



<https://doi.org/10.11646/bde.46.1.6>

Warburgiella spinoseta (Bryophyta: Sematophyllaceae): a new moss species from Kaua‘i, Hawai‘i

SI HE¹ & TIM FLYNN²

¹Missouri Botanical Garden, 4344 Shaw Blvd., St. Louis, MO 63110, USA

si.he@mobot.org; <https://orcid.org/0000-0001-6560-6933>

²National Tropical Botanical Garden, 3530 Papalina Road, Kalāheo, HI 96741, USA

tflynn@ntbg.org; <https://orcid.org/0009-0000-2803-3486>

Abstract

Warburgiella spinoseta is described and illustrated as a new moss species and a new genus record from Hawai‘i. The new species is morphologically similar to *W. cupressinoides* and *W. leptorhynchoides* to some extent, but it differs in having entirely smooth, strongly thick-walled, porose laminal cells, a strikingly spinose upper seta, and a campanulate-cucullate calyptra with a papillose apex and an entire base.

Key words: Hawaiian Islands, Pacific Islands, Taxonomy

Introduction

Warburgiella Müller Hal. in Brotherus (1900: 176) is sometimes cited as “Müll.Hal. ex Broth.”, but the generic description is clearly attributed (in quotes) to “C.Müll. in litt. 22.8. 1892.” (Tropicos.org 2023). The genus has traditionally been characterized by the presence of a mitrate to campanulate calyptra (Brotherus 1900, 1925, Thériot 1910, Fleischer 1923, Dixon 1935). However, Buck & Tan (1989) and Ramsay *et al.* (2004) considered this character to be barely consistent or to have been overemphasized. They concluded that the calyptra in *Warburgiella* appears campanulate but is technically of the cucullate type. Buck & Tan (1989) subsequently redefined *Warburgiella* based on its strongly circinate leaves with long, serrate apices, thick-walled alar cells, and non-collenchymatous exothecial cells. Indeed, Bartram (1961) was the first author to advocate that the genus should be defined based on its leaf characters rather than on the so-called mitrate to campanulate calyptra. In the most recent study of the Sematophyllaceae from Papua New Guinea, Tan *et al.* (2017) stated that *Warburgiella* is best identified by stem and branch leaves with an expanded base and an abruptly narrowed, long and cuspidate acumen with serrate margins.

Warburgiella is a relatively small genus, with 5–6 better-known species and approximately 20 accepted names worldwide (Brinda and Atwood 2023). Apart from a few species reported in Australia, China, the Philippines, and Papua New Guinea (Bartram 1939, Ramsay *et al.* 2004, Tan & Jia 1999, Tan *et al.* 2017), most of the species in this genus remain poorly understood. The known species of *Warburgiella* are typically found on tree trunks in shaded and wet habitats in subtropical and tropical forests across Southeast Asia and Australia. Recently, a moss specimen (*T.Flynn* 9632) was collected from an exposed, dripping wet root in a shaded lowland *Metrosideros* Banks ex Gaertner (1788: 170) mixed forest on Kaua‘i Island, Hawai‘i. This moss exhibits all the characteristics of *Warburgiella* but possesses several distinctive features, such as a strikingly spinose upper seta, entirely smooth and strongly porose laminal cells, and a campanulate-cucullate calyptra with a papillose apex and an entire base. These peculiar traits combined clearly indicate the presence of an undescribed species within the genus *Warburgiella*. Therefore, we propose to describe it as a new species of *Warburgiella* from Hawai‘i. The genus is also a new record to the Hawaiian Islands.

Material and methods

For morphological comparisons, we conducted a thorough examination of herbarium specimens in *Warburgiella* and related genera at the Missouri Botanical Garden herbarium (MO). The specimens were carefully rehydrated, dissected, and mounted in Hoyer's solution following Anderson (1954). Observations, measurements, and photography were carried out using both stereo and compound microscopes, specifically a Nikon Eclipse E400 equipped with a digital camera.

Taxonomic treatment

Warburgiella spinososeta S.He & T.Flynn, sp. nov. (Fig. 1)

Type: HAWAII. Kaua'i: Hanalei District, Halelea Forest Reserve, Kawailewa, SE flank below Namolokama, 22.11712°N, 159.48547°W, alt. 991 m, 26 Sep 2022, *T. Flynn 9632* (holotype, PTBG-090058; isotypes, BISH, CAS, MO, US).

Diagnosis. The new species is distinguished from all known species of *Warburgiella* by a character combination of a strikingly spinose upper seta, entirely smooth, and strongly thick-walled and porose laminal cells, non-collenchymatous exothecial cells, and a campanulate-cucullate calyptra with an entire base and a papillose apex.

Description

Plants medium-sized, green to yellowish green, moderately glossy, in mats appressed to the substrate. *Stems* creeping, to 4 cm long, irregularly branched with short branchlets; in cross section with 2–3 layers of small, strongly thick-walled outer cells, and larger, moderately thick-walled cortical cells; central strand absent; paraphyllia absent; pseudoparaphyllia foliose; axillary hairs with a single brownish basal cell (ca. 20 µm long) and 2 exceedingly elongate, hyaline apical cells (up to 140 µm long). *Stem* and *branch leaves* similar, 2.8–3.2 × 0.45–0.55 mm, oblong-lanceolate, abruptly narrowed to a long, slender, apex, with leaf acumen as long as the leaf base, moderately falcate-secund due to long-slender leaf acumen; margins subentire to serrulate near apex, entire below; costa absent; laminal cells linear, smooth, 70–85 µm long, with cell lumen 4–5 µm wide, strongly thick-walled, porose, with walls nearly as thick as the lumen; cells at insertion yellowish, shorter than cells above, incrassate, porose; alar cells 2–3 in 1 row at both basal angles, relatively thick-walled, enlarged, inflated, often hyaline, becoming yellowish with age; supra-alar cells in one row of much smaller and shorter cells. Autoicous. *Perigonia* and *perichaetia* on separate branches or secondary stems; perigonal leaves small, scale-like, antheridia naked, without paraphyses; outer perichaetial leaves much smaller, inner perichaetial leaves similar to vegetative leaves in shape, but smaller (ca. 1.4–1.8 mm long) and distinctly serrate above mid-leaf, sheathing at base, with basal cells differentiated into shorter and broader cells, without inflated alar cells. *Setae* elongate, orange when mature, 12–15 mm long, ca. 100 µm wide, smooth below, strongly spinose above 2/3 the seta length, spines up to 47 µm long, nearly half of the seta width. *Capsules* inclined, cylindrical, 0.8–0.9 × 0.45–0.55 mm, papillose at neck; exothecial cells rectangular, not collenchymatous, some upper cells with nodular thickenings horizontally or longitudinally; stomata on neck, immersed; opercula long-rostrate, nearly as long as the urn; annuli reddish, consisting of 3–4 rows of oblate cells; peristome double; exostome teeth 16, lanceolate, subulate, furrowed with a deep median groove line, densely papillose and cross-striate below, coarsely papillose above; endostome segments 16, slightly longer than the teeth, keeled, perforate, hyaline, papillose; basal membrane high; cilia 2, nodose, papillose. *Spores* papillose, 12–16 µm in diameter. *Calyptrae* campanulate-cucullate, split vertically on side, entire at base, weakly papillose near apex.

Etymology. The specific epithet '*spinososeta*' refers to its spinose setae.

Habitat: Mat-forming on exposed, dripping wet root in a shaded, narrow and steep-sided ravine along ephemeral watercourse. Lowland wet *Metrosideros* forest with *Psychotria*, *Dubautia*, *Melicope*, and *Cuanea* spp.

Distribution: Only found on Kaua'i Island, Hawai'i.

Conservation Status: This species has not undergone a scientific evaluation. Therefore, an appropriate conservation status code is "Not Evaluated" (IUCN 2022).

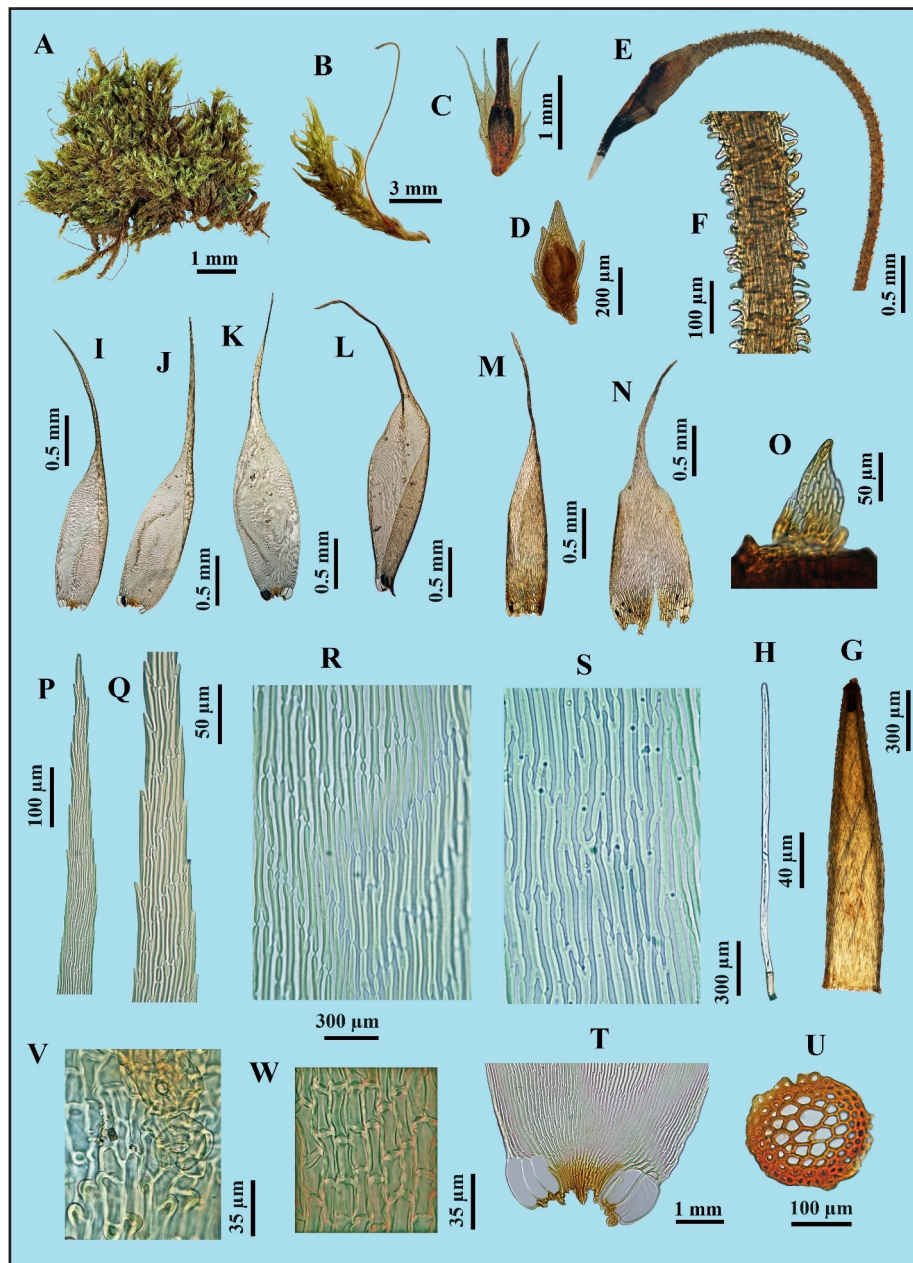


FIGURE 1. *Warburgiella spinososea*. A. Habit. B. A leafy branch with seta. C. Perichaetium. D. Perigonium. E. Capsule on seta. F. a portion of upper seta. G. Calyptra. H. Axillary hair. I–L. Leaves. M–N. Inner perichaetial leaves. O. Pseudoparaphyllum. P. Leaf apex. Q. Subapical laminal cells. R– S. Median laminal cells. T. Basal leaf and alar cells. U. Cross section of stem. V. A neck portion of capsule showing stomata and papillose exothecial cells. W. Exothecial cells. (A from <https://ntbg.org/database/herbarium/detail/PTBG1000094130>, accessed 18 Sep 2023; *T. Flynn 9632*, the holotype, PTBG; all other images prepared from *T. Flynn 9632*, isotype, MO).

Discussion

The setae of *Warburgiella* have historically been described as having variations from smooth to papillose on their upper seta surfaces. However, none have shown the strikingly spinose feature found in the new species (Fig. 1F). Most *Warburgiella* species typically present strongly falcate-secund leaves with distinctly serrate apical leaf margins. Their laminal cells are usually prorate and distinctly papillose, although occasionally some cells are smooth. In contrast, *Warburgiella spinososea* features moderately falcate-secund leaves that display fewer serrations on the leaf apex. Its laminal cells are entirely smooth, strongly thick-walled, and porose (Fig. 1R–S).

In the literature, Buck & Tan (1989), Ramsay *et al.* (2004), and Tan *et al.* (2017) have described the general pattern

in *Warburgiella* species as having laminal cells that range from weakly papillose to distinctly papillose. However, there is an exception in *W. cupressinoides* Müller Hal. in Brotherus (1900: 176), which occasionally exhibits smooth laminal cells alongside prorate and papillose cells. Unlike *W. spinososeta*, *W. cupressinoides* possesses both smooth cells and prorate or low papillose cells on the same leaves. This renders the leaf cells in *W. cupressinoides* not entirely smooth, as Bartram (1939) noted that they are smooth below or unipapillate above. Additionally, *W. cupressinoides* can be distinguished from *W. spinososeta* by its strongly serrate leaf apices, smooth or weakly papillose to pustulose upper setae, and mitrate or campanulate calyptra with a lacinate base (Bartram 1939). Furthermore, while the perichaetial leaves in *W. cupressinoides* are larger than the vegetative leaves, in *W. spinososeta*, the perichaetial leaves are smaller.

Warburgiella spinososeta also shares some similarities with *W. leptorhynchoides* (Mitten 1859: 103) Fleischer (1923: 1253) in terms of general leaf shape, a filiform leaf apex, enlarged alar cells, and weakly serrulate leaf acumens. However, the latter often has low-unipapillose laminal cells and smooth to only pustulose upper setae.

The entirely smooth, incrassate, strongly pitted laminal cells, and thin-walled alar cells observed in *W. spinososeta* bear a resemblance to certain species within *Acroporium* Mitten (1868: 182), particularly the highly variable and widespread species, *A. strepsiphylum* (Montagne 1844: 632) Tan in Touw (1992: 353) and *A. stramineum* (Reinwardt & Hornschuch 1829: 717) Fleischer (1923: 1301). However, *Acroporium* species can be distinguished by their typically strongly concave to convolute leaves, often exhibiting entire apical leaf margins, collenchymatous exothecial cells, and a typically cucullate calyptra (Ramsay *et al.* 2004, Tan *et al.* 2007).

In Hawai'i, *Warburgiella spinososeta* may also bear some resemblance to *Trichosteleum hamatum* (Dozy & Molkenboer 1844: 11) Jaeger in Jaeger & Sauerbeck (1878: 420) [= *Radulina hamata* (Dozy & Molkenboer 1844: 11) Buck & Tan (1989: 10) ≡ *Radulina borbonica* (Bélangier 1834: 97) Buck (1993: 208)] due to its distinctly spinose upper setae, long-rostrate operculae, and falcate-secund leaves (Bartram 1933). However, *T. hamatum* clearly differs by having laminal cells adorned with a row of small papillae over the lumen and strongly collenchymatous exothecial cells. The porose and never papillose laminal cells, as well as the non-collenchymatous exothecial cells, serve as key differentiators for *W. spinososeta* from *Trichosteleum hamatum*. Finally, uniformly unipapillose to pluripapillose laminal cells and strongly collenchymatous exothecial cells are reliable distinguishing features that separate other species of *Trichosteleum* Mitten (1868: 181) from *Warburgiella* (Tan *et al.* 2017).

The new species likewise shares some similarities with *Rhaphidostichum pustulatum* Hoe (1973: 313), which is found in Hawai'i and features incrassate, porose laminal cells. Nevertheless, *R. pustulatum* has a much shorter leaf acumen (approximately 1/4–1/5 the length of the leaf), lightly papillose cells throughout, and a smooth seta. The distinctive feature that sets *Warburgiella spinososeta* apart is its strongly spinose upper setae with spines measuring up to 45 µm in length (Fig. 1F), nearly half the width of the setae (approximately 100 µm wide).

Warburgiella spinososeta furthermore exhibits similarities to *Rhaphidostichum piliferum* (Brotherus 1905: 9) Brotherus (1925: 434) in terms of leaves ending in an abruptly narrowed, long, piliform acumen, as well as smooth, thick-walled, often incrassate, porose laminal cells. However, *R. piliferum* only has indistinctly pustulose setae near the apex and strongly collenchymatous exothecial cells.

The morphology of axillary hairs in *Warburgiella* has received limited attention in many previous studies. Buck & Tan (1989) described the genus as having axillary hairs with a single short, brownish basal cell and 1–2 elongate, hyaline apical cells. Although no previous studies have illustrated the exact details of axillary hairs in the genus to our knowledge, it is worth describing the formation of axillary hairs in *W. spinososeta* (Fig. 1H). In this species, each hair consists of a short, single brownish basal cell and two exceedingly elongate, hyaline apical cells. The remarkable length of the two apical cells and one much shorter basal cell distinguish them from the axillary hairs in some other pleurocarpous mosses (Higuchi 1985, Nishimura 1985).

Another related genus to *Warburgiella* is *Rhaphidorrhynchium* Bescherele ex Fleischer (Fleischer 1923: 1245). *Rhaphidorrhynchium* differs from *Warburgiella* in having strongly collenchymatous exothecial cells and non-sheathing inner perichaetial leaves (Ramsay *et al.* 2004). In the family Sematophyllaceae, most genera exhibit strongly collenchymatous exothecial cells, with only a few exceptions, including *Warburgiella*, which possesses non-collenchymatous exothecial cells (Fig. 1W).

Other selected specimens examined:—*Warburgiella breviseta* (Brotherus 1913: 93) Brotherus (1925: 429). PHILIPPINES. Luzon: Quezon Prov., 26 Apr 1984, *W.S. Gruezo & E. Juras WM9482* (MO-3071730); Mindanao: North Cotabato Prov., 30 Apr 2014, *J. Shevock 44993* (CAS, MO-6624248).

Warburgiella cupressinoides. PHILIPPINES. Bukidnon Prov., 23 Apr 2014, *J. Shevock 44845* (CAS, MO-6625920). Mondanao, Davao Prov., 13 Mar 1956, *J.V. Pancho 2567* (MO-5373000), *J.V. Pancho 2618* (MO-5373001). VIETNAM. Lam Dong, Lac Duong District, 12 Apr 2010, *S.He & K. Nguyen 42832* (MO-6236875).

Warburgiella leptocarpos (Schwägrichen 1827: 171) Fleischer (1923: 1253. **PHILIPPINES**. Luzon: Benguet Prov., E.D. Merrill 7863 (MO-757090).

Warburgiella leptorrhyncha (Jaeger 1878: 404) Brotherus (1925: 429). **MADAGASCAR**. Toamasina: Alaotra-Mangoro, 1 Oct 2018, J. Brinda 12288 (MO-6969411).

Warburgiella leucocytus (Müller 1851: 314) B.C. Tan *et al.* (1998: 221). **AUSTRALIA**. Tasmania: Tim Shea, 18 Mar 1973, D.A. Ratkowsky & A.V. Ratkowsky B61A (MO-6168434).

Warburgiella subleptorrhynchoides (Fleischer 1905: 321) Fleischer (1923: 1250) (\equiv *W. leptorrhynchoides*). **NEW CALEDONIA**. Mt. Boulinda, 13 Oct 1972, H. Moore 10083 (MO-5224940); Mt. Dzumac, 18 Jun 1981, G. McPherson 3854 (MO-3086272).

Warburgiella subpapuana Dixon (1943: 38) (\equiv *W. leptorrhynchoides*). **PAPUA NEW GUINEA**. Boridi, 6 Oct 1935, C.E. Carr 14434 (MO-2860911); Central, 18 Dec 1935, C.E. Carr 13872 (MO-405116).

This paper is dedicated in memory of Dr. David Meagher who was a strong advocate of bryology.

Acknowledgements

Thanks to Adam Williams, Kaua‘i District Botanist, Department of Land and Natural Resources, State of Hawai‘i and Scott Heintzman, Kaua‘i Plant Extinction Prevention Program Coordinator, Pacific Cooperative Studies Unit (PCSU), University of Hawai‘i at Mānoa for providing access to and guidance in the collection site. We are grateful to the two anonymous reviewers for their useful comments.

References

- Anderson, L.E. (1954) Hoyer's solution as a rapid permanent mounting medium for bryophytes. *The Bryologist* 57 (3): 242–244.
[https://doi.org/10.1639/0007-2745\(1954\)57\[242:HSAARP\]2.0.CO;2](https://doi.org/10.1639/0007-2745(1954)57[242:HSAARP]2.0.CO;2)
- Bartram, E.B. (1933) Manual of Hawaiian mosses. *Bernice P. Bishop Museum Bulletin* 101: 1–275.
- Bartram, E.B. (1939) Mosses of the Philippines. *Philippine Journal of Science* 68: 1–437.
- Bartram, E.B. (1961) Low altitude mosses from northeastern New Guinea. *Brittonia* 13: 368–380.
<https://doi.org/10.2307/2805415>
- Bélangier, C.P. (1834) *Voyage aux Indes Orientales, Botanique* 2(Crypt.). Ministres de la Marine et de l'Intérieur, Paris, pp. 81–192.
- Brinda, J.C. & Atwood, J.J. (2023) A Synopsis of *Warburgiella*. *The Bryophyte Nomenclator*, 19 June 2023. [<https://www.bryonames.org/nomenclator?group=warburgiella>]
- Brotherus, V.F. (1900) *Nachtrag zu den Musci*. Monsunia. Verlag von Wilhelm Engelmann, Leipzig, pp. 175–177.
- Brotherus, V.F. (1905) Contributions to the bryological flora of the Philippines. I. Öfversigt af Finska Vetenskaps-Societetens Förhandlingar 47 (14): 1–12.
- Brotherus, V.F. (1913) Contributions to the bryological flora of the Philippines IV. *The Philippine Journal of Science*, Section C 8: 65–98.
- Brotherus, V.F. (1925) *Musci (Laubmoose)* 2. Hälfte. 11. In: Engler, H.G.A. & Prantl, K. (Eds.) *Die Natürlichen Pflanzenfamilien* (ed. 2). Duncker & Humblot, Berlin, 542 pp., 796 fig.
- Buck, W.R. (1993) Taxonomic Results of the BRYOTROP expedition to Zaïre and Rwanda. 24. Leskeaceae, Brachytheciaceae, Stereophyllaceae, Plagiotheciaceae, Entodontaceae, Sematophyllaceae p. pte., Hypnaceae (except *Hypnum*). *Tropical Bryology* 8: 199–217.
<https://doi.org/10.11646/bde.8.1.25>
- Buck, W.R. & Tan, B.C. (1989 [1990]) The Asiatic genera of Sematophyllaceae associated with *Trichosteleum*. *Acta Bryolichenologica Asiatica* 1: 5–19.
- Dixon, H.N. (1935) A contribution to the moss flora of Borneo. *Journal of the Linnean Society, Botany* 50: 57–140.
<https://doi.org/10.1111/j.1095-8339.1935.tb01502.x>
- Dixon, H.N. (1943) Alpine mosses from New Guinea. *Farlowia* 1 (1): 25–40.
- Dozy, F. & Molkenboer, J.H. (1844) *Muscorum Frondosorum Archipelago Indico et Japonica*. H. W. Hazenberg & Soc., Leiden, [vi] + 22 pp.
- Fleischer, M. (1905) Neue Gattungen und Arten der Musci Archipelagi Indici. *Hedwigia* 44: 301–330.

- Fleischer, M. (1923) *Musci Buitenzorg* 4. Brill, Leiden, pp. i–xxxi + 1105–1729.
- Gaertner, J. (1788) *De Fructibus et Seminibus Plantarum*. 1. In: Gaertner, J. *Fructibus Seminibus Plantarum*. Typis Academiae Carolinae, Stutgardiae, 1–384, t. 1–t. 79.
<https://doi.org/10.5962/bhl.title.102753>
- Higuchi, M. (1985) A taxonomic revision of the genus *Gollania* (Musci). *Journal of the Hattori Botanical Laboratory* 59: 1–77.
https://doi.org/10.18968/jhbl.59.0_1
- Hoe, W.J. (1973) *Glossadelphus abortivapicus* and *Rhaphidostichum pustulatum*, new species of the Sematophyllaceae from Hawaii. *The Bryologist* 76: 310–314.
<https://doi.org/10.2307/3241338>
- IUCN (2022) Guidelines for Using the IUCN Red List Categories and Criteria, Version 15.1. Prepared by the Standards and Petitions Committee. [https://nc.iucnredlist.org/redlist/content/attachment_files/RedListGuidelines.pdf]
- Jaeger, A. & Sauerbeck, F. (1878) Adumbratio flore muscorum totius orbis terrarum. Part 8. *Bericht über die Thätigkeit St. Gallischen Naturwissenschaftlichen Gesellschaft 1876–1877*: 211–454.
- Mitten, W. (1859) Musci Indiae Orientalis, an enumeration of the mosses of the East Indies. *Journal of the Proceedings of Linnean Society, Botany, Supplement* 1: 1–171.
<https://doi.org/10.1111/j.1095-8339.1859.tb02466.x>
- Mitten, W. (1868) A list of the Musci collected by the Rev. Thomas Powell in the Samoa or Navigator's Islands. *Journal of the Linnean Society, Botany* 10: 166–195.
<https://doi.org/10.1111/j.1095-8339.1868.tb02029.x>
- Montagne, C. (1844) Diagnoses Muscorum quorundam Javanicorum. *London Journal of Botany* 3: 632–634.
- Müller, C. (1851) *Synopsis Muscorum Frondosorum Cognitorum* 2, fascicle 7–8, pages 161–510. Alb. Foerstner, Berlin.
- Nishimura, N. (1985) A revision of the genus *Ctenidium* (Musci). *Journal of the Hattori Botanical Laboratory* 58: 1–82.
https://doi.org/10.18968/jhbl.58.0_1
- Ramsay, H.P., Schofield, W.B. & Tan, B.C. (2004) The family Sematophyllaceae (Bryopsida) in Australia, part 2. *Acroporium, Clastobryum, Macrohymenium, Meiotheciella, Meiothecium, Papillidiopsis, Radulina, Rhaphidorrhynchium, Trichosteleum, and Warburgiella*. *Journal of the Hattori Botanical Laboratory* 95: 1–69.
https://doi.org/10.18968/jhbl.95.0_1
- Reinwardt, C.G.C. & Hornschuch, C.F. (1829) Musci frondosi Iavanici, reddidi coniunctis studiis et opera. *Nova Acta Physico-medica Academiae Caesareae Leopoldino-Carolinae Naturae Curiosorum Exhibentia Ephemerides sive Observationes Historias et Experimenta* 14 (2): 697–732.
- Schwägrichen, C.F. (1827) *Species Muscorum Frondosorum*, Supplementum 2, volumen 2, sectio 2. Barth, Leipzig, pp. 81–210 + plates 176–200.
- Tan, B.C. & Jia, Y. (1999) A preliminary revision of Chinese Sematophyllaceae. *Journal of the Hattori Botanical Laboratory* 86: 1–70.
https://doi.org/10.18968/jhbl.86.0_1
- Tan, B.C., Koponen, T. & Norris, D.H. (2007) Bryophyte flora of the Huon peninsula, Papua New Guinea. LXX. Sematophyllaceae (Musci) 1. *Acanthorrhynchium, Acroporium, Clastobryophilum, Pseudopiloecium, Radulina* and *Trichosteleum*. *Annales Botanici Fennici* 44 (Supplement a): 35–78. [<https://www.jstor.org/stable/23727694>]
- Tan, B.C., Koponen, T. & Norris, D.H. (2017) Bryophyte flora of the Huon Peninsula, Papua New Guinea. LXXVII. Sematophyllaceae (Musci) 3. *Macrohymenium, Mastopoma, Rhaphidorrhynchium, Sematophyllum, Trismegistia* and *Warburgiella*, with a key to the genera and a checklist of the taxa. *Acta Bryolichenologica Asiatica* 7: 3–70.
- Tan, B.C., Schofield, W.B. & Ramsay, H.P. (1998) Miscellanies of Australian Sematophyllaceae with a new genus, *Meiotheciella*. *Nova Hedwigia* 67: 213–223.
<https://doi.org/10.1127/nova.hedwigia/67/1998/213>
- Thériot, I. (1910) Diagnoses d'espèces et de variétés nouvelles de mousses (7e article). *Bulletin de Académie Internationale de Géographie Botanique* 20: 96–104.
- Touw, A. (1992) A survey of the mosses of the Lesser Sunda Islands (Nusa Tenggara), Indonesia. *Journal of the Hattori Botanical Laboratory* 71: 289–366.
https://doi.org/10.18968/jhbl.71.0_289
- Tropicos (2023) *Warburgiella*. Missouri Botanical Garden. 08 Sep 2023 [<https://tropicos.org/name/35001349>]