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Noteworthy Collections: First documented antheridia on *Palamocladium leskeoides* (Brachytheciaceae) in North America

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ABSTRACT

The collection reported here of *Palamocladium leskeoides,* made in Tennessee, represents the first documented observation of antheridia on this species in North America. *Palamocladium leskeoides* is a dioicous moss species with a pantropical distribution. Uncommon in the United States, it grows in disjunct populations in moist habitats on calcareous rock. We visited Rock Island State Park (Warren County, Tennessee) in 2019 and relocated a population of this species that was last collected from that location in 1979. Two small voucher specimens were collected and one was observed to have a perigonium containing antheridia attached to the stem. The invasive evergreen *Euonymus fortunei* was also observed covering surfaces that could otherwise be suitable habitat for *P. leskeoides.* We plan to assist Rock Island State Park with remediation of invasive plants to improve the available habitat and monitoring the population of this rare moss.
Key words: bryophytes, gametangia, mosses, perigonium, Tennessee

Palamocladium leskeoides (Hook.) E. Britton (Brachytheciaceae)
Warren County, TN: Within the Caney Fork River gorge below the Great Falls Dam in Rock Island State Park. Growing among invasive vascular plants and other bryophytes beneath a heavy deciduous tree canopy on the vertical surface of large limestone boulders between the bluff and river. (N 35.80523°, W 85.63211°) 18 May 2019, *J.M. Budke #298* with K.D. McFarland, T. Crabtree, V. Harpe, M.G. Oliver (TENN-B-0103150).

Significance

Sex expression in many bryophytes is uncommon and sex ratios are often female-skewed (Bisang and Hedenäs 2005; Bisang et al. 2014). *Palamocladium leskeoides* (Hook.) E. Britton (Brachytheciaceae) is a dioicous moss species with a pantropical distribution (Figure 1a; Hofmann 1997). Gametangia of this species have been rarely described (Fleischer 1922) and descriptions of these structures are lacking for North American populations (Crum and Anderson 1981; Ignatov 2014). Evidence of reproduction, in the form of sporophytes, are estimated to be present on 25% of *P. leskeoides* specimens (Hofmann 1997) and, in comparison to gametangia, sporophyte descriptions are more common in the literature (Hooker 1818; Fleischer 1922; Crum and Anderson 1981; Noguchi 1991; Hofmann 1997; Buck 1998; Gradstein et al. 2001; Wang and Hu 2008; Ignatov 2014). However, sporophyte descriptions in North American flora appear to be based on observations of specimens from outside the region (Crum and Anderson 1981; Ignatov 2014). We are here reporting the first documented observation of antheridia on *P. leskeoides* from the North American part of its distribution (Crum and Anderson 1981; Ignatov 2014).

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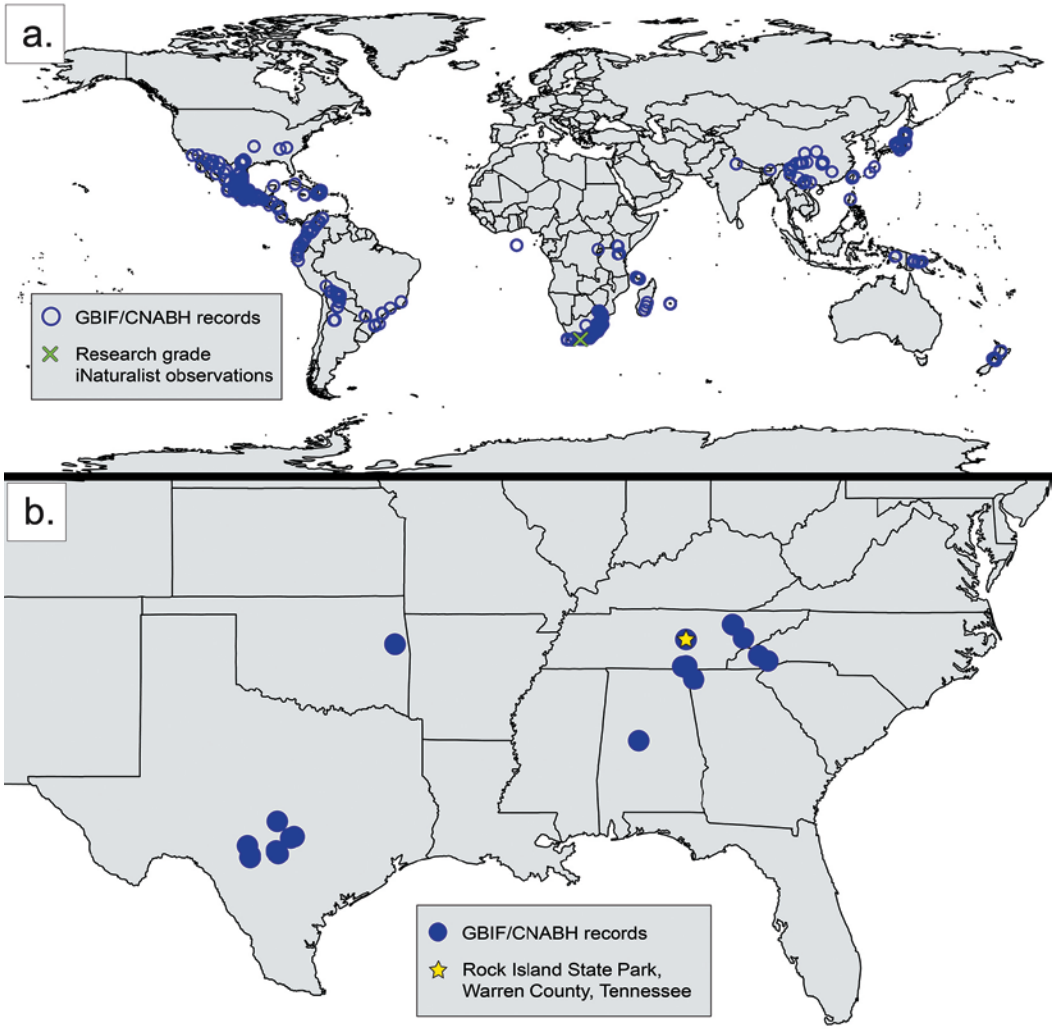

Figure 1. a. World map showing localities of *Palamocladium leskeoides* specimens and research grade observations made through iNaturalist (Global Biodiversity Information Facility, GBIF.org 2021). **b.** Close-up of the southeastern portion of the United States showing the localities of *P. leskeoides* specimens (Consortium of North American Bryophyte Herbaria, CNABH 2021).

Although not federally listed, *Palamocladium leskeoides* is an uncommon moss species in the United States with disjunct populations in Alabama, Georgia, North Carolina, Oklahoma, Tennessee, and Texas (Figure 1b; Ignatov 2014; CNABH 2021). A population has also been reported for Tucker County, West Virginia (Crum and Anderson 1981; Ignatov 2014), which would represent the northernmost extent of this species' distribution in North America. However, specimens documenting this population were not physically examined by Ignatov (17 November 2021, personal communication) and our searches for voucher specimens to verify this record have been unsuccessful. Thus we recommend updating the North American distribution for *P. leskeoides* to exclude West Virginia. Based on publicly available herbarium records (CNABH 2021; GBIF 2021), it is only known from one to five locations within each state (Figure 1b; CNABH 2021; GBIF 2021). Additionally, this species is listed as significantly rare in North Carolina (Wichmann 2021) and threatened in Tennessee (Crabtree 2016).

Palamocladium leskeoides grows in moist habitats on calcareous cliffs and boulders, typically at low or moderate elevations, within its range in the United States (Crum and Anderson 1981; Ignatov 2014). Throughout the rest of its global range it can be found growing in a wider variety of moist habitats including along road banks, on logs and soil, and epiphytic on trees (McFarland 1994; Hofmann 1997; Gradstein et al. 2001). *Palamocladium leskeoides* is a pleurocarpous moss that is rigid with a glossy or shiny green appearance (Figure 2a) with stem leaves that are plicate, ovate-triangular (Figure 2b), and broadly tapered with serrulate margins (Figure 2b, c; Crum and Anderson 1981; McFarland 1994; Gradstein et al. 2001; Ignatov 2014). Other key features of the leaves include a costa that ranges from two-thirds to the full length of the leaf lamina (Figure 2b) and alar cells that are squarish in shape in comparison to the elongate cells located throughout the rest of the lamina (Figure 2c, d; Crum and Anderson 1981; McFarland 1994; Gradstein et al. 2001; Ignatov 2014). The single perigonium was 810 μm × 375 μm in size with six ovate leaves surrounding two dehisced antheridia (Figure 2e, f). The antheridia were on average 345.0 μm × 86.3 μm in size and were intermingled with 15 paraphyses ranging from 410 to 510 μm in length that were each composed of six to seven elongate cells (Figure 2g).

Before 2019, the last known collection of *Palamocladium leskeoides* in Tennessee was made in 1992 from Savage's Garden in Anderson County (*Smith et al. #1978* [TENN-B-0039995]; CNABH 2021) and prior to that, this species was collected in 1979 from Rock Island State Park in Warren County (*Smith & Sharp #5012* [TENN-B-0039998]; CNABH 2021). A potential population of *P. leskeoides* was located at Rock Island State Park in 2009, but field observations were insufficient to confirm the identification and a collection was not made. In 2019 our team, composed of botanists from the University of Tennessee-Knoxville Herbarium (TENN) and the Tennessee Department of Environment and Conservation (TDEC), visited the site and located a single extant population of *P. leskeoides* growing on the vertical surfaces of shaded limestone boulders along the southern edge of the Caney Fork River. Two small voucher specimens were collected and deposited at the TENN Herbarium (*Budke et al. #298* [TENN-B-0103150] and *McFarland et al. #5-18-2019* [TENN-B-0103151]) to document this population. These field identified specimens were later confirmed under the microscope as *P. leskeoides,* based on the combined features of serrulate margins of the stem leaves, costae extending to the leaf tips, squarish alar cells, and porous basal cells (compound microscope, Laxco LMC-3000; digital camera, Leica MC190 HD; determined by K.D. McFarland). During this detailed examination we discovered a single gametophyte stem with a perigonium containing two antheridia (Figure 2e, f, g; *Budke et al. #298* [TENN-B-0103150]).

Because this is the first time gametangia of either sex have been documented in United States populations of *Palamocladium leskeoides* and sporophyte observations are still lacking for these populations, they are likely relying on asexual reproduction for population maintenance, a common reproductive strategy across bryophytes (Frey and Kürschner 2011). Since all members of the Brachytheciaceae, including *P. leskeoides,* lack specialized asexual propagules (Ignatov 2014), these populations are most likely reproducing clonally via fragmentation of the gametophyte stems or leaves. Populations relying on asexual reproduction can be widely distributed, but often have lower levels of genetic variation compared to those reproducing sexually (Chung and Kang 1996; Alonso-García et al. 2020), which could result in higher extinction risk (Hu et al. 2017; Alonso-García et al. 2020).

Palamocladium leskeoides is listed as threatened in Tennessee (Crabtree 2016). Maintaining the few existing populations of this species is critical for resource stewardship and species diversity in the state. We located only a single population of this species within the Caney Fork River gorge at Rock Island State Park and thus are concerned for its persistence. The Caney Fork River gorge is regularly scoured by high levels of water due to the daily release through the Great Falls Dam just upstream (TVA 2021), which may impact the ability of *P. leskeoides* to maintain a population across a wider area. Alongside this single population we also observed the creeping invasive evergreen *Euonymus fortunei* (Turcz.) Hand.-Mazz. (=*E. hederaceus* Champ. ex Benth., Celastraceae) growing over large areas of the limestone boulders, potentially shading out what would otherwise

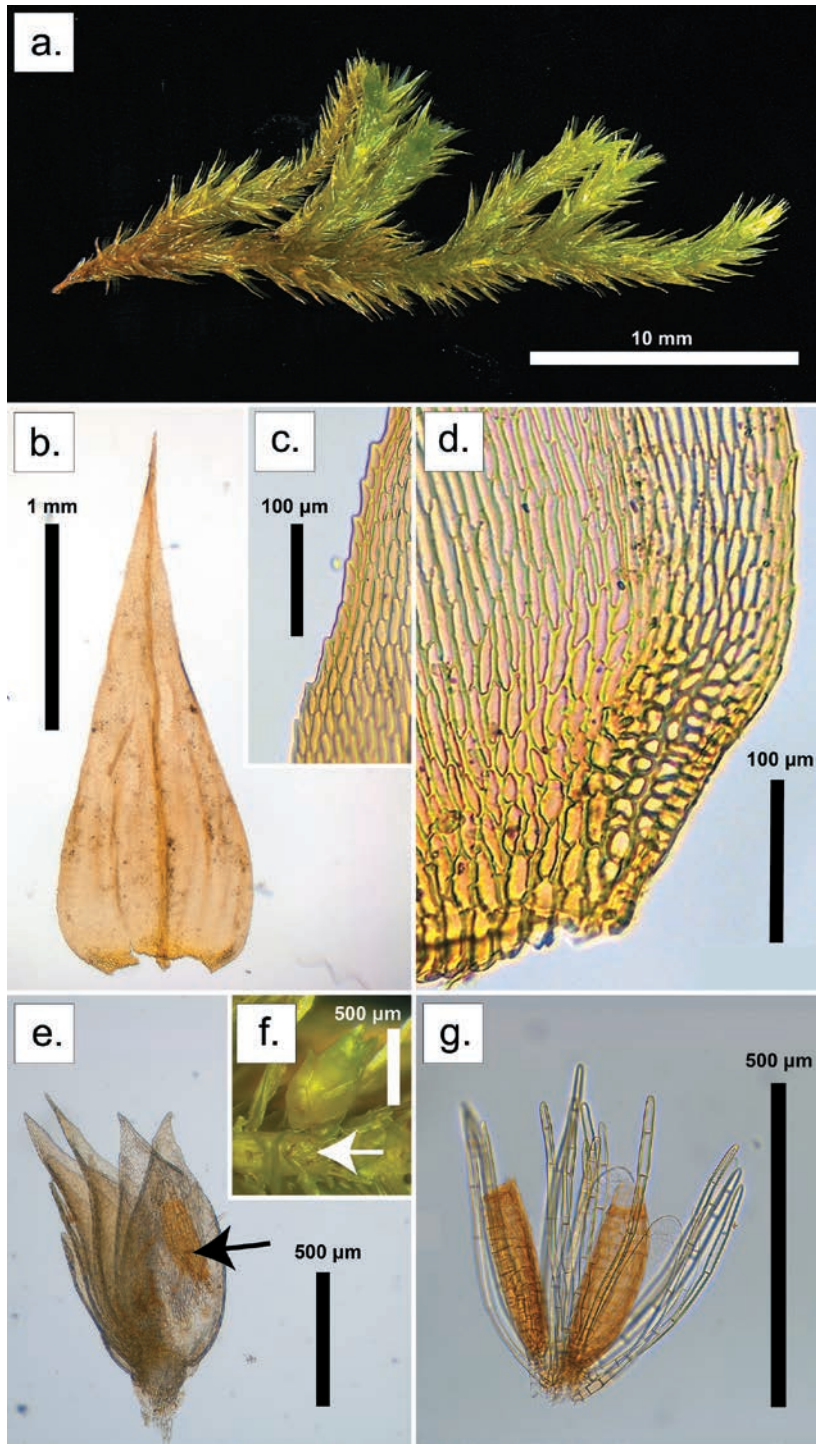

Figure. 2. *Palamocladium leskeoides* morphology of *Budke et al. #298*. **a.** Leafy gametophyte. **b.** Stem leaf showing the costa extending the full length of the leaf. **c.** Serrulate margin of the stem leaf. **d.** Square-shaped alar cells. **e.** Dissected perigonium with an antheridium visible through the leaves (arrow). **f.** Stem location where perigonium was attached (arrow). **g.** Dehisced antheridia and paraphyses dissected from the perigonium.

be suitable habitat for *P. leskeoides*. Suitable habitat is also present down river from the known site. A section of this down river area was searched without success, but more habitat remains to be surveyed in this watershed and other previously collected populations in Tennessee have yet to be revisited. Our team plans to coordinate with TDEC employees at Rock Island State Park to potentially assist with the management and removal of invasive plants to increase the amount of available habitat for this rare bryophyte species in Tennessee. In collaboration with TDEC's rare plant tracking (Crabtree 2016), we will monitor this population of *P. leskeoides* regularly to help ensure its persistence.

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