

DIMAS MARCHI DO CARMO

Revisão das espécies neotropicais de
***Dicranella s.l.* (Dicranellaceae, Bryophyta)**

Tese apresentada ao Instituto de Botânica da Secretaria de Infraestrutura e Meio Ambiente, como parte dos requisitos exigidos para a obtenção do título de DOUTOR em BIODIVERSIDADE VEGETAL E MEIO AMBIENTE, na Área de Concentração de Plantas Avasculares e Fungos em Análises Ambientais.

SÃO PAULO

2019

DIMAS MARCHI DO CARMO

Revisão das espécies neotropicais de
***Dicranella s.l.* (Dicranellaceae, Bryophyta)**

Tese apresentada ao Instituto de Botânica da Secretaria de Infraestrutura e Meio Ambiente, como parte dos requisitos exigidos para a obtenção do título de DOUTOR em BIODIVERSIDADE VEGETAL E MEIO AMBIENTE, na Área de Concentração de Plantas Avasculares e Fungos em Análises Ambientais.

ORIENTADOR: DR. DENILSON FERNANDES PERALTA

Ficha Catalográfica elaborada pelo **NÚCLEO DE BIBLIOTECA E MEMÓRIA**

C287r Carmo, Dimas Marchi do
Revisão das espécies neotropicais de *Dicranella s.l.* (Dicranellaceae, Bryophyta) / Dimas Marchi do Carmo -- São Paulo, 2019.
140p.; il.

Tese (Doutorado) -- Instituto de Botânica da Secretaria de Infraestrutura e Meio Ambiente, 2019.
Bibliografia.

1. Briófitas. 2. Musgos. 3. Dicranidae. I. Título.

CDU: 582.32

*Dedico essa tese à minha família, aos meus
amigos, colegas botânicos e cientistas*

Tudo tem seu apogeu e seu declínio. (...) É natural que seja assim, todavia, quando tudo parece convergir para o que supomos o nada, eis que a vida ressurge, triunfante e bela!
(...) Novas folhas, novas flores, na infinita benção do recomeço!

- Chico Xavier -

AGRADECIMENTOS

Apesar de me considerar agnóstico, gostaria de agradecer a realização desta tese primeiramente à Deus, o/a qual em minha concepção, é definido/a por uma força superior que rege e realiza todas as outras forças e energias vitais e essenciais existentes em nosso mundo. Durante os momentos de dificuldade foi o/a meu/minha principal consolador/a e estimulador/a para que eu continuasse seguindo sempre em frente e superando todos os desafios impostos.

Ao Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) pela bolsa de estudos concedida durante o período de doutorado, bem como à Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) pela bolsa concedida durante o período de prorrogação de seis meses do doutorado.

Gostaria de agradecer ao Instituto de Botânica de São Paulo (IBt), local onde realizei meus experimentos científicos, participei das disciplinas de pós-graduação e fiquei a maior parte do tempo durante o doutorado trabalhando e estudando. Obrigado por disponibilizar toda a infraestrutura, apoio e condições oferecidas para que a realização desse projeto fosse concluída.

À toda comissão do conselho de Pós-Graduação e ao PPG (Programa de Pós-Graduação) em Biodiversidade Vegetal e Meio Ambiente do Instituto de Botânica pelo apoio a todos os alunos de pós-graduação, preocupação e trabalho nas questões burocráticas, pedidos de bolsas e outros incentivos financeiros para a realização dos projetos desenvolvidos.

Ao Dr. Denilson Fernandes Peralta, diretor do Núcleo de Pesquisas em Briologia e meu orientador. Muito obrigado por toda companhia, amizade, apoio, cumplicidade, conselhos, ensinamentos, confiança, respeito e tantas outras coisas boas que me foram proporcionadas que eu poderia passar horas aqui escrevendo. Obrigado pela dedicação de seu tempo e oportunidade dessa convivência maravilhosa em que terei apenas boas lembranças. Nada disso estaria acontecendo se não fosse por você, serei eternamente grato.

Ao Dr. Paulo Eduardo Aguiar Saraiva Câmara pela ajuda e disponibilização do Laboratório de Biologia Molecular de Plantas da Universidade de Brasília (UnB). Obrigado também pelos conselhos, pela amizade, companhia, preocupação, explicação, apoio e dedicação de seu tempo durante minhas visitas e estágio no laboratório molecular, bem como nas disciplinas oferecidas e realizadas que enriqueceram minha formação.

À Dra. Micheline Carvalho-Silva pela orientação prestada durante meu estágio no Laboratório de Biologia Molecular de Plantas da Universidade de Brasília (UnB), ajudando

e me ensinando a utilizar os produtos químicos, reagentes e equipamentos laboratoriais, bem como na parte de análise filogenética e principalmente nos estudos sobre o alinhamento das sequências de bases nitrogenadas do DNA. Muito obrigado pela paciência, companhia e gentileza durante suas explicações.

Ao Dr. Michael Stech, do Instituto Naturalis Biodiversity Center de Leiden, Holanda, pelos conselhos e sugestões sobre os tipos de marcadores moleculares (primers) que poderiam ser utilizados em nosso projeto, bem como a parceria, as conversas, os estímulos e incentivos, as explicações e orientações referentes ao grupo de estudo e suas aplicações na biologia molecular.

À Dra. Sandra Regina Visnadi pelas conversas compartilhadas, momentos de descontração, conselhos, simpatia, companhia e ajuda sempre que requisitada como no fornecimento de materiais, referências bibliográficas e experiências.

Às representantes e membros de composição da minha banca de qualificação, Dra. Adriana Gugliotta, Dra. Regina Hirai e Dra. Anna Luiza Ilkiu Borges Benkendorff. Muito obrigado pelas sugestões, conselhos, modificações e explicações referentes ao tema e ao projeto que contribuíram e enriqueceram ainda mais o conteúdo desse trabalho.

À minha família, minha base de tudo, meu abrigo, meu conforto e minha paz. Muito obrigado Maristela (mãe), Silas (irmão) e Sidnei (pai). Sem vocês eu literalmente não seria nada. Não existem palavras para expressar minha gratidão e meu amor por todos vocês durante essa caminhada científica. Obrigado por me apoiarem sempre em todos os sentidos.

Aos meus queridos amigos conquistados durante o doutorado e que estarão sempre comigo. Muito obrigado família Briologia: Jéssica Soares de Lima, Marina Lemy Koga, Leandro de Almeida Amélio, Emanuelle Laís dos Santos, Aline Matos de Souza, Bianca Kalinowski Canestraro, Douglas Santos Oliveira, Gledson Julio da Silva e Juliana Leandro da Silva. Muito obrigado pela amizade de vocês, momentos de diversão e risadas, companhia, conversas produtivas (assim como as improdutivas também), pelos cafezinhos, bolachas, bolos, tortas, pães, salgados, guacamoles e toda “comilança” famosíssima da nossa seção.

Agradeço também aos meus queridos amigos do Herbário, em especial ao Rodrigo Sampaio Rodrigues, Marcela Inácio da Silva e Víctor Martins Gonzalez por toda companhia, amizade, momentos de descontração e risadas, “rolêzinhos” na paulista, festas, baladas, barzinhos, aniversários, praias, conversas e comidas. Agradeço também sempre o apoio na revisão de artigos, literaturas, conselhos e da convivência amistosa.

Aos amigos sempre presentes desde a minha adolescência até os dias de hoje, sempre me proporcionando altas risadas e momentos inesquecíveis de diversão, descontração, conversas, alegrias e apoio, muito obrigado Lari, Dê, Léo, Rê, Bruno, Will e minha

amiga/irmã/madrinha/alma gêmea Karen “Skévellers”, que mesmo longe sempre me liga, se importa comigo e me pergunta como estou, muito obrigado pela amizade de vocês, amo todos vocês.

Às minhas queridas amigas da faculdade Gabriela Pirani (Larika), Caroline Caetano (Salafrária), Dalila Rosatelli (Dá-lá) e Mariane Nascimento (Perrê-Kuxa), que mesmo após tantos anos de nossa graduação e formatura, estiveram comigo compartilhando momentos bons e ruins, conversando, lembrando e revivendo os melhores anos de nossas vidas e ansiando pelos próximos momentos maravilhosos que virão. Agradeço também à querida amiga, pesquisadora e atual curadora do herbário da Universidade Federal do ABC, Luana de Souza Prochazka, a menina que me ensinou como ser uma pessoa “bo-ni-ta”, jamais me esquecerei disso.

Gostaria de agradecer também às amigas Tamara Silva Dantas, Júlia Viegas Mundim, Daiane Valente e Tamara Poliana pelo auxílio durante minha estadia em Brasília, oferecendo apoio em relação à reserva do alojamento, alimentação no restaurante universitário, estudos e explicações durante as análises laboratoriais, além da companhia, momentos de diversão, descontração, lazer e conversas. Obrigado também ao Marcos Cunha por ter me ajudado, acompanhado e socorrido nos momentos em que mais precisei de ajuda. Ao querido André Moreira (Baba) por ter me divertido, se preocupado e por me deixar à vontade nos momentos em que me sentia desconfortável ou chateado com alguma coisa.

Obrigado também aos docentes que ministraram as disciplinas durante o período de doutorado e que contribuíram para o meu conhecimento e formação atual. Aos técnicos e funcionários do Instituto de Botânica, em especial ao Lauro Quaresma, por toda ajuda prestada quando solicitada, Luciana Benatti por me acompanhar e ajudar nas análises palinológicas de microscopia eletrônica de varredura (MEV), Kauê Fonseca por ajudar e me acompanhar nas análises microscópicas de medidas das briófitas, além das conversas e momentos de descontração e à Shirlei Soares Dassi, sempre prestativa, paciente e nos auxiliando na secretaria da PPG.

E finalmente, gostaria de agradecer a todos aqueles que contribuíram de alguma maneira direta ou indireta para a realização desse projeto, mas que infelizmente neste momento não foram citadas, gostaria de deixar os meus sinceros agradecimentos.

Resumo: (Revisão das espécies neotropicais de *Dicranella s.l.* (Dicranellaceae)). A brioflora da América Tropical é extremamente rica, sendo o norte dos Andes e o sudeste do Brasil as regiões com as maiores taxas de riqueza e endemismo. Para o Neotrópico, ainda existem áreas e grupos taxonômicos pouco explorados em relação ao quanto elas representam em biodiversidade mundial. O gênero *Dicranella* (Müll. Hal.) Schimp. estava tradicionalmente classificado na família Dicranaceae Schimp. baseando-se principalmente em caracteres morfológicos, no entanto, com o surgimento dos estudos moleculares e filogenéticos, as relações de parentesco, evolução e posição desse gênero permanecem incertas, necessitando de novas circunscrições. Atualmente, com base em dados moleculares e morfológicos, o gênero *Dicranella* está incluído na família Dicranellaceae Stech. e apresenta aproximadamente 158 espécies existentes no mundo e 40 espécies no Neotrópico. Contudo, apesar do elevado número de espécies existentes, ainda existe elevada carência de dados morfológicos e moleculares e nenhuma revisão taxonômica que verifique a validade do gênero, de seus sinônimos relacionados e de suas espécies descritas até o momento. Dessa maneira, com este projeto, temos como proposta de trabalho apresentar uma revisão taxonômica das espécies de *Dicranella s.l.* por meio de estudos nomenclaturais, morfológicos e moleculares para os táxons registrados no Neotrópico. A partir de referências bibliográficas consultadas, empréstimos de herbários nacionais e internacionais, consultas de materiais tipo e análises morfológicas foi possível realizar agrupamento utilizando o software PAST. Tivemos como resultados 634 espécimes analisados e o reconhecimento de 57 espécies de *Dicranella* ocorrentes no Neotrópico. Além disso, das 57 espécies encontradas na região neotropical, 50 apresentaram modificações em relação ao seu *status* taxonômico e nomenclatural, sendo necessário designar 42 lectótipos e 14 prováveis holótipos envolvendo o nome dessas espécies e de alguns sinônimos heterotípicos relacionados. A espécie *Dicranella hilariana* (Mont.) Mitt., até então considerada cosmopolita e com ampla plasticidade morfológica, a partir de análises nomenclaturais e morfológicas de seu material tipo, apresentou uma distribuição geográfica reduzida, bem como uma caracterização definitiva e padronizada de seus aspectos morfológicos. Para o Brasil foram consideradas 14 espécies de *Dicranella*, sendo oito endêmicas do Brasil, três novas ocorrências (*D. angustifolia*, *D. apolensis* e *D. harrisii*) para o país e mais de 40 novas ocorrências registradas nos estados brasileiros, já que oito espécies eram conhecidas apenas pela ocorrência de seu material tipo e todas as demais espécies tiveram sua distribuição geográfica no país aumentada. As espécies de *Dicranella* ocorrentes no Brasil apresentam hábito preferencialmente terrícola (59%) e maior ocorrência no domínio fitogeográfico da Mata Atlântica (54%). Uma filogenia, com base no marcador plastidial *rps4* e análises de

parcimônia, é apresentada pela primeira vez nesta tese para a família Dicranellaceae e alguns táxons de *Dicranella* ocorrentes no Brasil. Como resultado dessa análise filogenética, foi possível observar que as espécies de *Dicranella* que ocorrem no Brasil não pertencem ao mesmo clado de *Dicranella sensu stricto*, ou seja, saíram em um clado diferente do qual a espécie tipo do gênero está inserida. Também baseado nas análises morfológicas e moleculares, neste trabalho nós propomos sinonimizações entre algumas espécies de *Dicranella*, podendo ser citadas como exemplo a sinonimização de *D. martiana* em *D. hilariana*, além das sinonimizações de *D. riograndensis* e *D. boliviana* para *D. pabstiana*. A realização desse projeto permitiu preencher algumas lacunas de conhecimento das espécies de *Dicranella* ocorrente no Neotrópico, porém, mais estudos aprofundados são necessários, de preferência abrangendo também outras áreas da ciência biológica como a Ecologia, Palinologia e Ontogenia das espécies de *Dicranella s.l.*

Palavras-chave: Dicranidae, Dicranales, Taxonomia, Filogenia, musgos haplolepídeos.

Abstract: (Review of *Dicranella s.l.* (Dicranellaceae) neotropical species). The America Tropical bryoflora is extremely rich, being the Andes northern and Brazilian southeastern the regions with the highest richness and endemism rates. For the Neotropic, there are areas and taxonomic groups that remains scarcely explored in relation to the how much they represent in the biodiversity worldwide. The *Dicranella* (Müll. Hal.) Schimp. genus was traditionally classified in the Dicranaceae Schimp. family based mainly on morphological characters, however, with the increasement of molecular and phylogenetic studies, the parental relationships, evolution and position of this genus remains uncertain, requiring new circumscriptions. Currently, based on molecular and morphological data, the *Dicranella* genus is included in the Dicranellaceae Stech. family and has approximately 158 species worldwide and 40 species for the Neotropic. However, despite the high number of recorded species, there is a lack of morphological and molecular data and no taxonomic revision to verify the genus validity, its related synonyms and its described species so far. Thus, with this project, we aim to present a taxonomic revision of the *Dicranella s.l.* species through nomenclatural, morphological and molecular studies for the taxa registered in the Neotropic. Through of consulted bibliographies references, national and international herbaria loans, material type consultations and *clustering* morphological analysis performed by the PAST software, we obtained a total of 634 specimens analyzed and a conclusion of 57 *Dicranella* species occurring to the Neotropic. In addition, of the 57 species found in the neotropical region, 50 presented modifications in relation to their taxonomic and nomenclatural status, requiring 42 lectotypes and 14 probable holotypes involving the name of these species and some their related heterotypic synonyms. The *Dicranella hilariana* (Mont.) Mitt. species, until then were considered cosmopolitan and with high morphological plasticity, through of nomenclatural and morphological analysis of its material type, presented a reduced geographical distribution, as well as a definitive and standardized characterization of its morphological aspects. For Brazil, 14 *Dicranella* species were considered, with eight endemic from Brazil, three new occurrences (*D. angustifolia*, *D. apolensis* and *D. harrisii*) for the country and more than 40 new occurrences recorded in the Brazilian states, since eight species were known only by the occurrence of their material type and all other species had their geographical distribution in the country increased. The *Dicranella* species occurring in Brazil had preference to the terrestrial substrate (59%) and distribution in the Atlantic Forest phytogeographic domain (54%). A phylogeny, based on the plastidial marker *rps4* and parsimony analysis, is presented herein for the first time in this thesis for the Dicranellaceae family and some *Dicranella* taxa that occur in Brazil. As a result of this phylogenetic analysis, it was observed that the *Dicranella* species which occur in Brazil do not belong to

the same clade of *Dicranella sensu stricto*, that is, they came out in a different clade from which the genus species type is inserted. Also based on the morphological and molecular analysis, in this work we proposed likely synonyms among some *Dicranella* species, which could be represented such as the synonymization of *D. martiana* in *D. hilariana*, in addition the synonymization of *D. riograndensis* and *D. boliviana* to *D. pabstiana*. The achievement of this project allowed to fill some gaps knowledge about *Dicranella* species occurring in the Neotropic, however, further studies are needed, primarily including other biological science areas such as Ecology, Palynology and Ontogeny to *Dicranella s.l.* species.

Key-words: Dicranidae, Dicranales, Taxonomy, Phylogeny, haplolepidous mosses

SUMÁRIO

Agradecimentos.....	i
Resumo.....	iv
Abstract.....	vi
1. Introdução Geral.....	01
1.2. Histórico taxonômico do gênero <i>Dicranella</i>	05
2. Objetivos Gerais.....	08
3. Material e Métodos	08
3.1. Delimitação morfológica	08
3.2. Delimitação filogenética.....	10
4. Resultados.....	11
4.1. The identity of <i>Dicranella hilariana</i> (Mont.) Mitt.....	12
4.2. The <i>Dicranella</i> (Müll. Hal.) Schimp. (Dicranellaceae, Bryophyta) genus in Brazil...24	
4.3. A type catalog and a checklist of <i>Dicranella</i> species from Neotropic (Dicranellaceae, Bryophyta).....	63
4.4. Phylogenetic analyses of <i>Dicranella</i> (Müll. Hal.) Schimp. (Dicranellaceae, Bryophyta) in Brazil using the plastid gene <i>rps4</i>	102
4.5. Resultados Gerais.....	114
5. Considerações Finais.....	120
6. Referências complementares.....	122

1. Introdução Geral

A brioflora da América Tropical é extremamente rica, com aproximadamente 4.000 espécies, sendo 2.600 musgos, 1.350 hepáticas e 30 antóceros, distribuídas em 595 gêneros e 120 famílias, sendo o norte dos Andes e o sudeste do Brasil as regiões com as maiores taxas de riqueza e endemismo (Gradstein *et al.* 2001). A região Neotropical, apesar de sua grande extensão territorial, possui áreas ainda pouco exploradas em relação ao conhecimento da diversidade de briófitas, apresentando registros de uma ou poucas coletas em locais isolados e específicos (Crosby *et al.* 1999, Gradstein *et al.* 2001). Em relação à riqueza de *Dicranella* (Müll. Hal.) Schimp., existem aproximadamente 40 espécies registradas para a região Neotropical, porém, acredita-se que esse número pode chegar a 20 ou menos, uma vez que as espécies do gênero nunca foram revisadas (Gradstein *et al.* 2001).

No Brasil, está sendo realizado o levantamento das informações sobre as coleções de briófitas depositadas nos herbários e disponibilizadas através do Herbário Virtual da Flora e dos Fungos (<http://inct.florabrasil.net/>). Através desta iniciativa, é possível identificar as lacunas no conhecimento dos grupos de modo a facilitar o direcionamento dos estudos taxonômicos. O tratamento sistemático para alguns grupos de briófitas brasileiras é dificultado pela falta de informações, especialmente sobre o material tipo, além das dificuldades na identificação básica da morfologia. Na elaboração da listagem das espécies de briófitas do Brasil, por exemplo, inúmeros autores excluíram vários binômios conhecidos apenas pelo material tipo que não puderam ser revisados (Costa *et al.* 2011).

O gênero *Dicranella* (Müll. Hal.) Schimp. estava tradicionalmente circunscrito na família de musgos Dicranaceae Schimp. baseado em características morfológicas, entre as quais destacam-se os dentes do peristômio simples e bifurcados, características presentes no esporófito da planta (Allen 1994, Crum 1994, 2007, Ireland 2007, Ochyra *et al.* 2008). No entanto, com o advento dos estudos moleculares e filogenéticos, que levam em consideração as relações de parentesco e evolução dos organismos, foi observado que Dicranaceae constitui uma família parafilética e, dessa forma, um grupo “artificial”, sendo necessária uma revisão para esse grupo (Stech 1999, La Farge *et al.* 2000, 2002, Hedderson *et al.* 2004, Cox *et al.* 2010, Stech *et al.* 2012).

Na taxonomia sempre procuramos trabalhar com grupos monofiléticos, também chamados de grupos “naturais”, sendo assim, iremos considerar o gênero *Dicranella* incluído na família Dicranellaceae, constituindo um clado monofilético proposto por Stech & Frey (2008) baseado em estudos morfo-moleculares. A família Dicranellaceae é caracterizada por incluir plantas pequenas em tufos, gametófitos acrocápicos, seção transversal do caulídio

apresentando uma banda central de estereódeos. Filídios apressos ou ereto-espalhados, frequentemente flexuosos ou falcado-secundos, estreitamente lanceolados e frequentemente subulados, células da lâmina retangulares, lisas, células alares não diferenciadas, costa única, simples, estreita, sub-percurrente a percurrente, tipo-*Dicranum*, estereódeos em várias camadas, plantas dióicas ou autóicas, seta alongada, lisa, ereta ou sinuosa, caliptra cuculada, cápsula ereta a horizontal, simétrica, estrumosa, ovóide a curto-cilíndrica, lisa ou plicada, opérculo cônico a longo-rostrado, peristômio dicranóide, esporos, geralmente, papilosos (Frey & Stech 2009).

Alguns trabalhos já consideram *Dicranella* em Dicranellaceae (Frey & Stech 2009, Costa *et al.* 2011). A família apresenta cinco gêneros: *Bryotestua* Thér. & P.de La Varde (duas espécies), *Campylopodium* (Müll. Hal.) Besch. (quatro espécies), *Dicranella* (Müll. Hal.) Schimp. (158 espécies), *Leptotrichella* (Müll. Hal.) Lindb. (60 espécies) e *Microcampylopus* (Mull. Hal.) Fleisch. (quatro espécies), somando aproximadamente, 230 espécies distribuídas mundialmente (Frey & Stech 2009, Costa *et al.* 2011).

O gênero *Dicranella* representa, aproximadamente, 70% das espécies presentes na família Dicranellaceae, oscilando entre 100–158 espécies distribuídas mundialmente e, provavelmente, entre 20-40 espécies registradas na região Neotropical (1% do total de espécies de briófitas do Neotrópico e entre 20% - 25% das espécies de *Dicranella*), sendo encontrada desde altitudes a nível do mar até áreas montanhosas (4.400 m alt.), crescendo principalmente em solos expostos, barrancos de terra ou areia e sobre a rochas (Gradstein *et al.* 2001, Frey & Stech 2009).

Atualmente, são consideradas apenas três espécies de *Dicranella* ocorrentes no Brasil: *Dicranella guilleminiana* (Mont.) Mitt., *Dicranella hilariana* (Mont.) Mitt e *Dicranella vaginata* (Hook.) Cardot., sendo encontradas em praticamente todos os estados brasileiros, com exceção de Alagoas, Piauí, Rio Grande do Norte, Sergipe e Distrito Federal (Costa *et al.* 2011). No catálogo elaborado por Yano (2011), foram registradas 20 espécies de *Dicranella* existentes para o Brasil, contudo o *voucher* (material testemunho) dessas espécies não foi citado e algumas delas são conhecidas apenas pela existência de seu material tipo, ressaltando, dessa maneira, a necessidade de um trabalho de revisão para essas espécies.

O gênero *Dicranella* ainda apresenta algumas dificuldades para a identificação de suas espécies e não está bem definida em relação aos caracteres morfológicos, apresentando uma delimitação confusa ou praticamente impossível, caso o material esteja infértil (Allen 1994, Crum 1994, 2007, Ochyra *et al.* 2008). Geralmente, caracteriza-se pelo pequeno hábito, normalmente 1-2 cm, filídios eretos a eretos-espalhados, secundos a flexuosos, seta lisa e ereta, dentes do peristômio papilosos na parte distal, entretanto essas características ainda são

insuficientes e não exclusivas do gênero, apresentando sobreposição entre demais táxons (Frey & Stech 2008, Stech & Frey 2009, Stech *et al.* 2012). Essa dificuldade de posicionar o gênero, conforme os sistemas de classificação e as bibliografias existentes, pode estar refletida em consequência do momento em que a ciência taxonômica está vivenciando, essa dualidade existente entre as áreas da filogenia e da morfologia sistemática.

Além disso, usar como principais características taxonômicas a formação e ontogenia do peristômio pode ser arriscado, uma vez que suas estruturas talvez não estejam formadas e ainda apresentam pouco conhecimento sobre o seu desenvolvimento e validade em relação ao histórico evolutivo nessas espécies. O gênero *Dicranella* está inserido na subclasse Dicranidae, a qual se caracteriza pelos musgos haplolepídeos, ou seja, musgos que possuem uma camada, fileira, ou anéis de dentes do peristômio presentes no esporófito (Edwards 1984, La Farge *et al.* 2000, Hedderson *et al.* 2004). Segundo estudos moleculares, acredita-se que os musgos haplolepídeos tiveram origem de um ancestral diplolepídeo (duas camadas, fileiras ou anéis de dentes do peristômio), porém por motivos ainda em estudo, essa segunda camada foi perdida, reduzida ou não desenvolvida (Hedderson *et al.* 2004, Stech & Frey 2008, Cox *et al.* 2010, Stech *et al.* 2012). Essa informação, em relação à ontogenia do peristômio, ainda era desconhecida no período da descrição de novas espécies e não foi levada em consideração entre os musgos haplolepídeos, resultando ainda mais em identificação e classificação confusa e difícil para essas espécies.

Essa falta de delimitação das espécies do gênero *Dicranella* pode ser refletida e observada nos trabalhos em que os autores posicionam o gênero *Dicranella* na família Dicranaceae, podendo variar de nível hierárquico intrafamiliar conforme cada autor (Fleischer 1901-1902, Brotherus 1924, Dixon 1932, Hermann 1976, Walther 1983, Allen 1994, Crum 1994, Crosby *et al.* 1999, Gradstein *et al.* 2001, Crum 2007, Ochyra *et al.* 2008, Goffinet *et al.* 2009, Yano 2011, Carmo & Peralta 2016, Carmo *et al.* 2016, Santos *et al.* 2017, Carmo *et al.* 2018). Enquanto outros colocam o gênero em uma família monotípica, a família Dicranellaceae (Frey & Stech 2009, Larraín *et al.* 2010, Costa *et al.* 2011, Stech *et al.* 2012), com a sustentação de características morfológicas como o peristômio do esporófito do tipo dicranóide, ou seja, com dentes do peristômio haplolepídeos, sendo caracterizados com 16 dentes do peristômio, simples, bifurcados e com trabéculas ventrais mais espessas do que as dorsais (Luizi-Ponzo *et al.* 2006).

Os gêneros *Anisothecium* Mitt., *Bartleya* H. Rob., *Campylochaetium* Besch., *Diobelon* Hampe, *Leptotrichella* (Müll. Hal.) Lindb e *Microdus* Schimp. ex Besch. correspondem a nomes genéricos validamente publicados e, sobre aplicação de características morfológicas, são considerados por vários autores como sinônimos de

Dicranella (Scott & Stone 1976, Corley *et al.* 1981, Crosby & Magill 1981, Nakaniwa 1984, Allen 1994, Crum 1994, Ochyra 1997, Crum 2007, Ochyra *et al.* 2008, Schatz *et al.* 2019). Porém, até o momento, não existe nenhuma revisão mundial para *Dicranella* ou informações sobre sua relação e validação filogenética com esses gêneros relacionados e sinonimizados em virtude da elevada plasticidade morfológica, identificações errôneas e pelo elevado número de espécies existentes (Allen 1994, Crum 1994, Gradstein *et al.* 2001, Crum 2007, Ochyra *et al.* 2008, Frey & Stech 2009, Stech *et al.* 2012).

Stech (1999), La Farge *et al.* (2000, 2002), Hedderson *et al.* (2004), Frey & Stech (2009), Cox *et al.* (2010) e Stech *et al.* (2012) afirmam ainda que Dicranaceae e seus integrantes, nesse caso incluindo *Dicranella*, são polifiléticos e, ao contrário de Goffinet *et al.* (2009) que reconhece a família como monofilética, este grupo ainda precisa ser melhor estudado e circunscrito. Stech & Frey (2008) decidiram elevar a subfamília Dicranelloideae Lindb. Para Dicranellaceae Stech, visando a monofilia da família, discutindo ainda que a circunscrição da subfamília Dicranelloideae é difícil devido à pequena amostragem existente na inclusão de análises moleculares. Porém apontam que as espécies *Dicranella cerviculata* (Hedw.) Schimp *D. heteromalla* (Hedw.) Schimp., bem como o gênero *Campylopodium* e *Microcampylopus*, aparecem claramente separados de Dicranaceae *s.str.* em todos os últimos trabalhos envolvendo ferramentas moleculares (Stech 1999, La Farge *et al.* 2000, 2002, Hedderson *et al.* 2004, Tsubota *et al.* 2004, Stech 2004, Stech *et al.* 2012).

As espécies neotropicais de *Dicranella* representam uma riqueza significativa, uma vez que possuem 1/4 de suas espécies estimadas para o mundo (Gradstein *et al.* 2001, Frey & Stech 2009) e mesmo com essa importância em destaque, até o momento nenhum estudo aprofundado e focado nessas espécies foi realizado para essa região. Sendo assim, levando em consideração que Dicranellaceae é uma família recente (Stech & Frey 2008) e que apenas seis espécies de *Dicranella* (o maior gênero da família com 70% das espécies) foram incluídos nos estudos moleculares, consideramos fundamental estudar este gênero que possui elevado número de espécies neotropicais. Além disso, em virtude de muitos autores não considerarem os gêneros *Anisothecium*, *Leptotrichella*, *Metzleria* e *Microdus*, estamos considerando para este projeto *Dicranella s.l.* para incluir nas análises as espécies com a delimitação duvidosa, bem como verificar a validade dos sinônimos descritos com *Dicranella*.

1.2. Histórico taxonômico do gênero *Dicranella*

Antes de começar a descrever um pouco sobre o histórico taxonômico do gênero e mostrar a problemática envolvida quanto à sua classificação, gostaria de ressaltar que para todos os nomes corretos de espécies vegetais existentes, é necessário a existência de um “material tipo”, ou seja, a presença de uma exsiccata ou espécime testemunho em que aquele nome foi baseado. Para o material tipo que está designando o nome de uma determinada espécie, padroniza-se que este material (conjunto de espécimes, exsiccatas ou amostras) caracteriza e representa uma “espécie-tipo”. Sendo assim, atualmente a espécie-tipo do gênero nomeado *Dicranella* (Müll. Hal.) Schimp. é a espécie *Dicranella heteromalla* (Hedw.) Schimp, a qual foi descrita a partir do basônimo *Dicranum heteromallum* Hedw., de Johann Hedwig em 1801 na obra *Species Muscorum Frondosorum: descriptae et tabulis aeneis lxxvii coloratis illustratae* (Hedwig 1801). Essa obra realizada pelo botânico alemão, também conhecido como o “pai da Briologia”, é considerada o marco inicial para os estudos taxonômicos de briófitas, onde segundo o Código Internacional de Nomenclatura para Algas, Fungos e Plantas, todos os nomes de espécies de briófitas descritos anteriores à 1 de janeiro de 1801 devem ser considerados inválidos (Turland *et al.* 2018).

O gênero *Dicranella* (Müll. Hal.) Schimp. foi descrito pelo botânico e paleontólogo francês Guillaume Wilhelm Philipp Schimper em 1856 na obra *Corollarium Bryologiae Europaeae*. O autor usou como base para sua descrição a seção do gênero *Aongstroemia* sect. *Dicranella* estabelecida em 1848 pelo briologista alemão Johann Karl Müller, na obra *Synopsis Muscorum Frondosorum omnium hucusque Cognitorum*, onde este gênero estava classificado na família Leptotrichaceae Schimp. (Müll. Hal. 1848), a qual atualmente se encontra ilegítima, uma vez que sua origem e consolidação nomenclatural foi baseada em uma espécie-tipo inválida, no caso o gênero *Leptotrichum* Hampe ex Müll. Hal. (Turland *et al.* 2018). Porém, antes disso, o gênero *Dicranella* apresentou muitas alterações sobre a sua classificação e circunscrição que até hoje permanecem indefinidas, contraditórias e ainda não resolvidas.

Até o momento, o gênero possui seis sinônimos descritos que ainda não se conhece a relação e a validade entre eles, sendo representados por *Anisothecium*, *Bartleya*, *Campylochaetium*, *Diobelon*, *Leptotrichella* e *Microdus* (Scott & Stone 1976, Corley *et al.* 1981, Crosby & Magill 1981, Nakaniwa 1984, Allen 1994, Crum 1994, Ochyra 1997, Crum 2007, Ochyra *et al.* 2008, Schatz *et al.* 2019). A espécie-tipo de *Aongstroemia* sect. *Dicranella* é *Aongstroemia heteromalla* (Hedw.) Müll. Hal., uma combinação para a espécie obtida a partir do basônimo *Dicranum heteromallum* Hedw. No entanto, para a descrição do gênero

Dicranella, nenhum tipo havia sido selecionado por Schimper até então, o que de acordo com Código Internacional de Nomenclatura para Algas, Fungos e Plantas torna esse nome um nome inválido (Turland *et al.* 2018). Mas então como que o nome *Dicranella* surgiu e se estabeleceu?

Primeiramente, Schimper designou a espécie *Dicranella varia* (Hedw.) Schimp. como a espécie-tipo do gênero *Dicranella* (Müll. Hal.) Schimp. em 1860 (Schimper 1860), quatro anos após a publicação do gênero em *Corollarium Bryologiae Europaeae* (Schimper 1856). O problema desse evento aconteceria somente nove anos após quando o químico farmacêutico inglês William Mitten descreveria o gênero *Anisothecium* Mitt. utilizando como espécie-tipo do gênero a espécie *Anisothecium varium* (Hedw.) Mitt., a qual possui o mesmo basônimo de *Dicranella varia* (Hedw.) Schimp. (Mitten 1869). Dessa forma, o gênero *Anisothecium* Mitt. torna-se conseqüentemente um nome ilegítimo, pois a descrição do gênero *Anisothecium* Mitt. (Mitten 1869) foi baseada em um sinônimo do basônimo de *Dicranella* (Müll. Hal.) Schimp., resultando então na determinação do nome *Anisothecium* em um homotípico (Scott & Stone 1976, Corley *et al.* 1982, Margadant & Geisler 1995, Crum 2007), conseqüências que infringem as normas do Art. 6.4 e Art. 7 do Código Internacional de Nomenclatura para Algas, Fungos e Plantas (Turland *et al.* 2018).

Sendo assim, para evitar o enorme trabalho de mudar todos os nomes de espécies de *Dicranella* e *Anisothecium* que já haviam sido descritos, optou-se então pela permanência do nome do gênero *Dicranella* ao designar uma nova espécie-tipo, ou seja, foi realizada uma proposta para a conservação do nome *Dicranella* (Margadant & Geissler 1995). Dessa maneira, a espécie *Dicranella heteromalla* (Hedw.) Schimp. descrita lá em 1856 por Schimper foi a espécie escolhida, designada e aceita como lectótipo (Margadant 1972, Margadant & Geissler 1995). Outro caso curioso de proposição de espécie-tipo para o gênero *Dicranella*, foi quando o naturalista americano Robert Statham Williams designou para o gênero a espécie-tipo *Dicranella grevilliana* (Brid.) Schimp., (Williams 1913), a qual também é uma combinação nova de *Anisothecium grevillianum* (Brid.) Broth. Após muitos anos de negligenciamento da proposta feita por Schimper em 1860. Diante disso, já é possível imaginar a confusão nomenclatural existente entre as espécies envolvidas e a ênfase da necessidade de revisão taxonômica contida neste projeto.

Além de descrever o gênero *Dicranella*, Guillaume Wilhelm Philipp Schimper em 1856 na obra *Corollarium Bryologiae Europaeae*, descreveu uma nova família para abrigar diversos táxons, inclusive espécies de *Dicranella*, a qual ele nomeou como Dicranaceae por inúmeras características distintivas, dentre elas podemos citar o crescimento acrocárpico com caulídios frequentemente tomentosos; costa dos filídios frequentemente estreitas, seção

transversal da costa apresentando camadas diferenciadas em estereóides e/ou hialocistos e dentes do peristômio comumente haplolepídeos (Schimper 1856, Allen 1994, Crum 1994, Gradstein *et al.* 2001, Ireland 2007, Crum 2007, Ochyra *et al.* 2008). Sendo assim, os representantes de *Dicranella* que estavam circunscritos anteriormente na família Leptotrichaceae, passaram para a nova família Dicranaceae. Quando Schimper descreveu essa nova família, ele incluiu ao todo 49 espécies, sendo nove dentro do gênero *Dicranella*, representadas por: *D. cerviculata* (Hedw.) Schimper, *D. crispera* (Hedw.) Schimper, *D. curvata* (Hedw.) Schimper, *D. grevilliana* Schimper, *D. heteromalla* (Hedw.) Schimper, *D. rufescens* (Dicks.) Schimper, *D. schreberi* Schimper, *D. subulata* (Hedw.) Schimper e *D. varia* (Hedw.) Schimper (Schimper 1856).

Porém em 1848, Johann Karl Müller colocou as espécies de *Dicranella* dentro da seção de gênero *Aongstroemia* na família Leptotrichaceae, a qual foi utilizada como base para a descrição do gênero *Dicranella* por Schimper em 1856. Os representantes de *Dicranella* também já foram incluídos na família Aongstroemiaceae De Not. Na obra do alemão Georg Ernst Ludwig Hampe em 1879 (Hampe 1879), onde os autores fizeram referências de espécies de *Dicranella* com citações de descrições das espécies feitas em 1819 na *Flora Brasiliensis*. Enfim, tentando resumir de uma maneira prática, as espécies do gênero *Dicranella* já foram “definidas” e classificadas diversas vezes em diferentes famílias ao longo de seu histórico nomenclatural e taxonômico, permanecendo até os dias de hoje sem uma circunscrição definitiva que inclua todas as suas espécies, constituído assim um grupo artificial.

Como meio para amenizar esse problema, dois pesquisadores alemães Michael Stech e Wolfgang Frey em 2008 elevaram a hierarquia taxonômica da subfamília Dicranelloideae Lindb. para a criação de uma nova família denominada por eles de Dicranellaceae Stech, a qual possui ainda pouca sustentação, escassez de amostragem de espécies e carência de dados moleculares e morfológicos (Stech & Frey 2008, Frey & Stech 2009, Stech *et al.* 2012). No entanto, essa classificação proposta será a qual iremos utilizar para a apresentação desse trabalho como forma de apresentação e sustentação para os estudos e resultados desse projeto.

Atualmente, a família apresenta aproximadamente cerca de 230 espécies mundialmente distribuídas (Frey & Stech 2009). Por apresentar espécies extremamente pequenas, de difícil identificação, sem nenhuma revisão taxonômica ou circunscrição bem estabelecida, o gênero *Dicranella* estava sendo tradicionalmente incluso na família Dicranaceae mesmo em trabalhos recentemente publicados (Crum 2007, Ochyra *et al.* 2008, Goffinet *et al.* 2009, Yano 2011, Carmo & Peralta 2016, Carmo *et al.* 2016, Santos *et al.*

2017, Carmo *et al.* 2018). Porém, como dito anteriormente, a família Dicranaceae mostrou-se polifilética e muitos grupos foram formados à níveis hierárquicos intermediários de subclasses ou de subfamílias que ainda permanecem indefinidos (Brotherus 1924, Walther 1983, Frahm 1991, Stech 1999, La Farge *et al.* 2000, 2002, Stech & Frey 2008, Cox *et al.* 2010, Stech *et al.* 2012), o que levou à uma dificuldade maior de posicionar esse gênero considerando seus aspectos morfológicos, moleculares e evolutivos.

Sendo assim, estudar a taxonomia e a filogenia desse importante gênero de musgos no Neotrópico, e que ainda não possui uma revisão, é o que está sendo proposto neste trabalho. Dessa forma, contribuímos com um estudo das espécies de *Dicranella s.l.*, fornecendo informações atualizadas sobre a taxonomia, morfologia, filogenia, evolução e distribuição geográfica das espécies de *Dicranella* para o Neotrópico.

2. Objetivos Gerais

- Revisar a taxonomia dos binômios de *Dicranella s.l.* citados para o Neotrópico, definindo os caracteres morfológicos informativos para identificar as espécies;
- Contribuir com a filogenia de Dicranellaceae adicionando dados moleculares para as espécies de *Dicranella s.l.* existentes no Neotrópico.

3. Material e Métodos

3.1. Delimitação morfológica

Para a apresentação dos dados obtidos neste trabalho, inicialmente foram realizadas análises de uma lista de nomes de espécies de *Dicranella s.l.* citadas ocorrentes para o Neotrópico, área tropical que se estende do México até o Brasil, obtida a partir das seguintes referências: Wijk *et al.* (1959, 1969), Frahm (1991), Menzel (1992), Allen (1994), Churchill (1994), Crum (1994), Churchill & Linares (1995), Duarte Belo (1997), Crosby *et al.* (1999), Matteri (2003), Crum (2007), O'shea & Price (2008), Müller (2009), Costa *et al.* (2011), Jansen-Jacobs (2011), Yano (2011) e W3Tropicos (2019). Após essas análises, para os nomes encontrados, foram realizadas buscas, consultas e observações de seus materiais tipo em sites de consultas taxonômicas específicas como o Index Herbariorum, Jstor e Tropicos.

Além disso, foram pedidos empréstimos de exsicatas de herbários nacionais e internacionais correspondendo à nomes de espécies do gênero *Dicranella*, bem como os seus gêneros e sinônimos relacionados, representados por *Anisothecium*, *Bartleya*,

Campylochaetium, *Diobelon*, *Leptotrichella* e *Microdus* (Scott & Stone 1976, Corley *et al.* 1981, Crosby & Magill 1981, Nakaniwa 1984, Allen 1994, Crum 1994, Ochyra 1997, Crum 2007, Ochyra *et al.* 2008, Schatz *et al.* 2019). As exsiccatas observadas foram provenientes dos herbários ALCB, BM, G, JE, ICN, MG, MICH, NY, PC, R, RB, S, SJRP, SP, UB e UFP. A classificação da família Dicranellaceae seguiu Frey & Stech (2009). Os nomes das estruturas morfológicas e características utilizadas para a delimitação e circunscrição das espécies de *Dicranella* nas chaves de identificação seguiram Luiz-Ponzo *et al.* (2006) e Frey & Stech (2009).

Para a distribuição geográfica das espécies de *Dicranella* ocorrentes no Neotrópico, assim como os domínios fitogeográficos e substratos que elas ocupam, as referências bibliográficas consultadas e utilizadas como padrão foram Allen (1994), Crum (1994), Crosby *et al.* (1999), Crum (2007), Gradstein *et al.* (2001), Forzza *et al.* (2010), Larraín *et al.* (2010), Costa *et al.* (2011), Yano (2011), Carmo & Peralta (2016), Carmo *et al.* (2016, 2018). Enquanto um outro tipo de padrão de distribuição geográfica adotado para as espécies brasileiras, o qual classifica as espécies em distribuição rara, moderada e ampla seguiu conforme o adotado em Valente & Pôrto (2006).

Algumas coletas foram realizadas no Brasil para acrescentar dados e amostras nos herbários e nas análises filogenéticas. Conforme Gradstein *et al.* (2001), as espécies de *Dicranella* ocorrem com maior facilidade e abundância em regiões de elevadas altitudes e características de campos rupestres. Dessa maneira, foram realizadas saídas de campo para procurar e coletar mais amostras do gênero, as áreas visitadas foram Campos do Jordão – SP, Pico dos Marins – SP, Serra da Bocaina – SP, Serra da Canastra – MG, Serra da Caraça – MG, Serra do Itatiaia – RJ e Serra de Tepequém – RR.

Todas as amostras coletadas foram analisadas no Instituto de Botânica de São Paulo, na Seção de Briologia, quando necessário, lâminas permanentes foram preparadas utilizando glicerina de Kayser ou com solução de Hoyer para observar estruturas de difícil identificação (Anderson 1954). Essas análises foram realizadas com o auxílio de estereomicroscópio e microscópio óptico de luz. As exsiccatas confeccionadas e coletadas foram depositadas no herbário “Maria Eneyda Pacheco Kauffman Fidalgo” (SP).

Para a realização de um dendograma de agrupamento (*clustering*) morfológico, testes de modelo foram realizados com o auxílio do software PAST versão 3.01 (Hammer *et al.* 2001), nas características binárias de presença (1) e ausência (0). Essas análises foram calculadas utilizando o índice de similaridade de Jaccard (Magurran 1989), com a finalidade de observar e aproximar as espécies que apresentassem características morfológicas semelhantes.

Algumas análises de microscopia eletrônica de varredura (MEV) foram realizadas no

Instituto de Botânica para identificar possíveis características existentes nas estruturas dos esporófitos, como a cápsula, o peristômio, ânulo e os esporos, que poderiam ser utilizadas para a separação e identificação das espécies de *Dicranella*.

3.2. Delimitação filogenética

Para obter as sequências de táxons que ainda não estão disponíveis no Genbank, o DNA total foi extraído pelo método mini CTAB (Doyle & Doyle 1987, 1990) com protocolos modificados e padronizados, conforme Câmara (2006).

Após a extração, o DNA foi amplificado através da Reação em Cadeia da Polimerase (PCR), utilizando os marcadores plastidiais do gene *rps4*, codificante de uma proteína ribossomal (Hedderson *et al.* 2004, Hernandez-Maqueda *et al.* 2008, Stech & Quandt 2010), o marcador nuclear ITS, baseando-se principalmente nos primers 18SF – 26S (Stech & Quandt 2010) e o marcador mitocondrial NADH desidrogenase subunidade 5 (*nad5*) (Stech & Quandt 2010).

Os produtos do PCR foram sequenciados diretamente na Macrogen Inc. (Seoul, Korea). As sequências foram comparadas com as obtidas do GenBank utilizando o programa BLAST (Altschul *et al.* 1990), sendo assim, as buscas servirão para confirmar a filiação das sequências extraídas. No GenBank (<http://www.ncbi.nlm.nih.gov/genbank>) estão disponíveis apenas 38 sequências de *Dicranella* (7 espécies: *Dicranella cerviculata*, *D. flaccidula*, *D. heteromalla*, *D. nitidula*, *D. palustris*, *D. riparia* e *D. staphylina*), três de *Microdus* (todas incluídas e sinonimizadas em *Dicranella*) e uma de *Leptotrichella* (também incluída e sinonimizada em *Dicranella*), logo, para a realização desse estudo, novas sequências foram incluídas no GenBank. Foram utilizados como *outgroup* os gêneros estudados por Stech & Frey (2008): *Dicranum* (Dicranaceae), Fissiden (Fissidentaceae), *Leucobryum* e *Campylopus* (Leucobryaceae) e *Tortula* (Pottiaceae), cujos acessos encontram-se disponíveis no GenBank.

O alinhamento e edição das sequências foi verificado com o auxílio dos programas ClustaX (Higgins & Sharp 1988), PhyDE (Phylogenetic Data Editor) versão 0.9971 (Müller *et al.* 2010) e BioEdit (BioEdit Sequence and Alignment Editor) versão 7.1.3.0. (Hall 1999). As análises de máxima parcimônia (MP) e de Verossimilhança (Likelihood) foram realizadas com o auxílio do software PAUP* versão 4.0b10 (Câmara & Buck 2012). As pesquisas de máxima parcimônia e verossimilhança foram baseadas na busca heurística, 1.000 réplicas (random-addition-sequence replicates), troca de ramo (tree bisection-reconnection), MULTrees ativado, e *collapse zero-length branches* desativado. Os caracteres foram tratados

como equilibrados e não ordenados. Ao se encontrar mais de uma árvore de parcimônia, estas foram resumidas a apenas uma árvore de consenso estrito. Valores de bootstrap não paramétricos (Felsenstein 1985) foram gerados como buscas heurísticas com 1.000 repetições, cada uma com dez réplicas aleatórias. Os rearranjos foram restritos a 1.000.000 por repetição. Valores percentuais Bootstrap (BPV) ≥ 70 foram considerados como um bom suporte (Hillis & Bull 1993).

As análises moleculares foram realizadas em cooperação com os professores doutores Paulo E.A.S. Câmara e Micheline Carvalho-Silva no Laboratório de Biologia Molecular de Plantas da Universidade de Brasília (UnB), referências em taxonomia e filogenia de musgos no Brasil.

4. Resultados

Os resultados foram apresentados em duas partes para a apresentação dessa tese: o tópico 4 está relacionado com resultados obtidos e que originaram a produção de artigos científicos, sendo divididos em capítulos que foram representados em: 4.1. The identity of *Dicranella hilariana* (Mont.) Mitt., 4.2. The *Dicranella* (Müll. Hal.) Schimp. (Dicranellaceae, Bryophyta) genus in Brazil, 4.3. A type catalog and a checklist of *Dicranella* species from Neotropic (Dicranellaceae, Bryophyta) e 4.4. Phylogenetic analyses of *Dicranella* (Müll. Hal.) Schimp. (Dicranellaceae, Bryophyta) in Brazil using the plastid gene *rps4*.

Enquanto que no tópico 4.5 dessa tese, os resultados obtidos abrangeram, de maneira geral e simplificada, um resumo dos resultados obtidos durante a realização dessa tese de doutorado, mas que não originaram, no momento, artigos científicos. Os dois primeiros artigos já foram submetidos e atualmente encontram-se em situação de análise pelos editores e assessores das revistas, sendo assim estão escritos conforme as normas de cada um desses periódicos. Os dois últimos ainda iremos adequar e adaptar conforme as normas dos periódicos em que serão submetidos.

4.1. The identity of *Dicranella hilariana* (Mont.) Mitt.

Artigo proposto segundo as normas do *Journal of Bryology*

Dimas Marchi do Carmo^{a*}, Denilson Fernandes Peralta^a

^a *Instituto de Botânica, São Paulo, SP, Brazil. *dimas.botanica@gmail.com*

The identity of *Dicranella hilariana* (Mont.) Mitt. (Dicranellaceae, Bryophyta)

The *Dicranella hilariana* (Mont.) Mitt. was a combination of *Dicranum hilarianum* Mont. proposed by William Mitten in 1869, in the work *Musci Austro-Americani*, published in *The Journal of Linnean Society*. It is reported as frequent and widespread in tropical regions, however, the high morphological plasticity associated with this taxon, the uncertain taxonomy in relation to the name and phylogenetic position and the absence of herbarium samples are common obstacles encountered when identifying this species. Additionally, to date, there is no taxonomic revision for the genus. As a consequence, there are a great number of samples that have been ill-defined and misidentified, resulting in a wide geographic distribution and herbarium specimens that do not match with the real *D. hilariana* identity. In the present study, the *D. hilariana* holotype (PC0146145!) and two isotypes (BM000663421! and BM000663424!) were examined, with the intention of organizing and morphologically characterizing this species. Furthermore, it was demonstrated that both the gametophyte and sporophyte diagnosis characteristics can facilitate the identification of this taxon worldwide.

Keywords: *Dicranella*, *Dicranella hilariana*, *Dicranella martiana*, type material, synonyms

Introduction

The *Dicranum hilarianum* Mont. Species was described by the French naturalist Jean Pierre François Camille Montagne, in 1839, in his work entitled *Cryptogamae brasilienses* published in the *Annales des Sciences Naturelles*. Exactly thirty years later, this species was combined for *Dicranella hilariana* (Mont.) Mitt., by the English chemist William Mitten, in 1869, in his work *Musci Austro-Americani* published in the *The Journal of Linnean Society*. The original material used for the *D. hilariana* description was from samples collected in Brazil by Auguste de Saint-Hilaire. According to Mitten (1869), all these materials were deposited in the *Herbarium Montagne* and are currently maintained at the Muséum National d'Histoire Naturelle Cryptogams Herbarium of Paris (PC).

This study was motivated by the fact that *D. hilariana* is described in the literature as extremely common. It is often found growing on rocks, ravines and exposed soils, with a predominance in warmer regions (Ochyra *et al.* 2000). Additionally, the geographical distribution of this species is quite extensive and is frequently reported as being Neotropical (Crum & Steree 1957, Crum & Bartram 1958, Crum & Steere 1958, Florschütz 1964, Pursell 1973, Hermann 1976, Yano 1989, Menzel 1992, Allen 1994, Crum 1994, Churchill 1994, Churchill & Linares 1995, Duarte Bello 1997, Ochyra *et al.* 2000). Moreover, it has also been identified in southern areas of the United States (Crum 2007). *D. hilariana* have been found at altitudes ranging from sea level to 4400m, as well as in places with extreme climate conditions, such as Antarctica (Ochyra *et al.* 2000, Gradstein *et al.* 2001, Frey & Stech 2009).

In the literature, the *Dicranella* species is described as having great morphological plasticity, an extensive geographical area and a high number of names, in synonymy and different combinations. As a consequence, these characteristics complicate identifying this taxon and differentiating it from other species (Allen 1994, Crum 1994, Ochyra *et al.* 2000). It should be pointed out that the separation of *Dicranella* species is primarily based on sporophyte characteristics (Allen 1994, Crum 1994, Duarte Bello 1997, Churchill & Linares 1995, Crum 2007). However, this structure is not always available, and can also present different morphologies during its development (Dixon 1913, Allen 1994, Crum 1994, Crum 2007).

Many authors have suggested that a review of the *Dicranella* genus is urgent and necessary (Allen 1994, Crum 1994, Churchill & Linares 1995, La farge *et al.* 2000, 2002, Crum 2007, Ochyra *et al.* 2008, Stech & Frey 2008, Frey & Stech 2009, Stech & Quandt 2010, Stech *et al.* 2012), and this served as the motivation for this study. In addition, by re-evaluating the characteristics used for species separation, the goal of this review is to present

a tool, which can be used by researchers to aid in the taxonomic and morphological differentiation of this taxon, through the morphological analysis of its type material.

Materials and Methods

The holotype (PC0146145!) located at Musée National d'Histoire Naturelle – Paris (PC) and its isotypes deposited at BM herbarium “The Natural History Museum –London (BM000663421! and BM000663424!) were analyzed. The morphological variation and distribution was based on the 520 samples obtained from the ALCB, MG, MICH, QCA, R, SP and UFP herbaria. Thus, allowing for the assembly of a *D. hilariana* standardized plate (Figure 1 a-i).

In order to justify the *D. hilariana* synonymization with *Dicranella martiana* (Hampe) Hampe, the gametophyte and sporophyte characteristics of the *D. martiana* isotype were considered, which are also deposited at the PC herbarium (PC0129060!).

Permanent slides with glycerinated gelatin were prepared to analyze the gametophyte and sporophyte morphological characteristics of all the *D. hilariana* and *D. martiana* type samples. In addition, scanning electron microscopy (SEM) images of spores from *D. hilariana* were acquired and used for morphological observations (Figure 2 a-d).

Results and Discussion

The PC0146145! sample was considered to be the holotype, since it is from the Montagne collection, at the herbarium in Paris (PC). This sample is wrapped in an envelope and attached to a sheet with two more samples. In addition, the holotype also consists of a few loose plants with sporophytes and small fragments of debris and soil. There is a label, written by Jean Pierre Montagne, with “*Brésil Ex Col. Aug. S. Hilaire*” written on it, and another label signed by Ryszard Ochyra, in 2002, stating that this sample is the holotype.

The isotypes are attached to a sheet, with another ten samples, and a label signed by Ryszard Ochyra, in 2003, definitively identifying these samples as isotypes. The first isotype, BM000663421!, is a soil fragment glued to an envelope with some individuals presenting sporophytes, including a label with “*Brésil*” and “*St. Hilaire*” written in pencil, which are the country and name of the collector, respectively. The second isotype sample, BM000663424!, has four free gametophytes with sporophytes and labels indicating the country and collector of this species, which in this case are “*Brasilia*” “*St. Hilaire*”.

Some characteristics such as the leaves apex blunt and crenulate, recurved margins, erect and yellow seta and symmetric and smooth capsule were described as diagnostic features for *D. hilariana*, by Crum (1994), Ochyra *et al.* (2000) and Crum (2007). However, after observing the type materials and the other 520 samples, it was found that these characteristics are not diagnostic for *D. hilariana*, since these characteristics are modulated by a number of factors including: environmental conditions (i.e. temperature, humidity, soil moisture content, etc.), time and temperature at the time of identification, development stage and even the herborization technique (Dixon 1913, Allen 1994, Crum 2007), which are generally not taken into account when identifying the sample. Furthermore, the diagnostic characteristics for *D. hilariana* as proposed by Allen (1994), Crum (1994), Crum (2007), Frey & Stech (2009) are also present in other *Dicranella* species, such as: *D. apolensis*, *D. barnesii*, *D. brachyblepharis*, *D. cerviculata*, *D. exigua*, *D. heteromalla*, *D. lindigiana*, *D. martiana*, and *D. varia*. In fact, it would be nearly impossible to differentiate these species without the sporophytes.

Another characteristic used for the identification of *D. hilariana* species is the presence of a well-developed, wide and revoluble annulus, as previously described by Allen (1994), Crum (1994), Crum (2007) and Ochyra *et al.* (2008). This structure is characterized by one or more differentiated cell layers, located between the capsule operculum and urn, and is used for regulating the capsule opening (Luizi-Ponzo *et al.* 2006). However, the original description by Mitten (1869) does not include the annulus, and it is also not present in the type material. Therefore, using the presence of this structure for the identification of *D. hilariana* species is of little utility.

Larraín *et al.* (2010) affirm that the annulus is a structure that can be present in both *Dicranella* and *Anisothecium* species. It should be mentioned that both of these genera are currently without any taxonomic revision. In Edwards (1984), the author described the peristome development and all of the related structures among different haplolepideous moss species and considered them to be homologous. However, phylogenetic studies focusing on *Dicranella* species are scarce and are necessary to prove this suggestion (Stech & Frey 2008, Frey & Stech 2009, Stech & Quandt 2010, Stech *et al.* 2012).

Dicranella martiana (Hampe) Hampe (Glaziou 5183, PC0709297!) was morphologically separated from *D. hilariana*, based solely on the presence of an annulus (Mitten 1869, Hampe 1879, Allen 1994, Crum 1994, Churchill & Linares 1995, Duarte Bello 1997, Crum 2007, Ochyra *et al.* 2008, Larraín *et al.* 2010). However, previous work showed that this structure is related to sporophyte development and has some issues such as, the lack of knowledge about the development of sporophyte structures, the factors involved in the

emergence or not of this characteristic, the evolutionary relationship of these structures among *Dicranella* species and the absence of information pertaining to the annulus in the description of the species. (Dixon 1913, Edwards 1984). Thus, this structure is considered to be non-informative, and should not be employed for the separation of genus species or related genera (Allen 1994, Crum 1994, Crum 2007, Ochyra 2000, Stech & Frey 2008, Ochyra *et al.* 2008, Stech 2009, Larraín *et al.* 2010). Based on this evidence, it is proposed that *D. martiana* and *D. hilariana* be synonymized.

During exsiccate analysis, many samples that had been identified as *D. hilariana* were actually *D. lindigiana* (Hampe) Mitt. This is probably due to the morphological similarities of the gametophytes, as described by Allen (1994) and Crum (1994). Interestingly, it was found that these species can be differentiated based on the characteristics of the sporophytes. For example, the peristome of *D. lindigiana* is characterized as entire, papillose teeth, irregularly bifid, cleft or perforated, dorsally trabeculated, thickened but not vertically-striated, with the basal membrane reduced or absent (Luizi-Ponzo *et al.* 2006). On the other hand, the peristome of *D. hilariana* is dicranoid, with bifurcated teeth and a broad sinus, at least ½ of the teeth, ventrally-trabeculated, thickened, vertically striated and the basal membrane often present (Luizi-Ponzo *et al.* 2006, Frey & Stech 2009). Another useful criterion used for the separation of these species is based on the appearance of the exotecial cells, which are short (1-2: 1) in *D. lindigiana*, and long (3-6: 1) in *D. hilariana* (Crum 1994). Furthermore, following the *Dicranella* types analysis, it was observed that the shapes of the leaves, from these two species are quite distinct from one another. More specifically, the leaves of the *D. hilariana* species are characterized as oblong to oblong-lanceolate leaves (Figure 1 – b – e), while *D. lindigiana* (Hampe) Mitt. have lanceolate leaves (Mitten 1869, Hampe 1879, Allen 1994, Crum 1994, Churchill & Linares 1995, Duarte Bello 1997, Crum 2007, Ochyra *et al.* 2008, Larraín *et al.* 2010).

The geographical distribution of *D. hilariana* is considered to be Pan-neotropical; occurring in the United States, Mexico, Belize, Costa Rica, Cuba, Jamaica, Colombia, Ecuador, Venezuela, Guatemala, Honduras, Panama, Peru, Uruguay and Brazil (Crum & Steree 1957, Crum & Bartram 1958, Crum & Steere 1951, 1958, Florschütz 1964, Pursell 1973, Hermann 1976, Yano 1989, Menzel 1992, Allen 1994, Crum 1994, Churchill 1994, Churchill & Linares 1995, Duarte Bello 1997, Ochyra *et al.* 2000, Crum 2007, Ochyra *et al.* 2008) even reaching more extreme environments such as Antarctica (Ochyra *et al.* 2000). Through the exsiccate analysis and information presented here, it is proposed that *D. hilariana* has a more restricted occurrence to Tropical America (Neotropics), mainly growing on moist, argillaceous or sandy soils, more rarely on rocks, fallen tree trunks near lakes and

ravines along the roads in the regions known as Amazonia, Brazilian Planalto and Southeastern Brazil (Gradstein *et al.* 2001).

In conclusion, the characteristics currently employed to differentiate *D. hilariana* species are questionable, resulting in erroneous identifications and a broad geographic distribution. It was found that the sporophyte characteristics could be employed for differentiating *Dicranella* species, which has provided motivation for identifying other unique and novel informative characteristics, using the type analysis. However, evolutionary relationships, ecology and ontogeny of *Dicranella* need be ascertained. Remarkably, for this species, such information is still quite scarce.

Taxonomic Treatment

Dicranella hilariana (Mont.) Mitt., J. Linn. Soc., Bot. 12: 31. 1869;

≡ *Aongstroemia hilariana* (Mont.) Müll. Hal., Syn. Musc. Frond. 1: 443. 1848 ≡ *Microdus hilarianus* (Mont.) Besch., Index Bryol. 804. 1897. Basionym: *Dicranum hilarianum* Mont., Ann. Sci. Nat., Bot., sér. 2, 12: 52. 1 f. 2. 1839. **Type:** Brasilia meridionalis ad terram [A. Saint Hilaire *s.n.*] holotype (PC0146145! (hb Montagne), isotype BM000663421!; BM000663424!). Figure (1 a-i).

= *D. martiana* (Hampe) Hampe, Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening I Kjøbenhavn ser. 4, 1: 86. 1879. **Syn. Nov.** ≡ *Microdus martianus* (Hampe) Besch., Index Bryologicus 805. 1897. ≡ *Leptotrichella martiana* (Hampe) Ochyra, Fragmenta Floristica et Geobotanica 42: 563. 1997. Basionym: *Aongstroemia martiana* Hampe, Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening I Kjøbenhavn 4: 41. 1872. **Type:** Brazil, Province de Brésil, Prope Rio de Janeiro: A. Glaziou, n. 5183. (PC0129060!), isotype (PC0137970).

Plants yellow-brown to greenish, with tufts until about 16 mm high. Leaves insertion with cuneate base. Leaves spirally arranged, erect-flexuous when dry and erect-spreading when moist, oblong to oblong-lanceolate, apex blunt to rounded, often obtuse, stem leaves with costa subpercurrent; apical and middle cells quadrate to short-rectangular, basal cells rectangular to linear, alar cells undifferentiated, thin-walled; margins entire, unistratose, sometimes recurved, cross-section with two layers of stereids. Seta flexuous to straight, yellow to reddish according with age; capsules erect and symmetric, ovoid-oblong to cylindrical, smooth; exothecial cells elongate (3-6:1), peristome *Dicranum*-type, with peristome teeth divided more than ½ length distally, transversely estriolate below and colorless papillose above, annulus absent; spores papillose.

Thus, according to our studies, we believe that the characteristics that distinguishes the *D. hilariana* species are the oblong to oblong-lanceolate leaves, often with obtuse apices, quadratic apical cells and the absence of an annulus.

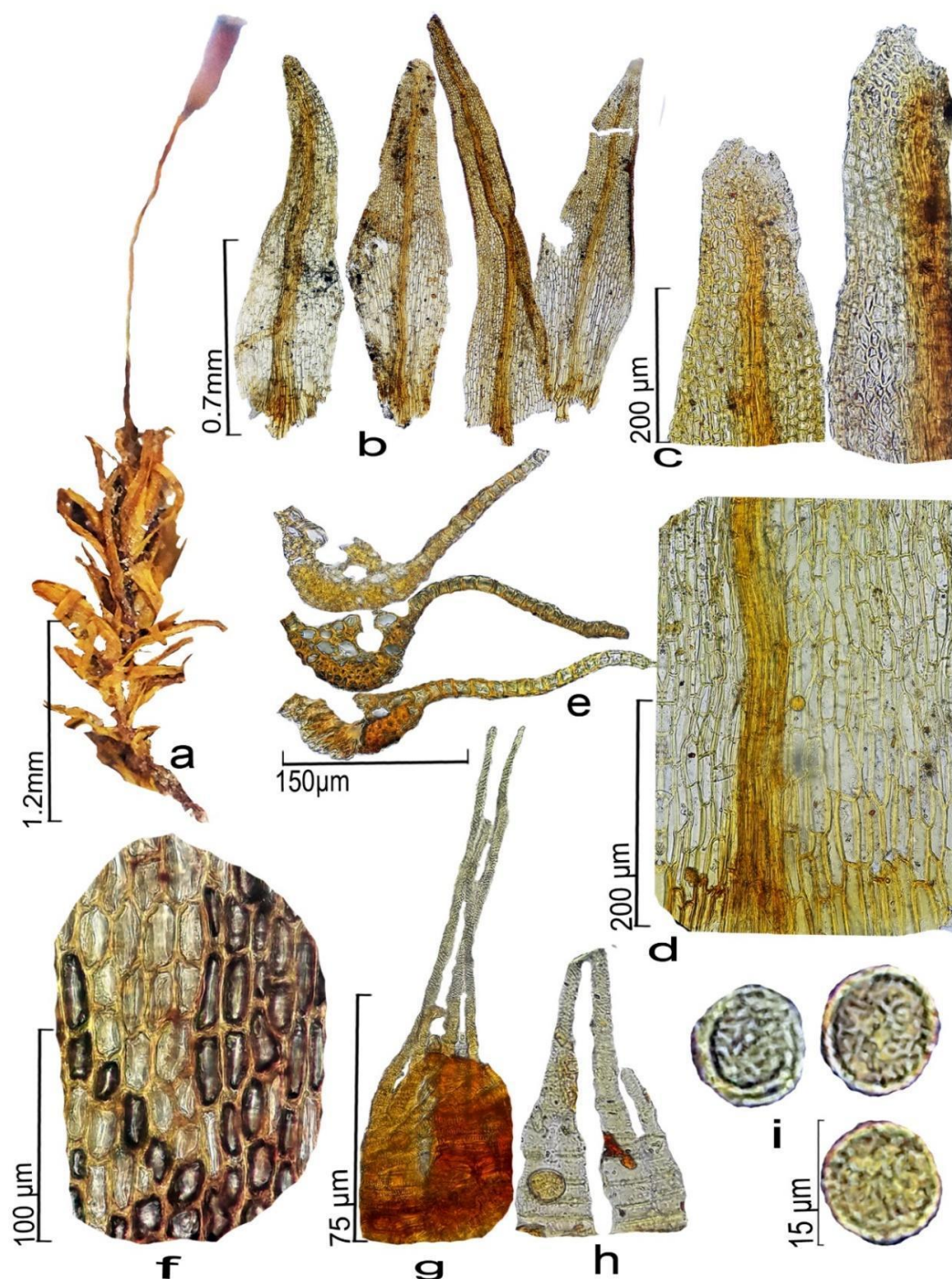


Figure 1 (a-i): *Dicranella hilariana* (Mont.) Mitt. a – Habit. b – Leaves. c – Leaves apex. d – Leaf base. e – Leaf cross-section. f – Exothecial cells. g – Peristome dicranoid, detail of teeth from a recent sample. h – Peristome dicranoid, detail of teeth from a late sample. i – Spores (from holotype PC0146145!).

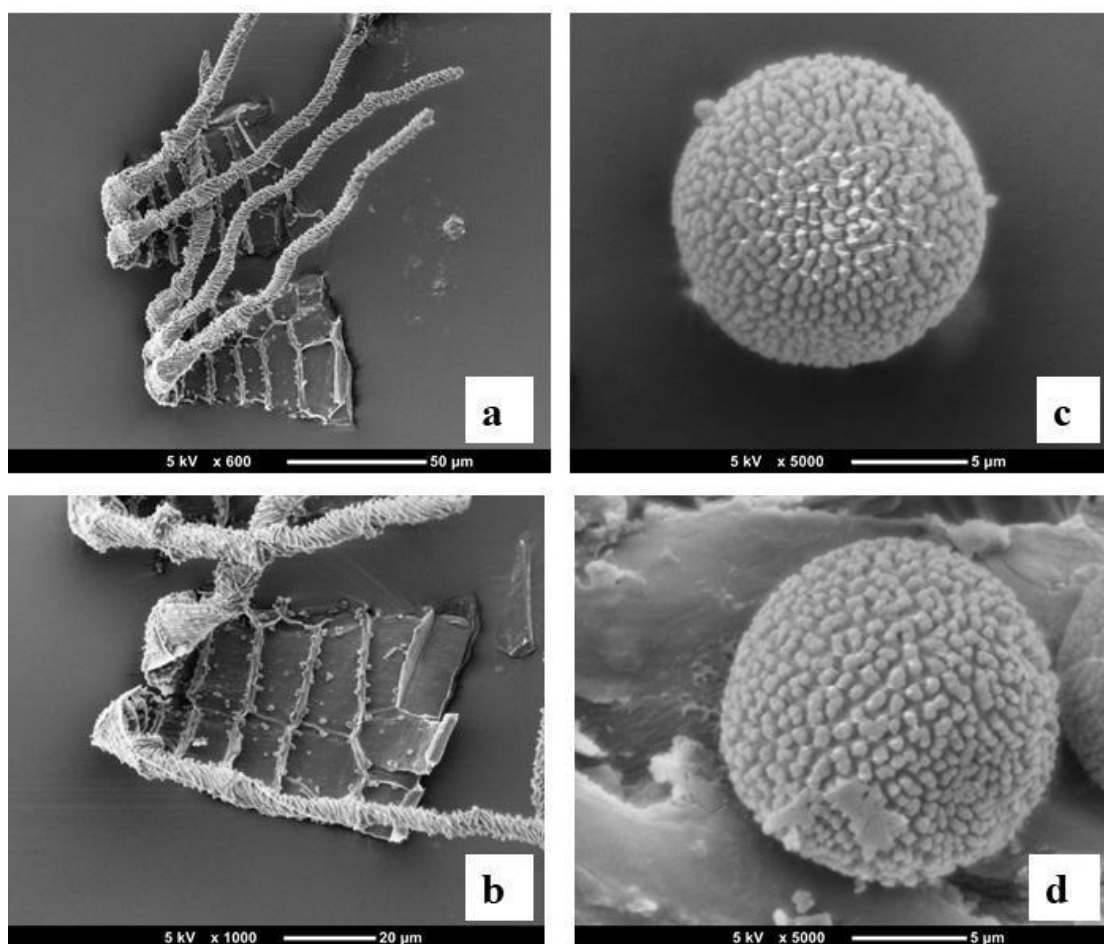


Figure 2: *Dicranella hilariana* (Mont.) Mitt. (a-b) SEM images of peristome dicranoid, detailed of teeth. (c-d) SEM images of spores. (a-d. *Vital 14936* (SP256988)).

Acknowledgements

The authors thank the curators of all curators and of the cited herbaria for the loan of specimens and the type material. The authors are grateful to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the doctoral grant and for providing funding to this project.

References

- Allen, B. 1994.** Moss flora of Central America. Part 1. Sphagnaceae-Calymperaceae. *Monographs in Systematic Botany from the Missouri Botanical Garden* 49: 1–242.
- Churchill, S.P. 1994.** *The mosses of Amazonian Ecuador*. AAU Reports 35: 1–211.
- Churchill, S.P. & Linares, C.E.L. 1995.** Prodrromus bryologiae novo-granatensis. Introducción a la flora de musgos de Colombia. Parte 1. Adelotheceaceae a

- Funariaceae. Instituto de Ciencias Naturales – Museo de Historia Natural. Biblioteca José Jerónimo Triana 12: 1–453.
- Costa, D.P., Pôrto, K.C., Luizi-Ponzo, A.P., Ilkiu-Borges, A.L., Bastos, C.J.P., Câmara, P.E.A.S., Peralta, D.F., Bôas-Bastos, S.B.V., Imbassahy, C.A.A., Henriques, D.K., Gomes, H.C.S., Rocha, L.M., Santos, N.D., Siviero, T.S., Vaz-Imbassahy, T.F. & Churchill, S.P. 2011.** Synopsis of the Brazilian moss flora: checklist, distribution and conservation. *Nova Hedwigia* 93(3–4): 277–334.
- Crosby, M.R., Magill, R.E., Allen, B. & He, S. 1999.** *A checklist of the Mosses. Missouri Botanical Garden*. St. Louis: Missouri Botanical Garden. Pp. 1–315.
- Crum, H. 1994.** *Dicranella*. In: Sharp, A.J., Crum, H. & Eckel, P. The Moss Flora of Mexico. *Memoirs of The New York Botanical Garden* 69: 1–1113.
- Crum, H. 2007.** *Dicranella*. In: Flora of North America. Editorial Committee (eds.): *Flora of North America north of Mexico*: pp. 386–393. Oxford University Press, New York.
- Crum, H. & Bartram, E.B. 1958.** A survey of the moss flora of Jamaica. *Bulletin of the Institute of Jamaica Science Series* 8: 1–90.
- Crum, H.A. & Steere, W.C. 1957.** The mosses of Puerto Rico and the Virgin Islands. In: O. von S. Whitelock (ed.), *Scientific Survey of Puerto Rico and the Virgin Islands*. 2(4). New York, The Academy, pp. 1–207.
- Crum, H. & Steere, W.C. 1958.** The mosses of Puerto Rico and the Virgin Islands. In: O. von S. Whitelock (ed.), *Scientific Survey of Puerto Rico and the Virgin Islands*. 3(4). New York, The Academy, pp. 395–599.
- Dixon, H.N. 1913.** A Remarkable Form of *Dicranella heteromalla* Schimp. *The Bryologist* 16(2): 29–30.
- Duarte Bello, P.P. 1997.** Musgos de Cuba. *Fontqueria* 47: 1–717.
- Edwards, S.R. 1984.** Homologies and Inter-relationships of moss peristomes. In: Schuster, R.M. *New Manual of Bryology*. The Hattori Botanical Laboratory 2: 658–695.
- Florschütz, P.A. 1964.** The mosses of Suriname. Part 1. Leiden: E.J. Brill. 1–271.
- Frey, W. & Stech, M. 2009.** Marchantiophyta, Bryophyta, Anthocerotophyta. Pp.13–263. In: Frey, W. *Bryophytes and seedless vascular plants. Syllabus of Plant Families* ed. 13: 3: I–IX.
- Gradstein, S.R., Churchill, S.P. & Salazar-Allen, N. 2001.** Guide to the bryophytes of Tropical America. *Memoirs of The New York Botanical Garden* 86: 1–577.
- Hampe, G.E.L. 1879.** Enumeration fuscorum frondosorum Brasiliae centralis, praecipue provinciarum Rio de Janeiro et S. Paulo, adhuc cognitorum. *Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening i Kjøbenhavn*. 1(4): 73–86.

- Hermann, F.J. 1976.** Recopilación de los musgos de Bolivia. *The Bryologist* 79(2): 125–171.
- Larraín, J., Suárez, G., Bednarek-Ochyra, H. & Ochyra, R. 2010.** The rediscovery of *Dicranella circinata* (Dicranellaceae, Bryophyta), with comments on other Southern South American species of *Dicranella*. *Nova Hedwigia* 91(3–4): 361–376.
- La Farge, C., Mishler, B.D., Wheeler, J.A., Wall, D.P., Johannes, K., Schaffer, S. & Shaw, A. J. 2000.** Phylogenetic relationships within the haplolepidous mosses. *The Bryologist* 103: 257–276.
- La Farge, C., Shaw, A.J. & Vitt, D.H. 2002.** The circumscription of the Dicranaceae (Bryopsida) based on the chloroplast regions trnL-trnF and rps4. *Systematic Botany* 27: 435–452.
- Luizi-Ponzo, A.P., Bastos, C.J.P., Costa, D.P., Pôrto, K.C., Câmara, P.E.A.S., Lisboa, R.C.L. & Bôas-Bastos, S.V. 2006.** Glossarium Polyglottum Bryologiae. 1–113.
- Menzel, M. 1992.** Preliminary checklist of the mosses of Peru (Studies on Peruvian bryophytes IV.). *Journal of the Hattori Botanical Laboratory* 71: 175–254.
- Mitten, W. 1869.** Musci Austro-Americani. *The Journal of the Linnean Society* 12: 31.
- Montagne, J.P.F.C. 1839.** Cryptogamae brasilienses. *Annales des Sciences Naturelles; Botanique, sér. 2* 12: 52. 1 f. 2. 1839.
- Ochyra, R., Ochyra-Bednarek, H., Arts, T. & Smith, R.I.L. 2000.** Occurrence of the neotropical moss *Dicranella hilariana* (Mont.) Mitt. In the Antarctic. *Tropical Bryology* 18: 153–160.
- Ochyra, R., Smith, R.L. & Bednarek-Ochyra, H. 2008.** The illustrated Moss Flora of Antarctica. Cambridge University Press. Pp. 1 – 683.
- Pursell, R.A. 1973.** Un censo de los musgos de Venezuela. *The Bryologist* 76: 473–500.
- Stech, M. & Frey, W. 2008.** A morpho-molecular classification of the mosses (Bryophyta). *Nova Hedwigia*. 86:1–2.
- Stech, M. & Quandt, D. 2010.** 20000 species and five key markers: The status of molecular bryophyte phylogenetics. *Phytotaxa* 9: 196–228.
- Stech, M., McDaniel, S.F., Hernández-Maqueda, R., Ros, R.M., Werner, O., Muñoz, J. & Quandt, D. 2012.** Phylogeny of Haplolepidous mosses – Challenges and perspectives. *Journal of Bryology* 34 (3): 160–173.
- Yano, O. 1989.** An additional checklist of Brazilian bryophytes. *Journal of the Hattori Botanical Laboratory* 66: 371–434.

APPENDIX

Specimens examined: **Brasil**. Acre: Rio Branco, Catuaba Experimental Station, ca. De 8 km NE of Rio Branco, 9°58'29" S, 67°48'36" W, 30-V-1987, *Vital, D.M. 14936* (SP256988); Amazonas: Manaus, Reserva da Campina, 3°06'07" S, 60°01'30" W, 08-VII-1974, *Griffin III, D. 04* (SP125224); idem, Bahia: Ilhéus, 5 km S de Ilhéus na estrada para Olivença, 14°47'20" S, 39°02'58" W, 14-VII-1991, *Vital, D.M. 20100* (SP353836); Distrito Federal: Brasilândia, Chapada Imperial, área particular, 15°00'00" S, 46°38'10" W, 02-VII-2016, *Peralta, D.F. 18752* (SP464138); idem, Espírito Santo: Fundão, ao longo da rodovia BR – 101, 19°55'57" S, 40°24'24" W, 15-IV-1980, *Vital, D.M. 8889* (SP 148504); idem, Goiás: Hidrolândia, ao longo da rodovia BR – 153, 16°57'44" S, 49°13'41" W, 10-IV-1976, *Vital, D.M. 6138* (SP135136); idem, Minas Gerais: Belo Horizonte, Jockey clube, 19°55'15" S, 43°56'16" W, 09-II-1976, *Vital, D.M. 5516* (SP134749); idem, São Roque de Minas, Parque Nacional da Serra da Canastra, 20°16'63" S, 46°55'94" W, 11-II-2012, *Carmo, D.M. 348* (SP436556); idem, Mato Grosso: Barra do Garça, acampamento dos ingleses, 15°53'24" S, 52°15'24" W, 29-V-1968, *Vital, D.M. 1384* (SP89826); idem, Sinop, Parque Florestal de Sinop, Rua das Avencas, Jardim Primavera, 11°50'03" S, 55°30'01" W, 05-XII-2008, *Borges, F.R. 367* (SP451280); idem, Mato Grosso do Sul: Ribas do Rio Pardo, Reflorestadora Estância S.A., 20°26'35" S, 53°45'33" W, 25-I-1979, *Yano, O. 1341* (SP147473); idem, Corguinho, Cachoeira do Córrego do Garimpo, 22-IV-2011, *Yano, O. 33022* (SP 425115); idem, Paraná: Campo Magro, Conceição dos Correa, base do Morro da Palha, 25°14'30" S, 49°28'36" W, 09-X-2016, *Canestraro, B.K. 980* (SP486191); idem, Ipiranga, ao longo da rodovia BR – 373, 25°01'26" S, 50°35'03" W, 15-III-1976, *Vital, D.M. 5813* (SP134928); idem, Rio de Janeiro: Paraty, ao longo da Rodovia Paraty-Cunha, 23°13'04" S, 44°42'47" W, 20-VIII-1987, *Vital, D.M. 15329* (SP257383); idem, Rio Grande do Sul: São Lourenço do Sul, ca. 5km N da entrada para São Lourenço do Sul, 31°10'48" S, 52°00'36", 09-VII-1980, *Vital, D.M. 8960* (SP148951); idem, Rondônia: Ji-Paraná, 10°26'20" S, 62°27'59" W, 07-X-1986, *Vital, D.M. 14206* (SP228972); idem, Roraima: Amajari, Serra do Tepequém, trilha para a Cachoeira do Paiva, 3°47'15" N, 61°46'06" W, 07-IX-2017, *Carmo, D.M. 1503* (SP482862); idem, Santa Catarina: Porto Belo, 27°09'28" S, 48°33'11" W, 17-IV-1980, *Yano, O. 2474* (SP 148569); idem, São Paulo: Campos do Jordão, Parque Estadual de Campos do Jordão, Rio Sapucaí trail, 22°41'23" N, 45°28'30" W, 03-X-2017, *Peralta, D.F. 21865* (SP483240); idem, Ibiúna, Bairro Sorocabuçu, 23°39'23" S, 47°13'21" W, 28-VII-1989, *Yano, O. 13289* (SP228215). **Colombia**. Santander. 25-X-1988, *Ireland, R.R. 23534* (SP239800).

4.2. The *Dicranella* (Müll. Hal.) Schimp. (Dicranellaceae, Bryophyta) genus in Brazil¹

Artigo proposto segundo as normas da *Acta Botanica Brasilica*

Dimas Marchi do Carmo^{2*} & Denilson Fernandes Peralta²

1. Part of PhD Thesis in Plants Biodiversity and Environment of the first author by Programa de Pós-Graduação do Instituto de Botânica de São Paulo.

2. Instituto de Botânica, Av. Miguel Stéfano, 3687 – CEP 04301902 – São Paulo, SP., Brazil.

*dimas.botanica@gmail.com

Abstract: The *Dicranella* genus was positioned in the Dicranaceae family, however, molecular studies verified that this genus belongs to a paraphyletic group. Moreover, this genus presents several taxonomic issues that make it difficult its identification. The purpose of this work was to analyze and describe the characteristics of Brazilian *Dicranella* species. This was mainly accomplished through the exsiccate analysis, new collections and Brazilian material types observations, since this genus revision content does not currently exist. All analyses were performed with exsiccates deposited in the SP herbaria, moreover, some loans were made with the collaboration of national and international herbaria. The analysis of 505 exsiccates revealed that there are 14 Brazilian *Dicranella* species and that most of these mosses inhabit terrestrial areas (59%) in the Atlantic Forest phytogeographical domain (54%). The *D. angustifolia* Mitt., *D. apolensis* R.S. Williams and *D. harrisii* (Müll. Hal.) Broth. were verified to be new records in Brazil and the geographical distribution of all the *Dicranella* species increased. The majority of *Dicranella* species identified are endemic to Brazil (57%). The present study not only provided new information about Brazilian *Dicranella* species, but also improved and expanded upon the existing knowledge of these species in Brazil.

Keywords: Dicranales, Dicranidae, haplolepideous species, mosses, taxonomic revision

Introduction

Species of the *Dicranella* (Müll. Hal.) Schimp. genus were historically positioned in Dicranaceae family. This assignment was primarily based on morphological characteristics, such as the presence of bifid peristome teeth (Ireland 2007). However, molecular studies have demonstrated that the Dicranaceae family contains a paraphyletic group, in which some taxa, including the *Dicranella* genus, do not have a well-defined circumscription or distinct diagnostic characteristics (Stech 1999; La Farge *et al.* 2000; 2002; Frey & Stech 2009; Cox *et al.* 2010; Stech *et al.* 2012). Due to this situation, the Dicranellaceae family was proposed with the purpose to minimize the subjectivity existing in Dicranaceae taxa delimitation and adding the *Dicranella* genus to a monophyletic family (Stech & Frey 2008).

The Dicranellaceae family was circumscribed and defined by the presence of a stem cross-section with a central band of stereids, leaves appressed or erect-spreading, often flexuose or falcate-secund, narrowly lanceolate and subulate, alar cells undifferentiated; costa present, single, simple, narrow; capsulae smooth, plicate or striate; operculum conic to long-rostrate, peristome dicranoid, calyptra cucullate and spores generally papillose (Stech & Frey 2008; Frey & Stech 2009). However, some of these characteristics are also present in other moss taxa such as Bryaceae, Pottiaceae, Ditrichaceae and Rhabdoweisiaceae families (Allen 1994; Churchill & Linares 1995; Duarte Bello 1997; Crum 2007; Ochyra *et al.* 2008; Frey & Stech 2009), making the identification process difficult and often times confusing. Additionally, the identification of *Dicranella* genus species is dependent on sporophyte reproductive structure characteristics, which are not always present (Allen 1994; Churchill & Linares 1995; Ochyra *et al.* 2000; Frey & Stech 2009).

Worldwide, there are currently 230 species in the Dicranellaceae family, of which 158 are *Dicranella*. Thus, this genus constitutes approximately 70% of the family (Frey & Stech 2009). In Brazil, only three species are currently considered: *Dicranella guillemianiana* (Mont.) Mitt., *Dicranella hilariana* (Mont.) Mitt and *Dicranella vaginata* (Hook.) Cardot. These species are found in nearly every Brazilian state, with the exception of Alagoas, Piauí, Rio Grande do Norte, Sergipe and Distrito Federal (Costa *et al.* 2011).

Publications referring to *Dicranella* genus in Brazil are scarce and limited to studies providing floristic surveys or checklists, where the presence of some species is registered locally (Bastos & Yano 1993; Visnadi & Vital 2000; Costa *et al.* 2011; Carmo *et al.* 2015; Oliveira & Peralta 2015; Pereira & Câmara 2015; Ristow *et al.* 2015; Carmo & Peralta 2016; Carmo *et al.* 2016; Santos *et al.* 2017). To date, there has been no taxonomic revision or delimitation of the characteristics used for the identification of *Dicranella* species in Brazil.

Furthermore, there are few herbaria collections of these species and a limited number of publications involving this genus, resulting in a confusing and difficult delimitation of their species, reinforcing the need for a taxonomic revision (Allen 1994; Churchill & Linares 1995; Crum 2007; Ochyra *et al.* 2008; Frey & Stech 2009; Stech *et al.* 2012).

The purpose of this work is to provide an aid for the identification of *Dicranella* species occurring in Brazil with an assemblage of an identification key and to present information and some comments about its morphological characteristics, the worldwide and Brazilian geographical distribution, the phytogeographic domains and substrates occupied. Many species were put for the first time in an identification key herein. This work is part of the Neotropic *Dicranella* species taxonomic revision and the studies directed to the Dicranales order, and contributes to the 2020 Flora of Brazil project.

Materials and Methods

The *Dicranella* species nomenclature types already cited for Brazil were analyzed (Yano 2011), with exception of: *Dicranella brasiliensis* (Duby) Bartram, *Dicranella guilleminiana* (Mont.) Mitt. And *Dicranella longirostris* (Schwägr.) Mitt. which were not found in the herbaria where they should have been deposited. Additionally, in order to gain a better understanding about the the morphological variations, species distribution in Brazil and to increase the number of samples, exsiccates from the ALCB, BM, G, JE, ICN, MG, MICH, NY, PC, R, RB, S, SJRP, SP, UB and UFP herbaria were also analyzed.

In addition to exsiccate loans, some collections were located in poorly explored areas, where few records of Brazilian *Dicranella* have been reported. According to the literature, *Dicranella* species are typically found at high altitudes and in rocky fields (Gradstein *et al.* 2001). Therefore, Campos do Jordão – SP, Pico dos Marins – SP, Serra da Bocaina – SP, Serra da Canastra – MG, Serra da Caraça – MG, Serra do Itatiaia – RJ and Serra de Tepequém – RR) were searched for new samples.

All of the collected materials were deposited in the “Maria Eneyda Pacheco Kauffman Fidalgo” herbaria, in (SP). Permanent slides were prepared using Kayser glycerine gelatin and analyzed using a stereomicroscope and an optical microscope. The nomenclature of the morphological characteristics in the descriptions, identification keys and comments are according Luizi-Ponzo *et al.* (2006) and Frey & Stech (2009) and the classification system was adopted from Frey & Stech (2009). The Brazilian geographic, worldwide distribution and phytogeographical domains were assigned as in Forzza *et al.* (2010), Costa *et al.* (2011),

Carmo & Peralta (2016) and Carmo *et al.* (2016). A Brazilian geographic distribution pattern as species rare, moderate and wide was assembled according to Valente & Pôrto (2006).

In the taxonomic treatment, the list of Brazilian *Dicranella* species was assembled in alphabetical order, with the protologue presence, nomenclatural type, examined material, Brazilian and worldwide geographical distribution, phytogeographic domains and occupied substrates. Additionally, comments about the morphology and ecology of each species is provided. For the species description, only diagnostic characteristics, based on observations of the samples, type material analysis and bibliographical consultations were employed (Schimper 1856; Mitten 1869; Allen 1994; Crum 1994; Duarte Bello 1997; Ochyra *et al.* 2000; Crum 2007; Larraín *et al.* 2010). To assign the geographic distribution of the *Dicranella* species, the material examined was represented by a sample from each Brazilian state, while the Brazilian states were represented according to Yano (1981). The new records to Brazil and its states are marked with an asterisk in front of the species name and with an asterisk to the new records occurring in the Brazilian states.

Results and Discussion

In total, 505 exsiccates from 14 national and international herbariums were analyzed. Of these, 24 were *Dicranella* type material and 14 *Dicranella* species were identified for Brazil. Since, *Dicranella affinis* Ångström, *D. caldensis* Ångström, *D. crinalis* Geh. & Hampe, *D. brasiliensis* (Duby) E.B. Bartram, *D. elata* Schimp. Ex Mitt., *D. glaziovii* (Hampe) Hampe, *D. guillemianiana* (Mont.) Mitt., *D. itatiaiae* (Müll. Hal.) Broth., *D. longirostris* (Schwägr.) Mitt. and *D. nitida* Broth. were only known by the type material and had not appeared in any new collection or samples deposited in the herbariums, they were disregarded in this new taxonomic revision proposal.

On the other hand, the *Dicranella fusca* Broth., *D. gymna* (Müll. Hal.) Broth., *D. juliformis* Broth., *D. pabstiana* (Müll. Hal.) Mitt., *D. puiggarii* Geh. & Hampe, *D. riograndensis* Broth., *D. subsulcata* (Hampe) Hampe and *D. ulei* (Müll. Hal.) Broth. species were known only by the type and after our review work, they are distributed and included in an identification key for the first time after their publication. According to our results, all *Dicranella* species found had their geographical distribution amplified, occurring predominantly in the Atlantic Forest (54%) (Fig. 1) and on terrestrial substrates (59%) (Fig. 2).

Altogether, eight *Dicranella* species (57%) were found with a rare geographical distribution pattern, five species (35%) had a moderate distribution pattern and only

Dicranella lindigiana species was considered to have a wide distribution pattern, occurring in ten or more Brazilian states (Valente & Pôrto 2006). The absence of bibliographies, limited collections and identification data for these species most likely contributed to the rare distribution associated with most of the Brazilian *Dicranella* species, which again emphasizes the need for carrying out this work. With regards to worldwide distribution patterns, the *Dicranella* species were characterized with only two patterns: endemic species from Brazil, which represented a total of eight (57%) species, and Neotropical species presented six species (43%).

According to the obtained results, it was verified that Brazil constitutes a significant area for *Dicranella* conservation and species richness, since most species (57%) are endemic to the country. From this work, we were able to achieve this result by reviewing and collecting the samples, indicating the *vouchers* to confirm, and recording and sharing information for future studies. The amount of information, with regards to geographic distribution, morphology and ecology, that existed for Brazilian *Dicranella* species was significantly increased by the present study.

After reviewing the samples, together with the type material analyses, it was determined that some of the characteristics can be disregarded, since they do not represent the morphological state of the plant, are subject to the interpretation of the taxonomist and are not informative. For example, the costa length varies between the leaves and periquecual leaves, and even between leaves of the same species or sample. This variability was also observed with other moss species, such as: *Bryum* (Ochi 1980) and *Campylopus* (Frahm 1991), thus complicating the identification process, at a specific level. However, to date, there are no studies involving the *Dicranella* species that cite this issue or take this discrepancy into consideration.

We can also cite the coloring characteristics, setae length as well as, capsulae length, texture and curvature, which may vary according to the season and development period in which the species were collected (Dixon 1913; Edwards 1984). In fact, it was observed that even the manner in which these species were deposited in the herbaria can influencing these characteristics. Furthermore, according to our studies and observations of the reviewed samples, it is common for the environmental and developmental issues of these species to be disregarded or maintained without any detailed analysis of these characteristics, which can introduce some mistakes at the time of species identification.

In addition, the *Dicranella* species characteristics used present some problems in its definition and identification, such as spore coloration and texture. Indeed, many identification keys utilize these characteristics when separating *Dicranella* species (Mitten

1869; Allen 1994; Crum 1994). In this work, we also used these characteristics to separate some Brazilian species, however, it is important to point out that these characteristics need to be revised and extended, since there were samples that presented different spore types in the same capsulae, that is, the same species presented different spore morphologies. It is plausible that these spores were at different development stages or were aborted (Mogensen 1981; 1983). To confirm either of these two possibilities would require palynological studies with *Dicranella* genus species.

Valid characteristics to separate the Brazilian *Dicranella* species are detailed in the identification key below. It was verified that the peristome type is a good characteristic, being dicranoid, the presence of bifid teeth to half, dorsally trabeculate and vertically striated, distally papillose and colorless, basal membrane often absent. Alternatively, species that present a seligerioid peristome are characterized by irregularly bifid teeth, cleft or perforated, entirely papillose, dorsally trabeculated but not vertically striated, with the basal membrane reduced or absent (Luizi-Ponzo *et al.* 2006; Frey & Stech 2009). Informative characteristics, including: leaf base insertion, leaf and apex shape, cell morphology and other characteristics that are also defined in the taxonomic treatment below:

Identification key for Brazilian *Dicranella* species.

1. Leaves with a distinct sheathing base.....2
 2. Basal leaf cells linear, narrow, with subula gradually narrow after lamina shoulder, costa occupying 1/3 subula width, with apex obtuse to acute.....*D. puiggarii*
 - 2'. Basal leaf cells quadratic to long-rectangular, with subula abruptly narrow after lamina shoulder, costa occupying the entire subula width, with apex long-acuminate.....3
 3. Basal leaf cells quadratic to short-rectangular, annulus attached to the capsulae.....*D. harrisii*
 - 3'. Basal leaf cells rectangular to long-rectangular, annulus absent.....*D. vaginata*
- 1'. Leaves with base cuneate or slightly sheathing.....4
 4. Leaves distal portion plane, subula absent.....5
 5. Peristome dicranoid.....6
 6. Leaves arrangement ascendent, erect-ascendent to erect-spreading, oblong and apex frequently obtuse.....*D. hilariana*
 - 6'. Leaves arrangement julaceous, imbricate and appressed, lanceolate and apex acuminate.....*D. juliformis*
 - 5'. Peristome seligerioid or absent.....7
 7. Peristome absent.....*D. gymna*

- 7'. Peristome present, seligerioid*D. lindigiana*
- 4'. Leaves distal portion incurvate, forming subula.....8
8. Costa median portion in cross-section without guide cells.....*D. fusca*
- 8'. Costa median portion in cross-section with guide cells.....9
9. Peristome seligerioid10
10. Capsules oblong to oblong-cylindrical, annulus absent or easily detachable
.....*D. apolensis*
- 10'. Capsules globose, annulus present, inconspicuous and attached to the capsulae
.....*D. ulei*
- 9'. Peristome dicranoid.....11
11. Annulus present.....12
12. Spores colorless, scarcely papillose*D. pabstiana*
- 12'. Spores, yellow, brownish to brown, densely papillose.....*D. subsulcata*
11. Annulus absent13
13. Leaves lanceolate to oblong-lanceolate, with apex gradually acuminate and costa
filling 1/3 of subula width.....*D. riograndensis*
- 13'. Leaves lanceolate, with apex abruptly long-acuminate, costa filling the entire
subula width.....*D. angustifolia*

****Dicranella angustifolia*** Mitt., J. Linn. Soc., Bot. 12: 35. 1869. Type: [Colômbia], Andes Bogotensis, in sylva supra Pacho (6000 ped.) ad viam, *J. Weir 138* (syntypes NY01093616, BM000879278, BM000879279, NY01093614, NY01093615, E00429158, E00429159, BM000724667); [Ecuador] Andes Quitensis, in sylva Canelos, Spruce 38b (syntypes NY01093613, BM000724669, E00429160).

Figure 3 A-I.

Examined material: BRASIL. Rio de Janeiro: Serra do Itatiaia, 22°29'46" S, 44°33'48" W, 01-XI-1987, *Schäfer-Verwimp*, A. 9260 (SP388369).

Geographic Distribution: *RJ. Neotropical.

Brazilian Phytogeographic Domains: Atlantic Forest.

This species is recognized by quite narrow and lanceolate leaves, with the basal portion of the leaves slightly dilated. In addition, as the name of the species suggests, it has

an elongated subula and a long-aristated apex, which is a unique and diagnostic characteristic among the known *Dicranella* species.

A new occurrence for this species in Brazil was found in Serra do Itatiaia in Rio de Janeiro, with an Atlantic Forest phytogeographical domain at an altitude of 1200 m. It was found growing on wet rocks, one of the substrates used by *Dicranella* species.

****Dicranella apolensis*** R.S. Williams, Bull. New York Bot. Gard. 3(9): 106. 1903. Type: Bolivia, on sand along stream, Apolo, 1 July 1902, *Williams 1743* (syntypes BM000879280 BM000879281, F0001106C, JE04000616, NY01093617).

Figure 4 A-I.

Examined material: BRASIL. Mato Grosso: Barra do Garça, 12-VII-1969, *Vital, D.M. 1552* (SP89947); idem, Mato Grosso do Sul: Corguinho, Cachoeira do Córrego do Garimpo, 22-IV-2011, *Yano, O. 33025*, (SP425118); idem, Minas Gerais: São Roque de Minas, Parque Nacional da Serra da Canastra, 20°18'09" S, 46°31'23" W, 17-VII-2014, *Peralta, D.F. 15591* (SP452013); idem, Catas Altas, Reserva Particular do Patrimônio Natural do Parque da Serra do Caraça, trilha da Cachoeira Cascatona, 20°05'53" S, 43°29'11" W, 20-VII-2016, *Carmo, D.M. 1438* (SP477410); idem, Paraíba: João Pessoa, km 115 da BR 101, 7°06'54" S, 34°51'47" W, 30-VIII-1980, *Yano, O. 2836* (SP191362); idem, Paraná: Ipiranga, trecho de rodovia da BR 373, 25°01'26" S, 50°35'03" W, 15-III-1976, *Vital, D.M. 5810* (SP134925); idem, Pernambuco: Cabo, Estação Gurjaú, 14-I-1984, *Yano, O. 9165* (SP191787); idem, Rio de Janeiro: Parati, Bairro do Curisco, 23°13'04" S, 44°42'47" W, 23-X-1988, *Vital, D.M. s/n* (SP374678); idem, São Paulo: Ubatuba, Parque Estadual da Ilha Anchieta (PEIA), 23°26'02" S, 45°04'16" W, 27-II-2003, *Peralta, D.F. 1501* (SP362428).

Geographic Distribution: *MG, *MS, *MT, *PB, *PE, *PR, *SP and *RJ. Neotropical.

Brazilian Phytogeographic Domains: Atlantic Forest and Cerrado.

The *Dicranella apolensis* species can be characterized by the presence of seligerioid peristomes or, in other words, irregularly bifid teeth, perforated or cleft, entirely papillose, without vertical or transverse striae (Frey & Stech 2009). In addition, among *Dicranella* species that have this same peristome type, this species is also distinguished by the presence of subula, costa median cross-section holding guide cells, capsules oblong to oblong-cylindrical, annulus absence and spores brownish to brown, densely papillose.

Previously, by its material type, this species was only known to exist in Bolivia, but the present study registered it for the first time in Brazil, with a moderate and frequent distribution, occurring in eight Brazilian states. In Brazil, it was found growing on rocks and wet or sandy soils, at altitudes between 5 and 1300 m, which may, at least partially, account for its greater frequency and geographic distribution, when compared to other *Dicranella* species.

Dicranella fusca Broth., Acta Soc. Sci. Fenn. 19(5): 5. 1891 \equiv *Aongstroemia fusca* (Broth.) Müll. Hal., Gen. Musc. Frond. 324. 1900. Type: [Brasilia], Prov. Minas Gerais, Caraça, ad rupes, [1885] *E. Wainio s.n.* (syntype H1155033 Hb-Brotherus, TUR00634).

Figure 5 A-G.

Examined material: BRASIL. Ceará: Guaramiranga, Maciço de Baturité, 4°15'48" S, 38°55'59" W, 16-X-1993, *Yano, O.* 20883 (SP273911); idem, Espírito Santo: Iconha, 20°47'35" S, 40°48'35" W, 17-IV-1965, *Vital, D.M.* 392 (SP89284); idem, Minas Gerais: Catas Altas, Reserva Particular do Patrimônio Natural do Parque da Serra do Caraça, trilha para a Gruta de Lourdes, 20°05'53" S, 43°29'11" W, 18-VII-2016, *Carmo, D.M.* 1389 (SP477361); idem, Paraná: Morretes, Parque Estadual Pico do Marumbi, trilha do Olimpo, 25°27'00" S, 48°55'05" W, 19-IV-2015, *Peralta, D.F.* 16767 (SP 460301); idem, Pernambuco: Fernando de Noronha, próximo à fenda do Morro, *Pereira, C.G. & Câmara, P.E.A.S.* 70 (SP458748); idem, Rio de Janeiro: Itatiaia, Parque Nacional do Itatiaia, 22°22'49" S, 44°41'18" W, 09-VI-2015, *Peralta, D.F.* 17167 (SP460705); idem, Roraima: Amajari, trilha para o platô Serra do Tepequém, 3°45'52" N, 61°41'14" W, 08-IX-2017, *Peralta, D.F.* 21568 (SP 482766); idem, Santa Catarina: Joinville, estrada para o Mirante, atrás do Parque Zoobotânico, 26°17'31" S, 48°49'40" W, 14-XI-2012, *Peralta, D.F.* 12675 (SP435090); idem, São Paulo: Campos do Jordão, Horto Florestal, trilha Celestina, 22°42'25" S, 45°27'59" W, 05-X-2017, *Carmo, D.M.* 1827 (SP484666).

Geographic Distribution: *CE, *ES, MG, *PE, *PR, *RR, *SC, *RJ and *SP. Endemic to Brazil.

Brazilian Phytogeographic Domains: Amazonia, Atlantic Forest and Cerrado.

Dicranella fusca can be characterized by the presence of leaves lanceolate, base cuneate, subula, basal cells rectangular quite narrow and thin, as well as median and apical

cells, peristome dicranoid and annulus quite attached to the capsulae, spores yellow, brownish to brown, densely papillose. However, in contrast to other Brazilian species, the absence of guide cells when performing a cross section on the leaves median portion was observed.

According to our analyses, many of the species identified as *Dicranella varia* (Hedw.) Schimp., were actually *Dicranella fusca*. When analyzing the description characteristics of the two species and comparing them with the type illustrated, it was understood and presumed that the two species are synonymous. However, it was only with the cellular characteristics observed with the *Dicranella varia* type slides and additional analyses that we were able to give a more conclusive diagnosis about this statement. However, since we did not have access to this type, it is not appropriate to propose this new synonymization.

In Brazil, this species was only known for its sample type which was collected at Serra do Caraça in Minas Gerais state. The present study extended the geographical distribution of this species as new occurrences in eight more Brazilian states, revealing that this species is relatively common throughout the country. Furthermore, based on the analyzed samples, it was determined that this species can grow on soils, rocks and even living tree trunks at altitudes of 200 – 1900 m.

Dicranella gymna (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 309. 1901 \equiv *Leptotrichella gymna* (Müll. Hal.) Ochyra, Fragm. Florist. Geobot. 42: 562. 1997 \equiv *Microdus gymnus* (Müll. Hal.) Paris, Index Bryol. Suppl. 244. 1900 \equiv *Aongstroemia gymna* Müll. Hal., Bull. Herb. Boissier 6: 43. 1898. Type: Brasilia, Serra Itatiaia, 1700 m. alta, in declivibus, Martio 1894, *E. Ule 1806* (H2719028 Hb-Brotherus).

Figure 6 A-I.

Examined material: BRASIL. Minas Gerais: Catas Altas, Reserva Particular do Patrimônio Natural do Parque da Serra do Caraça, trilha da Cachoeira Cascatona, 20°05'53" S, 43°29'11" W, 20-VII-2016, *Carmo, D.M. 1457* (SP477429).

Geographic Distribution: *MG and RJ. Endemic to Brazil.

Brazilian Phytogeographic Domains: Atlantic Forest.

Among the various characteristics that define this species, the absence of the the peristome is perhaps most notable, which is the reason why its name is gymna (Greek origin

= naked). However, caution must be taken not to associate all species without a peristome with *Dicranella gymna*, because in some cases, the peristome may have fallen off or was not yet formed, since the peristome development is associated to other variables that require further evaluation and understanding, such as climate change and/or developmental stage (Dixon 1913; Edwards 1984).

The *Dicranella gymna* species has its type from Brazil, only being registered in Serra do Itatiaia in Rio de Janeiro state. However, after analyzing the samples, it was found that *Dicranella gymna* also occurs in Serra do Caraça in Minas Gerais state, growing on soils and rocks at high altitudes ranging from 1000 to 1300 m.

**Dicranella harrisii* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 309. 1901 \equiv *Microdus harrisii* (Müll. Hal.) Paris, Index Bryol. Suppl. 244. 1900 \equiv *Aongstroemia harrisii* Müll. Hal., Bull. Herb. Boissier 5: 554. 1897. Type: Jamaica, Blue Mountains Peak, 7420 ped. Alta, in solo, [31] Martio 1896, *W. Harris 10068* Hb-Jamaicense (BM000879247, NY00615187, NY00615188, NY00615189, PC0129007, PC0129008).

Figure 7 A-I.

Examined material: BRASIL. Minas Gerais: Itamonte, Parque Nacional do Itatiaia, 22°17'02" S, 44°52'12" W, 04-VII-1991, *Vital, D.M. 19548*, (SP353378); idem, Paraná: Piraquara, 25°26'30" S, 49°03'48" W, 08-VI-1989, *Hatschbach, C.M. 53121* (SP231941); idem, Rio de Janeiro: Itatiaia, Parque Nacional do Itatiaia, 22°29'46" S, 44°33'48" W, 04-VII-1991, *Vital, D.M. s/n* (SP 387405); idem, São Paulo: Campos do Jordão, área urbana da cidade de Campos do Jordão, 22°43'07" N, 45°33'59" W, 1-X-2017, *Peralta, D.F. 21669* (SP 483044).

Geographic Distribution: *MG, *PR, *RJ and *SP. Neotropical.

Brazilian Phytogeographic Domains: Atlantic Forest.

The *Dicranella harrisii* species that presents a leaf insertion with the sheathing base, or vaginant lamina, that is, the leaf base forms a vaginant sheath. In addition, it also presents subula developing abruptly from the lamina shoulder, with apex long-acuminate, subulate and costa filling the entire subula width. It was often confused with *Dicranella vaginata*; however, it differs by the presence of quadratic to short-rectangular basal cells, annulus attached to the capsule and spores yellow to brown, often papillose.

In Brazil, the species was previously registered in Ceará state (Yano 2011; Oliveira & Peralta 2015), however there is no reference or *voucher* citation in the first paper that confirmed this assertion. On the other hand, the second reference, which had been cited, corresponded to a *Dicranella fusca* species. Thus, according to our studies, based on more than 500 exsiccates observed and in types analyzed, it was decided to exclude this occurrence from Ceará, making *Dicranella harrisii* a new occurrence in Brazil with a geographical distribution in four Brazilian states of the Atlantic Forest region. It was found growing in moist soils, ground banks and on rocks, at altitudes ranging from 900 to 1800 m.

Dicranella hilariana (Mont.) Mitt., J. Linn. Soc., Bot. 12: 31. 1869 \equiv *Aongstroemia hilariana* (Mont.) Müll. Hal., Syn. Musc. Frond. 1: 443. 1848 \equiv *Microdus hilarianus* (Mont.) Besch., Index Bryol. 804. 1897 \equiv *Dicranum hilarianum* Mont., Ann. Sci. Nat., Bot., sér. 2, 12: 52. 1 f. 2. 1839. Type: [Brasil], Ad terram, in Brasilia meridional, [A. Saint-Hilaire s.n.] (syntypes P0146145, BM000663421, BM000663424, P0728963).

Figure 8 A-I.

Examined material: BRASIL. Acre: Rio Branco, Estação experimental de Catuaba, ca. De 8 km NE de Rio Branco, 9°58'29" S, 67°48'36" W, 30-V-1987, Vital, D.M. 14936 (SP256988); idem, Minas Gerais: Belo Horizonte, Jockey clube, 19°55'15" S, 43°56'16" W, 09-II-1976, Vital, D.M. 5516 (SP134749); idem, Mato Grosso: Barra do Garça, acampamento dos ingleses, 15°53'24" S, 52°15'24" W, 29-V-1968, Vital, D.M. 1384 (SP89826); idem, Mato Grosso do Sul: Ribas do Rio Pardo, Reflorestadora Estância S.A., 20°26'35" S, 53°45'33" W, 25-I-1979, Yano, O. 1341 (SP147473); idem, Paraná: Campo Magro, Conceição dos Correia, base do Morro da Palha, 25°14'30" S, 49°28'36" W, 09-X-2016, Canestraro, B.K. 980 (SP486191); idem, Rio de Janeiro: Paraty, ao longo da Rodovia Paraty-Cunha, 23°13'04" S, 44°42'47" W, 20-VIII-1987, Vital, D.M. 15329 (SP257383); idem, Rondônia: Ji-Paraná, 10°26'20" S, 62°27'59" W, 07-X-1986, Vital, D.M. 14206 (SP228972); idem, São Paulo: Campos do Jordão, Parque Estadual de Campos do Jordão, trilha do Rio Sapucaí, 22°41'23" N, 45°28'30" W, 03-X-2017, Peralta, D.F. 21865 (SP483240).

Geographic Distribution: AC, MG, MS, MT, *PR, RJ, RO and SP. Neotropical.

Brazilian Phytogeographic Domains: Amazonia, Atlantic Forest and Cerrado.

Previously it was believed that the *Dicranella hilariana* species was not widely distributed throughout Brazil. However, according to our studies, many of the samples identified as *Dicranella hilariana* actually corresponded to *Dicranella lindigiana*, *Dicranella apolensis* or even to moss species from other families, such as: Bryaceae, Ditrichaceae, Mniaceae, Pottiaceae or Rhabdoweisiaceae. Characteristics used for the identification of *Dicranella hilariana*, include: oblong leaves, apex frequently obtuse, oblong to oblong-cylindrical capsulae, peristome dicranoid, annulus absence and spores scarcely papillose.

The *Dicranella hilariana* species has its type material from Brazil and its distribution among Brazilian states is classified as moderate with a new occurrence for Paraná state. It has presented an exclusively terrestrial habit, being found in ground banks, soils, borders of rivers and paved roads with different moisture and sun exposure levels. It has been found at altitudes ranging from 5 to 850 m.

Dicranella juliformis Broth., Bih. Kongl. Svenska Vetensk.-Akad. Handl. 26 fd. 3(7): 6. 1900. Type: Brazil, Minas Gerais, S. João d'El-Rei, ad terram sub rupibus, C.A. Lindman 1 (SB62519).

Figure 9 A-I.

Examined material: BRASIL. Amazonas: São Gabriel da Cachoeira, Rio Negro, 0°07'49" S, 67°05'21" W, 20-VII-1979, *Yano, O. 2114* (SP150603); idem, Goiás: Goiânia, ao longo da BR – 060, Km 19, 16°40'43" S, 49°15'14" W, 20-V-1976, *Vital, D.M. 6313* (SP135275); idem, Mato Grosso: Barra do Garça, 15°53'24" S, 52°15'24" W, 20-V-1968, *Vital D.M. 1347* (SP89810); idem, Minas Gerais: São Roque de Minas, Parque Nacional da Serra da Canastra, 20°15'34" S, 46°32'45" W, 14-II-2012, *Carmo, D.M. 468* (SP436672); idem, Paraná: Morretes, 25°28'37" S, 48°50'04" W, 05-VIII-1973, *da Luz, G.O.F. s/n* (SP90884); idem, Rio de Janeiro: Angra dos Reis, Ilha Grande, estrada para dois rios, 23°00'24" S, 44°19'05" W, 22-III-1995, *Yano, O. 23813* (SP282148); idem, Roraima: Amajari, Serra do Tepequém, planalto das Guianas, trilha para o platô da Serra de Tepequém, 3°45'52" N, 61°41'14" W, 08-IX-2017, *Peralta, D.F. 21571* (SP482769); idem, São Paulo: Peruíbe, Morro da Praia do Cibratel, 24°19'12" S, 46°59'54" W, 19-V-1966, *Vital, D.M. 865* (SP89439).

Geographic Distribution: *AM, *GO, MG, *MT, *PR, *RJ, *RR and *SP. Endemic to Brazil.

Brazilian Phytogeographic Domains: Amazonia, Atlantic Forest and Cerrado.

Dicranella julifomis is characterized by its julaceous aspect, with leaves quite imbricated, and the basis of its species name. It can be confused with *Dicranella hilariana*, but differs by the presence of julaceous gametophyte, leaves lanceolate, apex frequently acuminate and by the presence of an annulus in the sporophyte.

This species was only known for its type material and was described based on an original sample collected in the São João Del Rei municipality of Minas Gerais state, in Brazil. The present work extended its geographic distribution to another seven Brazilian states as new occurrences. It can be found on rocks, soils and moist ground banks in shaded locations. This species may also be found associated with other bryophyte species such as *Marchantia chenopoda* L., *Philonotis uncinata* (Schwägr.) Brid. and *Zoopsisidella* sp. in Brazil it was found occurring at altitudes of 5 to 1000 m.

Dicranella lindigiana (Hampe) Mitt., J. Linn. Soc., Bot. 12: 30. 1869 \equiv *Leptotrichella lindigiana* (Hampe) Ochyra, Fragm. Florist. Geobot. 42: 563. 1997 \equiv *Microdus lindigianus* (Hampe) Besch., Index Bryol. 804. 1897 \equiv *Seligeria lindigiana* Hampe, Ann. Sci. Nat., Bot., sér. 5, 3: 353. 1865. Type: [Colombia], Bogota, Socorro et Pic de Cuesta, altit. 1200-1400 metr., ad Barrancas in umbrosis, sept. 1863, A. Lindig [s.n.] (syntypes GOET013544, BM000879481, BM000879482, BM000879483, BM000879484, BM000879485, BM000879486, BM000879487, BM000879488, BM000879489, BM000879480, GOET013541, GOET013542, GOET013543, GOET013544, PC0129057, PC0695522).

Figure 10 A-H.

Examined material: BRASIL. Amazonas: Manaus, Reserva da Campina, 3°06'07" S, 60°01'30" W, 08-VII-1974, *Griffin III, D. 04* (SP125224); idem, Bahia: Ilhéus, 5 km S de Ilhéus na estrada para Olivença, 14°47'20" S, 39°02'58" W, 14-VII-1991, *Vital, D.M. 20100* (SP353836); idem, Distrito Federal: Brasilândia, Chapada Imperial, área particular, 15°00'00" S, 46°38'10" W, 02-VII-2016, *Peralta, D.F. 18752* (SP464138); idem, Espírito Santo: Fundão, ao longo da rodovia BR – 101, 19°55'57" S, 40°24'24" W, 15-IV-1980, *Vital, D.M. 8889* (SP 148504); idem, Goiás: Hidrolândia, ao longo da rodovia BR – 153, 16°57'44" S, 49°13'41" W, 10-IV-1976, *Vital, D.M. 6138* (SP135136); idem, Mato Grosso: Sinop, Parque Florestal de Sinop, Rua das Avencas, Jardim Primavera, 11°50'03" S, 55°30'01" W, 05-XII-2008, *Borges, F.R. 367* (SP451280); idem, Mato Grosso do Sul: Corguinho, Cachoeira do Córrego do Garimpo, 22-IV-2011, *Yano, O. 33022* (SP 425115); idem, Minas Gerais: São Roque de Minas, Parque Nacional da Serra da Canastra, 20°16'63" S, 46°55'94"

W, 11-II-2012, *Carmo, D.M. 348* (SP436556); idem, Paraná: Ipiranga, ao longo da rodovia BR – 373, 25°01'26" S, 50°35'03" W, 15-III-1976, *Vital, D.M. 5813* (SP134928); idem, Rio Grande do Sul: São Lourenço do Sul, ca. 5km N da entrada para São Lourenço do Sul, 31°10'48" S, 52°00'36", 09-VII-1980, *Vital, D.M. 8960* (SP148951); idem, Roraima: Amajari, Serra do Tepequém, trilha para a Cachoeira do Paiva, 3°47'15" N, 61°46'06" W, 07-IX-2017, *Carmo, D.M. 1503* (SP482862); idem, Santa Catarina: Porto Belo, 27°09'28" S, 48°33'11" W, 17-IV-1980, *Yano, O. 2474* (SP 148569); idem, São Paulo: Ibiúna, Bairro Sorocabuçu, 23°39'23" S, 47°13'21" W, 28-VII-1989, *Yano, O. 13289* (SP228215).

Geographic Distribution: *AM, *BA, *DF, *ES, *GO, *MT, *MS, MG, *PR, *RS, *RR, *SC and *SP. Neotropical.

Brazilian Phytogeographic Domains: Amazonia, Atlantic Forest and Cerrado.

Among all *Dicranella* species found in Brazil, *Dicranella lindigiana* is the most widely distributed species in Brazil. Sometimes mistaken for *Dicranella juliformis*, but distinguished by the presence of capsulae globose and peristome seligerioid. In cases when the sample does not contain a sporophyte, the identification between these two species becomes very difficult, making it practically impossible for them to be assured and morphologically separated. It can also be confused with *Dicranella apolensis*, presenting as distinctive characteristics only subula absence and annulus presence.

In the work of Ristow *et al.* (2015), this species was considered as a new record for Paraná. However, since the sample used in this work presented the peristome dicranoid as a characteristic and after our analysis of the *Dicranella lindigiana* morphological type and revision of more than 500 samples, it was decided that this record should not be considered. In addition, we could not identify or recognize this sample with the knowledge that we had at the moment, which reveals the need for more research efforts with this group and highlights the importance of taxonomic approaches when interpreting new data regarding bryophyte diversity.

The *Dicranella lindigiana* was the only species present in this work that can be considered to have a wide distribution, that is, occurring in ten or more Brazilian states. There have been 12 new occurrences in Brazilian states. This species is often found in terrestrial and rupicolous habitat, associated with *Fossombronia porphyrorhyza* (Nees) Prosk. Species, at altitudes up to 1300 m.

Dicranella pabstiana (Müll. Hal.) Mitt., J. Linn. Soc., Bot. 12: 31. 1869 \equiv *Aongstroemia pabstiana* Müll. Hal., Bot. Zeitung (Berlin) 15: 380. 1857. Type: Santa Catharina insula, solo limoso, ad vias et in declivibus ad flumen Rio de Velha, socio *Trematodontes squarrosus*: *Pabst* [s.n.] (syntypes BM000879300, BM000879300, BM000879301, G00116225, G00116226, NY01917788).

Figure 11 A-I.

Examined material: BRASIL. Minas Gerais: Miraf, Sítio Volta Fria, área particular, 21°12'05" N, 42°38'35" W, 11-III-2018, *Peralta, D.F.* 22630 (SP486428); idem, Santa Catarina: Urubici, Estrada para Serra do Corvo Branco, 28°02'35" S, 49°24'30" W, 16-XII-2017, *Canestraro, B.K.* 1131 (SP486290).

Geographic Distribution: *MG and SC. Endemic to Brazil.

Brazilian Phytogeographic Domains: Atlantic Forest.

The *Dicranella pabstiana* species can be characterized by leaves with cuneate base or slight sheathing, with an acuminate apex, median cross-section portion of the leaves presenting guide cells, peristome dicranoid, annulus present and spores colorless and scarcely papillose.

The material type of this species is from Santa Catarina state and presents a rare distribution in Brazil, since it has only been identified in this state. The present work, now reports this species as new occurrence in the Miraf municipality of Minas Gerais state, restricting it to the Atlantic Forest phytogeographical domain. It has been presented in Brazilian collections exclusively in a terrestrial habitat, growing in soils and moist banks, at altitudes between 500 -1000m.

Dicranella puiggarii Geh. & Hampe, Flora 64: 339. 1881 \equiv *Aongstroemia puiggarii* (Geh. & Hampe) Müll. Hal., (Gen. Musc. Frond.) 321. 1900. Type: Serra de Boa Vista inter Apiahy et Iporanga, statu imaturo, colore rufescente et foliis longioribus, 18.07.1879, *Puiggari s.n.* (prob. Holotype BM000879405).

Figure 12 A-J.

Examined material: Brasil. Santa Catarina: Grão Pará, Topo da Serra do Corvo Branco, 28°03'22" S, 49°22'01" W, 16-XII-2017 *Canestraro, B.K.* 1203 (SP486135).

Geographic Distribution: *SC and SP. Endemic to Brazil.

Brazilian Phytogeographic Domains: Atlantic Forest.

Among the species found in Brazil, that presented leaves inserted on the stem with a sheathing base or vaginant lamina, *Dicranella puiggarii* species differs due to its quite linear and narrow base cells. In addition, it also has a subula, which slightly and gradually narrows from the shoulder of the leaf, with costa filling up to 1/3 from the obtuse apex. Each of these characteristics are quite specific for this species, greatly facilitating the identification process.

Its gametophyte and leaves shape resemble the *Rhamphidium dicranoides* (Müll. Hal.) Paris species. However, the *D. puiggarii* peristome, which is quite specific and different from other *Dicranella* species or *Rhamphidium* species, contains small and triangular teeth, entire, smooth and colorless. Moreover, the plants are flattened dorsally-ventrally and the costa is distally smooth (Frey & Stech 2009). The geographical distribution of *D. puiggarii* in Brazil was only known by its type material collected in Serra da Boa Vista, São Paulo state. According to our results, this species is a new occurrence for the Serra do Corvo Branco ridge in Santa Catarina state, growing exclusively on moist soil banks, at an altitude up to 1244 m.

Dicranella riograndensis Broth., Bih. Kongl. Svenska Vetensk.-Akad. Handl. 26 fd. 3(7):7. 1900. Type: Rio Grande do Sul: Silveira Martins, ad. terram marginum viarum et fossarum, 01.01.1893, C.A. Lindman 190 (syntypes S-B62688, BM000879402).

Figure 13 A-H.

Examined material: BRASIL. Espírito Santo: Alegre, área ruderal próxima à cidade, 20°45'39" W, 41°32'05" W, 19-IV-2016, Peralta, D.F. 17956 (SP462407); idem, Paraná: Morretes, Parque Estadual Pico do Marumbi, próximo ao alojamento e do riacho, 25°26'20" S, 48°55'12" W, 25-VII-2014, Peralta, D.F. 16499 (SP455070); idem, Rio de Janeiro: Itatiaia, Parque Nacional do Itatiaia, 22°29'46" S, 44°33'48" W, 09-VII-1991, Vital, D.M. s/n (SP387677); idem, Rio Grande do Sul: Montenegro, 29°41'19" S, 51°27'40" W, 15-XI-1974, Sehnem, A. 2985 (SP219915); idem, Santa Catarina: Joinville, estrada para o Mirante atrás do Parque Zoobotânico, 26°17'31" S, 48°49'40" W, 14-XI-2012, Peralta, D.F. 12650 (SP435065).

Geographic Distribution: *ES, *PR, *RJ, RS and *SC. Endemic to Brazil.

Brazilian Phytogeographic Domains: Atlantic Forest.

The *Dicranella riograndensis* species are characterized by having a cuneate or slightly-sheathing base, leaves lanceolate to oblong-lanceolate, with an apex gradually acuminate, subulate and with costa occupying 1/3 of the subula, the median portion of the leaf cross-section presents guide cells, peristome dicranoid, annulus absent or not observed, spores brownish to brown, densely papillose.

This species was described in 1900 and its type material comes from Rio Grande do Sul state, this sample was the only one known in Brazil. Similar to *Dicranella harrisii*, this species was also cited as occurring in Paraná state by Yano (2011), without a *voucher* citation or any other reference material. Thus, we are considering this species as a new occurrence in Paraná state and three other Brazilian states. It has been found growing in terrestrial and rupicolous habits, growing in soils, ground banks, moist rocks and even in brick walls located, at altitudes between 200 and 1200 m.

Dicranella subsulcata (Hampe) Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn ser. 4, 1: 86. 1879 \equiv *Aongstroemia subsulcata* Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn 4: 42. 1872. Type: BRAZIL, Rio de Janeiro, *Glaziou 5181* (lectotype BM000879386 designated by Costa *et al.* (2016), P0129113, P0709291).

Figure 14 A-I.

Examined material: BRASIL. Santa Catarina: Rancho Queimado, ao longo da rodovia BR – 282, início do Vale Europeu, 27°41'14" S, 49°02'07" W, 17-XII-2017, *Canestraro, B.K. 1150* (SP486303).

Geographic Distribution: RJ and *SC. Endemic to Brazil.

Brazilian Phytogeographic Domains: Atlantic Forest.

The *Dicranella subsulcata* species is characterized by leaves inserted into the base slightly dilated, scarcely vaginant or sheathing, with subula and apex gradually long-acuminate, leaves oblong-lanceolate and the median portion of the leaf cross-section presenting guide cells, capsulae oblong, peristome dicranoid, annulus present and spores brownish to brown, densely papillose.

Previously, in Brazil, the occurrence was only known by the type material for this species from Rio de Janeiro state, but with this work its geographical distribution has been extended to the Rancho Queimado municipality in Santa Catarina state as a new occurrence. The *Dicranella subsulcata* species can easily be confused with *Dicranella riograndensis*, but differs by presence of an annulus, a structure that can only be evaluated when the sample is fertile, that is, with the sporophyte. It was found occurring in terrestrial habits, growing in soils of perturbed areas, in this case along a highway margin, at an altitude of 845 m.

Dicranella ulei (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 309. 1901 \equiv *Leptotrichella ulei* (Müll. Hal.) Ochyra, Fragm. Florist. Geobot. 42: 564. 1997 \equiv *Microdus ulei* (Müll. Hal.) Paris, Index Bryol. (ed. 2) 3: 240. 1905 \equiv *Seligeria ulei* Müll. Hal., Bull. Herb. Boissier 6: 45. 1898. Type: Brasilia, Minas Geraës, Serra Ouro Preto, in rupibus, Febr. 1892, *E. Ule 1435* (H2719026 H-Brotherus).

Figure 15 A-I.

Examined material: BRASIL. Amazonas: Manaus, Ponta Negra, 3°06'07" S, 60°01'30" W, 23-VII-1974, *Griffin III, D. 289* (SP125370); idem, Minas Gerais: São Roque de Minas, Parque Nacional da Serra da Canastra, trilha para a Cachoeira Casca D'Anta, 20°25'95" S, 46°54'58" W, 14-II-2012, *Carmo, D.M. 439* (SP436643).

Geographic Distribution: *AM and MG. Endemic to Brazil.

Brazilian Phytogeographic Domains: Amazonia and Cerrado.

Features of this species include the base cuneate, leaves lanceolate, apex acuminate, the median portion of the leaf cross-section presenting guide cells, capsulae globose to slightly oblong, peristome seligerioid, with irregular bifid teeth, cleft, spores brownish to brown, densely papillose, can also be considered as granular spores.

The *Dicranella ulei* type material was collected in Serra do Ouro Preto in Minas Gerais state, and the only occurrence for this species. However, according to our results, the species is quite rare, being limited to one to four Brazilian states and was also identified as a new occurrence in Amazonas state. The *Dicranella ulei* species was the only species of the genus that was not found in the Atlantic Forest phytogeographical domain. It occurs in terrestrial habitats/habits, growing in soils and moist banks, at altitudes ranging from 90 – 1400 m.

Dicranella vaginata (Hook.) Cardot, (Wiss. Erb. Schwed. Südpolar-Exp.) 4 (8): 60. 1908≡ *Dichodontium vaginatum* (Hook.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. (Gen. Sp. Musc. 1: 67) 1870–71: 363. 1872 ≡ *Anisothecium vaginatum* (Hook.) Mitt., J. Linn. Soc., Bot. 12: 39. 1869 ≡ *Aongstroemia vaginata* (Hook.) Müll. Hal., Syn. Musc. Frond. 2: 608. 1851 ≡ *Dicranum vaginatum* Hook., Pl. Crypt., Pl. 3B. 1816. Type: [Colombia. Amérique équatoriale, In convallibus Andium Granatensium inter Almaguar et Pasto, altitud. 1200-1500 hexapod, *Bonpland, A.J.A. [s.n.]* (syntypes BM000672167, BM000672165, BM000672166, BM000879337, BM000879338, BM000879340, BM000879, JE04009786, LINN166824, P3410657691; P0657690, P0657691).

Figure 16 A-I.

Examined material: BRASIL. Minas Gerais: Itamonte, Parque Nacional do Itatiaia, Brejo do Lapa, 22°21'27" S, 44°44'14" W, 10-VI-2015, *Peralta, D.F. 17419* (SP460957); idem, Santa Catarina: Grão Pará, 19-VIII-1981, *Hatschbach, G.G. 55716* (SP430723).

Geographic Distribution: *MG and *SC. Neotropical.

Brazilian Phytogeographic Domains: Atlantic Forest.

The origin of the name *Dicranella vaginata* species comes from the fact that this species presents a sheathing base quite specific with regards to leaf stem insertion, with a base strongly vaginant. It can be confused with *Dicranella harrisii*, but it differs in gametophyte size, being one the most robust and longer mosses among *Dicranella* species, varying from 2 to 5 cm. In contrast, gametophytes of *D. harrisii* are 3.5 mm, on average. In addition, *D. vaginata* possess rectangular to long-rectangular basal cells, annulus absence and spores colorless or slightly yellow to brownish, scarcely papillose, almost smooth.

Yano (2011) reported that this species occurs in the southern Brazilian states of Paraná and Rio Grande do Sul, yet the species samples were not mentioned or referenced. When we evaluated all of the existing *Dicranella* samples from this Brazilian region was concluded that this species has a rare geographical distribution in Brazil, with two Brazilian states, Minas Gerais and Santa Catarina, representing new records. Moreover, the samples cited in Yano (2011) were not associated with any reference to the *voucher*, making it difficult for these occurrences to be confirmed. This species has only been identified in the

Atlantic Forest phytogeographic domain, growing on substrates such as banks and moist soils, at altitudes ranging from 90 to 1400 m.

List of doubtful taxa:

Dicranella affinis Ångström

Dicranella caldensis Ångström

Dicranella crinalis Geh. & Hampe

Dicranella brasiliensis (Duby) E.B. Bartram

Dicranella elata Schimp. Ex Mitt.

Dicranella glaziovii (Hampe) Hampe

Dicranella guilleminiana (Mont.) Mitt.

Dicranella itatiaiae (Müll. Hal.) Broth.

Dicranella longirostris (Schwägr.) Mitt.

Dicranella nitida Broth.

Acknowledgements

The authors would like to thank the doctoral scholarship granted by CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) to the first author. We also grateful the Instituto de Botânica for the support with the equipment throughout the study and the curators and employees of all herbaria cited here that given to us the specimens loans for this work.

References

- Allen B. 1994. Moss flora of Central America. Part 1. Sphagnaceae-Calymperaceae. Monographs in Systematic Botany from the Missouri Botanical Garden 49: 1–242.
- Bastos CJP, Yano O. 1993. Musgos da zona urbana de Salvador, Bahia, Brasil. *Hoehnea* 20: 23–33.
- Carmo DM, Gasparino EC, Peralta DF. 2015. Análise comparativa de briófitas urbanas da região Noroeste do Estado de São Paulo com demais trabalhos em diferentes fitofisionomias brasileiras. *Pesquisas. Botânica* 67: 255–272.
- Carmo DM, Peralta DF. 2016. Survey of bryophytes in Serra da Canastra National Park, Minas Gerais, Brazil. *Acta Botanica Brasilica* 30(2): 254–265.

- Carmo DM, Lima JS, Amélio LA, Peralta DF. 2016. Briófitas do Parque Estadual da Serra do Mar, Núcleo de Santa Virgínia, Estado de São Paulo, Brasil. *Hoehnea* 43(2): 265–287.
- Churchill SP, Linares EL. 1995. *Prodromus bryologiae Novo-Granatensis: introduction a la flora de musgos de Colombia. Parte 1, Adelotheciaceae a Funariaceae.* – Biblioteca José Jerónimo Triana 12(1): 1–453.
- Costa DP, Pôrto KC, Luizi-Ponzo AP, *et al.* 2011. Synopsis of the Brazilian moss flora: checklist, distribution and conservation. *Nova Hedwigia* 93(93–94): 277–334.
- Costa DP, Peralta DF, Carvalho-Silva M, Câmara PEAS. 2016. Types of the moss based on Glaziou's collections from Brazil. *Taxon* 65(4): 839–861.
- Cox CJ, Goffinet B, Wickett NJ, Boles SB, Shaw AJ. 2010. Moss diversity: a molecular phylogenetic analysis of genera. *Phytotaxa* 9: 175–195.
- Crum H. 1994. *Dicranella*. In: Sharp AJ, Crum H, Eckel P. *The Moss Flora of Mexico. Memoirs of The New York Botanical Garden* 69: 1–1113.
- Crum H. 2007. *Dicranella*. In: *Flora of North America.* – Editorial Committee (eds.): *Flora of North America north of Mexico*: pp. 386–393. Oxford University Press, New York.
- Duarte Bello PP. 1997. Musgos de Cuba. *Fontqueria* 47: 1–717.
- Dixon HN. 1913. A Remarkable Form of *Dicranella heteromalla* Schimp. *The Bryologist* 16(2): 29–30.
- Edwards SR. 1984. Homologies and Inter-relationships of moss peristomes. In: Schuster RM. *New Manual of Bryology. The Hattori Botanical Laboratory* 2: 658–695.
- Forzza RC, Leitman PM, Costa AF, *et al.* 2010. Introdução. In: *Lista de espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro. Vol. 1. Jardim Botânico do Rio de Janeiro.* 875p.
- Frahm JP. 1991. Dicranaceae: Campylopodioideae, Paraleucobryoideae. *Flora Neotropica Monograph* 54: 1–237.
- Frey W, Stech M. 2009. Marchantiophyta, Bryophyta and Anthocerotophyta. In: Frey W, Stech M, Fischer E. *Syllabus of plant families. Bryophytes and seedless Vascular Plants*, v.13, pp. 1–419.
- Gradstein SR, Churchill SP, Salazar-Allen N. 2001. Guide to the Bryophytes of Tropical America. *Memoirs of The New York Botanical Garden* 86: 1–577.
- Ireland RR. 2007. Dicranaceae. In: Crosby MR, Delgadillo CM, Harris P, *et al.* *Flora of North America.* 27: 358–432.
- La Farge C, Mishler BD, Wheeler JA, *et al.* 2000. Phylogenetic relationships within the haplolepidaceous mosses. *The Bryologist* 103: 257–276.

- La Farge C, Shaw AJ, Vitt DH. 2002. The circumscription of the Dicranaceae (Bryopsida) based on the chloroplast regions *trnL-trnF* and *rps4*. *Systematic Botany* 27: 435–452.
- Larraín J, Suárez G, Bednarek-Ochyra H, Ochyra R. 2010. The rediscovery of *Dicranella circinata* (Dicranellaceae, Bryophyta), with comments on other Southern South American species of *Dicranella*. *Nova Hedwigia* 91(3–4): 361–376.
- Luizi-Ponzo AP, Bastos CJP, Costa DP, *et al.* 2006. Glossarium Polyglottum Bryologiae. 1–113.
- Mitten W. 1869. Musci Austro-Americani. *The Journal of the Linnean Society* 12: 31.
- Mogensen GS. 1981. The Biological Significance of Morphological Characters in Bryophytes: The Spore. *The Bryologist* 84(2): 187–207.
- Mogensen GS. 1983. The Spore. In: Schuster RM. *New Manual of Bryology*. The Hattori Botanical Laboratory 1: 325–342.
- Ochi H. 1980. A revision of the Neotropical Bryoideae, Musci. (First part). *The Journal of the Faculty of Education Tottori University Natural Sciences* 29: 49–154.
- Ochyra R, Bednarek-Ochyra H, Arts T, Smith RIL. 2000. Occurrence of the neotropical moss *Dicranella hilariana* (Mont.) Mitt. in the Antarctic. *Tropical Bryology* 18: 153–160.
- Ochyra R, Smith RIL, Bednarek-Ochyra H. 2008. *The Illustrated moss flora of Antarctica*. – Cambridge Univ. Press, Cambridge.
- Oliveira HC, Peralta DF. 2015. Adições à brioflora de musgos acrocárpicos (Bryophyta) do Estado do Ceará, Brasil. *Pesquisas. Botânica* 67: 37–50.
- Pereira CG, Câmara PEAS. 2015. Brioflora da Ilha de Fernando de Noronha, Brasil. *Pesquisas. Botânica* 67: 149–179.
- Ristow R, Schäfer-Verwimp A, Peralta DF. 2015. New records of bryophytes for the state of Paraná, Brazil. *Pesquisas. Botânica* 67: 65–80.
- Santos EL, Carmo DM, Peralta DF. 2017. Bryophytes of the cloud forest of Pico do Marumbi State Park, Paraná, Brazil. *Checklist* 13(6): 959–986.
- Schimper WP. 1856. *Corollarium Bryologiae Europaeae* 13.
- Stech M. 1999. A reclassification of the Dicranaceae (Bryopsida) based on non-coding cpDNA data. *Journal of the Hattori Botanical Laboratory*. 86: 137–159.
- Stech M, Frey W. 2008. A morpho-molecular classification of the mosses (Bryophyta). *Nova Hedwigia*. 86:1–2.
- Stech M, McDaniel SF, Hernández-Maqueda R, *et al.* 2012. Phylogeny of Haplolepidous mosses – Challenges and perspectives. *Journal of Bryology* 34 (3): 160–173.

- Valente EB, Pôrto KC. 2006. Hepáticas (Marchantiophyta) de um fragmento de Mata Atlântica na Serra da Jibóia, município de Santa Terezinha, BA, Brasil. *Acta Botanica Brasilica* 20(2): 433–441.
- Visnadi SR, Vital DM. 2000. Lista das briófitas ocorrentes no Parque Estadual das Fontes do Ipiranga – PEFI. *Hoehnea* 27(3): 279–294.
- Yano O. 1981. A checklist of Brazilian mosses. *The Journal of the Hattori Botanical Laboratory* 50: 279–456.
- Yano O. 2011. Catálogo de Musgos Brasileiros: literatura original, basiônimo, localidade tipo e distribuição geográfica. Publicações on line do Instituto de Botânica, Secretaria do Meio Ambiente, São Paulo, SP. Disponível em: www.botanica.sp.gov.br/files/2013/09/virtuais_2musgos.pdf.

ANNEX OF FIGURES

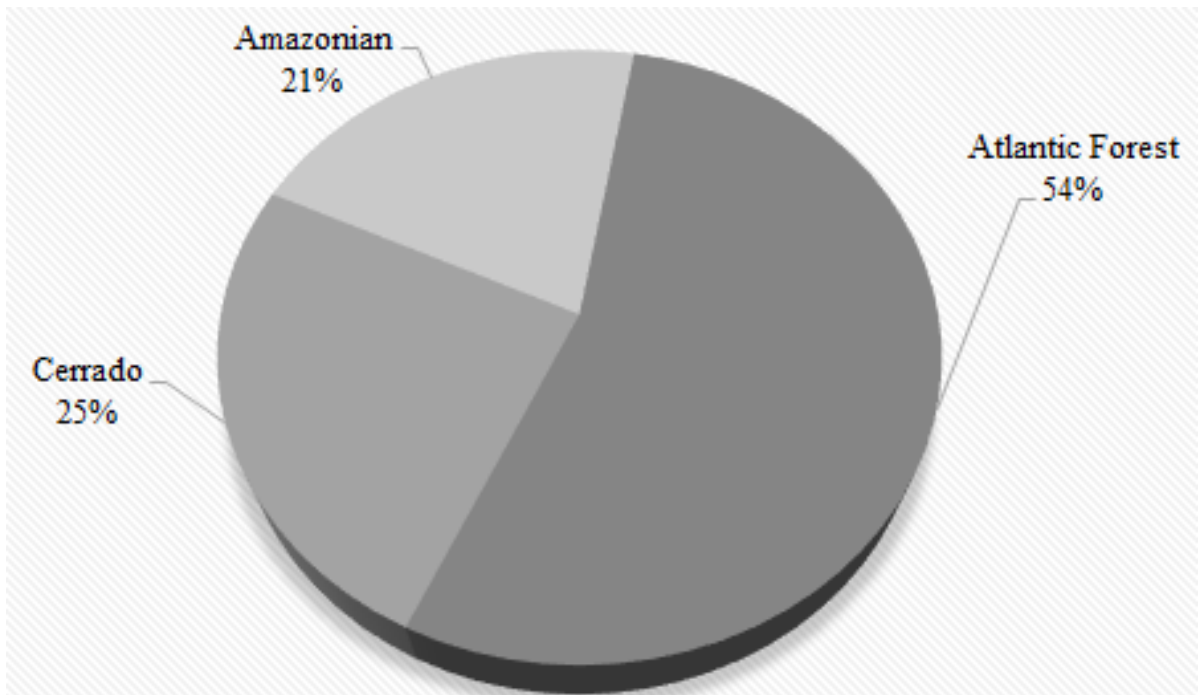


Figure 1. Distribution percentage of the Brazilian *Dicranella* species by Brazilian phytogeographical domain.

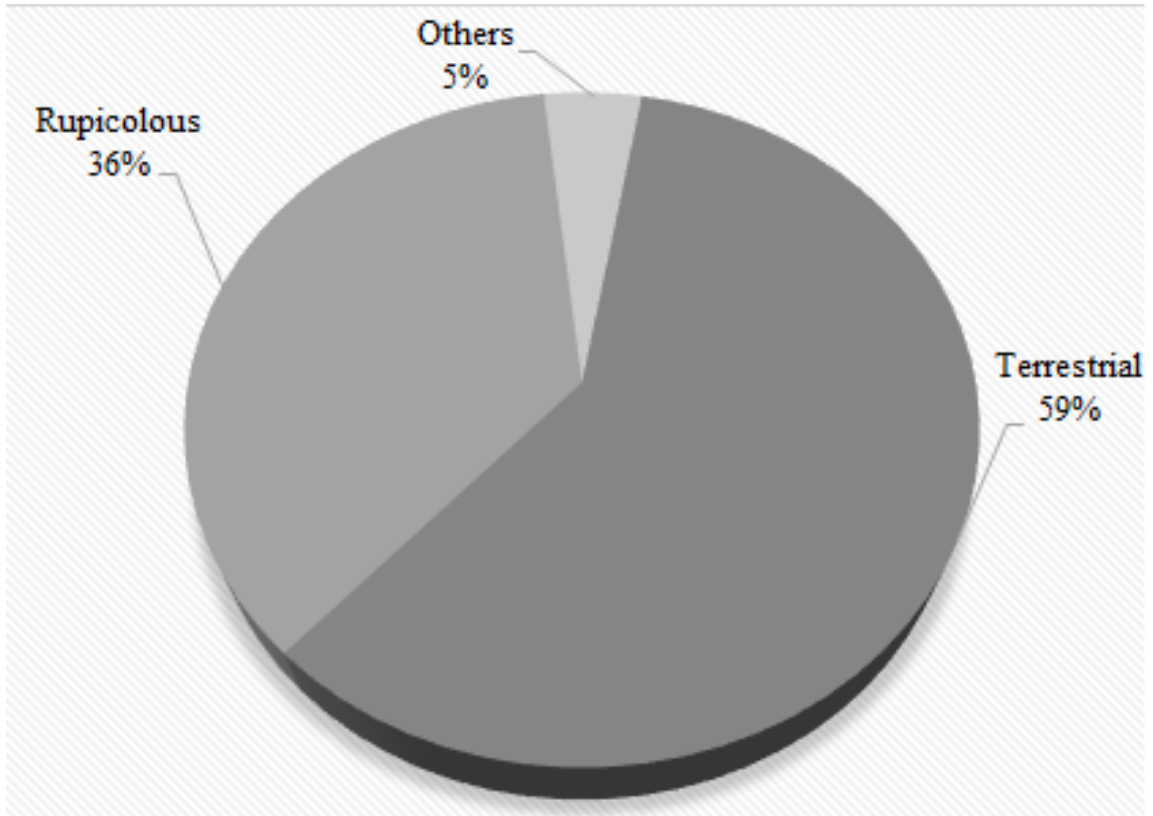


Figure 2. Distribution percentage of the Brazilian *Dicranella* species by substrate colonized.

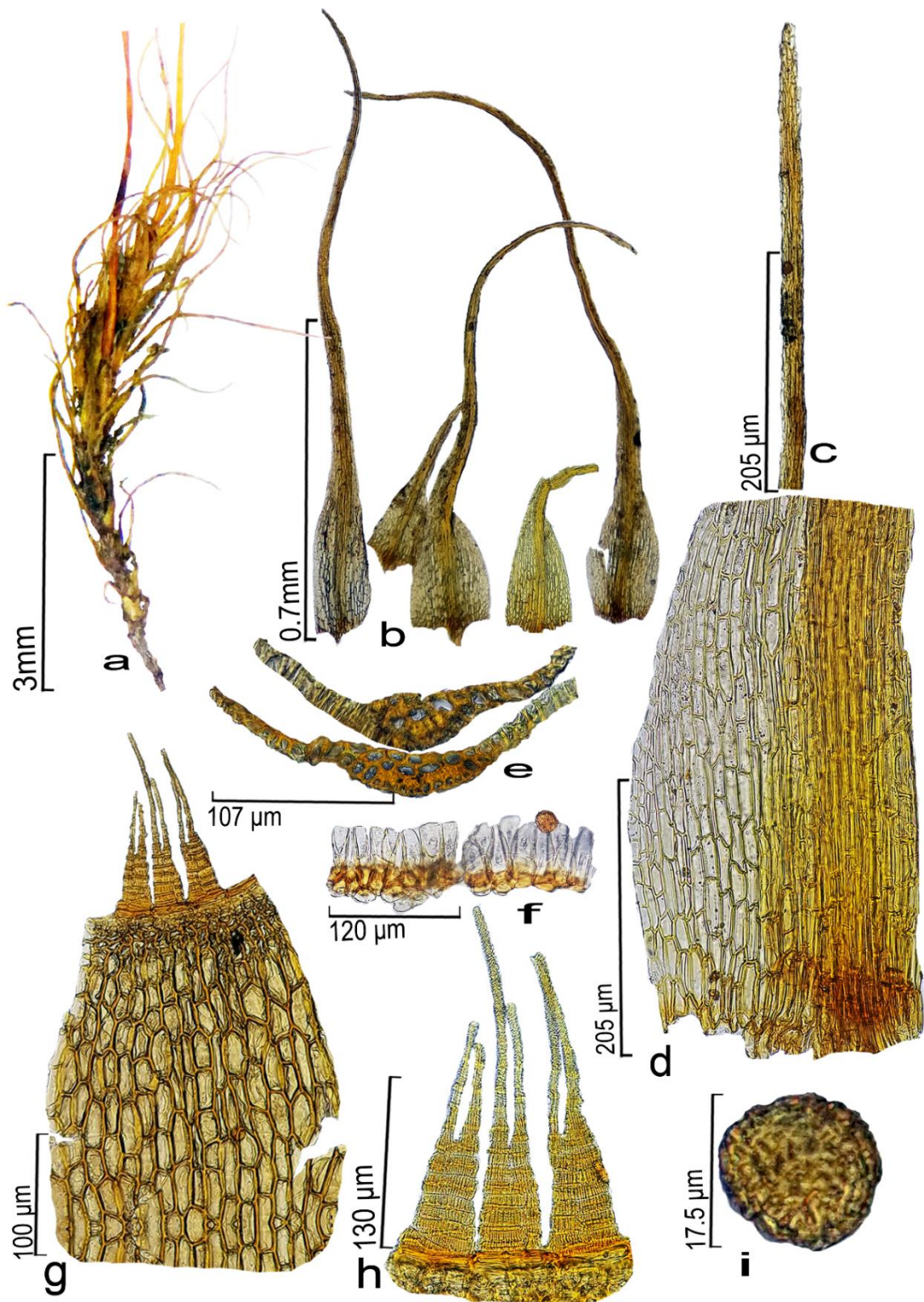


Figure 3. *Dicranella angustifolia* Mitt. **a.** habit; **b.** leaves; **c.** leaf apex; **d.** leaf base; **e.** leaf cross-sections; **f.** annulus; **g.** portion of peristome; exothecial cells; **h.** dicranoid peristome, detail of teeth; **i.** spore [Photos. D.M. Carmo].

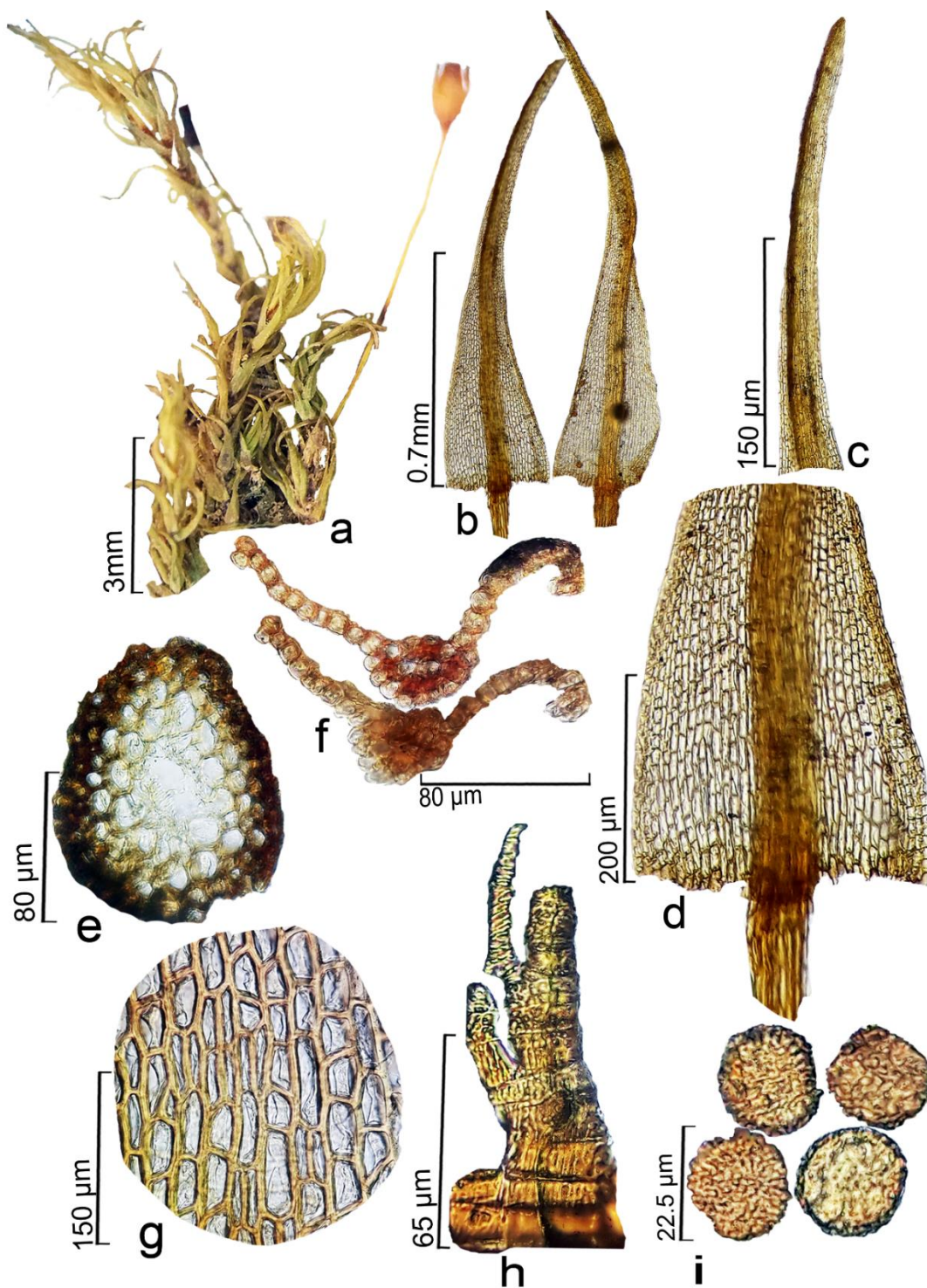


Figure 4. *Dicranella apolensis* R.S. Williams. **a.** habit; **b.** leaves; **c.** leaf apex; **d.** leaf base; **e.** stem cross-section; **f.** leaf cross-sections; **g.** exothecial cells; **h.** seligerioid peristome, detail of teeth; **i.** spores [Photos. D.M. Carmo].

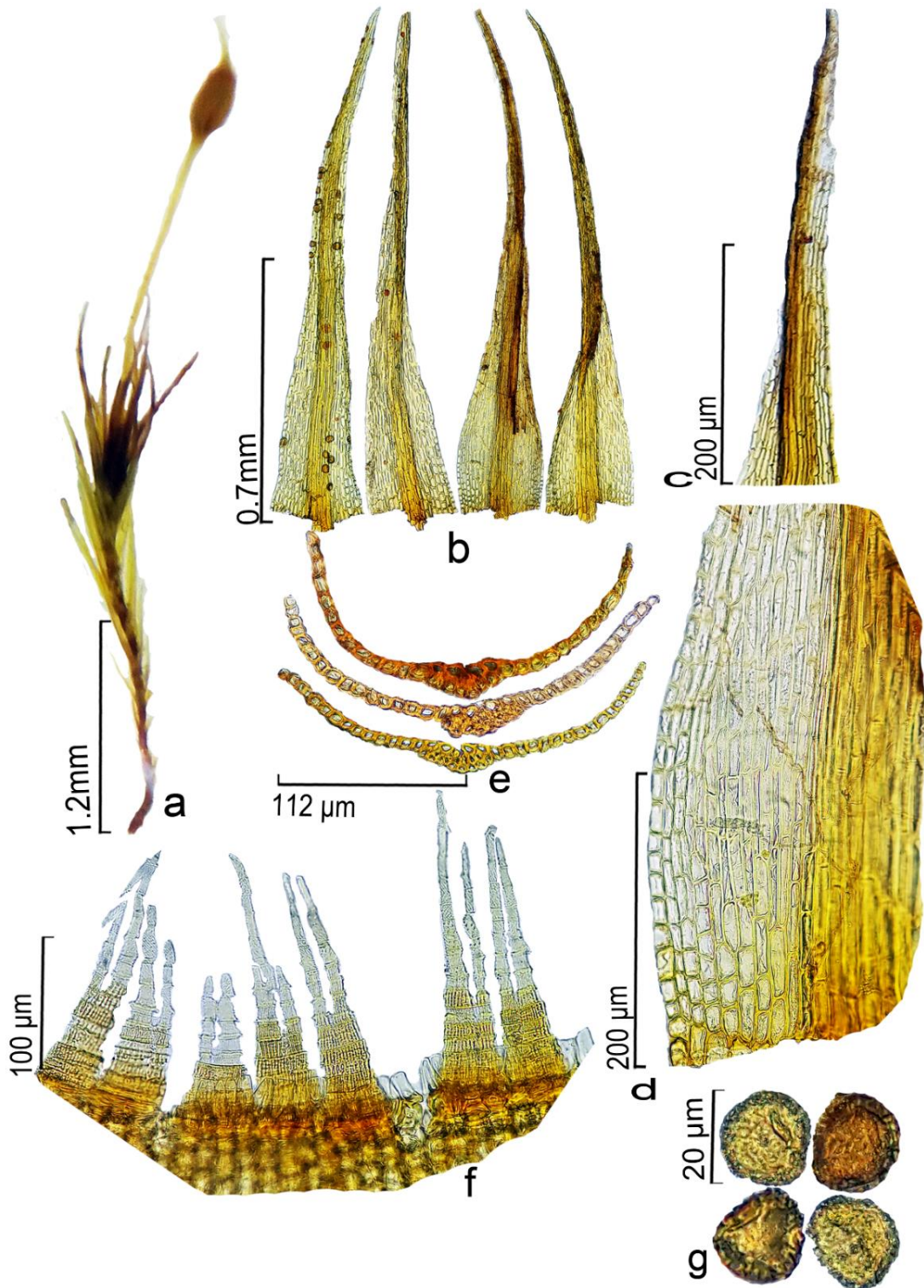


Figure 5. *Dicranella fusca* Broth. **a.** habit; **b.** leaves; **c.** leaf apex; **d.** leaf base; **e.** leaf cross-sections; **f.** portion of peristome, dicranoid teeth and annulus attached; **g.** spores [Photos. D.M. Carmo].

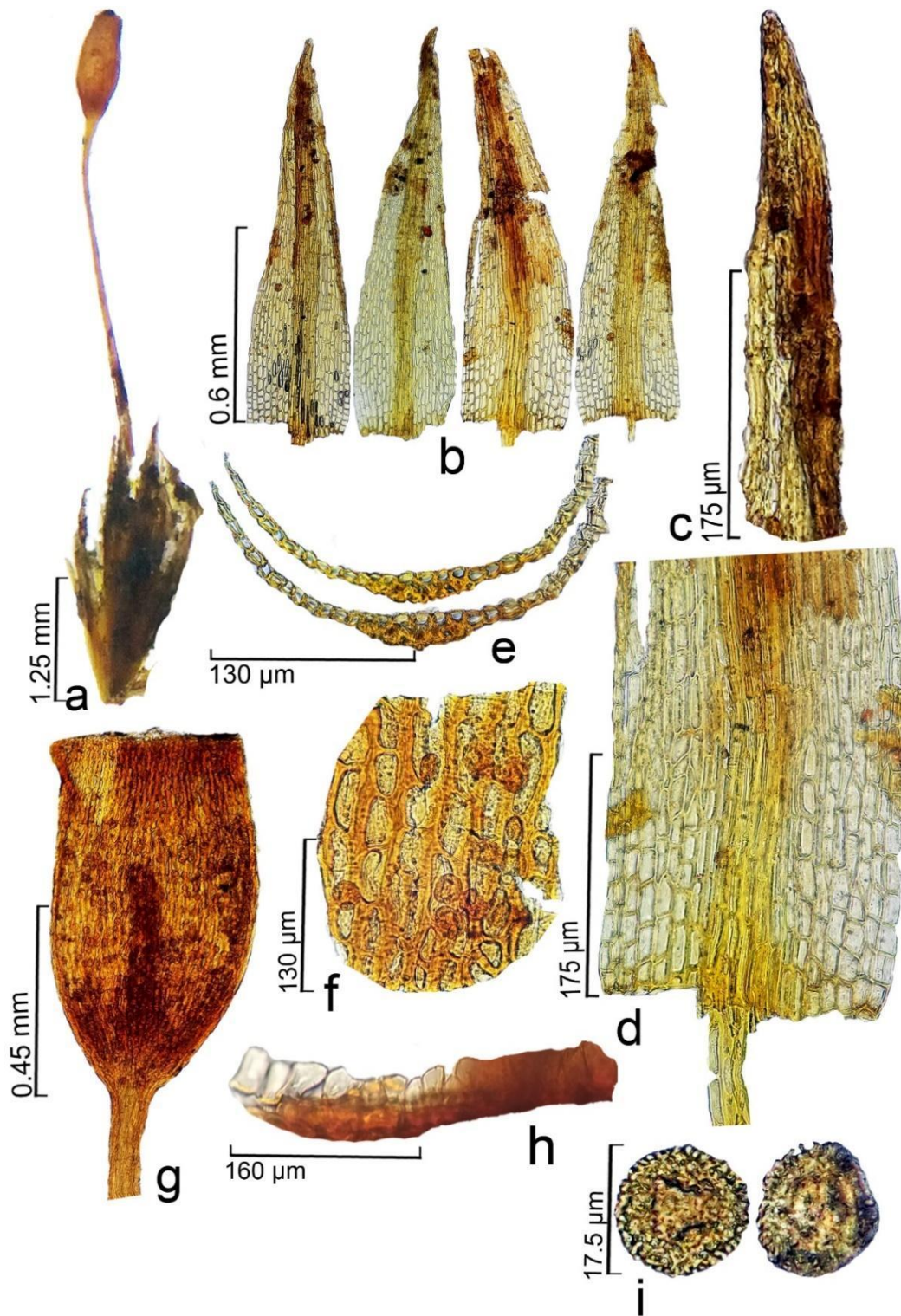


Figure 6. *Dicranella gymna* (Müll. Hal.) Broth. **a.** habit; **b.** leaves; **c.** leaf apex. **d.** leaf base. **e.** leaf cross-section; **f.** exothecial cells; **g.** capsulae without peristome; **h.** annulus attached; **i.** spores [Photos. D.M. Carmo].

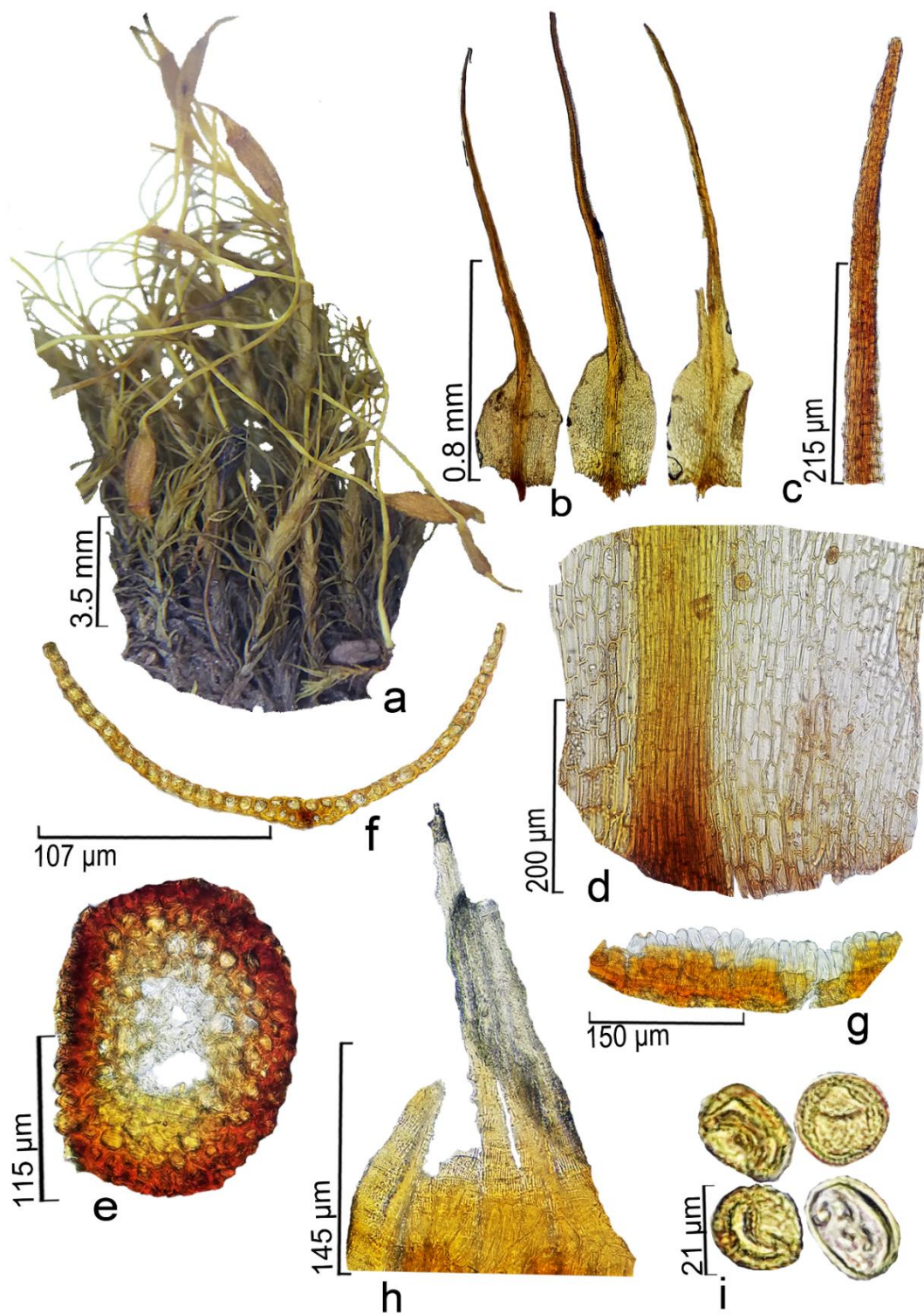


Figure 7. *Dicranella harrisii* (Müll. Hal.) Broth. **a.** habit; **b.** leaves; **c.** leaf apex; **d.** leaf base; **e.** stem cross-section; **f.** leaf cross-section; **g.** annulus attached; **h.** peristome dicranoid, detail of teeth; **i.** spores [Photos. D.M. Carmo].

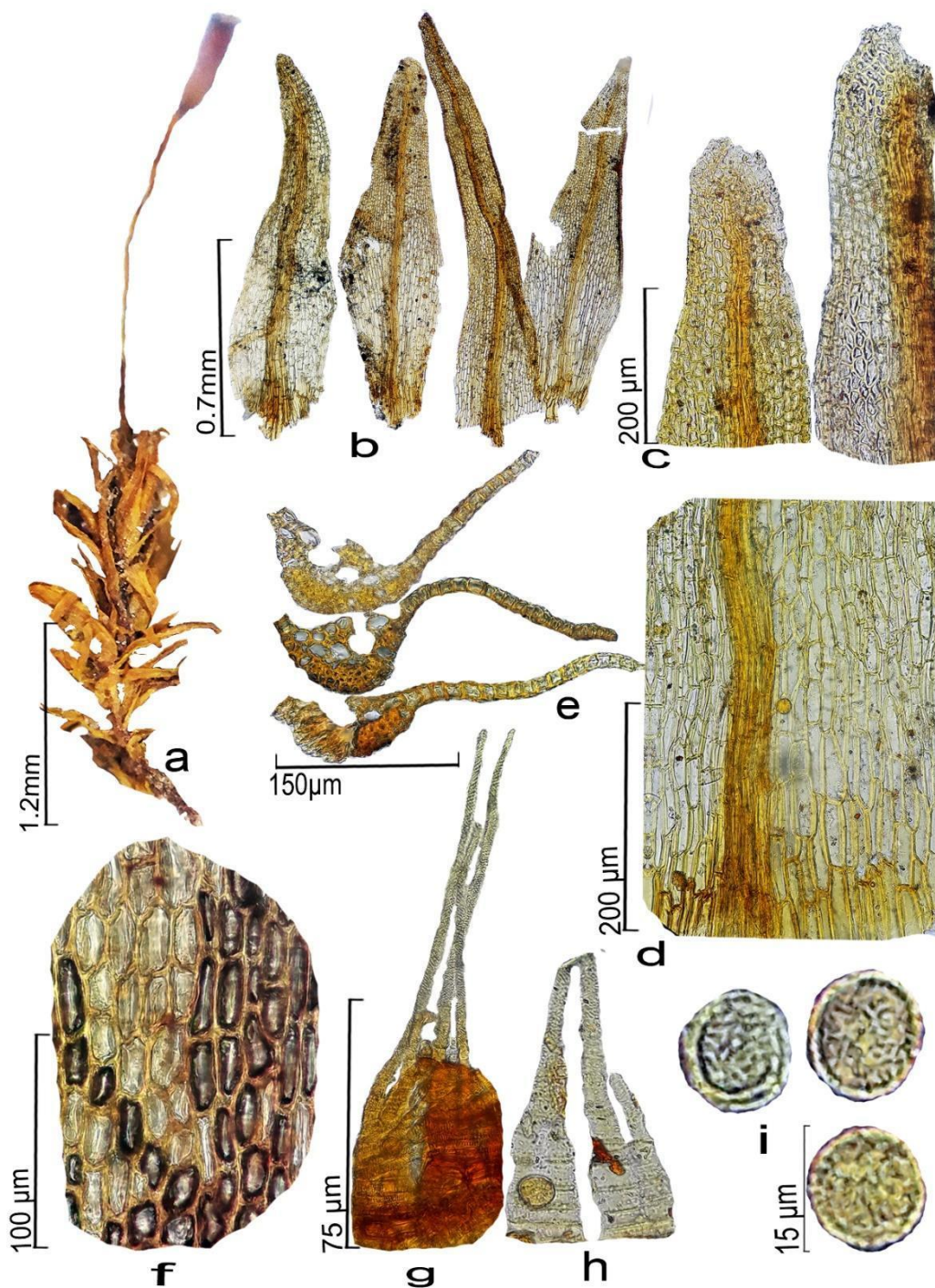


Figure 8. *Dicranella hilariana* (Mont.) Mitt. **a.** habit; **b.** leaves; **c.** leaves apex; **d.** leaf base; **e.** leaf cross-sections; **f.** exothecial cells; **g.** peristome dicranoid, detail of teeth from a recent sample; **h.** peristome dicranoid, detail of teeth from a later sample; **i.** spores [Photos. D.M. Carmo].

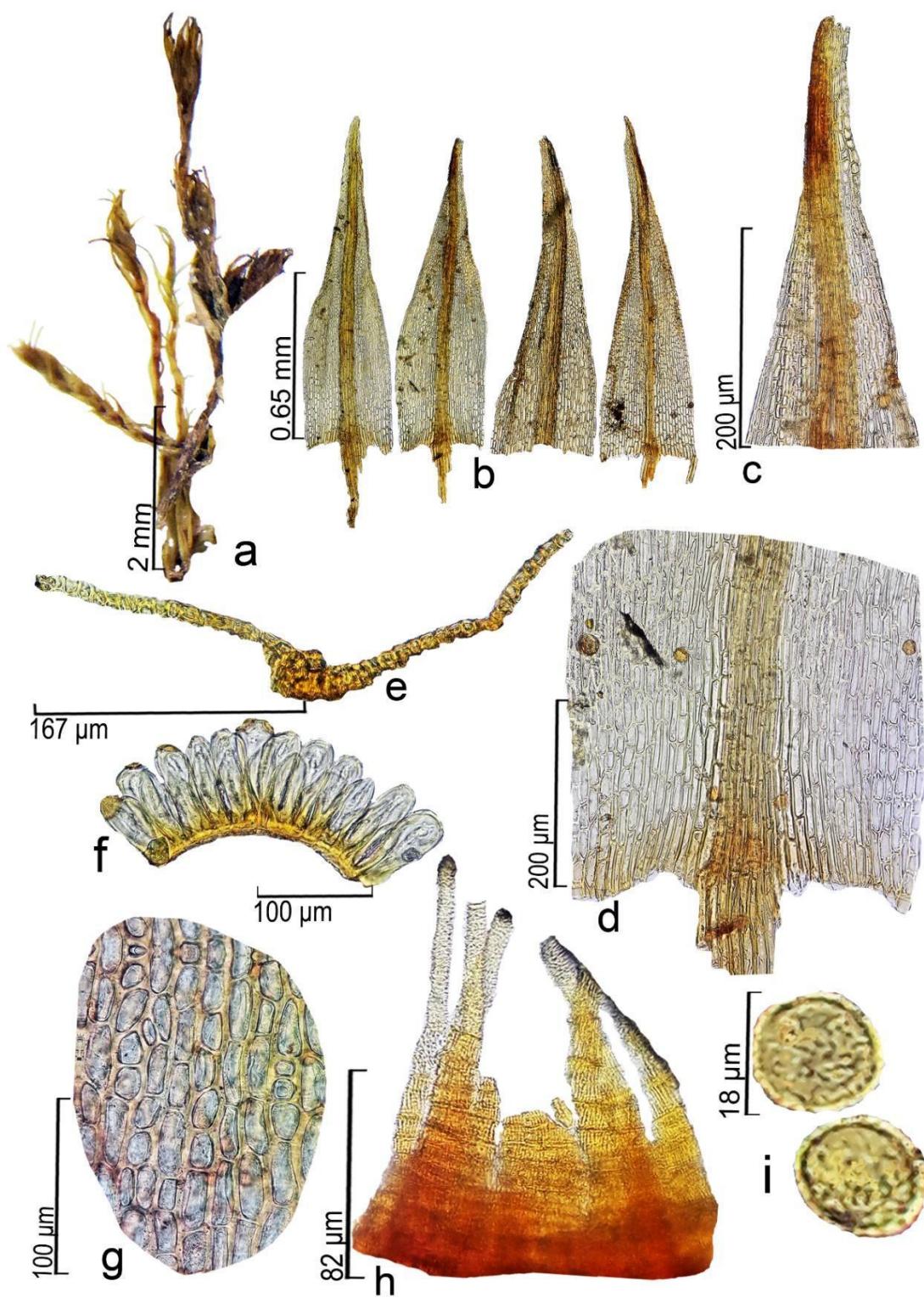


Figure 9. *Dicranella juliformis* Broth. **a.** habit; **b.** leaves; **c.** leaf apex; **d.** leaf base; **e.** leaf cross-sections; **f.** annulus; **g.** exothecial cells; **h.** peristome dicranoid, detail of teeth; **i.** spores [Photos. D.M. Carmo].

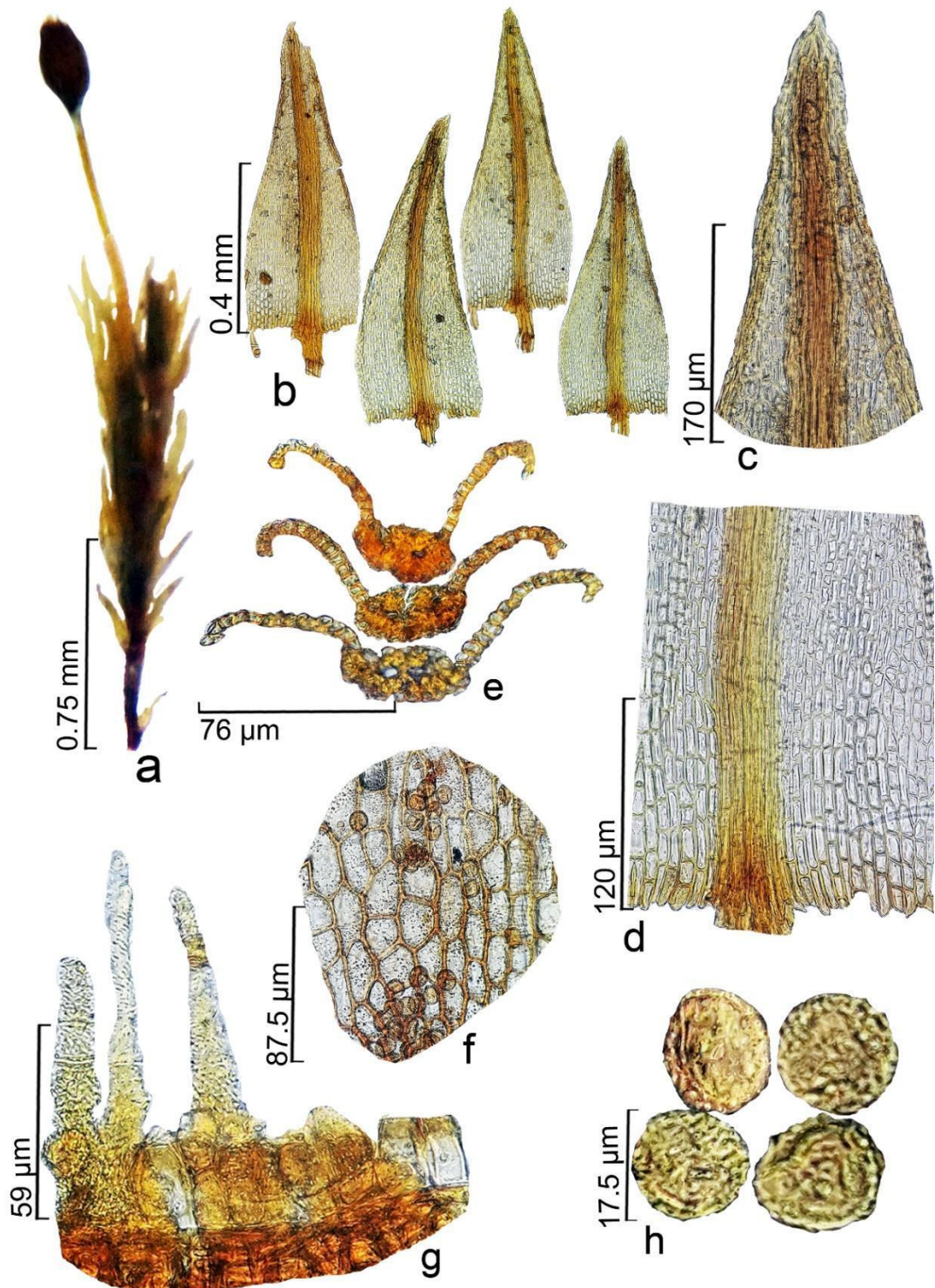


Figure 10. *Dicranella lindigiana* (Hampe) Mitt. **a.** habit; **b.** leaves; **c.** leaf apex; **d.** leaf base; **e.** leaf cross-sections; **f.** exothelial cells; **g.** peristome seligeroid, detail of teeth and the annulus attached; **h.** spores [Photos. D.M. Carmo].

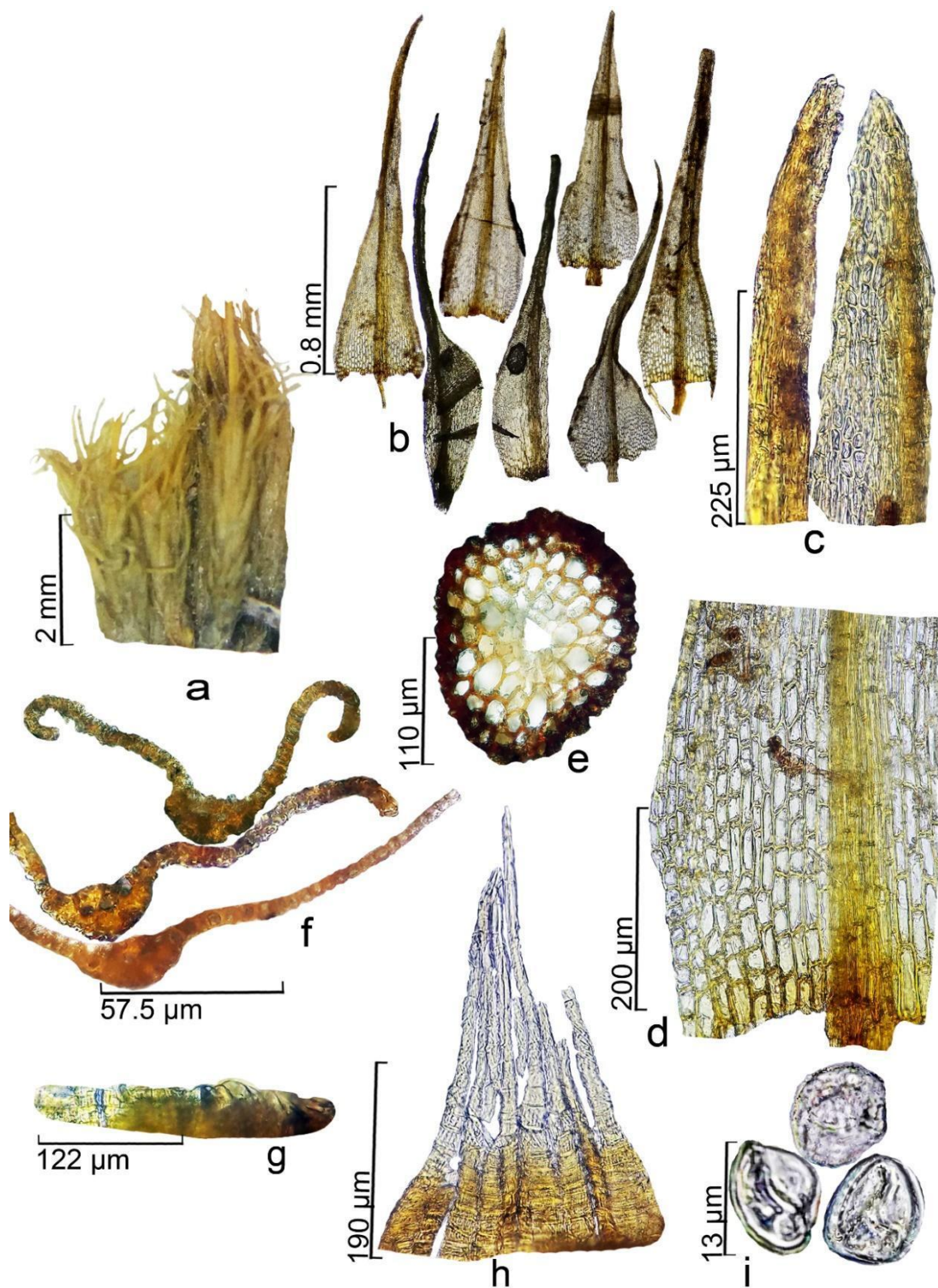


Figure 11. *Dicranella pabstiana* (Müll. Hal.) Mitt. **a.** habit; **b.** leaves; **c.** leaf apex; **d.** leaf base; **e.** stem cross-section; **f.** leaf cross-sections; **g.** annulus attached; **h.** peristome dicranoid, detail of teeth; **i.** spores [Photos. D.M. Carmo].

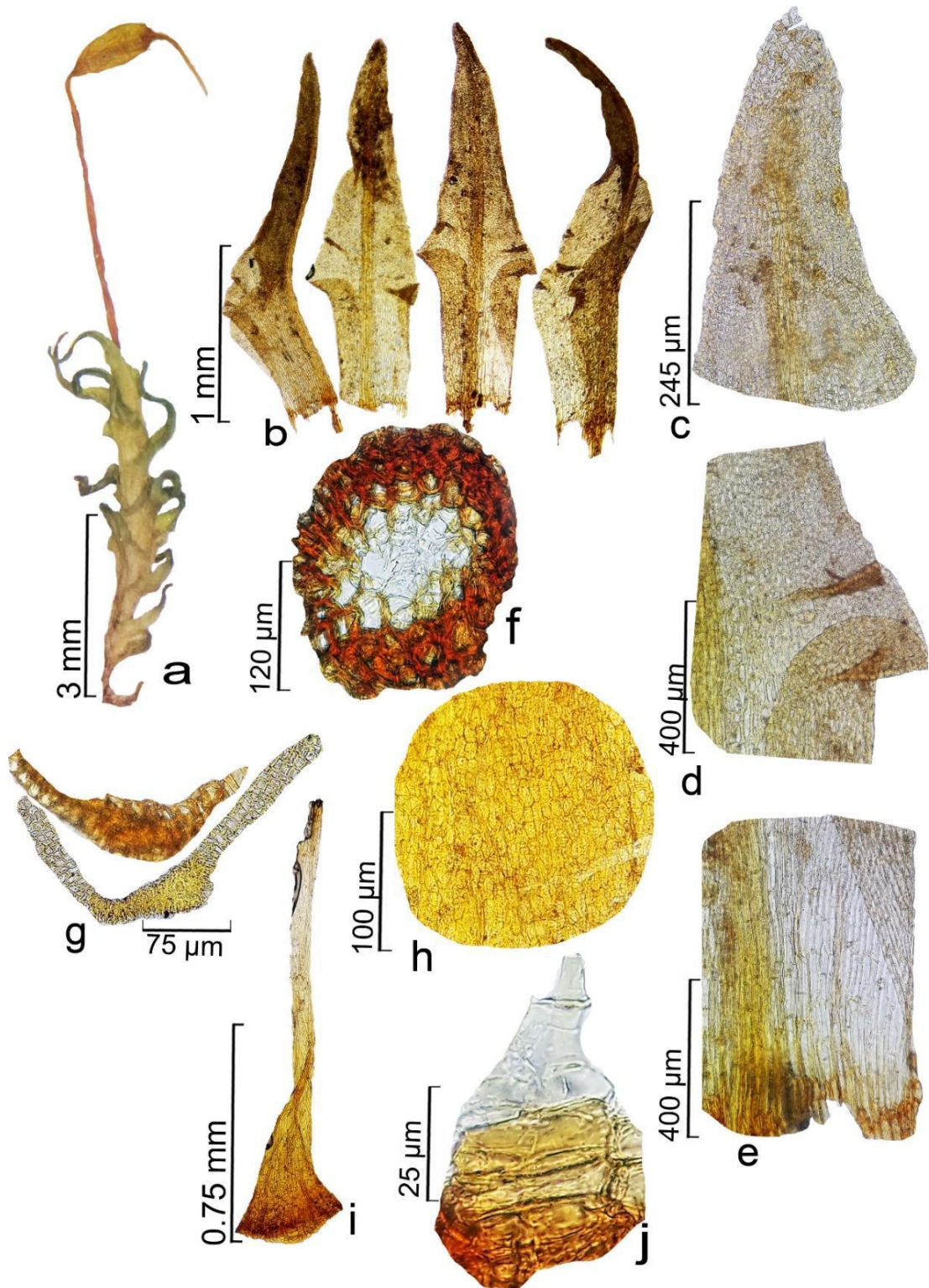


Figure 12. *Dicranella puiggarii* Geh. & Hampe. **a.** habit; **b.** leaves; **c.** leaf apex; **d.** leaf median portion; **e.** leaf base; **f.** stem cross-section; **g.** leaf cross-section; **h.** exothecial cells; **i.** calyptra; **j.** peristome, detail of teeth [Photos. D.M. Carmo].

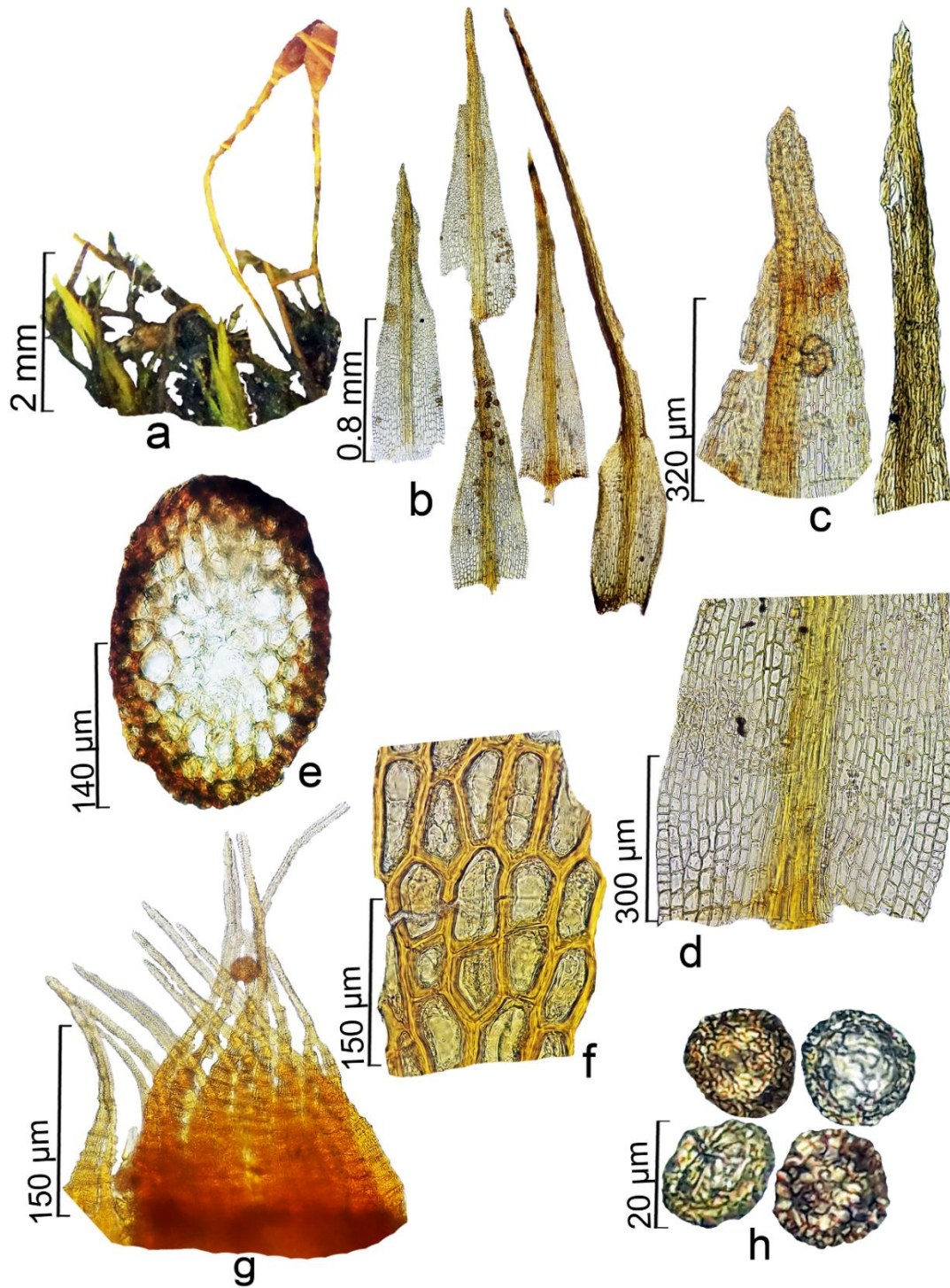


Figure 13. *Dicranella riograndensis* Broth. **a.** habit; **b.** leaves; **c.** leaves apex; **d.** leaf base; **e.** stem cross-section; **f.** exothecial cells; **g.** peristome dicranoid, detail of the teeth; **h.** spores [Photos. D.M. Carmo].

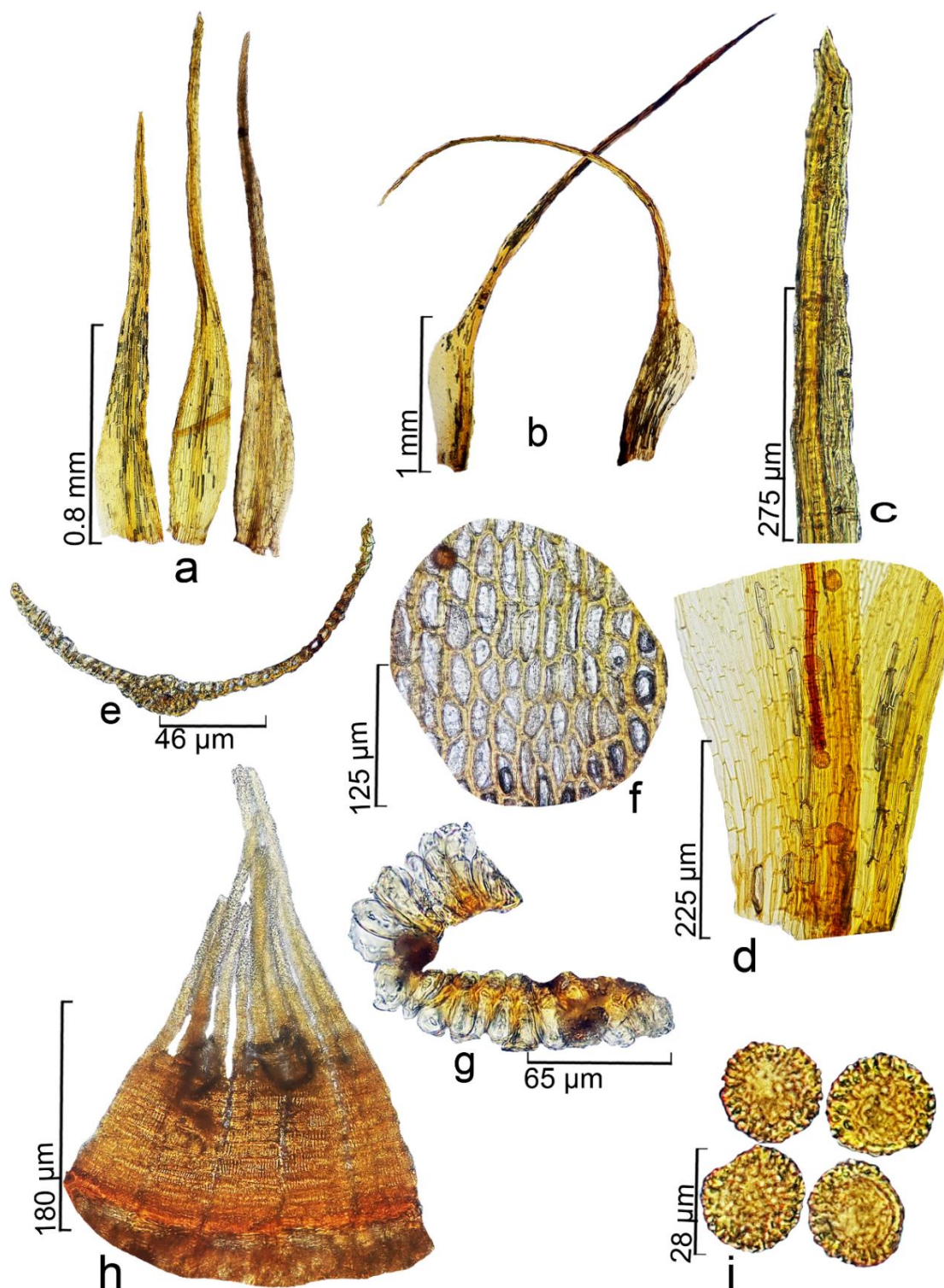


Figure 14. *Dicranella subsulcata* (Hampe) Hampe. **a.** leaves; **b.** perichaetial leaves; **c.** leaf apex; **d.** leaf base; **e.** leaf cross-section; **f.** exothecial cells; **g.** annulus; **h.** peristome dicranoid, detail of teeth; **i.** spores [Photos. D.M. Carmo].

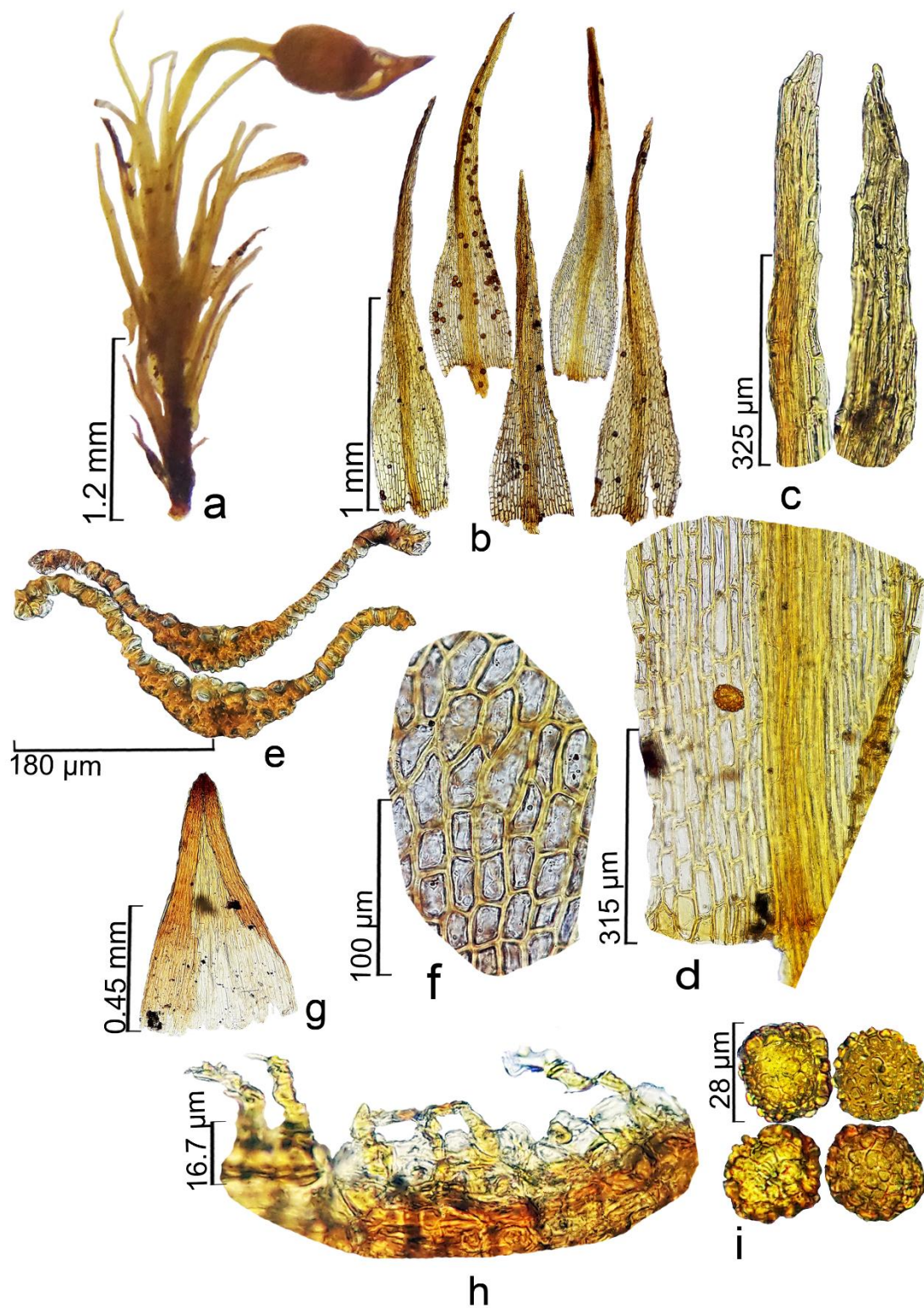


Figure 15. *Dicranella ulei* (Müll. Hal.) Broth. **a.** habit; **b.** leaves; **c.** leaves apex; **d.** leaf base; **e.** leaf cross-sections; **f.** exothecial cells; **g.** calyptra; **h.** peristome seligeroid, detail of teeth and the annulus attached; **i.** spores [Photos. D.M. Carmo].

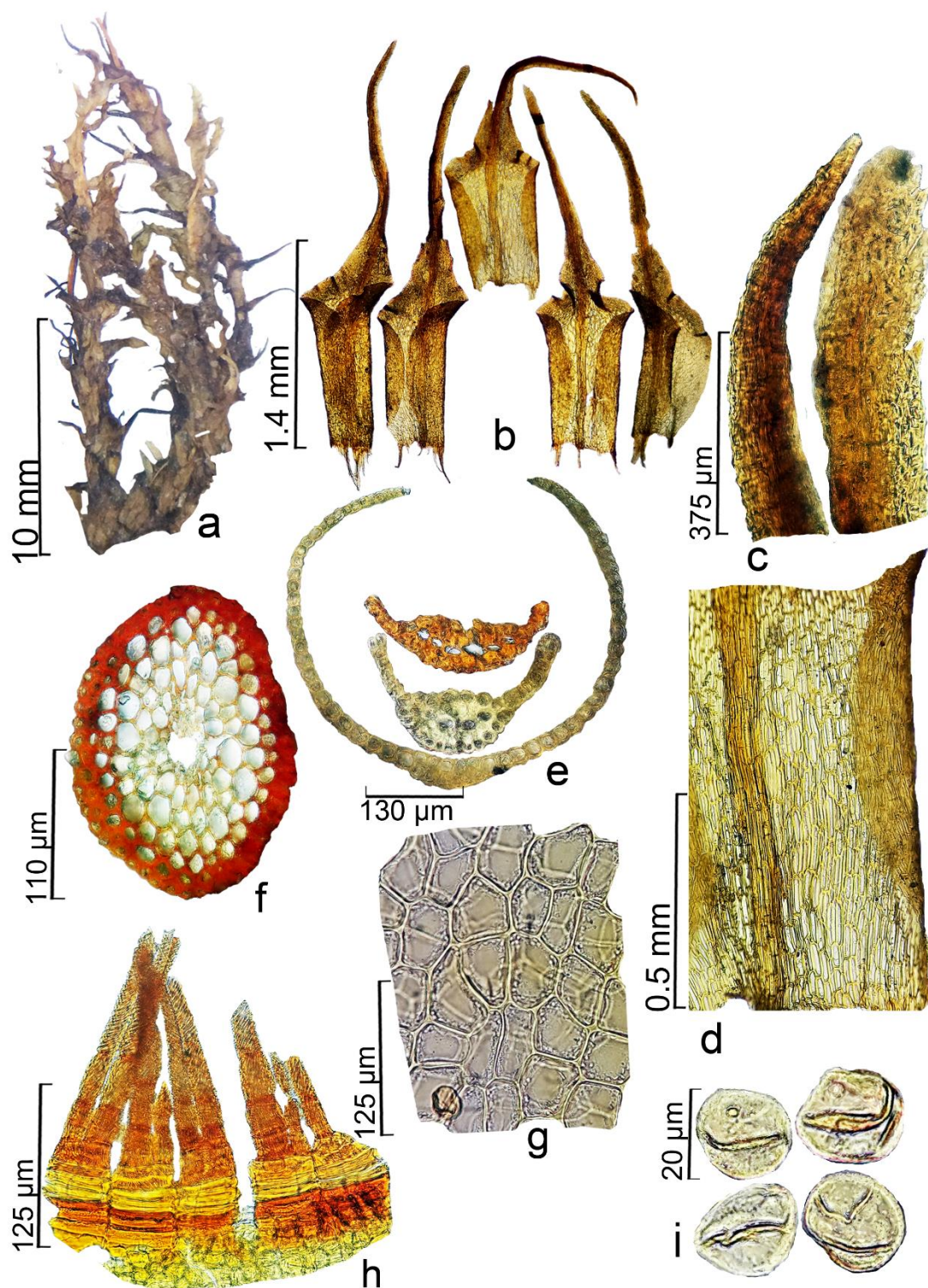


Figure 16. *Dicranella vaginata* (Hook.) Cardot. **a.** habit; **b.** leaves; **c.** leaves apex; **d.** leaf base; **e.** leaf cross-sections; **f.** stem cross-section; **g.** exothecial cells; **h.** dicranoid peristome, detail of teeth; **i.** spores [Photos. D.M. Carmo].

4.3. A type catalog and a checklist of *Dicranella* species from Neotropic (Dicranellaceae, Bryophyta)

Dimas Marchi do Carmo¹ & Denilson Fernandes Peralta²

Abstract: A type catalog and a checklist of *Dicranella* species from Neotropic (Dicranellaceae, Bryophyta). Despite the Neotropical region be quite extensive and with great botanical species richness, the bryophytes flora remains uncertain and with few studies about the taxonomic status of its species. In this study, the taxonomic status of several *Dicranella* species names occurring in Neotropic was verified. Through the loans provide by many international herbaria and bibliographies references consulted, 57 species name occurring in the Neotropical region were studied, of these, 34 lectotypes were designated and 12 probable holotypes indicated herein. Furthermore, the Neotropical distribution of the *Dicranella* species, the type specimen information, basynonyms, homotypic and heterotypic synonyms as well as the taxonomic status were provided in this catalog and checklist.

Keywords: Dicranidae, Dicranales, haplolepideous mosses, material type, taxonomic revision

¹ Instituto de Botânica, Av. Miguel Stéfano, 3687 - CEP 04301902 São Paulo, SP, Brazil.
E-mail: dimas.botanica@gmail.com

² Instituto de Botânica, Av. Miguel Stéfano, 3687 - CEP 04301902 São Paulo, SP, Brazil.
E-mail: denilsonfperalta@gmail.com

Introduction

The Neotropical biogeographic region constitutes a territorial unit comprising South and Central America reaching as far north as central Mexico (Sclater 1858, Wallace 1876, Morrone 2014). Despite its large territorial extension, there are few bryophytes registries with brief assessments of its general bryological status taxonomic and conservation (Crosby *et al.* 1999, Gradstein *et al.* 2001, Ellis & Price 2013). However, this pattern has started to change with the arisement of several floristic surveys and regional floras in the last sixty years approximately (Crum & Steere 1957, Crum & Bartram 1958, Crum & Steere 1958, Florschütz 1964, Pursell 1973, Hermann 1976, Gradstein & Weber 1982, Buck 1995, Robinson 1986, Menzel 1992, Allen 1994, Churchill 1994, Sharp *et al.* 1994, Churchill & Linares 1995, Delgadillo *et al.* 1995, Duarte-Bello 1997, Buck 1998, Churchill 1998, He 1998, Churchill *et al.* 2000, Matteri 2003, Ochyra *et al.* 2008, Larraín *et al.* 2010, Costa *et al.* 2011, Yano 2011, Carmo & Peralta 2016, Costa *et al.* 2016, Cañiza *et al.* 2017, Santos *et al.* 2017, Carmo *et al.* 2018).

The knowledge of type registers is an important characteristic for the taxonomists and for the understanding of the correct location, identification and nomenclature rules applied to type specimens (Frahm 1994, Câmara *et al.* 2014). Within the *Dicranella* genus, this kind of information are scarcely known since the type citations were often brief or rather vague (Ellis & Price 2013). Discover, study and identify the type specimens could be difficult for several reason and require a large amount of time and experience to check all herbarium specimens and good library facilities to confirm the status of type specimens with the protologue (Frahm 1999). Furthermore, locating the duplicates in herbaria, finding the type specimens which matches the species description protologue, lost collections by herbaria destruction in consequence of wars, fires or even through disregard with the herbaria conditions are some difficulties that could be found in studies with taxonomic approach (Merrill 1943, Câmara *et al.* 2014, Bordin *et al.* 2018).

The *Dicranella* genus need efforts about its taxonomic revision since present some issues in its nomenclatural historic that had not solved yet. For instance, many *Dicranella* species name remains without a suitable indication about their type specimens since the genus itself name was proposed through a lectotype designated to conserve its name (Margadant & Geissler 1995). However, there are some *Dicranella* species name which had their names validly published according to the International Code of Nomenclature for algae, fungi and plants (McNeill *et al.* 2012). Therefore, the accomplishment of this work aims to list and compile some type specimens of neotropic *Dicranella* species that had their names validly

published. Moreover, this work will provide information about what kind of type this species present, where they are deposited and how they are distributed in the neotropic, thus, with this findings future studies about new combinations and synonyms can be performed. Besides this, with this catalog and checklist, some lectotypes are designated herein when necessary.

Material and Method

The catalog is presented in alphabetical order among the neotropic *Dicranella* species name, the abbreviations used to identify the basionym, the homotypic and heterotypic synonyms, new combinations, the type are according to Frahm (1994), the herbarium code follows in accordance with Index Herbariorum (NYBG). The species names, basionyms and type information were taken from the main existing literary references for the Neotropic *Dicranella* species description such as: Hedwig (1801), Schimper (1856) and Mitten (1869). In order to perform this catalog, the searching on specific taxonomic websites such as TROPICOS and JSTOR were made. Beside this, the location where the types are deposited and how the author's names are abbreviated were followed according to Stafleu & Cowan's compilation (1976, 1979, 1981, 1985, 1986, 1988). Moreover, some specimens and type specimens loans were taken to verify the taxonomic status such as the type specimens indication, and if the information, given by the label of the exsicates, are according to the protologue with the publication where these species were described.

This work is based on the literature available and some herbaria consulted through exsicates and types specimens loans performed. The references used to accomplish the checklist and the Neotropical distribution are according to: Crum & Steere 1957, Crum & Bartram 1958, Crum & Steere 1958, Florschütz 1964, Pursell 1973, Hermann 1976, Gradstein & Weber 1982, Buck 1995, Robinson 1986, Menzel 1992, Allen 1994, Churchill 1994, Crum 1994, Churchill & Linares 1995, Delgadillo *et al.* 1995, Duarte-Bello 1997, Buck 1998, Churchill 1998, He 1998, Crosby *et al.* 1999, Churchill *et al.* 2000, Gradstein *et al.* 2001, Matteri 2003, Ochyra *et al.* 2008, Larraín *et al.* 2010, Costa *et al.* 2011, Yano 2011, Carmo & Peralta 2016, Carmo *et al.* 2016, Costa *et al.* 2016, Cañiza *et al.* 2017, Santos *et al.* 2017, Carmo *et al.* 2018. The herbaria consulted were ALCB, BM, G, GOET, H-Br, JE, MG, NYBG, P, QCA, R, S, SP, UFP. The countries which present an asterisk corresponds to a new occurrence that was verified through our samples survey and analyses, the voucher is available in the appendix 1 at the end of this manuscript and checklist.

Results and discussion

According this work, 34 lectotypes are designated herein and 12 species had their probable holotype indicated with specimens corresponding to the name protologue description of their original literature. Twenty-one species name had not their specimens type matching to the author's original herbaria specimen indicated (Stafleu & Cowan 1976, 1979, 1981, 1983, 1985, 1986, 1988) and their original herbaria deposited could not be consulted. The species which presented these conditions had comments about their original herbaria and type specimen discussed following their protologue presentation.

After our revision, seven species were considered doubtful in this catalog, since that for these species name a material type specimen was not designated or indicated. There is a list doubtful species at the end of this catalog list. These materials type were not designated because some information about the specimen's type were not found or are missing, such as where it was collected, which herbaria it was deposited, by whom or when it was collected, what is the right collector number and other examples that can be found in taxonomic studies. Some of these kind information, we could complete and were provided between brackets in the protologue of the species. The list containing the valid name published, material type designation, protologue, herbaria deposited, new combinations, heterotypic synonyms, the geographic distribution in the neotropical and comments about the types or new lectotype designation, is available below.

List of the Neotropical type specimens of *Dicranella*:

1. *Dicranella affinis* Ångström, Öfvers. Förh. Kongl. Svenska Vetensk.-Akad. 3(4): 3. 1876.

Type: Brasiliae, Minas Gerais, qui ad Caldas, *J.F. Widgren s.n.* (prob. Holotype S179564!).

Neotropical Distribution: Brazil.

The specimen housed at S herbarium (which is the original herbaria of this author according Stafleu & Cowan (1976) is the probable holotype. The specimens has a label indicating that this species could correspond to the holotype, and match exactly with the protologue information of this species.

2. *Dicranella angustifolia* Mitt., J. Linn. Soc., Bot. 12: 35. 1869. Type: [Colômbia], Andes Bogotensis, in sylva supra Pacho (6000 ped.) ad viam, *J. Weir 138* (lectotype

NY01093616! here designated, syntypes BM000879278!, BM000879279!, NY01093614!, NY01093615!, E00429158!, E00429159!, BM000724667!); [Ecuador] Andes Quitensis, in sylva Canelos, *Spruce 38b* (syntypes NY01093613!, BM000724669!, E00429160!).

Neotropical Distribution: Brazil*, Bolivia, Colombia, Ecuador, Venezuela.

The lectotype chose here is according to the original specimen from of author's herbarium description species (Stafleu & Cowan 1981) as well the same protologue information and morphological traits. Moreover, the sample NY01093616 presents a great quantity of sample.

3. *Dicranella apolensis* R.S. Williams, Bull. New York Bot. Gard. 3(9): 106. 1903. Type: Bolivia, on sand along stream, Apolo, 1 July 1902, *Williams 1743* (lectotype BM000879280! here designated, syntypes BM000879281!, F0001106C!, JE04000616!, NY01093617!).

Neotropical Distribution: *Brazil, Bolivia and Peru.

According to author's bryological personal herbaria, the samples collected and their bryophytes types should be deposited in NY (Stafleu & Cowan 1988). However, after analyzing the corresponding exsiccate through JSTOR site we realize that this sample do not corresponds the original label made by R.S. Williams or the type specimens indication. Besides, after observing the BM samples, we noticed that the these type specimen presented the same morphological characteristics as well the original label handwritten by the author himself and more reproductive structures and samples quantity than the NY specimen. The BM000879280 corresponds a type to *D. apolensis*, thus we are proposing a lectotype for this species in the accordance with was cited previously.

4. *Dicranella bicolor* (Müll. Hal.) Mitt., J. Linn. Soc., Bot. 12: 35. 1869 ≡ *Aongstroemia bicolor* Müll. Hal., Syn. Musc. Frond. 1: 444. 1848. Type: [Colombia] Columbia, ubi in in colonia Germanica, Toval altitudine 5500 ped., *Moritz 21b* (lectotype BM000879276!, here designated, syntype BM000879277!).

Neotropical Distribution: Colombia, *Ecuador and Venezuela

In accordance with original herbaria of this author species, the type specimen should be found or deposited in B herbarium (Stafleu & Cowan 1981), however this herbaria and the existing specimens that had deposited were destroyed in consequence of the Second World War in 1943 (Merrill 1943). Therefore the main Mull. Hal's species copies collected and used to new species descriptions were sent to others herbaria scattered around the world, primarily to FI and JE herbaria, but also to BM, S, H and NY (Stafleu & Cowan 1981). However, a sample corresponding to the collection and the original date described of this species, as well the morphological characteristics, was found in BM herbarium as sample 000879276, which is been proposed as above to a new lectotype designation.

5. *Dicranella bogotensis* (Hampe) Mitt., J. Linn. Soc., Bot. 12: 37. 1869 \equiv *Aongstroemia bogotensis* Hampe, Ann. Sci. Nat., Bot., sér. 5, 3: 357. 1865. Type: [Colombia] Bogota, altit. 2800 metr., ad Barrancas, inter alias, martio deoperculatam parce leg. A. Lindig. [s.n.] (prob. Holotype BM000879275!).

Neotropical Distribution: Colombia.

6. *Dicranella boliviana* Herzog, Biblioth. Bot. 87: 165. 1916. Type: Bolivia, [Prov. Cochabamba], Auf Edre am Wegrund bei Incacorral, ca. 2200 m, Januar 1908, Herzog 289 (prob. Holotype JE04000630!).

Neotropical Distribution: Bolivia and *Ecuador.

7. *Dicranella caldensis* Ångström, Öfvers. Förh. Kongl. Svenska Vetensk.-Akad. 3(4): 3. 1876. Type: Brasiliae, Minas Gerais, qui ad Caldas, J.F. Widgren s.n. (prob. Holotype SB240901!).

Neotropical Distribution: Brazil.

8. *Dicranella callosa* (Hampe) Mitt., J. Linn. Soc., Bot. 12: 36. 1869 \equiv *Aongstroemia callosa* Hampe, Linnaea 32: 134. 1863. Type: [Colombia, Nova Granada], In locis humidis umbrosus, Sinche Salto, 2600 metr. Febr. [1860, Lindig. 2060] (lectotype BM000873157!, here designated, syntypes BM000879264!, BM000879265!, BM000879266!, GOET012234!, NY01914667!, NY01917505!, PC0128971!, PC0128972!, PC0128973!).

Neotropical Distribution: Bolivia and Colombia.

9. *Dicranella campylophylla* (Taylor) A. Jaeger, Gen. Sp. Musc. 1: 86 (1870–71: 382). 1872
 ≡ *Anisothecium campylophyllum* (Taylor) Mitt., J. Linn. Soc., Bot. 12: 40. 1869 ≡
Aongstroemia campylophylla (Taylor) Müll. Hal., Syn. Musc. Frond. 2: 608. 1851 ≡
Dicranum campylophyllum Taylor, London J. Bot. 7: 281. 1848. Type: [Ecuador] On
 Pichincha, 8.VIII.1847, W. Jameson [133] (lectotype BM000879353! here designated,
 syntypes FLASB48421!, BM000879352!, BM000672168!, BM000672230!,
 G00047855!, G00047856!, G00047857!).

= *Aongstroemia persquarrosa* Dusén, Arkiv för Botanik 4(1): 11. 4 f. 1–10. 1905.

Type: Patagonia occidentalis in valle fluminis Aysen in rupibus, Febr.1897, P.
Dusén [s.n.] (lectotype S not seen, Hb-Dusén, designated by Ochyra & Newton
 (1985), syntypes BM000672171!, H, S), syn acc. Ochyra & Newton (1985
 [1986]).

= *Cheilothela vaginata* H. Rob., Phytologia 23: 390. F. 1–3. 1972. Type: Venezuela.
 Estado Mérida, a 2 km de la Ciudad de Mérida, sobre rocas, sitio húmedo, elev
 2,500 m, 22 fev 1971, N. Faria I (holotype US not seen, syntype FLASB 15565!,
 syn acc. Ochyra & Newton (1985 [1986]).

= *Dichodontium dicranelloides* Cardot, Bull. Herb. Boissier, 2, 5: 999. 1905. Type:
 “Svenska Sudpolarexpeditionen 1901-03, Nr. 17. *Dichodontium dicranelloides*
 Card. Sp. Nov. + *Webera alticaulis* (C.M.) Par. Tierra del Fuego, Ushuaia, in
 silva regione inferior, 11/3 1902, C. Skottsberg, det. J. Cardot” (lectotype S not
 seen, Hb-Cardot, designated by Ochyra & Newton (1985)), syntype “*Dicranella*
Jamesoni (Tayl.) Broth. Patagonia occ. In valle fl. Aysen in rupibus, Febr.1897,
 P. Dusén 11a” (BM not seen), syn acc. Ochyra & Newton (1985 [1986]).

= *Dichodontium dicranelloides* Card. Var. *falklandicum* Card., Bull. Herb. Boiss. Ser.
 2, 5: 999. 1905 ≡ *Dichodontium persquarrosus* (Dus.) Card. Var. *falklandicum*
 (Card.) Card., Wilss. Ergn. Schwed. Südpolar-Exp. 1901-1903, 4(8): 59. 1908.
 Type: “Svenska Sudpolarexpeditionen 1901-03. Nr. 198. *Dichodontium*
dicranelloides Card. Var. *falklandicum* Card. Var. nova Falkland Islands, Port
 Louis, in rupibus maritimus, 31/7 1902, C. Skottsberg, det. J. Cardot” (lectotype
 S not seen designated by Ochyra & Newton (1985), syntypes H not seen, S not
 seen).

- = *Dicranum cardotii* R. Br., Trans. & Proc. New Zealand Inst. 35: 329. Pl. 36, fig. 9. 1903 ≡ *Dicranella cardotii* (R. Br.) Dixon, New Zealand Inst. Bull. 3(3): 77. 1923 ≡ *Anisothecium cardotii* (R. Br.) Ochyra, Moss Fl. King George Island Antarctica 114. 1998. Type: [New Zealand] On damp banks, tributary of the River Hapuka, near Koikoura, *R. Brown* s.n. (lectotype BM not seen, Hb-Dixon, designated by Ochyra *et al.* (2008), syn acc. Robinson (1986), Ochyra *et al.* (2008) and Larraín *et al.* (2010).
- = *Dicranella symonsii* Dixon, Trans. Roy. Soc. South Africa 8: 183. 2. 1920 ≡ *Anisothecium symonsii* (Dixon) Broth., Nat. Pflanzenfam. (ed. 2) 10: 177. 1924. Type: [South Africa] On wet stones, Giant's Castle, alt. 7000 ft., Natal, 1915, *R.E. Symons* 8665 (holotype BM000672219!), syn acc. Ochyra & Newton (1985 [1986]).
- = *Dicranella wairarapensis* Dixon, New Zealand Inst. Bull. 3(2): 65. Pl. 4: f. 15. 1914 ≡ *Anisothecium wairarapense* (Dixon) Broth., Nat. Pflanzenfam. (ed. 2) 10: 177. 1924. Type: [New Zealand] Mauriceville, Wairarapa, North Island, December, 1908, *W. Gray* 27 (prob. Holotype BM not seen, Hb-Dixon not seen, syntype H not seen), syn acc. Ochyra & Newton (1985 [1986]).
- = *Dicranella watsii* Broth., Öfvers. Finska Vetensk.-Soc. Förh. 40: 162. 1898. Type: [Australia] New South Wales, Richmond River, Brooklet-Fernleigh Road, locis humidis, *W.W. Watts* 1075 (BM000965633!), 1099 (P0129141!, P0129142!), ≡ *Dichodontium watsii* Broth. In Broth. Et Watts., Proc. Linn. Soc. New South Wales 37: 366. 1912 ≡ *Anisothecium watsii* (Broth. In Broth. Et Watts.) Broth., Nat. Pflanzenfam. (ed. 2) 10: 177. 1924. Type: Mixed with *Campylium subrelaxum* Broth., etc. in "Glory Hole" (8944 ex p., ster.) (Holotype: "N.S.W. Mosses, *Watts* 8944 NA, *Dichodontium Watsii* n.sp. "Glory Hole", Yarrangobilly Cave, Ig. W.W. Watts, Jan.1906", H-Brotherus; Isotype BM000672200-Dixon), syn acc. Ochyra & Newton (1985 [1986]).

Neotropical Distribution: Argentina, Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela.

The sample that we are indicating as a lectotype is represented by BM000879353 for the species *Dicranella campylophylla*, since that we checked this sample and verified that the information presented in its label corresponded to the protologue information, moreover,

this sample is the same for the author's herbarium original collection (Stafleu & Cowan 1986).

Furthermore, in spite of we keep the synonymization proposed by Ochyra & Newton (1985), in this reference these authors perform a propose to the synonymization for *Dichodontium watsii* species, but with a different material types. Perhaps, something happened when Brotherus made the new combination to *Anisothecium* genus (Brotherus 1924) and further nomenclatural studies about this species name are need.

10. *Dicranella capituligera* (Müll. Hal.) Paris, (Index Bryol.) 227. 1896 \equiv *Anisothecium capituligerum* (Müll. Hal.) Thér. Na. Bryol. Lichénol. 7: 170. 1935 \equiv *Dichodontium capituligerum* (Müll. Hal.) Paris, Index Bryol. Suppl. 114. 1900 \equiv *Aongstroemia capituligera* Müll. Hal., Linnaea 42: 308. 1879. Type: [Argentina] Argentina Cordobensis, regionibus Las Penas, Sn. Francisco, Sn. Bartolo, Januario 1871, cum fructibus nonnullis vetustis et aliis paucis junioribus, [Dr. P.G. Lorentz s.n.] (lectotype JE04000600! here designated, syntype BM000879348!).

Neotropical Distribution: Argentina.

According to Stafleu & Cowan (1981), the original herbaria of this author's material type species designation should be found or deposited in B herbarium (Stafleu & Cowan 1981), however, the existing specimens were destroyed in consequence of the Second World War in 1943 (Merrill 1943). Therefore the main Müll. Hal's species copies collected and used to new species descriptions were sent to others herbaria scattered around the world, primarily to FI and JE herbaria, but also to BM, S, H and NY (Stafleu & Cowan 1981).

The sample chosen to a new lectotypification process was the JE04000600, this specimens contains morphological characteristics and protologue information according to description and publication of the species name.

11. *Dicranella circinata* Herzog, Na. Bryol. Lichénol. 23: 41. 1954. Type: Chile, Fl. V. Südchile Calbuco, Westküste, 28.8.1937. leg. G.H. Schwabe 167 (lectotype LIL not seen designated by Larraín *et al.* (2010), syntype JE04002236!).

Neotropical Distribution: Chile.

In Larraín *et al.* (2010) this species had its lectotype indicated through a discovery of some samples presenting fertile plants, which is a characteristic that aid the identification of many *Dicranella* species (Allen 1994, Crum 1994, Ochyra *et al.* 2000, Crum 2007, Ochyra *et al.* 2008, Larraín *et al.* 2010, Ellis & Price 2013).

12. *Dicranella consimilis* (Hampe) Mitt., J. Linn. Soc., Bot. 12: 32. 1869 \equiv *Aongstroemia consimilis* Hampe, Ann. Sci. Nat., Bot., sér. 5, 5: 336. 1866. Type: [Colombia], Bogota, Tequendama, 2500 met., in societate Conomitrii Lindigii parce ab *Lindigio* [*s.n.*] (prob. Holotype BM000879261!).

Neotropical Distribution: Colombia and Ecuador.

13. *Dicranella crenulata* Broth., Bih. Kongl. Svenska Vetensk.-Akad. Handl. 26 Afd. 3(7): 7. 1900 \equiv *Leptotrichella crenulata* (Broth.) Ochyra, Fragm. Florist. Geobot. 42: 561. 1997 \equiv *Microdus crenulatus* (Broth.) Paris, Index Bryol. (ed. 2) 3: 235. 1905. Type: Paraguay: Villa Rica, ad terram sub humidam [*C.A.M. Lindman*] 275 (prob. Holotype H2719015!, Hb-Brotherus).

Neotropical Distribution: Paraguay.

14. *Dicranella crinalis* Geh. & Hampe, Flora 64: 339. 1881 \equiv *Aongstroemia crinalis* (Geh. & Hampe) Müll. Hal., Gen. Musc. Frond. 324. 1900. Type: [Brasiliae], [S. Paulo] Prope Apiahy, Augusto 1879, [*J.J. Puiggari s.n.*] (prob. Holotype BM000879253!).

Neotropical Distribution: Brazil.

Mostly the original samples collected by Geh. & Hampe has deposited at the B herbaria (Stafleu & Cowan 1976), however with the destruction of this herbaria during the Second World War (Merrill 1943) many original specimens was transferred to other herbaria scattered in the world, mainly for instance to the BM, which is the original herbaria of the second author responsible to this species description. Thus, a sample corresponding to the morphological characteristics, protologue information and type localization was found at the BM herbaria with the number code as selected above to be considered as a lectotype.

15. *Dicranella ditissima* (Hampe) Mitt., J. Linn. Soc., Bot. 12: 34. 1869 \equiv *Aongstroemia ditissima* Hampe, Linnaea 32: 134. 1863. Type: [Colombia], in sylv. Manzanos ad Barrancos, 2800 metr., April. [1860] [*Lindig. 2062*] (lectotype BM000879252!, here designated, syntypes BM000879250!, BM000879251!, GOET012233!, NY01086230!, PC0129022!, PC0129023!, PC0129024!).

Neotropical Distribution: Colombia and *Ecuador.

We chose the sample BM000879252 due to this sample presenting great quantity of gametophytes and sporophytes comparing to the others of BM herbaria, which is the corresponding original author's herbaria of this species name (Stafleu & Cowan 1979).

16. *Dicranella elata* Schimp. Ex Mitt., J. Linn. Soc., Bot. 12: 33. 1869 \equiv *Aongstroemia elata* (Schimp. Ex Mitt.) Müll. Hal., Gen. Musc. Frond. 324. 1900. Type: [Peru]. Peruvia, prope San Govan in rupibus humidis, [1854]. *Lechler 2280* (lectotype BM000724679! here designated, syntypes BM000724672!, BM000724673!, BM000873156!, GOET012232!, NY01093621!, PC0128985!, PC0128986!, PC0128987!), [Ecuador] Andes Quitenses, in sylv. Canelos (3000 ped.), *Spruce 41* (syntypes BM000724671!, BM000724674!, BM000724675!, PC0128988!); Fl. Amazon, in praeruptis secus Obidos, [*sin. Leg.*] (syntypes BM000724677!, BM000724678!, BM000724680!, BM000724681!).

Neotropical Distribution: Brazil, Ecuador and Peru.

We chose to designate the sample BM000724679 as a lectotype due to this sample presenting great quantity of gametophytes and sporophytes comparing to the others of BM herbarium, which is the corresponding original author's herbaria of this species name (Stafleu & Cowan 1979).

Regarding the geographic distribution of this species in Brazil, in Churchill (1998), this species was cited for the Brazilian Amazonian in the Pará state, however the specimens sample used to this occurrence is a collect of Spruce without number collector deposited at the The New York Botanical Garden, NY herbarium. Therefore, we could not find this sample to check this geographic distribution and in our analyses this sample was not verified in Brazil.

17. *Dicranella exigua* (Schwägr.) Mitt., J. Linn. Soc., Bot. 12: 30. 1869 ≡ *Leptotrichella exigua* (Schwägr.) Ochyra, Fragm. Florist. Geobot. 42: 562. 1997 ≡ *Microdus exiguus* (Schwägr.) Besch., (Index Bryol.) 803. 1897 ≡ *Leptotrichum exiguum* (Schwägr.) Mitt., (J. Proc. Linn. Soc., Bot., Suppl.) 1: 9. 1859 ≡ *Aongstroemia exigua* (Schwägr.) Müll. Hal., (Syn. Musc. Frond.) 1: 444. 1848 ≡ *Weissia exigua* Schwägr., Sp. Musc. Frond., Suppl. 2(2): 93. Pl. 179. 1827. Type: Brasilia, in Serra d'Estrella, [1.II.1823] *Beyrichii* [4] (lectotype BM000879320! here designated, BM000879319!, BM000879321!, BM000879322!, JE04002367!).

Neotropical Distribution: Brazil, Caribbean, Cuba and Peru.

The samples used to designate the lectotype was BM000879320. The original author's herbarium corresponds to the Conservatoire et Jardin botaniques de la Ville de Genève, Switzerland, G (Stafleu & Cowan 1985). However, we could not find any sample that match to this species basionym or the description protologue information.

18. *Dicranella fuegiana* Cardot & Broth., Kongl. Svenska Vetensk. Acad. Handl., n.s. 63 (10): 12. 1923. Type: Chile, Terre de Feu: Sierra Valdivieso, in trajectu Paso de las Lagunas, alt. c. 700 m. s.m. 12.III.1908. *C.J.F. Skottsberg 747* (prob. Holotype PC0132004!).

Neotropical Distribution: Chile.

19. *Dicranella fusca* Broth., Acta Soc. Sci. Fenn. 19(5): 5. 1891 ≡ *Aongstroemia fusca* (Broth.) Müll. Hal., Gen. Musc. Frond. 324. 1900. Type: [Brasilia], Prov. Minas Gerais, Caraça, ad rupes, [1885] *E. Wainio s.n.* (lectotype H1155033! Hb-Brotherus, here designated, syntype TUR00634!).

Neotropical Distribution: Brazil.

20. *Dicranella glaziovii* (Hampe) Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn ser. 4, 1: 87. 1879 ≡ *Aongstroemia glaziovii* Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn 9: 253. 1877. Type: BRAZIL, Rio Preto, *Glaziou 9073* (lectotype BM000879248! designated by Costa *et al.* (2016), syntypes BM000879249!, P0071883!, P0128997!, P0709286!).

Neotropical Distribution: Brazil.

21. *Dicranella gymna* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 309. 1901 ≡ *Leptotrichella gymna* (Müll. Hal.) Ochyra, Fragm. Florist. Geobot. 42: 562. 1997 ≡ *Microdus gymnus* (Müll. Hal.) Paris, Index Bryol. Suppl. 244. 1900 ≡ *Aongstroemia gymna* Müll. Hal., Bull. Herb. Boissier 6: 43. 1898. Type: Brasilia, Serra Itatiaia, 1700 m. alta, in declivibus, Martio 1894, *E. Ule 1806* (lectotype H2719028! Hb-Brotherus, here designated).

Neotropical Distribution: Brazil.

22. *Dicranella harrisii* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 309. 1901 ≡ *Microdus harrisii* (Müll. Hal.) Paris, Index Bryol. Suppl. 244. 1900 ≡ *Aongstroemia harrisii* Müll. Hal., Bull. Herb. Boissier 5: 554. 1897. Type: Jamaica, Blue Mountains Peak, 7420 ped. Alta, in solo, [31] Martio 1896, *W. Harris 10068* Hb-Jamaicense (lectotype BM000879247! here designated, isotype: NY00615187!, NY00615188!, NY00615189!, PC0129007!, PC0129008!).

Neotropical Distribution: *Brazil, Caribbean, Costa Rica, Ecuador, Guatemala, Honduras, Jamaica, Nicaragua and Panama.

The collections of Müll. Hal. originally should be housed at the B herbarium, however, the existing specimens that had deposited were destroyed in consequence of the Second World War in 1943 (Merrill 1943). Therefore these specimens were sent to others herbaria scattered around the world, primarily to FI and JE herbaria, but also to BM, S, H and NY (Stafleu & Cowan 1981). For this lectotypification, we are indicating the sample BM000879276 found in the Natural History Museum, London, England, U.K., corresponding the BM herbarium.

23. *Dicranella hawaiiica* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 310. 13. 1901 ≡ *Microdus hawaiiicus* (Müll. Hal.) Paris, Index Bryol. Suppl. 245. 1900 ≡ *Aongstroemia hawaiiica* Müll. Hal., (Flora) 82: 446. 1896. Type: [Hawaii] Insulae Hawaiiicae, sine loco speciali, Wheeler, 1879, *Boswell [s.n.]* Hb-Geheeb. (prob. Holotype H2722003! Hb-Brotherus).

Neotropical Distribution: Hawaiian.

The sample found at the University of Helsinki, Finland represented by the herbarium and number code H2722003 was the only sample extant observed that present the morphological characteristics and the protologue information of the species publication. According to Stafleu & Cowan (1981), the original samples of Müll. Hal's species description should be deposited at Botanischer Garten und Botanisches Museum Berlin-Dahlem, Zentraleinrichtung der Freien Universität Berlin, Germany, represented by B herbarium, however, in consequence of the Second World War in 1943 (Merrill 1943) these samples were sent to others herbaria scattered around the world, primarily to FI and JE herbaria, but also to BM, S, H and NY (Stafleu & Cowan 1981).

24. *Dicranella hilariana* (Mont.) Mitt., J. Linn. Soc., Bot. 12: 31. 1869 ≡ *Aongstroemia hilariana* (Mont.) Müll. Hal., Syn. Musc. Frond. 1: 443. 1848 ≡ *Microdus hilarianus* (Mont.) Besch., Index Bryol. 804. 1897 ≡ *Dicranum hilarianum* Mont., Ann. Sci. Nat., Bot., sér. 2, 12: 52. 1 f. 2. 1839. Type: [Brasil], Ad terram, in Brasilia meridionali, [A. Saint-Hilaire s.n.]. (lectotype P0146145! designated here, syntypes BM000663421!, BM000663424!, P0728963!).

= *Campylochaetium mexicanum* Besch., Mém. Soc. Sci. Nat. Math. Cherbourg 16: 168. 1872 ≡ *Aongstroemia mexicana* (Besch.) Müll. Hal., Linnaea 38: 630. 1874 ≡ *Dicranella mexicana* (Besch.) A. Jaeger, Gen. Sp. Musc. 2: 637, 1877 [78: 373, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1880] ≡ *Campylopodium mexicanum* (Besch.) Paris., Index Bryol. (ed. 2) 1: 295. 1904. Type: [Mexico] Mirador (Sartorius in Hb-Schimper) (lectotype BM000879379! here designated, BM000879378!, NY00322518!); [Mexico] in monte Orizabensi, Liebmann in Hb-Montagne) (BM000879376!, NY00322517!), syn acc. Wijk *et al.* (1959).

= *Dicranella herminieri* Besch., Ann. Sci. Nat., Bot., sér. 6, 3: 180. 1876. Type: Guadeloupe (F. L'Herminier, in herb. Mus. Par., sub *Dicranella Guillemirii* Montg.) [s.n.] (lectotype P0129009! here designated, BM000879246!, NY00606261!, PC0129010!, PC0129011!), syn acc. FNA (2007).

= *Dicranum debile* Hook. & Wilson, Musci Amer., S. States 51, 52. 1841, non. *Dicranum debile* R. Br., Trans. & Proc. New Zealand Inst. 29: 456. 30 f. 7. 1897, hom ileg. ≡ *Cynodontium debile* (Hook. & Wilson) A. Jaeger, Gen. Sp. Musc. 1: 65 1870–71: 361., Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1872 ≡

- Dicranella debilis* (Hook. & Wilson) Lesq. & James, Man. Mosses N. America 66. 1884 ≡ *Microdus debilis* (Hook. & Wilson) Besch., Index Bryol. 803. 1897 ≡ *Aongstroemia debilis* (Hook. & Wilson) Müll. Hal., Gen. Musc. Frond. 324. 1900. Type: [U.S.A.] Banks of ditches and roadsides, South Carolina to Florida, [T. Drummond s.n.] (lectotype BM000965549! here designated, syntypes BM000965544!, BM000965549!, BM000965550!, BM000965553!, BM000965554!, BM000965555!, BM000965559!, DUKE0329760!, NY00339519!, NY00339520!), syn acc. Wijk *et al.* (1959).
- = *Dicranum tenuirostre* Kunze ex Schwägr., Sp. Musc. Frond., Suppl. 4, 308^a. 1842 ≡ *Aongstroemia tenuirostris* (Kunze ex Schwägr.) Müll. Hal., Syn. Musc. Frond. 1: 441. 1848 ≡ *Dicranella tenuirostris* (Kunze ex Schwägr.) Mitt., J. Linn. Soc., Bot. 12: 30. 1869 ≡ *Microdus tenuirostris* (Kunze ex Schwägr.) Besch., Index Bryol. 806. 1897. Type: [Chile] In Chile Australi, “Pr. Kunze in collectione plantarum siccarum, *Poeppigi 233* (BM not seen), syn acc. Wijk *et al.* (1959).
- = *Dicranella laxiretis* Renault & Cardot., Na. Bryol. 20: 30. 1893, non *Dicranella laxiretis* Herzog, Biblioth. Bot. 87: 14. 1916, hom. Ileg. ≡ *Microdus laxiretis* (Renault & Cardot) Paris., Index Bryol. (ed. 2) 3: 237. 1905, non *Microdus laxiretis* Broth., Symb. Sin. 4: 16. 1929, hom illeg. Type: [U.S.A., Iowa] *Langlois [s.n.]* (prob holotype NY00299728!), syn acc. FNA (2007).
- = *Dicranella leptotrichoides* Renault & Cardot., Bot. Gaz. 19: 237. 21^a. 1894 ≡ *Microdus leptotrichoides* (Renault & Cardot) Paris., Index Bryol. (ed. 2) 3: 237. 1905. Type: Louisiana: on slopes, Rivière Tchiffouté, Abita Springs, Covington, Fontainebleau near Mandeville, 1891-1892, *A.B. Langlois [s.n.]* (prob. Holotype NY00300126!), syn acc. FNA (2007).
- = *Dicranella recurvata* Ochyra, Arts & Lewis-Smith., Polish Polar Stud., 25th Int. Polar Symp. 166. 1998, invalid, no latin description. Type: (not seen), syn acc. Ochyra *et al.* (2000).
- = *Dicranella subserrulata* R.S. Williams., Bull. New York Bot. Gard. 3(9): 106. 1903. Type: [Bolivia] On sandy cut-bank, Huainachoirisa river, July 28, 1902 [*R.S. Williams 1741*] (lectotype NY01093686! here designated, BM000879387!, F0001111C!, JE04004295!), syn acc. Hermann (1976).
- = *Dicranum innovans* Müll. Hal., Bot. Zeitung (Berlin) 2: 709. 1844. Type: [Brazil] *G. Gardner 19* (syntype JE04004296!), syn acc. Wijk *et al.* (1962).

= *Dicranum sellowii* Hornsch., Fl. Bras. 1(2): 14. 1840. Type: [Uruguai], In campis montevidensibus, *Sellow* [s.n.] (not seen); [Brazil, Rio de Janeiro] prope Sebastianopolis, julio et Augusto, Merkel [s.n.] (not seen), syn acc. Wijk *et al.* (1962).

Neotropical Distribution: Bolivia, Brazil, Belize, Colombia, Costa Rica, Cuba, Ecuador, Guatemala, Guianas, Honduras, Jamaica, Mexico, Panama, Peru, Puerto Rico, Uruguay and Venezuela.

25. *Dicranella hookeri* (Müll. Hal.) Cardot, Bull. Herb. Boissier, sér. 2, 6: 4. 1906 ≡ *Anisothecium hookeri* (Müll. Hal.) Broth., Nat. Pflanzenfam. (ed. 2) 10: 178. 1924 ≡ *Aongstroemia hookeri* Müll. Hal., Syn. Musc. Frond. 2: 607. 1851. Type: [Chile], Insula Eremitae ad Cap. Horn, Ab. A. pellucida simillima notis datis differt. *J.D. Hooker* [s.n.] (lectotype BM000879334! here designated, syntypes BM000879336!, BM000879339!).

= *Aongstroemia patagonica* Müll. Hal., Hedwigia 36: 98. 1897 ≡ *Dichodontium patagonicum* (Müll. Hal.) Paris., Index Bryol. Suppl. 114. 1900 ≡ *Dicranella patagônica* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 311. 1901. Type: [Argentina] Patagonia, inter 50°-52° lat. Austr.: Moreno et Tonini in Museo de La Plata. (lectotype NY01086207! here designated), syn acc. Ochyra (1999).

= *Aongstroemia perdivaricata* Müll. Hal., Hedwigia 37: 115. 1898 ≡ *Dicranella perdivaricata* (Müll. Hal.) Paris, Index Bryol. Suppl. 117. 1900. Type: [Australia] Tasmania, Mt. Wellington, St. Crispins Well, 2000 ped. Alt., Nov. 1890, *W. A. Weymouth* (not seen), syn acc. Wijk *et al.* (1959).

= *Aongstroemia redunca* Müll. Hal., Hedwigia 37: 115. 1898. Type: (not seen), syn acc. Wijk *et al.* (1959).

= *Dicranella subclathrata* Lorentz., Moosstudien 159. 1864 ≡ *Dichodontium subclathratum* (Lorentz) Paris, Index Bryol. 324 1894 ≡ *Aongstroemia subclathrata* (Lorentz) Müll. Hal., Gen. Musc. Frond. 325. 1900. Type: Chile [*Krausse s.n.*] (syntypes BM000879332!, BM000879333!), syn acc. Wijk *et al.* (1959).

= *Aongstroemia subredunca* Müll. Hal., Hedwigia 37: 114. 1898 ≡ *Dicranella subredunca* (Müll. Hal.) Paris, Index Bryol. Suppl. 118. 1900. Type: Ad terr. Humid. Pac. Nov. Zeland austr. [*sin col.*] (not seen), syn acc. Wijk *et al.* (1959).

= *Leptotrichum jamesonii* Mitt., non *Dicranum jamesonii* Taylor, nom illeg., later homonym. Original material: (BM not seen), syn acc. Wijk *et al.* (1962).

= *Dicranum waimakaririense* R. Br. Bis, Trans. & Proc. New Zealand Inst. 35: 330. 36 f. 10. 1903. Type: [New Zealand] On wet precipitous rocks in the gorge of the River Waimakariri, growing in company with *D. tasmanicum*, which it approaches in all its characters except size. August, 1899, *Robert Brown* [s.n.] (not seen), syn acc. *Wijk et al.* (1962).

Neotropical Distribution: Argentina, Bolivia, Caribbean, Chile, Colombia, Ecuador and Venezuela.

26. *Dicranella itatiaiae* (Müll. Hal.) Broth., Nat. Pflanzenfam. (3): 309. 1901 ≡ *Microdus itatiaiae* (Müll. Hal.) Paris, Index Bryol. (ed. 2) 3: 237. 1905 ≡ *Leptotrichella itatiaiae* (Müll. Hal.) Ochyra, Fragm. Florist. Geobot. 42: 562. 1997 ≡ *Seligeria itatiaiae* Müll. Hal. Bull. Herb. Boissier 6: 45. 1898. Type: Brasilia, Serra Itatiaia, 2000 m. alta, in solo rupestri, Martio 1894: *E. Ule 1807* [Bryotheca brasiliensis 388] cum *Cladastomo Ulei* et *Psilopilo Ulei* associata viget. (lectotype SP451505! here designated, syntypes R000080364!).

Neotropical Distribution: Brazil.

27. *Dicranella juliformis* Broth., Bih. Kongl. Svenska Vetensk.-Akad. Handl. 26 fd. 3(7): 6. 1900. Type: Brazil, Minas Gerais, S. João d'El-Rei, ad terram sub rupibus, *C.A. Lindman 1* (lectotype SB62519! here designated).

Neotropical Distribution: Brazil.

The original author's herbarium collects should be housed at the University of Helsinki, Finland, represented by the herbarium code H (Stafleu & Cowan 1976). However, the only sample extant that represent the morphological characteristics and the protologue information observed, was the sample S62519 which is deposited at the Swedish Museum of Natural History, Stockholm, Sweden. Therefore, this is the specimens sample that we are choosing for a new lectotype designation.

28. *Dicranella lindigiana* (Hampe) Mitt., J. Linn. Soc., Bot. 12: 30. 1869 ≡ *Leptotrichella lindigiana* (Hampe) Ochyra, Fragm. Florist. Geobot. 42: 563. 1997 ≡ *Microdus lindigianus* (Hampe) Besch., Index Bryol. 804. 1897 ≡ *Seligeria lindigiana* Hampe, Ann.

Sci. Nat., Bot., sér. 5, 3: 353. 1865. Type: [Colombia], Bogota, Socorro et Pic de Cuesta, altit. 1200-1400 metr., ad Barrancas in umbrosis, sept. 1863 leg. A. Lindig [*s.n.*] (lectotype GOET013544! here designated, syntypes BM000879481!, BM000879482!, BM000879483!, BM000879484!, BM000879485!, BM000879486!, BM000879487!, BM000879488!, BM000879489!, BM000879480!, GOET013541!, GOET013542!, GOET013543!, GOET013544!, PC0129057!, PC0695522!).

= *Dicranella sphaerocarpa* Cardot., Na. Bryol. 36: 69. 1909 ≡ *Microdus sphaerocarpus* (Cardot) Broth., Nat. Pflanzenfam. (ed. 2) 10: 181. 1924. Type: [Mexico] Etat de Jalisco: Etzatlan [6500 feet., 6.X].1908, C.G. Pringle 10614 (lectotype P0129085! here designated, syntypes E00108445!, JE04001134!, JE04001135!, MO406056!, MO406057!, NY00597233!, NY00597236!, PC0129086!, PC0695512!, VT031842!), syn acc.Allen (1994).

Neotropical Distribution: *Brazil, Caribbean, Costa Rica, Colombia, Honduras and México.

The original author's herbarium collects should be housed at the The Natural History Museum, London, England, U.K., represented by the herbarium code BM (Stafleu & Cowan 1979). However, all materials type found that corresponds morphological traits and the protologue information observed in the basynonym of this name species are deposited at the Universität Göttingen, Germany, with the herbarium code GOET. Thus, the sample that we are indicating to represent a new lectotype for *Dicranella lindigiana* species is the specimens GOET013544, since that this sample we could check that presented great quantity of gametophytes and sporophytes.

29. *Dicranella lorentzii* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 311. 1901 ≡ *Anisothecium lorentzii* (Müll. Hal.) Broth., Nat. Pflanzenfam. (ed. 2) 10: 178. 1924 ≡ *Dichodontium lorentzii* (Müll. Hal.) Paris, Index Bryol. 322. 1894 ≡ *Aongstroemia lorentzii* Müll. Hal., (Linnaea) 43: 389. 1882. Type: Argentina subtropical, Sierra de Tucumán, in alpinis, der Cienega, 1872, [Dr. P.G. Lorentz, *s.n.*] (lectotype BM000879344! here designated, syntypes JE04000603!, JE04000604!, JE04000605!).

Neotropical Distribution: Argentina.

The original type specimen of this species should be found at the B herbaria, however, as cited previously, this herbaria was destroyed as consequence of the Second World War in 1943 (Merrill 1943) and the majority Mull. Hal's specimens collected were sent to others herbaria scattered around the world, primarily to FI and JE herbaria, but also to BM, S, H and NY (Stafleu & Cowan 1981).

According to Suárez *et al.* (2013) a lectotype of this species was indicated and found by the observation of some samples during a visit to the Natural History Museum of London in BM herbaria. The authors claimed that the BM sample was the only specimen extant for this species, however, the genus *Dicranella* and *Anisothecium* are considered synonyms or as the same taxa in a broad sense (Williams 1913, Scott & Stone 1976, Corley *et al.* 1981, Crum 1994, Gradstein *et al.* 2001, Smith 2004, Allen 2005, Casas *et al.* 2006, Hallingbäck *et al.* 2006, Crum 2007, Ochyra *et al.* 2008, Frey & Stech 2009) and there are three other specimens which were found that represent this specie as well, deposited at the JE herbaria.

Thus after analysing and comparing with the sample JE04000603, we concluded that these species corresponding to the same species of BM sample proposed by Suárez *et al.* (2013). In this catalog we are completing the information given in the lectotypification with the number sample that represent the type specimen of this species as cited previously above.

30. *Dicranella luteola* Mitt., J. Linn. Soc., Bot. 12: 33. 1869 \equiv *Aongstroemia luteola* (Mitt.) Müll. Hal., Gen. Musc. Frond. 325. 1900 \equiv *Microdus luteolus* (Mitt.) Paris, Index Bryol. (ed. 2) 3: 238. 1905. Type: Ecuador. Andes Quitenses, in sylva Canelos, loco Pueblo de Los Libaros (3000 ped.), *Spruce 44*. (lectotype BM000724682! here designated, syntypes BM000724683!, NY01093646!, NY01093647!).

Neotropical Distribution: Colombia and Ecuador.

Among all the materials type analyzed, we chose the sample BM000724682 as lectotype due to this specimens presenting a great quantity of material, gametophytes and sporophytes, besides, the label of this exsiccates contains all protologue information of this species.

According to Stafleu & Cowan (1981), the preferential material type used for species description of William Mitten's collection should be regarding at the New York Botanical Garden, NY herbarium, however, the gametophytes and sporophytes extant in these samples were very few, almost lacking. Besides, the exsiccate of these samples did not keep the complete protologue information according to the publication of this species.

31. *Dicranella macrostoma* (Müll. Hal.) Paris, Index Bryol. Suppl. 117. 1900 ≡ *Anisothecium macrostomum* (Müll. Hal.) Broth, Nat. Pflanzenfam. (ed. 2) 10: 77. 1924 ≡ *Aongstroemia macrostoma* Müll. Hal., Nuovo Giorn. Bot. Ital., n.s., 4: 38. 1897. Type: Bolivia. [Cochabamba, prope Choquecamata, 1.06.1889, *Germain 1064*] (lectotype H0129020! here designated, syntypes G00265681!, NY01914582!).

Neotropical Distribution: Bolivia.

According to Stafleu & Cowan (1981), the type specimen indication of this author should be found or deposited in B herbarium, however this herbarium was destroyed in consequence of the Second World War in 1943 (Merrill 1943). Therefore the main Müll. Hal.'s species copies collected and used to new species descriptions were sent to others herbaria scattered around the world, primarily to FI and JE herbaria, but also to BM, S, H and NY (Stafleu & Cowan 1981).

For this species name, we are indicating the sample H0129020 deposited at the University of Helsinki, Finland, to assume the new lectotype role due to the morphological traits and the protologue information extant in its exsiccate. Besides, there is a handwritten made by the author with the same information corresponding to the protologue of the species publication.

32. *Dicranella martiana* (Hampe) Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn ser. 4, 1: 86. 1879 ≡ *Microdus martianus* (Hampe) Besch., Index Bryol. 805. 1897 ≡ *Leptotrichella martiana* (Hampe) Ochyra, Fragm. Florist. Geobot. 42: 563. 1997 ≡ *Aongstroemia martiana* Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn 4: 41. 1872. Type: BRAZIL, Rio de Janeiro, *Glaziou 5183* (lectotype BM000879469! designated by Costa *et al.* (2016), syntypes BM000879470!, BM000879471!, P0129060!, P0709297!).

Neotropical Distribution: Brazil.

33. *Dicranella nitida* Broth., Acta Soc. Sci. Fenn. 19(5): 5. 1891 ≡ *Aongstroemia nitida* (Hedw.) Mitt., Ann. Mag. Nat. Hist., ser. 2, 8: 306. 1851, non *Aongstroemia nitida* (Broth.) Müll. Hal., Gen. Musc. Frond. 324. 1900, nom inval. Type: [Brazil], Minas Geraës, [Caraça] in terra arenosa; thecis immaturis et deoperculatis, species foliis arcte

imbricatis, brevibus, nitidis insignis, 1.I.1885, *E.A. Wainio s.n.* (lectotype BM000879240! here designated, syntypes TUR not seen, Hb – BR not seen).

Neotropical Distribution: Brazil.

The collections of Viktor Ferdinand Brotherus should be housed at the University of Helsinki, Finland, represented by the herbarium code H (Stafleu & Cowan 1976). However, we chose as a new lectotype the sample BM000879240. This specimen contains both morphological characteristics and the protologue information observed, we could not find the material type appurtenant to the H herbarium.

34. *Dicranella osculatiana* De Not., Mem., Reale Accad. Sci. Torino 18: 451. 1. 1859. Type: Colombia, Ad. fl. Naps. [1863] *Osculati s.n.* (lectotype BM000879239! here designated, syntype G00116229!).

Neotropical Distribution: Colombia and Ecuador.

The original author's materials type should be housed at the Università degli Studi di Genova, Italy, represented by the herbarium code GE. However, the samples belonging to this herbarium could not be found, thus we chose the sample BM000879239 to represent the morphological characteristics for the *Dicranella osculatiana* species. This lectotype designated is according to the protologue information.

35. *Dicranella pabstiana* (Müll. Hal.) Mitt., J. Linn. Soc., Bot. 12: 31. 1869 ≡ *Aongstroemia pabstiana* Müll. Hal., Bot. Zeitung (Berlin) 15: 380. 1857. Type: Santa Catharina insula, solo limoso, ad vias et in declivibus ad flumen Rio de Velha, socio *Trematodontes squarrosus*: *Pabst [s.n.]*. (lectotype BM000879300! here designated, syntype BM000879300!, BM000879301!, G00116225!, G00116226!, NY01917788!).

Neotropical Distribution: Brazil.

To represent this species, we chose the sample BM000879300 as a new lectotype designation. According to Stafleu & Cowan (1981), the type specimen indication of this author should be found or deposited in B herbarium, however this herbarium was destroyed in consequence of the Second World War in 1943 (Merrill 1943). Therefore the main Mull.

Hal's species copies collected and used to new species descriptions were sent to others herbaria scattered around the world, primarily to FI and JE herbaria, but also to BM, S, H and NY (Stafleu & Cowan 1981).

36. *Dicranella paraguensis* (Besch.) Broth., Nat. Pflanzenfam. I(3): 309. 1901 ≡ *Leptotrichella paraguensis* (Besch.) Ochyra, (Fragm. Florist. Geobot.) 42: 563. 1997 ≡ *Aongstroemia paraguensis* (Besch.) Müll. Hal., Gen. Musc. Frond. 324. 1900 ≡ *Microdus paraguensis* Besch., J. Bot. (Morot) 5: 145. 1891. Type: Paraguay: Péribébui, [1.VII.1879] *Balansa 3661* (lectotype PC0129150! here designated, syntypes BM000879462!, BM000879463!, BM000879464!, G00040425!, G00040427!, G00040428!, G00040429!, G00042267!, NY01917794!, NY01917795!, PC0129151!, PC0129152!, PC0695518!).

Neotropical Distribution: Paraguay.

This lectotype was chose due to this sample presenting a great quantity of samples, and many gametophytes and sporophytes. Moreover, this sample corresponds to the original author's herbarium collection, in this case, the material types samples were deposited by Émile Bescherelle at the Muséum National d'Histoire Naturelle, Paris, France, represented by the herbarium code P (Stafleu & Cowan 1976).

37. *Dicranella perrottetii* (Mont.) Mitt., J. Linn. Soc., Bot. 12: 35. 1869 ≡ *Aongstroemia perrottetii* (Mont.) Müll. Hal., Syn. Musc. Frond. 1: 434. 1848 ≡ *Campylopus perrottetii* (Mont.) M. Fleisch., Musci Buitenzorg 1: 102. 1904 ≡ *Dicranum perrottetii* Mont., Ann. Sci. Nat., Bot., sér. 2, 19: 241. 8 f. 1. 1843. Type: Ad terram humosam in insulâ Martinicensi hancce speciem invenit cl. *Perrottet*, [s.n.] (lectotype P0131956! here designated, syntypes BM000879235!, BM000879236!, BM000879237!).

Neotropical Distribution: Bolivia, Caribbean, Colombia, Costa Rica, Ecuador, Jamaica, Panama and Venezuela.

38. *Dicranella puiggarii* Geh. & Hampe, Flora 64: 339. 1881 ≡ *Aongstroemia puiggarii* (Geh. & Hampe) Müll. Hal., (Gen. Musc. Frond.) 321. 1900. Type: Serra de Boa Vista inter Apiahy et Iporanga, statu imaturo, colore rufescente et foliis longioribus, 18.07.1879, *Puiggarr s.n.* (prob. Holotype BM000879405!).

Neotropical Distribution: Brazil.

39. *Dicranella riograndensis* Broth., Bih. Kongl. Svenska Vetensk.-Akad. Handl. 26 fd. 3(7):7. 1900. Type: Rio Grande do Sul: Silveira Martins, ad. terram marginum viarum et fossarum, 01.01.1893 C.A. Lindman 190 (lectotype S B62688! here designated, syntypes BM000879402!).

Neotropical Distribution: Brazil.

The original author's herbarium of this species is represented by the University of Helsinki, Finland (H) (Stafleu & Cowan 1976). However, were found two samples representing the morphological characteristics and the same information in the description protologue of this species. Thus we chose to select the sample (S 62688) deposited in the Swedish Museum of Natural History, Stockholm, Sweden, as a lectotype due to this sample we could achieve the material type and studying its morphological characteristics.

40. *Dicranella rufipes* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 311. 1901 ≡ *Anisothecium rufipes* (Müll. Hal.) Dusén, Rep. Princeton Univ. Exp. Patagonia, Botany 8(3): 67. 1903 ≡ *Dichodontium rufipes* (Müll. Hal.) Paris, Index Bryol. 324. 1894 ≡ *Aongstroemia rufipes* Müll. Hal., Linnaea 43: 388. 1882. Type: Argentina Tucumanensis, in excelsis prope Tafi, 04.1873, [Dr. P.G. Lorentz, s.n.] (lectotype JE04000568! here designated, syntypes JE04000567!, JE04000569!).

Neotropical Distribution: Argentina.

For this species the original author's herbarium is originally represented by Botanischer Garten und Botanisches Museum Berlin-Dahlem, Zentraleinrichtung der Freien Universität, Berlin, Germany (B) herbarium (Stafleu & Cowan 1981), however this herbaria and the existing specimens that had deposited were destroyed in consequence of the Second World War in 1943 (Merrill 1943). Therefore the main Müll. Hal's species copies collected and used to new species descriptions were sent to others herbaria scattered around the world, primarily to FI and JE herbaria (Stafleu & Cowan 1981). Therefore, we chose de sample JE04000568, which is been proposed as above to a new lectotype designation.

41. *Dicranella sericea* E.B. Bartram, Na. Bryol. Lichénol. 33: 3. 1964 [1965]. Type: Ecuador. On moraine S of W. glacier of Antisana, 6450 m, *Grubb 2502a* (lectotype BM001231555! here designated, syntype FLAS not seen).

Neotropical Distribution: Ecuador.

The original herbarium of the author's material type specimens corresponds to Harvard University, Cambridge, Massachusetts, U.S.A., represented by the herbarium code FH according to Stafleu & Cowan (1976). However, a representative sample of this corresponding herbarium could not be found, thus we selected the sample BM001231555 as a new lectotype indication.

42. *Dicranella strumulosa* (Hampe) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 377 (Gen. Sp. Musc. 1: 81). 1872 ≡ *Aongstroemia strumulosa* Hampe, Linnaea 32: 133. 1863. Tipo: [Colombia], In sylv. Manzanos ad Barrancos, 2700 metr., Jul. Ex habitu Angstr. Subulatae C.M. A. tovariensi C.M. affinis primo adspectu theca strumulosa cognoscitur [A. Lindig 2108] (lectotype BM000879394! here designated, syntype BM000879392!, BM000879395!, BM000879396!, BM000879397!, GOET011823!, GOET012227!, GOET012228!, P0129104!, P0129105!).

Neotropical Distribution: Colombia.

43. *Dicranella submacrostoma* Broth., (Biblioth. Bot.) 87: 14 1916 ≡ *Anisothecium submacrostomum* (Broth.) Broth., Nat. Pflanzenfam. (ed. 2) 10: 77. 1924. Type: Bolivia, Cerros de Málaga, in einer feuchten Rinne, 01.VI.1911, *T.C.J. Herzog 4402* (prob. Holotype JE04000614!).

Neotropical Distribution: Bolivia.

The sample represented by JE04000614 was the only specimens extant that we could find which corresponds the morphological characteristics and the same protologue information with the publication description. According to Stafleu & Cowan (1975), this original material type used by the author's description should be housed at the H herbarium, however, any samples corresponding this herbarium can be found.

44. *Dicranella subsulcata* (Hampe) Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn ser. 4, 1: 86. 1879 \equiv *Aongstroemia subsulcata* Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn 4: 42. 1872. Type: BRAZIL, Rio de Janeiro, *Glaziou 5181* (lectotype BM000879386! designated by Costa *et al.* (2016), syntypes BM not seen, P0129113!, P0709291!)

Neotropical Distribution: Brazil.

45. *Dicranella tovariensis* (Müll. Hal.) Mitt., J. Linn. Soc., Bot. 12: 32. 1869 \equiv *Aongstroemia tovariensis* Müll. Hal., Syn. Musc. Frond. 1: 443. 1848. Type: [Bolivia] Columbia, ubi in colonia Tovar Germanica altitud. 5000 ped. Inter *Polytrichia* viget, A. Fendler 31 (lectotype P0129115! here designated).

Neotropical Distribution: Caribbean and Venezuela.

The original herbarium where this species should be deposited, according to respective original author's description was the B herbarium (Stafleu & Cowan 1981). However, with the Second World War in 1943, many material type specimens deposited there were destroyed (Merrill 1943). The material type of the sample P0129115 cited above for a new lectotype was the only specimens extant that matches with the description of the protologue information and the morphological characteristics regarding to this species.

46. *Dicranella trumpffii* (Hampe) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 387 (Gen. Sp. Musc. 1: 91) 1872 \equiv *Aongstroemia trumpffii* Hampe, Bot. Zeitung (Berlin) 17: 215. 1859. Type: Venezuela, Mt. Galipano, 6000 ped. Alta: A. Trumpff. *s.n.* (lectotype BM01231528! here designated, syntypes BM000879382!, BM000879383!, BM000879384!, BM0008793851, BM01231529!).

Neotropical Distribution: Venezuela.

47. *Dicranella ulei* (Müll. Hal.) Broth., Nat. Pflanzenfam. I(3): 309. 1901 \equiv *Leptotrichella ulei* (Müll. Hal.) Ochyra, Fragm. Florist. Geobot. 42: 564. 1997 \equiv *Microdus ulei* (Müll. Hal.) Paris, Index Bryol. (ed. 2) 3: 240. 1905 \equiv *Seligeria ulei* Müll. Hal., Bull. Herb. Boissier 6: 45. 1898. Type: Brasilia, Minas Geraës, Serra Ouro Preto, in rupibus, Febr.1892, E. Ule 1435 (lectotype H2719026! H-Brotherus here designated).

Neotropical Distribution: Brazil.

The main Mull. Hal's material type sample species should be deposited in the B herbarium, however the existing specimens that had deposited were destroyed in consequence of the Second World War in 1943 (Merrill 1943). Therefore the main Mull. Hal's species copies collected and used to new species descriptions were sent to others herbaria scattered around the world, primarily to FI and JE herbaria, but also to BM, S, H and NY (Stafleu & Cowan 1981). Thus we chose the sample H2719026 as a new lectotype for this species.

48. *Dicranella vaginata* (Hook.) Cardot, (Wiss. Erb. Schwed. Südpolar-Exp.) 4 (8): 60. 1908
 ≡ *Dichodontium vaginatum* (Hook.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. (Gen. Sp. Musc. 1: 67) 1870–71: 363. 1872 ≡ *Anisothecium vaginatum* (Hook.) Mitt., J. Linn. Soc., Bot. 12: 39. 1869 ≡ *Aongstroemia vaginata* (Hook.) Müll. Hal., Syn. Musc. Frond. 2: 608. 1851 ≡ *Dicranum vaginatum* Hook., Pl. Crypt., Pl. 3B. 1816. Type: [Colombia. Amérique équatoriale, In convallibus *Andium Granatensium* inter *Almaguar* et *Pasto*, altitud. 1200-1500 hexapod. *Bonpland*, A.J.A. [*s.n.*] (lectotype BM000672167! here designated, syntypes BM000672165!, BM000672166!, BM000879337!, BM000879338!, BM000879340!, BM000879341!, JE04009786!, LINN166824!, P0657690!, P0657691!).

= *Anisothecium jamesonii* Mitt., J. Linn. Soc., Bot. 12: 39. 1869. *Dicranella jamesonii* (Mitt.) Broth., Nat. Pflanzenfam. I(3): 311. 1901. *Aongstroemia jamesonii* (Mitt.) Müll. Hal., Gen. Musc. Frond. 321. 1900. *Dichodontium jamesonii* (Mitt.) A. Jaeger, Nat. Pflanzenfam. I(3): 311. 1901. Type: [Ecuador] loco Huambató in palude (9000 ped), *Spruce 34* (lectotype BM000724725! here designated, syntypes, BM000724726!, BM000724715!, BM000724720!, P0129044!, P0129045!, P0129046!, P0657693!); Ecuador]; syntypes, Hab. Andes Quitenes, *Jameson 13* (BM000672229!, BM000724721! BM000724724!; BM000879342!, BM000879354!); [Colombia] Andes Bogotensis *Weir* [*s.n.*] (BM000724716!, BM000724727!); [Argentina] Fuegia, in fretu Magellan, "Sandy Point" ad ribulus, *Lechler 11161* (BM000879335!); [Chile] Hermite Island, *Hooker* [*s.n.*] (BM000879334!), syn acc. Greene (1986).

= *Dicranella standleyi* E.B. Bartram, Contr. U.S. Natl. Herb. 26 (3): 57. 1. 1928. Type: Costa Rica, wet bank, Yerba Buena, northeast of San Isidro, Province of

Heredia, February 22 to 28, 1926, *P.C. Standley & J. Valerio 50086* (lectotype NY01093683! here designated, NY01093684!, P0657694!), syn acc. Wijk *et al.* (1962).

Neotropical Distribution: Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Panama and Peru.

49. *Dicranella venezuelana* (Dozy & Molk.) W.R. Buck, (*Brittonia*) 31: 472. 1979 ≡ *Campylostelium venezuelanum* Dozy & Molk., Prodr. Fl. Bryol. Surinam. [Natuurk. Verh. Holl. Maatsch. Wetensch. Haarlem, ser. 2, 10(3):] 38. Pl. 5 1854. Type: Venezuelae, Caracas, ubi collegit doctissimus, *P.W. Korthals* [*s.n.*] (lectotype P0701482! here designated, syntypes BM001006977!, BM001006978!, BM001006979!).

Neotropical Distribution: Venezuela.

The sample P07011482 was chosen to represent the new lectotype for this species since all species protologue information is in the label of this sample. In spite of this herbarium does not correspond the original author's herbarium (Stafleu & Cowan 1976), the samples cited above were the only found for this species at the moment.

50. *Dicranella weberbaueri* Broth. Bot. Jahrb. Syst. 56 (Beibl. 123): 4. 1920. Type: [*Peru. Puno,*] Prov. Sandia: Weg von Sandia nach Chunchusmayo, in der Nähe des Tambo Tsilluma, 1000 m, [*Weberbauer, 1221*] (prob holotype H1154013! Hb-Brotherus).

Neotropical Distribution: Peru.

List of doubtful taxa:

Dicranella argentinica (Müll. Hal.) Kindb., Index Bryol. 325. 1898. *Aongstroemia argentinica* Müll. Hal., (*Linnaea*) 42: 308. 1879. Type: Argentina Cordobensis, Ascochinga, ad rupes gneissaceas "nahe dem Badeplatze" cum Bryo recoluto rarissime fertilis, April, 1871 [*Dr. P.G. Lorentz, s.n.*] (not seen, herbarium not found).

Neotropical Distribution: Argentina.

Dicranella guilleminiana (Mont.) Mitt., J. Linn. Soc., Bot. 12: 32. 1869 ≡ *Aongstroemia guilleminiana* (Mont.) Müll. Hal., Syn. Musc. Frond. 1: 440. 1848 ≡ *Dicranum guilleminianum* Mont., Ann. Sci. Nat., Bot., sér. 2, 16: 267. 1841. Type: Insula Cuba, Wright 36 (syntypes BM not seen, FLAS not seen, NY not seen): Brasilia, *Herb. Montagne*; in monte Corcovado, Gardner [s.n.] (syntypes BM not seen, FLAS not seen, NY not seen); in prov. San Paulo, in sylvis prope Itu (2200 ped.), Weir 32 (syntypes BM not seen, FLAS not seen, NY not seen).

= *Dicranum sulcatum* Müll. Hal., Bot. Zeitung (Berlin) 2: 709. 1844. Type: (not seen, herbarium not found) syn acc. Wijk *et al.* (1962).

Neotropical Distribution: Bolivia, Brazil, Cuba and Caribbean.

Dicranella heteromalla (Hedw. Ex Brid.) Schimp., Coroll. Bryol. Eur. 13. 1856 ≡ *Cynodontium heteromallum* (Hedw.) Mitt., J. Linn. Soc., Bot. 8: 16. 1865 ≡ *Leptotrichum heteromallum* (Hedw.) Mitt., J. Proc. Linn. Soc., Bot., Suppl. 1: 11. 1857 ≡ *Aongstroemia heteromalla* (Hedw.) Müll. Hal., Syn. Musc. Frond. 1: 432. 1848 ≡ *Dicranodontium heteromallum* (Hedw.) A.W.H. Walther & Molendo, Laubm. Oberfrank. 98. 1868 ≡ *Dicranodon heteromallum* (Hedw.) Béhéré, Muscol. Rothom. 29. 1826 ≡ *Bryum heteromallum* (Hedw.) Sturm, Deutschl. Fl., Abt. II, Cryptog. 6: [9]. 1803 ≡ *Mnium heteromallum* (Hedw.) J.F. Gmel. Ex With., Syst. Arr. Brit. Pl. (ed. 4) 3: 784. 1801 ≡ *Dicranum heteromallum* Hedw. Ex Brid., Sp. Musc. Frond. 128. 1801. Type: In silvis ad truncos arborum, aggeres, vias cavas, in graminosis montium editiorum totius Europae (G not seen).

= *Aongstroemia aperula* Hampe in Müll. Hal., Gen. Musc. Frond. 323. 1900, *nom inval. No description*. Original Material: [China] Sino-Hymanayan [Wilhelm Sulpiz Kurz 2117] (BM000965501!, BM000965502!, BM000965503!, BM000965504!, BM000965505!, BM000965506!, G00265878!, HB-HAMPE), syn acc. Gangulee (1971).

= *Aongstroemia banatica* Hampe, *Oesterr. Bot. Z.* 11: 154. 1861. Type: Slaxruth 69 (BM000965533!), syn acc. Gangulee (1971).

= *Aongstroemia caucasica* Müll. Hal., Trudy Imp. S.-Peterburgsk. Bot. Sada 10(1): 256. 1887. Type: (not seen, herbarium not found), syn acc. Wijk *et al.* (1959).

= *Dicranella crassinervis* (Hampe) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 374 (Gen. Sp. Musc. 1: 78). 1872. *Aongstroemia crassinervis* Hampe, *Linnaea* 32: 133. 1863. Type: [Bolivia] Nova Granada, in sylv.

- Manzanos ad Barrancas, 2700 mtr. Jul. *Lindg.* 2109 (GOET012231!, NY01917636!, NY02032450!), syn acc. Gangulee (1971).
- = *Dicranella levieri* Müll. Hal. Ex Broth., Acta Soc. Sci. Fenn. 19(12): 67. 1892. *Aongstroemia levieri* (Müll. Hal. Ex Broth.) Müll. Hal., Gen. Musc. Frond. 323. 1900. Type: [Geórgia] Adjara, in regione silvarum media inter Khula et Danais Para-ul, ubi crum fructis vetusis 22. Juni.1890, E. Levier [s.n.] (H-BR not seen), syn acc. Wijk (1959).
- = *Bartramia perangusta* Dixon & Thér., Trav. Bryol. 1[13]: 11. 1942. Type: Japan, 1927-10-19, *Sasaoka, H.* 3605 (BM000965586!, PC0129020!), syn acc. Wijk *et al.* (1959).
- = *Campylopus henrici* Renauld & Cardot, Bot. Gaz. 13: 197. 14. 1888. Type: [U.S.A.] Kansas, Saline County, on sandy ground, where it was discovered by the late *Joseph Henry* [s.n.] (BM000965543!, NY01086794!, PC0692374!), syn acc. Wijk *et al.* (1959).
- = *Dicranella fitzgeraldii* Renauld & Cardot, Bot. Gaz. 13: 197, 13. 1888. *Dicranella heteromalla* var. *fitzgeraldii* (Renauld & Cardot) Grout Moss. Hand-lens Microsc. 91. 395. 1904. *Aongstroemia fitzgeraldii* (Renauld & Cardot) Müll. Hal., Gen. Musc. Frond. 324. 1900. *Dicranella heteromalla* subsp. *Fitzgeraldii* (Renauld & Cardot) Kindb. Eur. N. Amer. Bryin. 2: 208. 1897. Type: [U.S.A.], Sterile specimens gathered in Louisiana by Mr. *A.B. Langlois* [s.n.] (PC not seen), syn acc. FNA (2007).
- = *Dicranella fuscorufa* Stirt., Ann. Scott. Nat. Hist. 15(58): 108. 1906. Type: United Kingdom, 1904-08, *Anon. S.n.* (BM000965515!), syn acc. Gangulee (1971).
- = *Dicranella heteromalla* var. *latinervis* Cardot & Thér, Proc. Wash. Acad. Sci. 4: 297. 1902. Type: [U.S.A., Alaska], Douglas Island, *W. Trelease* 2389 (MO407804!, NY00299909!, P0129012!), *W. Trelease* 2389^a (MO407805!), syn acc. FNA (2007).
- = *Dicranum orthocarpum* Hedw., Sp. Musc. Frond. 131. 30 f. 1–5. 1801. *Dicranella heteromalla* var. *orthocarpa* (Hedw.) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 374 (Gen. Sp. Musc. 1: 78). 1872, non *Dicranella heteromalla* var. *orthocarpa* Broth., Classif. Mosses Japan 140, 1932. *Aongstroemia heteromalla* var. *orthocarpa* (Hedw.) Müll. Hal. Syn. Musc. Frond. 1: 433. 1848. *Dicranum subulatum* var. *orthocarpon* (Hedw.) Hampe, Flora 13: 42. 1830. *Dicranella varia* var. *orthocarpa* (Hedw.) Paris, Index Bryol. 361. 1896. Type: [unknown locality] *Beauvois, A.M.D.J.* 195 (syntype

- PH00079670!); [unknown locality] *H. 63* (syntype PH00038094!), syn acc. FNA (2007).
- = *Dicranella heteromalla* var. *pittieri* Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 31(1): 145. 1893. *Aongstroemia pittieri* (Renauld & Cardot) Müll. Hal., Gen. Musc. Frond. 323. 1900, Type: Colombia, 1860-07-01, [*sin leg*] 2109 (NY01917636!, NY02032450!), syn acc. Allen (1994).
- = *Dicranella levieri* Müll. Hal. Ex Broth., Acta Soc. Sci. Fenn. 19(12): 6, 1892, non *Dicranella levieri* Müll. Hal., Hedwigia 53: 264. 1913. *Aongstroemia levieri* (Müll. Hal. Ex Broth.) Müll. Hal., Gen. Musc. Frond. 323. 1900. Type: [Geórgia] Cauc. Minor occ: Adjaria, in regione silvarum media inter Khula *et* Danais Paralul, ubi cum fructibus vetustis 22. Junii. 1890, *E. Levier* [*s.n.*] (not seen), syn acc. Gangulee (1971).
- = *Dicranum pilosum* P. Beauv., Prodr. Aethéogam. 48, 54. 1805. Type: France [*sin leg, sin n.*] (P not seen), syn acc. Wijk *et al.* (1962).

Neotropical Distribution: Bolivia, Colombia, Costa Rica, Honduras and Panama.

Dicranella longirostris (Schwägr.) Mitt., J. Linn. Soc., Bot. 12: 30. 1869 ≡ *Leptotrichella longirostris* (Schwägr.) Ochyra, Fragm. Florist. Geobot. 42: 563. 1997 ≡ *Microdus longirostris* (Schwägr.) Schimp., Mém. Soc. Sci. Nat. Math. Cherbourg 16: 162. 1872 ≡ *Seligeria longirostris* (Schwägr.) Müll. Hal., Syn. Musc. Frond. 1: 421. 1848 ≡ *Leptotrichum longirostre* (Schwägr.) Müll. Hal., Bot. Zeitung (Berlin) 5: 806. 1847 ≡ *Weissia longirostris* (Schwägr.) Schwägr., Sp. Musc. Frond., Suppl. 2, 1: 54. Pl. 117. 1823 ≡ *Coscinodon longirostris* (Schwägr.) Brid., Muscol. Recent. Suppl. 4: 51. 1819[1818] ≡ *Trematodon longirostris* Schwägr., Sp. Musc. Frond., Suppl. 1 2: 343. 1816. Type: Guadelupe, in monte sulphurifero (4000 ped.), *Richard, Parker et Guilding* [*s.n.*] (syntypes G not seen, P0129058, NY not seen); Brasilia, Parahybuna, *G. Gardner 19* (syntypes G not seen, P not seen and NY not seen).

= *Dicranella pseudolongirostris* Cardot, Na. Bryol. 36: 68. 1909. Type: [Mexico] etat de Morelos, pres de Cuernavaca 1908, [*Cyrus G. Pringle*] 10661 (BM000879476!, BM000879477!, BM000879479!, E00108446!, JE04001133!, MO407806!, MO2201519!, NY00597231!, NY00597232!, PC0129075!, PC0129076!, PC0695520!, PH00002831!), syn acc. Crum (1994).

= *Dicranella sharpii* E.B. Bartram, Bryologist 50: 202. 1947. Type: [Guatemala] El Quiché, trailside bank below Nebaj, alt. 5650 ft., *A.J. Sharp 2448* (prob. Holotype

TENN01093682!, syntype DUKE0187608!, DUKE0187609!, MICH525400!); [Guatemala] Dept. Baja Verapaz, bank of trail, Civija, alt. 4000 ft., *A.J. Sharp 5188* (syntype TENN not seen, DUKE0187610!, MO2085762!) syn acc. Allen (1994).

= *Microdus crispulus* Besch., Ann. Sci. Nat., Bot., sér. 6, 3: 179. 1876. *Dicranella crispula* (Besch.) Broth. Nat. Pflanzenfam. I(3): 309. 1901. Type: Guadeloupe ou Martinique, [*sin col.*] (P not seen, HB not seen Husnot n. 136, BM000879478!), syn acc. Crum (1994).

Neotropical Distribution: Brazil, Caribbean, Costa Rica, Guatemala, Honduras, Mexico and Panama.

Dicranella planinervia (Taylor) A. Jaeger, Ber. Thätigk. St. Gallischen Naturwiss. Ges. 1870–71: 376 (Gen. Sp. Musc. 1: 80). 1872 ≡ *Anisothecium planinervium* (Taylor) Mitt., J. Linn. Soc., Bot. 12: 40. 1869 ≡ *Aongstroemia planinervia* (Taylor) Müll. Hal., (Syn. Musc. Frond.) 2: 605. 1851 ≡ *Dicranum planinervium* Taylor, (London J. Bot.) 7: 281 1848. Type: [Ecuador] On Pichincha, 8.8.1847, *Prof. W. Jameson [s.n.]* (FH not seen, BM not seen).

Neotropical Distribution: Ecuador.

Dicranella varia (Hedw.) Schimp., (Coroll. Bryol. Eur.) 13. 1856. ≡ *Anisothecium varium* (Hedw.) Mitt., J. Linn. Soc., Bot. 12: 40. 1869 ≡ *Dicranodon varium* (Hedw.) Béhéré, (Muscol. Rothom.) 1826 ≡ *Aongstroemia varia* (Hedw.) Müll. Hal., (Syn. Musc. Frond.) 1: 435. 1848 ≡ Basionym: *Dicranum varium* Hedw., (Sp. Musc. Frond.) 133. 1801. Type: [*Anon.*, 20] (isotype LINN-HS1668-20-2!).

= *Dicranum pulchellum* Blandow, Nomencl. Bot. (Steudel) 2: 153. 1824. Nom. nud in synonym (not seen), syn acc. Wijk *et al.* (1962).

= *Dicranella recurvata* Ochyra, Arts & Lewis Smith, Glowacki & Bednarek, Polish Polar Stud. 25 Int. Polar Symp, 166. 1998. Nom. nud in synonym (not seen), syn acc. Ochyra *et al.* (2008).

Neotropical Distribution: Colombia, Cuba, Guatemala, Haiti, Jamaica, Mexico and Peru.

Dicranella brasiliensis (Hampe) E.B. Bartram, Philipp. J. Sci., 68: 34. F. 31. 1939 ≡ *Weissia brasiliensis* (Hampe) Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn, ser. 4, 1: 86. 1879 ≡ *Oreoweisia brasiliensis* Hampe, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn ser. 3, 6: 135. 1874. Type: BRAZIL, Rio de Janeiro, *Glaziou 7052* (lectotype NY not seen designated by Griffin III (1986); syntypes BM not seen, P0029283!, P0709277!)

= *Uleopsis mamillosa* Thér., Na. Bryol. Lichénol. 9: 20. 11. 1936. Type: Ecuador, 1930-10-30, *Benoist, R. 3124* (PC0147124!), syn acc. Zander (1993).

Neotropical Distribution: Brazil

Acknowledgements

We acknowledge the Instituto de Botânica de São Paulo for the support all necessary staff throughout the study. We are grateful to all curators of the cited herbaria who provide the specimens loans of *Dicranella* type specimen for this study. This work was supported with financial support of CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) to the first author.

References

- Allen, B.** 1994. Moss flora of Central America. Part 1. Sphagnaceae-Calymperaceae. Monographs in Systematic Botany from the Missouri Botanical Garden 49: 1–242.
- Allen, B.H.** 2005. Maine Mosses. Sphagnaceae – Timmiaceae. Memoirs of The New York Botanical Garden 93: 1–419.
- Bordin, J., Peralta, D.F. & Yano, O.** 2018. Lectotypification of *Fissidens minutipes* (Müll.Hal.) Broth. And synonymization of *F. termitarum* (Herzog) Pursell. Journal of Bryology 40(2): 188–191.
- Buck, W. R.** 1985. A preliminary list of the mosses of Paraguay. Candollea 40: 201–209.
- Buck, W.R.** 1998. Pleurocarpous mosses of the West Indies. Memoirs of the New York Botanical Garden 82: 1–400.
- Câmara, P.E.A.S., Carvalho-Silva, M., Silva, M.S.D. & Peralta, D.F.** 2014. A catalog of Bryophyta types deposited at the National Museum of Brazil. Acta Botanica Brasilica 28(4): 539–547.

- Cañiza, B.D., Peralta, D.F. & Suárez, G.M.** 2017. New Records and Range Extension of Bryophytes for Paraguay. *Cryptogamie, Bryologie* 38(4):393–410.
- Carmo, D.M., Lima, J.S., Amélio, L.A. & Peralta, D.F.** 2016. Briófitas do Parque Estadual da Serra do Mar, Núcleo de Santa Virgínia, Estado de São Paulo, Brasil. *Hoehnea* 43(2): 265–287.
- Carmo, D.M., Lima, J.S., Silva, M.I., Amélio, L.A. & Peralta, D.F.** 2018. Briófitas da Reserva Particular do Patrimônio Natural da Serra do Caraça, Estado de Minas Gerais, Brasil. *Hoehnea* 45(3): 484–508.
- Carmo, D.M. & Peralta, D.F.** 2016. Survey of bryophytes in Serra da Canastra National Park, Minas Gerais, Brazil. *Acta Botanica Brasilica* 30(2): 254–265.
- Casas, C., Brugués, M. Cros, R.M. & Sérgio, C.** 2006. Handbook of mosses of the Iberian Peninsula and the Balearic Islands. Inst. D'Estud. Catalans, Barcelona.
- Churchill, S.P.** 1994. The mosses of Amazonian Ecuador. *AAU Reports* 35: 1–211.
- Churchill, S.P.** 1998. Catalog of Amazonian mosses. *Journal of the Hattori Botanical Laboratory* 85: 191–238.
- Churchill, S.P. & Linares, C.E.L.** 1995. Prodrómus bryologiae novo-granatensis. Introducción a la flora de musgos de Colombia. Parte 1. Adelotheciaceae a Funariaceae. Instituto de Ciencias Naturales – Museo de Historia Natural. Biblioteca José Jerónimo Triana 12: 1–453.
- Churchill, S.P., Griffin III, D.G. & Muñoz, J.** 2000. A checklist of the mosses of the tropical andean countries. *Ruizia* 17: 1–203.
- Corley, M.F.V., Crundwell, A.C., Düll, R., Hill, M.O. & Smith, A.J.E.** 1981. Mosses of Europe and the Azores; an annotated list of species, with synonyms from the recent literature. *Journal of Bryology* 11: 609–689.
- Costa, D.P., Pôrto, K.C., Luizi-Ponzo, A.P., Ilkiu-Borges, A.L., Bastos, C.J.P., Câmara, P.E.A.S., Peralta, D.F., Bôas-Bastos, S.B.V., Imbassahy, C.A.A., Henriques, D.K., Gomes, H.C.S., Rocha, L.M., Santos, N.D., Siviero, T.S., Vaz-Imbassahy, T.F. & Churchill, S.P.** 2011. Synopsis of the Brazilian moss flora: checklist, distribution and conservation. *Nova Hedwigia* 93(3–4): 277–334.
- Costa, D.P., Peralta, D.F., Carvalho-Silva, M. & Câmara, P.E.A.S.** 2016. Types of the moss names based on Glaziou's collections from Brazil. *Taxon* 65(4): 839–861.
- Crosby, M.R., Magill, R.E., Allen, B. & He, S.** 1999. A checklist of the Mosses. Missouri Botanical Garden. St. Louis: Missouri Botanical Garden. Pp. 1–315.
- Crum, H.A.** 1994. *Dicranella*. In: Sharp, A.J., Crum, H. & Eckel, P. The Moss Flora of Mexico. *Memoirs of The New York Botanical Garden* 69: 1–1113.

- Crum, H.A.** 2007. *Dicranella*. In: Flora of North America. – Editorial Committee (eds.): Flora of North America north of Mexico: pp. 386–393. Oxford University Press, New York.
- Crum, H.A. & Bartram, E.B.** 1958. A survey of the moss flora of Jamaica. Bulletin of the Institute of Jamaica Science Series 8: 1–90.
- Crum, H.A. & Steere, W.C.** 1957. The mosses of Puerto Rico and the Virgin Islands. In: O. von S. Whitelock (ed.), Scientific Survey of Puerto Rico and the Virgin Islands. 2(4). New York, The Academy, pp. 1–207.
- Crum, H.A. & Steere, W.C.** 1958. The mosses of Puerto Rico and the Virgin Islands. In: O. von S. Whitelock (ed.), Scientific Survey of Puerto Rico and the Virgin Islands. 3(4). New York, The Academy, pp. 395–599.
- Delgadillo C.M., Bello, B. & Cárdenas, A.S.** 1995. LATMOSS, A Catalogue of Neotropical Mosses. Monographs in systematic botany from the Missouri botanical Garden 56: 1–191.
- Duarte Bello, P.P.** 1997. Musgos de Cuba. Fontqueria 47: 1–717.
- Ellis, L.T. & Price, M.J.** 2013. Review of the type specimens for Hedwig's species of *Dicranella* (Dicranaceae). Journal of Bryology 35(4): 275–289.
- FNA. (Flora of North America Editorial Committee).** 2007. Bryophytes: Mosses. Fl. N. Amer. 27(1): i–xxi, 1–711.
- Florschütz, P.A.** 1964. The mosses of Suriname. Part 1. Leiden: E.J. Brill. 1–271.
- Frahm, J-P.** 1994. A type catalogue of Campylopodioideae and Paraleucobryoideae (Musci, Dicranaceae). Part I. Fragmenta Floristica et Geobotanica 39(1): 85–101.
- Frahm, J-P.** 1999. A type catalogue of Campylopodioideae and Paraleucobryoideae (Musci, Dicranaceae). Part II. Tropical Bryology 16: 17–102.
- Frey, W. & Stech, M.** 2009. Marchantiophyta, Bryophyta, Anthocerotophyta. Pp.13–263. In: Frey, W. Bryophytes and seedless vascular plants. Syllabus of Plant Families ed. 13: 3: I–IX.
- Gangulee, H.C.** 1971. Mosses E. India 2. Pp. (v–xiii) + xiv + 177–566. Privately published, Calcutta.
- Gradstein, S.R., Churchill, S.P. & Salazar-Allen, N.** 2001. Guide to the bryophytes of Tropical America. Memoirs of The New York Botanical Garden 86: 1–577.
- Gradstein, S.R. & Weber, W.A.** 1982. Bryogeography of the Galapagos Islands. Journal of Hattori Botanical Laboratory 52: 127–152.

- Greene, D.M.** 1986. A Conspectus of the Mosses of Antarctica, South Georgia, the Falkland Islands and Southern South America. British Antarctic Survey, Cambridge, U.S.A. 1 – 314p.
- Griffin III, D. G.** 1986. *Oreoweisia* (Dicranaceae, Musci) in tropical America: na annotated key to species. Cryptogamie: Bryologie, Lichénologie 7: 433–438.
- Hallingbäck, T., Lönnell, N., Weibull, H., Hedenäs, L. & von Knorring, P.** 2006. Nationalnyckeln till Sveriges flora och fauna. Bladmossor: Sköldmossor – blåmoosor. Bryophyta: *Buxbaumia* – *Leucobryum*. – ArtDatabanken, SLU, Uppsala.
- He, S.** 1998. A checklist of the mosses of Chile. Journal of Hattori Botanical Laboratory 85: 103–189.
- Hedwig, J.** 1801. Species muscorum frondosorum. Lipsiae [Leipzig]: sumtu Joannis Ambrosii Barthii.
- Hermann, F.J.** 1976. Recopilación de los musgos de Bolivia. The Bryologist 79(2): 125–171.
- Larraín, J., Suárez, G., Bednarek-Ochyra, H. & Ochyra, R.** 2010. The rediscovery of *Dicranella circinata* (Dicranellaceae, Bryophyta), with comments on other Southern South American species of *Dicranella*. Nova Hedwigia 91(3–4): 361–376.
- Margadant, W.D. & Geissler, P.** 1995. Seventeen proposals concerning nomina conservanda for genera of Musci. Taxon 44(4): 613–624.
- Matteri, C.M.** 2003. Los musgos (Bryophyta) de Argentina. Tropical Bryology 24: 33–100.
- McNeill, J., Barrie, F.R., Buck, W.R., Demoulin, V., Greuter, W., Hawksworth, D.L., Herendeen, P.S., Knapp, S., Marhold, K., Prado, J., Prud'Homme van Reine, W.S., Smith, G.F., Wiersema, J.H. & Turland, N.J.** 2012. International Code of Nomenclature for algae, fungi and plants (Melbourne Code). Regnum Vegetabile 154: 1–208.
- Menzel, M.** 1992. Preliminary checklist of the mosses of Peru (Studies on Peruvian bryophytes IV.). Journal of the Hattori Botanical Laboratory 71: 175–254.
- Merrill, E.D.** 1943. Destruction of the Berlin Herbarium. Science 98(2553): 490–491.
- Mitten, W.** 1869. Musci Austro-Americani. The Journal of the Linnean Society 12: 31.
- Morrone, J.J.** 2014. Cladistic biogeography of the Neotropical region: identifying the main events in the diversification of the terrestrial biota. Cladistics 30: 202–214.
- Newton, M.E.** 1977. A synoptic flora of South Georgian mosses: VI. *Cheilothela*, *Dicranella*, *Distichium*, *Myurella* and *Catagonium*. Brit. Antarct. Surv. Bull. 46: 1–21.

- Ochyra, R.** 1999. Antipodal mosses: XI. Additional new synonyms of *Anisothecium hookeri* (Dicranaceae). *Fragm. Florist. Geobot.* 44: 233–238.
- Ochyra, R., Bednarek-Ochyra, H., Arts, T. & Smith, R.I.L.** 2000. Occurrence of the neotropical moss *Dicranella hilariana* (Mont.) Mitt. in the Antarctic. *Tropical Bryology* 18: 153–160.
- Ochyra, R., Smith, R.L. & Bednarek-Ochyra, H.** 2008. The illustrated Moss Flora of Antarctica. Cambridge University Press. Pp. 1–683.
- Ochyra, R. & M. E. Newton.** 1985 [1986]. The taxonomy and distribution of *Dicranella cardotii* (R. Br. Ter.) Dix., na addition to the moss flora of Antarctica. *Lindbergia* 11: 94–98.
- Pursell, R.A.** 1973. Na censo de los musgos de Venezuela. *The Bryologist* 76: 473–500.
- Robinson, H.** 1986. Notes on the Bryogeography of Venezuela. *The Bryologist* 89(1): 8–12.
- Santos, E.L., Carmo, D.M. & Peralta, D.F.** 2017. Bryophytes of the cloud forest of Pico do Marumbi State Park, Paraná, Brazil. *Checklist* 13(6): 959–986.
- Schimper, W.P.** 1856. *Corollarium Bryologiae Europaeae* 13.
- Sclater, P.L.** 1858. On the general geographical distribution of the members of the class Aves. *Proceedings of the Linnean Society of London, Zoology* 2: 130–145.
- Scott, G.A.M. & Stone, I.G.** 1976. *Mosses of Southern Australia*. Academic Press. Canberra.
- Sharp, A.J., Crum, H. & Eckel, P.** 1994. The Moss Flora of Mexico. *Memoirs of the New York Botanical Garden* 69: 1–1113.
- Smith, A.J.E.** 2004. *The Moss Flora of Britain and England*, 2nd. Edition. Cambridge University. Press, Cambridge.
- Stafleu, F.A. & Cowan, R.S.** 1976. *Taxonomic Literature: A selective guide to botanical publications and collections with dates, commentaries and types*. V1 A – G. 1 – 1176.
- Stafleu, F.A. & Cowan, R.S.** 1979. *Taxonomic Literature: A selective guide to botanical publications and collections with dates, commentaries and types*. V2 H – Le. 1 – 1009.
- Stafleu, F.A. & Cowan, R.S.** 1981. *Taxonomic Literature: A selective guide to botanical publications and collections with dates, commentaries and types*. V3 Lh – O. 1 – 991.
- Stafleu, F.A. & Cowan, R.S.** 1983. *Taxonomic Literature: A selective guide to botanical publications and collections with dates, commentaries and types*. V4 P – Sak. 1 – 1221.

- Stafleu, F.A. & Cowan, R.S.** 1985. Taxonomic Literature: A selective guide to botanical publications and collections with dates, commentaries and types. V5 Sal – Ste. 1 – 1072.
- Stafleu, F.A. & Cowan, R.S.** 1986. Taxonomic Literature: A selective guide to botanical publications and collections with dates, commentaries and types. V6 Sti – Vuy. 1 – 932.
- Stafleu, F.A. & Cowan, R.S.** 1988. Taxonomic Literature: A selective guide to botanical publications and collections with dates, commentaries and types. V7 W – Z. 1 – 708.
- Suárez, G.M., Larrain, J. & Schiavone, M.M.** 2013. Rediscovery and Lectotypification of *Dicranella lorentzii* (Dicranellaceae, Bryophyta). Boletín de la Sociedad Argentina de Botánica 48(1): 53–57.
- Wallace, A.R.** 1876. The Geographical Distribution of Animals. Macmillan, London.
- Wijk, R. v. d., W. D. Margadant & P. A. Florschütz.** 1959. Index Muscorum. 1 (A–C). Regnum Veg. 17. Xxviii + 548 pages.
- Wijk, R. v. d., W. D. Margadant & P. A. Florschütz.** 1962. Index Muscorum. 2 (D–Hypno). Regnum Veg. 26. 535 pages.
- Williams, R.S.** 1913. Dicranaceae. North American Flora. 15: 77–158.
- Yano, O.** 1989. Na additional checklist of Brazilian bryophytes. Journal of the Hattori Botanical Laboratory 66: 371–434.
- Yano, O.** 2011. Catálogo de Musgos Brasileiros: literatura original, basiônimo, localidade tipo e distribuição geográfica. Publicações on line do Instituto de Botânica, Secretaria do Meio Ambiente, São Paulo, SP. Disponível em: www.botanica.sp.gov.br/files/2013/09/virtuais_2musgos.pdf.
- Zander, R.H.** 1993. Genera of the Pottiaceae: mosses of harsh environments. Bull. Buffalo Soc. Nat. Sci. 32. Vi + 378 pages.

Appendix 1. The specimens (*vouchers*) representing the new occurrences in the countries.

Examined materials: *Dicranella angustifolia* Mitt., BRASIL. Rio de Janeiro: Serra do Itatiaia, 22°29'46" S, 44°33'48" W, 01-XI-1987, *Schäfer-Verwimp*, A. 9260 (SP388369); *Dicranella apolensis* R.S. Williams, BRASIL. Mato Grosso: Barra do Garça, 12-VII-1969, *Vital*, D.M. 1552 (SP89947); idem, Mato Grosso do Sul: Corguinho, Cachoeira do Córrego do Garimpo, 22-IV-2011, *Yano*, O. 33025, (SP425118); idem, Minas Gerais: São Roque de Minas, Parque Nacional da Serra da Canastra, 20°18'09" S, 46°31'23" W, 17-VII-2014, *Peralta*, D.F. 15591 (SP452013); idem, Catas Altas, Reserva Particular do Patrimônio Natural do Parque da Serra do Caraça, trilha da Cachoeira Cascatona, 20°05'53" S, 43°29'11" W, 20-VII-2016, *Carmo*, D.M. 1438 (SP477410); idem, Paraíba: João Pessoa, km 115 da BR 101, 7°06'54" S, 34°51'47" W, 30-VIII-1980, *Yano*, O. 2836 (SP191362); idem, Paraná: Ipiranga, trecho de rodovia da BR 373, 25°01'26" S, 50°35'03" W, 15-III-1976, *Vital*, D.M. 5810 (SP134925); idem, Pernambuco: Cabo, Estação Gurjaú, 14-I-1984, *Yano*, O. 9165 (SP191787); idem, Rio de Janeiro: Parati, Bairro do Curisco, 23°13'04" S, 44°42'47" W, 23-X-1988, *Vital*, D.M. s/n (SP374678); idem, São Paulo: Ubatuba, Parque Estadual da Ilha Anchieta (PEIA), 23°26'02" S, 45°04'16" W, 27-II-2003, *Peralta*, D.F. 1501 (SP362428); *Dicranella bicolor* (Müll. Hal.) Mitt., ECUADOR. Província Morona-Santiago, Along Gualaceo-Gral. L. Plaza Gutiérrez ("Limón") Hwy, 30.4 km SE of bridge at entrance to Maylas Reserva Ecológica Natural, 28.2 km SE of shrine at the crest of the mountain, steep cloud forest on roadbank, ca. 2°59'S, 78°25'W, ca. 2230 m, 22-V-2001, *Buck W.R.* 39288 (QCA!); *Dicranella boliviana* Herzog. ECUADOR. Província Zamora-Chinchipe, Valle del Río San Francisco, Reserva Biológica "San Francisco", bosque montano y páramo, ca. 03°58'18" S, 79°04'44" W, ca. 1900 – 3000 m, V-2001, *Holz I. 1* (QCA!); idem, 79°04'44" W, *Holz I.* 352 (QCA!); idem, *Holz I.* 457 (QCA!); *Dicranella ditissima* (Hampe) Mitt. ECUADOR. Província Zamora-Chinchipe, ca. 11 km W of Zamora, ca. 53 km E of Loja, ca. 04°03'S, 78°59'W, ca. 1512 m, steep, cleared roadbank near bridge at waterfall, 26-V-2001, *Buck W.R.* 39415 (QCA!); *Dicranella harrisii* (Müll. Hal.) Broth. BRASIL. Minas Gerais: Itamonte, Parque Nacional do Itatiaia, 22°17'02" S, 44°52'12" W, 04-VII-1991, *Vital*, D.M. 19548, (SP353378); idem, Paraná: Piraquara, 25°26'30" S, 49°03'48" W, 08-VI-1989, *Hatschbach*, C.M. 53121 (SP231941); idem, Rio de Janeiro: Itatiaia, Parque Nacional do Itatiaia, 22°29'46" S, 44°33'48" W, 04-VII-1991, *Vital*, D.M. s/n (SP 387405); idem, São Paulo: Campos do Jordão, área urbana da cidade de Campos do Jordão, 22°43'07" N, 45°33'59" W, 1-X-2017, *Peralta*, D.F. 21669 (SP 483044); *Dicranella lindigiana* (Hampe) Mitt. BRASIL. Amazonas: Manaus, Reserva da Campina, 3°06'07" S,

60°01'30" W, 08-VII-1974, *Griffin III, D. 04* (SP125224); idem, Bahia: Ilhéus, 5 km S de Ilhéus na estrada para Olivença, 14°47'20" S, 39°02'58" W, 14-VII-1991, *Vital, D.M. 20100* (SP353836); idem, Distrito Federal: Brasilândia, Chapada Imperial, área particular, 15°00'00" S, 46°38'10" W, 02-VII-2016, *Peralta, D.F. 18752* (SP464138); idem, Espírito Santo: Fundão, ao longo da rodovia BR – 101, 19°55'57" S, 40°24'24" W, 15-IV-1980, *Vital, D.M. 8889* (SP 148504); idem, Goiás: Hidrolândia, ao longo da rodovia BR – 153, 16°57'44" S, 49°13'41" W, 10-IV-1976, *Vital, D.M. 6138* (SP135136); idem, Mato Grosso: Sinop, Parque Florestal de Sinop, Rua das Avencas, Jardim Primaveras, 11°50'03" S, 55°30'01" W, 05-XII-2008, *Borges, F.R. 367* (SP451280); idem, Mato Grosso do Sul: Corguinho, Cachoeira do Córrego do Garimpo, 22-IV-2011, *Yano, O. 33022* (SP 425115); idem, Minas Gerais: São Roque de Minas, Parque Nacional da Serra da Canastra, 20°16'63" S, 46°55'94" W, 11-II-2012, *Carmo, D.M. 348* (SP436556); idem, Paraná: Ipiranga, ao longo da rodovia BR – 373, 25°01'26" S, 50°35'03" W, 15-III-1976, *Vital, D.M. 5813* (SP134928); idem, Rio Grande do Sul: São Lourenço do Sul, ca. 5km N da entrada para São Lourenço do Sul, 31°10'48" S, 52°00'36", 09-VII-1980, *Vital, D.M. 8960* (SP148951); idem, Roraima: Amajari, Serra do Tepequém, trilha para a Cachoeira do Paiva, 3°47'15" N, 61°46'06" W, 07-IX-2017, *Carmo, D.M. 1503* (SP482862); idem, Santa Catarina: Porto Belo, 27°09'28" S, 48°33'11" W, 17-IV-1980, *Yano, O. 2474* (SP 148569).

4.4. Phylogenetic analyses of *Dicranella* (Müll. Hal.) Schimp. (Dicranellaceae, Bryophyta) in Brazil using the plastid gene *rps4*¹

Dimas Marchi do Carmo^{2*} & Denilson Fernandes Peralta²

1. Parte da tese de Doutorado em Biodiversidade Vegetal e Meio Ambiente do primeiro autor pelo Programa de Pós-Graduação do Instituto de Botânica de São Paulo.

2. Instituto de Botânica, Av. Miguel Stéfano, 3687 – CEP 04301902 – São Paulo, SP., Brasil
*dimas.botanica@gmail.com

Abstract: The Dicranellaceae family was created after an elevation of the hierarchical subfamily level Dicranelloideae. Currently, there are about 230 species worldwide distributed into five genera in the Dicranellaceae family: *Bryotestua* Thér. & P.de La Varde, *Campylopodium* (Müll. Hal.) Besch., *Dicranella* (Müll. Hal.) Schimp., *Leptotrichella* (Müll. Hal.) Lindb. And *Microcampylopus* (Mull. Hal.) Fleisch. The genus *Dicranella* constitutes approximately 70% of the family, moreover, the identification of *Dicranella* species is often dependent on sporophyte reproductive structure characteristics, which are not always present. In Brazil, only three species are currently considered: *Dicranella guilleminiana* (Mont.) Mitt., *Dicranella hilariana* (Mont.) Mitt and *Dicranella vaginata* (Hook.) Cardot. To date, there has been no taxonomic revision or specific delimitation for the identification of *Dicranella* species in Brazil. Regarding the molecular studies, there are few data of *Dicranella* included in the phylogenetic studies, nowadays these species constitute an ill-defined circumscription and a paraphyletic group. With the aid of specimens analyses, loans of material types and plastidial marker *rps4* gene sequences, focusing on the Brazilian species, we aim to provide new insights and information about this overlooked group. Altogether, 634 exsicates from 14 national and international herbaria were analyzed, of these, only 15 samples had success in all laboratorial process. As result, we found two different cladograms well supported separating one group of the neotropical species and another with the genus type species *Dicranella heteromalla*, that is, perhaps the tropical and Brazilian species are other group different from *Dicranella*, for support this statement, further studies about phylogenetic of this group are need.

Keywords: Dicranidae, Dicranelloideae, Dicranales, haplolepidous species, mosses

Introduction

The Dicranellaceae family was proposed by Stech & Frey (2008) based on molecular and morphological traits of its species. These authors elevated the subfamily Dicranelloideae and defined this proposition supported in several characteristics, for instance the presence of a stem cross-section with a central band of stereids, leaves appressed or erect-spreading, often flexuose or falcate-secund, narrowly lanceolate and subulate, alar cells undifferentiated; costa present, single, simple, narrow; capsulae smooth, plicate or striate; operculum conic to long-rostrate, peristome dicranoid, calyptra cucullate and spores generally papillose (Stech & Frey 2008; Frey & Stech 2009). However, some of these characteristics are also present in other moss taxa such as Bryaceae, Pottiaceae, Ditrichaceae and Rhabdoweisiaceae families (Allen 1994; Churchill & Linares 1995; Duarte Bello 1997; Crum 2007; Ochyra *et al.* 2008; Frey & Stech 2009), which makes the identification process difficult and often times confusing.

Currently, there are about 230 species worldwide distributed into five genera in the Dicranellaceae family: *Bryotestua* Thér. & P.de La Varde (two species), *Campylopodium* (Müll. Hal.) Besch. (four species), *Dicranella* (Müll. Hal.) Schimp. (158 species), *Leptotrichella* (Müll. Hal.) Lindb. (60 species), and *Microcampylopus* (Müll. Hal.) Fleisch. (four species). Thus, the genus *Dicranella* constitutes approximately 70% of the family (Frey & Stech 2009). Additionally, the identification of *Dicranella* genus species is often dependent on sporophyte reproductive structure characteristics, which are not always present (Allen 1994; Churchill & Linares 1995; Ochyra *et al.* 2000; 2008, Frey & Stech 2009). In Brazil, only three species are currently considered: *Dicranella guillemianiana* (Mont.) Mitt., *Dicranella hilariana* (Mont.) Mitt and *Dicranella vaginata* (Hook.) Cardot., these species are found in nearly every Brazilian state, with the exception of Alagoas, Piauí, Rio Grande do Norte, Sergipe and Distrito Federal (Costa *et al.* 2011).

The publications about the occurrence of the genus *Dicranella* in Brazil are scarce and limited to studies providing floristic surveys or checklists, where the presence of some species is registered locally (Bastos & Yano 1993; Visnadi & Vital 2000; Costa *et al.* 2011; Carmo *et al.* 2015; Oliveira & Peralta 2015; Pereira & Câmara 2015; Ristow *et al.* 2015; Carmo & Peralta 2016; Carmo *et al.* 2016; Santos *et al.* 2017, Carmo *et al.* 2018). To date, there has been no taxonomic revision or specific delimitation of the characteristics used for the identification of *Dicranella* species in Brazil. Furthermore, there are few herbaria collections of these species and a limited number of publications involving this genus, resulting in a confusing and difficult delimitation of their species, reinforcing the need for

more works regarding this group (Allen 1994; Churchill & Linares 1995; Crum 2007; Ochyra *et al.* 2008; Frey & Stech 2009; Stech *et al.* 2012).

The *Anisothecium*, *Leptotrichella*, *Metzleria* and *Microdus* genus are considered synonyms of *Dicranella* (Crum 1994, Gradstein *et al.* 2001, Crum 2007, Ochyra *et al.* 2008) and according to Stech (1999), Stech & Frey (2008), Frey & Stech (2009) and Stech *et al.* (2012) the representatives of Dicranellaceae family need further studies because, until the moment, there are few molecular data included in the phylogenetic analysis. Molecular studies have shown that some *Dicranella* species do not have a well-defined circumscription or distinct diagnostic characteristics and that this group present a paraphyletic condition, appearing clearly separated from Dicranaceae *s.str.* or other haplolepidaceous groups (Stech 1999; La Farge *et al.* 2000; 2002; Hedderson *et al.* 2004; Tsubota *et al.* 2004; Frey & Stech 2009; Cox *et al.* 2010; Stech *et al.* 2012).

Regarding *Dicranella* tropical species, there is not a representative or sample extant in the worldwide dataset bank GenBank, which is a problem for the taxonomic understanding of this group since that neotropical species represent approximately 62% of worldwide *Dicranella* (Gradstein *et al.* 2001). The number of sequences present is few and is associated only with species of temperate regions of Europe and North America. Therefore, the purpose of this work is providing an initial comparative phylogenetic study of the *Dicranella* species, focusing on the Brazilian species to verify how they are related within Dicranellaceae through the use of plastidial marker *rps4* gene sequences. Additionally, we aim to provide new insights and information about this overlooked group. This work is part of the taxonomic revision of the Neotropical species of *Dicranella* and studies directed to the Dicranales order, contributing to the 2020 Flora of Brazil project.

Materials and Methods

Taxon and locus sampling - Collections were performed in poorly explored areas, where few records of Brazilian *Dicranella* have been reported. According to the literature, *Dicranella* species are typically found at high altitudes and in rocky fields (Crum 1994, Gradstein *et al.* 2001, Crum 2007). Therefore, Campos do Jordão – SP, Pico dos Marins – SP, Serra da Bocaina – SP, Serra da Canastra – MG, Serra da Caraça – MG, Serra do Itatiaia – RJ and Serra de Tepequém – RR) were the areas searched for new samples. All sample collected was deposited in the “Maria Eneyda Pacheco Kauffman Fidalgo” herbaria (SP), in the São

Paulo Botanic Institute. Permanent slides were prepared using Kayser glycerine gelatin and analyzed using a stereomicroscope and an optical microscope.

The classification system adopted for Dicranellaceae family was based from Stech & Frey (2008) and Frey & Stech (2009). The *Dicranella* species identification was made with the aid based in Allen (1994), Crum (1994), Ochyra *et al.* (2000), Gradstein *et al.* (2001), Crum (2007), Ochyra *et al.* (2008) and Larraín *et al.* (2010). There were some taxa which were synonymized using the reference and the combinations proposed by Gao (1994), Ochyra *et al.* (2003) and Staples *et al.* (2004).

The taxon sampling for the molecular and phylogenetic analyses was obtained from herbaria SP, however before this decision, samples from ALCB, BM, G, JE, ICN, MG, MICH, NY, PC, QCA, R, RB, S, SJRP, SP, UB and UFP were consulted to verify the quality of this samples and into attempt for its identification. The part of the material selected was the gametophyte, in preference which one do not presents soil, sandy, or any possible contaminants in its composition. Besides this, we preferred choose the recent samples, at least in thirty years ago for the DNA extraction, which we believe have a better probability to have a conservative DNA for amplification. The sequence chosen to compare these species was the plastidial gene encoding the ribosomal protein 4 (*rps4*), which the forward primer (*rps5'*) starts with the codon ATG and the reverse primer (*trnS*) is situated in *trnS* gene, encoding an amino acid transporter (Souza-Chies *et al.* 1997, Hedderson *et al.* 2004, Shaw *et al.* 2005, Cox *et al.* 2010, Stech & Quandt 2010). The information about the taxon used, GenBank accession numbers and the specimen voucher are provided in Table 1.

DNA extraction, PCR, sequencing and phylogenetic analyses - For obtaining the sequences of the taxa that do not are found in the GenBank dataset (<http://www.ncbi.nlm.nih.gov/genbank>) yet, the total genomic DNA was extracted using the mini-CTAB (Doyle & Doyle 1987, 1990) method with protocols modified and standardized according to Câmara (2006). After the extraction, the DNA was amplified through Polymerase Chain Reaction (PCR) with 35 cycles of thirty seconds at 94°C (denaturing), one minute between 50°C and 54°C (annealing) and two minutes at 72°C (extension), preceded by na initial melting step at 94°C for two minutes and followed by a final extension period of seven minutes at 72°C (Hedderson *et al.* 2004, Santos & Stech 2016).

The authenticity and the check of PCR products was performed after run in agarose gel electrophoresis for approximately thirty minutes, once amplified, the PCR fragments were sent to Macrogen (Seoul, Korea) for the purification and the assemblment bidirectional of the sequences. The sequences obtained were compared in the GenBank using the BLAST

program (Altschul *et al.* 1990). Thus, the available searches to compare the sequences obtained are represented by the taxa *Dicranella cerviculata*, *D. flaccidula*, *D. heteromalla* and *D. palustris*. For the outgroup, the selected taxa used was *Fissidens bryoides* Hedw., due to mainly in many phylogenetic works this group presented a sister clade for *Dicranella* species within Dicranales order (La farge *et al.* 2002, 2000, Hedderson *et al.* 2004, Stech & Frey 2008) (Table 1).

The alignment and edition of the sequence were made with the aid of computers programs and softwares such as Clustal X (Higgins & Sharp 1988), PhyDE (Phylogenetic Data Editor) version 0.9971 (Müller *et al.* 2010) and BioEdit (BioEdit Sequence and Alignment Editor) version 7.1.3.0. (Hall 1999). The phylogenetic analyses of maximum parsimony (MP) were carried out in the software PAUP* version 4.0b10 (Câmara & Buck 2012) with heuristic searches implemented using random sequence addition with 1000 replicates and 10 random addition cycles per bootstrap pseudoreplicate with the same options in effect. Bootstrap percentage values (BPV) ≥ 70 were considered as good support (Hillis & Bull 1993).

All the molecular and laboratory analyses were performed in cooperation with the researchers Paulo E.A.S. Câmara and Micheline Carvalho-Silva of Plants Molecular Biology Laboratory of Brasília University (UnB), who are references of mosses phylogeny and taxonomy in Brazil.

Results and Discussion

In total, 505 exsiccates from 14 national and international herbariums were analyzed. Of these, 72 samples were chosen for laboratorial works and only 15 samples had success in all laboratorial process, represented by DNA extraction, amplification and sequencing for our phylogenetic analyses. Our results were a consequence of some difficulties found during this work, such as the scarce samples deposited in herbaria, difficulty to find this species in field, the confusing identification based only in sporophyte traits (Allen 1994, Crum 1994, Ochyra *et al.* 2000, Crum 2007, Ochyra *et al.* 2008, Larraín *et al.* 2010) and the lack of suitable protocol for laboratory analyses for the neotropical *Dicranella* species.

This is the first phylogenetic study performed for the Dicranellaceae and with a approach to *Dicranella* genus, since the previously studies which used these species included few taxa and does not considered neotropical *Dicranella* species (La Farge *et al.* 2000, 2002; Hedderson *et al.* 2004, Stech & Frey 2008, Frey & Stech 2009, Cox *et al.* 2010, Stech *et al.* 2012, Santos & Stech 2016). Thus, this study increase the knowledge about the evolutive

relation of this group between other haplolepidous mosses, beyond to contribute to new molecular data for the Dicranellaceae.

According to our findings in the cladogram, there are two main clades formed in this phylogeny using *rps4* gene sequences presenting a good Bootstrap support ($BPV \geq 70\%$) (Hillis & Bull 1993). One of these is constituted by *Dicranella* species from temperate and colder regions, moreover is the clade where the typical species for the description of *Dicranella* genus, represented by *Dicranella heteromalla* (Hedw.) Schimp. is inserted (Margadant & Geissler 1995). Regarding this result, we decided call this clade as “*Dicranella* clade” or real “*Dicranella*”. Whereas the other major clade is compound by *Dicranella* species occurring in Brazil and other genus related within the family Dicranellaceae such as *Campylopodium*, *Leptotrichella* and *Microcampylopus* (Frey & Stech 2009) (Figure 1).

The clade formed by *Dicranella palustris* (Dicks.) Crundw. Ex E.F. Warb. species is separated from the other *Dicranella* clades and formed an independent group with a great bootstrap ($BPV=100\%$) support in the parsimony analyses (Figure 1). Presumably this result can be regarded as a consequence of these species basionym corresponding to a *Bryum palustre* Dicks. species, a lineage completely distinct to Dicranellaceae family and their representatives (Cox & Hedderson 1999, Stech & Frey 2008, Cox *et al.* 2010). Recent phylogenies works have been shown that the lineage of *Bryum* species corresponds different orders within mosses group supported by even morphological as molecular features (Cole *et al.* 2019, Liu *et al.* 2019) Therefore, our results are according with these studies and corroborates these findings.

In spite of this study include new taxa for molecular data, there were some other samples which could not be identify and are representatives preceded by the code “DL”. These species are separated from the *Dicranella heteromalla* clade and are inserted in the clade with neotropical *Dicranella* species and the other related genus (Figure 1). For identifying these species, further taxonomic studies about this group are need.

Acknowledgements

We would like to acknowledge Dr. Paulo Eduardo Aguiar Saraiva Câmara and Dr. Micheline Carvalho-Silva for supporting the molecular analyses and providing access to the Plants Molecular Biology Laboratory of Universidade de Brasília (UnB). We also thank Dr. Michael Stech for the advice and explanations about the phylogeny of *Dicranella*. The first author thanks the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for a doctoral grant.

References

- Allen, B.** 1994. Moss flora of Central America. Part 1. Sphagnaceae-Calymperaceae. Monographs in Systematic Botany from the Missouri Botanical Garden 49: 1–242.
- Altschul, S.F., Gish, W., Miller, W., Myers, E.W. & Lipman, D.J.** 1990. Basic Local Alignment Search Tool. *Journal of Molecular Biology* 215(3): 403–410.
- Bastos, C.J.P. & Yano, O.** 1993. Musgos da zona urbana de Salvador, Bahia, Brasil. *Hoehnea* 20: 23–33.
- Carmo, D.M. & Peralta, D.F.** 2016. Survey of bryophytes in Serra da Canastra National Park, Minas Gerais, Brazil. *Acta Botanica Brasilica* 30(2): 254–265.
- Carmo, D.M., Gasparino, E.C. & Peralta, D.F.** 2015. Análise comparativa de briófitas urbanas da região Noroeste do Estado de São Paulo com demais trabalhos em diferentes fitofisionomias brasileiras. 2015. *Pesquisas. Botânica* 67: 255–272.
- Carmo, D.M., Lima, J.S., Amélio, L.A. & Peralta, D.F.** 2016. Briófitas do Parque Estadual da Serra do Mar, Núcleo de Santa Virgínia, Estado de São Paulo, Brasil. *Hoehnea* 43(2): 265–287.
- Carmo, D.M., Lima, J.S., Silva, M.I., Amélio, L.A. & Peralta, D.F.** 2018. Briófitas da Reserva Particular do Patrimônio Natural da Serra do Caraça, Estado de Minas Gerais, Brasil. *Hoehnea* 45(3): 484–508.
- Câmara, P.E.A.S.** 2006. Molecular contribution on the systematic placement of the moss genus *Paranapiacabaea*. *Boletim do Instituto de Botânica (São Paulo)* 18: 159-163.
- Câmara, P.E.A.S. & Buck, W.R.** 2012. A re-interpretation of the Fabroniaceae, a phylogenetic perspective. *The Bryologist* 115(1): 109–117.
- Churchill, S.P. & Linares, E.L.** 1995. *Prodromus bryologiae Novo-Granatensis: introduction a la flora de musgos de Colombia. Parte 1, Adelotheciaceae a Funariaceae.* – Biblioteca José Jerónimo Triana 12(1): 1–453.
- Cole, T.C.H., Hilger, H.H. & Goffinet, B.** 2019. Bryophyte Phylogeny Poster.
- Costa, D.P., Pôrto, K.C., Luizi-Ponzo, A.P., Ilkiu-Borges, A.L., Bastos, C.J.P., Câmara, P.E.A.S., Peralta, D.F., Bôas-Bastos, S.B.V., Imbassahy, C.A.A., Henriques, D.K., Gomes, H.C.S., Rocha, L.M., Santos, N.D., Siviero, T.S., Vaz-Imbassahy, T.F. & Churchill, S.P.** 2011. Synopsis of the Brazilian moss flora: checklist, distribution and conservation. *Nova Hedwigia* 93(3–4): 277–334.
- Cox, C.J. & Hedderson, T.A.J.** 1999. Phylogenetic relationships among the ciliate arthrodontous mosses: evidence from chloroplast and nuclear DNA sequences. *Plant Systematics and Evolution* 215: 139–139.

- Cox, C.J., Goffinet, B., Wickett, N.J., Boles, S.B. & Shaw, A.J.** 2010. Moss diversity: a molecular phylogenetic analysis of genera. *Phytotaxa* 9: 175–195.
- Crum, H.** 1994. *Dicranella*. In: Sharp AJ, Crum H, Eckel P. The Moss Flora of Mexico. Memoirs of The New York Botanical Garden 69: 1–1113.
- Crum, H.** 2007. *Dicranella*. In: Flora of North America. – Editorial Committee (eds.): Flora of North America north of Mexico: pp. 386–393. Oxford University Press, New York.
- Doyle, J.J. & Doyle, J.L.** 1987. A rapid DNA isolation procedure for small amount of fresh leaf tissue. *Phytochemical Bulletin* 19: 11–15.
- Doyle, J.J. & Doyle, J.L.** 1990. Isolation of plant DNA from fresh tissue. *Focus* 12: 13–15.
- Duarte Bello, P.P.** 1997. Musgos de Cuba. *Fontqueria* 47: 1–717.
- Frey, W. & Stech, M.** 2009. Marchantiophyta, Bryophyta and Anthocerotophyta. In: Frey W, Stech M, Fischer E. Syllabus of plant families. Bryophytes and seedless Vascular Plants, v.13, pp. 1–419.
- Gao, C.** 1994. Flora Bryophytorum Sinicorum. 1. Sphagnales, Andreaeales, Archidiales, Dicranales. 368 pp. Science Press, Beijing.
- Gradstein, S.R., Churchill, S.P. & Salazar-Allen, N.** 2001. Guide to the Bryophytes of Tropical America. Memoirs of The New York Botanical Garden 86: 1–577.
- Hall, T.A.** 1999. BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series* 45: 95–98.
- Hedderson, T.A., Murray, D.J., Cox, C.J. & Nowell, T.L.** 2004. Phylogenetic relationships of haplolepideous mosses (Dicranidae) inferred from *rps4* gene sequences. *Systematic Botany* 29(1): 29–41.
- Higgins, D.G. & Sharp, P.M.** 1988. Clustal: A package for performing multiple sequence alignment on a microcomputer. *Gene* 73: 237–244. [https://doi.org/10.1016/0378-1119\(88\)90330-7](https://doi.org/10.1016/0378-1119(88)90330-7)
- Hillis, D.M. & Bull, J.J.** 1993. An empirical test of bootstrapping as a method for assessing confidence in phylogenetic analyses. *Systematic Biology* 42: 182–192.
- La Farge, C., Mishler, B.D., Wheeler, J.A., Wall, D.P., Johannes, K., Schaffer, S. & Shaw, A.J.** 2000. Phylogenetic relationships within the haplolepideous mosses. *The Bryologist* 103: 257–276.
- La Farge, C., Shaw, A.J. & Vitt, D.H.** 2002. The circumscription of the Dicranaceae (Bryopsida) based on the chloroplast regions *trnL-trnF* and *rps4*. *Systematic Botany* 27: 435–452.

- Larraín, J., Suárez, G., Bednarek-Ochyra, H. & Ochyra, R.** 2010. The rediscovery of *Dicranella circinata* (Dicranellaceae, Bryophyta), with comments on other Southern South American species of *Dicranella*. *Nova Hedwigia* 91(3–4): 361–376.
- Liu, Y., Johnson, M.G., Cox, C.J., Medina, R., Devos, N., Vanderpoorten, A., Hedenäs, L., Bell, N.E., Shevock, J.R., Agüero, B., Quandt, D., Wickett, N.J., Shaw, A.J. & Goffinet, B.** 2019. Resolution of the ordinal phylogeny of mosses using targeted exons from organellar and nuclear genomes. *Nature Communications*
- Margadant, W.D. & Geissler, P.** 1995. Seventeen proposals concerning nomina conservanda for genera of Musci. *Taxon* 44(4): 613–624.
- Müller, J., Müller, K., Neinhuis, C. & Quandt, D.** 2010. PhyDE v0.9971: Phylogenetic Data Editor. – <http://www.phyde.de>.
- Ochyra, R., Bednarek-Ochyra, H., Arts, T. & Smith, R.I.L.** 2000. Occurrence of the neotropical moss *Dicranella hilariana* (Mont.) Mitt. In the Antarctic. *Tropical Bryology* 18: 153–160.
- Ochyra, R., Zarnowiec, J. & Bednarek-Ochyra, H.** 2003. Census Catalogue of Polish Mosses. *In: Biodiversity of Poland 3*, Z. Mirek (ed.), p. 372. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.
- Ochyra, R., Smith, R.I.L. & Bednarek-Ochyra, H.** 2008. *The Illustrated moss flora of Antarctica*. – Cambridge Univ. Press, Cambridge.
- Oliveira, H.C. & Peralta, D.F.** 2015. Adições à brioflora de musgos acrocárpicos (Bryophyta) do Estado do Ceará, Brasil. *Pesquisas. Botânica* 67: 37–50.
- Pereira, C.G. & Câmara, P.E.A.S.** 2015. Brioflora da Ilha de Fernando de Noronha, Brasil. *Pesquisas. Botânica* 67: 149–179.
- Ristow, R., Schäfer-Verwimp, A. & Peralta, D.F.** 2015. New records of bryophytes for the state of Paraná, Brazil. *Pesquisas. Botânica* 67: 65–80.
- Santos, M.B. & Stech, M.** 2016. Tackling relationships and species circumscriptions of *Octoblepharum*, an enigmatic genus of haplolepidous mosses (Dicranidae, Bryophyta). *Systematics and Biodiversity* 15(1): 16–24.
- Santos, E.L., Carmo, D.M. & Peralta, D.F.** 2017. Bryophytes of the cloud forest of Pico do Marumbi State Park, Paraná, Brazil. *Checklist* 13(6): 959–986.
- Shaw, A.J., Cox, C.J. & Goffinet, B.** 2005. Global Patterns of Moss Diversity: Taxonomic and Molecular Inferences. *Taxon* 54(2): 337–352.
- Souza-Chies, T.T., Bittar, G., Nadot, S., Carter, L., Besin, E. & Lejeune, B.** 1997. Phylogenetic analysis of Iridaceae with parsimony and distance methods using the plastid gene *rps4*. *Plant Systematics and Evolution* 204: 109–123.

- Staples, G.W., Imada, C.T., Hoe, W.J. & Smith, C.W.** 2004. A revised checklist of Hawaiian mosses. *Tropical bryology* 25: 35–70.
- Stech, M.** 1999. A reclassification of the Dicranaceae (Bryopsida) based on non-coding cpDNA data. *Journal of the Hattori Botanical Laboratory*. 86: 137–159.
- Stech, M. & Frey, W.** 2008. A morpho-molecular classification of the mosses (Bryophyta). *Nova Hedwigia*. 86:1–2.
- Stech, M. & Quandt, D.** 2010. 20000 species and five key markers: the status of molecular bryophyte phylogenetics. *Phytotaxa* 9: 196–228.
- Stech, M., McDaniel, S.F., Hernández-Maqueda, R., Ros, R.M., Werner, O., Muñoz, J. & Quandt, D.** 2012. Phylogeny of Haplolepideous mosses – Challenges and perspectives. *Journal of Bryology* 34 (3): 160–173.
- Tsubota, H., De Luna, E., González, D., Ignatov, M.S. & Deguchi H.** 2004. Molecular phylogenetics and ordinal relationships based on analyses of a large-scale data set of 600 *rbcL* sequence of mosses. *Hikobia* 14: 149–170.
- Visnadi, S.R. & Vital, D.M.** 2000. Lista das briófitas ocorrentes no Parque Estadual das Fontes do Ipiranga – PEFI. *Hoehnea* 27(3): 279–294.

Table 1. A list of taxa used for the analyses with the taxon, accession number of GenBank and voucher indicated. The accession number in bold represent the sequences obtained in this study but that were not included in the dataset of GenBank.

Taxon	GenBank accession number	Voucher
Dicranellaceae		
<i>Campylopodium euphorocladum</i> (Müll. Hal.) Besch.	AY908095.1	
<i>Campylopodium medium</i> (Duby) Giese & J.-P. Frahm	KX580497.1	Eggers CEL2/3
<i>Campylopodium</i> sp.	AB842426	Price 1064
<i>Dicranella apolensis</i> Williams	DL33	Carmo et al. 1438
<i>Dicranella cerviculata</i> (Hedw.) Schimp.	KX580505.1	Stech B970824.1
<i>Dicranella fusca</i> Broth.	DL47	Peralta et al. 17743
<i>Dicranella harrisii</i> (Müll. Hal.) Broth.	DL29	Peralta et al. 21669
<i>Dicranella heteromalla</i> (Hedw.) Schimp.	AF231272.1	La Farge 99
<i>Dicranella heteromalla</i> (Hedw.) Schimp.	AY908099.1	Goffinet 8162
<i>Dicranella heteromalla</i> (Hedw.) Schimp.	KX580506.1	Stech B960905.1
<i>Dicranella juliformis</i> Broth.	DL46	Peralta et al. 21571
<i>Dicranella pabstiana</i> (Müll. Hal.) Mitt.	DL34	Peralta & Brito 22630
<i>Dicranella palustris</i> (Dicks.) Crundw. Ex E.F. Warb.	AJ553995.1	Hedderson 8818
<i>Dicranella palustris</i> (Dicks.) Crundw. Ex E.F. Warb.	KX580510.1	Frahm s.n.
<i>Dicranella riograndensis</i> Broth.	DL28	Peralta et al. 17956
<i>Dicranella riograndensis</i> Broth.	DL35	Peralta et al. 16499
<i>Dicranella</i> sp.	AB842342.1	Cox 1031
<i>Dicranella</i> sp.	DL10	Peralta 9740
<i>Dicranella</i> sp.	DL11	Yano 31821
<i>Dicranella</i> sp.	DL12	Peralta 5909
<i>Dicranella</i> sp.	DL7	Yano 30314
<i>Dicranella</i> sp.	DL8	Peralta 8764
<i>Dicranella</i> sp.	DL9	Peralta 5600
<i>Dicranella subsulcata</i> (Hampe) Hampe	DL32	Canestraro & Lozano 1150
<i>Leptotrichella flaccidula</i> (Mitt.) Ochyra	KX580520.1	Schultze-Motel 3209
<i>Microcampylopus leucogaster</i> (Müll. Hal.) B.H. Allen	AY908136.1	Lyon 137 A
<i>Microcampylopus khasianus</i> (Griffiths) Giese & J.-P. Frahm	KX580527.1	Schäfer-Verwimp & Verwimp 20891
Fissidentaceae		
<i>Fissidens bryoides</i> Hedw.	LC272016.1	Kamiyama 9938

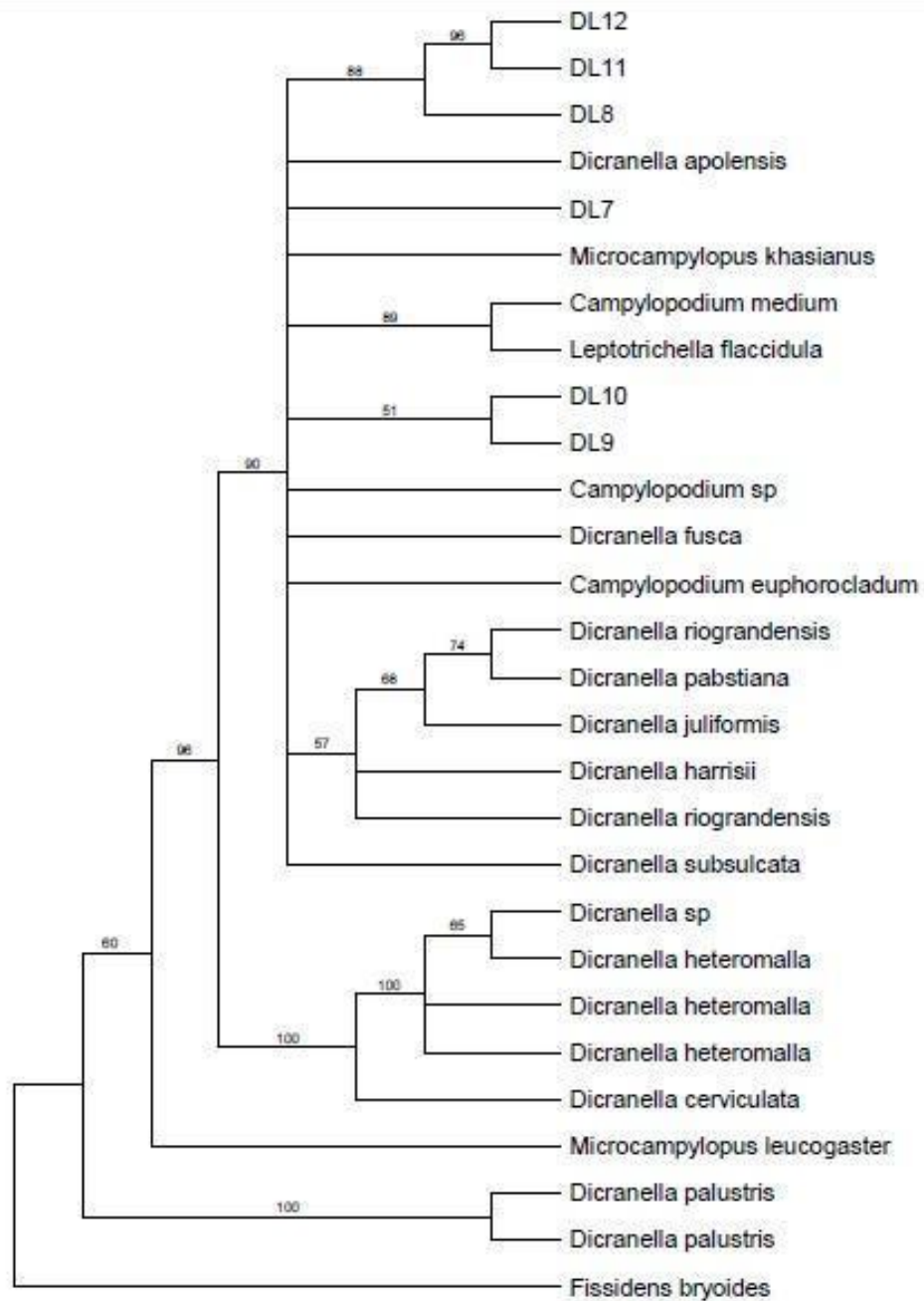


Figure 1. Parsimonious tree from unweighted analyses of the *rps4* sequences for Dicranellaceae taxons. Number indicating Bootstrap $\geq 50\%$ for individual nodes.

4.5. Resultados Gerais

No total, entre os 57 nomes citados e encontrados ocorrentes na região Neotropical, nós conseguimos analisar, avaliar e revisar 50 materiais tipo desses nomes, representando aproximadamente um total de 88% das espécies de *Dicranella s.l.* estudadas. Dessa forma, conseguimos obter informações que eram desconhecidas anteriormente para as espécies do gênero. Essas informações foram agrupadas e comparadas em uma planilha, dessa forma nós conseguimos avaliar quais seriam as possíveis características existentes e que seriam interessantes utilizar para a separação e identificação das espécies. Além disso, no total foram analisadas 634 amostras (ou espécimes) de *Dicranella s.l.* avaliadas e revisadas provenientes de herbários nacionais e internacionais representados pelas siglas dos herbários ALCB, BM, G, JE, ICN, MG, MICH, NY, PC, QCA, R, RB, S, SJRP, SP, UB e UFP. Todas essas amostras tiveram lâminas permanentes confeccionadas, contendo em sua composição estruturas tanto do gametófito, quanto do esporófito (isso quando essa estrutura se encontra presente). Também, nas lâminas permanentes, análises detalhadas de secções transversais dos filídios, caulídios, cápsula e dentes do peristômio, quando presentes na amostra, eram realizadas.

Ainda em relação aos estudos morfológicos e de delimitação das espécies de *Dicranella*, após considerar e analisar todas as características para a discriminação das espécies, um dendograma de agrupamento (*clustering*) foi gerado com todas as espécies ocorrentes no neotrópico que conseguimos verificar (Figura 1). Para a realização desse dendograma, 16 testes de modelo foram realizados, contudo é importante lembrar que as relações em um dendograma utilizando o índice de similaridade de Jaccard, pelo método de agrupamento pareado UPGMA e com índices de correlação cofenético $\geq 0,7$, representam apenas a similaridade numérica colocada entre as características. Portanto, para o dendograma que está sendo representado na figura 1, selecionamos o modelo teste em que colocamos as características morfológicas representadas pelos filídios oblongos, base amplexante, peristômio dicranoide, seligerioide, esporos lisos e papilosos se restringindo à grupos, enquanto as demais características, nós rodamos elas no programa PAST de maneira “livre” nas análises. Além disso, levamos em consideração apenas as espécies que apresentavam cápsulas e dentes do peristômio no material tipo, desse modo, consideramos tanto as características do gametófito, quanto do esporófito para a separação e identificação dessas espécies.

Essa análise foi importante para avaliarmos as características morfológicas que aproximam as espécies, assim como estabelecer possíveis combinações e sinonimizações

novas para esse grupo de elevado número de espécies. Com as análises dos materiais tipo e das mais de 600 exsicatas, podemos inferir que a espécie *Dicranella angustifolia* Mitt. e a *Dicranella weberbaueri* Broth. são sinônimos heterotípicos, uma vez que se diferenciam apenas pela presença de esporos na primeira. Em outras palavras, a espécie *D. weberbaueri* provavelmente também apresenta esporos, uma vez que se trata de um musgo com o desenvolvimento de esporófitos, ou seja, não é porque esses esporos ainda não foram visualizados ou registrados que necessariamente a espécie não o tenha.

Três espécies também apresentaram características morfológicas muito semelhantes, representadas por *Dicranella boliviana* Herzog, *Dicranella pabstiana* (Müll. Hal.) Mitt., e *Dicranella riograndensis* Broth. A espécie *D. boliviana* Herzog se diferencia de *D. pabstiana* (Müll. Hal.) Mitt apenas pela coloração e textura dos esporos, no entanto, após nossas observações, percebemos que em algumas amostras, o esporófito dessas espécies apresentava as duas morfologias de esporos dentro de suas cápsulas. A presença tanto do esporo liso e hialino, quanto dos castanhos a amarronzados e papilosos na mesma cápsula, pode ser resultado da má formação desses esporos, caracterizando então células estéreis ou abortadas (Mogensen 1981, 1983). Dessa forma, consideramos essa característica como pouco informativa, ou duvidosa, para separar as espécies de *Dicranella*, resultando então em uma possível sinonimização entre as espécies *D. boliviana* e *D. pabstiana*.

Outra característica “polêmica” que percebemos em nossos estudos, é a presença ou não do ânulo nas espécies de *Dicranella*. O ânulo é uma estrutura presente no esporófito entre a urna da cápsula e o opérculo, que facilita a abertura da cápsula e a dispersão dos esporos (Luizi-Ponzo *et al.* 2006). Essa estrutura dificilmente foi levada em consideração durante a descrição das espécies de *Dicranella* ou consta no protólogo das mesmas. Além disso, geralmente quando a cápsula precisa ser aberta para analisar suas características morfológicas internas, o ânulo pode ser perdido ou destruído nesse processo, podendo então levar o taxonomista a um erro de interpretação ou de identificação dessas espécies.

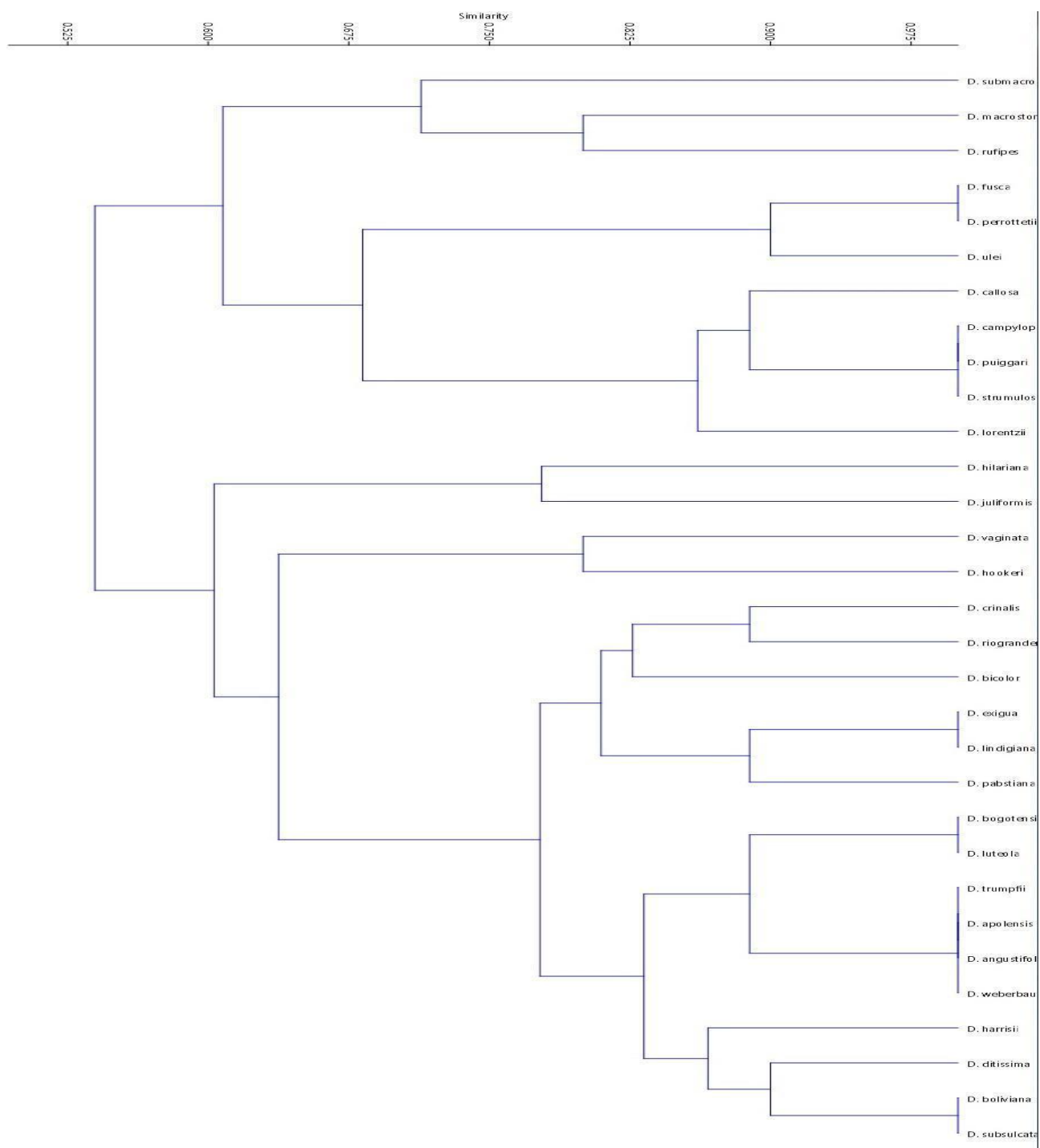


Figura 1. Dendrograma das espécies de *Dicranella* utilizando o índice de similaridade de Jaccard, pelo método de agrupamento pareado UPGMA com índice de correlação cofenético (CCF) igual a 0,77.

Entre as espécies *Dicranella boliviana* Herzog e *Dicranella riograndensis* Broth., a presença do ânulo na primeira é a única característica que separa essas duas espécies, logo, consideramos que a justificativa estabelecida para diferenciar e separar essas duas espécies como muito frágil, o que também nos motiva acreditar que elas sejam espécies sinônimas. Sendo assim, esses casos das três espécies citadas anteriormente (*D. boliviana*, *D. pabstiana* e *D. riograndensis*) estão definidas por características que consideramos de baixa confiabilidade, nos induzindo a propor que essas três espécies, na verdade sejam apenas uma. Contudo, para verificar essa suposição, análises e estudos mais aprofundados sobre o desenvolvimento do esporófito e de seus esporos precisam ser avaliados, melhorados e estimulados para essas espécies.

Como resultado desse trabalho, conseguimos analisar a nomenclatura, morfologia e ocorrência da espécie, até então considerada generalista, *Dicranella hilariana* (Mont.) Mitt. na região Neotropical. Em virtude da dificuldade existente em identificar as espécies do gênero *Dicranella*, bem como a ausência de referências bibliográficas para essa finalidade, muitas espécies que apresentavam um “perfil” de *Dicranella* eram logo consideradas e identificadas como *Dicranella hilariana*. Após essa revisão, e que está mais detalhada no capítulo 4.1 “The identity of *Dicranella hilariana* (Mont.) Mitt. (Dicranellaceae, Bryophyta)”, verificamos que a diversidade das espécies de *Dicranella* não se restringe apenas à espécie *D. hilariana*, como muitas vezes era considerado. No Brasil, por exemplo, muitas espécies que estavam identificadas como *D. hilariana*, correspondiam na verdade às espécies *Dicranella fusca* Broth., *Dicranella lindigiana* (Hampe) Mitt. ou *Dicranella apolensis* R.S. Williams., conseguimos chegar a essa conclusão com a análise dos materiais tipos e da revisão das 634 exsiccatas analisadas.

No Brasil eram consideradas apenas três espécies de *Dicranella* existentes: *Dicranella guilleminiana* (Mont.) Mitt., *D. hilariana* (Mont.) Mitt. e *D. vaginata* (Hook.) Cardot. (Costa *et al.* 2011). Após esse trabalho de revisão taxonômica, análise de exsiccatas, materiais tipo e novas coletas realizadas, estamos considerando para o país a ocorrência de 14 espécies, sendo três novas ocorrências para o Brasil (*D. angustifolia* Mitt., *D. apolensis* R.S. Williams and *D. harrisii* (Müll. Hal.) Broth.) e diversas novas ocorrências em diferentes estados brasileiros. As espécies *Dicranella affinis* Ångström; *Dicranella caldensis* Ångström; *Dicranella crinalis* Geh. & Hampe, *Dicranella brasiliensis* (Duby) Bartr., *Dicranella elata* Schimp. Ex Mitt., *Dicranella glaziovii* (Hampe) Hampe, *Dicranella guilleminiana* (Mont.) Mitt., *Dicranella itatiaiae* (Müll. Hal.) Broth., *Dicranella longirostris* (Schwägr.) Mitt. e *Dicranella nitida* Broth., foram consideradas excluídas ou com ocorrência duvidosa no

Brasil, em virtude dessas espécies serem conhecidas apenas pela existência de seu material tipo e não terem sido encontradas novamente nos herbários existentes ou nas novas coletas realizadas pelo país após essa nossa revisão. As informações em relação à esses resultados estão mais detalhadas e explicadas no capítulo 4.2 “The *Dicranella* (Müll. Hal.) Schimp. (Dicranellaceae, Bryophyta) genus in Brazil” dessa tese.

Para as espécies ocorrentes e citadas na região Neotropical, um catálogo envolvendo um grande número de espécies de *Dicranella s.l.* foi realizado e está melhor abordado no capítulo 3 desta tese: “A type catalog and a checklist of *Dicranella* species from Neotropic (Dicranellaceae, Bryophyta)”. Neste catálogo foram levantados aproximadamente 60 nomes de espécies citadas para a região, superando as estimativas previstas e estipuladas em Gradstein *et al.* (2001). A realização desse estudo permitiu então que informações como, o material tipo, prováveis holótipos, lectótipos, combinações e sinonimizáveis fossem estabelecidas, completando assim as informações necessárias e básicas da taxonomia das espécies de *Dicranella*. Além disso, evidenciou também a carência e a ausência de informações existentes que necessitavam de uma revisão (Margadant 1972, Margadant & Geissler 1995, Ellis & Price 2013), visto que como resultado, tivemos 34 lectótipos e 12 prováveis holótipos estipulados, designados e indicados neste catálogo.

Após essa compilação de espécies da região Neotropical, sete espécies ainda são consideradas com status taxonômicos duvidoso e sem definição ou designação de seu tipo, sendo representados pelas espécies: *Dicranella argentinica* (Müll. Hal.) Kindb., *Dicranella brasiliensis* (Hampe) Bartr., *Dicranella guilleminiana* (Mont.) Mitt., *Dicranella heteromalla* (Hedw.) Schimp., *Dicranella longirostris* (Schwägr.) Mitt., *Dicranella planinervia* (Taylor) A. Jaeger e *Dicranella varia* (Hedw.) Schimp.

Em relação aos estudos filogenéticos desenvolvidos durante essa tese de doutorado, conseguimos observar que, no momento, o melhor marcador utilizado para trabalhar com as espécies de *Dicranella* é o marcador plastidial do gene codificador da proteína ribossomal 4 (*rps4*). No tópico “Material e Métodos” dessa tese, inicialmente propusemos trabalhar com três marcadores moleculares, no entanto, durante a análise e os testes utilizando esses marcadores percebemos que o material genético não amplificou e os testes moleculares não tinham os resultados esperados. Dessa forma, conversamos com o especialista Dr. Michael Stech, referência em filogenia do grupo, e ele nos recomendou o uso de um outro primer de origem plastidial, o *trnL-F*, bem como o protocolo de PCR que eles utilizam em seu laboratório (Santos & Stech 2016). O primer *trnL-F* é qualificado pela sequência gênica que envolve genes codificantes (éxons) de proteínas transportadoras dos aminoácidos, como a leucina, e genes não codificantes (íntrons) e, dessa maneira, se caracteriza por um primer que

abrange longas cadeias de nucleotídeos nas espécies de musgos, cujo primer forward (Cm) inicia-se geralmente na sequência CGAAAT e o primer reverse (Fm) na sequência ATTTGA (Taberlet *et al.* 1991, Hernández-Maqueda *et al.* 2008, Stech & Quandt 2010).

Seguimos sua recomendação e os resultados começaram a melhorar, contudo para o primer *trnL-F* que ele havia nos designado, as amostras não tiveram sucesso durante a PCR, resultando em “bandas escorridas” durante a observação na câmara escura pela luz UV após a eletroforese, indicando assim um material genético degradado e sem eficiência para as seguintes etapas de sequenciamento e análises filogenéticas. Resolvemos então dividir a própria sequência e região do *trnL-F* em porções menores de primers, ou seja, ao invés de obtermos o intervalo de *trnL-F* pelos primers Cm – Fm, nós tentamos amplificar essa mesma região utilizando os primers Cm – Dm e Em – Fm (Taberlet *et al.* 1991, Hernández-Maqueda *et al.* 2008, Stech & Quandt 2010). No entanto, esse tipo de metodologia teve uma análise um pouco mais demorada e trabalhosa para se conseguir os resultados esperados e conseguir apresentar até a realização dessa tese.

Portanto, após realizar mais de 400 tipos de testes utilizando outras combinações de reagentes, amostras, temperaturas de metilação, anelamento, desnaturação do DNA e diferentes protocolos, temos como principal resultado para a apresentação dessa tese, as análises moleculares das amostras de espécies que foram submetidas aos marcadores *rps4* e outras, porém em quantidades menores que permitiriam uma boa análise filogenética, submetidas ao marcador nuclear ITS, baseado-se nos primers 18SF – 26S (Stech & Quandt 2010).

Um artigo científico foi produzido como resultado desse trabalho e está sendo melhor explicado no capítulo 4.4. “Phylogenetic analyses of *Dicranella* (Müll. Hal.) Schimp. (Dicranellaceae, Bryophyta) in Brazil using the plastid gene *rps4*” dessa tese. Neste artigo nós utilizamos as metodologias e análises necessárias para avaliar as relações filogenéticas das espécies brasileiras e avaliar suas relações dentro da família Dicranellaceae. Além disso, é importante ressaltar que esses procedimentos obtidos nas análises moleculares trabalhados com o grupo, até então não haviam sido testados e, mesmo assim, geraram uma grande quantidade de resultados que podem ainda ser trabalhados e estudados futuramente.

5. Considerações Finais

Após os estudos durante esses quatro anos de realização da tese de doutorado, conseguimos adquirir uma experiência muito maior em relação ao conhecimento biológico, taxonômico, ecológico e evolutivo do grupo. Além disso, com a observação e todas as anotações referentes aos materiais tipo obtidos, a quantidade de espécimes analisadas e as informações gerada, acreditamos ter melhores resultados e uma quantidade maior de materiais para pesquisas futuras envolvendo o grupo *Dicranella* e os demais gêneros relacionados.

Contudo, também é preciso levar em consideração a quantidade ainda escassa de materiais existentes depositados nos herbários, as relações taxonômicas de outras espécies de *Dicranella s.l.* e que ainda permanecem incertas, bem como aumentar os estudos filogenéticos e a quantidade de amostras de sequências genéticas depositadas no GenBank. Além disso, ainda existem relações nomenclaturais entre as espécies que estão indeterminadas, materiais tipos que ainda não foram analisados ou encontrados, possíveis sinonimizações e muitos estudos que podem ser abordados relacionado ao complexo grupo *Dicranella*. Estudos palinológicos ou de desenvolvimento (ontogenia) do esporófito, por exemplo, podem ser melhorados, incentivados e realizados, visto que as características do esporófito são as principais utilizadas para a separação das espécies de *Dicranella*.

Outras áreas da ciência biológica como por exemplo a Ecologia, Fisiologia e a Anatomia, também deveriam ser mais incentivadas e realizadas, não apenas para o grupo *Dicranella*, mas como para toda biologia de briófitas existentes. Essas áreas de estudos auxiliam e complementam a ciência taxonômica uma vez que, para conseguirmos entender a identidade biológica de um grupo de organismos, devemos estar conscientes de que estes seres não são isolados ou definidos apenas pelas suas características morfológicas e moleculares, sendo influenciados pelo ambiente que habitam e mais uma série de fatores que ainda são desconhecidos pela ciência. Desse modo, pesquisas relacionadas e compartilhadas entre as diferentes áreas da ciência que abrangem os organismos, precisam cada vez mais ser estabelecidas e estimuladas.

Acreditamos que com o desenvolvimento desta tese, algumas pequenas lacunas do conhecimento para o grupo *Dicranella s.l.* foram preenchidas, ao mesmo tempo em que novos questionamentos e curiosidades foram levantadas e apontadas, o que é absolutamente normal para as pessoas que praticam ciência se deparar. Afinal de contas, a ciência, assim como tudo que existe no planeta oriundo da ação humana, está submetida às alterações, reflexões e diferentes interpretações ao longo do tempo. A beleza da vida, e da diversidade

biológica, está nessa incessante dinâmica em tentarmos encontrar um sentido ou uma explicação para entendermos tudo que nos rodeia. Em meu caso particular, busquei entender com uma abordagem taxonômica nesses quatro anos de doutorado, um pequeníssimo grupo de organismos vegetais existentes na natureza, denominados até então de *Dicranella*, mas que se apresentou com uma importância e uma complexidade imensa conforme eu os conhecia.

De maneira geral, cada organismo então possui um propósito durante sua efêmera passagem pela vida, muitos talvez não sejam conscientes do qual está exercendo, porém, uma vez que essa energia vital está presente, uma imensidão de oportunidades, propósitos e consequências também estará sendo originada. Sendo assim, cabe a nós, também como organismos presentes na natureza, estarmos conscientes sobre como levamos nossa vida e com o que nós estamos contribuindo dentro desse ciclo. Quais nossas responsabilidades? Quais nossas oportunidades? Quais consequências temos que lidar? Enfim, resumindo, qual será o nosso propósito?

“Tudo evolui, não há realidade ou fatos eternos, assim como não há verdades absolutas”

- Friedrich Nietzsche -

6. Referências complementares

- Allen, B.** 1994. Moss flora of Central America. Part 1. Sphagnaceae-Calymperaceae. Monographs in Systematic Botany from the Missouri Botanical Garden 49: 1–242.
- Altschul, S.F., Gish, W., Miller, W., Myers, E.W. & Lipman, D.J.** 1990. Basic Local Alignment Search Tool. *Journal of Molecular Biology* 215(3): 403–410.
- Anderson, L.E.** 1954. Hoyer's solution as a rapid permanent mounting medium for bryologists. *The Bryologist* 57: 242–244.
- Brotherus, V.F.** 1924. Musci (Laubmoose) III. Unterklasse Bryales: II. Spezieller Teil. 10 (1). In: Engler, A. & K. Prantl, K. Die Natürlichen Pflanzenfamilien. (eds.2) 143–314 pp. Leipzig: W. Engelmann.
- Carmo, D.M. & Peralta, D.F.** 2016. Survey of bryophytes in Serra da Canastra National Park, Minas Gerais, Brazil. *Acta Botanica Brasilica* 30(2): 254–265.
- Carmo, D.M., Lima, J.S., Amélio, L.A. & Peralta, D.F.** 2016. Briófitas do Parque Estadual da Serra do Mar, Núcleo de Santa Virgínia, Estado de São Paulo, Brasil. *Hoehnea* 43(2): 265–287.
- Carmo, D.M., Lima, J.S., Silva, M.I., Amélio, L.A. & Peralta, D.F.** 2018. Briófitas da Reserva Particular do Patrimônio Natural da Serra do Caraça, Estado de Minas Gerais, Brasil. *Hoehnea* 45(3): 484–508.
- Câmara, P.E.A.S.** 2006. Molecular contribution on the systematic placement of the moss genus *Paranapiacabaea*. *Boletim do Instituto de Botânica (São Paulo)* 18: 159–163.
- Câmara, P.E.A.S. & Buck, W.R.** 2012. A re-interpretation of the Fabroniaceae, a phylogenetic perspective. *The Bryologist* 115(1): 109–117.
- Churchill, S.P.** 1994. The mosses of Amazonian Ecuador. *AAU Reports* 35: 1–211.
- Churchill, S.P. & Linares, E.L.** 1995. Prodrômus bryologiae Novo-Granatensis: introduction a la flora de musgos de Colombia. Parte 1, Adelotheciaceae a Funariaceae. – *Biblioteca José Jerónimo Triana* 12(1): 1–453.
- Corley, M.F.V., Crundwell, A.C., Düll, R., Hill, M.O. & Smith, A.J.E.** 1981. Mosses of Europe and the Azores; an annotated list of species, with synonyms from the recent literature. *Journal of Bryology* 11: 609–689.
- Costa, D.P., Pôrto, K.C., Luizi-Ponzo, A.P., Ilkiu-Borges, A.L., Bastos, C.J.P., Câmara, P.E.A.S., Peralta, D.F., Bôas-Bastos, S.B.V., Imbassahy, C.A.A., Henriques, D.K., Gomes, H.C.S., Rocha, L.M., Santos, N.D., Siviero, T.S., Vaz-Imbassahy, T.F. & Churchill, S.P.** 2011. Synopsis of the Brazilian moss flora: checklist, distribution and conservation. *Nova Hedwigia* 93(3–4): 277–334.

- Cox, C.J., Goffinet, B., Wickett, N.J., Boles, S.B. & Shaw, A.J.** 2010. Moss diversity: a molecular phylogenetic analysis of genera. *Phytotaxa* 9: 175–195.
- Crosby, M. R. & R. E. Magill.** 1981. A Dictionary of Mosses. Monographs in Systematic Botany from the Missouri Botanical Garden v. 3. 43 pp.
- Crosby, M.R., Magill, R.E., Allen, B. & He, S.** 1999. A checklist of the Mosses. Missouri Botanical Garden. St. Louis: Missouri Botanical Garden. pp. 1–315.
- Crum, H.** 1994. *Dicranella*. In: Sharp AJ, Crum H, Eckel P. The Moss Flora of Mexico. Memoirs of The New York Botanical Garden 69: 1–1113.
- Crum, H.** 2007. *Dicranella*. In: Flora of North America. – Editorial Committee (eds.): Flora of North America north of Mexico: pp. 386–393. Oxford University Press, New York.
- Dixon, H.N.** 1913. A Remarkable Form of *Dicranella heteromalla* Schimp. *The Bryologist* 16(2): 29-30.
- Dixon, H.N.** 1932. Classification of mosses. In: Verdoorn, F. in Manual of Bryology, ed. 397–412pp. The Hague: Martius Nijhoff.
- Doyle, J.J. & Doyle, J.L.** 1987. A rapid DNA isolation procedure for small amount of fresh leaf tissue. *Phytochemical Bulletin* 19: 11–15.
- Doyle, J.J. & Doyle, J.L.** 1990. Isolation of plant DNA from fresh tissue. *Focus* 12: 13–15.
- Duarte Bello, P.P.** 1997. Musgos de Cuba. *Fontqueria* 47: 1–717.
- Edwards, S.R.** 1984. Homologies and Inter-relationships of moss peristomes. In: Schuster, R.M. New Manual of Bryology. The Hattori Botanical Laboratory 2: 658–695.
- Ellis, L.T. & Price, M.J.** 2013. Review of the type specimens for Hedwig's species of *Dicranella* (Dicranaceae). *Journal of Bryology* 35(4): 275–289.
- Felsenstein, J.** 1985. Confidence limits on phylogenies: an approach using the bootstrap. *Evolution* 39: 783–791.
- Fleischer, M.** 1900–1902. Die Musci der Flora von Buitenzorg (zugleich Laubmoosflora von Java), erster band Sphagnales; Bryales, v.1. Leiden: Brill.
- Forzza, R.C., Leitman, P.M., Costa, A.F., Carvalho, J.R., Peixoto, A.L., Walter, B.M.T., Bicudo, C., Zappi, D., Costa, D.P., Lleras, E., Martinelli, G., Lima, H.C., Prado, J., Stehmann, J.R., Baumgratz, J.F.A., Pirani, J.R., Sylvestre, L., Maia, L.C., Lohmann, L.G., Queiroz, L.P., Silveira, M., Coelho, M.N., Mamede, M.C., Bastos, M.N.C., Morin, M.P., Barbosa, M.R., Menezes, M., Hopkins, M., Secco, R., Cavalcanti, T.B. & Souza, V.C.** 2010. Introdução. In: Lista de espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro. Vol. 1. Jardim Botânico do Rio de Janeiro. 875p.

- Frahm, J-P.** 1991. Dicranaceae: Campylopodioideae, Paraleucobyoideae. *Flora Neotropica Monograph* 54: 1–237.
- Frey, W. & Stech, M.** 2009. Marchantiophyta, Bryophyta and Anthocerotophyta. In: Frey W, Stech M, Fischer E. *Syllabus of plant families. Bryophytes and seedless Vascular Plants*, v.13, pp. 1–419.
- Goffinet, B., Buck, W.R. & Shaw, A.J.** 2009. Morphology, anatomy and classification of the Bryophyta. In: Goffinet, B. & Shaw, A.J. *Bryophyte Biology* (eds 2) edn., 55–138 pp. Cambridge: Cambridge University Press.
- Gradstein, S.R., Churchill, S.P. & Salazar-Allen, N.** 2001. Guide to the Bryophytes of Tropical America. *Memoirs of The New York Botanical Garden* 86: 1–577.
- Hall, T.A.** 1999. BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series* 45: 95–98.
- Hammer, Ø., Harper, D.A.T. & Ryan, P.D.** 2001. PAST - Paleontological Statistics Software Package for Education and Data Analysis, versão. 1.73. *Paleontologia Electronica* 4(1): 1–9. Disponível em: <http://www.palaeo-electronica.gov>. Acesso em 28 nov 2016.
- Hedderson, T.A., Murray, D.J., Cox, C.J. & Nowell, T.L.** 2004. Phylogenetic relationships of haplolepidous mosses (Dicranidae) inferred from rps4 gene sequences. *Systematic Botany* 29(1): 29–41.
- Hedwig, J.** 1801. *Species muscorum frondosorum*. Lipsiae [Leipzig]: sumtu Joannis Ambrosii Barthii.
- Hermann, F.J.** 1976. Recopilación de los musgos de Bolivia. *The Bryologist* 79(2): 125–171.
- Hernández-Maqueda, R., Quandt, D., Werner, O. & Muñoz, J.** 2008. Phylogeny and classification of the Grimmiaceae/Ptychomitriaceae complex (Bryophyta) inferred from cpDNA. *Molecular Phylogenetics and Evolution* 46: 863–877.
- Higgins, D.G. & Sharp, P.M.** 1988. Clustal: A package for performing multiple sequence alignment on a microcomputer. *Gene* 73: 237–244. [https://doi.org/10.1016/0378-1119\(88\)90330-7](https://doi.org/10.1016/0378-1119(88)90330-7).
- Hillis, D.M. & Bull, J.J.** 1993. An empirical test of bootstrapping as a method for assessing confidence in phylogenetic analyses. *Systematic Biology* 42: 182–192.
- Ireland, R.R.** 2007. Dicranaceae. In: Crosby MR, Delgadillo CM, Harris P, *et al.* *Flora of North America*. 27: 358–432.
- Jansen-Jacobs, M.J.** 2011. *Flora of the Guianas. Series C: Bryophytes Fascicle 2. Musci IV*. Royal Botanic Gardens, Kew, U.K.

- La Farge, C., Mishler, B.D., Wheeler, J.A., Wall, D.P., Johannes, K., Schaffer, S. & Shaw, A.J.** 2000. Phylogenetic relationships within the haplolepideous mosses. *The Bryologist* 103: 257–276.
- La Farge, C., Shaw, A.J. & Vitt, D.H.** 2002. The circumscription of the Dicranaceae (Bryopsida) based on the chloroplast regions *trnL-trnF* and *rps4*. *Systematic Botany* 27: 435–452.
- Larraín, J., Suárez, G., Bednarek-Ochyra, H. & Ochyra, R.** 2010. The rediscovery of *Dicranella circinata* (Dicranellaceae, Bryophyta), with comments on other Southern South American species of *Dicranella*. *Nova Hedwigia* 91(3–4): 361–376.
- Luizi-Ponzo, A.P., Bastos, C.J.P., Costa, D.P., Pôrto, K.C., Câmara, P.E.A.S., Lisboa, R.C.L. & Bôas-Bastos, S.V.** 2006. Glossarium Polyglottum Bryologiae: Versão Brasileira do Glossário Briológico. Juiz de Fora. 1–113 pp.
- Margadant, W.D.** 1972. Notes on the Nomenclature of Musci (Communicationes Biohistoricae Ultrajectinae n. 33). *Lindbergia* 1(3/4): 121–129.
- Margadant, W.D. & Geissler, P.** 1995. Seventeen proposals concerning nomina conservanda for genera of Musci. *Taxon* 44(4): 613–624.
- Magurran, A.E.** 1989. Diversidad Ecológica y su medición. Ediciones Vedral. Barcelona.
- Matteri, C.M.** 2003. Los musgos (Bryophyta) de Argentina. *Tropical Bryology* 24: 33–100.
- Menzel, M.** 1992. Preliminary checklist of the mosses of Peru (Studies on Peruvian bryophytes IV.). *Journal of the Hattori Botanical Laboratory* 71: 175–254.
- Mitten, W.** 1869. Musci Austro-Americani. *The Journal of the Linnean Society* 12: 31.
- Mogensen, G.S.** 1981. The Biological Significance of Morphological Characters in Bryophytes: The Spore. *The Bryologist* 84(2): 187–207.
- Mogensen, G.S.** 1983. The Spore. In: Schuster, R.M. *New Manual of Bryology*. The Hattori Botanical Laboratory 1: 325–342.
- Müller Hal., C.** 1848. *Synopsis Muscorum Frondosorum omnium hucusque Cognitorum* 1: 430.
- Müller, F.** 2009. An updated checklist of the mosses of Chile. *Archive for Bryology*. 58: 1–124.
- Müller J., Müller, K., Neinhuis, C. & Quandt, D.** 2010. PhyDE v0.9971: Phylgenetic Data Editor. – <http://www.phyde.de>.
- Nakanishi, M.** 1984. *Schistostega pennata*, new to Ibaraki Prefecture. 132. *Proceedings of the Bryological Society of Japan* 3: 189–191.
- Ochyra, R.** 1997. *Leptotrichella* replaces *Microdus* (Musci, Dicranaceae). *Fragmenta Floristica et Geobotanica* 42: 559–565.

- Ochyra, R., Smith, R.I.L. & Bednarek-Ochyra, H.** 2008. The Illustrated moss flora of Antarctica. – Cambridge Univ. Press, Cambridge.
- O’Shea, B.J. & Price, M.J.** 2008. An updated checklist of the mosses of Paraguay. *Tropical Bryology* 29: 6–37.
- Santos, M.B. & Stech, M.** 2016. Tackling relationships and species circumscriptions of *Octoblepharum*, an enigmatic genus of haplolepidous mosses (Dicranidae, Bryophyta). *Systematics and Biodiversity* 15(1): 16–24.
- Santos, E.L., Carmo, D.M. & Peralta, D.F.** 2017. Bryophytes of the cloud forest of Pico do Marumbi State Park, Paraná, Brazil. *Checklist* 13(6): 959–986.
- Schimper, W.P.** 1856. *Corollarium Bryologiae Europaeae* 13.
- Schimper, W.P.** 1860. *Synopsis muscorum Europaeorum praemissa introductione de elementis clix + v + 733 pp.* E. Schweizerbart, Stuttgart.
- Scott, G.A.M. & Stone, I.G.** 1976. *Mosses of Southern Australia.* Academic Press. Canberra.
- Stech, M.** 1999. A reclassification of the Dicranaceae (Bryopsida) based on non-coding cpDNA data. *Journal of the Hattori Botanical Laboratory.* 86: 137–159.
- Stech, M.** 2004. Supraspecific Circumscription and Classification of *Campylopus* (Dicranaceae, Bryopsida) Based on Inferences from Sequence Data. *Systematic Botany* 29(4): 817–824.
- Stech, M. & Frey, W.** 2008. A morpho-molecular classification of the mosses (Bryophyta). *Nova Hedwigia.* 86:1–2.
- Stech, M., McDaniel, S.F., Hernández-Maqueda, R., Ros, R.M., Werner, O., Muñoz, J. & Quandt, D.** 2012. Phylogeny of Haplolepidous mosses – Challenges and perspectives. *Journal of Bryology* 34 (3): 160–173.
- Taberlet, P., Gielly L., Pautou, G. & Bouvet, J.** 1991. Universal primers for amplification of three non-coding regions of chloroplast DNA. *Plant Molecular Biology* 17: 1105–1109.
- Tsubota, H., De Luna, E., González, D., Ignatov, M.S. & Deguchi, H.** 2004. Molecular phylogenetics and ordinal relationships based on analyses of a large-scale data set of 600 *rbcL* sequence of mosses. *Hikobia* 14: 149–170.
- Turland, N.J., Wiersema, J.H., Barrie, F.R., Greuter, W., Hawksworth, D.L., Herendeen, P., Knapp, S., Kusber, W-H., Li, D-Z., Marhold, K., May, T.W., McNeill, J., Monro, A.M., Prado, J., Price, M.J. & Smith, G.F.** 2018. Código Internacional de Nomenclatura para algas, fungos e plantas (Código de Shenzhen). RiMa. Editora. *Regnum Vegetabile* v. 159.

- Walther, K.** 1983. Bryophytina. Laubmoose. Unterklasse Bryidae. In: Gerloff J. & Poelt. J. A. Engler's Syllabus der Pflanzenfamilien. v.2, (eds.) 31–88pp. Berlin: Gebrüder Borntraeger.
- Wijk, R. van der, Margadant, W.D. & Florschütz, P.A.** 1959. Index Muscorum. (A–C, Appendix). Regnum Vegetabile. v. 1. 17. xxviii + 548 pages.
- Wijk, R. van der, Margadant, W.D. & Florschütz, P.A.** 1969. Index Muscorum. (T–Z, Appendix). Regnum Vegetabile. v. 5. 65. xii + 922 pages.
- Williams, R.S.** 1913. Dicranaceae. North American Flora. 15: 77–158.
- Yano, O.** 2011. Catálogo de Musgos Brasileiros: literatura original, basiônimo, localidade tipo e distribuição geográfica. Publicações on line do Instituto de Botânica, Secretaria do Meio Ambiente, São Paulo, SP. Disponível em: www.botanica.sp.gov.br/files/2013/09/virtuais_2musgos.pdf.