

## NEW RECORDS OF LICHENS AND LICHENICOLOUS FUNGI FROM KENYA AND TANZANIA (EAST AFRICA)

**Edit Farkas<sup>1\*</sup>, László Lőkös<sup>2</sup>, Arthur M. Muhoro<sup>3</sup> & Nóra Varga<sup>1</sup>**

<sup>1</sup>*Institute of Ecology and Botany, Centre for Ecological Research, H-2163 Vácraátót, Hungary;* <sup>2</sup>*Department of Botany, Hungarian Natural History Museum, H-1431 Budapest, Hungary;* <sup>3</sup>*Doctoral School of Biological Sciences, Hungarian University of Agriculture and Life Sciences, H-2100 Gödöllő, Páter K. u. 1, Hungary;*  
*\*E-mail: farkas.edit@ecolres.hu*

**Abstract:** Hungarian collections of lichen-forming and lichenicolous fungi from Kenya and Tanzania were studied analysing morphological and anatomical characters, as well as secondary chemistry by chromatography (HPTLC). Altogether 39 species of lichen-forming fungi and three species of lichenicolous fungi have been recognized and deposited in VBI. The lichens *Bulbothrix kenyana*, *Chrysothrix xanthina*, *Lobaria discolor*, *Parmotrema durumae* and *P. taitae* were discovered as new for Tanzania; *Usnea abissinica* and *U. sanguinea* are new for Kenya. The first records of the lichenicolous fungi *Didymocyrtis* cf. *melanelixiae*, *Lichenocmium erodens* and *Spirographa lichenicola* are presented from East Africa.

**Keywords:** distribution of species, floristics, lichen-forming fungi, lichen parasites, new distribution records

### INTRODUCTION

The current knowledge on East African fruticose and foliose lichens is mostly based on the identification book ‘Macrolichens of East Africa’ by Dougal Swinscow and Hildur Krog (Swinscow and Krog 1988). Data on lichenicolous fungi can be found sporadically in various literature sources (e.g., Kondratyuk and Galloway 1995; Farkas and Flakus 2016; Suija *et al.* 2018; Flakus *et al.* 2019). Zhurbenko has recently described several new species from Kenya, Tanzania and Uganda (Zhurbenko 2021, 2022) from diverse hosts. In our recent publication on identification key of East African collections, we concentrated on the parmelioid taxa (Farkas and Muhoro 2022). Here we report on East African collections – kept in the lichen herbarium VBI (abbreviation according to Thiers 2023) –



which were partly collected in the framework of the Usambara Rain Forest Research Project (in 1980s) in cooperation between the Hungarian Academy of Sciences and the Royal Swedish Academy of Sciences, as well as the Sokoine Agricultural University, Dar es Salaam/Morogoro, Tanzania; and also during various other study trips during the professorship of Tamás Pócs in the Morogoro Campus (1985–1990). Small lichen fragments were also collected for educational purposes in Kenya recently. Approximately 120 specimens of various morphological groups with lichenicolous fungi from the collections of Edit Farkas (1986, 1989, Tanzania), Arthur Macharia Muhoro (2020–2021, Kenya) and Tamás Pócs (1985–1990, Tanzania) were studied recently by stereo and compound research microscopes and high performance thin layer chromatography (HPTLC). The purpose of the study was the identification of species to increase our knowledge on the distribution of lichen-forming and lichenicolous fungi in East Africa.

## **MATERIALS AND METHODS**

Morphology and anatomy of the thalli were studied using a Nikon Eclipse/NiU compound microscope and a Nikon SMZ18 stereomicroscope. Micrographs were prepared using a Nikon DS-Fi1c and Fi3 camera with NIS-Elements BR ML software. HPTLC analysis for studying lichen secondary metabolites was carried out according to standard methods by Arup *et al.* (1993) and Molnár and Farkas (2011). The specimens are deposited in the Lichen Herbarium VBI (Vácrátót, Hungary).

## RESULTS AND DISCUSSION

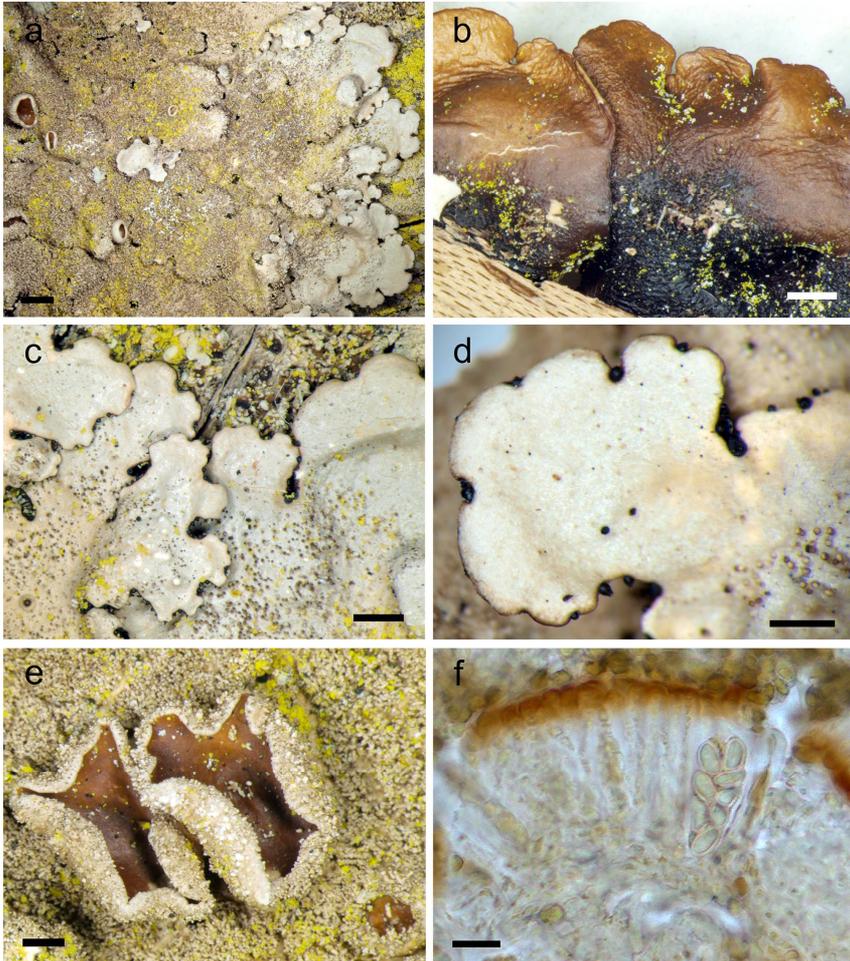
### Annotated checklist of the lichen-forming and lichenicolous fungi

Taxa are listed in alphabetical order. Lichenicolous fungi are indicated by #. New distribution data are indicated by \* (for Kenya or Tanzania), \*\* (for East Africa). Lichenised fungi were identified by E. Farkas, L. Lőkös and A.M. Muhoro in 2022. Lichenicolous fungi were identified by N. Varga in 2022. Locality data and the detected lichen secondary metabolites are given, distribution and some of the most important morphological/anatomical characters of the species are analysed according to available literature data, especially in the case of distributional novelties.

#### \**Bulbothrix kenyana* Kirika, Divakar & Lumbsch

Tanzania: Tanga Region, East Usambara Mts, roadside and secondary vegetation between Amani Research Station and Greenway's forest house, lignicolous at 850–900 m a.s.l., E. Farkas 86209/B, 25–26.10.1986 (VBI 6180 – atranorin, salazinic acid, with *Chrysothrix xanthina*); Morogoro Region, Northern Uluguru Mts, near the town of Morogoro, valley leading S from Bigwa Mission to Lupanga peak, on E-facing slope, from bark of *Dahlbergia lactea* in dry rocky woodland at 1,100–1,200 m a.s.l., T. Pócs 88191/P, 28.09.1988 (VBI 1691, as *Bulbothrix isidiza* (Nyl.) Hale – atranorin, salazinic acid).

The species was described on the basis of an extended, worldwide molecular genetic study a few years ago (Kirika *et al.* 2017). While identifying the specimen from the East Usambara Mts (VBI 6180), a careful investigation of the most important characters (emaculate upper surface, pale brown lower surface, marginal cilia reduced to bulbate nodules, *Figure 1*), resulted in the recognition of this species as a new distribution record from Tanzania and the taxonomic revision of a specimen earlier identified as *B. isidiza* (VBI 1691). Both *B. isidiza* and *B. kenyana* contain atranorin and salazinic acid and the ascospore sizes are overlapping: 10–15 × 5–7 µm in *B. isidiza* (Swinscow and Krog 1988), 7.5–15.0 × 5.0–7.5 µm (10.30–11.75 × 6.00–7.00 µm, ± SD = 1.8–1.7 × 1.3–4.0 µm, n = 40) in *B. kenyana* (Kirika *et al.* 2017), while in our specimens are the following: (10)–11.7–(13.8) × (4.7)–5.9–(6.9) µm ± 1.22 × 0.75 (n = 16) (VBI 6180) and (10.6)–12–(14) × (4.4)–5.7–(7) µm ± 1.7 × 1.22 (n = 10) (VBI 1691).



**Figure 1.** *Bulbothrix kenyana*: **a**), a part of the thallus richly covered by isidia, with a few apothecia and marginal lobes, **b**), a pale brown lower surface with a papillate to naked zone towards the margin, **c-d**), marginal lobes with cilia reduced to bulbate nodules and with often brown tipped isidia on the lamina, **e**), two large apothecia and a small one on the thallus richly covered with isidia and with granules of *Chrysothrix xanthina*, **f**), asci and ascospores in section (a–c, e, f: VBI 6180, with *Chrysothrix xanthina*; d: VBI 1691). Scales: a = 2 mm, b, c, e = 1 mm, d = 500  $\mu$ m, f = 10  $\mu$ m.

***Canoparmelia* cf. *texana* (Tuck.) Elix & Hale**

Tanzania: Southern Uluguru Mts in Morogoro District, secondary grasslands dominated by *Panicum lukwangulense* with scattered *Agauria*, riverfalls at the E edge of Lukwangule Plateau, ramicolous at 2,350–2,450 m a.s.l., T. Pócs, R. Ochyra & H. Bednarek, 88111/M, 08–09.06.1988 (VBI 6178 – with *Flavoparmelia caperata*, caperatic acid (?), protocetraric acid (?), usnic acid; VBI 6179 – with *Flavoparmelia caperata*, atranorin, caperatic acid, usnic acid, unidentified substance).

Widely found in East Africa, widespread in subtropical and temperate regions, but not known from Europe (Swinscow and Krog 1988; Discover Life 2023; Lichenportal 2023). This collection morphologically agrees with characters of *C. texana*, however chemically is related with *Flavoparmelia caperata*. The repeated HPTLC analysis (of VBI 6179) confirmed the occurrence of substances found in the first analysis (caperatic acid (?), protocetraric acid (?), usnic acid in VBI 6178) and detected the presence of atranorin additionally and a further so far unidentified substance. Currently it is regarded a new chemical variety of *C. texana*, but it could well represent a so far undescribed new species. Therefore, this species needs further, more careful investigations, especially because a recent molecular genetic analysis confirmed that *C. texana* is not monophyletic and the species delimitation in *Canoparmelia* requires revision (cf. Kirika *et al.* 2022).

**\**Chrysothrix xanthina* (Vain.) Kalb**

Tanzania: Arusha Region. W slope of Mt Meru, *Pinus patula* plantation along Laikinoi road above Olmotonyi village, corticolous on *Pinus*, at 2,110 m a.s.l., T. Pócs & J. Kjelland-Lund 88293/LA 13. 12.1988 (VBI 6249 – pinastric acid); Tanga region, West Usambara Mts, Shagayu Forest Reserve, *Acacia mearnsii* secondary forest plantation NW of Mlalo Mission, corticolous at 1,450–1,500 m a.s.l., E. Farkas 86200/LA, 20.10.1986 (VBI 6247 – pinastric acid); Roadside and secondary vegetation between Amani Research Station and Greenway's forest house, lignicolous at 850–900 m a.s.l., E. Farkas 86209/D, 25–26.10.1986 (VBI 6246 – calycin, pinastric acid); Former Marvera Forest Reserve E of Marvera Tea Estate, 6 km of Amani, very degraded forest fragment with cardamom and other plantations, corticolous at 1,000–1,800 m a.s.l., E. Farkas & T. Pócs 86244/CP, 12.11.1986 (VBI 6248 – pinastric acid); Iringa Region, Mufindi Highlands, Colin Congdon's Garden in Mufindi, corticolous on *Pinus* at 1,860 m a.s.l., E. Farkas 89129/LA, 12.04.1989 (VBI 6250 – pinastric acid).

As it was mentioned earlier, this crustose-leprose species consists of fine granules (20–50 µm) and contains a yellow pigment, pinastric acid (all specimens above) and rarely also

another yellow pigment (calycin) is produced in tropical specimens (VBI 6246).

It has been mentioned from Kenya, but probably new for Tanzania (Kalb 2001). More recent studies consider it a tropical and temperate region species growing on bark of both coniferous and deciduous trees, also on lignum and seldom on sheltered, somewhat shaded sandstone (Harris and Ladd 2008; Elix and Kantvilas 2007).

***Coccocarpia palmicola*** (Spreng.) Arv. & D.J. Galloway

Tanzania: Tanga Region, Muheza District, East Usambara Mts, Mlinga Peak, saxicolous on rocky outcrops near the southern summit between 1,020–1,060 m a.s.l., E. Farkas 86229/C, 05.11.1986 (VBI 6236).

Widespread in the tropics and subtropics, extending into warm temperate regions; in East Africa it is found from sea level to c. 2,000 m a.s.l. in sheltered lowland and montane forest (Swinscow and Krog 1988).

**\*\**Didymocyrtis cf. melanelixiae*** (Brackel) Diederich, R.C. Harris & Etayo

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (on *Parmotrema austrosinense* – VBI 6210, VBI 6215 with *Lichenocnium erodens*, on *Parmotrema reticulatum* – VBI 6224).

The shape (ellipsoid to subspherical) and size (4.8–5 × 3.2–3.5 µm, length/width>1.4) of the conidia – having one bigger or two smaller guttules – are in the range of the original description (Brackel 2011).

The species has a wide distribution area and it occurs mainly on parmelioid lichens (Ertz *et al.* 2015).

***Dirinaria aegialita*** (Afzel. ex Ach.) B.J. Moore

Growing together with *Parmotrema tinctorum* (VBI 6245).

Common on trees and shrubs, and also on lava, in open woodland, scrub, parks, avenues, and plantations from sea level to 2,000 m altitude. Widespread in East Africa, worldwide in the tropics (Swinscow and Krog 1988).

***Flavoparmelia caperata* (L.) Hale**

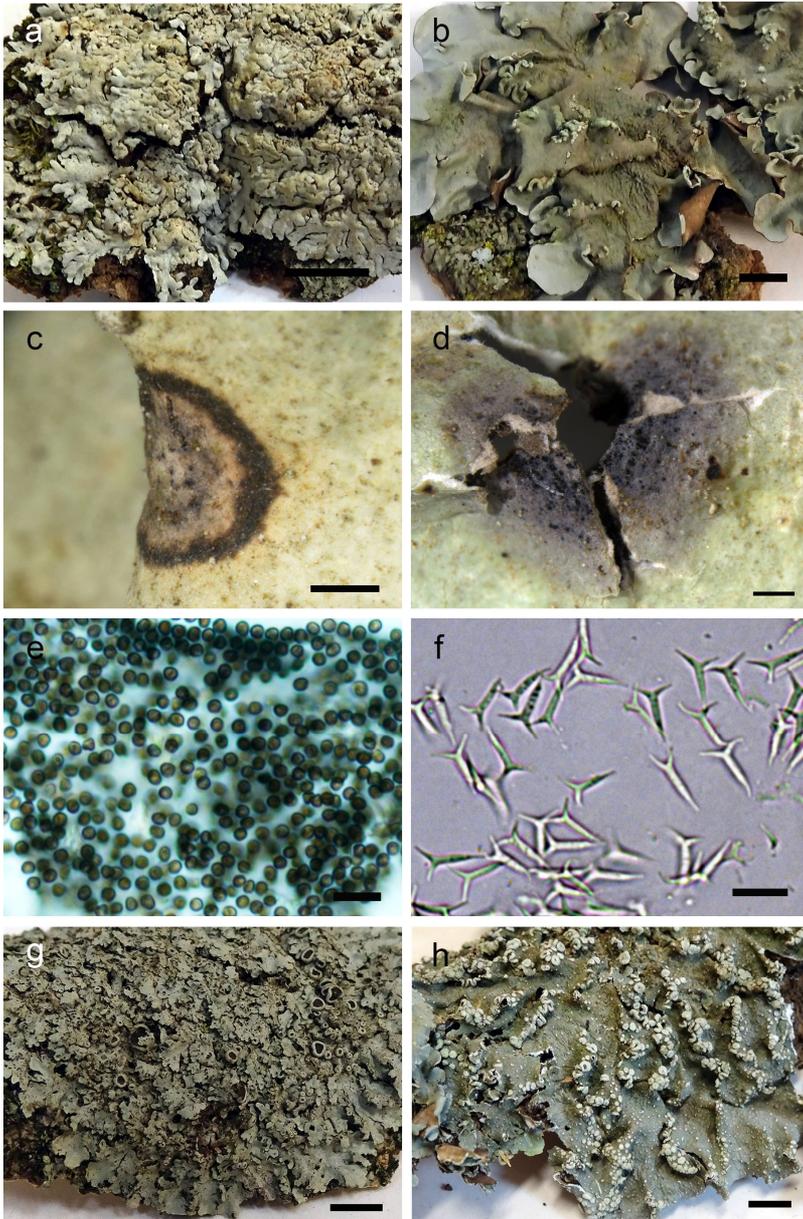
Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6197, VBI 6198 – usnic acid, caperatic and protocetraric acid). — Tanzania: Pienaar S Heights S of Babati, Bereku F. R., mist-affected miombo on the ridge at 1,700 m a.s.l., T. Pócs 87217/BB, 24.10.1987 (VBI 6169 – atranorin, caperatic acid, protocetraric acid, usnic acid).

Corticolous in artificial habitats and well-lit sites in montane forests, rarely terrestrial in the low alpine zone, common and widespread between 1,500 and 3,600 m altitude. Cosmopolitan, mainly temperate, widely distributed in East Africa (Swinscow and Krog 1988). *F. caperata* is a bark dwelling species growing on numerous, different trees and shrubs in temperate forests. It occurs rarely also on rocks, however, more often at the northern part of its range (Hale 1976). It is commonly observed in disturbed forests and urban areas, and in some areas of its range the population size of *F. caperata* is suggested to be increasing due to climate change (Søchting 2004). It is abundant and frequent in many different habitats that experience substantial anthropogenic alteration, possibly linked to increased growth in high light situations (Ellis 2019). Compared to many lichens *F. caperata* is relatively pollution tolerant (Will-Wolf *et al.* 2014), though it does show signs of pollution stress in urban and suburban areas in Eastern Algeria (Ali Ahmed *et al.* 2014). Therefore, severe air pollution is a threat to this species (cf. Allen *et al.* 2020).

***Heterodermia cf. diademata* (Taylor) D.D. Awasthi**

Kenya: Uasin Gishu county, in Eldoret in Sukunanga estate opposite Toyota Kenya, c. 1.5 km from Sosiani River along Nakuru road, from bark of trees, 0°29'32" N, 35°18'06" E, 2,129 m a.s.l., A.M. Muhoro 20/01, 23.08.2020 (VBI 6157 – with *Pyxine berteroaana*; atranorin, zeorin).

On trunks and branches of trees (*Figure 2a*) and also on sheltered rocks, common in artificial as well as natural habitats at 1,000 to over 3,500 m altitude. Widely found in East Africa and worldwide in the tropics (Swinscow and Krog 1988; GBIF 2023a).



**Figure 2.** Habit and morphological details of selected lichens and lichenicolous fungi. a), *Heterodermia diademata* (VBI 6157), b), *Parmotrema austrosinense* (VBI 6158), c), *Lichenocodium erodens* on *P. austrosinense* (VBI 6205), d), *Spirographa lichenicola* on *P. austrosinense* (VBI 6205), e), conidia of *L. erodens*, f), conidia of *S. lichenicola*, g), *Phaeophyscia confusa* (VBI 6153), h), *Punctelia borrieri* (VBI 6151). Scales: a, b, g, h = 1 cm, c, d = 500  $\mu$ m, e, f = 10  $\mu$ m.

***Hypotrachyna polydactyla*** (Krog & Swinscow) T.H. Nash

Tanzania: Morogoro District, Nguru Mts, relatively dry bush on the shallow soil of the rocky summit E of Maskati at 2,100 m a.s.l., T. Pócs, 88039/AA, 16.03.1988 (VBI 6173 – atranorin, lividic acid complex).

On trees and occasionally on rocks in the lower montane forest, at 1,900 to 2,400 m altitude, not common. Found in Kenya, Tanzania, also in America (Swinscow and Krog 1988; GBIF 2023b).

***Leucodermia boryi*** (Fée) Kalb

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6209 – atranorin, zeorin, + 1(-2) water repellent substance(s)).

The former *Heterodermia leucomelos* (L.) Poelt was divided into two subspecies (ssp. *leucomelos* and ssp. *boryi* (Fée) Swinscow & Krog). However, Kalb in a recent study (Mongkolsuk *et al.* 2015) suggested the separation of these taxa at species level. The salazinic acid containing specimens are recombined in a new genus as *Leucodermia leucomelos* (L.) Kalb. The specimen studied here is lacking salazinic acid (and one of the detected water repellent substances can be identified as japonene minor – cf. Mongkolsuk *et al.* 2015), therefore it is kept as *L. boryi*.

Both taxa are common on trees and shrubs, sheltered rocks, and grassy banks, in general preferring some shade, from sea level up to c. 3,500 m altitude *L. boryi* is the commoner of the two in East Africa, but their distribution over the area is about the same, widely distributed in East Africa and widespread in the world's tropics. *L. leucomelos* extends to cooler regions, reaching the temperate zones (Swinscow and Krog 1988). According to Mongkolsuk *et al.* (2015) *L. boryi* occurs more rarely on mossy rocks in montane evergreen forest and lower montane forest; it is found also in warm temperate regions.

**\*\*#*Lichenocodium erodens*** M.S. Christ. & D. Hawksw.

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (on *Parmotrema austrosinense* (Figure 2b) – VBI 6217, VBI 6215 – with *Didymocyrtis* cf. *melanelixiae*, on *Parmotrema cooperi* – VBI 6207, on *Parmotrema reticulatum* – VBI 6190, VBI 6218, VBI 6223). — Tanzania: Tanga Region, East Usambara Mts, Mlinga Peak area, moist and moderately mossy forest around the peak (with *Podocarpus milanjanus*, *Memecylon greenwayi*), on *Podocarpus* twigs

between 900–1,050 m a.s.l., E. Farkas & A. Borhidi 86230a/BC, 05.11.1986 (on *Parmotrema durumae* – VBI 6240); Southern Highlands, on *Brachystegia* bark near Sao Hill sawmills at 1,920 m a.s.l., Kata Pócs 86174/BA, 23–25.12.1986 (on *Parmotrema andinum* – VBI 6170).

This fungus is highly pathogenic on various lichen hosts (Hawksworth 1977; Darmostuk 2019) causing bleached, black margined necrotic spots on the surface of the host (*Figure 2c*). In the middle of each spot there are several pycnidia containing brown, spherical conidia (*Figure 2e*). It seems to be common also in East Africa.

**\**Lobaria discolor*** (Bory ex Delise) Hue

Tanzania: Tanga region, West Usambara Mts, Shagayu Forest Reserve, SE range of Shagein, corticolous in montane evergreen forest at 1,850–2,050 m a.s.l., E. Farkas 86205/G, 22.10.1986 (VBI 6167 – fatty acid, gyrophoric acid).

Corticolous in montane forest at c. 2,200 m altitude – rare in East Africa (Kenya, Madagascar, Reunion). Found also in South America, more frequent in Japan, Indonesia, Australia (Swinscow and Krog 1988; GBIF 2023c). It is new for Tanzania.

***Parmotrema abessinicum*** (Kremp.) Hale

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6203 – atranorin + unidentified substance).

Corticolous in dry, well-lit sites, often in artificial habitats, common and widespread at 900 to 2,600 m altitude in East Africa (Swinscow and Krog 1988). It has further scattered records in West and South Africa, Central and South America and Thailand (GBIF 2023d).

***Parmotrema andinum*** (Müll. Arg.) Hale

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6187 – lecanoric acid). — Tanzania: Southern Highlands, on *Brachystegia* bark near Sao sawmills at 1,920 m a.s.l., Kata Pócs 86174/BA, 23–25.12.1986 (VBI 6170 – atranorin, lecanoric acid, (zeorin)).

Corticolous, rarely saxicolous, in dry, well-lit sites on open hillsides, at edge of woodland, and in parks and gardens, common and widespread at 900 to 2,400 m altitude. Widely distributed in Africa, found also in Asia, Central and South America (Swinscow and Krog 1988; GBIF 2023e).

***Parmotrema austrosinense* (Zahlbr.) Hale**

Kenya: Uasin Gishu county, in Eldoret in Sukunanga estate opposite Toyota Kenya, c. 1.5 km from Sosiani River along Nakuru road, from bark of trees, 0°29'32" N, 35°18'06" E, 2,129 m a.s.l., A.M. Muhoro 20/01, 23.08.2020 (VBI 6158 – atranorin, divaricatic, lecanoric acid; VBI 6160 – atranorin; VBI 6161 – atranorin); Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6189, VBI 6205, VBI 6215, VBI 6217, VBI 6225 – atranorin, lecanoric acid, VBI 6210 – (atranorin), lecanoric acid). — Tanzania: Arusha Region, Mt Hanang N of Katesh, dry evergreen montane forests on the S foot near Himit village at 2,000–2,300 m a.s.l., T. & B. Pócs 87211/H, 22–23.10.1987 (VBI 6175 – atranorin, lecanoric acid); Pienaar S Heights S of Babati, Bereku F. R., mist-affected miombo on the ridge at 1,700 m a.s.l., T. Pócs 87217/B, 24.10.1987 (VBI 6168 – atranorin, lecanoric acid); Morogoro District, Nguru Mts, relatively dry bush on the shallow soil of the rocky summit E of Maskati at 2,080 m a.s.l., T. Pócs 88039/BB, 16.03.1988 (VBI 6174 – atranorin, lecanoric acid).

Corticolous (*Figures 2b–d*) or more rarely saxicolous in well-lit sites, both natural and artificial, common and widespread at 1,000 to 3,000 m altitude. Widely distributed in East Africa. Widespread in tropical and temperate regions (Swinscow and Krog 1988). Together with lichenicolous fungi *Didymocyrtis cf. melanelixiae*, *Lichenocodium erodens* (*Figure 2c*) and *Spirographa lichenicola* (*Figure 2d*).

***Parmotrema cetratum* (Ach.) Hale**

Tanzania: Tanga Region, Muheza District, East Usambara Mts, Mlinga Peak, rocky outcrops near the southern summit between 1,020–1,060 m a.s.l., E. Farkas 86229/C, 05.11.1986 (VBI 6235 – atranorin, salazinic acid).

It was known from Kenya and Tanzania as corticolous on well-lit, mist-affected hills at 1,400 to 2,600 m altitude, uncommon. Widespread in temperate regions (Swinscow and Krog 1988). This record is from rocky substrate.

***Parmotrema cooperi* (Steiner & Zahlbr.) Sérus.**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6199, VBI 6202, VBI 6204, VBI 6206, VBI 6207 – atranorin, lecanoric acid, VBI 6200 – atranorin, usnic acid, lecanoric acid). — Tanzania: Tanga region, West Usambara Mts, Shagayu Forest Reserve, upper part of the Mt Kwashemhambu with montane rainforest (*Ocotea usambarensis*, *Podocarpus milanjanus*) and patches of elfin forest between 1,750–1,900 m a.s.l., E. Farkas 86202/S, 20.10.1986 (VBI 6165 – atranorin, lecanoric acid).

Corticolous or rarely saxicolous in dry, well-lit sites, common and widespread from sea level to 3,000 m altitude. Widely distributed in Africa, Asia, Australia (Swinscow and Krog 1988).

**\**Parmotrema durumae*** (Krog & Swinscow) Krog & Swinscow

Tanzania: Tanga Region, East Usambara Mts, Kwamkoro F. R., SE of Kwamkoro Tea Estate, heavily logged intermediate rainforest of *Ocotea usambarensis*, *Cephalosphaera*, *Variodendron*, etc. at 900–1,030 m a.s.l., E. Farkas 86214/N, 28.10.1986 (VBI 6163 – alectoronic acid, atranorin,  $\alpha$ -collatolic acid); Mlinga Peak area, moist and moderately mossy forest around the peak (with *Podocarpus milanjanus*, *Memecylon greenwayi*), on *Podocarpus* twigs between 900–1,050 m a.s.l., E. Farkas & A. Borhidi 86230a/BC, 86230a/B, 05.11.1986 (VBI 6240, VBI 6242 – atranorin, alectoronic acid,  $\alpha$ -collatolic acid).

Saxicolous on dry, exposed rock at 1,750 to 2,100 m altitude, uncommon. Earlier found in Kenya and Uganda, also in South Africa and Madagascar (Swinscow and Krog 1988). It is new for Tanzania.

***Parmotrema eciliatum*** (Nyl.) Hale

Tanzania: Tanga region, West Usambara Mts, Shagayu Forest Reserve, SE range of Shagein, montane evergreen forest at 1,850–2,050 m a.s.l., E. Farkas 86205/GA, 22.10.1986 (VBI 6181 – atranorin, unidentified substance, (norstictic acid), stictic acid); Mlinga Peak area, moist and moderately mossy forest around the peak (with *Podocarpus milanjanus*, *Memecylon greenwayi*), on *Podocarpus* twigs between 900–1,050 m a.s.l., E. Farkas & A. Borhidi 86230a/BB, 05.11.1986 (VBI 6244 – atranorin, stictic acid).

It was found rarely in Tanzania, South Africa, Asia, Central and South America, West Indies and Australia as corticolous in lower montane forest, from 800 to 1,200 m altitude, rare (Swinscow and Krog 1988). Our record was collected at higher elevation (1,850–2,050 m a.s.l.)

***Parmotrema eunetum*** (Stirt.) Hale

Tanzania: Kilimanjaro Mts, closed, 2–4 m tall *Erica arborea* heath at the forest line, around Machame Hut and the gorge below between 2,900–3,300 m a.s.l., K., S. & T. Pócs 87173/AS, 22–23.06.1987 (VBI 6171 – atranorin, fatty acid, lecanoric acid, norstictic acid, atranorin, gyrophoric acid).

Mainly corticolous, sometimes saxicolous, common and widespread in mist-affected inselbergs and montane forest, extending to the low alpine zone (on rocks), at 1,600 to 3,800 m altitude. It has scattered records in Africa, Asia, West Indies (Swinscow and Krog 1988).

***Parmotrema hababianum* (Gyeln.) Hale**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6208, VBI 6216 – atranorin, lichesterinic and protolichesterinic acid).

Mainly corticolous in dry, well-lit habitats, common and widespread at 800 to 2,650 m altitude, but mainly at 1,500–2,000 m. Found in East Africa, Asia, North and South America (Swinscow and Krog 1988).

***Parmotrema holobum* (Hale) Hale**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6220, VBI 6222 – atranorin, lecanoric acid).

It was known as corticolous at sea level by the Indian Ocean and in well-lit mist-affected upland habitats, up to 1,800 m altitude, fairly common, but found in East Africa, only in Kenya, Tanzania and Uganda (Swinscow and Krog 1988). The current record was collected at 2,454 m a.s.l.

***Parmotrema nilgherrense* (Nyl.) Hale**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6221 – atranorin, 4 fatty acids, pigment).

Corticolous in montane forest and the ericaceous zone, saxicolous in the low alpine zone, common and widespread at 2,000 to 3,600 m altitude. Found in East Africa and Asia (Swinscow and Krog 1988).

***Parmotrema reticulatum* (Taylor) M. Choisy**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6186, VBI 6188, VBI 6190, VBI 6201, VBI 6218, VBI 6219, VBI 6223, VBI 6224, VBI 6226 – atranorin, salazinic acid). — Tanzania: Tanga Region, Muheza District, East Usambara Mts, Mlinga Peak area, moist forest below the southern summit on a small rock at the spring near campsite at 770 m, E. Farkas 86230b/C, 05.11.1986 (VBI 6243 – atranorin, salazinic acid).

Corticolous, saxicolous, and terricolous in a wide variety of natural and artificial habitats, common and widespread at 1,000 to

3,000 m altitude. Widely distributed in East Africa. Widespread throughout the tropical and temperate regions (Swinscow and Krog 1988).

***Parmotrema rimulosum*** (C.W. Dodge) Hale

Kenya: Uasin Gishu county, in Eldoret in Sukunanga estate opposite Toyota Kenya, c. 1.5 km from Sosiani River along Nakuru road, from bark of trees, 0°29'32" N, 35°18'06" E, 2,129 m a.s.l., A.M. Muhoro 20/01, 23.08.2020 (VBI 6159 – atranorin,  $\alpha$ -collatolic acid).

A relatively rare species, found both in Kenya and Tanzania, also in South Africa between 1,800–2,900 m altitude on bark in mist-affected and montane forests (Swinscow and Krog 1988). Known from Queensland and New South Wales, Australia (McCarthy 2020).

**\**Parmotrema taitae*** (Krog & Swinscow) Krog & Swinscow

Tanzania: Tanga Region, East Usambara Mts, Kwamkoro F. R., SE of Kwamkoro Tea Estate, heavily logged intermediate rainforest of *Ocotea usambarensis*, *Cephalosphaera*, *Variodendron*, etc., ramicolous at 900–1,030 m a.s.l., E. Farkas 86214/NA, 28.10.1986 (VBI 6162 – atranorin, fumarprotocetraric acid); Mlinga Peak, rocky outcrops near the southern summit between 1,020–1,060 m a.s.l., E. Farkas 86229/A, 86229/AB, 86229/ABB, 86229/AA, 86229/AAA, 05.11.1986 (VBI 6231, VBI 6233, VBI 6237 – atranorin, fumarprotocetraric acid, VBI 6232, VBI 6234 – atranorin, fatty acid, fumarprotocetraric acid).

Earlier known from Kenya as saxicolous on granitic rock at 2,000 m altitude (Swinscow and Krog 1988). The here presented new records from Tanzania are both saxicolous and ramicolous.

***Parmotrema tinctorum*** (Nyl.) Hale

Tanzania: Tanga Region, Muheza District, East Usambara Mts, Mlinga Peak area, moist forest below the southern summit on a small rock at the spring near campsite at 770 m, saxicolous, E. Farkas 86230b/B, 86230b/BB, 05.11.1986 (VBI 6241, VBI 6245 – atranorin, lecanoric acid).

Corticolous, rarely saxicolous, in mangroves, coastal hills, and well-lit upland habitats, widespread and common up to about 2,700 m altitude. Widely distributed in East Africa. Widespread in tropical and temperate regions (Swinscow and Krog 1988).

***Phaeophyscia* cf. *confusa*** Moberg

Kenya: Uasin Gishu county, in Eldoret in Sukunanga estate opposite Toyota Kenya, c. 1.5 km from Sosiani River along Nakuru road, from bark of trees, 0°29'32" N, 35°18'06" E, 2,129 m a.s.l., A.M. Muhoro 20/01, 23.08.2020 (VBI 6153 – no substance detected by HPTLC).

Corticolous (*Figure 2g*) in open woodland and on wayside trees, occasionally saxicolous, at 1,200 to 3,500 m altitude, locally common. Widely found in East Africa (Swinscow and Krog 1988).

***Polyblastidium japonicum*** (M. Satô) Kalb (syn.: *Heterodermia japonica* (M. Satô) Swinscow & Krog)

Tanzania: Tanga Region, Muheza District, East Usambara Mts, former Marvera F.R., E of Marvera Tea Estate, 6 km NE of Amani Forest fragment with cardamom and other plantations, very degraded, corticolous at 1,000–1,800 m a.s.l., E. Farkas & T. Pócs 86244/CA, 12.11.1986 (VBI 6166 – atranorin, terpenoid, zeorin).

Common on trunks and branches of moderately shaded trees and shrubs, at 1,800 to 3,700 m altitude. Widely distributed in East Africa. Found also in South Africa, the Canary Islands, Asia, New Zealand (Swinscow and Krog 1988).

***Punctelia borreri*** (Sm.) Krog

Kenya: Uasin Gishu county, in Eldoret in Sukunanga estate opposite Toyota Kenya, c. 1.5 km from Sosiani River along Nakuru road, from bark of trees, 0°29'32" N, 35°18'06" E, 2,129 m a.s.l., A.M. Muhoro 20/01, 23.08.2020 (VBI 6151, VBI 6154 – gyrophoric acid); Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6183, VBI 6184, VBI 6185 – gyrophoric acid).

Corticolous (*Figure 2h*) or rarely saxicolous, in both natural and artificial habitats, common and widespread between 1,400 and 3,400 m altitude. Widely distributed in East Africa. Widespread in tropical and temperate regions of the northern and southern hemispheres (Swinscow and Krog 1988).

***Pyxine berteroana*** (Fée) Imshaug

Kenya: Uasin Gishu county, in Eldoret in Sukunanga estate opposite Toyota Kenya, c. 1.5 km from Sosiani River along Nakuru road, from bark of trees, 0°29'32" N, 35°18'06" E, 2,129 m a.s.l., A.M. Muhoro 20/01, 23.08.2020 (VBI 6155 – fertile, VBI 6156 – sterile; lichexanthone).

Widely distributed but uncommon on trees and shrubs, often in artificial habitats, at 1,800 to c. 2,000 m altitude, tolerates shade. Found in Kenya, Tanzania and Uganda. Widespread in the tropics and subtropics (Swinscow and Krog 1988).

**Ramalina pusiola** Müll. Arg.

Kenya, Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6193 – usnic acid, sekikaic and homosekikaic acid).

Common and widespread on tree trunks and branches in the lower montane forest and mist-affected woodland at 1,400 to 2,500 m altitude in East Africa (Swinscow and Krog 1988). Also found in South America (Brazil – Kashiwadani and Kalb 1993; Venezuela – Marcano and Morales Mendez 1994).

**\*\*#Spirographa lichenicola** (D. Hawksw. & B. Sutton) Flakus, Etayo & Miądl.

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (on *Parmotrema austrosinense* – VBI 6225, on *Parmotrema reticulatum* – VBI 6226).

This parasitic fungus causes bleached patches with a greyish circle on the surface of the host (*Figure 2d*). The main axis of the Y-shaped conidia (*Figure 2f*) is 8.2–10.2 × 1.6 µm, arms (= appendages) 4.1–4.4 µm (n = 50) are agreeing well with data presented in the original description (cf. 6–11.5 × 1.2 µm, appendages 2.5–6 µm – Hawksworth 1976). Although Flakus *et al.* (2019) concluded mainly from their molecular genetic results in South America that *Spirographa* species are strongly host-specific (at the generic level of the host), it is confirmed also by the current East African records occurring on various *Parmotrema* species. This species can be widespread also in East Africa.

**Sticta papyracea** Delise

Tanzania: Tanga region, West Usambara Mts, Shagayu Forest Reserve, upper part of the Mt Kwashemhambu with montane rainforest (*Ocotea usambarensis*, *Podocarpus milanjanus*) and patches of elfin forest, corticolous between 1,750–1,900 m a.s.l., E. Farkas 86202/F, 20.10.1986 (VBI 6164 – caperatic acid (?)).

Corticolous in montane forest, at 900 to 2,100 m altitude, rare, but found throughout the tropics and subtropics (Swinscow and Krog 1988).

***Teloschistes exilis* (Michx.) Vain.**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6194 – parietin, falacinal).

On twigs and small branches of shrubs and trees that are either sheltered or in a frequently humid environment, at 1,300 to 2,500 m altitude, common. Found in East and South Africa and the Americas (Swinscow and Krog 1988; GBIF 2023f).

***Teloschistes flavicans* (Sw.) Norman**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6191 – parietin, falacinal).

On shrubs and trees in sheltered and exposed places, in artificial as well as natural habitats, at 1,100 to 3,100 m altitude, common. Widely distributed in East Africa, widespread in the tropics and extending to warmer parts of the temperate zone (Swinscow and Krog 1988; GBIF 2023g).

**\**Usnea abissinica* Motyka**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6192 – usnic acid, salazinic acid, VBI 6214 – usnic acid, 2 fatty acids, protocetraric acid).

On trunks of *Erica acrophya*, probably at c. 3,000 m altitude, a single locality is known from Ethiopia (Swinscow and Krog 1988). New distribution record for Kenya.

***Usnea angulata* Ach. (syn.: *Usnea undulata* Stirt.)**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6195 – usnic acid, salazinic acid).

On twigs of shrubs in open woodland and scrub at 1,000 to 2,000 m altitude, common in rather dry exposed scrubland. Found in East and South Africa, also in Madeira (Swinscow and Krog 1988).

***Usnea rubicunda* Stirt.**

Together with *U. sanguinea* (VBI 6228).

Common and widespread, mainly on the trunks and large branches of trees in sheltered places, occasionally also on rocks and in the grassy banks of tracks, at 1,500 to 2,500 m altitude. Widely distributed in East Africa, worldwide in the tropics and extending through the subtropics to the temperate zone (Swinscow and Krog 1988).

**\**Usnea sanguinea* Swinscow & Krog**

Kenya: Nyeri county, at the foot of Mt Kenya, c. 1 km from Naro Moru entry gate to Kenya wildlife service in Gitinga village, from bark, twigs and branches of trees in tropical rainforest, 0°10'25.84" S, 37°9'3.40" E, 2,454 m a.s.l., A.M. Muhoro 21/01, 14.08.2021 (VBI 6196 – usnic acid, VBI 6211, VBI 6212, VBI 6213, VBI 6227, VBI 6228, VBI 6229, VBI 6230 – usnic acid, 2 fatty acids, protocetraric acid).

Locally common in Arusha National Park (Tanzania) on branches of trees and shrubs in open woodland at 1,500 to 2,600 m altitude (Swinscow and Krog 1988). New distribution record for Kenya.

***Xanthoparmelia africana* Hale**

Tanzania: Kilimanjaro Mts, Marangu Route, scattered, dwarf subalpine *Philippia* bush with lava rocks on the ridge above Horombo Hut, between 3,820–4,000 m a.s.l., T. Pócs & S. Orbán, 89150/M, 21.05.1989 (VBI 6177).

Saxicolous in the alpine zone at 3,400 to 4,300 m altitude, where it is locally common. Collected in Kenya, Tanzania, Uganda and South Africa (Swinscow and Krog 1988).

***Xanthoparmelia salkiboensis* Hale**

Tanzania: Kilimanjaro Mts, Marangu Route, scattered, dwarf subalpine *Philippia* bush with lava rocks on the ridge above Horombo Hut, between 3,820–4,000 m a.s.l., T. Pócs & S. Orbán, 89150/BA, 21.05.1989 (VBI 6176 – fatty acid, salazinic acid, usnic acid).

A rare species, since it grows in high elevation (3,600–4,000 m altitude) in Kenya and Tanzania (Hale 1990).

***Xanthoparmelia subramigera* (Gyeln.) Hale**

Tanzania: Tanga Region, Muheza District, East Usambara Mts, submontane riverine rainforest along Hunga stream S of Derema village, on the granitic riverbed rocks, at 840 m a.s.l., K. Pócs 87037/V, 16.02.1987 (VBI 6172 – fatty acid, fumarprotocetraric acid, protocetraric acid, succinprotocetraric acid, usnic acid); Amani East F.R., above Sigi River bridge, saxicolous in streamside vegetation and wet rainforest (lowland type) between 470–500 m a.s.l., E. Farkas 86236/B,

08.11.1986 (VBI 6239 – fatty acid, fumarprotocetraric acid, protocetraric acid, succinprotocetraric acid, usnic acid); Mlinga Peak, saxicolous on rocky outcrops near the southern summit, between 1,020–1,060 m a.s.l., E. Farkas 86229/B, 05.11.1986 (VBI 6238 – fumarprotocetraric acid, protocetraric acid, succinprotocetraric acid, usnic acid).

It is a saxicolous species between 400 and 3,000 m a.s.l., common and widespread, especially between 1,000 and 2,000 m. It grows in East and South Africa, Canary Islands, Mauritius, southern part of the Russian Pacific Far East, South Korea, Japan, New Zealand and the Americas (Swinscow and Krog 1988; GBIF 2023h).

## CONCLUSIONS

More than half (23 species) of the 42 species listed above belonged to the parmelioid clade, thus the recently published identification key (Farkas and Muhoro 2022) could be tested on both Kenyan and Tanzanian specimens. Only *Parmotrema eciliatum* was not treated in the key (Farkas and Muhoro 2022), however, it was possible to identify almost all further species by the former key of Swinscow and Krog (1988). Our work led to confirming distribution records of the parmelioid and other groups. The occurrence of *Bulbothrix kenyana* (recently described, Kirika *et al.* 2017) in Tanzania widens the distribution area of the species known so far from various localities in Kenya. Further new distribution records were also detected: *Chrysothrix xanthina*, *Lobaria discolor*, *Parmotrema durumae* and *P. taitae* were discovered as new from Tanzania; *Usnea abissinica* and *U. sanguinea* are new for Kenya. Future field studies in these and other countries in East Africa may result in further interesting records that widens our knowledge in this field. The lichenicolous fungi *Didymocyrtis* cf. *melanelixiae*, *Lichenocodium erodens* and *Spirographa lichenicola* are presented for the first time from East Africa. Since Suija *et al.* (2018) and Zhurbenko (2021, 2022) described several new lichenicolous species from Kenya and Tanzania recently, further taxonomic novelties are expected by a more detailed study in this promising region.

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