



Molecular and morphological circumscription of *Brachythecium coruscum* as a separate taxon from *Brachythecium albicans* (Brachytheciaceae, Bryophyta)

ISABEL DRAPER¹, VICENTE MAZIMPAKA¹ & LARS HEDENÄS²

¹ Departamento de Biología (Botánica), Facultad de Ciencias, Universidad Autónoma de Madrid, c/ Darwin, 2. E-28049, Madrid, Spain; email: isabel.draper@uam.es; vicente.mazimpaka@uam.es

² Enheten för Botanik, Naturhistoriska riksmuseet, Box 50007, SE-104 05, Stockholm, Sweden; email: lars.hedenas@nrm.se

Abstract

Nuclear ITS, and chloroplast rpl16 and trnG sequences, together with morphological data, were used to circumscribe some problematic taxa within the complex around the pleurocarpous moss *Brachythecium albicans*. *Brachythecium coruscum* is consistently different from *B. albicans*, and its description is here amended. On the contrary, segregation of *Brachythecium dumetorum* from *B. albicans* is unsupported both according to molecular and morphological data, and the two taxa are therefore considered to be synonyms.

Introduction

Mosses (Bryophyta) are the second largest group of land plants, with ca. 13,000 species (Goffinet *et al.* 2009). They are present in most land environments, and in ecosystems subject to harsh conditions such as the tundra they co-dominate the vegetation together with lichens. In spite of their ecological importance, the taxonomy of several groups of mosses remains partly unresolved. Part of the taxonomical problems can result from the phenotypic plasticity of some taxa that could be induced by variable environmental conditions (e.g. Vanderpoorten & Jacquemart 2004). But there are also a significant number of taxa that have been misunderstood because their morphological characters were not clearly described or because those morphological features selected as diagnostic were not the most suitable ones. In this context, the use of molecular techniques has in general helped to clarify the taxonomy (e.g. Draper & Hedenäs 2008, 2009a; Hedenäs 2011a; Shaw 2009).

The family Brachytheciaceae Schimper (1876: 637), with ca. 560 species (Frey & Stech 2009), is one of the largest among the pleurocarpous mosses. It constitutes an example of a family traditionally regarded as taxonomically problematic due to the morphological plasticity exhibited by some of its members. The latest studies on the phylogeny and taxonomy of the family resolved the identity of several uncertain taxa (e.g. Draper & Hedenäs 2008, 2009a,b; Hedenäs *et al.* 2012; Huttunen & Ignatov 2004; Huttunen *et al.* 2007; Ignatov & Milyutina 2007a,b; Orgaz *et al.* 2011, 2012), although others still remain unclear. Among the latter, the complex around *Brachythecium albicans* (Hedwig 1801: 251) Schimp. in Bruch *et al.* (1853: 553) still awaits a better understanding.

Brachythecium albicans is a widespread circumpolar species of the Northern Hemisphere that in addition occurs in Chile (Müller 2009), Argentina (Matteri 2003), Australia (Dierssen 2001; Hedenäs 2002), and New Zealand (Beever *et al.* 1992). In Europe it is sub-boreal (Duell 1985) and occurs at lower elevations throughout most of the continent (Frey *et al.* 2006). It has also been reported from the Azores archipelago (Frahm 2005) and Madeira island (Hedenäs 1992).

In northern Europe and North America, golden and robust subarctic specimens with strongly plicate leaves were described as *Brachythecium coruscum* I. Hagen (1908: 3). This taxon resembles both *B. albicans*, which is paler and with less plicate leaves, and *Brachythecium salebrosum* (Hoffman 1795: 74 ex Hedwig 1801: 257) Schimp. in Bruch *et al.* (1853: 20), with angular cells in a more shortly decurrent band. Because of these similarities, its status has varied across time: it has been treated either as a separate species (e.g. Duell 1985; Frey *et*

Taxonomic changes

Brachythecium albicans (Hedwig 1801: 251) Schimp. in Bruch *et al.* (1853: 553). Type:—”*Hypnum albicans* Neck. Hedw. St. Crypt. Vol. IV, p. 13. T. 5”, the left specimen on a sheet [lectotype G!, herb. Hedwig-Schwaegrichen (Hedenäs 1996)].

= *Brachythecium albicans* var. *dumetorum* Limpr. in Cohn (1876: 73) ≡ *Brachythecium dumetorum* (Limpr.) G. Roth (1905: 453) ≡ *Hypnum albicans* var. *dumetorum* (Limpr.) H. Möller (1907: 145) ≡ *Brachythecium albicans* subsp. *dumetorum* (Limpr.) J.J. Amann (1918: 301), *syn. nov.* Probable type:—[Poland, Silesia] Grünberg ii.7i [?] Säbor am Seegraben, Everken (BP-56537!).

Acknowledgements

We thank Michael Ignatov, Sanna Huttunen, and the curators of TRH, O, BP, BCB, H, MUB, NY, and VIT, for specimen searches and loans. S.H. is also gratefully acknowledged for providing some molecular sequences used in this study. V.M. gratefully acknowledges the hospitality and facilities received from the staff of the Swedish Museum of Natural History, and especially from the staff of S. Financial support was provided through Artdatabanken (Artprojektet dha 143/05 1.4, to L. Hedenäs). The stay of V.M. at S was funded by Artdatabanken, and the Autonomous University of Madrid (UAM) contributed to the travel expenses. We finally thank two anonymous referees for their useful comments to improve the original manuscript and the editor Matt Von Konrat for his interest in accelerating the publishing processes.

References

- Amann, J. (1918) *Flore des mousses de la Suisse. Deuxième partie. Bryogéographie de la Suisse*. Genève, 414 pp.
- Beever, J., Allison, K.W. & Child, J. (1992) *The mosses of New Zealand*. University of Otago Press, 214 pp.
- Bruch, P., Schimper W.P. & Gümbel, T. (1853) *Bryologia europaeae seu Genera Muscorum Europaeorum Vol. 6. Sumpitibus Librariae E. Schweizerbart, Stuttgart*.
<http://dx.doi.org/10.5962/bhl.title.50508>
- Cohn, F. (1876) *Kryptogamen-Flora von Schlesien*. J.U.Kern's Verlag, Breslau, 283 pp.
- Dierssen, K. (2001) Distribution, ecological amplitude and phytosociological characterization of European bryophytes. *Bryophytorum Bibliotheca* Band 56: 1–289.
- Draper, I. & Hedenäs, L. (2008) *Sciuro-hypnum tromsoeense* (Kaurin & Arnell) Draper & Hedenäs, a distinct species from the European mountains. *Journal of Bryology* 30: 271–278.
<http://dx.doi.org/10.1179/174328208x300697>
- Draper, I. & Hedenäs, L. (2009a) *Sciuro-hypnum dovrense* (Limpr.) Draper *et* Hedenäs comb. nov., a distinct Eurasian alpine species. *Cryptogamie, Bryologie* 30: 289–299.
- Draper, I. & Hedenäs, L. (2009b) Circumscription of European taxa within the *Sciuro-hypnum reflexum* complex (Brachytheciaceae, Bryophyta), based on molecular and morphological data. *Taxon* 58: 572–584.
- Duell, R. (1985) Distribution of European and Macaronesian mosses (Bryophytina). Part II. *Bryologische Beiträge* Band 5: 184–185.
- Duell, R. (1992) Distribution of European and Macaronesian mosses (Bryophytina). Annotations and Progress. *Bryologische Beiträge* Band 8/9: 1–223.
- Frahm, J.-P. (2005) An evaluation of the bryophyte flora of the Azores. *Tropical Bryology* 26: 57–79.
- Frey, W., Frahm, J.-P., Fischer, E. & Lobin, W. (eds.) (2006) *The Liverworts, Mosses and Ferns of Europe*. Harley Books, Essex, England, 512 pp.
- Frey, W. & Stech, M. (2009) Division Bryophyta Schimp. (Musci, Mosses). In: Frey, W. (ed.) *Syllabus of plant families. Adolf Engler's Syllabus der Pflanzenfamilien, 13th edition. Part 3. Bryophytes and seedless vascular plants*. Gebrüder Borntraeger, Berlin, pp. 116–257.
- Goffinet, B., Buck, W.R. & Shaw, A.J. (2009) Morphology, anatomy, and classification of the Bryophyta. In: Goffinet, B. & Shaw, A.J. (eds.) *Bryophyte Biology*. Cambridge University Press, Cambridge, pp. 445–486.
- Hagen, I. (1908) Mousses nouvelles. *Det Kongelige Norske Videnskabers Selskabs Skrifter* 3: 3–4.
- Hartman, C.J. (1838) *Handbok i Skandinaviens Flora, Tredje Upplagen*. Zacharias Haeggström, Stockholm, 350 pp.
- Hedenäs, L. (1992) Flora of Madeiran Pleurocarpous mosses (Isobryales, Hypnobryales, Hookeriales). *Bryophytorum Bibliotheca* Band 44: 5–165.
- Hedenäs, L. (1996) Taxonomic and nomenclatural notes on Australian Brachytheciaceae. *Nova Hedwigia* 62: 451–465.
- Hedenäs, L. (2002) An overview of the family Brachytheciaceae (Bryophyta) in Australia. *Journal of the Hattori Botanical*

Laboratory 92: 51–90.

- Hedenäs, L. (2008) Molecular variation and speciation in *Antitrichia curtispindula* s.l. (Leucodontaceae, Bryophyta). *Botanical Journal of the Linnean Society* 156: 341–354.
<http://dx.doi.org/10.1111/j.1095-8339.2007.00775.x>
- Hedenäs, L. (2011a) Relationships among *Cratoneuron curvicaule*, *C. filicinum* var. *filicinum*, and *C. filicinum* var. *atrovirens* (Bryophyta: Amblystegiaceae). *Journal of Bryology* 33: 99–104.
<http://dx.doi.org/10.1179/1743282010y.0000000017>
- Hedenäs, L. (2011b) Incongruence among morphological species circumscriptions and two molecular data sets in *Sarmentypnum* (Bryophyta: Calliergonaceae). *Taxon* 60: 1596–1606.
- Hedenäs, L., Draper, I., Milyutina, I. & Ignatov, M.S. (2012) ITS and morphology tell different histories about the species of the *Sciuro-hypnum reflexum* complex (Brachytheciaceae, Bryophyta). *The Bryologist* 115: 153–172.
<http://dx.doi.org/10.1639/0007-2745-115.1.153>
- Hedwig, J. (1801) *Species Muscorum Frondosorum*. Parisiis, A. Koenig, sumtu J. A. Barthii, Lipsiae (Leipzig), 352 pp.
- Hoffman, G.F. (1795) *Deutschlands Flora oder botanisches Taschenbuch*, vol. 2. Erlangen: Bey Johann Jacob Palm, 200 pp.
- Huelsenbeck, J.P. & Ronquist, F. (2001) MrBayes: Bayesian inference of phylogeny. *Bioinformatics* 17: 754–755.
<http://dx.doi.org/10.1093/bioinformatics/17.8.754>
- Huttunen, S., Gardiner, A. & Ignatov, M.S. (2007) Advances in knowledge of the Brachytheciaceae (Bryophyta). In: Newton, A.E. & Tangney, R.H. (eds.), *Pleurocarpous Mosses: Systematics and Evolution*. CRC Press, Oxon (U.K.), pp. 111–140.
<http://dx.doi.org/10.1201/9781420005592.ch6>
- Huttunen, S. & Ignatov, M.S. (2004) Phylogeny of the Brachytheciaceae (Bryophyta) based on morphology and sequence level data. *Cladistics* 20: 151–183.
<http://dx.doi.org/10.1111/j.1096-0031.2004.00022.x>
- Ignatov, M.S. & Afonina, O.M. (eds.) (1992) Check-list of mosses of the former USSR 1. *Arctoa* 1: 1–86.
- Ignatov, M.S. & Huttunen, S. (2002[2003]) Brachytheciaceae (Bryophyta) – a family of sibling genera. *Arctoa* 11: 245–296.
- Ignatov, M.S. & Milyutina, I.A. (2007a) On *Sciuro-hypnum oedipodium* and *S. curtum* (Brachytheciaceae, Bryophyta). *Arctoa* 16: 47–61.
- Ignatov, M.S. & Milyutina, I.A. (2007b) A revision of the genus *Sciuro-hypnum* (Brachytheciaceae, Bryophyta) in Russia. *Arctoa* 16: 63–86.
- Jensen, C. (1898) Mosser fra Øst-Grønland. *Meddelelser om Grønland* 15: 363–446.
- Jensen, C. (1939) *Skandinaviens bladmosflora*. Ejnar Munksgard, København, 535 pp.
- Jordan, W.C., Courtney, M.W. & Neigel, J.E. (1996) Low levels of intraspecific genetic variation at a rapidly evolving chloroplast DNA locus in North American duckweeds (Lemnaceae). *American Journal of Botany* 83: 430–439.
<http://dx.doi.org/10.2307/2446212>
- Kelchner, S.A. (2000) The evolution of non-coding chloroplast DNA and its application in plant systematics. *Annals of the Missouri Botanical Garden* 87: 482–498.
<http://dx.doi.org/10.2307/2666142>
- Kindberg, N.C. (1888) Enumeratio muscorum (Bryneorum et Sphagnaceorum), qui in Groenlandia, Islandia et Faeroer occurrunt. *Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening i Kjøbenhavn* 49: 293–304.
- Kindberg, N.C. (1903) *Skandinavisk Bladmosflora, I hort ofversigt*. C.E. Fritzes, 200 pp.
- Matteri, C.M. (2003) Los musgos (Bryophyta) de Argentina. *Tropical Bryology* 24: 33–100.
- Möller, H. (1907) Ett par upplysningar angående den snart utkommande förteckningen öfver Skandinaviens mossor. *Botaniska Notiser* 1907: 141–145.
- Müller, K. (2004) SeqState – primer design and sequence statistics for phylogenetic DNA data sets. *Applied Bioinformatics* 4: 65–69.
<http://dx.doi.org/10.2165/00822942-200504010-00008>
- Müller, F. (2009) An updated checklist of the mosses of Chile. *Archive for Bryology* 58: 1–124.
- Müller, K., Müller, J., Neinhuis, C. & Quandt, D. (2006) PhyDE – Phylogenetic Data Editor, v0.995. Program distributed by the authors <http://www.phyde.de>.
- Nyholm, E. (1965) *Illustrated Moss Flora of Fennoscandia*. II. Musci. Fasc. 5. CWK Gleerup, Lund, 647 pp.
- Orgaz, J.D., Cano, M.J. & Guerra, J. (2011) *Sciuro-hypnum* (Brachytheciaceae) in the Mediterranean region. *The Bryologist* 114: 595–610.
<http://dx.doi.org/10.1639/0007-2745-114.3.595>
- Orgaz, J.D., Cano, M.J. & Guerra, J. (2012) Typification, taxonomy and distribution of *Brachythecium erythrorrhizon* Schimp. (Brachytheciaceae, Bryophyta) in the Mediterranean Region. *Nova Hedwigia* 95: 227–231.
<http://dx.doi.org/10.1127/0029-5035/2012/0040>
- Pacak, A. & Szwejkowska-Kulinska, Z. (2000) Molecular data concerning allopolyploid character and the origin of chloroplast and mitochondrial genomes in the liverwort *Pellia borealis*. *Journal of Plant Biotechnology* 2: 101–108.
- Paris, E.G. (1900) *Index Bryologicus Supplementum Primum*. Georg & Cie, Libraires-Éditeurs, Gèneve, 334 pp.
- Podpěra, J. (1954) *Conspectus muscorum Europaeorum*. Praha, 687 pp.
- Posada, D. (2008) jModelTest: Phylogenetic Model Averaging. *Molecular Biology and Evolution* 25: 1253–1256.
<http://dx.doi.org/10.1093/molbev/msn083>

- Ronquist, F. & Huelsenbeck, J.P. (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* 19: 1572–1574.
<http://dx.doi.org/10.1093/bioinformatics/btg180>
- Roth, G. (1905) *Die Europäischen Laubmoose* 2. Wilhelm Engelmann, Leipzig, 733 pp.
- Schimper, W.P. (1876) *Synopsis Muscorum Europaeorum, Editio Secunda*. E. Schweizerbart, Stuttgart, 886 pp.
- Schljakov, R. N. (1952) Novinki dlja brioflori SSSR [Ad bryofloram URSS novitates]. *Botaničeskie Materialy Otdela Sporovyh Rastenij, Botaničeskogo Instituta imeni V. L. Komarova Akademii Nauk SSSR* 8: 213–223.
- Shaw, A.J. (2009) Bryophyte species and speciation. In: Goffinet, B. & Shaw, A.J. (eds.) *Bryophyte Biology*. Cambridge University Press, Cambridge, pp. 445–486.
<http://dx.doi.org/10.1017/cbo9780511754807.012>
- Simmons, M.P. & Ochoterena, H. (2000) Gaps as Characters in Sequence-Based Phylogenetic Analyses. *Systematic Biology* 49: 369–381.
- Stech, M. & Frahm, J.P. (1999) The status of *Platyhypnidium mutatum* Ochyra & Vanderpoorten and the systematic value of the Donrichardiaceae based on molecular data. *Journal of Bryology* 21: 191–195.
<http://dx.doi.org/10.1179/jbr.1999.21.3.191>
- Vanderpoorten, A. & Jacquemart, A.-L. (2004) Evolutionary mode, tempo, and phylogenetic association of continuous morphological traits in the aquatic moss genus *Amblystegium*. *Journal of Evolutionary Biology* 17: 279–287.
<http://dx.doi.org/10.1111/j.1420-9101.2004.00686.x>
- Weber, F. & Mohr, D.M.H. (1807) *Botanisches Taschenbuch*. Akademischen Buchhandlung, Kiel, 509 pp.
- Weimarck, H. (1937) *Förteckning över Skandnaviens växter. 2 Mossor*. C.W.K. Gleerups Förlag, Lund, 85 pp.

Appendix 1.

List of studied specimens (Herbarium voucher, country, locality, collector, and collection date). Specimens included in the morphological study are marked with *. ID for the vouchers included in the molecular analyses and GenBank Accession number are provided in brackets (ID ITS; rpl16; trnG) for specimens included in the molecular study. Lacking sequences are indicated with —.

***Brachythecium albicans* (Hedwig) Schimp. in Bruch *et al.* (typical):** S-B85088*, Sweden, Södermanland, *L. Hedenäs*, 01-11-1986; S-B88414*, Sweden, Södermanland, *L. Hedenäs*, 25-03-1990 (ID70 KC300018; KC300074; KC299962); S-B88277, Sweden, Södermanland, *L. Hedenäs*, 19-03-1994 (D479 KC300031; KC300087; KC299975); S-B89542, Sweden, Södermanland, *L. Hedenäs*, 11-03-1990 (D478 KC300030; KC300086; KC299974); S-B139428*, Sweden, Skåne, *E. Nyholm*, 18-05-1970; S-B112804*, Sweden, Skåne, *E. Tuveesson*, 02-1931; S-B89543, Sweden, Skåne, *L. Hedenäs*, 18-04-1993 (ID84 KC300019; KC300075; KC299963); S-B140748*, Sweden, Dalarna, *H. Möller*, 27-04-1913; S-B88283*, Sweden, Uppland, *L. Hedenäs*, 06-07-1987 (D480 KC300032; KC300088; KC299976); S-B88282*, Sweden, Uppland, *L. Hedenäs*, 11-05-1992; S-B52356*, Sweden, Uppland, *G. Een*, 1-03-1959; S-B28794, Sweden, Uppland, *L. Hedenäs*, 1-03-1998 (ID94 KC300021; KC300077; KC299965); S-B141004*, Sweden, Västerbotten, *E. Von Kruesenstjerna*, 03-05-1942; S-B140954*, Sweden, Jämtland, *G. Åberg*, 27-04-1913; S-B140978*, Sweden, Medelpad, *E. Collinder*, 11-08-1890; S-B140999*, Sweden, Ångermanland, *H.W. Arnell*, 20-05-1874; S-B141034*, Sweden, Torne Lappmark, *E. Jäderholm*, 7-08-1911; S-B87486, Sweden, Gotland, *L. Hedenäs*, 29-08-1992 (ID92 KC300020; KC300076; KC299964); S-B88271, Sweden, Gotland, *L. Hedenäs*, 20-10-1989 (D477 KC300033; KC300089; KC299977); S-B141132*, Finland, Helsingfors, *O. Lindberg*, 10-1879; S-B141138*, Finland, Karelia Ladogensis, *W.M. Linnaniemi*, 14-11-1907; S-B141094*, Norway, Østfold, *Ryan*, 24-07-1887; S-B63122*, Norway, Finnmark, *L. Hedenäs*, 24-07-2001 (ID87 KC300022; KC300078; KC299966); S-B141143*, Denmark, Sjælland, *C. Jensen*, 05-1882; S-B141147*, Denmark, Sjælland, *A. Hesselbo*, 14-04-1906; S-B193716*, Poland, Suwalki, *R. Ochyra*, 16-07-1978; S-B88272*, Estonia, Saaremaa, *L. Hedenäs*, 14-06-1989; S-B193715*, United Kingdom, Scotland, *A.C. Crundwell*, 18-03-1973; S-B39492*, France, Charente-maritime, *Pierrot*, 01-02-1970; S-B122427*, Germany, Baden-Württemberg, *L. Hedenäs*, 18-04-1998 (D473 KC300028; KC300084; KC299972); S-B122280, Poland, Wielkopolskie, *H. Bednarek-Ochyra & R. Ochyra*, 13-04-1987 (D472 KC300027; KC300083; KC299971); S-B111459*, Switzerland, Ticino, *L. Hedenäs*, 13-04-2006 (D474 KC300029; KC300085; KC299973); S-B8604*, Portugal, Madeira, *L. Hedenäs*, 9-09-1991; MAUAM-Bryo00029, Spain, Segovia, *Garilleti & Lara*, 2-09-1990 (ID71 KC300017; KC300073; KC299961); MAUAM-Bryo00030*, Spain, Madrid, *Garilleti & Lara*, 11-09-1988; S-B8603, Portugal, Madeira, *L. Hedenäs*, 16-04-1990 (D471 KC300026; KC300082; KC299970); S-B54202, Australia,