



Original Paper

The genus *Brittonodoxa* (Sematophyllaceae) in Brazil

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Abstract

This study presents an update on the occurrence of the genus *Brittonodoxa* in Brazil with diagnosis, taxonomic comments, illustrations, and geographical distribution data. We recognized three species from Brazil and the geographical distribution of two of them is being expanded: *B. cataractae* is being reported here for the first time the states of ES, RJ, and RS, and *B. lithophila* in the Amazon Forest and Pampa biome, occurring in the states of AM, ES, MA, MS, MT, PA, PR, RJ, RS, and TO.

Key words: Bryophyta, Atlantic Forest, endemic species, Hypnales, mosses.

Resumo

Neste trabalho apresentamos uma atualização da ocorrência do gênero *Brittonodoxa* no Brasil, com diagnose, comentários taxonômicos, ilustração e distribuição no Brasil. São reconhecidas três espécies para o Brasil, destas duas tiveram seu registro de ocorrência ampliado: *B. cataractae* teve seu registro de ocorrência ampliado para os estados do ES, RJ e RS; e *B. lithophila* teve seu registro ampliado para os biomas Floresta Amazônica e Pampa, e para os estados do AM, ES, MA, MS, MT, PA, PR, RS, RJ e TO.

Palavras-chave: Bryophyta, Floresta Atlântica, espécies endêmicas, Hypnales, musgos.

Introduction

Brittonodoxa W.R. Buck, P.E.A.S. Câmara & Carv.-Silva is a genus of the family Sematophyllaceae, described by Carvalho-Silva *et al.* (2017). According to these authors, the name of the genus as given in homage to Elizabeth G. K. Britton, one of the first female bryologists in the world. The genus comprises species previously placed in *Sematophyllum* Mitt. or *Rhaphidostegium* (Schimp.) De Not. Molecular phylogenetic analyses resolved the taxonomic conflict and showed *Brittonodoxa* to be a monophyletic genus within the Sematophyllaceae crown clade (Carvalho-Silva *et al.* 2017).

According to Carvalho-Silva *et al.* (2017), most species of the Sematophyllaceae crown clade, including all species of the clades (*e.g.*, *Donnellia* Austin, *Jirivanaea* U.B.Deshmukh & Rathor, and *Pterogoniopsis* Müll.Hal), can be recognized by the presence of alar cells of the Brotherelloid type and are restricted to the New World, except for the

clades *Brittonodoxa* and “*Rhaphydorrhynchium*”. *Brittonodoxa* is a tropical genus composed of six species distributed in Mexico, Central and South America, and West Indies, with some species in Africa (Carvalho-Silva *et al.* 2017).

Although, *Brittonodoxa* has low to moderate bootstrap support value, its species can be distinct using morphological characteristics (Carvalho-Silva *et al.* 2017). They are easily recognized by their ovate to ovate-lanceolate and concave leaves and, acute to short-acuminate, rhomboid to hexagonal cells (Evangelista-dos-Santos & Valente 2022a) and can be differentiated from the other genera of Sematophyllaceae (*e.g.*, *Donnellia* and *Meiothecium* Mitt.) based on the morphological characteristics of the peristome. The morphology of the exostome and endostome is considered a good feature to distinguish the genera of this family.

Recent studies on species of Sematophyllaceae in Brazil have revealed novelties in the genus *Brittonodoxa*. Hence, in this study, we present

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updated taxonomic, morphological, and ecological descriptions, illustrations, and geographical distribution statuses of *Brittonodoxa* species from Brazil.

Material and Methods

The Flora e Funga do Brasil (Câmara & Carvalho-Silva 2020) was used, as a baseline in this study. Type materials and herbarium specimens were obtained from ALCB, ASE, BM, CEPLAC, HABIT, HBRA, HNTD (duplicates), HUCCS, HUEFS, HUNEB, HUESPI, JE, NY, MBM, MG, PACA, SP, UB, UFP, UPCB, VIES (duplicates), and VIC (duplicates).

The species are listed in alphabetical order. The delimitations of the genus and the species were based on photos of the types and relevant bibliography (Buck 1998; Carvalho-Silva *et al.* 2017; Evangelista-dos-Santos *et al.* 2021; Evangelista-dos-Santos & Valente 2022a). The morphological terminology followed Luiz-Ponzo *et al.* (2006) and Calzadilla & Churchill (2014). The substrates classification follows Richards (1984), Fudali (2001), and Molinaro & Costa (2001).

Descriptions, recognized synonyms, illustrations, comments, distribution in Brazil, substrate types, selected material, and maps are provided for each species. New occurrences are

indicated by an asterisk (*). Distribution maps were prepared using ArcGis v.10.2, based on the geographic coordinates of the collections. All shapefiles and geographical information were obtained from the IBGE (Instituto Brasileiro de Geografia e Estatística 2022) database.

Results and Discussion

Brittonodoxa is represented in Brazil by three species: *Brittonodoxa cataractae* (W.R. Buck) W.R. Buck, P.E.A.S. Câmara & Carv.-Silva, *Brittonodoxa lithophila* (Hornsch.) W.R. Buck, P.E.A.S. Câmara & Carv.-Silva, and *Brittonodoxa subpinnata* (Brid.) W.R. Buck, P.E.A.S. Câmara & Carv.-Silva. *Brittonodoxa cataractae* and *B. lithophila* are endemic to Brazil. With the present work, the geographical distribution of species that were little known until now is being expanded. *Brittonodoxa cataractae* is being expanded in the Atlantic Forest biome (Fig. 1), and *B. lithophila* is reported for the first time from the Amazon Forest and Pampa biome (Fig. 1). *Brittonodoxa subpinnata* is widely distributed, in mesic to humid forests (Buck 1998) and in urban environments (Evangelista-dos-Santos *et al.* 2021), in Brazil, has a wide distribution (Fig. 1).

Taxonomic treatment

Key to *Brittonodoxa* species of Brazil

1. Leaves orbicular to ovate; apex mucronate or obtuse; leaf cells rhomboidal 10–15 µm long 2. *Brittonodoxa lithophila*
- 1'. Leaves lanceolate to oblong-lanceolate; apex acute to acuminate; leaf cells rhomboidal to short-rhomboidal 2
 2. Setae 4–5 mm; endostome with a high basal membrane; segments papillose; cilia single 1. *Brittonodoxa cataractae*
 - 2'. Setae 1–1.7 mm; endostome with a high basal membrane; segments smooth; cilia single or rudimentary 3. *Brittonodoxa subpinnata*

1. *Brittonodoxa cataractae* (W.R. Buck) W.R. Buck, P.E.A.S. Câmara & Carv.-Silva, Taxon 66(4): 823. 2017 ≡ *Sematophyllum cataractae* W.R. Buck, Brittonia 35: 328. 1983. Type: Brazil. Santa Catarina. Serra Geral, Jan. 1890, E. Ule s.n. (Holotype NY!, Isotype NY!). Fig. 2

Plants medium-sized, golden-green; stems ca. 2–3 cm long, irregularly branched; leaves oblong to lanceolate, 1–1.5 mm long, acute, concave, margins entire; cells short-rhomboidal at apex, 9–12 µm long, linear-flexuous at base,

20–30 µm long; alar cells smaller, hyaline, oblong, 17–22 µm long; supra-alar cells 1–2 rows, quadrate to sub-rectangular. Setae elongate, smooth, 4–5 mm long; capsule oblong; exothecial cells quadrate to sub-rectangular, collenchymatous; operculum long-rostrate; exostome triangular, bordered, with zig-zag median line, cross-striolate below, papillose above, trabeculate at back; endostome with a high basal membrane, segments papillose, perforate, cilia single.

Selected material examined: ESPÍRITO SANTO: Domingos Martins, Parque Estadual da Pedra Azul, 2.X.2016, *T.S. Dantas et al.* 789 (UB). RIO DE JANEIRO: Parque Nacional de Itatiaia, 1.XI.2006, *P.E.A.S. Câmara* 17 (UB). RIO GRANDE DO SUL: Jardim Botânico, Caxias do Sul, 5.IV.2007, *J. Bordin & A. Brunetto* 623 (HUCS). SANTA CATARINA: Morrão do Antão, Ilha de Santa Catarina, *J. Bordin* (HUCS 4951). SÃO PAULO: Campos do Jordão, Parque Estadual de Campos do Jordão, 22.VI.1993, *O. Yano* 19540 (HUCS).

Brittonodoxa cataractae can be recognized by the shape of the leaves, the poorly developed alar cells and 1–2 rows of supra-alar cells, the bordered exostome, perforate endostome segments

and single cilia. The records of the occurrence this species, which was known to occur only around the type locality, are being expanded with the present study. Studies like the present on can contribute to a better understanding of the distribution of this species. According to Buck (1983), *B. cataractae* is very similar to *Sematophyllum cubense* Buck, but, it can be distinguished the more ovate leaves with entire margins, the smaller alar cells, and endostome cilia.

Brittonodoxa cataractae is endemic of Brazil, distributed in the Atlantic Forest and Pampa biome. Here, we confirm the occurrence in the states of

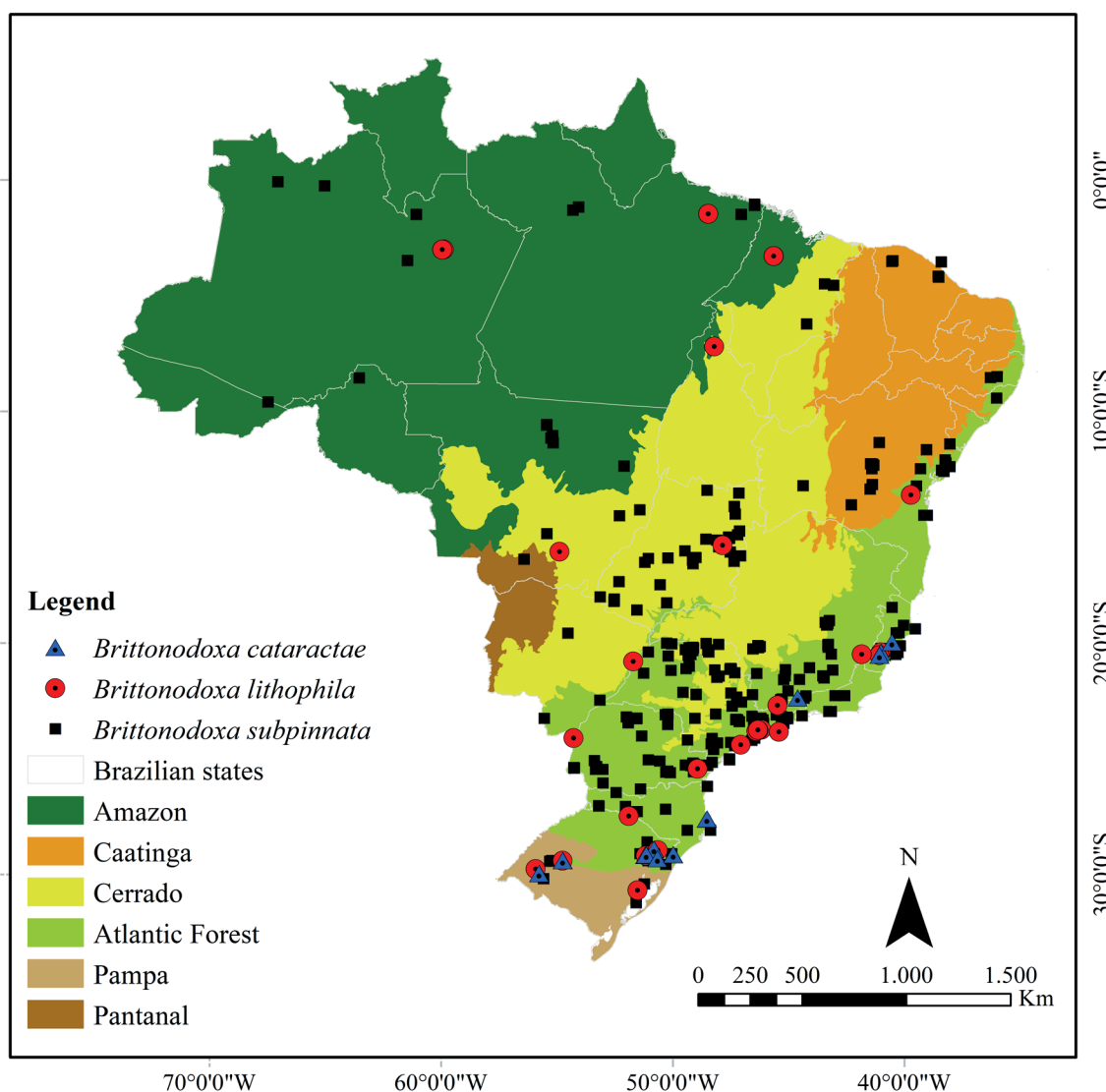


Figure 1 – Map of geographical distribution of *Brittonodoxa cataractae*, *Brittonodoxa lithophila*, and *Brittonodoxa subpinnata* in Brazilian states and Phytogeographic biome. Source IBGE (2022, adapted).

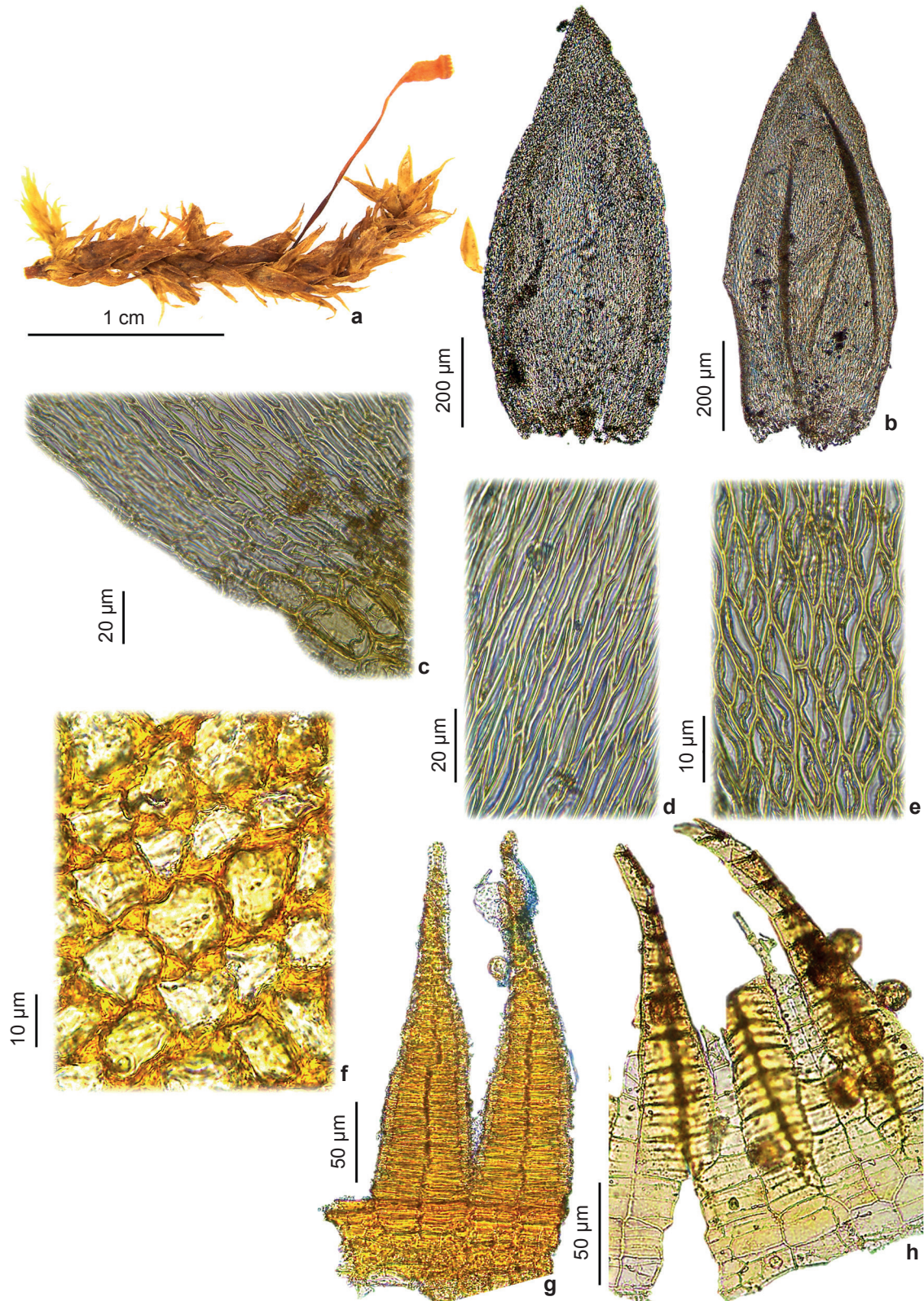


Figure 2 – a-h. *Brittonodoxa cataractae* – a. gametophyte; b. leaves; c. alar cells; d. basal cells; e. apical cells; f. exothecial cells; g. exostome; h. endostome. (from holotype NY1178850).

Espírito Santo*, Rio de Janeiro*, Rio Grande do Sul*, and Santa Catarina. The species can be found in Ombrophilous forest, growing on decaying roots, trees, soil, or rocks at 250–1,339 m alt.

2. *Brittonodoxa lithophila* (Hornsch.) W.R. Buck, P.E.A.S. Câmara & Carv.-Silva, Taxon 66(4): 823. 2017 ≡ *Hypnum lithophilum* Hornsch. in Martius, *Fl. bras.* 1(2): 84. 1840 ≡ *Sematophyllum lithophilum* (Hornsch.) Ångström in Öfvers. Kongl. Vetensk.-Akad. Förh. 33(4): 42. 1876 ≡ *Sematophyllum loxense* var. *lithophilum* (Hornsch.) Lindb., Moss. Dillen. Hist. Musc.: 20. 1883, nom. illeg. ≡ *Rhaphidostegium lithophilum* (Hornsch.) Broth. in Bih. Kongl. Svenska Vetensk.- Akad. Handl. 21, Afd. 3(3): 50. 1895 ≡ *Rhaphidostegium loxense* var. *lithophilum* (Hornsch.) Paris, Index Bryol.: 1099. 1898, nom. illeg. Type: Brazil, Serra dos Órgãos, H.C. Beyrich *s.n.* (Lectotype BM), designated by Buck (1998).

= *Hypnum loxense* var. *rivulare* Müll. Hal., Syn. Musc. Frond. 2: 332. 1851. ≡ *Rhaphidostegium loxense* var. *rivulare* (Müll. Hal.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 390. 1878. Type: Brasilia [Brazil] in lapidibus rivolorum pr. Novo-Friburgum, Beirich *s.n.* (Syntype H-BR) *syn. fide* Buck (1998).

= *Acroporium catharinense* Sehnem, Pesquisas, sér. Bot. 32: 109-110. pl. 4. 1978. Type: Brazil, Santa Catarina, Morro do Antão, Sehnem 3204. (Holotype PACA!) *syn. fide* Câmara *et al.* (2015). Fig. 3

Plants well developed, golden, green to golden green; stems ca. 3–4 cm long, irregularly branched; leaves orbicular to ovate, 1–1.5 mm long, mucronate or obtuse, concave, margins entire; cells rhomboidal at apex 10–15 µm, linear to linear flexuous at base 15–30 µm; alar cells smaller, hyaline or yellow, oblong, 30–40 µm; supralar cells 2–4 rows, quadrate to sub-rectangular, inflated. Setae elongate, smooth, 7–10 mm long; capsule cylindrical; exothecial cells quadrate to sub-rectangular, collenchymatous; operculum long-rostrate; exostome triangular, bordered, zig-zag median line, cross-striolate below, papillose above, trabeculate at back; endostome with a high basal membrane, segments papillose, perforate, cilia single.

Selected material examined: AMAZONAS: Manaus, 10.VI.1979, *O. Yano 1415* (SP). BAHIA: Nova Esperança, Estação Ecológica Wenceslau Guimarães, Trilha Água Vermelha, 4.XII.2017, *C. Bastos 6147* (ALCB). DISTRITO FEDERAL: Centro Olímpico da UnB, 25.XI.2000, *T.I. Luna 2046* (UB). ESPÍRITO

SANTO: Domingos Martins, Parque Estadual da Pedra Azul, 2.X.2016, *T.S. Dantas et al. 779* (UB). MARANHÃO: município de Zé Doca, Aldeia dos Guajaras, 30.VIII.2017, *R.R. Oliveira 106* (SP). MATO GROSSO: município Juscimeira, 15.VII.1981, *D.M. Vital 9892* (SP). MATO GROSSO DO SUL: município de Três Lagoas, Reserva Agroflorestal, 12.IX.1992, *O. Yano & M.P. Marcelli 17066* (SP). MINAS GERAIS: Alto do Caparaó, Parque Nacional do Caparaó, Vale Verde, 10.VII.2009, *J. Bordin 1563* (HUCS). PARÁ: Belém, Museu Emílio Goeldi, 4.I.1928, *P. Occhioni* (RB 174819). PARANÁ: Morretes, Vêu de Noiva, 18.VIII.1987, *R. Kummorow & J. Cordeiro 2944* (HUCS). RIO GRANDE DO SUL: Caxias do Sul, Parque dos Macaquinhos, 15.X.2005, *J. Bordin 153* (HUCS). SÃO PAULO: Paranapiacaba, Reserva do Instituto de Botânica, 12.III.2009, *R. Wasum 4459* (HUCS). TOCANTINS: Araguaína, Chácara Dom Orione, 18.I.2017, *R. Santos-Silva 400* (SP).

Brittonodoxa lithophila can be recognized by the orbicular to ovate shape of the leaves with mucronate or obtuse apices. Buck (1998) described the leaves of this species as broadly ovate and obtuse-mucronate with compact alar cells. Some leaves may have an acute apex, but the other essential characteristics do not change (Evangelista-dos-Santos *et al.* 2021). This species occurs preferentially close to rivers or on submerged rocks.

Buck (1998) included *Sematophyllum cochleatum* (Broth.) Broth. as a heterotypic synonym of *B. lithophila*, but after analyzing the Isotypes deposited in New York Botanical Garden (NY01179097 and NY01179098) we do not consider them as a synonym. *Sematophyllum cochleatum* presents numerous, quadratic to short quadratic alar cells, in 4–5 rows. This species is more related to *Rhaphidostegium amnigenum* Broth., also considered a synonym of *B. lithophila* by Buck (1998), however recent phylogenetic analysis has transferred *R. amnigenum* to the genus *Trichosteleum* Mitt. (Carvalho-Silva *et al.* 2017).

Brittonodoxa lithophila is endemic of Brazil, distributed in the Amazon, Atlantic Forest, Cerrado and Pampa. Here, we confirm the occurrence in the states of Amazonas*, Bahia, Distrito Federal, Espírito Santo*, Maranhão*, Minas Gerais, Mato Grosso do Sul*, Mato Grosso*, Pará*, Paraná*, Rio de Janeiro*, Rio Grande do Sul, Santa Catarina, São Paulo and Tocantins*. The species can be found in rainforests, montane forests, and igarapés (side channels of rivers), growing on decaying roots, trees, soil, or rocks at 213–1,385 m alt.

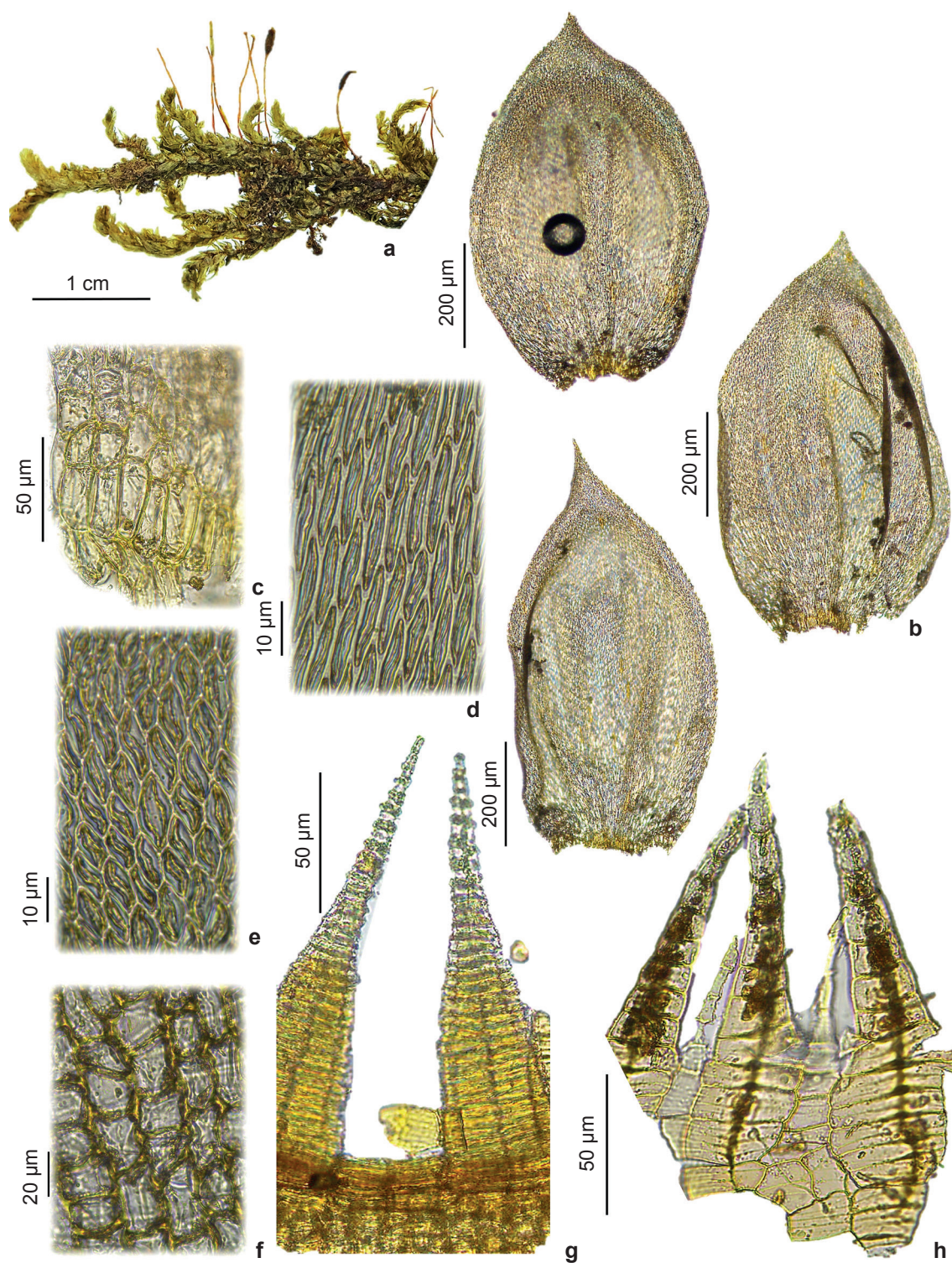


Figure 3 – a-h. *Brittonodoxa lithophila* – a. gametophyte; b. leaves; c. alar cells; d. basal cells; e. apical cells; f. exothecial cells; g. exostome; h. endostome. (from paratype of heterotypic synonym PACA73161).

3. *Brittonodoxa subpinnata* (Brid.) W.R. Buck, P.E.A.S. Câmara & Carv.-Silva, Taxon 66(4): 824. 2017 = *Leskea subpinnata* Brid., Muscol. Recent. Suppl. 2: 54. 1812 = *Hypnum subpinnatum* (Brid.) Arn. in Mém. Soc. Linn. Paris 5: 302. 1827 = *Rhaphidostegium subpinnatum* (Brid.) E. Britton in Bryologist 21: 28. 1918 = *Sematophyllum subpinnatum* (Brid.) E. Britton in Bryologist 21: 28. 1918. - type: In Hispaniola ad arboreas habitas, P.A. Poiteau s.n. (Holotype B, probably lost; Isotype: NY!).

= *Hypnum loxense* Hook., Syn. Pl. 1: 62. 1822 = *Sematophyllum loxense* (Hook) Mitt., J. Linn. Soc., Bot. 12: 479. 1869. = *Rhaphidostegium loxense* (Hook) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1876-77: 390. 1878. (Holotype BM! [photo]). *syn. fide* Buck (1998)

= *Aptychus aurantius* Müll.Hal., Hedwigia 37: 257. 1898. = *Rhaphidostegium aurantium* (Müll. Hal.) Paris, Index Bryol. Suppl. 295. 1900. = *Sematophyllum aurantium* (Müll.Hal.) Broth., Nat. Pflanzenfam., ed. 2, 11: 432. 1925. (Isotype NY! [photo]). *syn. fide* Buck (1998). Fig. 4

Plants well developed, golden, green to golden green; stems ca. 2–4(–6) cm long, irregularly branched; leaves lanceolate to oblong-lanceolate, 0.8–1.1 mm long, acute to acuminate, concave, margins entire; cells rhomboidal at apex 0.9–1.1 µm, linear to linear flexuous at base 15–20 µm; alar cells smaller, yellow, oblong, 12–15 µm; supralar cells 4–5 rows, quadrate to sub-rectangular, inflated. Setae elongate, smooth, 1–1.7 mm long; capsule cylindrical; exothecial cells rectangular to quadrate, collenchymatous; operculum long-rostrate; exostome triangular, bordered, with zig-zag median line, cross-striolate below, papillose above, trabeculate at back; endostome with a high basal membrane, segments smooth, perforate, cilia single or rudimentary.

Selected material examined: ACRE: Rio Branco, 1.VI.1987, *D.M. Vital 15038* (PACA). ALAGOAS: Estação Ecológica Murici, Mata da Bananeira, 2.XII.2004, *K.C. Pôrto* (UFP 48924). AMAZONAS: Presidente Figueredo, Rio Urubú, 30.VI.2014, *C.E. Zartman 8789* (UB). BAHIA: São Francisco do Conde, Fazenda Engenho madrugá, *C.J.P. Bastos* (HUNEB 4886). CEARÁ: Ubajara, Sítio São Luís, 18.VII.2017, *M.E.B. Sousa 36* (HUESPI). DISTRITO FEDERAL: Chapada Imperial, Cachoeira Três Marias, 7.VII.2016, *P.E.A.S. Câmara 3815* (UB). ESPÍRITO SANTO: Parque Estadual Pedra Azul, 29.X.2009, *L.T. Penha 679* (HUEFS). GOIÁS: Alto Paraíso de Goiás, Parque Nacional da Chapada dos Veadeiros, 5.V.2016, *M.G. Facco 477* (UB). MARANHÃO: Área de Proteção

Ambiental Buriti do Meio, 16.V.2014, *Conceição & Bonfim 65* (HABIT). MINAS GERAIS: Santana do Riacho, Parque Nacional Serra do Cipó, 11.VI.2011, *P.E.A.S. Câmara 1871* (UB). MATO GROSSO: Várzea Grande, Loteamento Santa Cecília, 14.VIII.2009, *T.E.C. Meneguzzo 242* (UB). PARÁ: Santarém, Rio Cupari afluente do Rio Tapajós, 6.XII.2010, *R. Gama 814* (UB). PARAÍBA: Areia, Reserva Ecológica da Mata do Pau-Ferro, 11.IX.2009, *M.P.P. Silva 350* (UFP). PERNAMBUCO: Cabo de Santo Agostinho, Reserva Ecológica Garjaú, Mata do Cuxio, 7.II.2003, *L.D.P. Alvarenga* (UFP 51002). PIAUÍ: Granja, Serra da Ubatuba, 28.IV.2012, *E.B. Sousa 2582* (HUESPI). PARANÁ: Curitiba, São José dos Pinhais, Reserva Biológica Cambuí, 30.VI.1979, *A.A.R. Meijer 79* (MBM). RIO DE JANEIRO: Nova Friburgo, estrada de Olaria para São Lourenço, 29.III.1989, *D.P. Costa 839* (RB). RORAIMA: Bonfim, 8.VIII.1995, *R.L. Santiago 218* (UFP). RIO GRANDE DO SUL: Nova Esperança do Sul, Gruta Nossa Senhora de Fátima, 3.IX.2017, *D.V. Valente 1320* (UB). SANTA CATARINA: Imaruí, Lagoa Imaruí, 21.VIII.1992, *G. Hatschbach 57900* (MBM). SERGIPE: Itabaiana, Serra da Itabaiana, Parque dos Falcões, *F.S. Dantas 288* (ASE). SÃO PAULO: Santo André, Paranapiacaba, 12.III.2009, *R. Wasum 4463* (HUCS).

Brittonodoxa subpinnata presents a wide range of morphological variation, especially in the leaf shape, which has led to misidentifications. Because of this, a high number of heterotypic synonyms, approximately 209, were listed in Tropicos (2022, <<https://tropicos.org/name/>>), which need a revision. In the present work, we have included only a few of the names corresponding to those whose types we analyzed, on order to avoid excessive elaboration.

Some materials analyzed in this study were mistakenly identified as *B. subpinnata* and actually corresponded to species such as *Meiothecium boryanum* (Müll.Hal.) Mitt., *Donnellia commutata* (Müll.Hal.) W.R. Buck, and *Jirivanaea caespitosa* (Hedw.) U.B. Deshmukh & Rathor. The oblong leaves with recurved margins and the peristomal structure are unmistakable features of *M. boryanum* (Buck 1998; Evangelista-dos-Santos *et al.* 2021). This species presents a single peristome, with a hyaline, linear, non-trabeculate, scarcely papillose exostome (Evangelista-dos-Santos & Valente 2022b). In *D. commutata*, in turn, the leaves are lanceolate, the alar cells are scarcely inflated, and the endostome is reduced or absent (Buck 1998; Evangelista-dos-Santos *et al.* 2021). The leaves of *J. caespitosa* are oblong lanceolate and the alar cells are well developed (Evangelista-dos-Santos *et al.* 2021).

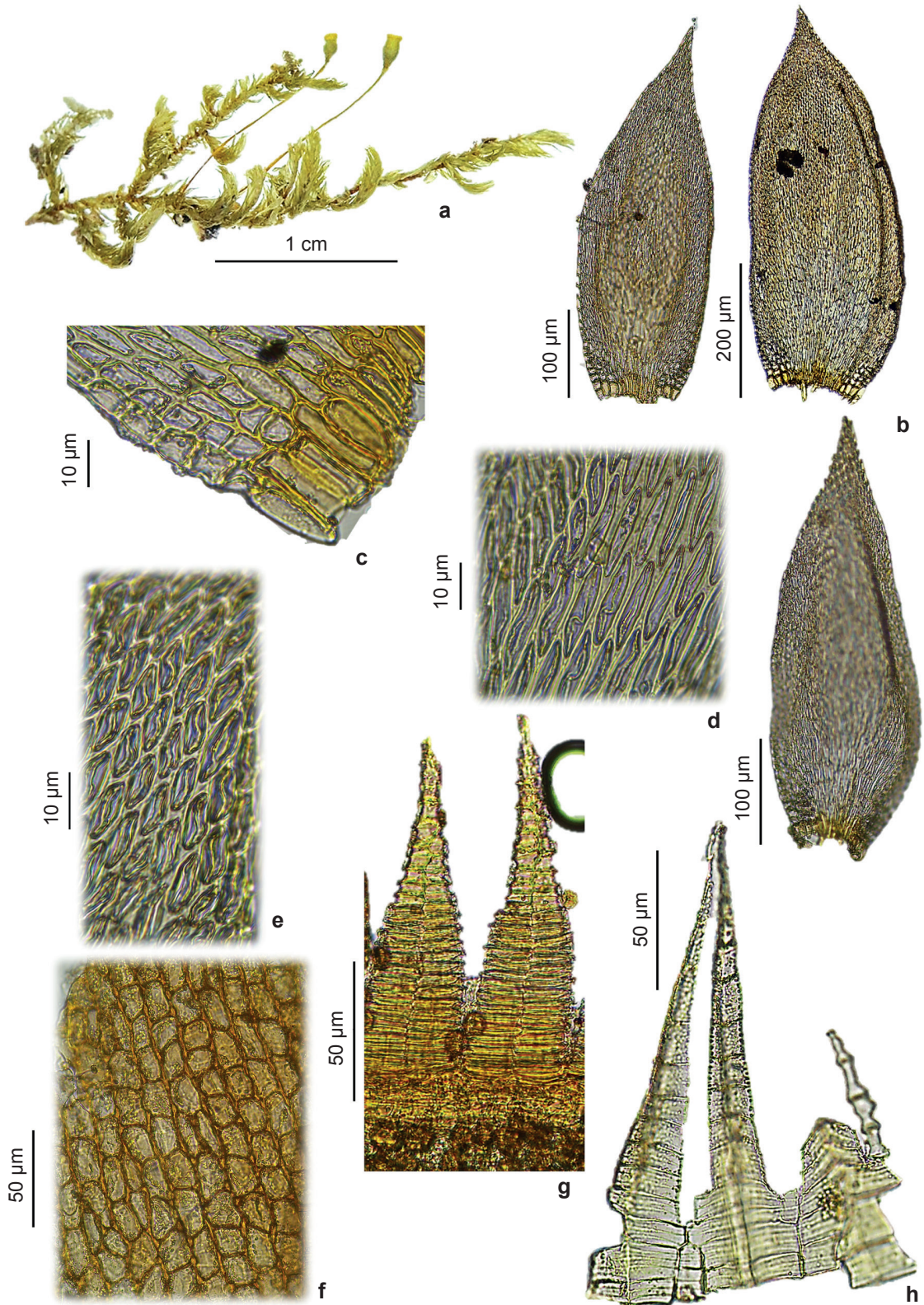


Figure 4 – a-h. *Brittonodoxa subpinnata* – a. gametophyte; b. leaves; c. alar cells; d. basal cells; e. apical cells; f. exothecial cells; g. exostome; h. endostome. (HUEFS 153881).

According to Görts-Van Rijn (1996), *B. subpinnata* grows preferably on exposed habitats, presenting curved branches and broad leaves. In habitats with higher humidity, the branches are erect and the leaves are patent-spreading, usually smaller and more slenderly ovate (Görts-Van Rijn 1996).

Brittonodoxa subpinnata is distributed in Brazil in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado, and Pampa. Here, we confirm the occurrence in the states of Acre, Alagoas*, Amazonas, Bahia, Ceará, Distrito Federal, Espírito Santo, Goiás, Maranhão, Minas Gerais, Mato Grosso, Pará, Paraíba, Paraná, Pernambuco, Piauí, Rio de Janeiro, Roraima, Rio Grande do Sul, Santa Catarina, Sergipe, and São Paulo. The species can be found in rainforests, rupestrian fields montane forests, restinga forests (sandy coastal plain vegetation), and igarapés (side channels of rivers), growing on decaying roots, base of trees, soil, rocks, or anthropic substrates at 83–1385 m alt.

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Data availability statement

In accordance with Open Science communication practices, the authors inform that all data are available within the manuscript.

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