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Parmotrema (*Parmeliaceae*, lichenized *Ascomycota*) with alectoronic acid: two new species, a checklist and a preliminary worldwide key

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Abstract. A preliminary study of the *Parmotrema* species with alectoronic acid revealed a list of 63 such species worldwide. Two of these are newly described here, *Parmotrema columnatum*, with inflated apothecial stipes, and *Parmotrema marginatihiatum*, with abundant lobules, both from Brazil. A checklist with the main literature for each species and a working key are presented together with some illustrations of types or fresh collections, mainly from Brazil.

Key words: Brazil, lichens, *Parmelia*, UV test

Introduction

The study of *Parmotrema* is quite challenging, since there are about 420 validly described species (Spielmann, unpublished data), and new findings came to light in recent years, showing that even small areas, when investigated in detail, reveal a high diversity (e.g., Masson et al. 2024).

One of the possible approaches to study this megadiverse genus is to delimit "chemical groups", and then to revise the available names in detail. In this sense, we revised the species with salazinic acid (Spielmann & Marcelli 2020), focusing on the types available to ensure a good application of the available names. The second step is the study of populations from old and recent collections, that is still under investigation. But everyone facing the effort necessary to this kind of investigation knows that it takes a lot of time, with thousands of specimens to compare and analyze through detailed morphology, chemistry, habitat preferences and distribution, and when possible, its genes.

So, what to do when you realize that in a short time it is impossible to revise in detail all chemical groups of *Parmotrema*? To arrange several PhDs for each group? No doubt a monographic approach based on modern taxonomic tools would be very welcome. In the meantime, the use of working keys to the known species can help in raising the problems existing in their delimitation, as well as showing the amazing diversity in some groups, as is the case with the *Parmotrema* species with medullary alectoronic (and often α-collatolic) acid. Additionally, we provide a list of the accepted species with their synonyms, some notes and main literature.

Material and methods

Alectoronic acid can be detected by exposing the medulla to a 365 nm UV light, which reveals a bluish white (or greenish white) color (Fig. 1A), as well as by the KC+ rose → quickly orange reaction (or pink-red, according with Orange et al. 2001). Its microcrystals are tiny, flat, colorless, rectangular plates (Taylor 1967), while in TLC in solvent A the R_F is 33 (Elix 2014). In some species of *Parmotrema*, the marginal cilia react K+ violet, especially cilia with coppery reddish glints. For making this reaction, it is usual to insert the cilia in a capillary tube with potassium hydroxide (Fig. 1B).

The collection and study of the two new species followed classical methods in lichenology (Fink 1905; Hale 1979; Brodo et al. 2001), and for the description of the taxa the Protocol of the Grupo de Estudos Liquenológicos was followed (Canêz & Marcelli 2006).

Results and discussion

Checking the extensive literature at our disposal, we were able to find 63 species of *Parmotrema* with alectoronic acid (including *Parmotrema columnatum* and *Parmotrema*

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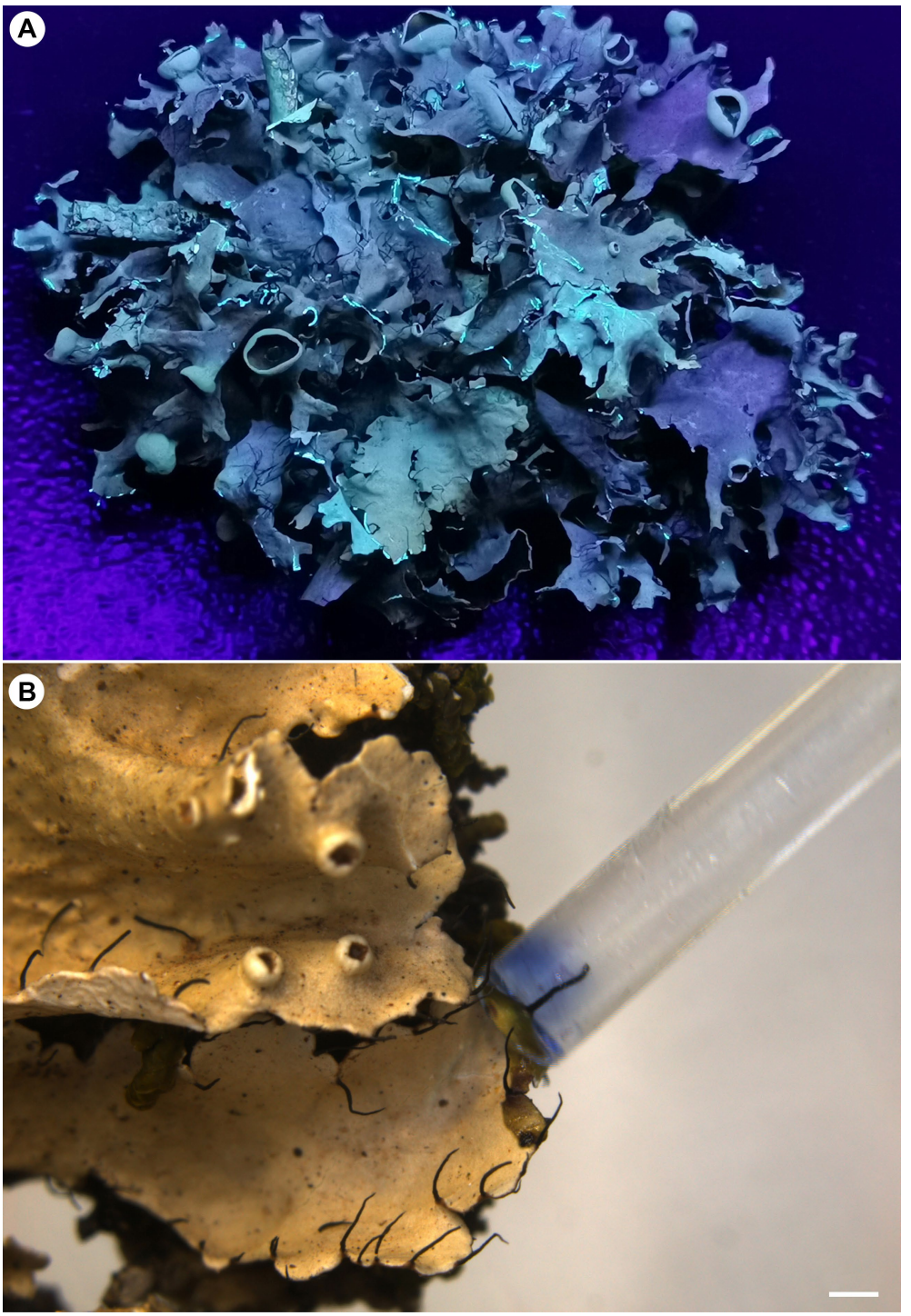

Figure 1. A – field picture of the thallus of *Parmotrema wainii* under UV light (from Brazil, Rio Grande do Sul); B – the cilium of *Parmotrema argentinum* is inserted in a capillary tube with potassium hydroxide. Scale: B = 1 mm.

marginatihiatum, the two new species proposed here). This number is apparently sound, since Hale (1965) described 21 species with alectoronic acid, Kurokawa (1987) 26, and checking Rambold et al. (2026), we found 52 species containing this substance.

Our data show that all but one species with alectoronic acid produce atranorin in the upper cortex. The exception is *Parmotrema alectoronicum*, with cortical usnic acid. With relation to the medullary substances, only *P. subrigidum* presented the combination of alectoronic and norstictic acid. *Parmotrema sublatifolium* has alectoronic and bourgeanic acid, and fatty acids are present only in *P. stenopteris*. Four species produce alectoronic and gyrophoric acid: *P. alectoronicum*, *P. direagens*, *P. diversum* and *P. lobulascens*. Six species have alectoronic and protocetraric acid: *P. amaniense*, *P. columnatum*, *P. deflectens*, *P. nemorum*, *P. subdeflectens* and *P. thailandicum*.

The presence of alectoronic acid is negatively related to other substances. It is (still) not detected in species containing norlobaridone (Honda et al. 2016), salazinic acid (Spielmann & Marcelli 2020), cryptochlorophaeic acid, diffractaic acid, echinocarpic acid, lecanoric acid, lichexanthone, olivetoric acid, stictic acid and vulpinic acid (Spielmann, unpublished data).

Only four species of *Parmotrema* with alectoronic acid do not produce marginal cilia in the lobes: *Parmotrema pancheri*, *P. exquisitum*, *P. thailandicum* and *P. crinitoides* (cilia lacking or very rarely sparse in this species).

It is interesting to note that no species of the former genera *Canomaculina*, *Concamerella*, *Rimelia* and *Rimeliella*, now considered to belonging to *Parmotrema*, contain alectoronic acid. Therefore, the presence of this substance is apparently an attribute of *Parmotrema* s. str. and the former genus *Parmelaria* (below referred to as *Parmotrema thomsonii*).

Two new species of *Parmotrema* with alectoronic acid

Parmotrema columnatum Benatti & Marcelli, sp. nov. (Fig. 2)

MycoBank MB 864773

Type: Brazil, São Paulo State, Municipality of Ilha Comprida, in the south of the island alongside the road, near the ferry to Cananéia city, inside the low restinga forest, on a tree branch at the border of the forest, 2 Apr. 2004, leg. L.S. Canêz, M.N. Benatti, M.P. Marcelli & A.A. Spielmann 1326 (SP – holotype).

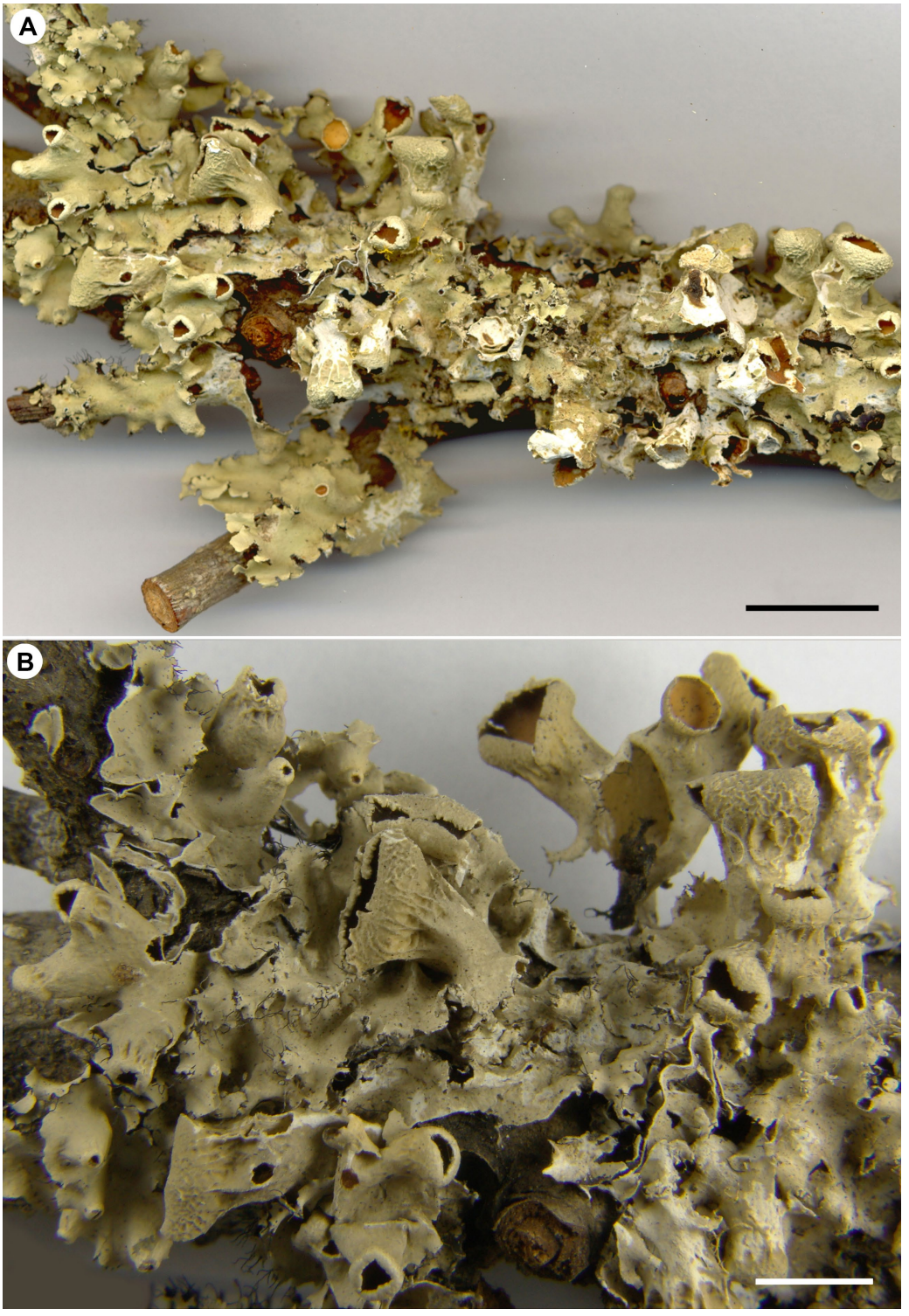

Figure 2. Holotype of *Parmotrema columnatum* (SP). A – thallus; B – detail of the apothecia. Scales: A = 1 cm, B = 5 mm.

Diagnosis: *Parmotrema columnatum* has no vegetative propagules, produces medullary protocetraric acid and alectoronic acid, the apothecium stipes are very inflated, the ascospores are longer than 20 µm, and the conidia are bacillar or short filiform 4.0–6.5(–8.0) µm, what distinguish them from the other species with this medullary chemistry.

Desciption. Thallus corticicolous, lobed to sublobed, light greyish green to tan in the herbarium, till 13.0 cm large, submembranaceous. Lobes irregularly ramified, 1.5–5.5 mm wide, the surface continuous to irregularly cracked, smooth to slightly rugose, crowded, usually raised, occasionally somewhat adnate in the distal parts, little adpressed to loosely attached, the apices subrotund to irregular, subplane to sometimes slightly involute, the margins smooth, subcrenate or irregular, subplane to subascending, slightly undulate, sublacinulate. Lacinules irregularly distributed along all the thallus margin, more distinct in the center, mixed with young irregular lobules, plane, short, 0.3–2.1 × 0.2–0.9 mm, simple to irregular, acute or truncate, the underside concolorous with the thallus lower border to cream under the lobes bearing apothecia. Maculae weak to distinct, punctiform, sometimes aggregated, restricted to the amphithecia and stipes of the apothecia; Cilia black, simple, sometimes furcate or irregular, 0.10–1.30 mm × ~0.05 mm, frequent to abundant, all over the margin, scarce only at the lobe apices. Soredia, isidia, and pustules absent. Medulla white, without any pigmentation. Underside black, lustrous, with smooth areas and here and there slightly rugose or with veins, near the border naked, brown and becoming cream or white under lobes producing apothecia, sometimes variegate, 1.0–7.0 mm wide, attenuated when brown to distinct when cream or white. Rhizines concolorous with underside, simple to irregularly branched, 0.10–0.60 × 0.05–0.10 mm, few to frequent, homogeneously distributed, but absent in some parts. Apothecia concave to cupuliform, 0.3–5.8 mm diam., submarginal to subapical, stipitate, partly originating on the subcanaliculate apices of the lobes, their margins smooth or denticulate, eciliate, amphithecia smooth when young, becoming strongly veined at age; stipes broadly inflated, smooth when young, becoming vertically pleated or veined at age; disk brown, epruinose, imperforate, splitting and becoming convoluted, involute to revolute-opened upon ageing. Ascospores ellipsoid, 22.5–31.0 × 12.5–18.0 µm, episporium 2.5–4.0 µm. Pycnidia frequent, submarginal to laminal, the ostioles black. Conidia bacillar to short filiform, 4.0–6.5(–8.0) × ~1.0 µm.

Chemistry. Spot tests: upper cortex K+ yellow, UV−; medulla K+ faint yellow, C−, KC+ rose turning pale orange, P+ orange, UV+ bluish white. TLC/HPLC: atranorin (minor), chloroatranorin (minor), alectoronic acid (major), α-collatolic acid (major), protocetraric acid (major), methyl pseudoalectoronate (trace), methyl pseudo-α-collatolate (trace), β-alectoronic acid (minor), β-collatolic acid (minor), dehydrocollatolic acid (minor), dehydroalectoronic acid (trace).

Comments. *Parmotrema pachysporum* Hale is perhaps the closest species to *P. columnatum*. According to Hale (1965), it has much wider 10.0–15.0 mm lobes, longer cilia (1.0–2.5 mm), ciliate apothecia, and larger ascospores (30.0–34.0 µm) than those of *P. columnatum*. However, Hale's description does not mention the stipe morphology or the conidia morphology, or if the cilia can be ramified.

Parmotrema amaniense (Steiner & Zahlbruckner) Krog & Swinscow is also morphologically similar. According to Krog & Swinscow (1981) and Swinscow & Krog (1988), it has wider lobes (0.5–1.5 cm), stipes that become narrower upon ageing, ciliate lobulate-dentate apothecia, ascospores that reach greater sizes (25.0–40.0 µm), and the conidia subtly sublageniform. These authors also noted the existence of three chemical strains in South Africa. The nearest to *P. columnatum* is that containing protocetraric acid, α-collatolic acid, and variable traces of alectoronic acid, which they consider the most similar to the type specimen of *P. amaniense*. Fleig (1997) cited *P. amaniense* from the Brazilian southern state of Rio Grande do Sul, commenting that her material does not present alectoronic acid, what agrees with other strains pointed by Swinscow & Krog (1988). However, in her description, there are morphological and chemical differences from the African material of Swinscow & Krog (1988).

Another species similar to *P. columnatum* is *P. subrugatum* (Kremp.) Hale, but in this species the apothecia are ciliate and dentate-lacinulate, and the conidia unciform (Benatti et al. 2010).

Parmotrema marginatihiatum Marcelli & A.A. Spielm., sp. nov. (Fig. 3)

MycoBank MB 864774

Type: Brazil, Rio Grande do Sul, Municipality of Boqueirão do Leão, Linha Sinimbuzinho, Perau da Nega, 29°20′02.2″S, 52°26′27.9″W, 440 m alt., saxicolous on roadside, close to a stream, in partial shade, 24 Feb. 2004, leg. A.A. Spielmann & L.S. Canêz 1166 (SP – holotype, B – isotype).

Diagnosis: A *Parmotrema* with atranorin in the upper cortex and alectoronic acid in the medulla, the thallus ornate with rounded lobules sprouting from openings of the lobe margins.

Description. Thallus saxicolous, greenish gray, lobate, adnate, membranaceous, 7–11 cm broad; maculae absent; lobes irregularly branched, laterally overlapping, (2–)4–12 mm wide, median axis extended, apex rounded, plane to concave; margin subundulate to strongly undulate, entire or crenate to deeply incised, particularly towards the center; lateral margin plane to undulate, ascending to imbricated, seemingly corroded because of openings due to separation of the upper and under cortices, and usually giving rise to conspicuous, rounded, vegetative lobules 0.2–3.5 × 0.2–5.0 mm or becoming irregularly cicatrizing; distal surface smooth to slightly scrobiculate, opaque to shiny, widely undulate, becoming rugose and cracked in the center; lacinules absent; cilia simple or with lateral branches (Fig. 3B), sparse to frequent, evenly distributed, sometimes with a copper pigment K+ reddish violet, 0.10–1.50 × 0.02–0.10 mm. Pustules, soredia, and isidia absent. Medulla white without any pigmentation. Lower surface black, shiny, smooth, rugose or with veins that

sometimes form a reticulate pattern, with pits; marginal zone brown, or tan under lobes with young apothecia, 1–4 mm wide, sharp to attenuate, shiny, bare or rarely with a few rhizines, smooth to rugose or veined; rhizines black, simple or branched, 0.20–2.50 × 0.02–0.15 mm, abundant, homogeneously distributed, but denser in some spots. Apothecia laminal, juvenile, rare, margin smooth, eciliate; ascospores absent. Pycnidia submarginal, ostiole black; conidia filiform, straight or slightly arcuate, 7.5–10.0 × ~1.0 µm.

Chemistry. Spot tests: cortex K+ yellow, UV–; medulla K–, C–, KC+ rose → quickly orange, P–, UV+ bluish white. TLC/HPLC: atranorin [minor], chloroatranorin [minor], alectoronic acid [major], α-collatolic acid [minor], dehydrocollatolic acid [trace], β-collatolic acid [trace], β-alectoronic acid [trace].

Comments. *Parmotrema marginatihiatum* is distinguished by the rounded vegetative lobules and the opened lateral margin associated with short cilia (up to 1.5 mm long), alectoronic acid in the medulla (KC+ rose → quickly orange, UV+ bluish white) and filiform conidia. The lobules produced by this species are considered vegetative, not propagules of dispersion.

The lateral margin of the thallus opens early by separation of the cortices, but this opening is later cicatrized, and the margin assumes an aspect of being eaten away, often

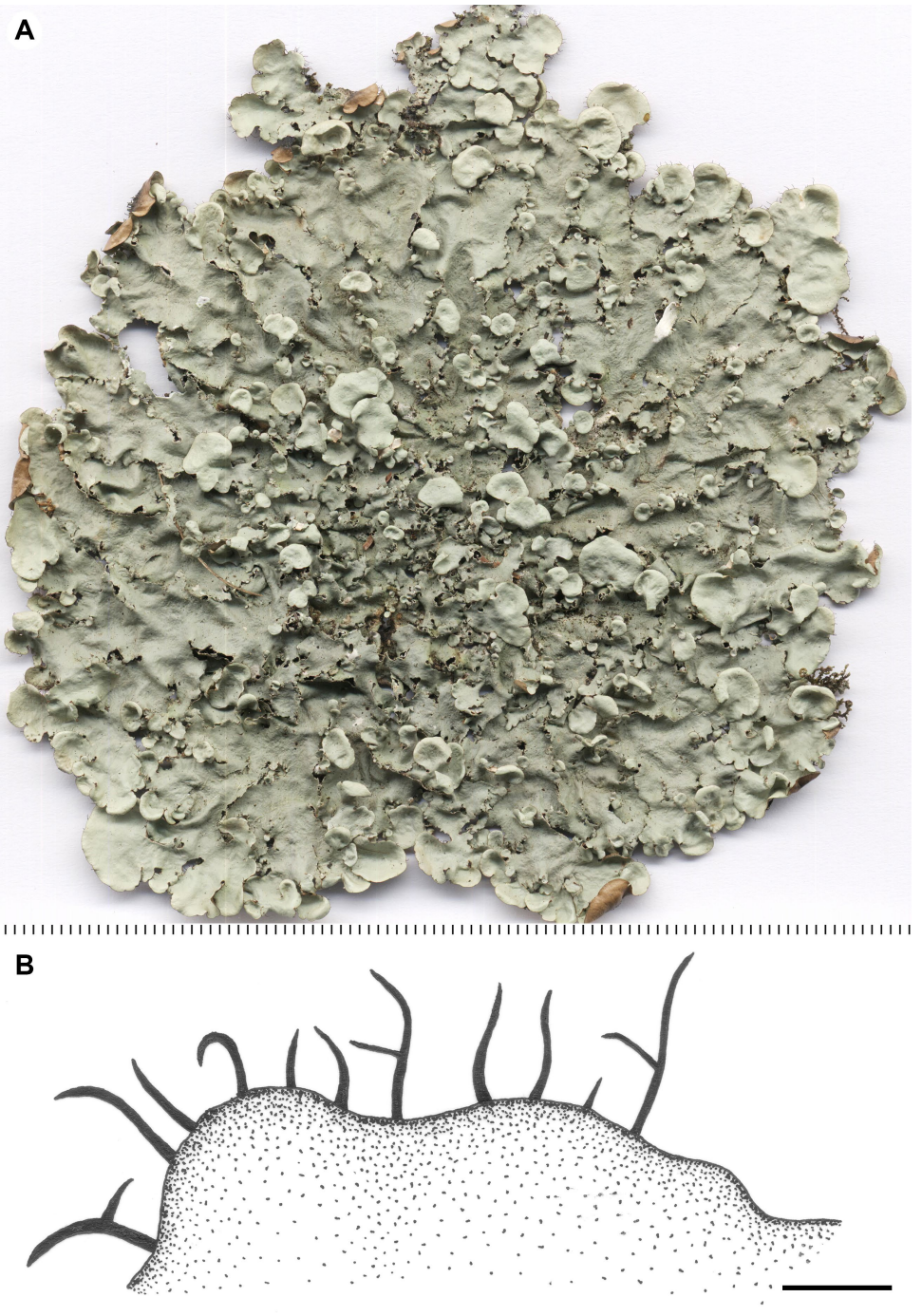

Figure 3. Holotype of *Parmotrema marginatihiatum* (SP). A – thallus; B – detail of the cilia. Note the lateral branching. Scales: A – in millimeters, B = 0.5 mm.

showing the lower cortex. This marginal opening process, without the formation of pustules or soredia, is, as far as we know, not yet reported from *Parmotrema* species. At first, the examined specimens were considered as eroded by some physical or biological process with origin outside the lichen. However, more accurate analysis revealed that all the stages of this process belong to the natural development of the species, and the epithet "*marginatihiatum*" is a reference to this (Latin *hiatus* = opening).

Parmotrema marginatihiatum is close to *P. wainii* (A.L. Smith) Hale and *P. pseudobreviciliatum* Adler, Elix & Hale. However, besides the noticeable lobules and the splitting young margins, there are other subtle differences. The lectotype of *P. wainii* (TUR!) has a radial, non-brittle thallus (Fig. 4A), with large lobes (8–15 mm), long cilia (frequently 2–4 mm), and short conidia (5–7 µm). The thallus of *P. pseudobreviciliatum* (holotype: BAFC!, Fig. 4B) can be very brittle, with narrow lobes (4–10 mm), short cilia (often less than 1 mm long, rarely up to 2.5 mm) and long conidia (8.5–12 µm). This species sometimes produces marginal isidioid, cylindrical to triangular formations (also on the apothecial margin), but these are very different from the rounded lateral lobules of *P. marginatihiatum*. Nevertheless, the habitat of these two species is very similar, "on rocks in protected sites (near small streams)" (Adler 1989).

Fleig (1997) asserted that *P. pseudobreviciliatum* is a synonym of *P. wainii*. However, if we look just at the

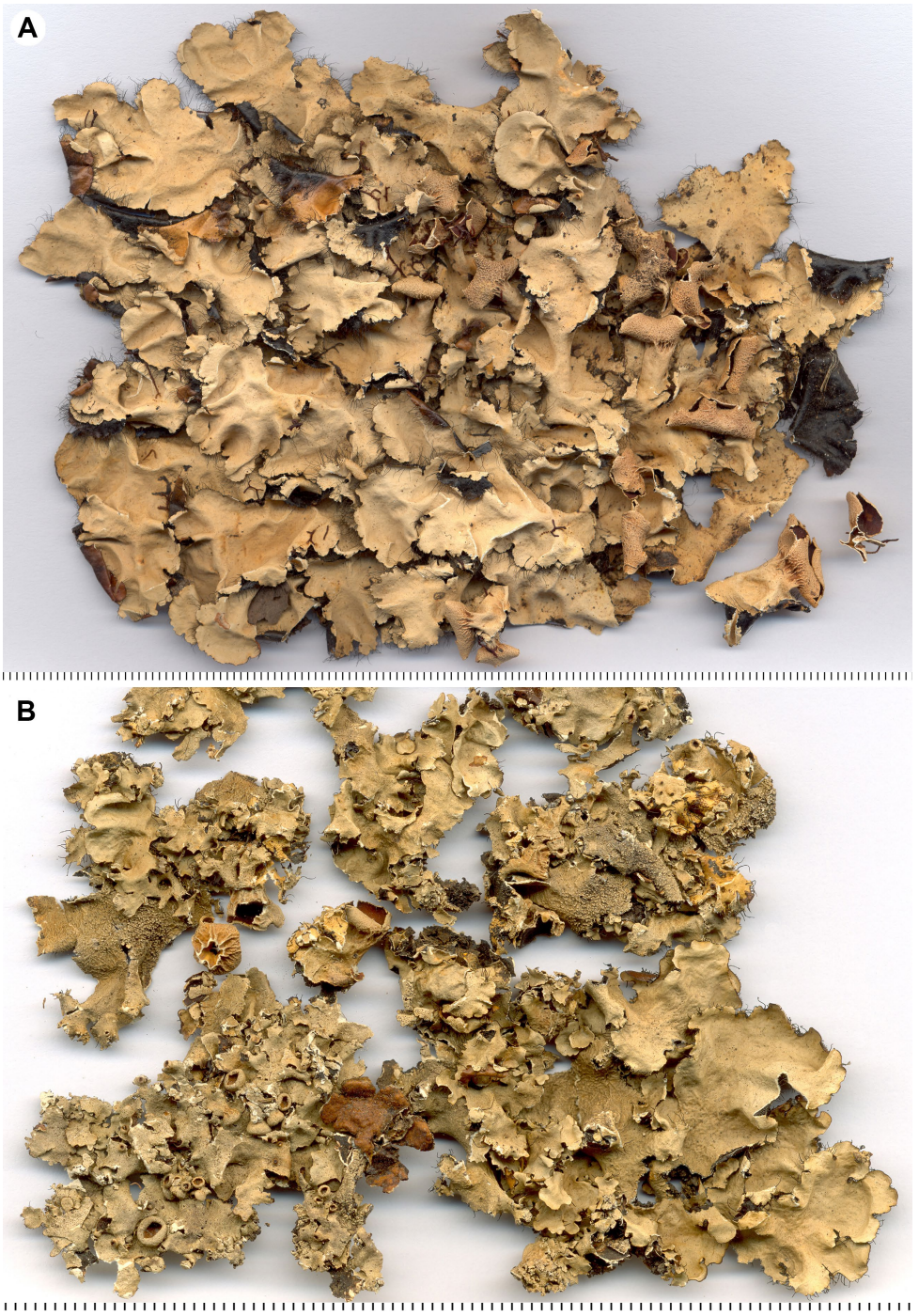

Figure 4. A – lectotype of *Parmotrema wainioi* (TUR); B – holotype of *Parmotrema pseudobreviciliatum* (BAFC). Scales in millimeters.

types, the two species can be easily set apart. Nevertheless, Fleig (1997) studied a bulk of specimens from many herbaria, and especially her own collections made for more than 20 years in Southern Brazil. Her comments attest a careful habitat analysis, and her ecological reflections must be taken in mind. In this way, we prefer not to say a final word about this proposal. Studies based on DNA from fresh specimens could contribute a lot to the clarification of this intricate group of species.

Two further species with alectoronic acid related to *P. marginatihiatum* are *P. breviciliatum* (Hale) Hale and *P. maclayanum* (Müll. Arg.) Hale. Both differ because the thalli are more or less elevated, the conidia are sublageniform, and the lateral lobules are lacking (Krog & Swinscow 1981; Adler 1989).

Compiled key for the *Parmotrema* species worldwide with alectoronic acid

1 Upper cortex yellow, with usnic acid . . . . . ***P. alectoronicum***

Upper cortex gray, with atranorin 2

2(1) Margins of lobes lacking cilia (or rarely very sparse in *P. crinitoides*) 3

Margins of lobes ciliate 6

3(2) Thallus sorediate . . . . . ***P. exquisitum***

Thallus without soredia 4

4(3) Medulla P+ orange (protocetraric acid) . . . . . ***P. thailandicum***

Medulla P− (lacking protocetraric acid) 5

5(4) Apothecia perforate; conidia bacilliform . . . ***P. pancheri***

Apothecia imperforate; conidia sublageniform . . . . . ***P. crinitoides***

6(2) Medulla K+ orange-red (norstictic acid) . . . . . ***P. subrigidum*** (chemical strain 2)

Medulla K− or K+ dirty yellow (norstictic acid absent) 7

7(6) Medulla P+ orange, with protocetraric acid 8

Medulla P−, without protocetraric acid 13

8(7) Thallus without isidia or soredia 9

Thallus isidiate or sorediate 11

9(8) Conidia sublageniform . . . . . ***P. amaniense***

Conidia bacilliform 10

10(9) Apothecial margins ciliate . . . . . ***P. pachysporum***

Apothecial margins eciliate . . . . . ***P. columnatum***

11(8) Thallus isidiate . . . . . ***P. nemorum***

Thallus sorediate 12

12(11) Marginal cilia often simple; medulla without protolichesterinic acid . . . . . ***P. deflectens***

Marginal cilia often branched; medulla with protolichesterinic acid . . . . . ***P. subdeflectens***

13(7) Thallus with isidia, soredia, pustules or schizidia [if apothecia with isidioid outgrowths, check *Parmotrema mirum*] 14

Thallus lacking propagules [if with vegetative lobules, check *P. marginatihiatum*] 35

Thallus with isidia, soredia, pustules or schizidia

14(13) Thallus with schizidia, i.e., the upper cortex cracking and flaking, usually giving rise to laminal pustulate-sorediate areas 15

Thallus without schizidia; isidia, soredia or pustules present 16

15(14) Apothecia perforate; soredia mainly laminal; medulla white or with patches of orange pigment (skyrin); lower side brown to mottled tan and naked in a broad zone along the margins . . . . . ***P. rimulosum***

Apothecia imperforate; soredia mainly marginal; medulla white; lower side marginal zone brown or white variegated . . . . . ***P. sorediiferum***

16(14) Thallus with isidia or sorediate isidia 17

Thallus with soredia, pustules, or sorediate-pustulate 21

17(16) Thallus usually with coralloid sorediate isidia . . . . . ***P. mellissii***

Thallus exclusively isidiate, not forming soredia . . . 18

18(17) Medulla white throughout or rarely tinged with yellow 19

Medulla white in the upper part and orange in the lower part, or with orange patches 20

19(18) Isidia irregularly cylindrical, simple to coralloid or flattening, very frequently with long lateral cilia . . . . . ***P. crossotum***

Isidia shorter and more homogeneous in shape, usually cylindrical, with no tendency to flatten, frequently ciliate [apparently only in the apices] . . . . . ***P. nanfongense***

20(18) Isidia cylindrical; upper medulla white, the lower part orange (euplectin) . . . . . ***P. erasmium***

Isidia wart-like; medulla white, with patches of orange pigment (skyrin) . . . . . ***P. verrucatum***

21(16) Thallus with pustules, or pustulate-sorediate (if upper cortex cracking and flaking, check step 13) 22

Thallus exclusively with soredia 23

22(21) Pustules forming soredia; lobules absent; corticicolous . . . . . ***P. kamatii***

Pustules not forming soredia; lobules dense near margins; saxicolous . . . . . ***P. awasthii***

23(21) Soralia P+ Sulphur yellow (psoromic acid) . . . . . ***P. direagens***

Soralia P−, without psoromic acid [if medulla P+ orange check step 12] 24

24(23) At least some cilia with a coppery glint, K+ purple or violet 25

Cilia without any coppery glint, K− 27

25(24) Medulla with an orange-red pigment (euplectin, K+ purple, TLC!) near the soralia or in the older parts of the thallus; soredia often in arbuscular "cauliflower-like" structures [if thallus isidiate, check *Parmotrema erasmium*] . . . . . ***P. hypomiltoides***

Medulla white or with different orange pigment (skyrin, K+ purple, TLC!); sorediate arbuscular structures absent 26

26(25) Thallus membranaceous; upper cortex emaculate; apothecia imperforate; ascospores 10–12 × 6–7 µm . . . . . ***P. rampoddense***

Thallus coriaceous; upper cortex often maculate; apothecia perforate; ascospores 26–30 × 10–17 µm . . . . . ***P. negrosorientale***

27(24) Lower surface with conspicuous white blotches near the lobe margins . . . . . ***P. louisianae***
Lower surface brown or white mottled only below the sorediate lobes 28

28(27) Medulla C+ rose (gyrophoric acid) . . . ***P. lobulascens***
Medulla C− (gyrophoric acid, if present, only detectable by TLC) 29

29(28) Medulla with bourgeanic acid . . . . . ***P. sublatifolium***
Medulla without bourgeanic acid 30

30(29) Upper surface strongly maculate; conidia bacilliform or filiform 31
Upper surface emaculate or very faintly maculate; conidia sublageniform, filiform or unknown 32

31(30) Apothecia imperforate; conidia bacilliform, 7–10.5 µm . . . . . ***P. natalense***
Apothecia perforate; conidia filiform, 10–16 µm . . . . . ***P. pseudonilgherrense***

32(30) Orange pigment K+ purple (rhodophyscin) in the lower medulla; conidia filiform, 10–12 µm long . . . ***P. arnoldii***
Orange pigment (rhodophyscin) absent, medulla entirely white; conidia sublageniform, 5–8 µm long, or unknown 33

33(32) Cilia 0.5–1.5 mm long . . . . . ***P. subpallescens***
Cilia 4–6.5 mm long 34

34(33) Thallus membranaceous; upper surface with blackened areas . . . . . ***P. gloriosum***
Thallus coriaceous; upper surface without blackened areas . . . . . ***P. poolii***

Thallus lacking propagules [*Parmotrema marginatihiatum* produce vegetative lobules]

35(13) Pycnidia marginal, verruciform, with gaping ostioles . . . . . ***P. thomsonii***
Pycnidia laminal or submarginal, slightly prominent but never verruciform, ostioles not gaping 36

36(35) Thallus with abundant rounded, vegetative lobules . . . . . ***P. marginatihiatum***
Thallus without vegetative lobules (*Parmotrema maclayanum* can develop ± sublobulate margins) 37

37(36) Medulla with fatty acids . . . . . ***P. stenopteris***
Medulla without fatty acids 38

38(37) Thallus conspicuously lacinulate 39
Thallus without lacinules or lacinules restricted to marginal lobes 41

39(38) Conidia unciform . . . . . ***P. hyperlaciniatulum***
Conidia sublageniform or bacilliform to short filiform, often arcuate 40

40(39) Conidia sublageniform; medulla white . . . . . ***P. laciniatulum***
Conidia bacilliform to short filiform, often arcuate; medulla with orange pigmented spots . . . . . ***P. conidioarcuatum***

41(38) Apothecia perforate, at least at the maturity 42
Apothecia imperforate [if apothecia with isidioid outgrowths often bearing pycnidia, and disc occasionally perforate, check *Parmotrema uberrimum*] 51

42(41) Medulla entirely white, without any K+ purple pigment 43
Medulla usually with the upper part white, and the lower part at least partially orange or orange-red; pigmented medulla K+ purple (skyrin) 48

43(42) Apothecia ciliate 44
Apothecia eciliate 46

44(43) Saxicolous . . . . . ***P. ornatulum***
Corticicolous 45

45(44) Apothecia with isidioid outgrowths; ascospores 26–43 × 13–21.5 µm . . . . . ***P. mirum***
Apothecia without isidioid outgrowths; ascospores 17–19 × 9–10 µm . . . . . ***P. wirthii***

46(43) Conidia sublageniform . . . . . ***P. maclayanum***
Conidia filiform 47

47(46) Conidia 10–13 µm long; ascospores 17–24 × 12–13.3 µm . . . . . ***P. rigidum***
Conidia 11–20 µm long; ascospores 9–15 × 5–9 µm . . . . . ***P. subrigidum*** (chemical strain 1)

48(42) Upper surface strongly maculate . . . . ***P. nilgherrense***
Upper surface emaculate or faintly maculate 49

49(48) Apothecia eciliate . . . . . ***P. chiapense***
Apothecia ciliate 50

50(49) Saxicolous; ascospores 14–15 × 6–12 µm . . . . . ***P. brasiliense***
Corticicolous; ascospores 30–35 × 16–18 µm . . . . . ***P. corniculans***

51(41) Medulla entirely white, without any K+ purple pigment 52
Medulla usually with the upper part white, and the lower part at least partially orange or orange-red, or at least orange in some points 59

52(51) Apothecia ciliate 53
Apothecia eciliate 55

53(52) Conidia sublageniform . . . . . ***P. durumae***
Conidia filiform 54

54(53) Amphithecia rugose, without isidioid outgrowths . . . . . ***P. argentinum***
Amphithecia covered with coarse isidioid outgrowths . . . . . ***P. uberrimum***

55(52) Upper surface strongly white-maculate; medulla C+ rose (gyrophoric acid) . . . . . ***P. diversum***
Upper surface emaculate or slightly maculate in older parts or near the apothecia; medulla C− (gyrophoric acid absent) 56

56(55) Conidia sublageniform 57
Conidia filiform 58

57(56) Saxicolous; cilia short, 1–2 mm long . . . ***P. breviciliatum***
Corticicolous; cilia longer, 2–4 mm . . . . ***P. procerum***

58(56) Corticicolous; cilia short, 0.4–0.9 mm long; α-collatolic acid dominant . . . . . ***P. vartakii***
Saxicolous; cilia longer, up to 2.5 mm; alectoronic acid dominant . . . . . ***P. pseudobreviciliatum***

59(51) Apothecia ciliate; conidia bacillar to filiform 60
Apothecia eciliate; conidia unciform 62

60(59) Cilia long, 2–6 mm ..... ***P. wainii***
Cilia short, 0.2–1.5 mm 61

61(60) Ascospores 16–18 × 8–10 µm ..... ***P. laongii***
Ascospores 28–30 × 10–15 µm ..... ***P. maraense***

62(59) Lower marginal zone white to ivory... ***P. subrugatum***
Lower marginal zone brown 63

63(62) Pycnidia submarginal on the lobes .... ***P. restingense***
Pycnidia almost absent in the lobes, frequent to very abundant on the stipes and apothecia ..... ***P. pycnidiocarpum***

The species of *Parmotrema* with alectoronic acid

This list does not claim to be exhaustive, but it is focused on the indication of the main literature with descriptions and/or comments about the species.

Parmotrema alectoronicum C.H. Ribeiro & M.P. Marcelli, 2002 (Fig. 5A)

Notes. This is the only known *Parmotrema* species with medullary alectoronic acid that contains cortical usnic acid.

References. Ribeiro (1998), Marcelli & Ribeiro (2002).

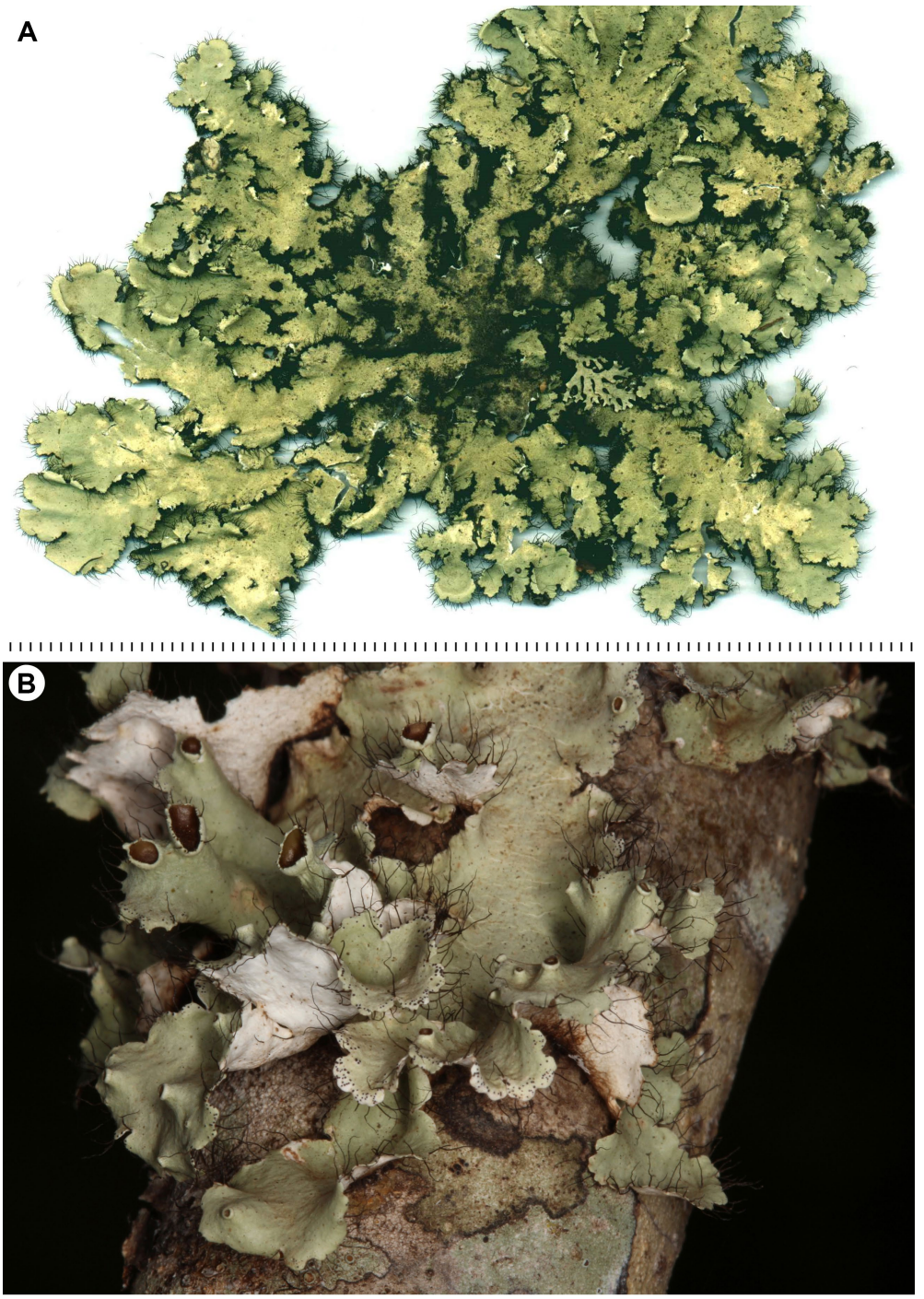

Figure 5. A – holotype of *Parmotrema alectoronicum* (SP); B – *Parmotrema argentinum* (A.A. Spielmann 12704, Brazil), field picture. Note the undermargin white. Scale in millimeters.

Parmotrema amaniense (Steiner & Zahlbr.) Krog & Swinscow, 1983

≡ *Parmelia amaniensis* Steiner & Zahlbr., 1926.

Notes. Krog & Swinscow (1981) used a wide species concept for this species, as explained in detail by Masson et al. (2024). However, Krog (2000) listed specimens with atranorin, protocetraric acid and alectoronic acid. The records from Brazil, Rio Grande do Sul by Fleig (1997), and Paraná by Donha (2005) probably refer to another species, since those specimens do not produce alectoronic acid. The same applies for one record from Tanzania (Alstrup et al. 2010).

References. Zahlbruckner (1926), Krog & Swinscow (1981, 1983), Swinscow & Krog (1988), Fleig (1997), Ribeiro (1998), Krog (2000), Donha (2005), Alstrup et al. (2010), Masson et al. (2024).

Parmotrema argentinum (Kremp.) Hale, 1974 (Fig. 5B)

≡ *Parmelia argentina* Kremp., 1878.

Notes. The conidia of *Parmotrema argentinum* are assumed here as being filiform. They were not described in the protologue (Krempelhuber 1878). Hale (1965) asserted that they were quite short, 5–7 µm long, but without indicating the conidial type. The same measurement was indicated by Egan et al. (2016), stating that the conidia were "sublageniform". Since the descriptions of these authors are otherwise identical, and since all other authors found filiform conidia, to attribute the sublageniform type to the conidia of *P. argentinum* is probably a mistake. Krog & Swinscow (1981) revised the type and found rod-shaped, 6–8 µm long conidia. Donha (2005) found bacilliform conidia, 7–8 µm long; Canêz (2005) found filiform conidia, 10–13.8 µm long. And finally, Torres (2018) describes them as filiform, 6–10 µm long.

References. Hale (1958, 1965, 1974), Canêz (2005), Donha (2005), Kukwa et al. (2012), Torres (2018).

Parmotrema arnoldii (Du Rietz) Hale, 1974

≡ *Parmelia arnoldii* Du Rietz, 1924.

Notes. The apothecia are imperforate (isolectotype: H, photo!).

References. Hale (1965, 1969, 1974), Dey (1978), Galloway (1985), Park (1990), Brodo et al. (2001), Nash & Elix (2002), Chen et al. (2005), Hawksworth et al. (2008), Kukwa et al. (2012), Mishra & Upreti (2017).

Parmotrema awasthii Divakar & Upreti, 2003

References. Divakar & Upreti (2003, 2005).

Parmotrema brasiliense Hale, 1990

References. Hale (1990), Kukwa et al. (2012).

Parmotrema breviciliatum (Hale) Hale, 1974

≡ *Parmelia breviciliata* Hale, 1965.
= *Parmelia latissima* f. *microspora* Lynge, 1914.

References. Hale (1965, 1974), Krog & Swinscow (1981), Adler (1989).

Parmotrema chiapense (Hale) Hale, 1974

≡ *Parmelia chiapensis* Hale, 1965.

Notes. In the description of *Parmotrema chiapense*, Egan et al. (2016) asserted that the conidia were not seen. But in the key for the species the authors gave the conidia as "5–7 um long". However, in the same step of the key (26) the measurements of the ascospores are different from that in the description.

References. Hale (1965, 1974), Egan et al. (2016).

Parmotrema columnatum Benatti & Marcelli, 2026 (Fig. 2)

References. This paper.

Parmotrema conidioarcuatum Marcelli, Benatti & Elix, 2011 (Fig. 6A)

Notes. Marginally very lacinulate, and often forming "bouquet" like lobe structures.

References. Benatti (2005), Jungbluth (2006), Marcelli et al. (2011), Marcelli & Benatti (2011).

Parmotrema corniculans (Nyl.) Hale, 1974

≡ *Parmelia corniculans* Nyl., 1885.

Notes. Excipulum more or less dentate and frequently, but not always, ciliate (Hale 1965).

References. Hale (1965, 1974), Louwhoff & Elix (1999).

Parmotrema crinitoides J.C. Wei, 1991

= *Parmelia proboscidea* var. *eciliata* J.D. Zhao, 1964.

Notes. Known only from China (Chen et al. 2005). The records of Elix & Streimann (1999) from Australia and Divakar & Upreti (2005) from India actually belong to *Parmotrema paracrinitum* Elix, a species with stictic acid and without alectoronic acid (Elix 2007).

References. Chen et al. (2005).

Parmotrema crossotum D.M. Masson & Sérus., 2024

References. Masson et al. (2024).

Parmotrema deflectens (Kurokawa) Streimann, 1986

≡ *Parmelia deflectens* Kurokawa, 1979

Notes. Masson et al. (2024) found specimens quite similar to *Parmotrema deflectens*, but having a fragile upper cortex that flakes off (schizidia?) and with skyrin in some soralia. If the presence of schizidia is confirmed, probably these specimens belong to a new species, not *P. deflectens* as defined by Kurokawa (1979). Masson et al. (2024) concluded that this is a case of species complex.

References. Kurokawa (1979), Krog & Swinscow (1981), Louwhoff & Elix (1999), Louwhoff (2001), Chen et al. (2005), Masson et al. (2024).

Parmotrema direagens (Hale) Hale, 1974

≡ *Parmelia direagens* Hale, 1965.

Notes. Winnem (1975) recognized three chemical strains in this species.

References. Hale (1965, 1974), Winnem (1975), Kurokawa (1979), Swinscow & Krog (1988), Louwhoff & Elix (1999), Divakar & Upreti (2005).

Parmotrema diversum (Hale) Hale, 1974

≡ *Parmelia diversa* Hale, 1973.

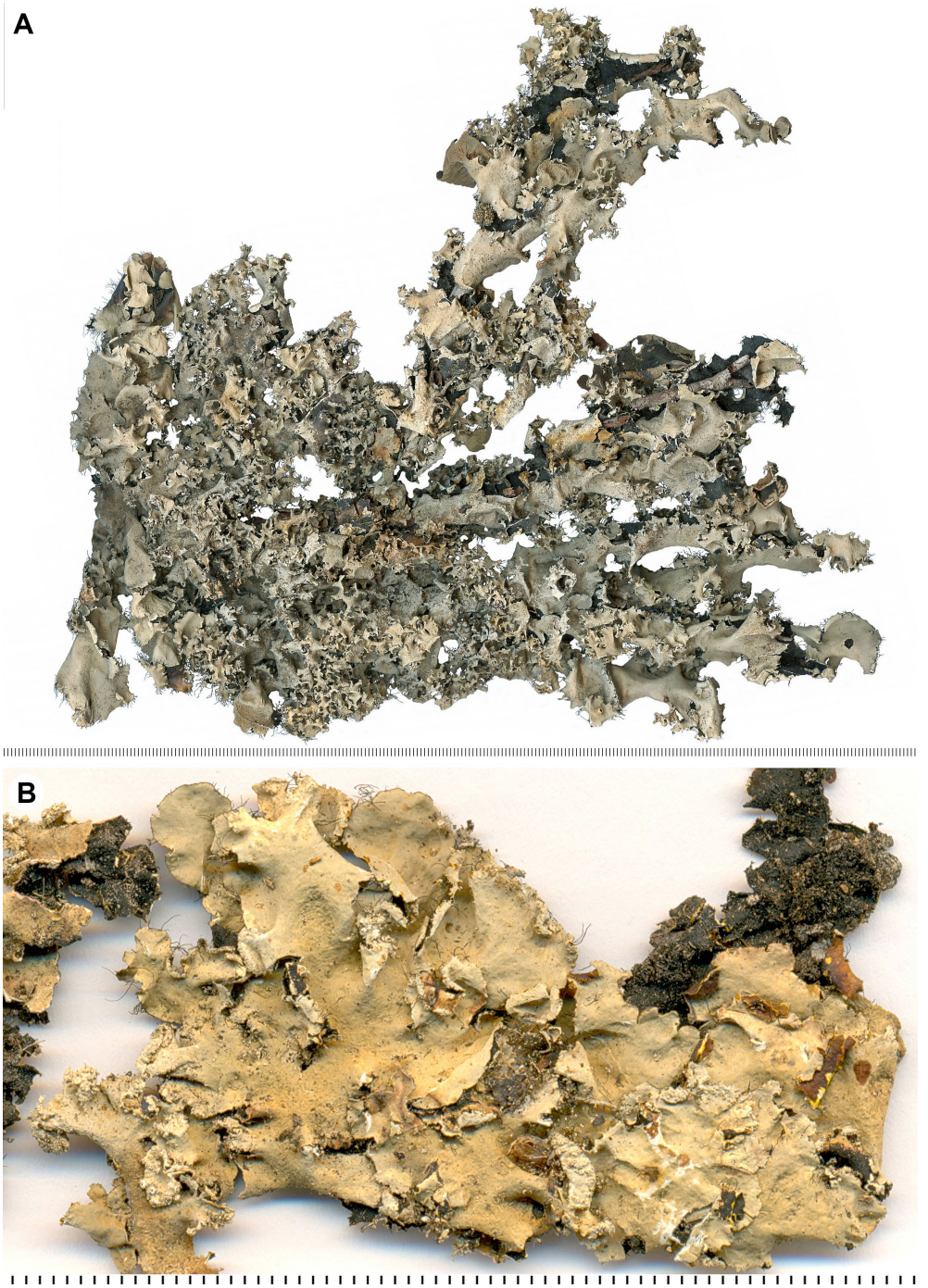

Figure 6. A – holotype of *Parmotrema conidioarcuatum* (SP); B – holotype of *Parmotrema erasmium* (F). Scales in millimeters.

References. Winnem (1975), Krog & Swinscow (1981).

Parmotrema durumae (Krog & Swinscow) Krog & Swinscow, 1983

≡ *Parmelia durumae* Krog & Swinscow, 1981.

References. Krog & Swinscow (1981, 1983), Swinscow & Krog (1988), Louwhoff & Elix (1999), Louwhoff (2001).

Parmotrema erasmium (Hale) Hale, 1974 (Fig. 6B)

≡ *Parmelia erasmia* Hale, 1965.

Notes. The medullary pigment in *Parmotrema erasmium* is euplectin, while in *P. mellissii* it is skyrin (Egan et al. 2016).

References. Hale (1965), Egan et al. (2016), Masson et al. (2024).

Parmotrema exquisitum (Kurokawa) DePriest & B. Hale, 1998

≡ *Parmelia exquisita* Kurokawa, 1987.

References. Kurokawa (1987), Fleig (1997, as synonym of *P. rampoddense*), DePriest & Hale (1998).

Parmotrema gloriosum (Kurokawa) Streimann, 1986

≡ *Parmelia gloriosa* Kurokawa, 1979.

References. Louwhoff & Elix (1999), Louwhoff (2001).

Parmotrema hyperlaciniatulum Benatti, Marcelli & Elix, 2010 (Fig. 7A)

References. Benatti et al. (2010), Marcelli & Benatti (2011).

Parmotrema hypomiltoides (Vain.) Kurokawa, 1998 (Fig. 7B)

≡ *Parmelia hypomiltoides* Vain., 1890.
≡ *Parmotrema hypomiltoides* (Vain.) Hale ex DePriest & B. Hale, 1998, combination superfluous.

Notes. The combination proposed by DePriest and B. Hale was published in the April–June 1998 Mycotaxon volume. Therefore, the paper of Kurokawa & Moon, published in March 28, 1998, antedates it. Fleig (1997) also proposed the new combination, but her thesis was not valid for nomenclatural novelties.

Although Kurokawa & Moon (1998) proposed the synonymizing of *Parmotrema aurantiacoparvum* under *P. hypomiltoides*, this proposal is not accepted here, since *P. aurantiacoparvum* is a primarily isidiate species without alectoronic acid, while *P. hypomiltoides* is primarily sorediate, with alectoronic acid. The conidia of *P. hypomiltoides* are bacilliform, 6–7.5 µm (Canêz 2005).

References. Vainio (1890), Hale (1965), Fleig (1997), Kurokawa & Moon (1998), Ribeiro (1998), Louwhoff & Elix (1999), Canêz (2005), Jungbluth (2006), Spielmann & Marcelli (2009).

Parmotrema kamatii Patw. & A.V. Prabhu, 1977

≡ *Parmelia kamatii* (Patw. & A.V. Prabhu) Ajay Singh, 1980.

References. Patwardhan & Prabhu (1977), Divakar & Upreti (2005).

Parmotrema laciniatulum Krog, 1991

References. Krog (1991).

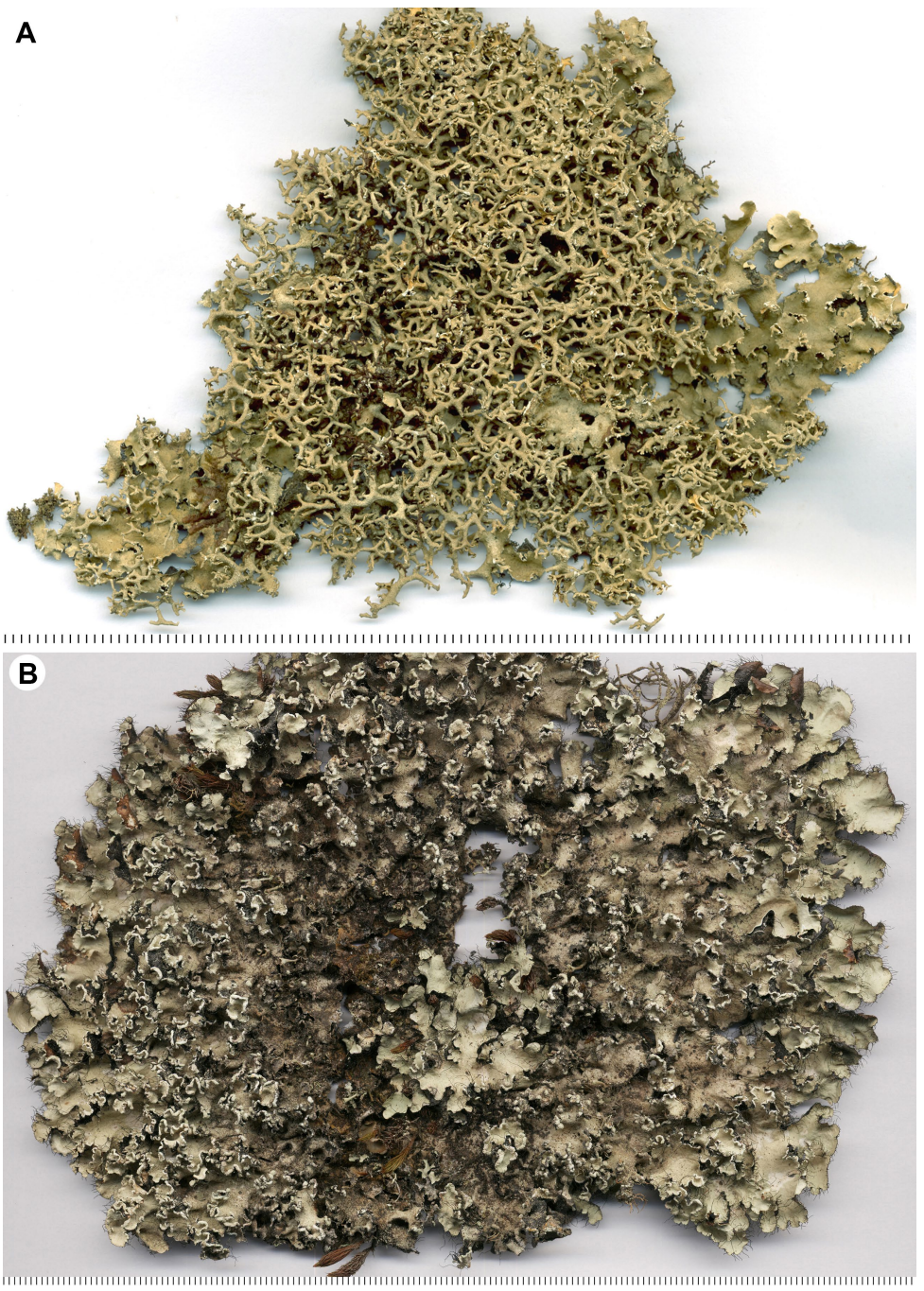

Figure 7. A – holotype of *Parmotrema hyperlaciniatulum* (SP); B – *Parmotrema hypomiltoides* (Spielmann 1253, SP). Scales in millimeters.

Parmotrema laongii (Lynge) Marcelli & Jungbluth, 2007 (Fig. 8A)

≡ *Parmelia laongii* Lynge, 1914.

References. Hale (1958, 1960), Jungbluth (2006), Marcelli et al. (2007).

Parmotrema lobulascens (Steiner) Hale, 1974

≡ *Parmelia lobulascens* Steiner, 1903.

References. Hale (1965, 1974), Winnem (1975), Swinscow & Krog (1988), Louwhoff (2001).

Parmotrema louisianae (Hale) Hale, 1974

≡ *Parmelia louisianae* Hale, 1971.

Notes. Conidia are filiform, 10–12 × 1 µm. (Nash & Elix 2002).

References. Hale (1971, 1974), Krog & Swinscow (1981), Swinscow & Krog (1988), Nash & Elix (2002), Chen et al. (2005).

Parmotrema maclayanum (Müll. Arg.) Hale, 1974

≡ *Parmelia maclayana* Müll. Arg., 1891.

References. Hale (1965, 1974), Krog & Swinscow (1981), Swinscow & Krog (1988), Louwhoff & Elix (1999), Louwhoff (2001), Paz-Bermúdez et al. (2023).

Parmotrema maraense Hale, 1990

References. Hale (1990), Benatti (2005), Donha (2005), Marcelli & Benatti (2011).

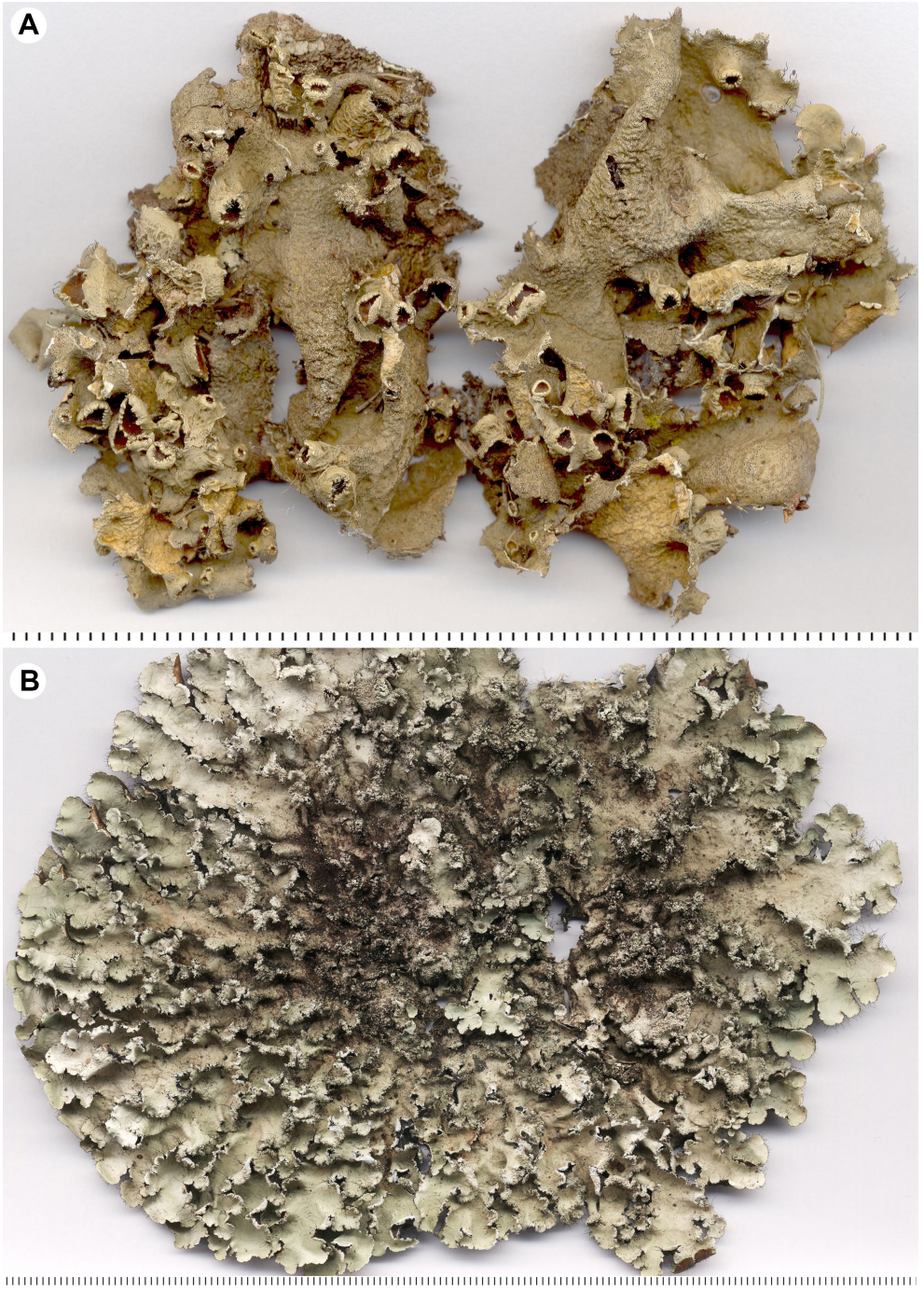

Figure 8. A – *Parmotrema laongii* (Peralta 2349, SP); B – *Parmotrema mellissii* (Spielmann 111, SP). Scales in millimeters.

Parmotrema marginatihiatum Marcelli & A.A. Spielm., 2026 (Fig. 3)

References. This paper.

Parmotrema mellissii (C.W. Dodge) Hale, 1974 (Figs 8B, 9A).

≡ *Parmelia mellissii* C.W. Dodge, 1959.

Notes. The sequenced specimen identified as *Parmotrema paulense* by Stelate et al. (2022) belongs to *P. mellissii* (see Masson et al. 2024).

References. Hale (1965, 1969, 1974, 1979), Moore (1968), Winnem (1975), Awasthi (1976), Dey (1978), Hale (1979), Galloway (1985), Swinscow & Krog (1988), Elix (1994), Fleig (1997), Ribeiro (1998), Louwhoff & Elix (1999), Brodo et al. (2001), Eliasaro (2001), Kurokawa & Lai (2001), Louwhoff (2001), Nash & Elix (2002), Eliasaro & Donha (2003), Benatti (2005), Canêz (2005), Chen et al. (2005), Divakar & Upreti (2005), Donha (2005), Spielmann & Marcelli (2009), Marcelli & Benatti (2011), Bungartz & Spielmann (2019), Masson et al. (2024).

Parmotrema mirum D.M. Masson, Magain & Sérus., 2024

References. Masson et al. (2024).

Parmotrema nanfongense (Kurokawa) DePriest & B. Hale, 1998

≡ *Parmelia nanfongensis* Kurokawa, 1987.

References. Kurokawa (1987), DePriest & Hale (1998), Louwhoff & Elix (1999), Louwhoff (2001), Masson et al. (2024).

Parmotrema natalense (Steiner & Zahlbr.) Hale, 1974

≡ *Parmelia natalensis* Steiner & Zahlbr., 1926.

References. Hale (1965, 1974), Winnem (1975).

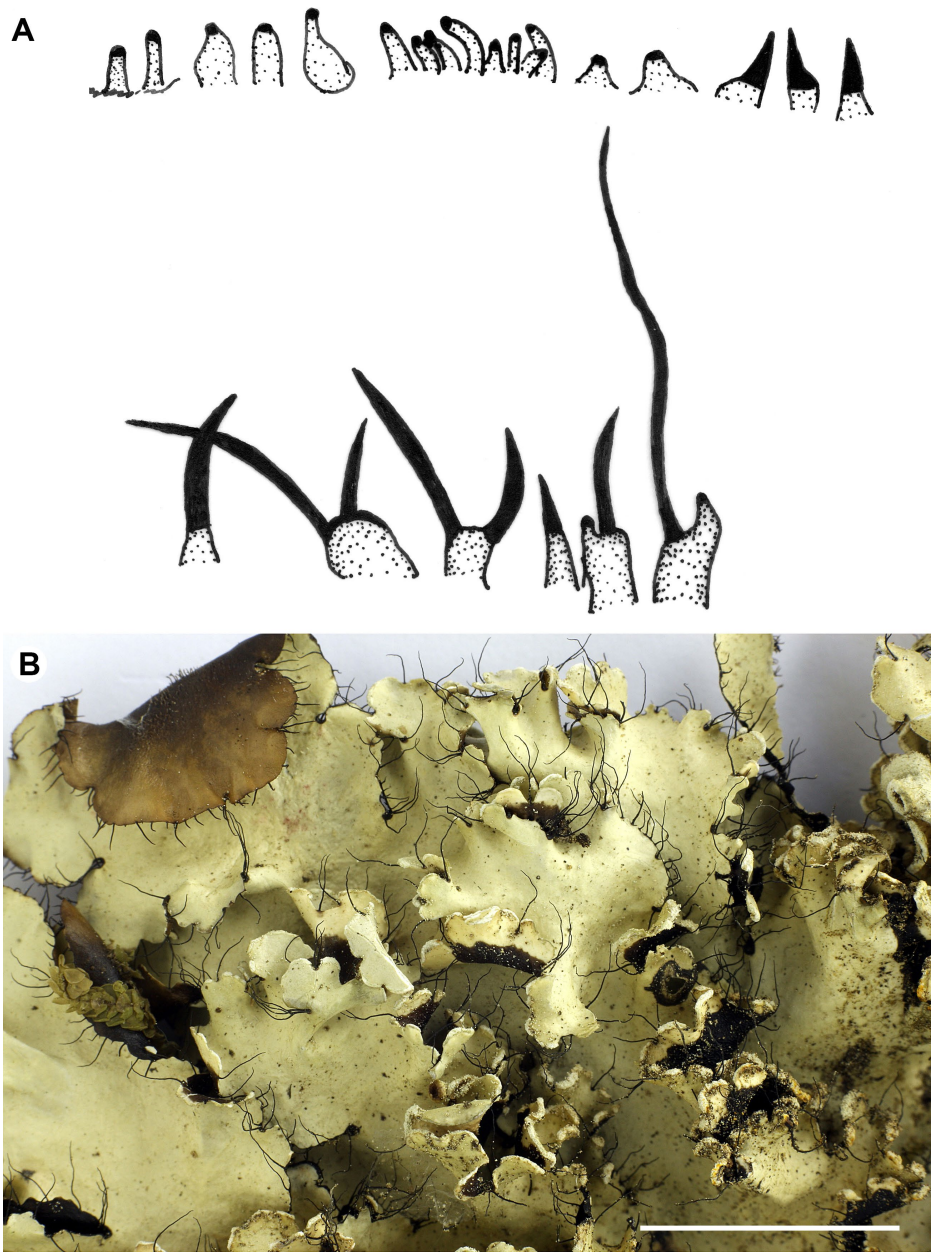

Figure 9. A – ciliate isidia in *Parmotrema mellissii* (Spielmann 111, SP); B – holotype of *Parmotrema negrosorientale* (herb. Schumm, photo: Felix Schumm). Scale: B = 1 cm.

Parmotrema negrosorientale Elix & Schumm, 2001 (Fig. 9B)

References. Elix & Schumm (2001).

Parmotrema nemorum D.M. Masson, Magain & Sérus., 2024

References. Masson et al. (2024).

Parmotrema nilgherrense (Nyl.) Hale, 1974

≡ *Parmelia nilgherrensis* Nyl., 1869.

References. Hale (1965, 1974), Winnem (1975), Swinscow & Krog (1988), Louwhoff & Elix (1999), Louwhoff (2001), Chen et al. (2005), Donha (2005), Divakar & Upreti (2005).

Parmotrema ornatulum (Hale) Hale, 1974

≡ *Parmelia ornatula* Hale, 1965.

References. Hale (1965, 1974).

Parmotrema pachysporum (Hale) Hale, 1974

≡ *Parmelia pachyspora* Hale, 1965.

References. Hale (1965, 1974), Krog & Swinscow (1981).

Parmotrema pancheri (Hue) Hale, 1974

≡ *Parmelia pancheri* Hue, 1899.

Notes. In the protologue, Hue (1899) described bacilliform conidia, 5–6 µm long, while they are 8–10 µm long according to Chen et al. (2005).

References. Hue (1899), Hale (1965, 1974), Louwhoff (2001), Chen et al. (2005).

Parmotrema poolii (Dodge) Krog & Swinscow, 1983

≡ *Parmelia poolii* Dodge, 1959.

References. Krog & Swinscow (1981, 1983), Swinscow & Krog (1988), Elix (1994), Louwhoff & Elix (1999), Louwhoff (2001).

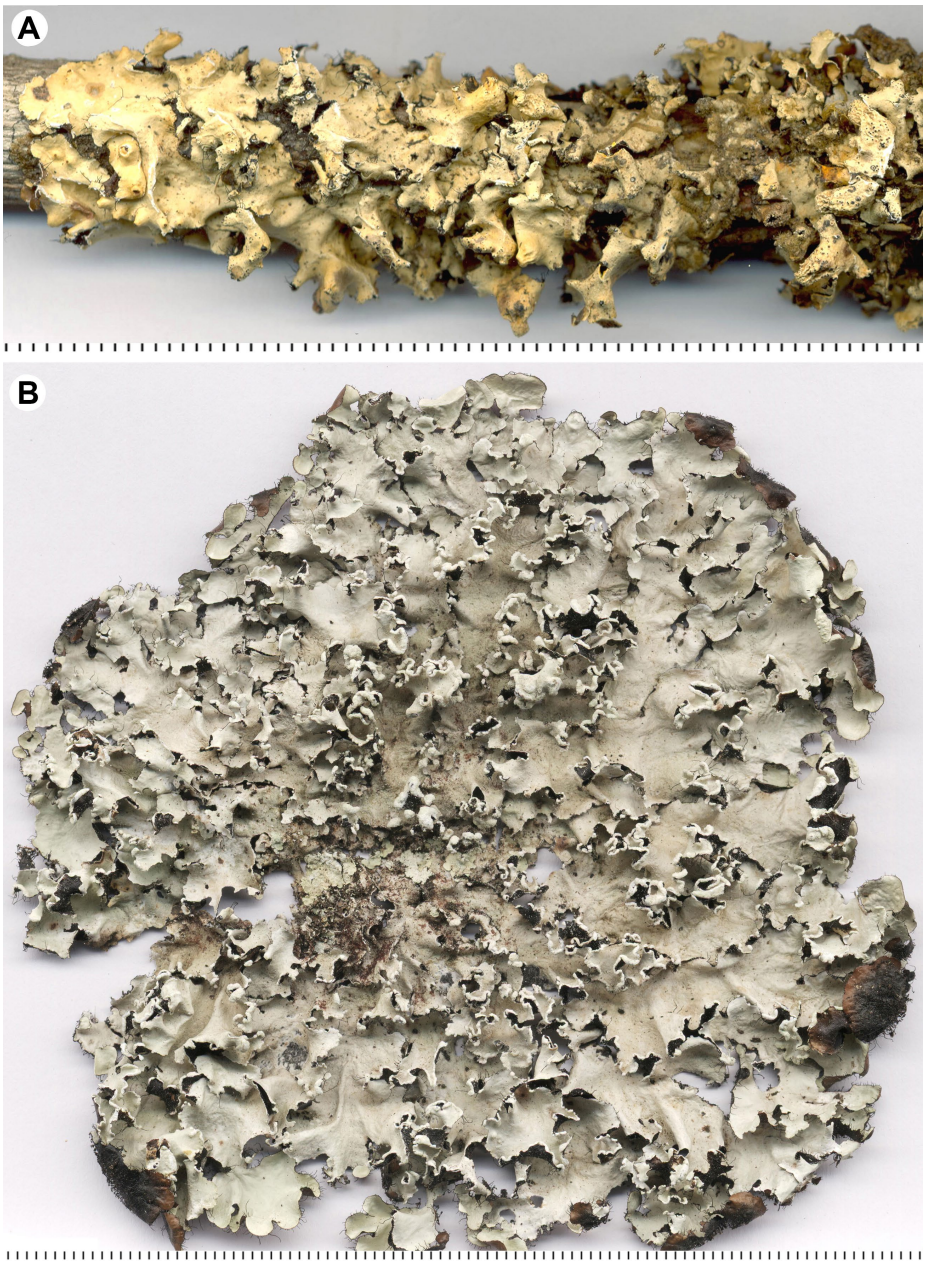

Figure 10. A – holotype of *Parmotrema pycnidiocarpum* (SP); B – *Parmotrema rampoddense* (Spielmann 106, SP). Scales in millimeters.

Parmotrema procerum (Steiner & Zahlbr.) Hale, 1974

≡ *Parmelia procera* Steiner & Zahlbr., 1926.

References. Hale (1965, 1974), Krog & Swinscow (1981), Louwhoff (2001).

Parmotrema pseudobreviciliatum Adler, Elix & Hale, 1989 (Fig. 4B)

Notes. In the protologue (Adler 1989), this species is assumed to have imperforate apothecia, but the study of the holotype of *Parmotrema pseudobreviciliatum* (BAFC!) revealed at least one perforated apothecium. Further comparisons are necessary to understand the concept of this lichen.

References. Fleig (1997), Adler (1989).

Parmotrema pseudonilgherrense (Asahina) Hale, 1977

≡ *Parmelia pseudonilgherrensis* Asahina, 1954.

References. Hale (1965, 1977), Winnem (1975), Elix (1994), Canêz (2005), Chen et al. (2005), Divakar & Upreti (2005).

Parmotrema pycnidiocarpum Benatti, Marcelli & Elix, 2011 (Fig. 10A)

References. Marcelli et al. (2011).

Parmotrema rampoddense (Nyl.) Hale, 1974 (Fig. 10B)

≡ *Parmelia rampoddensis* Nyl., 1900.
= *Parmelia subinvoluta* Hale, 1959.

References. Hale (1959, 1965, 1969, 1974, 1979), Moore (1968), Winnem (1975), Awasthi (1976), Elix (1994), Fleig (1997), Ribeiro (1998), Louwhoff & Elix (1999), Brodo et al. (2001), Eliasaro (2001), Kurokawa & Lai (2001), Louwhoff (2001), Canêz (2005), Chen et al. (2005), Divakar

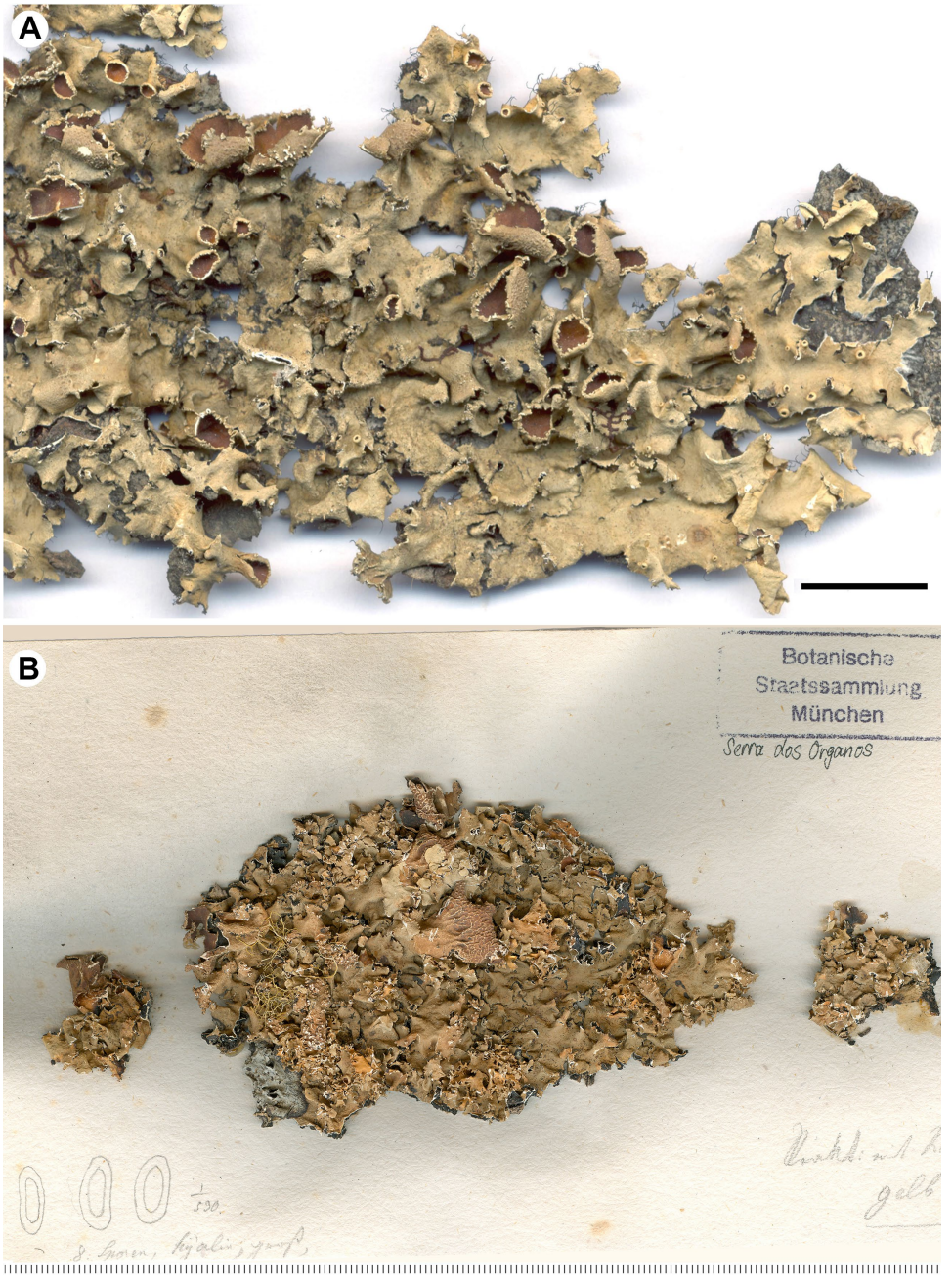

Figure 11. A – holotype of *Parmotrema restingense* (SP); B – holotype of *Parmotrema subrugatum* (M). Scales: A = 1 cm, B – in millimeters.

& Upreti (2005), Spielmann & Marcelli (2009), Bungartz & Spielmann (2019).

Parmotrema restingense Marcelli, Benatti & Elix, 2010 (Fig. 11A)

References. Benatti (2005), Jungbluth (2006), Masson et al. (2024).

Parmotrema rigidum (Lynge) Hale, 1974 (Fig. 12)

≡ *Parmelia rigida* Lynge, 1914.

References. Lynge (1914), Hale (1958, 1965, 1969, 1974), Fleig (1997), Canêz (2005).

Parmotrema rimulosum (Dodge) Hale, 1974

≡ *Parmelia rimulosa* Dodge, 1959.

References. Hale (1965, 1974), Winnem (1975), Krog & Swinscow (1981), Swinscow & Krog (1988), Elix (1994).

Parmotrema sorediiferum Hale, 1986

References. Hale (1986), Kukwa et al. (2012).

Parmotrema stenopteris (Kurokawa) Hale ex DePriest & B. Hale, 1998

≡ *Parmelia stenopteris* Kurokawa, 1973.

References. Kurokawa & Mineta (1973).

Parmotrema subdeflectens D.M. Masson, Magain & Sérus., 2024

References. Masson et al. (2024).

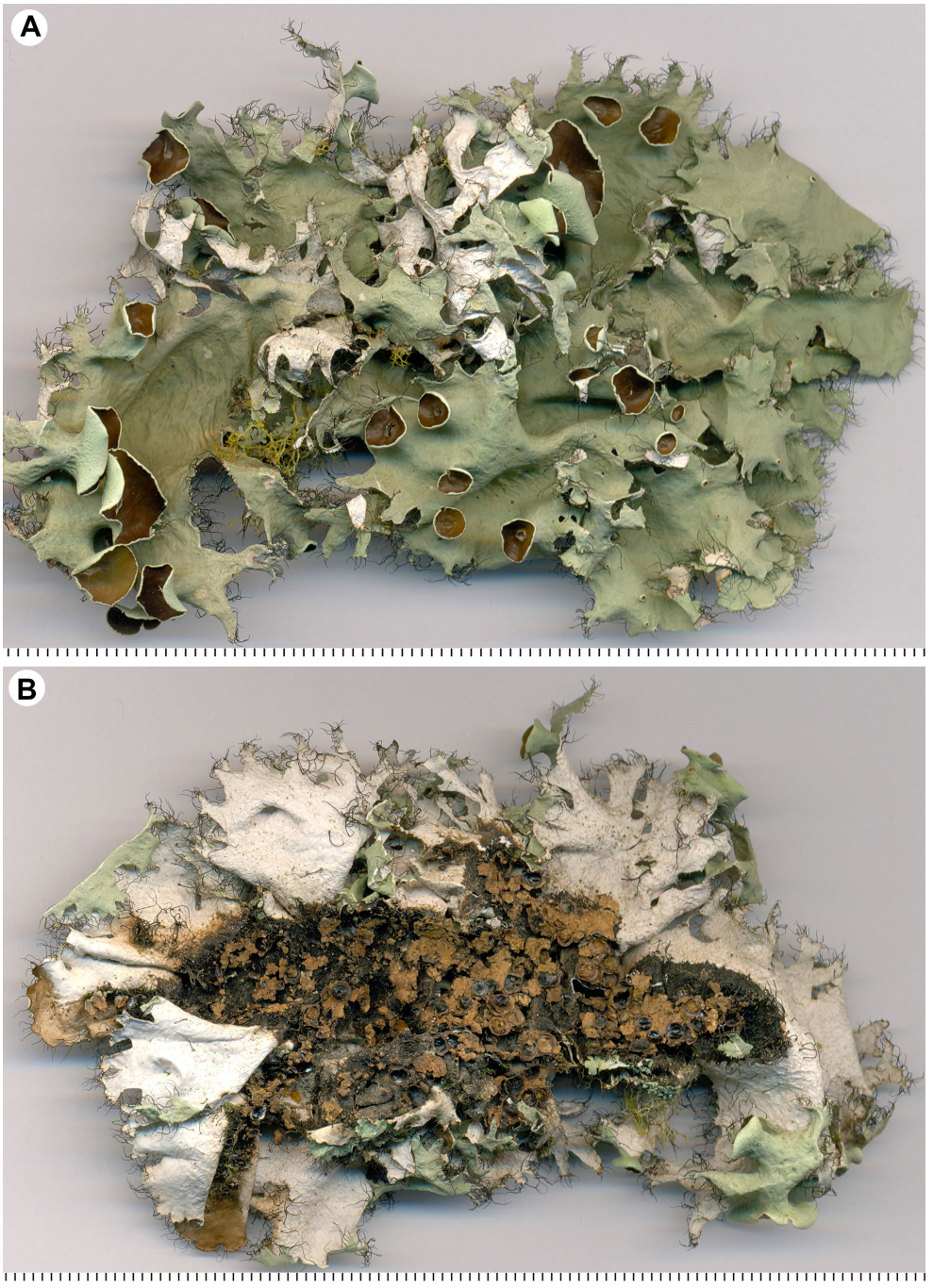

Figure 12. *Parmotrema rigidum* (Brazil, RS, Spielmann 9489, CGMS). A – upper surface; B – undersurface. Scales in millimeters.

Parmotrema sublatifolium (J.D. Zhao, L.W. Hsu & Z.M. Sun) J.C. Wei, 1991

≡ *Parmelia sublatifolia* J.D. Zhao, L.W. Hsu & Z.M. Sun, 1978.

References. Chao et al. (1978), Chen et al. (2005), Elix (2008).

Parmotrema subpallescens (Kurokawa) Kurokawa, 1991

≡ *Parmelia subpallescens* Kurokawa, 1987.
= *Parmelia arnoldii* f. *pallescens* Asahina, 1940.

References. Kurokawa (1987, 1991).

Parmotrema subrigidum Egan, 2005

Notes. Egan et al. (2005) recognized two chemical strains: (1) atranorin, alectoronic acid, and (2) atranorin, alectoronic acid and norstictic acid.

References. Egan et al. (2005).

Parmotrema subrugatum (Kremp.) Hale, 1974 (Fig. 11B)

≡ *Parmelia subrugata* Kremp., 1868.

References. Vainio (1890), Lynge (1914), Hale (1965, 1974, 1979), Winnem (1975), Elix (1994), Fleig (1997), Ribeiro (1998), Louwhoff & Elix (1999), Eliasaro (2001), Kurokawa & Lai (2001), Benatti (2005), Canêz (2005), Chen et al. (2005), Donha (2005), Jungbluth (2006), Spielmann & Marcelli (2009: 575), Marcelli & Benatti (2011).

Parmotrema thailandicum Elix & Pooprang, 1999

References. Pooprang et al. (1999).

Parmotrema thomsonii (Stirt.) A. Crespo, Divakar & Elix, 2010

References. Masson et al. (2024).

Parmotrema uberrimum (Hue) Hale, 1974

≡ *Parmelia uberrima* Hue, 1916.

Notes. Although Krog & Swinscow (1981) asserted that the apothecia of *P. uberrimum* can become perforate with age, they apparently assume that the apothecia are primarily imperforate, when comparing the species with *P. argentinum* (Krog & Swinscow 1981, p. 220) and *P. durumae* (at p. 179).

References. Krog & Swinscow (1981).

Parmotrema vartakii Hale, 1977

Notes. Similar to *P. wainii*, but the marginal cilia are short (less than 1 mm long), and lacking at the apothecia margins. Instead of the predominance of the alectoronic acid, α-collatolic acid is the predominant medullary substance (Hale 1977).

References. Hale (1977), Elix et al. (2002), Divakar & Upreti (2005).

Parmotrema verrucatum Louwhoff & Elix, 1999

References. Louwhoff & Elix (1999), Louwhoff (2001).

Parmotrema wainii (A.L. Smith) Hale, 1974 (Fig. 4A)

≡ *Parmelia wainii* A.L. Smith, 1922.

References. Vainio (1890, as *Parmelia proboscidea*), Hale (1965, 1974), Fleig (1997), Elix & McCarthy (1998), Ribeiro (1998), Eliasaro (2001), Louwhoff (2001), Donha (2005), Sipman (2005), Spielmann & Marcelli (2009).

Parmotrema wirthii Hale, 1990

References. Hale (1990).

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This paper is dedicated to our esteemed friend and colleague André Aptroot, for his indefatigable work on lichenology, especially when dealing with thousands of collections and determinations of lichens from Brazil.

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