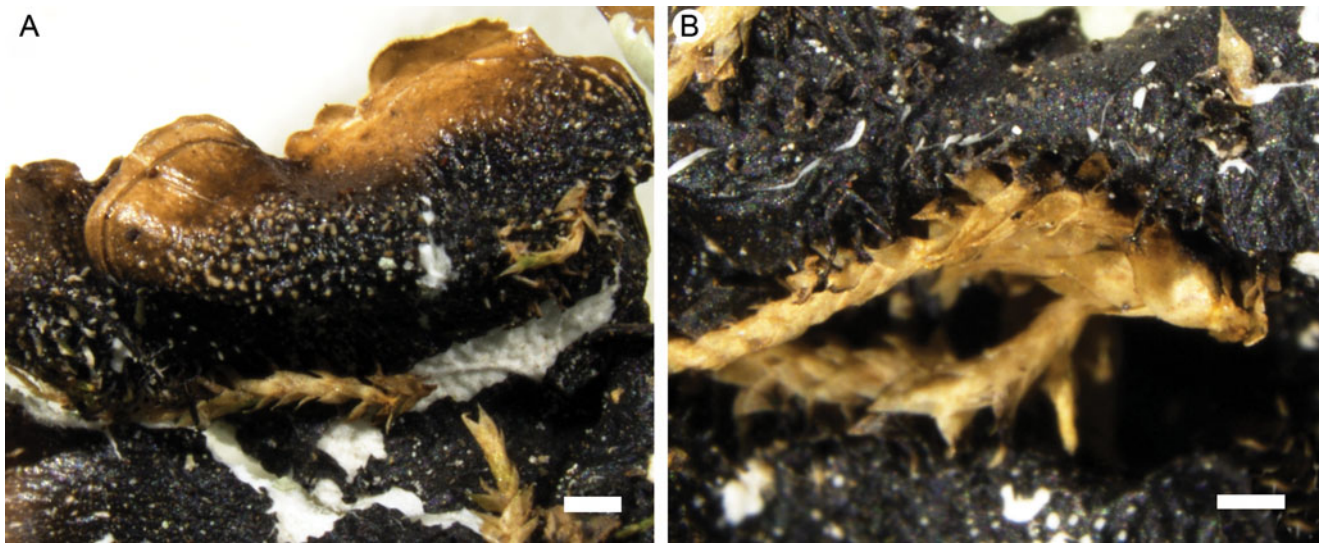
#### Specimen details

**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

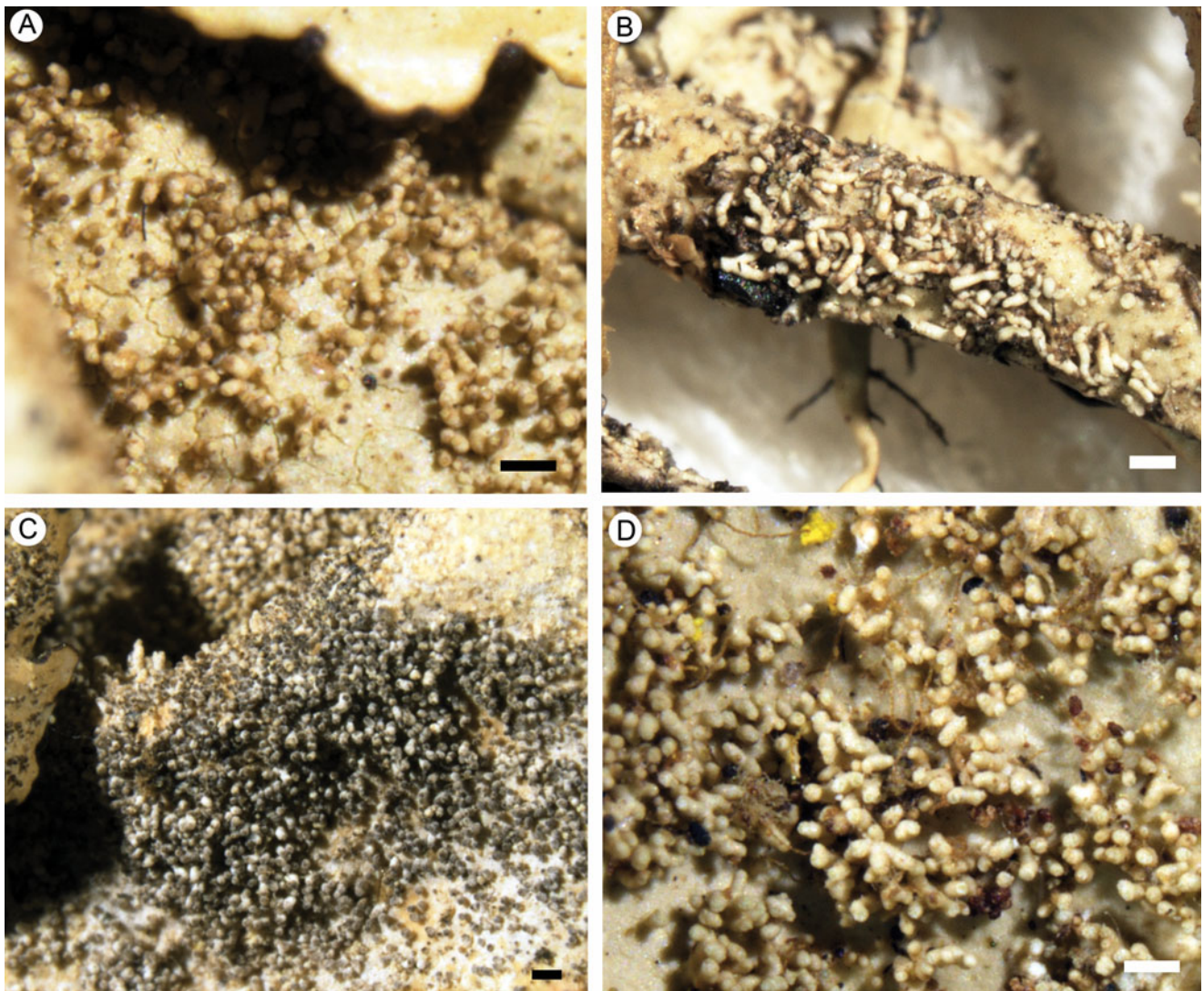


**Fig. 2.** Appendages on the thallus. A, bulbate cilia indicated by arrows (*Bulbothrix isidiza*, VBI 1691). B, branched rhizine (*Parmotrema ultralucens*, VBI 2217). Scales: A & B = 0.5 mm. In colour online.



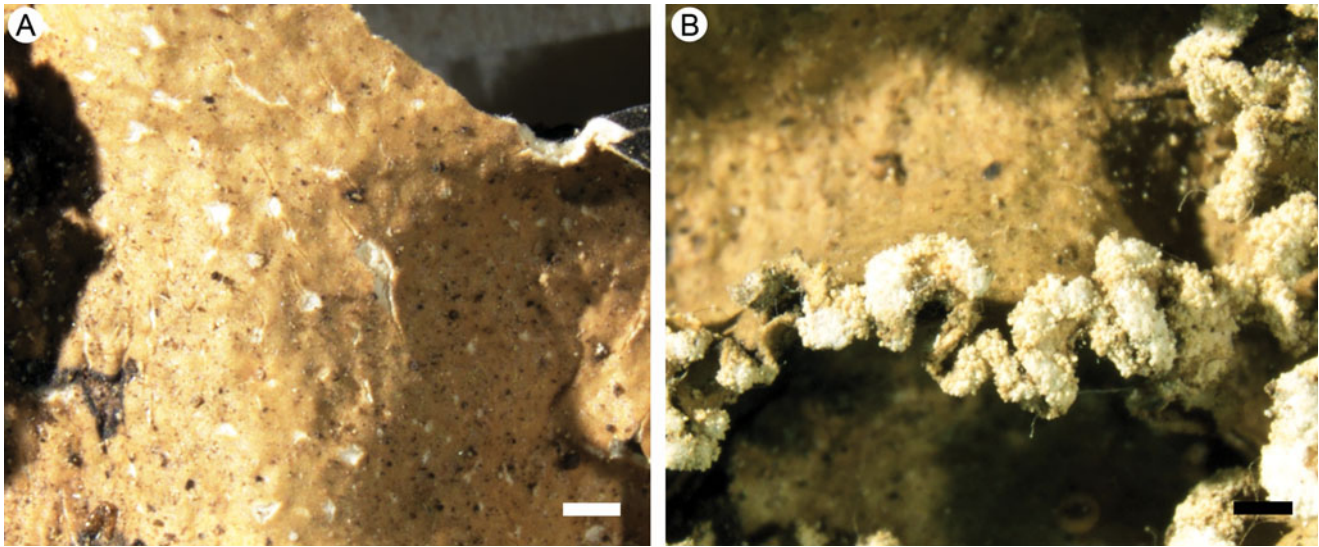


**Fig. 3.** Lower surface of the thallus (*Flavoparmelia caperata*, A. M. Muhoro 21/01). A, paler zone at the margin with pale rhizines. B, inner dark rhizines. Scales: A & B = 0.5 mm. In colour online.



**Fig. 4.** Laminar 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.





**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.

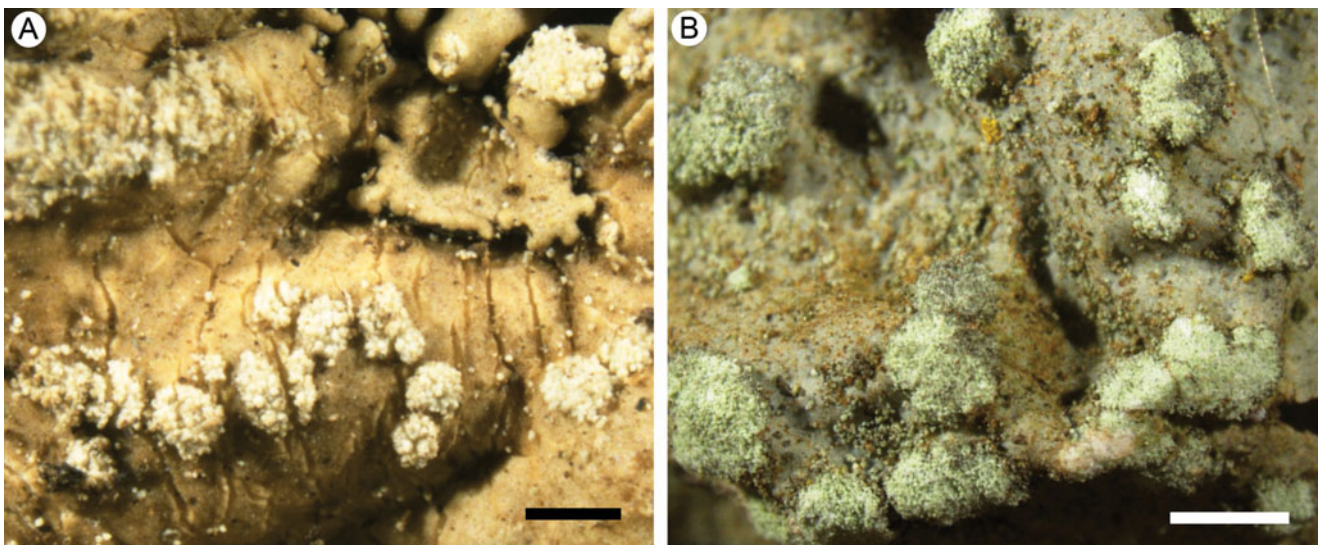
**Specimens used for micrographs.** *Bulbothrix isidiza* (Nyl.) Hale. **Tanzania:** Morogoro Region: Northern Uluguru Mts, near the town of Morogoro, valley leading S from Bigwa Mission to Lupanga peak, on E-facing slope, alt. 1100–1200 m, from bark of *Dahlbergia lactea* in dry rocky woodland, 1988,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



- '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 soledians** (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



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  $5\text{--}10 \times 5\text{--}7.5 \mu\text{m}$ ; pycnidia not seen in material from Kenya; cortex K+ yellow, UV–, secalononic 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  $8\text{--}12 \times 6\text{--}8 \mu\text{m}$  . . . . . **Bulbothrix sensibilis** (Steiner & Zahlbr.) Hale  
 Ascospores  $16\text{--}20 \times 8\text{--}12 \mu\text{m}$  . . . . . **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 kenya** 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* Lyngé (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

4(2)	Soredia, isidia or dactyls present	5
	Soredia, isidia or dactyls absent	9
5(4)	Laminal, punctiform soralia present	<b>Canoparmelia texana</b> (Tuck.) Elix & Hale
	Isidia or dactyls present	6
6(5)	Laminal dactyls with open tips present	<b>Canoparmelia pustulescens</b> (Kurok.) Elix
	Cylindrical isidia present	7
7(6)	Upperside matt, emaculate, Pd+ orange-red (protocetraric acid)	<b>Canoparmelia amazonica</b> (Nyl.) Elix & Hale
	Upperside maculate, cracked and rugose, Pd–, containing perlatolic acid or divaricatic acid	8
8(7)	Medulla with perlatolic acid	<b>Canoparmelia caroliniana</b> (Nyl.) Elix & Hale
	Medulla with divaricatic acid	<b>Canoparmelia concrecens</b> (Vain.) Elix & Hale
9(4)	Lobes 1–3 mm wide	<b>Canoparmelia rodriguesiana</b> (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)	<b>Canoparmelia nairobiensis</b> (J. Stein. & Zahlbr.) Elix & Hale
	Upperside emaculate; medulla with protocetraric acid (Pd+ orange-red)	<b>Canoparmelia somaliensis</b> (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	<b>Hypotrachyna fissicarpa</b> (Kurok.) Hale
	Rhizines densely branched; medulla K+ red (salazinic acid); corticolous species	<b>Hypotrachyna sublaevigata</b> (Nyl.) Hale
4(2)	Rhizines mainly simple; di- <i>O</i> -methylgyrophoric acid and related substances ('horrescens complex' <sup>1</sup> ) present	<b>Hypotrachyna damaziana</b> (Zahlbr.) Krog & Swinscow
	Rhizines distinctly branched; chemistry otherwise	5
5(4)	Medulla C+ rose (gyrophoric acid)	<b>Hypotrachyna scytophylla</b> (Kurok.) Hale
	Medulla C+ yellow-orange or C–	6
6(5)	Rhizines moderately branched; medulla KC+ orange, barbatic acid, 4- <i>O</i> -demethylbarbatic acid and obtusatic acid	<b>Hypotrachyna ducalis</b> (Jatta) Hale
	Rhizines densely dichotomously branched; medulla KC+ orange, barbatic acid (major) obtusatic acid (minor)	<b>Hypotrachyna kenyana</b> Kirika <i>et al.</i>
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	<b>Hypotrachyna polydactyla</b> (Krog & Swinscow) T. H. Nash
	Thallus with isidia; chemistry otherwise	9

<sup>1</sup>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*-methylhiassic acid, 4,5-di-*O*-methylhiassic acid, lecanoric acid, and 3-hydroxygyrophoric acids (Benatti 2012b).



- 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 spatulata** (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.*

- 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  $\alpha$ -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  $\pm$ 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



- 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 holobum** (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 holobum** (Hale) Hale  
Lobe margins ascending; pycnoconidia sublageniform; thalline exciple rarely ciliate; medulla C– (norlobaridone and/or protolichesterinic acid) . . . . . **Parmotrema abessinicum** (Kremp.) Hale

- 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,  $\pm\alpha$ -collatolic acid,  $\pm$ 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,  
 $\pm\alpha$ -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,  $\pm\alpha$ -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 (leca-  
 noric 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



- 41(40) Upper cortex with a reticulate pattern of maculae and cracks; rhizines in part squarrose ..... **Parmotrema subsidiosum** (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

- 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 araucarium** (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,  $\pm\alpha$ -collatolic acid,  $\pm$ gyrophoric acid) . . . . . **Parmotrema lobulascens** (J. Stein.) Hale  
Medulla UV– (gyrophoric acid and/or norlobaridone,  $\pm$ norstictic acid) . . . . . **Parmotrema subschimperii** (Hale) Hale
- 76(74) Thallus saxicolous . . . . . 77  
Thallus normally corticolous . . . . . 78



- 77(76) Medulla UV+ (alecoronic 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+ (alecoronic or  $\alpha$ -collatolic acid) or UV- (protolichesterinic acid) .....  
 ..... **Parmotrema subarnoldii** (Abbayes) Hale  
 Cilia poorly developed, present only in the lobe axils; medulla UV- ( $\pm$ 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+ (alecoronic 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

- 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 borrieri** (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

- 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(1) 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 soresiose; 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; isidia 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), loxodine . . . . . **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



- 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.* 2016a, b, c, 2017a, 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 niasense* (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 usambarensis* (J. Steiner & Zahlbr.) Buaruang *et al.* [as '*usambarensis*'], *MycKeys* 28 [actually 23], 58 (2017)', and incorrectly listed in Buaruang *et al.* (2017) as '*Parmotrema usambarensis* (J. Steiner & Zahlbr.) Krog & Swinscow, *Lichenologist* 19, 424 (1987)', since this refers to the publication of *Pseudoparmelia usambarensis* (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. conrescens* (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 1974a, 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.* 2016c, 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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