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SMALL ECILIATE SPECIES OF PARMELIACEAE (ASCOMYCOTA) FROM "PARQUE ESTADUAL DA CANTAREIRA", SÃO PAULO STATE, BRAZIL: THE GENUS HYPOTRACHYNA[1]

PEQUENAS ESPÉCIES ECILIADAS DE PARMELIACEAE (ASCOMYCOTA) DO "PARQUE ESTADUAL DA CANTAREIRA", SÃO PAULO, BRASIL: GÊNERO HYPOTRACHYNA[1]

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ABSTRACT - We surveyed the genus Hypotrachyna in "Parque Estadual da Cantareira" (Cantareira State Park) and its surroundings and found 12 species. Its species are recognized as having foliose thalli with narrow laciniate to sublaciniate lobes, usually ≤ 1.0 cm wide, with typical dichotomously branching rhizines and eciliate margins. Some species have a thick marginal line with rhizines that can be confused with cilia. Their medullary chemical constituents are one of the most complex among Parmeliaceae, with many substances not yet identified. In this work we are presenting the first citation of *Hypotrachyna everniiformis* and *Hypotrachyna* cf. *lividescens* for the State of São Paulo, in addition to also presenting an identification key, descriptions, comments and illustrations for the species cited are provided.

Keywords: Cantareira Mountain Range; Atlantic Rainforest; Eciliate margins; *Hypotrachyna everniiformis*; *Hypotrachyna* cf. *lividescens*; Lichenized fungi.

RESUMO - O levantamento das espécies pertencentes ao gênero Hypotrachyna no Parque Estadual da Cantareira e arredores revelou a ocorrência de 12 espécies. Suas espécies são reconhecidas por apresentar talos foliosos laciniados a sublaciniados estreitos em geral ≤ 1,0 cm larg., com uma típica formação de rizinas dicotomicamente ramificadas, sem cílios marginais verdadeiros, algumas espécies apresentam uma linha marginal espessa com presença de rizinas que podem ser confundidas com cílios. A química medular é uma das mais complexas entre os gêneros de Parmeliaceae com muitas substâncias ainda não identificadas. Neste trabalho estamos apresentando a primeira citação de *Hypotrachyna everniiformis* e *Hypotrachyna* cf. *lividescens* para o Estado de São Paulo, além de apresentar também uma chave de identificação, são fornecidas descrições, comentários e ilustrações para as espécies citadas.

Palavras-chave: Serra da Cantareira; Mata Atlântica; Margens eciliadas; Fungos liquenizados, *Hypotrachyna everniiformis*; *Hypotrachyna* cf. *lividescens*.

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1 INTRODUCTION

Hale (1974) proposed the genus *Hypotrachyna* (Vainio) Hale for the *Parmelia* species group, subgenus *Parmelia*, section *Hypotrachyna* Vainio. This genus has generally laciniate or sublaciniate thalli, a complete absence of marginal cilia, and dichotomously branched rhizines that typically cover the lower cortex. Some species could develop a thick black marginal line on their laciniae edges, from which the rhizines might eventually project and thus be mistaken by scarce, rare cilia. However, these rhizine projections differ from the true cilia found on the laciniae of the *Hypotrachyna* species subgenus *Parmelinopsis* or genus *Bulbothrix* (see species in these genera discussed in Benatti 2012).

Approximately 165 *Hypotrachyna* species were first count worldwide (Nash et al. 2002), a number raised to almost 270 (Lücking et al. 2017; Aptroot and Cáceres 2018; Kirika et al. 2019; Lendemer and Allen 2019, 2020; Wang et al. 2020; Rodrigues et al. 2022), with 53 recorded for Brazil (Marcelli 2004 apud Benatti 2014a). Recently, Sipman et al. (2009) recorded 140 species for the Neotropics, including 12 new species added for Brazil.

In Brazil, approximately 400 species of lichenized fungi were recorded for the Atlantic Forest (Benatti 2014b), of the 850 species previously expected for this biome (Marcelli 1998a), which includes the "Serra da Cantareira" (Cantareira Mountain Range). More recently, a new update raised the count to almost 800 species (Cáceres et al. 2017), but this not includes the regions on south and south-eastern Brazil, referring solely the north-eastern region.

Benatti (2012) published an article on the small ciliate Parmeliaceae species from "Parque Estadual da Cantareira" (including *Bulbothrix* Hale, *Parmelinella* Elix & Hale, and *Parmelinopsis* Elix & Hale, this last one currently synonymized with *Hypotrachyna*). Benatti et al. (2013) also studied the cyanolichen species of *Coccocarpia* Pers., Collema Webber ex F.H. Wigg., *Leptogium* (Sw.) Gray, and the *Parmotrema* (Wulfen) A.Massal. species (Benatti 2013, 2014a). Benatti and Jungbluth (2014) and Benatti and Marcelli (2017, 2019) studied several genera of *Physciaceae*, and Benatti (2014b) assessed the small eciliate Parmeliaceae of genera *Canoparmelia* and *Crespoa*. These studies include 63 species belonging to 15 genera, accounting for 40 species currently added to the list of Marcelli (1998b).

In this study, we analyzed the foliose lichenized species of *Hypotrachyna* (Vain.) Hale (except the subgenus *Parmelinopsis*, already studied in a previous paper) from "Parque Estadual da Cantareira" and adjacent localities. An artificial key, descriptions, and comments are presented for all species found.

2 MATERIAL AND METHODS

The methodology for collecting lichenized fungi is described in Hale (1987), Malcolm and Galloway (1997), and Benatti and Marcelli (2007). The macro and microscopic features of the specimens (including both direct and indirect somatic and reproductive structures of the thallus) were observed with a stereomicroscope and an optical microscope.

The material was collected from the "Reserva da Serra da Cantareira" and deposited in the herbarium "Maria Eneyda P. Kauffmann Fidalgo" (SP) of the "Instituto de Pesquisas Ambientais" (formerly "Instituto de Botânica") and identified according to Fink (1905), Hale (1979) and Galloway (1985, 2007). The historical, geographical, and climatological data of the study locality are described in Benatti (2012).

Chemical analyzes consisted of spot tests, UV light irradiation, microchemical tests, and Thin-Layer Chromatography (TLC) with eluents I) 85:15 v/v toluene: acetic acid and II) 180:45:5 v//v/v toluene: dioxane: acetic acid, Thin-Layer Chromatography (TLC) with 85:15 v/v toluene: acetic acid and 180:45:5 v//v/v toluene: dioxane: acetic acid, following Asahina and Shibata (1954), Elix (2014), Walker and James (1980), White and James (1985), Huneck and Yoshimura (1996), Bungartz (2001) apud Benatti (2014a), and Orange et al. (2001).

3 RESULTS AND DISCUSSION

We studied 125 collected specimens of foliose lichenized fungi comprising 12 *Hypotrachyna* species (Parmeliaceae). Of these, three species did not form vegetative propagules, pustulae, or dactyls, while eight

had either isidia, soralia, or dactyls. Most species are known from São Paulo State (except *H. everniiformis*, and *H. lividescens*, which are new records presented here). In general, these species are rarely cited (see the geographical distributions of the species for Brazil).

Hypotrachyna is recorded herein for the first time for the study locality, a dense forest area amidst the most extensive urban conglomerate in South America and an Atlantic Rainforest reserve in an urbanized region of Brazil.

Most species are known from other localities from São Paulo State; *Hypotrachyna everniiformis* and *H. lividescens* are new records for São Paulo state and corresponds to "rare" (or little known) species for Brazil.

Almost all *Hypotrachyna* specimens were corticolous on tree trunks, branches, or twigs, except for a few *H. dentella* specimens, which were also found on rocks or were muscicolous. Few specimens formed apothecia (about two or three sometimes a single one, except in the case of species solely reproducing by apothecia, that all contained ascomata), but not all had mature and developed ascospores (see descriptions below). *Hypotrachyna everniiformis, H. imbricatula*, and *H. intercalanda* were the only species that developed apothecia with mature ascospores. Pycnidia were often absent, being very scarce in some, and only *H. steyermarkii* had conidia.

Hypotrachyna dentella (Hale & Kurok.) Hale, *H. imbricatula* (Zahlbr.) Hale, and *H. steyermarkii* (Hale) Hale formed true, cylindrical isidia, while *H. brueggerii* Marcelli & Ribeiro, *H. dactylifera* (Vainio) Hale, and *H. protoformosana* Elix, T. H. Nash & Sipman formed pustulae or dactyls.

Hypotrachyna subformosana Hale ex Elix, T. H. Nash & Sipman and *H. lividescens* (Kurok.) Hale had soredia, while *Hypotrachyna everniiformis* (Zahlbr.) Elix, T. H. Nash & Sipman, *H. intercalanda* (Vain.) Hale, and *H. novella* (Vain.) Hale formed only apothecia.

Hypotrachyna showed the most variable and complex chemical constituents in Parmeliaceae. *Hypotrachyna novella*, *H. protoformosana*, and *H. subformosana* have cortical lichexanthone, while all others have only cortical atranorin. The main medullary substances found were barbatic acid (*H. chlorina*, *H. dentella, H. imbricatula*), echinocarpic acid (*H. dentella*), lividic acid (*H. dactylifera, H. lividescens, H. subformosana*), olivetoric acid (*H. intercalanda*, *H. lividescens*) and protocetraric acid (*H. brueggerii*, *H. protoformosana*), and those acids of the gyrophoric complex (*H. everniiformis*), mostly combined with diverse substances (see comments after species descriptions).

4 IDENTIFICATION KEY OF *HYPOTRACHYNA* SPECIES FROM "PARQUE ESTADUAL DA CANTAREIRA" AND ADJACENT LOCALITIES

1. Thallus with pustulae or vegetative propagules (soredia, isidia, lobules, or lacinules)

2. Thallus sorediate or lacinulate

3. Thallus lacinulate, medulla pale yellow ...……...……..……. *H. chlorina*

3'. Thallus sorediate, medulla white

4. Thallus with cortical lichexanthone (upper cortex K-) …..……..…….. *H. subformosana*

4'. Thallus with cortical atranorin (upper cortex K+ yellow) ...……....…….... *H. lividescens*

2'. Thallus pustulate or isidiate (pustulae might erode into coarse granular soredia)

5. Thallus with hollow pustulae or dactyls

6. Medulla KC-, P+ yellow, UV-, containing protocetraric acid ……..…...….... *H. brueggerii*

6'. Medulla KC+ rose, P-, containing other acids

7. Upper cortex with lichexanthone (UV+ yellow, K-); pustulae bubbleform, verruciform, or irregular, partially bursting into coarse, granular soredia ……..….. *H. protoformosana*

7'. Upper cortex with atranorin (UV-, K+ yellow); hollow structures with digitiform aspect resembling isidia (dactyls), usually not bursting into soredia when maturing …… *H. dactylifera*

5'. Thallus with solid isidia

8. Thallus K+ yellow, P+ orange, with echinocarpic acid ……..……..... *H. dentella*

8'. Thallus K-, with C+ and KC+ reactions, with barbatic acid

9. Laciniae narrow, usually ≤ 2 mm wide; isidia often ciliate ..... *H. steyermarkii*

9'. Laciniae wider, usually ≥ 2 mm wide; isidia always eciliate; ……..... *H. imbricatula*

1'. Thallus without vegetative propagules; only apothecia present

10. Upper cortex K-, UV+ yellow (lichexanthone); medulla C- and KC-; laciniae plane to slightly concave or convex ..……..……..……... *H. novella*

10'. Upper cortex K+ yellow, UV- (atranorin); medulla C+ and KC+

11. Medulla C+ and KC+ rose; laciniae convex to canaliculate, partially revolute ……... …….. *H. everniiformis*

11'. Medulla C+ and KC+ reddish rose → pale orange; laciniae plane to concave, contiguous to laterally overlapped ……...……...…… *H. intercalanda*

5 DESCRIPTIONS

1. *Hypotrachyna brueggeri* Ribeiro & Marcelli

Mitteilungen aus dem Institut für Allgemeine Botanik Hamburg 30-32: 134. 2002.
Type: Brazil, state of Minas Gerais, Municipality of Lima Duarte, “Parque Estadual do Ibitipoca”, on a bush (candeia) in the illuminated forest, behind the researcher´s quarters, 19-III-1994, leg. Ribeiro & Marcelli 397 (holotype SP 264703!; isotype in B)
Figs. 1a, b

Known distribution: Brazil, states of Minas Gerais, São Paulo and Santa Catarina (Marcelli and Ribeiro 2002, Menezes et al. 2018, Aptroot et al. 2021a).

Thallus pale grayish green; fragments 4−5.5 cm in diameter. Laciniae 0.2−1.5 mm wide, sublinear, usually flat to rarely concave, contiguous to laterally overlapping or crowded, adnate to slightly elevated, slightly adhered, isotomic to irregularly dichotomously branched; axils oval, apex rounded to mostly subtruncate, margins with a black linear rim; upper surface continuous to irregularly cracked, occasionally losing cortex portions due to dactyl formation, rugose. Adventitious Lobules or Lacinulae absent. Dactyls laminal to submarginal, up to 2 mm high and 0.5 mm thick, not breaking or bursting (except when damaged), not sorediate, scarce to frequent, mainly with an isidioid appearance (sometimes bubble-shaped), mostly simple to occasionally irregularly branched, with somewhat loose hyphae inside.

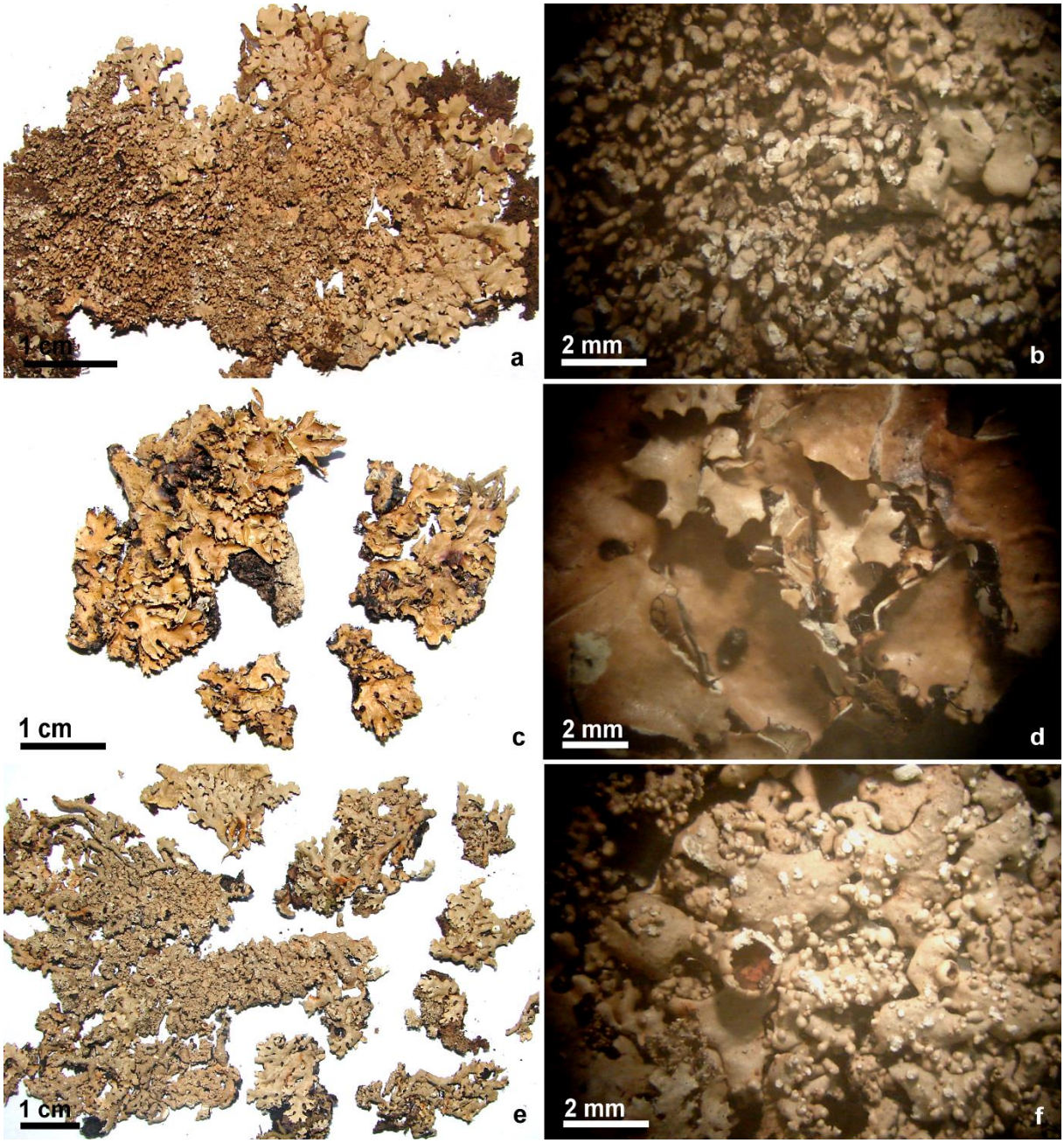

Figure 1. **a-f.** Habit and detail of the upper cortices of *Hypotrachyna specimens.* **1a, b**. *Hypotrachyna brueggeri* (M. P. Marcelli 10997). **1c, d**. *H. chlorina* (M. N. Benatti 1057). **1e, f**. *H. dactylifera* (M. P. Marcelli 10963). Bars = 1 cm (a, c, e); 2 mm (b, d, f).

Figura 1. **1a-f.** Hábito e detalhe dos córtices superiores dos espécimes de *Hypotrachyna*. **1a, b.** *H. brueggeri* (M. P. Marcelli 10997). **1c, d.** *H. chlorina* (M. N. Benatti 1057). **1e, f.** *H. dactylifera* (M. P. Marcelli 10963). Barras = 1 cm (a, c, e); 2 mm (b, d, f).

Maculae absent. Soredia and true Isidia absent. Medulla white (no orange pigment patches found). Lower cortex black, shiny, smooth to rugose or venate; marginal zone unicolored, brown, clear, shiny, rugose or venate. Rhizines 0.3−1.5 mm long, anisotomic to irregularly branched, with usually 2-3 dichotomies, concolor, black, frequent to abundant, distributed throughout the lower surface. Apothecia absent; Pycnidia absent.

Chemistry – Upper cortex: K+ yellow, UV- (atranorin). Medulla: K-, C-, KC- or +weakly rose, UV-, P+ yellow (protocetraric acid).

Specimens examined: this species grows on tree bark; BRAZIL, SÃO PAULO: Municipality of São Paulo, Serra da Cantareira, "Parque Estadual da Cantareira", surroundings of the "Lago das Carpas", 9.I.1991, M.P. Marcelli et al. 10997 (SP).

Comments: recognized by the frequent formation of isidioid-looking dactyls and the presence of medullary protocetraric acid. The central axis of the dactyls formed by dense hyphae is an unique feature. The only specimen found has entire dactyls without signs of crumbling into coarse soredia, in contrast to the specimens studied by Sipman et al. (2009).
The species is very similar to *H. dactylifera*, however, with more pronounced, bubble-like, inflated pustulae in addition to the typical digitiform dactyls, and also differs by the KC+rose and UV+blue medullary reactions due the presence of lividic and colensoic acids, instead of protocetraric acid. The aspect proportion of the pustulae might vary on other specimens.
Marcelli and Ribeiro (2002) differentiated it from *H. consimilis*, which is isidiate rather than having dactyls or pustulae. Apart from the presence of protocetraric acid, the medullae did not react KC+ rose (the P reaction was yellow as expected).
Our specimen did not show any small irregularly distributed spots of an orange pigment on the lower portion of the medulla or on the exposed parts of the broken dactyls, as seen on the type material.

2. *Hypotrachyna chlorina* (Müll. Arg.) Hale
Smithsonian Contributions to Botany 25: 28. 1975.
Basionym: *Parmelia chlorina* Müll. Arg.. *Flora* 63: 267. 1880.
Type: Brazil, Petrópolis, col. Deventer (G!, lectotype).
Figs. 1c, d

Known distribution: Central America (Haiti, Panama), South America: Venezuela, Peru, and Brazil (states of Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo and Paraná) (Fraga Junior et al. 2023, Hale 1975; Ribeiro 1998; Sipman et al. 2009; Spielmann 2006).

Thallus grayish green; fragments 1–5 cm in diameter. Laciniae (0.5−) 1−4 mm wide, sublinear, concave, laterally overlapping to crowded, loosely attached, raised, isotomic to irregularly dichotomously branched, axils oval to obtuse, apex truncate to acute, margins irregular; upper surface continuous to occasionally irregularly cracked, smooth to rugose. Lacinulae 0.2–1.8 × 0.1–0.4 mm, frequent, plane to concave, truncate to acute, simple to dichotomously branched, laminal to marginal. Maculae distinct, punctiform, laminal. Pustulae, Soredia and Isidia absent. Medulla pale yellow. Lower cortex black, shiny, rugose to venate; marginal zone unicolored, black to brown or pale brown, clear, shiny, smooth. Rhizines 0.2−0.9 (−1.2) mm long, isotomic to anisotomic or irregularly branched, usually with 2-5 dichotomies, concolor, black, frequent throughout the lower surface. Apothecia absent. Pycnidia scarce, laminar, casually distributed, with black ostioles; conidia not found.

Chemistry – Upper cortex: K+yellow, UV- (atranorin). Medulla: K+yellow, C+yellow, KC-, P-, UV+bluish (barbatic and colensoic acids).

Specimen examined: this species grows on tree bark; BRAZIL, SÃO PAULO: Serra da Cantareira, "Parque Estadual da Cantareira", VI.2000, M.N. Benatti 1057 (SP).

Comments: recognized by the abundant lacinulae throughout the thallus, the yellow medullae, and the presence of medullary barbatic acid (the only specimen found did not react KC+orange like *H. imbricatula* and *H. steyermarkii*).
Marcelli and Ribeiro (2002) differentiated it from *H. peruviana*, (which also has yellow medullae) by the presence of flattened isidia, and from *H. rhabdiformis* due to the white medullae and presence of medullary salazinic acid instead of barbatic acid. No traces of secalonic acid were detected on the specimen found.
The spot test reactions differed from those mentioned by Sipman (2009), but TLC confirmed the presence of the expected substances adding the possible presence of colensoic acid (which does interfere with the spot test color reaction of the barbatic acid). The holotype has a black marginal zone (Hora

2015), with a sparsely rhizinate lower cortex, while our specimen has partially brown lower margins and rhizines more frequently scattered throughout the lower cortex.

3. *Hypotrachyna dactylifera* (Vain.) Hale
Smithsonian Contributions to Botany 25: 30. 1975.
Basionym: *Parmelia dactylifera* Vain. *Acta Societatis pro Fauna et Flora Fennica* 7(7): 57. 1890.
Type: Brazil, state of Minas Gerais, Municipality of Conselheiro Lafaiete (Lafayete), Vainio 363 (TUR, lectotype, BM, FH, M, P, UPS, isolectotypes).
Figs. 1e, f

Known distribution: Africa, South America: Peru, Colombia, and Brazil (states of Mato Grosso do Sul, Minas Gerais, São Paulo, Rio de Janeiro, Santa Catarina and Rio Grande do Sul) (Hale 1975; Moon et al. 2000; Nash et al. 1998; Ribeiro 1998; Sipman et al. 2009; Spielmann 2006).

Thallus pale grayish green; fragments 1−8 cm in diameter. Laciniae 0.5−1.5 (−2) mm wide, sublinear, plane to concave or convex, rarely contiguous to primarily laterally overlapped, adnate to rarely elevated, adpressed to slightly adhered; isotomic to anisotomic, dichotomously branched, pinnate, axils oval to obtuse, apex truncate to subtruncate, margins with a black linear rim; upper surface continuous, rugose. Lacinulae or Lobules absent. Dactyls common, with inflated isidioid appearance, sometimes irregular with a pustule-like aspect, 0.2–0.8 mm high, not eroding or bursting into soredia (the irregular and more branched ones might erode and form granules, similar to coarse soredia), mostly simple to sometimes irregularly branched, erect, firm, laminar. Maculae absent. Soredia and true Isidia absent (mainly dactyls or occasionally more irregularly shaped pustulae). Medullae white. Lower cortex black, opaque to shiny, smooth, rugose, venate, papillate; marginal zone unicolor to variegate, black or brown and attenuate, opaque to shiny, smooth, papillate. Rhizines 0.2−0.8 (−1.4) mm long, anisotomic or irregularly dichotomously branched, usually with two to four dichotomies, concolor, black, frequent to abundant throughout the surface. Apothecia cupuliform, 0.5–1.5 mm wide, laminal, subpedicelate, margins crenate, unornamented, amphytecia irregularly rugose, disc continuous, brown, epruinose; ascospores absent (hymenia without asci). Pycnidia not found.

Chemistry – Upper cortex: K+yellow, UV-. Medulla: K-, C-, KC+rose, P-, UV+bluish. The SP 265409 specimen showed Atranorin, Lividic acid, 2'-*O*-Methylphysodic acid, Colensoic acid, and an unidentified substance (Rf =18, eluent II) by TLC. The Marcelli 10963 specimen showed Atranorin, Lividic acid, 3-Hydroxycolensoic acid, and the same unidentified substance (Rf =18, eluent II) by TLC. The Marcelli 11813 and 11814 specimens showed Atranorin, Lividic acid, 2'-*O*-Methylphysodic acid, 4-*O*- Methylphysodic acid, and the unidentified substance (Rf =18, eluent II) by TLC. The specimens were chemically similar as they contained Atranorin and Lividic acid as the main substances. Although Benatti 21, Marcelli 11806, and Benatti 1283 are morphologically identical to the other specimens, they contain atranorin, physodic, and colensoic acids, with variable traces of physodic acid derivatives, chemically resembling *H. dactylifera* as described by Sipman et al. (2009). We treated them as chemotypes since the substances involved are mainly from the same chemical group. The morphology of two other specimens was somewhat variable, so we consider them uncertain; althought morphologically similar to the other three, Benatti 1328 showed atranorin, 3-hydroxycolensoic acid, 4-*O*-methylphysodic acid, and Benatti 20 showed atranorin, 3-hydroxycolensoic acid, 4-*O*-methylphysodic acid with an unidentified Rf=18 substance by TLC. Due to the morphological similarities with the other specimens, we are not sure if they could be chemotypes or perhaps very similar taxa not yet described. These two deviated slightly from other specimens by having a K+ yellow medullary reaction (perhaps due to atranorin in the upper medullae portions) and not reacting KC+ rose (again, this could be because the atranorin masqueraded the reaction).

Specimens examined: this species grows on tree bark; BRAZIL, SÃO PAULO: Serra da Cantareira, "Parque Estadual da Cantareira", V.2000, M.N. Benatti 20, 21 (SP); VI.2000, M.N. Benatti 1283, 1328 (SP); in the surroundings of "Lago das Carpas", 9.I.1991,

M.P. Marcelli et al. 10963 (SP); idem, *Araucaria angustifolia* wood in the track to the "Pé-de-Galinha", 25.VI.1991, M.P. Marcelli et al. 11469 (SP); idem, near the lake close to the Park administration, 15.VII.1991, M.P. Marcelli & A. Rezende 11806 (SP); idem, 16.VII.1991, leg. M.P. Marcelli et al. 11813, 11814 (SP).

Comments: recognized by the dactyls (inflated pustulae resembling the overall digitiform appearance of isidia) and remarkably small thalli. It can be distinguished from *H. brueggerii* by pustulae morphology and medullary chemistry.
According to Ribeiro (1998), can be confused with *H. endochlora* which has a pale yellow medulla. It also differs from *Hypotrachyna formosana* that has cortical lichexanthone (K-, UV+yellow) instead of atranorin, and by the pustules that do originate soredia. The medulla reacts UV+ bluish but not the alectoronic green blue of *Parmotrema* species. Sipman et al. (2009) mentioned that some dactyls could erode (we found few eroded ones in our specimens, usually the oldest, with a somewhat irregular shape). The dactyls observed were not club-shaped nor had an internal hyphae cord attaching them to the thalli, characteristics of *H. polydactyla*, a similar species.
Besides chemical variations, Benatti 20 and 1328 specimens are non-maculate and with more irregular pustulae (although partially dactyliform) that occasionally appeared to erode.

4. *Hypotrachyna dentella* (Hale & Kurok.) Hale

Smithsonian Contributions to Botany 25: 33. 1975.
Basionym: *Parmelia dentella* Hale & Kurok. *Studies on Parmelia subgenus Parmelia* 36(4): 172. 1964.
Type: Cheaha State Park, Clay County, Alabama, McCullough 570 (US, holotype, TNS, Isotype).
Figs. 2a, b

Known distribution: North America **(**USA, Mexico), Central America, and South America: Venezuela and Brazil (states of Ceará, Mato Grosso, Goiás, Minas Gerais, Rio de Janeiro, São Paulo, Paraná and Rio Grande do Sul) (Alves 2014; Canêz 2005; Eliasaro 2001; Eliasaro and Adler 1997; Eliasaro 2001; Eliasaro and Adler 1997; Eliasaro et al. 1998; Esslinger and Egan 1995; Hale 1975; Hansen 2018; Jungbluth 2006; Menezes et al. 2018; Nash et al. 2002; Marcelli 1991, 1992, 2004; Osorio and Fleig 1988; Pereira and Marcelli 1989; Spielmann 2005, 2006).

Thallus (pale) grayish green (darker on densely isidiate portions); fragments 2−9.5 cm in diameter. Laciniae (0.5−) 1−2.5 (−4.2) mm wide, sublinear, plane to slightly concave or convex, laterally overlapped to mostly crowded, adnate to raised, adpressed to slightly adhered, isotomic to anisotomic or occasionally irregularly dichotomously branched, pinnate, axils oval, apex truncate, margins with a black linear rim; upper surface continuous, smooth to slightly rugose. Lobules absent, Lacinulae absent to scarce, adventitious, plane, marginal to rarely laminal, truncate to acute, simple to dichotomous, sometimes growing amidst the isidia. Maculae weak to distinct, dense, punctiform, laminal (among the several scars left by the isidia). Pustulae and Soredia absent. Isidia 0.1–0.7 mm high, cylindrical (a few can flatten originating lacinulae), diameter irregular, mostly simple or rarely with few ramifications, laminal, erect, variably firm to caducous, concolor or with brown apices, without ornamentation.

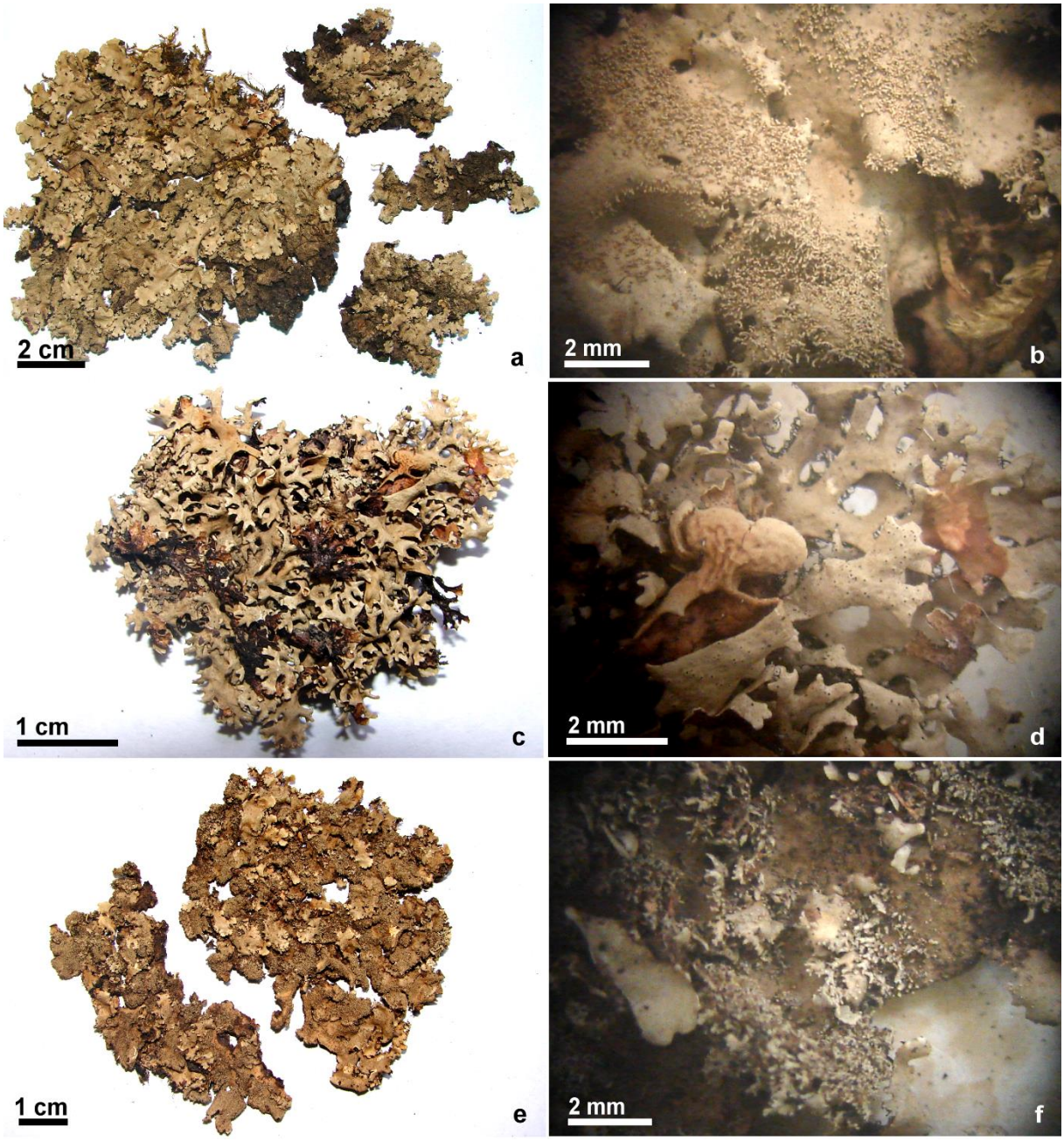

Figure 2. **a-f**. Habit and detail of the upper cortices of *Hypotrachyna specimens.* **2a, b**. *Hypotrachyna dentella* (M. P. Marcelli 10977). **2c, d**. *Hypotrachyna everniformis* (M. P. Marcelli 6066). **2e, f**. *Hypotrachyna imbricatula* (M. N. Benatti 8). Bars = 2 cm (a); = 1mm (c, e); = 2mm (b, d, f).

Figura 2. **a-f**. Hábito e detalhe dos córtices superiores dos espécimes de *Hypotrachyna*. **2a, b**. *Hypotrachyna dentella* (M. P. Marcelli 10977). **2c, d**. *Hypotrachyna everniformis* (M. P. Marcelli 6066). **2e, f**. *Hypotrachyna imbricatula* (M. N. Benatti 8). Barras = 2 cm (a); = 1mm (c, e); = 2mm (b, d, f).

Medulla white. Lower cortex black, shiny, smooth to rugose, venate or papillate; marginal zone unicolor (to partially variegate in some specimens), attenuate, pale to dark brown or black, clear, shiny, papillate, sometimes with a few rhizines. Rhizines 0.1−1.1 mm long, isotomic to irregularly dichotomously branched, usually with one to four dichotomies (occasionally with several more), concolor, black, frequent to abundant, scattered but sometimes grouped in patches on the lower surface. Apothecia mostly absent to very rare, slightly concave (only one found), 1.4 mm in diameter, laminal, sessile, margins crenate, without ornamentation, amphythecia smooth, disc continuous, pale brown, epruinose; ascospores absent (hymenia without asci); Pycnidia absent.

Chemistry – Upper cortex: K+ yellow, UV- (atranorin). Medulla: K+ yellow, C- or + pale yellow, KC- or pale yellow, P+ orange-red, UV+ greenish (Barbatic, Echinocarpic and Conechinocarpic acids, traces of protocetraric acid, and unidentified substances, possibly contaminants found only in the specimens SP 265307 and SP 265018). The SP 265314, SP 265316, SP 265313, and SP 265309 specimens also contained trace amounts of an unknown substance (the SP 265309 specimen was the only one with trace amounts of barbatic acid). Several specimens (SP 265164, SP 416082, SP 265110, SP 265142, SP 265115) also contained a trace amount of a substance that could be a derivative of protocetraric acid (Rf = 17, eluent I).

Specimens examined: mostly found on tree bark, but also on musci and rocks; BRAZIL, SÃO PAULO: Municipality of São Paulo, Serra da Cantareira, "Parque Estadual da Cantareira", V.2000, leg. M.N. Benatti 8 (SP); idem, VI.2000, M.N. Benatti 999, 1007, 1013, 1015, 1069, 1076, 1290, 1325, 1329, 1330, 1375 (SP); idem, at the vicinities of the "Lago das Carpas", 9.I.1991, M.P. Marcelli et al. 10932, 10965, 10977, 10998, 11005 (SP); idem, *Araucaria angustifolia* wood in the way to the "Pé de Galinha" 25.VI.1991, M.P. Marcelli et al. 11458 (SP); idem, 25.VI.1991, M.P. Marcelli et al. 11547 (SP); idem, near the lake close to the Park administration, 16.VII.1991, leg. M.P. Marcelli et al. 11813 (SP); idem, road to the "Lago das Carpas", 30.III.1992, M.P. Marcelli et al. 13458, 13460 (SP); idem, "Núcleo da Pedra Grande", 18.V.1992, M.P. Marcelli et al. 13531, 13566, 13603, 13604 (SP).

Comments: as Hale (1975) pointed out, *H. dentella* is morphologically similar to *H. imbricatula*, differing from it by the smaller thalli (usually few cm wide even when mature), overall narrower laciniae (mostly below 2.5 mm wide) and medullary chemistry containing lacking echinocarpic acid (P-). *H. dentella* is morphologically similar to *H. imbricatula*, overall narrower laciniae (usually less than 2.5 mm wide) and medullary chemistry lacking echinocarpic acid.
Some specimens have laciniae with slightly rounded apices and a pale brown lower marginal zone sometimes devoid of rhizines similar to *Canoparmelia* specimens. The Marcelli 11005 specimen, found on granitic rock, has generally narrow laciniae and fewer isidia than other specimens but did not differ significantly in any other morphological and chemical aspects.
No rodophyscin-like orange pigment was found on any of the specimens. Some specimens, (Marcelli 11813, 13458, 13531, 13603, 13604) have partially thicker isidia resembling small dactyls (although they are not hollow) like those found in *H. brueggerii* or *H. dactylifera*. Overall, the morphology is very similar between the specimens studied (with some slight differences such as laciniae tending to upper width limits and sometimes variegated lower margins), besides the medullary chemistry being identical.

5. ***Hypotrachyna everniiformis*** (Zahlb.) Elix, T. H. Nash & Sipman
Australasian Lichenology 54: 4. 2004.
Basionym: *Parmelia everniformis* ('evemiaeformis') Zahlb., Sitzungsber.
Kaiserl. Akad. Wiss., Math.-Naturw. Cl., Abt. I, Ill: 416. 1902.
Type: Brazil, state of Rio de Janeiro, Municipality of Petropolis, s.d., Hohnel 163 (W, lectotype).
Figs. 2c, d

Known distribution: Bolivia, Brazil: state of Rio de Janeiro (Kukwa and Ossowska 2022; Vareschi 1973, as *Parmelia everniaeformis*, Sipman et al. 2009). This species is first cited for the state of São Paulo.

Thallus pale grayish green, 2−5 cm in diameter. Laciniae 0.4−1 (–3) mm wide, sublinear, convex to slightly canaliculate, contiguous, laterally overlapped to crowded, elevate to revolute, slightly adhered to loosen, anisotomic dichotomously branched, axils oval to obtuse, apex truncate to acute, margins with a linear black rim; upper surface continuous to irregularly cracked, slightly rugose. Lobules and Lacinulae absent. Maculae absent. Pustulae, Soredia and Isidia absent. Medulla white. Lower cortex black to partially dark brown, shiny, rugose, marginal zone unicolor, pale brown, attenuate, shiny, papillate. Rhizines 0.1−0.4 mm long, anisotomic to irregularly dichotomously branched, with two to several dichotomies, concolor, black, frequent to abundant, distributed throughout the lower

surface. Apothecia 1–3 mm in diameter, concave, laminar, subpedicelate, margins crenate, without ornamentations, amphythecia irregularly rugose, disc round, fissured, epruinose, orange-brown; ascospores 8 per ascus, ellipsoid, hyaline, (10−) 12.5−17.5 × 7.5−10 µm, epispore ca. 1 µm. Pycnidia laminar, casually distributed, with black ostioles; conidia absent.

Chemistry – Upper cortex: K+ yellow, UV- (atranorin). Medulla: K-, C+ rs, KC+ rs, UV-, P-. TLC indicated a substance with similar behavior to gyrophoric acid; however, typically related microcrystals were not obtained using GE. The result was the same for all four samples. This substance is probably ovoic acid.

Specimens examined: found on tree bark; BRAZIL, SÃO PAULO: Municipality of São Paulo, Serra da Cantareira, "Parque Estadual da Cantareira", V.2000, leg. M.N. Benatti 17 (SP); idem, VI.2000, leg. M.N. Benatti 1041, 1044; (SP); idem, Municipality of Mairiporã, Serra da Cantareira, village construction, 11-III-1989, leg. M.P. Marcelli 6066 (SP).

Comments: *Hypotrachyna everniiformis* can be recognized by the thallus lacking vegetative propagules with convex to canaliculated laciniae, cortical lichenxanthone and usually medullary substances of the gyrophoric complex. The specimens studied were somewhat problematic, as they can only be identified as *H. everniiformis* (or eventually *H. pluriformis*, that also does not reproduce by vegetative propagules, but did not appear to be typical specimens of the latter). The smaller ascospores and overall morphology (most laciniae were very narrow and convex; although some were concave, they were not precisely canaliculated) more closely resembled *H. everniiformis*. Although our material did not contain gyrophoric acid (C+rs e KC+rs), the unknown acid could belong to the same group, and be ovoic acid. We are not sure whether the specimens are indeed *H. pluriformis*, but they do not fit well into any other species except *H. everniformis*.

Hypotrachyna everniformis was synonimized with *H. pluriformis* (Hale 1975; Sipman et al. 2009), and although morphologically similar, it could be distinguished by the presence of ovoic acid and traces of gyrophoric acid, as in contrast *H. pluriformis* contains gyrophoric acid and traces of ± 5-*O*-Methylhiascic acid and related compounds (none of the latter substances could be confirmed in our specimens). *Hypotrachyna everniformis* can also be distinguished from *H. pluriformis* by the smaller ascospores (10-17.5 × 7.5-10 µm vs. 14-25 × 8-11 µm), the broader brown lower marginal zone and sparser rhizines (Sipman et al. 2009).

Ribeiro (1998) treated they as synonyms and found differences from Hale's specimens in the lacinia shape. As in our specimens, they appear not to be incisively canaliculate.

The overall morphology and chemistry of our specimens were similar as described by Hale (1975) and Ribeiro (1998) for *H. pluriformis*. Specimens cited by these authors deviate from the proportion and quantity of rhizines in the species, but our material frequently had abundant rhizines covering the lower cortex, and it is somewhat similar to *H. intercalanda*, but with much larger ascospores and a different chemistry (see description ahead).

6. *Hypotrachyna imbricatula* (Zahlb.) Hale

Smithsonian Contributions to Botany 25: 41. 1975.

Basionym: *Parmelia imbricatula* Zahlb.. *Denkschrift Akademie der Wissenschaft in Wien. Mathematischnaturwissenschaftliche Klasse* 83: 168. 1909.

Type: Brazil, state of São Paulo, Municipality of Itapecerica, col. Schiffner (W, lectotype, MICH, isotype).

Figs. 2e, f

Known distribution: Asia (China, Phillipines, Taiwan); North, Central, and South America (Brazil: states of Amazonas, Alagoas, Bahia, Mato Grosso, Distrito Federal, Minas Gerais, Rio de Janeiro, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul) (Chen et al. 2003; Elix and Schumm 2001; Gumboski and Eliasaro 2011; Hale 1975; Kirika et al. 2019; Kurokawa and Lai 2001; Barros and Xavier Filho 1972; Oliveira Junior et al. 2020; Spielmann 2006).

Thallus pale grayish green (dark at most isidiate portions), fragments 2.5−12 cm in diameter. Laciniae 0.5−4 mm wide, sublinear, plane to convex, laterally overlapped to crowded; adnate to elevate, slightly adhered, isotomic to anisotomic dichotomously branched, pinate to irregular, axils oval, apex truncate to subtruncate, margins with a linear black rim;

upper surface continuous to irregularly cracked, smooth to rugose. Lobules and Lacinulae scarce to common, adventitious, plane, marginal to laminar, truncate to acute, simple to dichotomous, growing amidst the isidia. Maculae dense, punctiform, laminal (distributed among many scars left by the isidia). Pustulae and Soredia absent. Isidia 0.1–0.4 mm high, cylindric with mostly regular diameter, simple or with few ramifications, rarely becoming more branched, laminal, erect to rarely procumbent, firm, concolor, without ornamentation. Medulla white. Lower cortex black, shiny, rugose, venate, marginal zone unicolor to variegate, pale brown to black, clear, shiny, papillate. Rhizines 0.1−0.8 (−1.3) mm long, isotomic, anisotomic, or irregularly dichotomously branched, usually with two to four dichotomies, concolor, black, abundant, mostly grouped on patches scattered over the lower surface. Apothecia uncommon, up to 5 mm in diameter, cupuliform, margins crenate, isidiate when developed, amphithecia rugose, isidiate, non-ornamented, disc circular, brown, epruinose; ascospores rare (most hymenia without asci or damaged, and many immature asci), 8 per ascus, ellipsoid, hyaline, 11.5−17.5 (−20) × (8−) 10−12 µm, epispore ca. 1 µm. Pycnidia not found.

Chemistry – Upper cortex: K+ yellow, UV- (commonly atranorin, rarely in trace amounts). Medulla: K-, C+ orange, KC+ orange, P-, UV- (barbatic acid, obtusatic acid, colensoic acid, physodic acid, 4-*O*- Methylphysodic acid, 4-*O*-demethylbarbatic acid, norcolensoic acid, norobtusatic acid, rarely traces of protocetraric and of unidentified substances, most likely contaminants). The substances found were somewhat variable, except for the constant presence of barbatic, obtusatic, and 4-*O*-Methylphysodic acids. The SP 264929 and SP 265431 specimens also showed possible presence of evernic acid among the other substances.

Specimens examined: found on tree bark; BRAZIL, SÃO PAULO: Municipality of São Paulo, Serra da Cantareira, "Parque Estadual da Cantareira", VI.2000, leg. M.N. Benatti 1003, 1011, 1026, 1030, 1031, 1061, 1286, 1289, 1305, 1381 (SP); Municipality of Mairiporã, Serra da Cantareira, village construction, 11-III-1989, leg. M.P. Marcelli 6022, 6023, 6033, 6055, 6057, 6058 (SP); idem, Municipality of São Paulo, Serra da Cantareira, "Parque Estadual da Cantareira", at the vicinities of the "Lago das Carpas", 9.I.1991, M.P. Marcelli et al. 10943, 10952, 10953, 10964, 10966, 10967, 10969, 10971, 10978, 10979, 10982, 11012 (SP); idem, Municipality of São Paulo, "Parque Estadual da Cantareira", at the vicinities of the Lago das Carpas, 25.VI.1991, leg. M.P. Marcelli et al. 11444, 11445, 11468 (SP); idem, *Araucaria angustifolia* wood in the way to the "Pé de Galinha" 9.I.1991, leg. M.P. Marcelli et al. 11450 (SP); idem, at the vicinities of the "Lago das Carpas", near the park administration, 15.VII.1991, leg. M.P. Marcelli & A. Rezende 11803 (SP); idem, Serra da Cantareira, hillside forest, 9.XII.1991, leg. M.P. Marcelli et al. 12519 (SP); idem, "Parque Estadual da Cantareira", at the main road to the "Lago das Carpas", 30.3.1992, leg. M.P. Marcelli et al. 13418 (SP); idem, "Núcleo da Pedra Grande", 18.V.1992, M.P. Marcelli et al. 13601,13605, 13611, 13612, 13616 (SP).

Comments: *Hypotrachyna imbricatula* is characterized by the presence of medullary barbatic acid (C+ and KC+ orange) and laminal branched isidia. Distinguished from *H. costaricensis* that has no positive medullary reactions, has wider laciniae, and according to Ribeiro (1998) dense rhizines covering the lower surface. Distinguished from *H. steyermarkii* that has narrower laciniae and ciliate isidia.

Hypotrachyna dentella and *H. imbricatula* are morphologically similar but the second differ markedly in the broader laciniae and absence of echinocarpic acid. Some *H. imbricatula* specimens could have lacinae of minimal width, but their ascospores are of typical size – and not smaller like those found in *H. dentella*.

Sipman et al. (2009) compared *H. imbricatula* with *H. orientalis*, but did not include a description of it. *Hypotrachyna orientalis* differ by the absence of macules and a more membranaceous, fragile thallus. *Hypotrachyna orientalis* specimens have variable maculae, and the thallus is sometimes neither leathery nor membranous but something in between (we regard that rigidity should be considered with caution as it could be influenced by environmental factors). This species lacks obtuse and norobtuse acids, possibly present in

the specimens analyzed here. For these reasons, we considered all specimens as *H. imbricatula*. *Hypotrachyna spinulosa* has similar morphology and medullary chemistry but differs from *H. imbricatula* because the spinules (Sipman et al. 2009) resembling laminal cilia (i.e., they do not grow from isidia as in *H. steyermarkii*) rather than typical cylindrical isidia.

7. *Hypotrachyna intercalanda* (Vain.) Hale
Smithsonian Contributions to Botany 25: 42. 1975.
Basionym: *Parmelia intercalanda* Vain. *Acta Societatis pro Fauna et Flora Fennica* 7(7): 53. 1890.
Type: Brazil, state of Minas Gerais, Sítio, col. Vainio 899 (TUR-V 3014, lectotype, BM, M, UPS, isolectotypes).
Figs. 3a, b

Known distribution: Asia and South America: Argentina and Brazil (states of Pará, Mato Grosso, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Paraná, Santa Catarina, and Rio Grande do Sul) (Divakar and Upreti 2003, 2005; Eliasaro 2001, Eliasaro et al. 1998, Fraga Junior et al. 2023; Gumboski and Eliasaro 2011, Hale 1975, Jungbluth 2006; Lynge 1914 as *Parmelia fragilis* Lynge, Ribeiro 1998, Spielmann 2006, Zahlbruckner 1909). Divakar and Upreti (2003) and Divakar and Upreti (2005) collected specimens from India. The Indian specimens identified as *H. intercalanda* were later confirmed to belong to a different taxon by Divakar and Crespo (2018).

Thallus grayish green, often pale, fragments 2−9 cm in diameter. Laciniae 0.4−2.5 (very rare −5) mm wide, sublinear, plane to concave, contiguous to laterally overlapped, adnate, adpressed, isotomic dichotomously branched, pinate, axils oval, apex truncate, margins with a linear black rim; upper surface continuous, rugose. Lobules and Lacinulae absent. Maculae weak, punctiform, laminar. Pustulae, Soredia and Isidia absent. Medulla white. Lower cortex black, shiny, lower surface rugose, venate; marginal zone unicolor, brown, clear, shiny, rugose, papillate. Rhizines 0.1−0.6 (–1.1) mm long, isotomic dichotomously branched, furcate or with two dichotomies, concolor, black, scarce to mostly frequent on the entire lower surface. Apothecia slightly concave to concave, 1–4 mm diam., laminar to rarely submarginal, sessile to subpedicelate, margins smooth to crenate, without ornamentation, amphythecia smooth to irregularly rugose, disc circular continuous, brown, epruinose. Ascospores rare (hymenia often damaged, darkened, without asci or with immature asc), 8 per ascus, ellipsoid, hyaline, (6−) 7−10 (−13) × (4−) 5−7.5 µm, epispore ca. 1 µm. Pycnidia uncommon, submarginal, of casual distribution, with black ostioles; conidia bacilliform (weakly bifusiform?), 5–6 × 1 µm.

Chemistry – Upper cortex: K+ yellow, UV- (atranorine). Medulla: K-, C+ reddish rose, KC+ reddish rose → pale orange, P-, UV+ bluish (olivetoric acid). Marcelli 6063, 11585, and 16916 specimens have nearly identical morphology to the others but appear to have substances with a TLC behavior akin to the gyrophoric and lecanoric acids (and variable trace amounts of two unidentified substances) instead of olivetoric acid; however, they did not form crystals using GE and GAW reagents. It is still uncertain if they could represent chemotypes or a similar undescribed taxon.

Comments: recognized by the absence of vegetative propagules or pustulae, and the presence of medullary olivetoric acid. It differs from both *H. pluriformis* and *H. physcioides* by the smaller, about half the size (13−17 × 8−10 µm), ascospores (Ribeiro 1998). *Hypotrachyna intercalanda* is somewhat similar differing by the presence of medullary protocetraric acid.

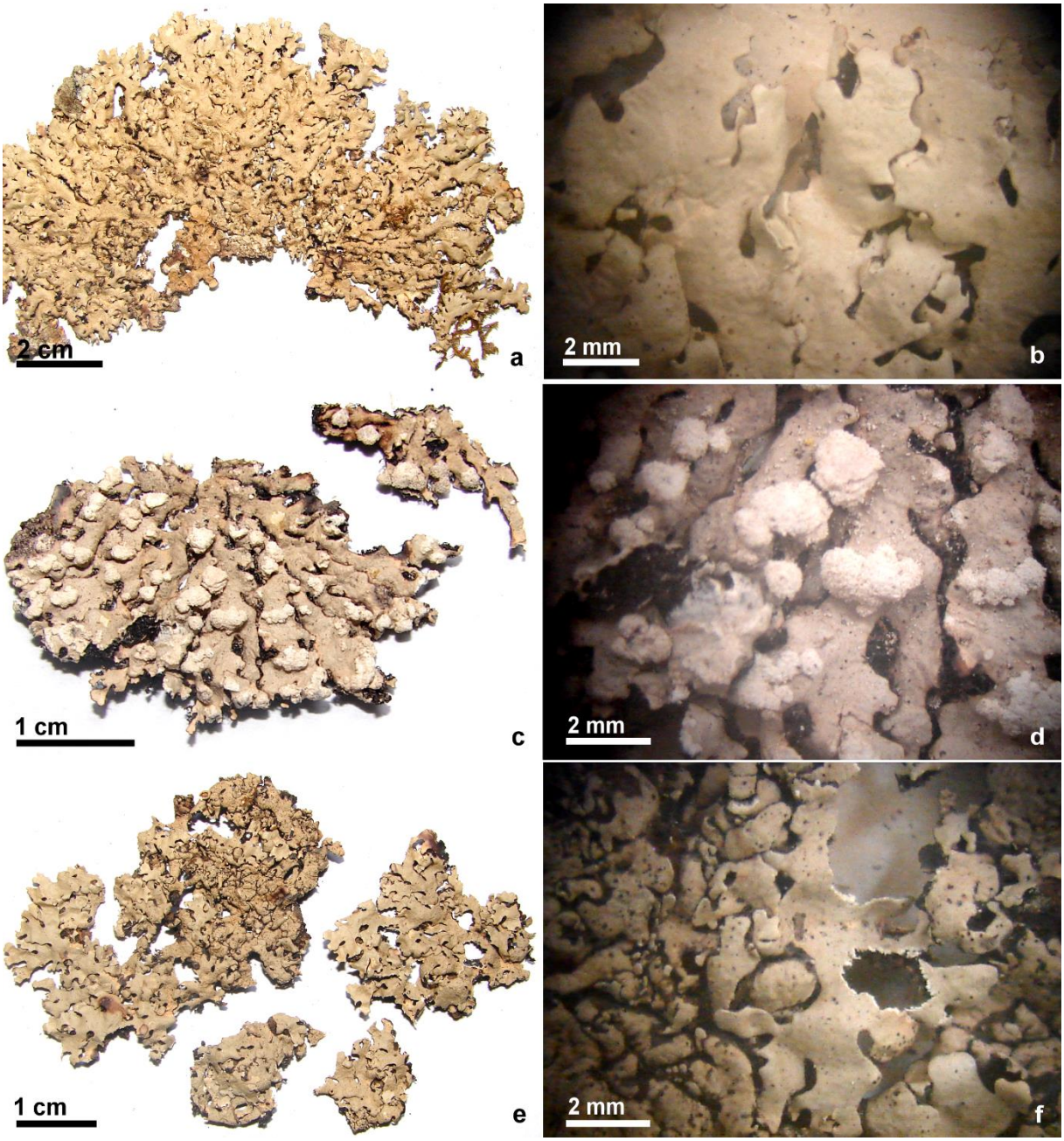

Figure 3. **3a-f**. Habit and detail of the upper cortices of *Hypotrachyna* specimens. **3a, b**. *Hypotrachyna intercalanda* (M. N. Benatti 1280). **3c, d**. *Hypotrachyna* cf. *lividescens* (M. P. Marcelli 10980). **3e, f**. *Hypotrachyna novella* (M. P. Marcelli 10928). Bars = 2 cm (a); = 1 cm (c, e); = 2mm (b, d, f).

Figura 3. **3a-f**. Hábito e detalhe dos córtices superiores dos espécimes de *Hypotrachyna*. **3a, b**. *Hypotrachyna intercalanda* (M. N. Benatti 1280). **3c, d**. *Hypotrachyna* cf. *lividescens* (M. P. Marcelli 10980). **3e, f**. *Hipotrachyna novella* (M. P. Marcelli 10928). Barras = 2 cm (a); = 1 cm (c, e); = 2mm (b, d, f).

The conidia found sometimes appear to be subtly bifusiform, while at other times they do not show a clear pattern of fuses, appearing to be mostly bacilliform.
According to Sipman et al. (2009), *H. pulvinata* differs by having medullary evernic and lecanoric acids and being distinctly maculate (the author referred to *H. intercalanda* as emaculate, but our specimens showed some weak, irregular, disperse punctiform maculae), while *H. osteoleuca* differs by having cortical lichexanthone (UV+ yellow).
Some specimens (see chemistry above) are chemically different but similar to most specimens with olivetoric acid and their position is uncertain. As they do not contain evernic acid and we could not confirm the presence of gyrophoric and lecanoric acids, they were also difficult to ascribe to perhaps *H. pulvinata*.

8. *Hypotrachyna* cf. *lividescens* (Kurok.) Hale
Phytologia 28: 341. 1974.
Basionym: *Parmelia lividescens* Kurok., in Hale & Kurokawa, *Contributions from the United States National Herbarium:* 36: 181. 1964.
Type: South Africa. Natal: Distr. Polela. Polela Forest, on bark, 10 Nov 1953, Almbom 9490 (LD, holotype).
Figs. 3c, d

Known distribution: Australia, Europe, Africa, North America, Central America and South America: Colombia, and Brazil (states of Santa Catarina and Rio Grande do Sul (Aptroot et al. 2021a; Elix 1994; Masson 2004, 2005; Sipman et al. 2009) Our record could be the first citation for São Paulo State. However, we could not ascertain it because the medullary chemistry is not fully certified.

Thallus pale grayish green; fragments 1−3 cm in diameter. Laciniae 0.4−1.5 (−2.5) mm wide, sublinear, plane to convex, usually laterally overlapped to rarely contiguous, adnate, slightly adpressed, anisotomic dichotomously branched, axils oval to acute, apex truncate, margins with a linear black rim; upper surface continuous to irregularly cracked, rugose. Lacinulae adventitious, scarce, 0.1−0.3 mm long, plane, irregular, infrequent at the thallus margins. Maculae absent. Pustulae and Isidia absent.
Soredia granular, originated from capitate, laminar and submarginal soralia. Medulla white. Lower cortex black, shiny, rugose, venate, marginal zone variegate, brown to black, clear, shiny, papillate. Rhizines 0.2−0.5 mm long, isotomic to anisotomic or irregularly branched, with two to five or occasionally more dichotomies, concolor, black, abundant, throughout the lower surface. Apothecia and Pycnidia absent.

Chemistry – Upper cortex: K+ yellow, UV- (atranorin). Medulla: K-, C+ rose, KC+ reddish rose→orange, UV+ bluish (undetermined substances). TLC indicates a primary substance with a pattern similar to olivetoric acid; however, we did not observe the typical microcrystals expected for this substance. The Marcelli 10980 specimen also showed traces of what appears to be protocetraric acid, possibly a contaminant.

Specimens examined: this species grows on tree bark; BRAZIL, SÃO PAULO: Municipality of São Paulo, Serra da Cantareira, "Parque Estadual da Cantareira", at the vicinities of the "Lago das Carpas", 9.I.1991, M.P. Marcelli et al. 10960, 10980 (SP).

Comments: *Hypotrachyna lividescen*s recognized in accordance with Sipman et al. (2009) by the usually narrow laciniae (less than 1.5 mm wide), the emaculate upper surface, and capitate laminal soralia.
TLC showed a medullary substance that could be olivetoric acid; however, we did not observe typical microcrystals expected for this substance, and atranorin is the cortical substance. Sipman et al. (2009) also cited that *H. intercalanda* would be the fertile counterpart of *H. lividescens*
The overall morphology of the sorediate *H. laevigata* group is similar, and only the chemistry differentiates them with certainty. Most species in this group also have much wider laciniae up to several mm wide (Hale 1975). It is also somewhat similar to *H. subaffinis* (Hale 1975) regarding soralia but differ in cortical and medullary chemistry (lichexanthone and echinocarpic acid, respectively, in *H. subaffinis*).
Hypotrachyna lividescens could also be confused with *H. producta*, a similar sorediate species with a C+ red medullary reaction.

However *H. producta* has more loosely attached and broader (1.5-5 mm wide) laciniae and contains anziaic acid instead of olivetoric acid.

9. *Hypotrachyna novella* (Vain.) Hale

Smithsonian Contributions to Botany 25: 49. 1975.

Basionym: *Parmelia novella* Vain. *Acta Societatis pro Fauna et Flora Fennica* 7(7): 56. 1890.

Type: Brazil, state of Minas Gerais, Sítio, Vainio 1028 (TUR, lectotype, BM, FH, M, isolectotypes).

Figs. 3e, f

Known distribution: Asia, Africa and South America: Venezuela and Brazil (states of Mato Grosso, Mato Grosso do Sul, Distrito Federal, Bahia, Minas Gerais, Rio de Janeiro, São Paulo and Rio Grande do Sul) (Alstrup et al. 2010; Aptroot et al. 2021b; Chen et al. 2003; Hale 1975, Lynge 1914; Mistry 1998; Sipman et al. 2009; Spielmann 2006).

Thallus pale grayish green: fragments 1−4 cm in diameter. Laciniae 0.5−2 mm wide, sublinear; plane to slightly concave or convex, laterally overlapped to crowded, adnate to elevate, adpressed to slightly adhered, irregularly dichotomously branched, pinate, axils oval, apex truncate, margins with a linear black rim; upper surface continuous to irregularly cracked, rugose. Lobules and Lacinulae absent. Maculae absent. Pustulae, Soredia and Isidia absent. Medulla white. Lower cortex black, shiny, rugose, venate, marginal zone unicolor, brown, clear, shiny, papillate. Rhizines 0.2−0.6 (−1) mm long, irregularly dichotomously branched, with two to five dichotomies, concolor, black, frequent, distributed throughout the lower surface. Apothecia immature, 0.5–1.5 mm in diameter, slightly concave, laminal, sessile, margins crenate, without ornamentation, amphytecia irregularly rugose, disc circular, continuous, epruinose, brown; ascospores absent (hymenia without asci). Pycnidia laminar, of casual distribution, with black ostioles; conidia absent.

Chemistry – Upper cortex: K-, UV+ yellow (lichexantone). Medulla: K+ yellow→brown, C-, KC-, UV-, P- (Lividic acid, possibly 3-Hydroxycolensoic and Colensoic acids and traces of unidentified substances). The only specimen found shows an unexpected reaction to medullary K tests, possibly due to lichexanthone amounts in the upper part of the medulla.

Specimen examined: this species grows on tree bark; BRAZIL, SÃO PAULO: Municipality of São Paulo, Serra da Cantareira, "Parque Estadual da Cantareira", at the vicinities of the "Lago das Carpas", 9.I.1991, M.P. Marcelli et al. 10928 (SP).

Comments: *Hypotrachyna novella* is recognized by the presence of cortical lichexathone and medullary lividic acid. It can be distinguished from *H. minima* and *H. brasiliana* that both contain medullary protocetraric acid (KC+ rs), and from *H. osteoleuca* and *H. erythrodes* due to the yellowish medulla, containing respectively olivetoric acid (C+ and KC+ orange) and physodalic acid (K+ red) (Ribeiro (1998).

The single specimen analyzed here is emaculate, the rhizines not dense at the lower cortex, as observed by Hora (2015). It could not be assigned to any other known species due to the overall morphology and chemistry. As in Hale (1975) there is no mention nor presence of maculae.

The closest species is *H. livida* (Taylor) Hale since both have similar morphology and identical medullary chemistry (Sipman et al. 2009), but they differ by the presence of atranorin and chloroatranorin in *H. livida* and lichexanthone in *H. novella*.

10. *Hypotrachyna protoformosana* Elix, T. H. Nash & Sipman

Flora Neotropica Monograph 104: 128. 2009.

Type: Brazil, São Paulo, 20km E of Cruzeiro, on bark, 1978, K. Kalb & G. Plobst s.n. (herb. Kalb 21041, holotype).

Figs. 4a, b

Known distribution: Papua New Guinea, Africa, Dominican Republic, and Brazil (states of Mato Grosso, Alagoas, Bahia, Minas Gerais, and São Paulo) (Aptroot and Souza 2021; Oliveira Junior et al. 2020, 2021; Sipman et al. 2009; Swinscow and Krog 1988).

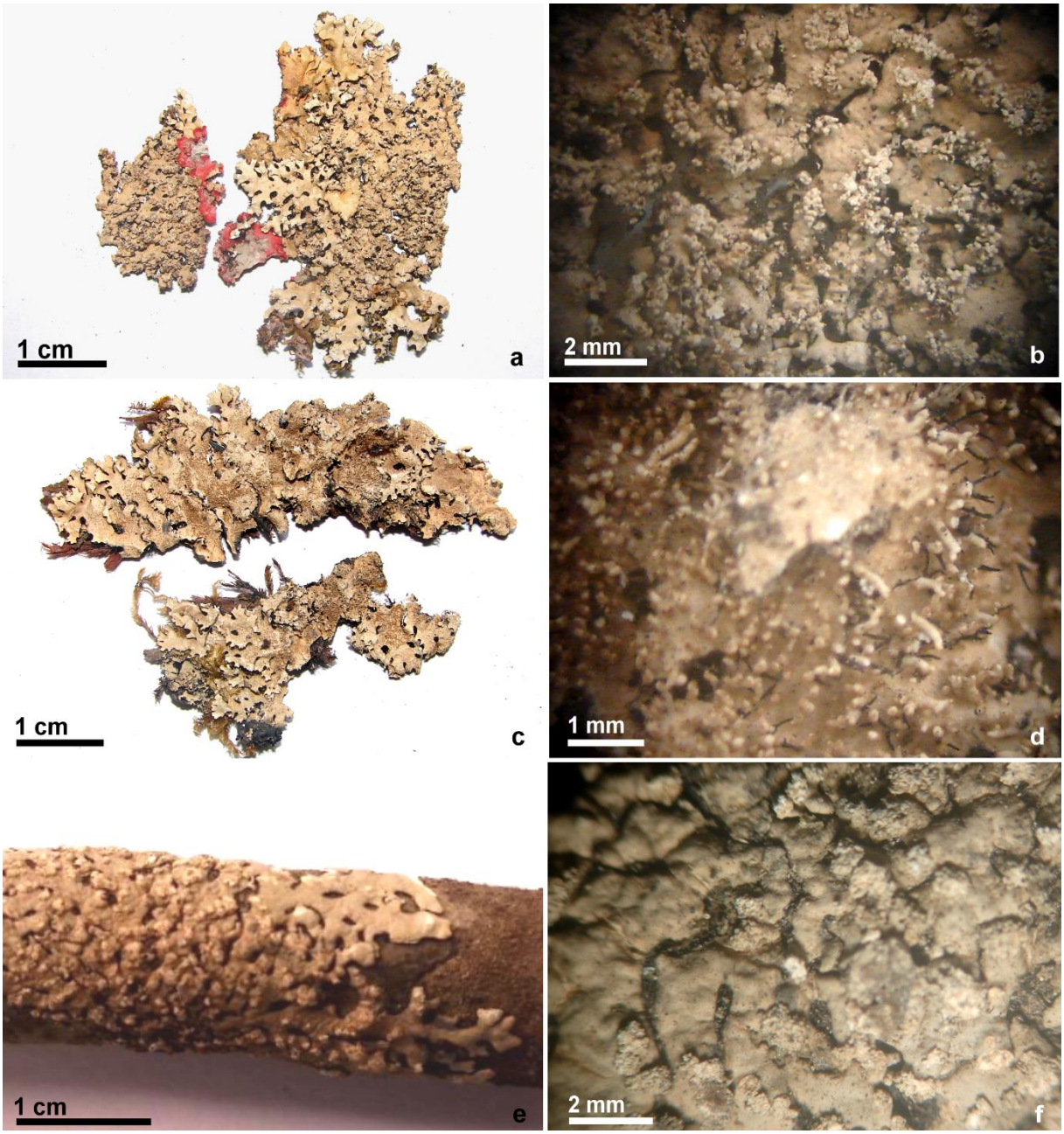

Figure 4. **4a-f**. Habit and detail of the upper cortices of *Hypotrachyna* specimens. **4a, b**. *Hypotrachyna protoformosana* (M. P. Marcelli 11475). **4c, d**. *Hypotrachyna steyermarkii* (M. N. Benatti 5). **4e, f**. *Hypotrachyna subformosana* (M. P. Marcelli 10958). Bars = 1 cm (a, c, e); = 2 mm (b, f); = 1 mm (d).

Figura 4. **4a-f**. Hábito e detalhe dos córtices superiores de espécimes de *Hypotrachyna*. *4a, b*. *Hypotrachyna protoformosana* (M. P. Marcelli 11475). **4c, d**. **Hypotrachyna steyermarkii** (M. N. Benatti 5). **4e, f**. *Hypotrachyna subformosana* (M. P. Marcelli 10958). Barras = 1 cm (a, c, e); = 2 mm (b, f); = 1 mm (d).

Chemistry – Upper cortex: K-, UV+ yellow (lichexanthone). All specimens found contain both typical cortical substances. Medulla: K-, C-, KC+ rs, P+ orange, UV- (protocetraric acid, physodic acid derivatives, and traces of unidentified substances). An orange K+ purple pigment (rodophyscin) can be found among the most eroded, mature pustulae, and below the disc in mature apothecia.

Thallus pale grayish green; fragments 1.5−6.5 cm in diameter. Laciniae 0.5−2 (−3) mm wide, sublinear, plane to concave or rarely convex, contiguous to rarely laterally overlapped, adnate, adpressed; isotomic dichotomously branched, pinate; upper surface continuous to irregularly cracked, smooth to mostly rugose, axils oval to rarely obtuse, apex truncate, margins with a black linear rim. Lobules and Lacinulae absent. Pustulae entire to partially eroding, bubbleform or with an inflated, isidiate aspect (dactyls) when more developed, occasionally becoming sorediate, verruciform, sometimes with an orange K+ purple pigment, laminal to marginal. Maculae absent. Soredia granular, coarse, originated from pustula decomposition, laminal. True Isidia absent (occasionally some branched digitiform pustulae like dactyls, up to 2 mm high). Medulla white. Lower cortex black, shiny, rugose or venate, marginal zone unicolor, brown to black, clear, shiny, papillate. Rhizines 0.1−0.6 mm long, anisotomic to most irregularly dichotomously branched, often with two to three, rarely four dichotomies, concolor, black, frequent to abundant throughout the lower surface. Apothecia plane to slightly concave, 2−3 mm in diameter, laminal, sessile, margin crenate, amphithecia sometimes pustulate around the disc; disc circular, continuous, brown, epruinose, imperforate, orange pigment K+ purple often present below the disc; ascospores not observed (hymenia darkened or damaged). Pycnidia absent.

Specimens examined: this species grows on tree bark; BRAZIL, SÃO PAULO: Municipality of Mairiporã, Serra da Cantareira, village construction, 11-III-1989, leg. M.P. Marcelli 6030, 6075 (SP); idem, Municipality of São Paulo, "Parque Estadual da Cantareira", *Araucaria angustifolia* wood in the way to the "Pé de Galinha" 25.VI.1991, M.P. Marcelli et al. 11475 (SP); idem, Municipality of São Paulo, "Parque Estadual da Cantareira", "Núcleo da Pedra Grande", 18-V-1992, leg. M.P. Marcelli et al. 13618 (SP).

Comments: recognized by the dense, mostly laminal isidioid pustulae (dactyls), the UV+ yellow upper cortex (lichexathone), and by the presence of physodic and occasionally protocetraric medullary acids. It resembles *H. osseoalba* but is distinguished mainly by the presence of protocetraric acid, which is absent in the latter.
Hypotrachyna mirabilis differs by a rose medulla, and *H. malmei* by the irregular shape and disposition of the pustulae, which also do not erode into soredia (Ribeiro 1998). Only one specimen out of the four examined here had a few eroded pustulae, but no soredia.
The Marcelli 11475 specimen has more coralloid pustulae, with a remarkable isidia appearance, resembling dactyls. The isidia are UV+ rose reacting and often show an orange pigment when cut, occasionally seen on other parts of the thallus. Otherwise, it is similar to the other specimens, including the chemical components. The pustulae look more bubble-like in the early stages but often become more isidiate in aspect, with a dactyl-like appearance when mature, as observed in all the other thalli.

11. *Hypotrachyna steyermarkii* (Hale) Hale
Smithsonian Contributions to Botany 25: 65. 1975.
Basionym: *Parmelia steyermarkii* Hale. *Phytologia* 28: 269. 1974b.
Type: Venezuela, Amazonas, Sierra Parima, Steyermark (Holotype, US).
Figs. 4c, d

Known distribution: North, Central, and South America. Brazil. (States of Bahia, Minas Gerais, Rio de Janeiro, São Paulo, Santa Catarina and Rio Grande do Sul) (Aptroot et al. 2022; Hale 1975; Menezes et al. 2018; Ribeiro 1998; Spielmann 2006).

Thallus dark grayish green; fragments 1−7 cm in diameter. Laciniae 0.4−1.5 (−2) mm wide, sublinear, plane to concave, contiguous to laterally overlapped, adnate to elevate, adpressed to slightly adhered, isotomic to anisotomic dichotomously branched, pinnate to irregular, axils oval, apex truncate, margins with a linear black rim; upper surface continuous, smooth. Lacinulae rare, adventitious, occasionally present, mainly on the central thallus parts, plane, acute, dichotomous. Maculae absent (thallus often with scars left by fallen isidia). Pustulae and Soredia absent. Isidia 0.1–0.67 mm high, cylindric with irregular diameter, simple to irregularly branched, rarely becoming coralloid, laminal, erect to procumbent, firm, concolor sometimes with brown apices, apex

and sides variably ciliate, sometimes bearing pycnidia. Medulla white. Lower cortex black, shiny, smooth to rugose or venate, marginal zone unicolor, brown, clear, shiny, papillate. Rhizines 0.1−0.8 mm long, isotomic to irregularly dichotomously branched, usually with two to four dichotomies, concolor, black, frequent to abundant throughout the lower surface. Apothecia absent. Pycnidia scarce, few appearing on mature isidia or laminal, with black ostioles, conidia bacilliform, weakly to distinct bifusiform, 5.0–6.5 × 1.0 µm.

Chemistry – Upper cortex: K+ yellow, UV- (atranorin). Medulla: K-, C+ orange, KC+ orange, UV-, P- (barbatic acid, 4-*O*-Methylphysodic acid, 4-*O*-Demethylbarbatic acid).

Specimens examined: this species grows on tree bark; BRAZIL, SÃO PAULO: Municipality of São Paulo, Serra da Cantareira, "Parque Estadual da Cantareira", V.2000, leg. M.N. Benatti 5 (SP); idem, at the vicinities of the "Lago das Carpas", 9.I.1991, M.P. Marcelli et al. 10946 (SP); idem, *Araucaria angustifolia* wood in the way to the "Pé de Galinha" 25.VI.1991, leg. M.P. Marcelli et al. 11471, 11472 (SP).

Comments: *Hypotrachyna steyermarkii* is quite similar to *H. imbricatula* in morphology and chemistry, differing by the procumbent, ciliate isidia (the only eciliate *Hypotrachyna* that is known to form cilia on another structure besides the marginal zone, as observed in subgenus *Parmelinopsis*). The latter species also has broader laciniae (up to 5 mm wide), especially at mature thalli. *Hypotrachyna steyermarkii* can also be distinguished from *H. kriegeri*, *H. costaricensis*, and *H. consimilis* by the presence of medullary barbatic acid (C+ and KC+ orange) (Ribeiro 1998). Not all isidia on a thallus, even the most developed ones, might bear cilia. Some thalli have few ciliate isidia that make them look as small *H. imbricatula* specimens. It differs from *Hypotrachyna horrescens* (Taylor) Krog & Swinscow in having profuse ciliate isidia, which are usually scarcer in this other species, which also has nitidously ciliate margins, and has a very different chemistry containing medullary substances of the horrescens complex like s 3-metoxi-2,4-di-0-metilgiroforic acid, 5-0-metilhiascic acid, and girophoric acid. In early developed thalli, the narrow laciniae width could be the sole difference to *H. imbricatula*, as no isidia might develop cilia at this maturation state.
Sipman et al. (2009) mentioned isidia that could become lobulated, but these were not observed here (being in accordance with all other morphological and chemical characteristics). They are procumbent, even the most branched ones. During maturation, some isidia remain on the thallus (they do not detach) and grow, acquiring the appearance of laciniae. This could be the trigger point for cilia production on the isidia, which seems to be similarly conditioned, as no cilia were observed in very young isidia (the inflection point in lobes could be due to the maturation of the isidia that do not detach, turning to laciniae aspect; the production of cilia on the isidia could also be similarly conditioned).

12. *Hypotrachyna subformosana* Hale ex Elix, T. H. Nash & Sipman

Flora Neotropica Monograph 104: 153. 2009.
Type: Brazil, state of Pará: ca. 20km N of the border with Mato Grosso on Cuiaba-Santarem highway (Br-163), on a tree in broad, sandy, level plain along the "Rio Braço de Norte", 43Q-480m, 25 Apr 1983, Brako & Dibben 5951 (holotype, NY).
Figs. 4e, f

Known distribution: Fiji Islands, North, Central, and South America: Venezuela Argentina and Brazil. (States of Pará, Distrito Federal, Pernambuco, Bahia, Minas Gerais, Espírito Santo and São Paulo (Brako et al. 1985; Aptroot and Cáceres 2018; Buril 2015; Fraga Junior et al. 2023; Michlig et al. 2024; Silva et al. 2023; Sipman et al. 2009).

Thallus pale grayish green: fragments up to 4 cm in diameter. Laciniae 0.3−1.5 mm wide; sublinear, plane to convex, contiguous to laterally overlapped, adnate, adpressed, isotomic dichotomously branched, pinnate to irregular, axils oval, apex truncate, margins with a linear black rim; upper surface continuous to irregularly cracked (mainly ate mos sorediate parts), smooth to rugose. Lobules and Lacinulae absent. Pustulae and Isidia absent. Maculae absent. Soredia granular, originated from laminar to submarginal, capitate to irregularly shaped soralia. Medulla white. Lower cortex black, shiny, smooth to rugose or venate, marginal zone variegate, brown to black, clear, shiny, papillate. Rhizines 0.1−0.4 mm long, irregularly branched, with two to four dichotomies, concolor, black, frequent, distributed throughout the lower surface. Apothecia and Pycnidia absent.

Chemistry – Upper cortex: K-, UV+ yellow (lichenxantone). Medulla: K+ yellow, C+ weakly yellow, KC+ rose→orange, UV-, P+ orange

(lividic acid, 2'-*O*-Methylphysodic acid, and an unidentified substance at Rf 18, eluent II on TLC).

Specimens examined: this species grows on tree bark; BRAZIL, SÃO PAULO: Municipality of São Paulo, Serra da Cantareira, "Parque Estadual da Cantareira", VI.2000, leg. M.N. Benatti 1025 (SP); idem, at the vicinities of the "Lago das Carpas", 9.I.1991, M.P. Marcelli et al. 10958 (SP).

Comments: recognized by the presence of cortical lichexanthone (UV+ yellow), medullary lividic and 2'-*O*-Methylphysodic acids (KC+ rose, P+ gives a somewhat orange reaction in the specimens), and the round, laminal to marginal soralia.
Can be distinguished from *H. formosana*, which has pustulae and contains medullary physodic acid. It can be confused with *H. nana* and *H. pseudosinuosa*, which have solely cortical atranorin (Ribeiro 1980). Some early-stage soralia might look like verruciform pustulae but soon erode into typical orbicular, capitate, or irregular soralia. The specimens found have narrower laciniae than those cited by Sipman et al. (2009), although they are within the given measures. *Hypotrachyna subbafinis* is perhaps the closest similar species, differing in having medullary protoceetraric acid.
Besides the additional presence of cortical atranorin, the smaller laciniae width (which usually are 1-3 mm wide), and the presence of 2'-*O*-methylphysodic acid, all other features are consistent with *H. subformosana*, and no other species approach this overall. Other close species have different morphology or chemistry (Sipman et al. 2009). The combination of narrow laciniae, capitate soralia, cortical lichexanthone, and medullary lividic acid can only lead to *H. subformosana*.

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7 AUTHOR CONTRIBUTIONS

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