

NOTEWORTHY COLLECTIONS

NEW BRYOPHYTE STATE RECORD FOR WISCONSIN, USA: *PALUDELLA SQUARROSA* (HEDW.) BRID. (MEESIACEAE), TUFTED FEN MOSS

Keir Wefferling

Cofrin Center for Biodiversity
University of Wisconsin-Green Bay
2420 Nicolet Drive, Green Bay, WI 54311
wefferlk@uwgb.edu

Significance of the Report: First collection of *Paludella squarrosa* in the State of Wisconsin.

Previous Knowledge: *Paludella squarrosa* (Hedw.) Brid. (Meesiaceae) (Tufted fen moss) is a circumboreal species (CBH 2024; Vitt 2014a). In North America it is relatively abundant in the Rocky Mountains and northern Cascades (Alaska south to northern Washington and Colorado, south and east to Yukon, British Columbia, and southwest Alberta), is spottily distributed throughout the central provinces and territories of Canada (Northwest Territories, Nunavut, Saskatchewan, and Manitoba), and is more abundant around the Great Lakes, Hudson Bay, and eastern Canada. In the United States it has been collected in northern New England (Maine, New York and Vermont), the upper Great Lakes region (Iowa, Michigan, Minnesota, and now Wisconsin), the middle to southern Rocky Mountains (Colorado, Montana, and Wyoming), and in Washington State. *Paludella squarrosa* is relatively abundant in Iceland and Scandinavia and occurs sporadically throughout the rest of northern Eurasia (Vitt 2014a; CBH 2024; NatureServe 2024).

Discussion: Within Wisconsin, *Paludella squarrosa* is known only from Oconto County in northeastern Wisconsin at Waupee Lake Swamp Research Natural Area on the Chequamegon-Nicolet National Forest. *Paludella* was found growing at the northern edge of a mineral-rich, alkaline lake on a floating sedge-peat mat bordering a white cedar swamp (or northern wet-mesic forest) near the main inlet to the lake. Waupee Lake is a calcareous groundwater-fed lake that has an unusually high number of rare and/or threatened, calcium-loving plant species (Janke 1998; Brzeskiewicz 2015; Epstein 2017). Waupee Lake Swamp is at the western edge of the largest wetland complex—including northern wet-mesic forest, lowland hardwood forest, alder thicket, northern sedge meadow, marsh communities, and “northern fen”—in the Northeast Sands Ecological Landscape (Epstein 2017).

Three specimens of *Paludella squarrosa* were collected in the boreal rich fen at Waupee Lake Swamp, either on a floating mat or on peaty soil with the fol-

lowing tracheophytes: *Amelanchier arborea* (F. Michx.) Fernald, *Andromeda glaucophylla* Link, *Calopogon tuberosus* (L.) Britton, Sterns & Poggenb., *Campanula aparinoides* Pursh, *Carex diandra* Schrank, *Carex lasiocarpa* Ehrh., *Carex magellanica* Lam., *Chamaedaphne calyculata* (L.) Moench, *Comarum palustre* L., *Cornus canadensis* L., *Cypripedium acaule* Aiton, *Cypripedium parviflorum* Salisb., *Drosera rotundifolia* L., *Eriophorum viridicarinarum* (Engelm.) Fernald, *Galium boreale* L., *Gaultheria hispidula* Dombey, *Ilex mucronata* (L.) M. Powell, Savol. & S. Andrews, *Ilex verticillata* (L.) A. Gray, *Kalmia polifolia* Wengen., *Larix laricina* (Du Roi) K. Koch, *Menyanthes trifoliata* L., *Osmundastrum cinnamomeum* (L.) C. Presl, *Picea mariana* (Mill.) Britton, Sterns & Poggenb., *Platanthera dilatata* (Pursh) Lindl. ex L.C. Beck, *Rhododendron groenlandicum* (Oeder) Kron & Judd, *Rubus pubescens* Raf., *Sarracenia purpurea* L., *Saxifraga pensylvanica* L., *Solidago uliginosa* Nutt., *Thelypteris palustris* Schott, *Thuja occidentalis* L., *Toxicodendron vernix* (L.) Kuntze, *Triglochin maritima* L., *Typha latifolia* L., *Vaccinium oxycoccus* L., *Vaccinium myrtilloides* Michx. The tracheophytes were identified in the field but not collected during visits to the site. Appendix 1 lists all the bryophyte species collected in association with *Paludella squarrosa* at the Waupee Lake site. Of the 23 species of co-occurring bryophytes found at Waupee Lake Swamp, 20 are county records for Oconto County (Freire et al. 2020); this brings the total number of bryophyte species recorded for the county from 128 to 148.

A number of bryophytes present at the site are considered indicator species of moderate-rich to extreme-rich fens, including *Calliergon giganteum*, *Calliergonella cuspidata*, *Campylium stellatum*, *Meesia triquetra*, *Hamatocaulis vernicosus*, *Helodium blandovii*, *Sphagnum warnstorffii*, and *Tomentypnum nitens*; tracheophyte rich fen indicators include *Carex diandra* Schrank, *Platanthera dilatata* (Pursh) Lindl. ex L.C. Beck, and *Triglochin maritima* L. (Chee and Vitt 1998; Vitt and Chee 1990). Crum and Anderson (1981) note the following bryophyte associates of *Paludella squarrosa*: *Campylium stellatum*, species of *Cinclidium* Sw., *Drepanocladus trifarius* (F. Weber & D. Mohr) Broth., *Meesia triquetra*, *Meesia uliginosa* Hedw., *Scorpidium scorpioides* (Hedw.) Limpr., and *Sphagnum warnstorffii*. Of these associates, only *Campylium stellatum*, *Meesia triquetra*, and *Sphagnum warnstorffii* have been located at Waupee Lake Swamp; *Drepanocladus trifarius*, *Meesia uliginosa*, and *Scorpidium scorpioides* are known from other rich fen sites in Wisconsin.

Ongoing searches in Wisconsin for *Paludella squarrosa* since 2021 have not yielded additional occurrences, despite repeated visits to other sites considered suitable (Epstein 2017; S. Janke, personal communication; K. Doyle, personal communication). In Wisconsin, boreal rich fen is most common along the Door Peninsula (northeastern Wisconsin), with a few additional recognized sites on the “mainland” of the state, mainly in northeastern Wisconsin (Epstein 2017). *Paludella squarrosa* is apparently quite rare in Wisconsin, although suitable habitat appears to be present in the state. According to Chee and Vitt (1990), *Paludella* is known from intermediate to extreme-rich fens, though Vitt (2014b) indicates that the species is restricted to extreme-rich fens. Though Wisconsin has other rich fen sites with several rich fen indicator species, perhaps the conditions are rarely sufficient for *Paludella* to thrive.

A review of herbarium records of *Paludella squarrosa* in the Upper Great Lakes region shows that ca. 39 vouchered specimens have been collected from approximately 26 locations in Ontario, Canada (most recently in 2013); nine vouchered specimens have been collected from approximately eight locations in three counties in Minnesota (most recently in 1984); and ca. 17 vouchered specimens have been collected from approximately ten locations in three counties in Michigan (most recently in 1974) (CBH 2024). A search of iNaturalist (2024) records from the western Great Lakes region shows six observations from Ontario, Canada, three from the single known Wisconsin site, one observation from the Lower Peninsula of Michigan, and no further observations from Minnesota.

Paludella squarrosa is found in calcareous wet fens in North America and Eurasia (Vitt 2014a, Jenkins 2020) and has an obligate wetland indicator status (Gillrich and Bowman 2010). Specific habitat for *P. squarrosa* has been described as wet calcareous substrates and fens in Maine (Ledlie and Allen 2019), calcareous fens in Minnesota (Leete et al. 2016), bogs and bog margins in Michigan (Mazzer and Sharp 1963), montane calcareous fens in Montana (Elliot and Pipp 2020), rich graminoid fens in New York (Slack 1992), mineral-rich fens in Vermont (Thompson et al. 2019) and montane flow-through fens dominated by graminoids in Wyoming (Heidel and Jones 2006).

Diagnostic Characters: *Paludella squarrosa* is a small but conspicuous dioicous acrocarpous moss 3–7cm in height with tidy five-ranked squarrose leaves, serrulate distally, and with a luxuriant vestiture of rhizoids up the stems; the sporophytes (not seen) have setae 2.5–4.5 cm and the capsule is 2–3 mm (Vitt 2014a). As described by D. Vitt in the *Flora of North America North of Mexico*, “*Paludella* is one of the most spectacular moss species in the flora area” (Vitt 2014a). *Paludella* is described by H. Crum in *Mosses of the Great Lakes Forest*, as “one of the most attractive and curious mosses” (Crum 1983) and by Crum and Anderson (1981) as “a most curious moss, of unbelievable appearance. It is very attractive. It resembles no other moss in its densely tomentose stems and extremely squarrose-recurved leaves with the tips folded downward in such a way that they seem heart-shaped.”

Specimen Citations: WISCONSIN: Oconto County: 45.196543, –88.355258 at 290.5m elevation, on a floating peat-sedge mat in a boreal rich fen at the largest inlet to Waupee Lake Swamp at the north end of the lake; September 6, 2021, *Wefferling, Berkopec, and Eicchorn 764* (UWGB). 45.196543, –88.355258 at 291m elevation, in peaty soil in a boreal rich fen at the northwest side of Waupee Lake; June 17, 2022, *Wefferling and Smith 851* (UWGB). 45.196514, –88.355254 at 291m elevation, in peaty soil in a boreal rich fen at the northwest side of Waupee Lake; June 17, 2022, *Wefferling and Smith 861* (UWGB).

ACKNOWLEDGMENTS

This work would not have been possible without permission and logistical support from the United States Forest Service (USFS) offices; I gratefully acknowledge permission to access and collect plant specimens within the Waupee Lake Swamp Research Natural Area on the Chequamegon-Nicolet National Forest (CNNF), facilitated by Ann Dassow, Heather Jensen, Christel Kern, Susan Krage, Allie Niemeyer, Linda Parker, and Ryan Vinhal. Collections and observations at the site were

performed with the help of Sarah Baughman, Joan Berkopec, Ron Eicchorn, Nicholas Gabbard, Jason Miller, and Al Powell. Funding comes from the Wisconsin Coastal Management Program, grant number AD239125 – 024.02 and an American Philosophical Society Franklin Research Grant. Justin J. Bournoville (CNNF) provided extensive details resulting from a literature search on the taxon when preparing a USFS Risk Assessment report. Steve Janke (also CNNF) shared valuable information regarding habitat quality and history of the site, and Kevin Doyle (Wisconsin Department of Natural Resources, Natural Heritage Inventory) has shared useful insights into potential indicator species and additional sites to search. Emmet Judziewicz (University of Wisconsin, Stevens Point) and an anonymous reviewer provided helpful reviews of an earlier draft of the manuscript, and Michael Huft (Editor, The Great Lakes Botanist) provided careful editing and additional helpful comments that greatly improved the paper.

LITERATURE CITED

- Brzeskiewicz, M. E. (2015). Establishment Record for Waupee Lake Swamp Research Natural Area, Chequamegon-Nicolet National Forest, Lakewood-Laona District, Oconto County, Wisconsin. Rhinelander, Wisconsin: USDA, Forest Service, Chequamegon-Nicolet National Forest.
- Chee, W.-L., and D. H. Vitt. (1998). The vegetation, surface water chemistry and peat chemistry of moderate-rich fens in Central Alberta, Canada. *Wetlands* 9: 227–261.
- CBH (2024). Consortium of bryophyte herbaria. Occurrence records for *Paludella squarrosa*. CBH Portal [web application]. Available at <https://bryophyteportal.org/portal/>. (Accessed September 19, 2024).
- Crum, H. A. (1983). Mosses of the Great Lakes forest. University of Michigan, Ann Arbor.
- Crum, H. A., and L. E. Anderson. (1981). Mosses of eastern North America, Volume 1. Columbia University Press, New York, N.Y.
- Elliot J. C., and A. K. Pipp. (2020). A checklist of Montana mosses (1880–2018). Helena, Montana: Montana Natural Heritage Program.
- Epstein, E. E. (2017). Natural communities, aquatic features, and selected habitats of Wisconsin. Chapter 7 in *The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management*. PUB- SS-1131H 2017. Wisconsin Department of Natural Resources, Madison.
- Freire, A. V., E. J. Judziewicz, and F. Bowers (2020). Bryophytes of Butternut Pines, Oconto County, Wisconsin. *The Great Lakes Botanist* 59: 178–190.
- Gillrich J. J., and K. C. Bowman. (2010). The use of bryophytes as indicators of hydric soils and wetland hydrology during wetland delineations in the United States ERDC/CRREL TR-10-9. U.S. Army Corps of Engineers, Engineer Research and Development Center, Hanover, New Hampshire.
- Heidel, B., and G. Jones. (2006). Botanical and ecological characteristics of fens in the Medicine Bow Mountains, Medicine Bow National Forest, Albany and Carbon Counties, Wyoming. FS Agreement No. 02-CS-11020600-033 M8. Wyoming Natural Diversity Database, University of Wyoming, Laramie.
- iNaturalist. (2024). Available at <https://www.inaturalist.org>. (Accessed September 19 2024).
- Janke, S. (1998). Chequamegon-Nicolet National Forest Research Natural Area evaluation report: Waupee Lake. Unpublished reports on file in Park Falls Headquarters.
- Jenkins, J. (2020). Mosses of the northern forest: A photographic guide. Cornell University Press, Ithaca, New York.
- Ledlie, P., and B. Allen. (2019). Maine Mosses: County Checklist. *Rhodora* 121: 297–327.
- Leete, J. H., W. R. Smith, J. A. Janssens, and N. Aaseng. (2016). Technical criteria for identifying calcareous fens in Minnesota. Excerpted from Final report to the U.S. EPA: Test of the technical criteria for identifying and delineating calcareous fens in Minnesota and draft revised technical criteria for identifying calcareous fens in Minnesota, 2005. Minnesota Department of Natural Resources, St. Paul.
- Mazzer, S. J., and A. J. Sharp. (1963). Some moss reports for Michigan. *The Bryologist* 66: 68–69.
- NatureServe. (2024). Comprehensive report for *Paludella squarrosa*. NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available at https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.127491/Paludella_squarrosa. (Accessed September 19, 2024).

- Slack, N. G. (1992). Rare and endangered bryophytes in New York State and eastern United States: Current status and preservation strategies. *Biological Conservation* 59: 233–241.
- Thompson, E. H., E. R. Sorenson, and R. J. Zaino. (2019). *Wetland, woodland, wildland: A guide to the natural communities of Vermont*, second edition. Vermont Fish and Wildlife Department, Montpelier.
- Vitt, D. H. (2014a). *Paludella*, P. 34 in *Flora of North America*, Volume 28: Bryophyta, part 2, *Flora of North America* Editorial Committee, editors. Oxford University Press, New York, N.Y.
- Vitt, D. H. (2014b). A key and review of bryophytes common in North American peatlands. *Evansia* 31: 121–158.
- Vitt, D. H., and W.-L. Chee (1990). The relationships of vegetation to surface water chemistry and peat chemistry in fens of Alberta, Canada. *Vegetatio* 89: 87–106.

APPENDIX 1. Bryophyte vouchers collected in a boreal rich fen at Waupee Lake Swamp Research Natural Area. All were collected by Keir Wefferling and colleagues at the north end of Waupee Lake near 45.1964, –88.3554, ca. 290m elevation and deposited at UWGB. Species that are county records for Oconto County are marked with an asterisk (*).

- **Aulacomnium palustre* (Hedw.) Schwägr., *Wefferling and Gabbard 1012* (August 11, 2022)
- **Calliergon giganteum* (Schimp.) Kindb., *Wefferling and Miller 866* (June 17, 2022)
- **Calliergonella cuspidata* Loeske, *Wefferling and Miller 854* (June 17, 2022), *Wefferling and Gabbard 1009* (August 11, 2022), *Wefferling and Gabbard 1014* (August 11, 2022)
- **Campylium stellatum* (Hedw.) C.E.O. Jensen, *Wefferling and Gabbard 1013* (August 11, 2022)
- **Drepanocladus aduncus* (Hedw.) Warnst., *Wefferling and Miller 845* (June 17, 2022)
- Fuscocephalozia lunulifolia* (Dumort.) Vána & L. Söderstr., *Wefferling and Gabbard 1016* (August 11, 2022), *Wefferling and Gabbard 1029* (August 11, 2022)
- **Hamatocaulis vernicosus* (Mitt.) Hedenäs, *Wefferling, Berkopec, and Eicchorn 766* (September 6, 2021), *Wefferling and Miller 852* (June 17, 2022)
- **Helodium blandovii* (F. Weber & D. Mohr) Warnst., *Wefferling, Berkopec, and Eicchorn 765* (September 6, 2021), *Wefferling and Miller 869* (June 17, 2022), *Wefferling and Gabbard 1018* (August 11, 2022)
- **Meesia triquetra* (Richt.) Ångstr., *Wefferling and Miller 873* (June 17, 2022), *Wefferling, Baughman, and Powell 1820* (June 7, 2024)
- **Paludella squarrosa* (Hedw.) Brid., *Wefferling, Berkopec, and Eicchorn 764* (September 6, 2021), *Wefferling and Miller 851* (June 17, 2022), *Wefferling and Miller 861* (June 17, 2022)
- Polytrichum strictum* Bridel, J. Bot. (Schrader), *Wefferling and Miller 871* (June 17, 2022), *Wefferling and Miller 872* (June 17, 2022), *Wefferling and Gabbard 1011* (August 11, 2022)
- **Riccardia multifida* (L.) Gray, *Wefferling and Gabbard 1015* (August 11, 2022)
- **Sphagnum capillifolium* (Ehrh.) Hedw., *Wefferling, Berkopec, and Eicchorn 754* (September 6, 2021), *Wefferling, Berkopec, and Eicchorn 755* (September 6, 2021), *Wefferling and Miller 850* (June 17, 2022)
- **Sphagnum centrale* C.E.O. Jensen, *Wefferling and Gabbard 1030* (August 11, 2022)
- **Sphagnum contortum* Schultz, *Wefferling and Gabbard 1034.1* (August 11, 2022), *Wefferling and Gabbard 1034.2* (August 11, 2022)
- **Sphagnum divinum* Flatberg & K. Hassel, *Wefferling, Berkopec, and Eicchorn 753* (September 6, 2021), *Wefferling, Berkopec, and Eicchorn 756* (September 6, 2021), *Wefferling and Miller 849* (June 17, 2022), *Wefferling and Gabbard 1007* (August 11, 2022)
- **Sphagnum fuscum* (Schimp.) H. Klinggr., *Wefferling, Berkopec, and Eicchorn 762* (September 6, 2021), *Wefferling and Gabbard 1022* (August 11, 2022), *Wefferling and Gabbard 1023* (August 11, 2022)
- **Sphagnum girgensohnii* Russow, *Wefferling, Berkopec, and Eicchorn 751* (September 6, 2021), *Wefferling, Berkopec, and Eicchorn 760* (September 6, 2021), *Wefferling and Gabbard 1033* (August 11, 2022)
- Sphagnum russowii* Warnst., *Wefferling and Gabbard 1021* (August 11, 2022)
- **Sphagnum squarrosum* Crome, *Wefferling and Miller 864* (June 17, 2022), *Wefferling and Gabbard 1027* (August 11, 2022), *Wefferling and Gabbard 1028* (August 11, 2022)

-
- **Sphagnum teres* (Schimp.) Ångstr. ex C. Hartm., *Wefferling and Gabbard 1008* (August 11, 2022), *Wefferling and Miller 1819* (June 7, 2024)
- **Sphagnum warnstorfii* Russow, *Wefferling, Berkopec, and Eicchorn 768* (September 6, 2021), *Wefferling and Miller 863* (June 17, 2022)
- **Tomentypnum nitens* (Hedw.) Loeske, *Wefferling and Gabbard 1006* (August 11, 2022)
-