

Taxonomic and nomenclatural novelties in *Syntrichia* (*Bryophyta: Pottiaceae*), with reinstatement of an endemic continental Antarctic species

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Abstract. Taxonomic implications of the phylogeographic studies based on multilocus sequencing of nuclear and chloroplast DNA regions of *Syntrichia sarconeurum*, long considered to be Antarctic endemic moss species, are summarised. Molecular analyses confirmed the conspecificity of *Syntrichia sarconeurum* with *S. lithophila* and *S. pygmaea*. This taxonomic conclusion implies that the correct name for the species in the genus *Syntrichia* is *S. lithophila* and *S. sarconeurum* is a new synonym of this name. It is because *S. sarconeurum* takes priority from 2007, whereas *S. lithophila* is based on *Tortula lithophila* which was validly published in 1906 and it is the next earliest legitimate name at the rank of species to be used. *Syntrichia sarconeurum*, as traditionally conceived, proved to be a heterogeneous taxon actually consisting of two distinct species, namely *S. lithophila* and *S. frigidideserticola* nom. nov., which is a new name for *Sarconeurum antarcticum* whose epithet is not available in *Syntrichia*. Australian and New Zealand plants of *Syntrichia* with propaguloid leaf apices are definitely distinct from South American and Antarctic *S. lithophila* and *S. frigidideserticola* and the correct name for them is *S. abruptinervis* comb. nov., based on *Tortula abruptinervis*.

Key words: Antarctica, Australasia, bryophytes, nomenclature, Patagonia, South America, taxonomy

Introduction

The moss genus *Syntrichia* Brid., as traditionally circumscribed, is one of the largest genera of the *Pottiaceae* and consists of about 80 species that are distributed on all continents (Crosby et al. 2000). In the Antarctic it is represented by five species and one variety that are mainly distributed in the Antarctic Peninsula region of West Antarctica. Only two species, *S. magellanica* (Mont.) R. H. Zander and *S. sarconeurum* Ochyra & R. H. Zander, are generally considered to be panantarctic in distribution, the latter of which appears to be widespread and locally common in continental East Antarctica (Ochyra et al. 2008).

Syntrichia sarconeurum is a very distinctive species of moss in the Antarctic, which differs from all other species in this biome by having fleshy and swollen, deciduous leaf apices forming caducous propagules which are often present on some leaves in the apical comal group. The only other species in Antarctica which possess such propaguloid leaf apices are two species of

Tortella (Lindb.) Limpr., *T. fragilis* (Drumm.) Limpr. and *T. alpicola* Dixon, which are immediately distinguished from *S. sarconeurum* by their hyaline basal cells that are highly differentiated from the upper chlorophyllose cells and extend strongly up the margins to form a distinct V-shaped basal region. In contrast to *Tortella* species, the hyaline basal cells in *S. sarconeurum* are differentiated juxtacostally across the leaf base, and the junction line with the upper chlorophyllose cells is gradual and not sharply defined. In addition, *S. sarconeurum* only has an adaxial stereid band in the costa, whereas *Tortella* species have adaxial as well as abaxial stereid bands.

As indicated on the label of one of the syntypes in the Mitten herbarium at NY, *Syntrichia sarconeurum* was first collected by J. D. Hooker on 6 January 1843 on the small Cockburn Island off the north-eastern coast of the Antarctic Peninsula during the British Antarctic Expedition 1839–1843, under the command of Captain James C. Ross (Headland 1989). It was described and illustrated by Wilson & Hooker (1847) as a new species, *Didymodon glacialis* Hook. f. & Wilson, although they were uncertain of the generic affinities of this new

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species and placed it in the genus *Didymodon* Hedw. with a question mark. It was an unfortunate choice of the specific epithet because these authors overlooked the name *D. glacialis* (Funck ex Brid.) Wallr. (Wallroth 1831: p. 184), which made the name of their new species an illegitimate later homonym. However, the epithet *glacialis* was soon legitimised as *Leptotrichum glaciale* Müll. Hal. (Müller 1851: p. 611).

In 1899 Carsten E. Borchgrevink, a leader of the British-financed *Southern Cross* Expedition of 1898–1900, which was the first British venture of the Heroic Age of Antarctic exploration, collected a moss in Victoria Land in continental East Antarctica which was reported by Gepp (1902) as an unnamed species of *Barbula* Hedw. It was soon described by Bryhn (1902) as a new genus and species, *Sarconeurum antarcticum* Bryhn. Subsequently, the species was rediscovered on Ross Island off Victoria Land by the British *Discovery* Expedition of 1902–1903 under the command of Robert F. Scott (Headland 1989). The material was examined by Cardot (1907) who found that it was identical to *Leptotrichum glaciale* of Müller (1851) and to *Sarconeurum antarcticum*. Considering the unique habit of this species due to the propaguloid leaf apices, Cardot (1907) maintained *Sarconeurum* Bryhn as a separate genus, making the relevant nomenclatural change, *Sarconeurum glaciale* (Müll. Hal.) Cardot & Bryhn upon transfer of *Leptotrichum glaciale* to *Sarconeurum*.

Caducous leaf apices are not unique to *Sarconeurum glaciale* but they are also known in other species of pot-tialean mosses, including the Fuegian *Tortula lithophila* Dusén and *T. pygmaea* Dusén which are now considered conspecific, the former name having priority (Ochyra & Zander 2007). The ostensible morphological similarity of these three species prompted Greene (1975) to consider them identical, thereby extending the geographical range of *S. glaciale* to Patagonia and Tierra del Fuego in southern South America.

Ochyra & Zander (2007) accepted the congenericity of *Sarconeurum* and *Syntrichia* because they found that the genericity of the former, *Sarconeurum antarcticum* which was then considered to be conspecific with *S. glaciale*, fits perfectly into the concept of *Syntrichia* sect. *Aesio-tortula* R. H. Zander. As a result, this species was transferred to the genus *Syntrichia*, but its name was changed to *Syntrichia sarconeurum* which was published as an explicit substitute for the legitimate name *Leptotrichum glaciale* because the epithet *glacialis* was unavailable in *Syntrichia* due to *S. glacialis* (Kunze ex Müll. Hal.) R. H. Zander (Zander 1993: p. 269). At the same time these authors accepted *S. lithophila* to be a distinct species, though closely related to *S. sarconeurum* (Ochyra & Zander 2007).

A taxonomic treatment of the Antarctic species of *Syntrichia* with caducous leaf apices, including an identification key, descriptions and geographical distribution, will be published separately. The present account intends to address the taxonomic and nomenclatural implications of the phylogeographic studies of the broadly conceived *S. sarconeurum* based on molecular analyses (Sařuga et al. 2022).

Materials and methods

The work is based on a comprehensive study of the relevant literature concerning the Antarctic representatives of the genus *Syntrichia* and related South American and Australasian taxa to propose adequate taxonomic and nomenclatural changes congruent with a recent detailed genetic assessment of the samples from the whole geographical range of the species concerned (Sařuga et al. 2022). The analysis of morphological features relied upon examination of extensive herbarium collections from KRAM and nomenclatural changes are based upon study of the type specimens from BM, FH, L, NY, O, PC, S and UPS. The proposed nomenclatural changes have been implemented in accordance with the relevant provisions of the *International Code of Nomenclature for algae, fungi, and plants* (ICNafp) (Turland et al. 2018).

Results and discussion

As presently circumscribed, *Syntrichia sarconeurum* is morphologically a very variable species (Ochyra et al. 2008) and its phenotypic plasticity is coupled with the conspicuous genetic variation (Selkirk et al. 1997; Skotnicki et al. 1999, 2000, 2004). With the recent availability of new molecular data, it has been firmly established that the different representatives previously referred to this taxon, should no longer be considered as representing one and the same species (Sařuga et al. 2022). Phylogenetic reconstruction, in particular that based on ribosomal nuclear sequences, as well as network estimation of all known haplotypes from southern South America (Patagonia), East and West Antarctica, identified three main genetic lineages demarcating the clear separation between specimens from Patagonia, the peri-Antarctic archipelagoes of the South Orkney Islands and the South Shetland Islands, the Antarctic Peninsula region south to Alexander Island, as well as Coats Land and Dronning Maud Land (continental Antarctica) on the one hand and those from the remaining coastal and inland areas of the Antarctic continent on the other. A genetic discontinuity has also been found within specimens from Victoria Land localities corresponding, geographically, to the position of the Borchgrevink Coast versus Dufek and Scott Coast. These genetic results strongly challenged the taxonomic status of *S. sarconeurum* and show that an extended biosystematic analysis is needed to draw reliable conclusions at the taxonomic level. Published multilocus analyses have converged with conclusions based on morphological studies, providing additional support for this view. However, the morphological diversification between specimens from different parts of Victoria Land has not been confirmed.

As a result of detailed molecular and morphological studies, *Syntrichia sarconeurum* is considered conspecific with *S. lithophila* as some earlier authors suggested (Greene 1975; Matteri 1982, 1985; Lightowlers 1985). However, according to Art. 11.4 of the ICNafp (Turland et al. 2018) the correct name for the ultimate species has to be *S. lithophila* which is based on *Tortula lithophila*, a legitimate name validly published in 1906 (Dusén 1906)

and it is the next earliest legitimate name at the rank of species to be used. In contrast, *S. sarconeurum* takes priority from 2007 when it was published as an explicit substitute for the legitimate names *Leptotrichum glaciale* and *Sarconeurum antarcticum* because the epithets *glacialis* and *antarctica* were unavailable in *Syntrichia* since they were blocked by *Syntrichia glacialis* (Müll. Hal.) R. H. Zander and *S. antarctica* (Hampe) R. H. Zander (Ochyra & Zander 2007).

Syntrichia lithophila occurs in Patagonia and Tierra del Fuego in southern South America, in the Antarctic Peninsula region in West Antarctica and on Coats Land and Dronning Maud Land in westernmost East Antarctica. On the other hand, the plants widely distributed in East Antarctica, from MacRobertson Land to Victoria Land and Marie Byrd Land, were originally described as *Sarconeurum antarcticum* which is here reinstated as a species in its own right. This species is named *Syntrichia frigorieserticola* Ochyra, Saługa & Ronikier which is published as an explicit substitute for *Sarconeurum antarcticum* under Art. 6.11 of the ICNafp (Turland et al. 2018) because the epithet *antarcticum* is blocked in *Syntrichia* by *S. antarctica* (Hampe) R. H. Zander (Zander 1993: p. 267).

Finally, the Australian and New Zealand plants once determined as *Syntrichia pygmaea* (Zander 1993; Streimann 1997; Streimann & Klanzenga 2002) are definitely distinct from South American and Antarctic ones, as also supported by the genetic data (Saługa et al. 2022). Actually, they represent a separate species which was originally described from New Zealand as *Tortula abruptinervis* Dixon (Dixon 1923), which was subsequently considered identical to *S. pygmaea* by Zander (1993: p. 267) who also intended to transfer this species to *Syntrichia* but the relevant new combination was not validly published because the basionym was not cited. It is validated here.

Nomenclatural implications

The conspecificity of *Syntrichia sarconeurum* and *S. lithophila* and the reinstatement of *Sarconeurum antarcticum* as a distinct species necessitate the following synonymy and nomenclatural changes.

Syntrichia lithophila (Dusén) Ochyra & R. H. Zander, *Fragm. Florist. Geobot. Polonica* 14: 210. 2007

≡ *Tortula saxicola* Dusén, *Bot. Not.* 1905: 301. 15 Dec. 1905, hom. illeg. [non *Tortula saxicola* Cardot, 31 Oct. 1905] ≡ *Tortula lithophila* Dusén, *Ark. Bot.* 6(8): 23, pl. 8 f. 14 & pl. 9 f. 2–5. 1906 [‘lithopila’ corr. l.c. 24, 38].

Type citation: Fuegia septentrionalis, in saxis.

Lectotype (vide Ochyra & Zander 2007: p. 210): “Plantae in regione Magellanico lectae. 109. *Tortula lithophila* Dus. Tierra del Fuego: Porvenir 1895 23/xii P. Dusén” – UPS!; isolectotypes: L!, PC!, S-Roth/Möller!

= *Didymodon glacialis* Hook. f. & Wilson, *Fl. Antarct.* 2: 408, pl. 152 f. 6. 1847, hom. illeg. [non *D. glacialis* (Funck ex Brid.) Wallr., 1831] ≡ *Leptotrichum glaciale* Müll. Hal., *Syn. Musc. Frond.* 2: 611. 1851 ≡ *Sarconeurum glaciale* (Müll. Hal.) Cardot & Bryhn in F. J. Bell, *Natl. Antarct. Exped. Nat. Hist.* 3 Musci: 3. 1907 ≡ *Syntrichia sarconeurum* Ochyra & R. H.

Zander, *Fragm. Florist. Geobot. Polonica* 14: 210. 2007 [non *Syntrichia glacialis* (Kunze ex Müll. Hal.) R. H. Zander, 1993 ≡ *Barbula glacialis* Kunze ex Müll. Hal., 1849; nec non *S. antarctica* (Hampe) R. H. Zander, 1993 ≡ *Barbula antarctica* Hampe, 1849].

Type citation: Cockburn Island, lat. 64° S. 57° W (barren).

Lectotype (vide Ochyra et al. 2008: p. 377): “Cockburn Island N°. 4. *Didymodon ? glacialis* H. fil & Wils.” – BM-Wilson!; isolectotypes: BM!, NY-Mitten! (4 specimens), PC!, syn. nov.

= *Tortula pygmaea* Dusén, *Ark. Bot.* 6(10): 8, pl. 1 f. 13–17.

1907 ≡ *Syntrichia pygmaea* (Dusén) R. H. Zander, *Bull. Buffalo Soc. Nat. Sci.* 32: 269. 1993.

Type citation: Patagonia australis ad lac. Lago Argentino ad saxa campestris nec non in fageto ad truncos arborum.

Lectotype (vide Ochyra & Zander 2007: p. 210): “Plantae Patagonicae e territorio S^{ia} Cruz reportatae. *Tortula pygmaea* Dus. Lago Argentino in fageto ad truncos putridos Jan. a. 1905 P. Dusén” – S!; isolectotypes: BM!, PC!, S! First synonymised by Ochyra & Zander (2007: p. 210).

Notes. (1) When describing *Tortula lithophila*, Dusén (1906) used initially the epithet *lithopila*. It was an orthographic error which was immediately corrected by the author elsewhere in the same paper and the epithet *lithophila* is generally accepted for this species. It is worth noting that Dusén (1905) originally described this species as *Tortula saxicola* but he soon discovered that this name was a later homonym of *T. saxicola* Cardot, a species described one month and a half earlier, on 31 October 1905, by Cardot (1905), also from material collected in Tierra del Fuego. Accordingly, a year later Dusén (1906) substituted the illegitimate name *T. saxicola* Dusén for *T. lithophila*.

(2) Initially, Cardot (1908) accepted both *Tortula lithophila* and *T. pygmaea* as distinct species. However, when Cardot & Brotherus (1923) later reported material collected in Andine Patagonia by the Swedish Expedition to Patagonia und Tierra del Fuego of 1907–1909 as *T. pygmaea*, they only accepted *T. pygmaea* and placed *T. lithophila* in synonymy of this name. It was an incorrect conclusion because *T. lithophila* was actually an earlier name having priority, thus the situation should be reversed. This error was noted by the compilers of *Index muscorum* (Wijk et al. 1969) and *T. lithophila* was accepted as a distinct species and *T. pygmaea* was considered its synonym.

Syntrichia frigorieserticola Ochyra, Saługa & Ronikier, nom. nov.

≡ *Sarconeurum antarcticum* Bryhn, *Nyt Mag. Naturvidensk.* 40: 205, pl. 1 f. 1–10 & pl. 2 f. 1–12. 1902 [non *S. antarctica* (Hampe) R. H. Zander].

Type citation: Habitat in terra antarctica „Newnes-Land” et in terra antarctica „Geikie-Land”, ubi clarus Carsten Borchgrevink [sic!], versus tractus austro-polares observandi causa peregrinatus, circiter sub parallelis 73° latitudinis australis et 170° longitudinis orientalis hunc muscum solum anno 1899 reperivit et specimina perpauca unde domum adtulit. Loco primo altitudine supra mare metrorum 6–7, in loco secundo altitudine circiter 100 m., locis ambobus ad rupes detritas, sociis speciebus lichenum mihi ignotis.

Lectotype (vide Ochyra et al. 2008: p. 377): “*Sarconeurum antarcticum* Bryhn In peninsula antarctica „Newnes-Land” 20 pedes supra mare 1898–1900 leg. C. Borchgrevink” – O-Bryhn!; isolectotypes: H-Brotherus!, O-Bryhn (2 specimens)!, PC!

Syntype: “*Sarconeureum antarcticum* Bryhn In terra antarctica (100 m.) „Gikie-Land” leg. E. Borchgrevink” – O-Bryhn!; isosyntypes: BM!, FH!, O!

Note. The species name *frigidideserticola* means a dweller of cold icy deserts which correspond to severe climatic conditions in continental Antarctica where this species is known to occur. It is a compound epithet derived from the Latin words *frigus* meaning cold or frost, *desertum* denoting desert and *-cola* signifying -dweller which is used adjectivally in compound words but then treated as a noun in apposition for all genders (it is derived, in turn, from the Latin verb *colo* meaning inhabit or dwell).

Syntrichia abruptinervis (Dixon) R. H. Zander ex Ochyra, Sařuga & Ronikier, comb. nov.

≡ *Tortula abruptinervis* Dixon, New Zealand Inst. Bull. 3: 150, pl. 8 f. 6., 1 Aug. 1923 [*Syntrichia abruptinervis* (Dixon) R. H. Zander, Bull. Buffalo Soc. Nat. Sci. 32: 323. 1993, nom. inval. basion. non citat.].

Type citation: [New Zealand] On trees, with *Orthotricha*, &c.; bank of Waipoua River, Masterton, Wairarapa; Nov. 1914; W. Gray, No. 213.

Type: not seen.

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References

- Bryhn, N. 1902. *Sarconeureum*, genus muscorum novum. *Sarconeureum antarcticum* sp. nov. In: Wille, N. (ed.), *Mitteilungen über einige von C. Borchgrevink auf dem antarctischen Festlande gesammelte Pflanzen. I. Nyt Magazin for Naturvidenskaberne* 40: 204–208 + Tab. 1–2. <https://www.biodiversitylibrary.org/item/109237#page/212/mode/1up>
- Cardot, J. 1905. Notice préliminaire sur les mousses recueillies par l'Expédition antarctique suédoise. I. Espèces de la région magellanique. *Bulletin de l'Herbier Boissier, Série 2*, 5(11): 997–1011 [effectively published on 31 October 1905]. <https://www.biodiversitylibrary.org/item/104932#page/1077/mode/1up>
- Cardot, J. 1907. Musci. In: Bell, F. J. (ed.), *National Antarctic Expedition 1901–1904. Natural history*. Vol. 3. Zoology and botany (Invertebrata: marine Algae, Musci). Printed by order of the Trustees of the British Museum, London, 6 pp. + 2 pls. <https://www.biodiversitylibrary.org/item/15646#page/403/mode/1up>
- Cardot, J. 1908. La flore bryologique des terres magellaniques, de la Géorgie du Sud et de l'Antarctide. In: *Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition 1901–1903 unter Leitung von Dr. Otto Nordenskjöld*. Band 4. Lieferung 8. Lithographisches Institut des Generalstabs, Stockholm, 298 pp. + 11 pls. https://bibdigital.rjb.csic.es/medias/02/cd/b0/18/02cdb018-ef02-4bdb-afca-4cb441273610/files/CAR_Fl_Bryol_Magell.pdf
- Cardot, J. & Brotherus, V. F. 1923. Botanische Ergebnisse der Schwedischen Expedition nach Patagonien und dem Feuerlande 1907–1909. X. Les mousses. *Kongliga Svenska Vetenskapsakademiens Handlingar* 63(10): 1–74 + pls. 1–4. <https://bibdigital.rjb.csic.es/en/records/item/12063-botanische-ergebnisse-der-schwedischen-expedition-nach-patagonien-und-dem-feuerlande-les-mousses>
- Crosby, M. R., Magill, R. E., Allen, B. & He, S. 2000. *A checklist of the mosses*. Missouri Botanical Garden, St. Louis, 320 pp.
- Dixon, H. N. 1923. Studies in the bryology of New Zealand, with special reference to the herbarium of Robert Brown, of Christchurch, New Zealand. Part III. *New Zealand Institute Bulletin* 3(3): 75–152 + pls. vii–viii. <https://www.biodiversitylibrary.org/item/67752#page/109/mode/1up>
- Dusén, P. 1905. Musci nonnulli novi e Fuegia et Patagonia reportati. *Botaniska Notiser* 1905(6): 299–310 [effectively published on 15 December 1905]. <https://www.biodiversitylibrary.org/item/210848#page/664/mode/1up>
- Dusén, P. 1906. Beiträge zur Bryologie der Magellansländer, von Westpatagonien und Südchile. IV. *Arkiv för Botanik* 6(8): 1–40 + Taf. 1–12. <https://www.biodiversitylibrary.org/item/91215#page/217/mode/1up>
- Dusén, P. 1907. Beiträge zur Bryologie der Magellansländer, von Westpatagonien und Südchile. V. *Arkiv för Botanik* 6(10): 1–32 + Taf. 1–6. <https://www.biodiversitylibrary.org/item/91215#page/336/mode/1up>
- Gepp, A. 1902. XXI. Cryptogamia. Musci. In: *Report on the collections of natural history made in Antarctic regions during the voyage of the 'Southern Cross'*, p. 319. British Museum (Natural History), London. <https://www.biodiversitylibrary.org/item/63052#page/332/mode/1up>
- Greene, S. W. 1975. The Antarctic moss *Sarconeureum glaciale* (C. Muell.) Card. et Bryhn in southern South America. *British Antarctic Survey Bulletin* 41/42: 187–191.
- Headland, R. K. 1989. *Chronological list of Antarctic expeditions and related historical events*. Cambridge University Press, Cambridge – Sydney, ix + 730 pp.
- Lightowers, P. J. 1985. *Tortula lithophila* Dus. is *Sarconeureum glaciale* (C. Muell.) Card. et Bryhn. *The Bryologist* 88(4): 365–366. <https://doi.org/10.2307/3242677>
- Matteri, C. M. 1982. Patagonian bryophytes 6. Fruiting *Sarconeureum glaciale* (C. Muell.) Card. et Bryhn newly found in southern Patagonia. *Lindbergia* 8(2): 105–109. <https://www.jstor.org/stable/20149428>
- Matteri, C. M. 1985. Catalogo de los musgos. In: Boelcke, O., Moore, D. M. & Roig, F. A. (eds), *Transecta botanica de la Patagonia austral*, pp. 265–297. Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina), Instituto de la Patagonia (Chile) and Royal Society (Gran Bretaña), Buenos Aires, Buenos Aires.
- Müller, C. 1851. *Synopsis muscorum frondosorum omnium hucusque cognitorum*. Pars secunda. Musci vegetationis pleurocarpicae. Sumptibus Alb. Foerstner, Berolini, 772 pp. <https://www.biodiversitylibrary.org/item/84#page/1/mode/1up>
- Ochyra, R. & Zander, R. H. 2007. Is *Tortula lithophila* conspecific with *Sarconeureum glaciale* (Bryopsida: Pottiaceae)? *Fragmenta Floristica et Geobotanica Polonica* 14: 209–212 (in Polish with extensive English summary). http://bomax.botany.pl/cgi-bin/pubs/data/article_pdf?id=4070
- Ochyra, R., Lewis Smith, R. I & Bednarek-Ochyra, H. 2008. *The illustrated moss flora of Antarctica*. Cambridge University Press, Cambridge, xvii + 685 pp. [+ 24 unnumbered pp. with plates].
- Sařuga, M., Ochyra, R. & Ronikier, M. 2022. Phylogeographical breaks and limited connectivity among multiple refugia in a pan-Antarctic moss species. *Journal of Biogeography* 49(11): 1991–2004. <https://doi.org/10.1111/jbi.14476>
- Selkirk, P. M., Skotnicki, M. L., Adam, K. D., Connett, M. B., Dale, T., Joe, T. W. & Armstrong J. 1997. Genetic variation in Antarctic populations of the moss *Sarconeureum glaciale*. *Polar Biology* 18: 344–350. <https://doi.org/10.1007/s003000050198>
- Skotnicki, M. L., Mackenzie, A. & Selkirk, P. M. 2004. Mosses surviving on the edge: origins, genetic diversity, and mutations in Antarctica. In: Goffinet, B., Hollowell, V. & Magill, R. (eds), *Molecular*

- systematics of bryophytes. Monographs in Systematic Botany from the Missouri Botanical Garden* 98: 388–403.
- Skotnicki, M. L., Ninham, J. A. & Selkirk, P. M. 1999. Genetic diversity and dispersal of the moss *Sarconeurum glaciale* on Ross Island, East Antarctica. *Molecular Ecology* 8: 753–762. <https://doi.org/10.1046/j.1365-294X.1999.00619.x>
- Skotnicki, M. L., Ninham, J. A. & Selkirk, P. M. 2000. Genetic diversity, mutagenesis and dispersal of Antarctic mosses – a review of progress with molecular studies. *Antarctic Science* 12(3): 363–373. <https://doi.org/10.1017/S0954102000000419>
- Streimann, H. 1997. *Musci Australasiae Exsiccati*. Fasc. 14 (no. 351–400). Cryptogamic Herbarium, Centre for Plant Biodiversity Research, Canberra, 26 [unnumbered] pp.
- Streimann, H. & Klanzenga, N. 2002. Catalogue of Australian mosses. *Flora of Australia Supplementary Series* 17: [1–5] + 1–259.
- Turland, N. J., Wiersema, J. H., Barrie, F. R., Greuter, W., Hawksworth, D. L., Herendeen, P. S., 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. (eds). 2018. *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017*. [Regnum Vegetabile Volume 159]. Koeltz Scientific Books on behalf of the International Association for Plant Taxonomy, Glashütten, xxxviii + 254 pp. <https://doi.org/10.12705/Code.2018>
- Wallroth, F. G. 1831. *Flora cryptogamica Germaniae*. Pars prior continens Filices, Lichenastra, Muscos et Lichenes. Sumtibus J. L. Schragii, Norimbergae, xxvi, [xxvii] + 654 pp. https://books.google.pl/books?id=iCmdYXjRID0C&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
- Wijk, R. van der, Margadant, W. D. & Florschütz, P. A. 1969. *Index muscorum*. Volume 5 (T–Z, Appendix). [Regnum Vegetabile Volume 65]. International Bureau for Plant Taxonomy and Nomenclature of the International Association for Plant Taxonomy, Utrecht, xii + 922 pp.
- Wilson, W. & Hooker, J. D. 1847. Musci. In: Hooker, J. D., *The botany of the Antarctic voyage of H. M. Discovery ships Erebus and Terror in the years 1839–43, under the command of Captain Sir James Clark Ross, Kt., R. N., F. R. S.* Vol. 1. Flora antarctica. Part. II., Botany of Fuegia, the Falklands, Kerguelen's Land, etc., pp. 395–423, 550–551 + pls. cli–clv. Reeve Brothers, London. <https://www.biodiversitylibrary.org/item/22023#page/431/mode/1up>
- Zander, R. H. 1993. Genera of the *Pottiaceae*: mosses of harsh environment. *Bulletin of the Buffalo Society of Natural Sciences* 32: i–vi + 1–378.