

THIRTY-SIX SPECIES OF THE LICHEN GENUS *PARMOTREMA* (LECANORALES, ASCOMYCOTA) NEW TO BOLIVIA

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Abstract. This paper presents information on 36 species of the lichenized genus *Parmotrema* A. Massal. new to Bolivia. *Parmotrema sorediiferum* Hale, *P. soredialiphaticum* Estrabou & Adler and *P. wrightii* L. I. Ferraro & Elix are reported here from their second localities worldwide. *Parmotrema brasiliense* Hale and *P. nylanderii* (Lyngé) Hale were discovered for the first time outside of Brazil. Notes on the taxonomy, chemistry and distribution of each species are provided.

Key words: distribution, lichen substances, Neotropics, Parmeliaceae, parmelioid lichens, taxonomy

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INTRODUCTION

The genus *Parmotrema* A. Massal. is characterized by foliose thalli forming short and broad, rarely elongated, often ciliate lobes, a pored epicortex, cylindrical conidia and the intermediate type of lichenan between *Cetraria*-type lichenan and *Xanthoparmelia*-type lichenan. The lower surface of the thallus is white to black, usually sparingly rhizinate with a wide bare marginal zone, sometimes irregularly rhizinate or finely short-rhizinate with scattered much longer rhizines mixed without an erhizinate margin or with a very narrow one. A wide range of secondary metabolites may occur in the medulla, with atranorin and/or usnic acid being present in the upper cortex (Hale 1965; Blanco *et al.* 2005; Crespo *et al.* 2010).

Currently the genus as now circumscribed comprises ca 350 species which occur mostly in the tropics, especially in the Pacific Islands and South America (Blanco *et al.* 2005; Crespo *et al.* 2010). Despite all the recent activity around *Parmotrema*, however, many regions are still poorly known, among these Bolivia. Up to now 13 species have been reported from that country (Nylander

1859, 1885; Rusby 1896; Herzog 1922; Hale 1965; Ferraro & Elix 1993; Feuerer *et al.* 1998; Flakus *et al.* 2011; Rodriguez Flakus *et al.* 2012), a very small number as compared to the list of species for neighboring Brazil (see Feuerer 2011). Recent explorations indicate that the number is a large underestimation.

This paper presents 36 species new to Bolivia, bringing the total to 49 *Parmotrema* species known from Bolivia, and making it clear that the genus is not significantly less diverse in Bolivia than the northern Andes: for Colombia 55 species are reported (Sipman *et al.* 2008) and for Venezuela 64 species (López Figueiras 1986). Only Brazil with 90 species (Feuerer 2011) may be distinctly more diverse.

MATERIAL AND METHODS

The present study is based on material deposited in B, KRAM, LPB and UGDA. Morphology was examined with a standard stereomicroscope. Lichen substances were investigated by thin layer chromatography (TLC)

in solvents A, B, B', C and G following the methods described by Culberson and Kristinsson (1970) and Orange *et al.* (2001). Additionally, the spot test reaction with C (commercial bleach) was applied separately or in combination with K (10% solution of potassium hydroxide) (KC test; Orange *et al.* 2001). For all species the presence of substances reported in the literature was confirmed in the Bolivian specimens, but not always in all available specimens. Usually only the main secondary metabolites are reported here; they may be accompanied by traces of various related substances. The presence of chloroatranorin was not studied; it often accompanies atranorin in traces. The descriptions of the species are based mostly on literature as the Bolivian material was often limited.

THE TAXA

Parmotrema aberrans (Vain.) Hale

Phytologia **28**(4): 334. 1974. – *Parmelia xanthina* f. *abberans* Vain., Ann. Acad. Soc. Faun. Fl. Fenn. **7**(7): 37. 1890.

The species is characterized by its yellowish green thallus, ciliate or crenate to isidiate-dissected thallus margin, isidia present usually close to the thallus margin, and black, moderately rhizinate lower side with wide bare marginal zone (Hale 1965; Sipman 2005). Hale (1965) reported atranorin, usnic acid and lecanoric acid. In the Bolivian specimen, unidentified fatty acids were additionally detected.

The species is known only from the Neotropics from Mexico to Paraguay (Hale 1965).

SPECIMEN EXAMINED. BOLIVIA. DEPT. SANTA CRUZ. Prov. Vallegrande, Cuchillo de Quiñai between the Villmontes-Mataral Road and the Rio El Bañado, 18°23'S, 64°08'W, ca 1900 m, mixed mataral shrub and dry woodland, on stone, 4 June 1985, *M. Lewis 85-547A* (LPB).

Parmotrema affluens (Hale) Hale

Phytologia **28**(4): 334. 1974. – *Parmelia affluens* Hale, Phytologia **22**: 141. 1971.

The species has a broad, marginally sorediate thallus with eciliate margins, a yellow medulla and according to Hale (1971a, 1974) it produces atranorin, secalonic acid A (= entothetin) with ad-

ditional unidentified pigments, protocetraric acid and echinocarpic acid. We detected also usnic acid in the Bolivian material. This substance was not known from *P. affluens* previously; its production may be taxonomically significant and may indicate a new taxon, but since no molecular data are available for the material containing and lacking usnic acid we refrain from describing a new species.

Parmotrema affluens is a rare lichen reported previously only from Brazil, Peru and India (Hale 1971a).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Nor Yungas, Comunidad Cultural Unidos, 36 km por camino de Caranavi hacia Sapecho, 15°41'S, 67°30'W, 1300 m, plantación de café, epífita, 22 Aug. 1997, *K. Bach 400 et al.* (B). DEPT. LA PAZ. Prov. Bautista Saavedra, 15 km de Camata hacia Apollo, 15°13'S, 68°41'W, 1300 m, bosque semi deciduo, epífita, 24 June 1997, *K. Bach 216 et al.* (B). DEPT. SANTA CRUZ. Prov. Florida, Refugio 'Los Volcanes' 18°06'S, 63°36'W, 1000 m, bosque semi-deciduo, epífita, 5 Oct. 1997, *K. Bach 644 et al.* (B).

Parmotrema argentinum (Kremp.) Hale

Phytologia **28**(4): 334. 1974. – *Parmelia argentina* Kremp., Flora **61**: 476. 1878.

The species is characterized by rather large (up to 1 mm or more in diam.), imperforate and ciliate apothecia, a more or less maculate upper surface, ciliate thallus margins, a black, sparsely rhizinate lower side with a distinctly delimited ivory to white marginal zone, a 50–70 µm high hymenium and small ascospores measuring 11–22 × 6–12 µm (see Hale 1965; Sipman 2005). Atranorin and alectoronic acid were reported from the species (Hale 1965), but our material also contains α-collatolic acid and minor to trace amounts of substances related to alectoronic acid.

Parmotrema argentinum is known from Asia (Taiwan) and the Neotropics, where it was reported previously from Argentina, Brazil, Mexico, Paraguay and Venezuela (Hale 1965; Calvelo & Liberatore 2002).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Ayopaya, 20 km de Cocapata hacia Cotacajes, 16°46'S, 66°44'W, 2000 m, bosque semideciduo disturbado, epífita, 15 May 1997, *K. Bach 83, 90 et al.*

(B, LPB). DEPT. SANTA CRUZ. Prov. Florida, Refugio 'Los Volcanes' 18°06'S, 63°36'W, 1000 m, bosque semi-decidual, epifita, 2 Oct. 1997, *K. Bach 603, 618a, 631 et al.* (B, LPB). Prov. Ibañez, Jardín botánico, 17°43'S, 63°03'W, 380 m, bosque seco, epifita, 30 Sept. 1997, *K. Bach 594* (B, LPB).

Parmotrema arnoldii (Du Rietz) Hale

Phytologia **28**(4): 335. 1974. – *Parmelia arnoldii* Du Rietz, *Nyt Mag. Naturvidensk.* **62**: 80. 1924.

The thallus lobes of *P. arnoldii* are sparsely ciliate and lacinate, especially in the center; the soralia are mostly submarginal on the lacinae but sometimes also marginal on the thallus, and the lower marginal zone is narrow, non-rhizinate and mostly black. The species produces atranorin, alectoronic and α -collatolic acids, sometimes also skyrin (= rhodophyscin) (Hale 1965; Sipman 2005; Jabłońska *et al.* 2009). The Bolivian specimens lacked skyrin.

Parmotrema arnoldii is very widely distributed, being known from Africa, Asia, Europe, Oceania, Macaronesia and North and South America (for more information see Jabłońska *et al.* 2009).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Carrasco, Carrasco National Park, near Sehuencas village, 2220 m, 17°30'12"S, 65°16'30"W, 21 July 2008, *P. Rodriguez 744 et al.* (LPB). DEPT. TARIJA. Prov. Aniceto Arce, Filo de Sidras, 22°14'50"S, 64°33'28"W, 1064 m, Tucumano-Boliviano submontane forest, on twig, 22 Nov. 2010, *A. Flakus 18400* (KRAM, LPB).

Parmotrema austrosinense (Zahlbr.) Hale

Phytologia **28**(4): 335. 1974. – *Parmelia austrosinensis* Zahlbr., *Symb. Sin* **3**: 192. 1930.

Parmotrema austrosinense is characterized by mineral grey, wide and eciliate lobes, marginal and sinuate soralia, and a black and rhizinate center of the lower surface with a light brown, mottled, ivory or white and non-rhizinate, broad marginal zone. The species produces atranorin and lecanoric acid (Hale 1965; Elix 1994; Sipman 2005).

It is a Pantropical species, known from tropical regions of Africa, Asia, Australia, North and South America and Oceania (Hale 1965; Elix 1994; Cal-

velo & Liberatore 2002; Wolseley *et al.* 2002; Divakar & Upreti 2005; Benatti & Marcelli 2009; Esslinger 2011).

SPECIMEN EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Capinota, Carretera a Capinota, 2470 m, on bark, 30 June 1988, *M. Cadina 21* (as admixture in specimen of *Cetrelia* sp.) (LPB).

Parmotrema brasiliense Hale

Biblioth. Lichenol. **38**: 109. 1990.

The thallus of the species is grey, rather large, papery, without vegetative propagules and with a partly orange-pigmented medulla due to the presence of skyrin; the lobes become short lacinate-lobulate. The apothecia are perforate to imperforate, the hymenium is ca 60 μ m high and the ascospores are 14–15 \times 6 μ m. It produces atranorin, alectoronic and α -collatolic acids and skyrin (Hale 1990; Sipman 2005). An additional, unidentified pigment was detected in the medulla of the Bolivian specimens.

One of the Bolivian specimens was sterile, thus its identification is not certain, but the morphology of the thallus was very similar to the fertile sample so it is included here. The morphology of the fertile specimens agrees well with the description, but the indicated dimensions of the ascospores are slightly different (12–17 \times 7–9 μ m). However, as the species was known from very limited material, its ascospore variation might have not been entirely known.

Parmotrema brasiliense was known previously only from Brazil (Hale 1990).

SPECIMENS EXAMINED. BOLIVIA. DEPT. SANTA CRUZ. Prov. Guarayos, Plan de Manejo AISU, Reserva Vida Silvestre Rios Blanco y Negro, 15°01'58"S, 62°46'36"W, 242 m, lowland Amazon forest, 24 July 2009, on bark, *A. Flakus 13903 & P. Rodriguez* (KRAM). DEPT. TARIJA. Prov. Aniceto Arce, vicinity of Tarija town, 22°14'56"S, 64°32'55"W, 883 m, Tucumano-Boliviano secondary submontane forest, on bark, 21 Nov. 2010, *A. Flakus 18372* (LPB; sterile material).

Parmotrema cristatum (Nyl.) Hale

Phytologia **28**(4): 335. 1974. – *Parmelia cristata* Nyl., *Flora* **52**: 291. 1869.

Parmotrema cristatum (as *Parmelia cristata*) was considered synonymous with *Parmotrema appendiculatum* (Fée) Hale (as *Parmelia appendiculata* Fée) (Hale 1965), but later Hale (1974) showed that the two taxa differ in chemistry. In general the species is characterized by a grey, lacinate and ciliate thallus, apothecia with ciliate margins, the absence of soredia and isidia, and a black, sparsely rhizinate lower surface, which is lighter, erhizinate and scabrid at the marginal zone. It contains atranorin, protocetraric acid and unidentified pigments (Halle 1974; Sipman 2005; Hale 1965, sub *P. appendiculata*).

Previously the species was reported only from Brazil (Hale 1974) and Venezuela (Hale 1965, type locality of *Parmelia cristata*).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Yacuma, Reserva de la Biósfera y Estación Biológica del Beni, near Estación Biológica del Beni, 14°51'07"S, 66°20'23"W, 175 m, island of lowland Amazon forest amidst savanna, on branches, 6 Nov. 2010, *A. Flakus 17857* & *F. Saavedra* (KRAM, LPB).

Parmotrema cristiferum (Taylor) Hale

Phytologia **28**(4): 335. 1974. – *Parmelia cristifera* Taylor, London J. Bot. **6**: 165. 1847.

The species is characterized by a grey, emaculate, coriaceous thallus with eciliate to sparsely ciliate margins, linear marginal soralia, a black, sparsely rhizinate lower side with a brown, broad, usually erhizinate marginal zone, and large ascospores. It produces atranorin and salazinic acid, often associated with consalazinic acid (Hale 1965; Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 1999; Sipman 2005; Spielmann 2009). One Bolivian specimen (*Derakshani 7*) also contained traces of pigments, but these might be the result of contamination.

Parmotrema cristiferum is thought to be a Pan-tropical species (Hale 1965; Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 1999, 2002; Calvelo & Liberatore 2002; Wolseley *et al.* 2002; Spielmann 2009; Esslinger 2011), but some older records may belong to other taxa listed by Hale (1965) as synonyms of, for example, *P. gardneri* (see Sérusiaux 1984), which later were shown to differ from *P. cristiferum*.

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Sur Yungas, Mapurichuqui, towards Villazon, 15°31.749'S, 67°23.058'W, 450 m, on *Theobroma cacao*, 22 May 1999, *N. Derakshani 7* (B). DEPT. SANTA CRUZ. Prov. J. M. de Velasco, Sendero de goma near Florida village, 14°37'48"S, 61°12'02"W, 170 m, lowland Amazon secondary forest, on bark, 16 Dec. 2009, *A. Flakus 16062* & *P. Rodriguez* (KRAM).

Parmotrema crocoides (Hale) Hale

Phytologia **28**(4): 335. 1974. – *Parmelia crocoides* Hale, Contrib. U.S. Natl. Herb. **36**: 244. 1965.

Parmotrema crocoides develops large thalli with a shiny, more or less maculate upper surface and a yellow to orange medulla. The species lacks vegetative propagules and its lower surface is black, sparsely rhizinate, with a brown and erhizinate marginal zone (Hale 1965, 1974; Sipman 2005). It contains atranorin, gyrophoric acid and secaloninic acid A with several unidentified pigments (Hale 1974). Hale (1965) reported other substances but later withdrew that finding as erroneous (see Hale 1974). In the Bolivian material we also detected minor amounts of lecanoric acid. One specimen (*Bach 121*) additionally contained lichexanthone; it may belong to an undescribed species, but that determination requires more studies on richer material.

The species is known only from the Neotropics (Brazil, Costa Rica, Mexico, Panama) (Hale 1965, 1974).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Ballivan, entre Yucumo y Rurrenabaque, 15°07'S, 67°08'W, 900-950 m, bosque siempreverde, sobre corteza, 6 Aug. 1997, *K. Bach 383, 384 et al.* (B, LPB). DEPT. LA PAZ. Prov. Franz Tamayo, Río Bilipisa, ca 10 km NW de Apolo, 14°36'S, 68°27'W, 1100 m, bosque semideciduo disturbado con *Anadenanthera*, sobre corteza, 4 July 1997, *K. Bach 236* (LPB); DEPT. COCHABAMBA. Prov. Ayopaya, 20 km de Cocapata hacia Cotacajes, 16°46'S, 66°44'W, 2000 m, bosque semideciduo disturbado de 5 m de altura, sobre corteza, 15 May 1997, *K. Bach 121 et al.* (B).

Parmotrema dilatatum (Vain.) Hale

Phytologia **28**(4): 335. 1974. – *Parmelia dilatata* Vain., Acta Soc. Fauna Fl. Fenn. **7**(7): 33. 1890.

The species has a broad, marginally sorediate thallus lacking cilia, a white medulla and a black, sparsely rhizinate lower surface with a brown and erhizinate marginal zone. The soralia are linear on peripheral lobes and subcapitate on ascending lateral lobes (Hale 1974; Elix 1994; Sipman 2005). It produces atranorin, echinocarpic (often together with conechinocarpic), protocetraric and sometimes also usnic acids (Hale 1974, 1986; Elix 1994). Specimens containing secalononic acid A reported by Elix (1994) may belong to *P. affluens*. The two species differ only in the pigmentation of the medulla (pigmented in *P. affluens*, not pigmented in *P. dilatatum*) (Hale 1974; see also remarks under *P. affluens*), and Krog and Swinscow (1981) considered them synonymous. Since there are no molecular data to confirm this suggestion we follow the current practice.

The species was reported as Pantropical (e.g., Hale 1965; Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 2002; Wolseley *et al.* 2002; Divakar & Upreti 2005; Benatti & Marcelli 2011), but as Hale (1965) and other authors used a rather wide concept of *P. dilatatum*, some records may belong to other taxa such as *P. robustum* or *P. affluens*.

SPECIMEN EXAMINED. BOLIVIA. DEPT. BENI. Prov. Ballivan, entre Yucumo y Rurrenabaque, 15°06'S, 67°07'W, 750 m, cresta con bosque siempreverde, 3 Aug. 1997, *K. Bach 372 et al.* (B).

Parmotrema eciliatum (Nyl.) Hale

Phytologia **28**(4): 336. 1974. – *Parmelia crinita* var. *eciliata* Nyl., Flora **52**: 291. 1869. – *Parmelia eciliata* (Nyl.) Nyl., in Fournier, Mexic. Pl. **1**: 3. 1872.

Parmotrema eciliatum can be recognized by its grey, loosely adnate thallus, sparse cilia and black, sparsely rhizinate lower surface with a broad, bare, brown, tan to white variegated marginal zone; the margins of the thallus are crenate to lobulate-dissected (Hale 1965; Elix 1994; Sipman 2005). The morphology of the Bolivian specimens matches well the characteristics of the species, but the hymenium was lower (70 µm) than previously reported by Hale (1965). The species produces atranorin and the stictic acid complex, including

hypostictic acid (Hale 1965; Elix 1994). Also detected in the Bolivian material were menegazziaic acid (minor) and norstictic acid (trace); to our knowledge those metabolites were not previously reported from this species.

The species was reported from Australia, East and Southern Africa, Asia (Taiwan, Japan) and the Neotropics (e.g., Argentina, Brazil, Cuba, Mexico) (Hale 1960, 1965; Elix 1994; Calvelo & Libertore 2002).

SPECIMENS EXAMINED. BOLIVIA. DEPT. CHUQUISACA. Prov. Tomina, Monteagudo near Sucre, 1400 m, montane forest, on wood, 8 March 1981, *S. G. Beck 6390* (LPB). DEPT. COCHABAMBA. Prov. Ayopaya, near Cotacajes, 16°46'S, 66°44'W, 2000 m, on bark, 15 May 1997, *K. Bach 116 et al.* (B, LPB). DEPT. TARIJA. Prov. Aniceto Arce, Filo de Sidras, 22°14'50"S, 64°33'28"W, 1064 m, Tucumano-Boliviano submontane forest, on branches, 22 Nov. 2010, *A. Flakus 18594* (KRAM, LPB).

Parmotrema endosulphureum (Hillmann) Hale

Phytologia **28**(4): 336. 1974. – *Parmelia tinctorum* var. *endosulphurea* Hillmann, Feddes Repert. Spec. Nov. Regni Veg. **48**: 8. 1940. – *Parmelia endosulphurea* (Hillmann) Hale, Contrib. U.S. Natl. Herb. **36**: 251. 1965.

The thallus of the species is broad-lobed, isidiate, eciliate with a pale yellow medulla and a black, sparsely rhizinate lower surface in the center with a broad, bare marginal zone. The ascospores are 19–23 × 6–9 µm (Hale 1965, Sipman 2005). Hale (1974) and Louwhoff and Elix (2000) reported atranorin, gyrophoric acid and the eumittrin N complex from the species. Also detected in the Bolivian material was lecanoric acid, and an unidentified terpenoid in two specimens (*Flakus 13191* and *13243*).

The species was reported from East Africa, Oceania, the southern U.S.A. and the Neotropics, where it is especially common in the Caribbean (e.g., Hale 1965; Louwhoff & Elix 2000; Esslinger 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Yacuma, Reserva de la Biosfera y Estación Biológica del Beni, near Estación Biológica del Beni, 14°51'07"S, 66°20'23"W, 175 m, island of lowland Amazon forest amidst savanna, on bark, 6 Nov. 2010, *A. Flakus*

17910 & *F. Saavedra* (KRAM, LPB). DEPT. LA PAZ. Prov. Sur Yungas, Alto Beni, Sarjana, 15°38.517'S, 67°08.940'W, 420 m, on *Theobroma cacao*, 22 June 1999, *N. Derakshani* 55 (B). DEPT. SANTA CRUZ. Prov. Guarayos, Virgen de Pilar near Chonta village, Reserva Vida Silvestre Rios Blanco y Negro, 15°38'54"S, 62°57'37"W, 229 m, lowland Amazon forest, on bark, 22 June 2009, *A. Flakus* 13191, 13243 & *P. Rodriguez* (KRAM, LPB).

***Parmotrema erubescens* (Stirt.) Krog & Swinscow**

Lichenologist **15**(2): 130. 1983. 1968. – *Parmelia erubescens* Stirt., Scott. Natural. **4**: 201. 1878. – *Canomaculina erubescens* (Stirt.) Elix, Mycotaxon **65**: 477. 1997.

Parmotrema erubescens is characterized by the absence of vegetative propagules, a scrobiculate upper surface with effigurate maculae, a distinctly ciliate thallus margin, and a brown to blackish brown and densely rhizinate lower surface without a bare marginal zone; the rhizines are dimorphic. It contains atranorin, salazinic and consalazinic acids (Krog & Swinscow 1981; Spielmann 2009). In one Bolivian specimen atranorin was not detected, probably due to its low concentration.

The species was reported from Australia, Brazil, Kenya and Oceania (Krog & Swinscow 1981; Elix 1997; Spielmann 2009).

SPECIMENS EXAMINED. BOLIVIA. DEPT. SANTA CRUZ. Prov. Caballero, East Cordillera, Siberia village, 17°49'38"S, 64°45'14"W, 3480 m, open area near montane cloud forest, on soil, 11 Dec. 2004, *A. Flakus* 4505 (KRAM, LPB). DEPT. TARIJA. Prov. Aniceto Arce, Seranía de Propiedad Arnold, 22°13'19"S, 64°33'41"W, 1309 m, Tucumano-Boliviano montane forest, on bark, 24 Nov. 2010, *A. Flakus* 18713 & *J. Quisbert* (KRAM, LPB).

***Parmotrema flavescens* (Kremp.) Hale**

Phytologia **28**(4): 336. 1974. – *Parmelia glaberrima* var. *flavescens* Kremp., Flora **52**: 223. 1869. – *Parmelia flavescens* (Kremp.) Nyl, Flora **68**: 607. 1885.

Parmotrema flavescens develops a yellow to yellowish, coriaceous, isidiate thallus with sparsely ciliate margins. The upper surface is opaque and reticulately cracked with age, whereas

the lower surface is black, sparsely rhizinate in the center, and brown and lacking rhizines at the broad marginal zone. The species produces atranorin and usnic, gyrophoric, salazinic and consalazinic acids (Hale 1965; Spielmann 2009). Hale (1965) did not report gyrophoric acid from *P. flavescens* but it is present in the type material (Spielmann 2009).

The species is known only from the Neotropics, where it was reported from Brazil, Colombia, Costa Rica, Mexico, Guatemala, Honduras and Venezuela (Hale 1965; Umaña-Tenorio *et al.* 2002; Spielmann 2009). An African record (see Spielmann 2009) needs confirmation.

SPECIMENS EXAMINED. BOLIVIA. DEPT. SANTA CRUZ. Prov. Chiquitos, near Santa Cruz de la Vieja, Mirador a San José de Chiquitos village, 17°52'21"S, 60°45'41"W, 501 m, Cerrado forest, on bark, 5 Dec. 2010, *A. Flakus* 19297, 19300 *et al.* (KRAM, LPB).

***Parmotrema flavomedullosum* Hale**

Mycotaxon **1**(2): 110. 1974.

The species is characterized by grey, sorediate thalli with a yellow medulla, eciliate margins, and a black, sparsely rhizinate lower surface with a wide, brown, erhizinate marginal zone. The soredia are coarse and produced in submarginal to laminal soralia (Hale 1974; Sipman 2005). Hale (1974) reported atranorin, gyrophoric acid, secalononic acid A (= entothein) and additional unidentified pigments. In the Bolivian material lecanoric acid also was detected.

The species was known previously from Brazil, Panama, Paraguay and Venezuela (Hale 1974).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Chapare, near Bulo Bulu village, near Río Chimoré, 16°58'19"S, 65°21'11"W, 283 m, lowland Amazon forest, on bark, 9 Dec. 2010, *A. Flakus* 19731 & *J. Quisbert* (KRAM, LPB). DEPT. SANTA CRUZ. Prov. Florida, Refugio 'Los Volcanes', 18°06'S, 63°36'W, 1000 m, on bark, 4 Oct. 1998, *K. Bach* 640 *et al.* (B, LPB).

***Parmotrema gardneri* (C. W. Dodge) Sérus.**

Bryologist **87**: 84. 1968. – *Parmelia gardneri* C. W. Dodge, Ann. Missouri Bot. Gard. **46**: 179. 1959.

The species can be recognized by its loosely adnate, coriaceous thallus, marginal soralia (linear along the margins or subcapitate, rarely also spreading submarginally) and eciliate or sparingly ciliate thallus margins. The lower surface is black, sparsely rhizinate in the center, and brown and lacking rhizines at the broad marginal zone. The species produces atranorin and protocetraric acid as the main secondary metabolites, sometimes also with unidentified fatty acids (Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 1999, 2002; Benatti & Marcelli 2011). Fatty acids were detected only in three Bolivian samples; in one sample traces of pigments also were detected, most probably due to contamination from other lichens.

The species is very similar to *P. robustum* but the thallus of the latter is membranous and sometimes contains usnic acid (Krog & Swinscow 1981; Sipman 2005). Some specimens, however, were intermediate in thallus structure; the distinction between the two species should be confirmed by molecular studies.

Parmotrema gardneri is a Pantropical species known from Africa, Australia, Oceania, North America, South America and Papua New Guinea (e.g., Hale 1965; Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 1999, 2000, 2002; Wolseley *et al.* 2002; Benatti & Marcelli 2011; Esslinger 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Ballivan, entre Yucumo y Rurrenabaque, 15°05'S, 67°07'W, 350 m, sobre corteza, 21 July 1997, *K. Bach 359 et al.* (LPB). DEPT. COCHABAMBA. Prov. Carrasco, Carrasco National Park, near Sehuenca village, 17°30'12"S, 65°16'30"W, 2220 m, montane cloud forest, on bark, 21 July 2008, *M. Kukwa 6329, 6528* (LPB, UGDA). DEPT. LA PAZ. Prov. Iturrealde, near Santa Rosa de Maravillas village, 13°57'55"S, 68°00'35"W, 320 m, preandean Amazon forest, on bark of tree, 30 July 2008, *M. Kukwa 6964a* (LPB, UGDA); Prov. Nor Yungas, Coroico village, 16°11'10"S, 67°43'16"W, 1550 m, Yungas montane forest, 6 June 2010, on bark, *A. Flakus 16425.1 & P. Rodriguez* (KRAM, LPB). DEPT. SANTA CRUZ. Prov. Chiquitos, near Santa Cruz de la Vieja, Mirador a San José de Chiquitos village, 17°52'21"S, 60°45'41"W, 500 m, Cerrado forest, on bark, 5 Dec. 2010, *A. Flakus 19340, 19342 et al.* (KRAM, LPB).

Parmotrema internexum (Nyl.) Hale *ex* DePriest & B. W. Hale

Mycotaxon **67**: 204. 1998. – *Parmelia internexa* Nyl., Flora **68**: 609. 1885.

The species can be recognized by its grey thallus, cylindrical, non-ciliate isidia, and black lower surface with a dark brown, narrow, papillate marginal zone (Hale 1965; Sipman 2005). It produces atranorin and the stictic acid complex (Sipman 2005).

The species was reported previously from Brazil and the eastern U.S.A. (Nylander 1885; Marcelli 1991; Esslinger 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. SANTA CRUZ. Prov. Florida, Refugio 'Los Volcanes' 18°06'S, 63°36'W, 1000 m, bosque semideciduo, epífita, 2 Oct. 1997, *K. Bach 610, 630 et al.* (B, LPB).

Parmotrema latissimum (Fée) Hale

Phytologia **28**(4): 337. 1974. – *Parmelia latissimum* Fée, Ess. Crypt. Suppl.: 119. 1837.

Parmotrema latissimum is characterized by wide, eciliate lobes, a black, rhizinate lower surface with a wide, brown, bare marginal zone, sublageniform conidia, the absence of vegetative propagules, and the production of atranorin, salazinic acid and consalazinic acid (Hale 1965; Sipman 2005; Spielmann 2009).

The species was reported from Asia, Oceania and numerous countries in the Neotropics (e.g., Hale 1960, 1965; Louwhoff & Elix 2000; Louwhoff 2001; Calvelo & Liberatore 2002; Divakar & Upreti 2005; Spielmann 2009).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Yacuma, Reserva de la Biósfera y Estación Biológica del Beni, near Estación Biológica del Beni, 14°51'07"S, 66°20'23"W, 175 m, island of lowland Amazon forest amidst savanna, on bark, 6 Dec. 2010, *A. Flakus 17864, 17868 & F. Saavedra* (KRAM, LPB).

Parmotrema leucosemothetum (Hue) Hale

Phytologia **28**(4): 337. 1974. – *Parmelia leucosemotheta* Hue, Nouv. Arch. Mus. Hist. Nat. Paris, 4 Sér. **1**: 192. 1899. – *Canomaculina leucosemotheta* (Hue) Elix, Mycotaxon **65**: 477. 1997.

The species is characterized by its effigurate maculation of the upper cortex, ciliate thallus margins, almost exclusively marginal soralia, and a dark brown to black lower surface with a distinct bare, brown (sometimes white mottled) marginal zone. It produces atranorin, salazinic acid and consalazinic acid (Hale 1965; Krog & Swinscow 1981; Sipman 2005; Spielmann 2009).

The Bolivian material of *P. leucosemothetum* is very variable in terms of maculae development and density of rhizines on the lower surface, even within a single thallus. Some specimens are distinctly maculate but with some lobes almost without maculae. Rhizines can reach the thallus edge of some lobes, but on others they are completely absent in a broad marginal zone. Perhaps *P. leucosemothetum* consists of several cryptic species, as in *P. cetratum* (Ach.) Hale and *P. reticulatum* (Ach.) M. Choisy (see Divakar *et al.* 2005; Del-Prado *et al.* 2011).

The species is known from Africa, both Americas and Asia (Hale 1965; Krog & Swinscow 1981; Calvelo & Liberatore 2002; Spielmann 2009).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Carrasco, 'Mojon Pampa' along creeks and ravines in an area locally known as 'Rio Mojon' and 'Mojon Pampa', ca 2 km E of Rio Lapacara and 7 km W of Rancho Pairumani, 17°30'S, 65°25'W, ca 3420 m, ravines along the creek with giant *Polylepis* woods, on boulder, 26 June 1985, *M. Lewis 85-277* (LPB). DEPT. LA PAZ. Prov. Franz Tamayo, Río Bilipisa, ca 10 km NW de Apolo, 14°36'S, 68°27'W, 1100 m, bosque semi-deciduo disturbado con *Anadenanthera*, sobre corteza, 4 July 1997, *K. Bach 242* (LPB). DEPT. TARIJA. Prov. Aniceto Arce, Filo de Sidras, camp of guards near Tarija, 22°14'50"S, 64°33'28"W, 1064 m, Tucumano-Boliviano submontane forest, 22 Nov. 2010, on bark, *A. Flakus 18435.1 & P. Rodriguez* (KRAM, LPB).

Parmotrema masonii L.I. Ferraro

Hickenia 1(34): 191. 1979.

The species is characterized by its yellowish thallus with distinctly and richly ciliate margins, the absence of vegetative propagules, imperforate apothecial discs, black lower surface with abundant rhizines and dark brown, bare marginal zone and the production of atranorin, salazinic (with

consalazinic) acid and hypoconstictic acid (Ferraro 1979; Spielmann 2009; Pérez-Pérez *et al.* 2011).

Parmotrema masonii was known previously only from Argentina, Brazil and Paraguay (Ferraro 1979; Calvelo & Liberatore 2002; Spielmann 2009).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Ayopaya, 20 km de Cocapata hacia Cotacajes, 16°46'S, 66°44'W, 2000 m, bosque semisecundo disturbado de 5 m de altura en una quebrada, epífita, 15 May 1997, *K. Bach 84 et al.* (LPB). DEPT. LA PAZ. Prov. Bautista Saavedra, 15 km de Camata hacia Apollo, 15°13'S, 68°41'W, 1400 m, bosque semi deciduos, saxicola, 27 June 1997, *K. Bach 230 et al.* (B, LPB); Prov. Nor Yungas, Cieneguillas, 16°35'S, 67°26'W, 1300 m, bosque deciduos, epífita, 14 Dec. 1997, *K. Bach 927* (B, LPB).

Parmotrema mellissii (C. W. Dodge) Hale

Phytologia 28(4): 337. 1974. – *Parmelia mellissii* C. W. Dodge, *Ann. Missouri Bot. Gard.* 46: 134. 1959.

Parmotrema mellissi can be recognized by its grey thalli with ciliate, crenate to isidiate and dissected margins, marginal and laminal isidia which often become granular and sorediate, and with age also coralloid branched and ciliate. The lower surface is black and rhizinate with a wide, bare, brown, tan or white mottled marginal zone. The medulla is white or partly reddish orange near the lower cortex. The species contains atranorin, alectoronic acid and often skryrin (= rhodophyscin) (Hale 1965; Krog & Swinscow 1981). Skryrin was found only in one Bolivian specimen.

The species was reported from the southern U.S.A., the Neotropics from Mexico to Colombia and Brazil, Africa (e.g., Canary Islands, Kenya), Asia (e.g., Japan, Laos), Australia and Oceania (e.g., Hale 1965; Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 1999, 2002; Louwhoff 2001; Wolseley *et al.* 2002; Esslinger 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Carrasco, Carrasco National Park, 18 km N of Monte Punku village, between Ch'iqtá rumi and Phaqcha settlements, 17°27'22"S, 65°16'24"W, 2700 m, montane cloud forest, close to the river, on bark of tree, 20 July 2008, *M. Kukwa 6264* (LPB, UGDA); Ch'iqtá rumi, 17°28'44"S, 65°17'06"W, 2120 m, montane cloud

forest, close to the river, on bark of tree, 21 July 2008, *M. Kukwa 6285a*, 6296 (LPB, UGDA); near Sehuencas village by Rio Lopez Mendoza river, S17°30'26", W65°16'55", 2226 m, montane cloud forest, on bark of tree, 22 July 2008, *M. Kukwa 6640* (LPB, UGDA).

***Parmotrema mirandum* (Hale) Hale**

Phytologia **28**(4): 337. 1974. – *Parmelia miranda* Hale, Contrib. U.S. Natl. Herb. **36**: 273. 1965.

This rare species is characterized by its yellowish green thallus with ciliate margins, marginal soralia, black lower surface with densely rhizinate areas and brown, pale brown or partly beige, bare marginal zone. It produces hypoconstictic, salazinic and consalazinic acids (Hale 1965; Spielmann 2009; Pérez-Pérez *et al.* 2011).

Parmotrema mirandum was reported only from Brazil, Mexico and Venezuela (Hale 1965; Spielmann 2009; Pérez-Pérez *et al.* 2011).

SPECIMEN EXAMINED. BOLIVIA. DEPT. BENI. Prov. Nor Yungas, Cieneguillas, 16°35'S, 67°26'W, 1300 m, bosque deciduos, epífita, 14 Dec. 1997, *K. Bach 927b* (B). Note. The duplicate of this specimen in LPB belongs to *Parmotrema tinctorum*.

***Parmotrema neotropicum* Kurok.**

in Hale, Mycotaxon **5**(2): 437. 1977. – *Rimeliella neotropica* (Kurok.) Kurok., Ann. Tsukuba Bot. Gard. **10**: 6. 1991. – *Canomaculina neotropica* (Kurok.) Elix, Mycotaxon **65**: 477. 1997.

The species is characterized by a yellowish thallus, laminal to submarginal and marginal isidia sometimes breaking up into soredioid granules, effigurate maculae, a veined, brown lower surface, dimorphic rhizines and the presence of usnic acid, atranorin, salazinic and consalazinic acids (Hale 1977; Marcelli & Benatti 2008; Spielman 2009).

It was known previously from the southern U.S.A., Brazil, Costa Rica, Cuba and Mexico (Hale 1977; Umaña-Tenorio *et al.* 2002; Marcelli & Benatti 2008; Spielman 2009).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Ayopaya, 20 km de Cocapata hacia Cotacajes, 16°46'S, 66°44'W, 2000 m, bosque semideciduo disturbado, saxícola, 15 May 1997, *K. Bach 102, 99 et al.* (B, LPB). DEPT. LA PAZ. Prov. Franz Tamayo,

Río Bilipisa, ca 10 km NW de Apolo, 14°36'S, 68°27'W, 1100 m, bosque semideciduos disturbado con *Anadenanthera*, epífita, 4 July 1997, *K. Bach 243* (LPB).

***Parmotrema nylanderii* (Lyngé) Hale**

Smithsonian Contr. Bot. **33**: 54. 1976. – *Parmelia nylanderii* Lyngé, Ark. Bot. **13**(13): 82. 1914. – *Parmelina nylanderii* (Lyngé) Hale, Phytologia **28**(5): 483. 1974.

The thallus of *P. nylanderii* is yellowish, ciliate at the margins and pustulate. The pustules are rugose or orbicular, submarginal, and produce granular soredia. The lower surface is irregularly rhizinate, black, with a brown, bare marginal zone. The species has very characteristic chemistry and produces usnic, gyrophoric, salazinic, consalazinic and hypoconstictic acids (Hale 1976; Sipman 2005; Spielmann 2009). In the Bolivian collection most of the pustules has almost entirely turned into soredia; the material was also fertile.

Previously the species was reported only from a few localities in Brazil (Lyngé 1914; Hale 1960; 1976; Spielmann 2009).

SPECIMENS EXAMINED. BOLIVIA. DEPT. SANTA CRUZ. Prov. Chiquitos, near Santa Cruz de la Vieja, Mirador a San José de Chiquitos village, 17°52'21"S, 60°45'41"W, 500 m, Cerrado forest, on rock, 5 Dec. 2010, *A. Flakus 19320 et al.* (KRAM, LPB).

***Parmotrema permutatum* (Stirt.) Hale**

Phytologia **28**(4): 338. 1974. – *Parmelia permutata* Stirt., Scott. Natural. **4**: 252. 1878.

The species can be distinguished by its grey thallus with the lower part of the medulla orange-yellow, and marginal cilia and soralia. The lower surface is black, sparsely rhizinate, with a brown, bare marginal zone. The species contains atranorin, gyrophoric acid and unidentified pigments (Hale 1965, 1974; Sipman 2005); lecanoric acid also was detected in the Bolivian material.

It is a rarely recorded species with a Pantropical distribution. In South America it was reported only from Brazil, and elsewhere from Australia, South Africa, Ethiopia, Ivory Coast, Kenya, Uganda, India, Sumatra, Thailand, Papua New Guinea and Haiti (Hale 1965; Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 1999).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Nor Yungas, Coroico village, 16°11'10"S, 67°43'16"W, 1550 m, Yungas montane forest, on tree, 6 June 2010, *A. Flakus 16428* & *P. Rodriguez* (KRAM, LPB). DEPT. TARIJA. Prov. Aniceto Arce, Filo de Sidras, camp of guards near Tarija, 22°14'50"S, 64°33'28"W, 1060 m, Tucumano-Boliviano submontane forest, on bark, 22 Nov. 2010, *A. Flakus 18515.1* & *P. Rodriguez* (KRAM, LPB).

Parmotrema robustum (Degel.) Hale

Phytologia **28**(4): 338. 1974. – *Parmelia robusta* Degel., Göteborgs Kungl. Vetensk. Samhälles Handl. ser. B, **7**: 33. 1941.

The diagnostic characters of *P. robustum* are its membranaceous thallus, sparse marginal cilia (sometimes cilia absent), short laciniae with marginal soralia, a black, sparsely rhizinate lower surface with a broad, brown erhizinate zone, and the production of protocetraric acid and atranorin, sometimes also with usnic and fatty acids (Elix 1994; Louwhoff & Elix 1999; Sipman 2005). In the Bolivian material usnic acid was detected in one specimen, and in one sample five different fatty acids were found.

The species was considered to be synonymous with *P. dilatatum* (Hale 1965), but the latter additionally contains echinocarpic acid (Hale 1977; Elix 1994; Louwhoff & Elix 1999). *Parmotrema robustum* is very similar to *P. gardneri* but the thallus of the latter is more coriaceous; for more details see notes under *P. gardneri*.

Parmotrema robustum is widely distributed. It was reported from Europe, eastern Australia, New Zealand, India, Thailand, Papua New Guinea, Macaronesia and the Neotropics (Brazil, Colombia, Costa Rica, Ecuador, Venezuela) (e.g., Elix 1994; Divakar & Upreti 2005; Louwhoff & Elix 1999, 2002; Wolseley *et al.* 2002; Feuerer 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Chapare, near Incachaca village, S 17°14'13"S, 65°49'02"W, 2290 m, Yungas montane cloud forest, on wood, 10 June 2006, *A. Flakus 8292* (KRAM, LPB). DEPT. LA PAZ. Prov. Bautista Saavedra, 15 km de Charazani hacia Apolo, 15°11'S, 68°52'W, 2400 m, bosque humedo secundario, epifita y terrestre, 07.1997,

K. Bach 293, 336a et al. (B, LPB); *ibid.*, 2450 m, bosque seco, base de troncos, 2 July 1997, *K. Bach 306 et al.* [B; note: specimen in LPB belongs to *Parmotrema perlatum* (Huds.) M. Choisy]; Prov. Iturrealde, forest above Tumupasa village, 14°08'51"S, 67°53'34"W, 350 m, preandean Amazon forest, on bark of tree, 31 Aug. 2008, *M. Kukwa 7041, 7087* (LPB, UGDA). DEPT. SANTA CRUZ. Prov. Chiquitos, near Santa Cruz de la Vieja, Mirador a San José de Chiquitos village, 17°52'21"S, 60°45'41"W, 500 m, Cerrado forest, on bark, 5 Dec. 2010, *A. Flakus 19282 et al.* (KRAM, LPB); Prov. Guarayos, Plan de Manejo AISU, Reserva Vida Silvestre Rios Blanco y Negro, 15°01'49"S, 62°46'36"W, 240 m, lowland Amazon forest, 25 July 2009, on bark, *A. Flakus 14186, 14270* & *P. Rodriguez* (KRAM, LPB); Prov. J. M. de Velasco, near Florida village, Parque Nacional Noel Kempff Mercado, 14°35'50"S, 61°50'46"W, 215 m, Cerrado forest, on bark, 15 Dec. 2009, *A. Flakus 15725, 15746* & *P. Rodriguez* (KRAM, LPB).

Parmotrema rubifaciens (Hale) Hale

Phytologia **28**(4): 339. 1974. – *Parmelia rubifaciens* Hale, Contrib. U.S. Natl. Herb. **36**: 261. 1965.

The species is characterized by its membranaceous, eciliate thallus with a white medulla, marginal to submarginal soredia, and a black, sparsely rhizinate lower surface with a brown, bare marginal zone. It produces atranorin and norstictic acid (Hale 1965, 1974; Sipman 2005); lecanoric acid also was detected in the Bolivian material.

Parmotrema rubifaciens was reported previously from Brazil, Costa Rica, Mexico and Nicaragua (Hale 1965; Harris 1990; Umaña-Tenorio *et al.* 2002; Marcelli & Benatti 2010).

SPECIMENS EXAMINED. BOLIVIA. DEPT. SANTA CRUZ. Prov. Ibañez, Jardín Botánico, 17°43'S, 63°03'W, 380 m, bosque seco, sobre corteza, 30 Sept. 1997, *K. Bach 595* (B, LPB).

Parmotrema sancti-angeli (Lyngé) Hale

Phytologia **28**(4): 339. 1974. – *Parmelia sancti-angeli* Lyngé, Ark. Bot. **13**(13): 35. 1914.

This is a ciliate and sorediate species with mainly marginal, linear soralia, with a large grey thallus, a black and sparsely rhizinate lower surface with an erhizinate, brown to white mottled

margin, and a white medulla with or without orange patches near the lower cortex. It contains atranorin, gyrophoric, \pm lecanoric acids and also skyrin (= rhodophyscin) in orange spots (Hale 1965; Krog & Swinscow 1981; Sipman 2005; Louwhoff & Elix 1999).

Parmotrema sancti-angeli is a Pantropical species known from Africa, Australia, Asia (e.g. India, Thailand), North America, South America and Oceania (Hale 1965; Krog & Swinscow 1981; Louwhoff & Elix 1999; Calvelo & Liberatore 2002; Wolseley *et al.* 2002; Benatti & Marcelli 2009).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Nor Yungas, Coroico town, 16°11'10"S, 67°43'16"W, 1550 m, Yungas montane forest, on bark, 6 June 2010, *A. Flakus* 16425 & *P. Rodriguez* (KRAM, LPB).

Parmotrema simulans (Hale) Hale

Phytologia **28**(4): 339. 1974. – *Parmelia simulans* Hale, Phytologia **22**: 32. 1971.

The species belong to a group of species with a reticulately white-maculate and cracked upper thallus surface. It usually is strongly lacinate, especially in the center of the thallus, and develops coarse soredia mostly on those laciniae. The medulla is white and the lower surface is dark brown with dense, simple to squarrosely branched rhizines. It contains atranorin and caperatic acid (Hale 1971b; Sipman 2005).

Krog and Swinscow (1981) considered *P. simulans* to be synonymous with *P. reticulatum*, but since the latter is polyphyletic (see Del-Prado *et al.* 2011) it is better to keep *P. simulans* as a distinct species.

The species seems to be rare. It was reported from the Neotropics (Brazil, Dominican Republic, Haiti, Mexico, Uruguay), the U.S.A., South Africa and Uganda (Hale 1971b; Krog & Swinscow 1981, sub *Parmelia reticulata* Taylor; Esslinger 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Carrasco, Carrasco National Park, near Sehuencas village, 17°30'12"S, 65°16'30"W, 2220 m, montane cloud forest, with some rocks in open place, on bark of tree, 21 July 2008, *M. Kukwa* 6569 (LPB, UGDA).

Parmotrema sorediiferum Hale

Mycotaxon **25**(1): 89. 1986.

Parmotrema sorediiferum is characterized by a grey, ciliate thallus with marginal soralia soon developing into a broad submarginal zone of soralia and open sorediate pustules which form dense masses, a fragile cortex flaking off in places, a white medulla, and a black, sparsely rhizinate lower surface with a broad, pale brown to white mottled, bare marginal zone. The species produces atranorin, alectoronic acid and α -collatolic acid (Hale 1986; Sipman 2005).

The species was known previously only from the type locality in Venezuela (Hale 1986). The type specimen occurred on rock; Bolivian material was found on bark.

SPECIMENS EXAMINED. BOLIVIA. DEPT. TARIJA. Prov. Aniceto Arce, Papachacra, 21°41'36"S, 64°29'33"W, 2195 m, Tucumano-Boliviano montane forest with *Alnus acuminata*, on bark, 26 Nov. 2010, *A. Flakus* 19809 & *J. Quisbert* (KRAM, LPB).

Parmotrema soredialiphaticum Estrabou & Adler

Mycotaxon **66**: 134. 1998.

The species can be distinguished by its grey, eciliate thallus dactyls becoming sorediate, white medulla, and black, sparsely rhizinate lower surface with a broad, brown, ivory to mottled marginal zone. The species produces atranorin and unidentified fatty acids (Estrabou & Adler 1998; Sipman 2005).

Previously *P. soredialiphaticum* was reported only from the type locality in Argentina (Estrabou & Adler 1998; Calvelo & Liberatore 2002).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Nor Yungas, near Pacallo village, 16°12'10"S, 67°50'39"W, 1360 m, montane forest, on rock, 3 Aug. 2008, *M. Kukwa* 7135 (LPB, UGDA).

Parmotrema subarnoldii (Abbeyes) Hale

Phytologia **28**(4): 339. 1974. – *Parmelia subarnoldii* Abbeyes, Mém. Inst. Sci. Madagascar, sér. B **10**: 113. 1961.

The species is characterized by a grey thallus with conspicuous cilia 2–6 mm long distributed around the lobe tips, and marginal soralia on broad lobes or terminal soralia on narrow, lateral lobes. The medulla usually is entirely white (occasionally with orange patches) and the lower surface is black, sparsely rhizinate, with a broad, erhizinate, brown and shiny marginal zone. It produces atranorin and protocetraric acid as constant secondary metabolites (Hale 1965; Elix 1994; Sipman 2005). Elix (1994) and Louwhoff and Elix (1999) reported protolichesterinic acid also (accompanied sometimes by lichesterinic acid and skyrin), which was reported as not constant by Krog and Swinscow (1981) and was not found in the Bolivian material.

It is a Pantropical species, but rather rare. Previously it was reported from Africa (Kenya, Madagascar, Uganda), Asia (India, Indonesia, Thailand), Australia, Papua New Guinea and the Neotropics (Brazil, Mexico) (Hale 1965; Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 1999; Wolseley *et al.* 2002; Divakar & Upreti 2005; Benatti & Marcelli 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Carrasco, Carrasco National Park, between Sehuencas and Monte Punku villages, ca 2650 m, montane cloud forest, on humus or rocks, 22 July 2008, *M. Kukwa 6575* (LPB, UGDA).

Parmotrema subisidiosum (Müll. Arg.) Hale

Phytologia **28**(4): 339. 1974. – *Parmelia cetrata* var. *subisidiosa* Müll. Arg., Bot. Jahrb. Engler **20**: 256. 1894. – *Parmelia subisidiosa* (Müll. Arg.) C. W. Dodge, Ann. Missouri Bot. Gard. **46**(1–2): 87. 1959. – *Rimelia subisidiosa* (Müll. Arg.) Hale & Fletcher, Bryologist **93**(1): 29. 1990.

Parmotrema subisidiosum can be distinguished by its grey thallus with ciliate margins and reticular maculae, the simple to coralloid and sometimes ciliate isidia, and the black and rhizinate lower surface with a narrow, brown, smooth or papillate marginal zone. It produces atranorin, salazinic acid and consalazinic acid (Krog & Swinscow 1981; Sipman 2005; Spielmann 2009).

The species is known from Africa, North America and South America (Brazil, Venezuela, Uruguay) (Krog & Swinscow 1981; Osorio 1992; Spielmann 2009; Esslinger 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Carrasco, Carrasco National Park, near Sehuencas village, 17°30'12"S, 65°16'30"W, 2220 m, montane cloud forest, with some rocks in open place, on bark of tree, 21 July 2008, *M. Kukwa 6457* (LPB, UGDA). DEPT. LA PAZ. Prov. Nor Yungas, Hacienda Sacramento, ca 8 km del camino principal de Chuspipata hacia Coroico, 16°24'S, 67°47'W, 2500 m, pared rocosa de 3 m de altura, saxícola, 20 Sept. 1997, *K. Bach 575 et al.* (B).

Parmotrema subsumptum (Nyl.) Hale

Mycotaxon **5**(2): 434. 1977. – *Parmelia subsumpta* Nyl., Flora **52**: 117. 1869. – *Rimeliella subsumpta* (Nyl.) Kurok., Ann. Tsukuba Bot. Gard. **10**: 9. 1991. – *Canomaculina subsumpta* (Nyl.) Elix, Mycotaxon **65**: 477. 1997.

The species develops large, grey and ciliate thalli with white, effigurate maculae and a white medulla. The soralia are marginal and the lower surface is pale brown to brown, rarely black, evenly rhizinate (with dimorphic rhizines) up to the margins or with a narrow, bare, smooth to veined marginal zone. It produces atranorin, salazinic acid and consalazinic acid (Hale 1965; Krog & Swinscow 1981; Louwhoff & Elix 1999; Sipman 2005; Spielmann 2009). Louwhoff and Elix (1999) reported usnic acid also in some specimens, but that substance was not found in the Bolivian material.

This widely distributed species was reported from Africa, Asia, North America, Oceania and South America (from Venezuela to Argentina) (Hale 1965; Krog & Swinscow 1981; Louwhoff & Elix 1999; Calvelo & Liberatore 2002; Divakar & Upreti 2005; Spielmann 2009; Esslinger 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. COCHABAMBA. Prov. Ayopaya, 20 km de Copapata hacia Cotacajes, 16°46'S, 66°44'W, 2000 m, bosque semideciduo disturbado, saxícola, 15 May 1997, *K. Bach 108 et al.* (B, LPB); Prov. Carrasco, Carrasco National Park, near Sehuencas village, 17°30'12"S, 65°16'30"W, 2220 m, montane cloud forest, along the road and close to the settlement, on bark of tree, 21 July 2008, *M. Kukwa 6328* (LPB, UGDA). DEPT. TARIJA. Prov. Aniceto Arce, Serranía de Propiedad Arnold, 22°13'19"S, 64°33'41"W, 1309 m, Tucumano-Boliviano montane forest, on bark, 24 Nov. 2010, *A. Flakus 18815* & *J. Quisbert* (KRAM, LPB).

Parmotrema tinctorum (Despr. ex Nyl.) Hale

Phytologia **28**(4): 339. 1974. – *Parmelia tinctorum* Nyl., Flora **55**: 547. 1872.

The species can be distinguished by its large grey thalli with laminal, thin, cylindrical isidia, a white medulla and eciliate margins. The lower surface is black and sparsely rhizinate, with a broad, brown, bare marginal zone. It contains atranorin and lecanoric acid (Hale 1965; Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 1999).

This widely distributed species is known from every continent except Europe (Hale 1965; Krog & Swinscow 1981; Elix 1994; Louwhoff & Elix 1999, 2002; Calvelo & Liberatore 2002; Wolseley *et al.* 2002; Divakar & Upreti 2005; Esslinger 2011).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Yacuma, Reserva de la Biósfera y Estación Biológica del Beni, near Estación Biológica del Beni, 14°51'07"S, 66°20'23"W, 175 m, island of lowland Amazon forest amidst savanna, on bark, 6 Nov. 2010, *A. Flakus 17870 & F. Saavedra* (KRAM, LPB). DEPT. LA PAZ. Prov. Bautista Saavedra, 15 km de Camata hacia Apollo, 15°13'S, 68°41'W, 1400 m, bosque semideciduo, sobre corteza, 27 June 1997, *K. Bach 228 et al.* (B, LPB); Prov. Franz Tamayo, Cutu Sacha, trayecto hasta Machua, al Este de Apolo por el camino a San José de Uchupiamonas, 14°31'10"S, 68°16'47"W, 1600–2220 m, sabanas con restos de bosque montano estacional húmedo y matorrales y arbustadas secundarios, saxícola, 22–23 July 2002, *A. Fuentes 5217* (LPB); Prov. Nor Yungas, Cieneguillas, 16°35'S, 67°26'W, 1300 m, bosque deciduo con *Astronium* y *Anadenanthera*, exposición S, epífita, 14 Dec. 1997, *K. Bach 927a* (B); *ibid.*, *K. Bach 927b* (LPB); near Pacallo village, 16°12'10"S, 67°50'39"W, 1360 m, montane forest, on stone, 3 Aug. 2008, *M. Kukwa 7119* (LPB, UGDA). DEPT. SANTA CRUZ. Prov. Chiquitos, near Santa Cruz de la Vieja, Mirador a San José de Chiquitos village, 17°52'21"S, 60°45'41"W, 500 m, Cerrado forest, on rock, 5 Dec. 2010, *A. Flakus 19290, 19339, 19343, 19363, 19368 et al.* (KRAM, LPB); Prov. Cordillera, Charrata village near camp of guards, Parque Nacional y Área Natural de Manejo Integrado Kaa-Iya del Gran Chaco, 18°28'05"S, 62°05'43"W, 307 m, Chaqueño forest, on bark, 2 Nov. 2010, *A. Flakus 20192 & J. Quisbert* (KRAM, LPB); gas pipeline Bolivia-Brazil, near Tucavaca colony, Parque Nacional y Área Natural de Manejo Integrado Kaa-Iya del Gran Chaco, 18°30'19"S,

60°57'14"W, 280 m, Chiquitano forest, 4 Dec. 2010, on bark, *A. Flakus 19026, 19166, 19206 & J. Quisbert* (KRAM, LPB); Prov. Florida, Refugio 'Los Volcanes' 18°06'S, 63°36'W, 1000 m, bosque semideciduo, epífita, 5 Oct. 1998, *K. Bach 644a et al.* (B). Prov. J. M. de Velasco, Camino los Fierros near Florida village, Parque Nacional Noel Kempff Mercado, 14°32'25"S, 61°03'13"W, 215 m, lowland Amazon forest, on bark, 14 Dec. 2009, *A. Flakus 15575 & P. Rodriguez* (KRAM, LPB); Los Vicito near Santa Rosa village, 15°50'00"S, 61°29'00"W, 350 m, savanna vegetation, on bark, 17 Dec. 2009, *A. Flakus 16272 & P. Rodriguez* (KRAM, LPB). DEPT. TARIJA. Prov. Aniceto Arce, camp of guards near Tarija, 22°14'56"S, 64°32'55"W, 880 m, Tucumano-Boliviano secondary submontane forest, on bark, 21 Nov. 2010, *A. Flakus 18355* (KRAM, LPB). Serranía de Propiedad Arnold, 22°13'19"S, 64°33'41"W, 1309 m, Tucumano-Boliviano montane forest, on bark, 24 Nov. 2010, *A. Flakus 18783 & J. Quisbert* (KRAM, LPB).

Parmotrema wrightii L. I. Ferraro & Elix

Mycotaxon **49**: 405. 1993.

The species is characterized by a grey, coriaceous and eciliate thallus, a black and sparsely rhizinate lower surface with a broad, brown, bare marginal zone, and substipitate, imperforate apothecia with ascospores measuring 20–22 × 12–14 µm. It produces atranorin and norstictic, echinocarpic and connorstictic acids (Ferraro & Elix 1993). The Bolivian material was sterile.

Previously the species was known only from the type locality in Brazil (Ferraro & Elix 1993).

SPECIMENS EXAMINED. BOLIVIA. DEPT. BENI. Prov. Ballivian, near Reyes village, 14°18'10"S, 67°18'49"W, 192 m, savanna vegetation, on bark, 5 Dec. 2004, *A. Flakus 4391* (KRAM, LPB).

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