

**NEW AND NOTEWORTHY REPORTS
ON COLORADO LICHENS AND LICHEN ALLIES, 2:
*BIATOROPSIS USNEARUM***

SETH J. RAYNOR

Museum of Natural History
University of Colorado - Boulder
UCB 350, Boulder, Colorado 80309
seth.raynor@colorado.edu

JENNIFER KESLER

Boulder County Open Space
2520 55th St, Boulder, Colorado 80301
jenkesler8363@gmail.com

ERIN A. MANZITTO-TRIPP

Department of Ecology & Evolutionary Biology, and
Museum of Natural History
University of Colorado - Boulder
UCB 350, Boulder, Colorado 80309
erin.manzittotripp@colorado.edu

ABSTRACT

Biatoropsis usnearum is reported from Colorado for the first time, based on a specimen collected by the authors in 2018 from the Front Range Mountains of north-central Colorado. This population was found growing on thalli of *Usnea perplexans*. Its occurrence throughout North America is likely more common (and geographically broader) than presently understood, owing to frequent overlooking of populations. We provide discussion on its geographical range and identification.

Biatoropsis usnearum Räsänen is a widespread, likely cosmopolitan lichenicolous heterobasidiomycete that so far as known is confined to members of the host genus *Usnea* (Diederich & Christiansen 1994; Goward et al. 1994; Ertz & Diederich 2008). In North America, it is encountered sporadically but has been widely reported from both eastern and western regions (Goward et al. 1994; Etayo & Breuss 1998; Wetmore 2009; Tripp & Lendemer 2020; Consortium of North American Lichen Herbaria), primarily within the continental USA but also in southern Canada (Millanes et al. 2016). *Biatoropsis usnearum* is known to be similarly widespread in Europe (Kowalewska & Kukwa 2014), including western areas such as the Azores (Berger & Aptroot 2002) and Canary Islands (Ertz & Diederich 2008), northern portions such as Sweden (Millanes et al. 2014b) and eastern countries such as Turkey (Etayo & Breuss 1998). Although less commonly reported, the species also occurs in South America, Africa, Asia, and Australia (Diederich & Christiansen 1994; Hafellner 2008; Zhurbenko et al. 2012; Urbanavichene & Urbanavichus 2014; Upadhyay et al. 2015).

Whereas some lichenicolous fungi are parasitic on algal constituents of a given lichen (Grube & Hafellner 1990; Tuovinen et al. 2019), *Biatoropsis usnearum* is a mycoparasite that makes contact with host hyphae through haustorial anatomy common to many members of the Tremellales, including *Biatoropsis* (Grube & de los Rios 2001; Millanes et al. 2011). As reported by Diederich & Christiansen (1994), the parasite attacks a number of different species of *Usnea*. Diederich & Christiansen (1994) noted that in mixed populations containing several species of *Usnea*, not all species are infected suggesting some possibility that host specificity may limit infection rates. Nonetheless, *Biatoropsis usnearum* has been reported from a large variety of host species including *U. perplexans* (Goward et

al. 1994; Zhurbenko et al. 2012; Yazici & Etayo 2015), *U. quasirigida* (Grube & de los Rios 2001), *U. subfloridana* (Hafellner 2008), *U. florida* (Kukwa et al. 2013), and others as reported in Diederich & Christiansen (1994).

Biatoropsis usnearum is characterized by its pale pink to pale tan galls (basidiomata) that are convex and occur across the surface of infected *Usnea* thalli. Development of galls was studied extensively by Grube & de los Rios (2001), who reported that the galls include a large amount of host (*Usnea*) hyphae in addition to hyphae of the parasite (see also de los Rio et al. [2002] who demonstrated these hyphae to be strongly intermingled). Morphological variation present within and among different populations of *B. usnearum* is evident across its range (Millanes 2014; Millanes et al. 2016). It is likely that some of this variation is attributable to evolutionary history — *Biatoriopsis usnearum* consists of at least seven different lineages whose diversification seems to have been driven in part by host switching (Millanes et al. 2014).

Diederich & Christiansen (1994; see also Goward et al 1994) reported that in many portions of its range, the parasite is rather common. Like other lichenicolous fungi, however, such populations are frequently overlooked. During fieldwork to scout potential field sites in preparation for the annual conference of the American Bryological and Lichenological Society in 2018, a single population of *Biatoropsis usnearum* was encountered by the authors parasitizing *Usnea perplexans*. Further investigation suggests that vouchered material of this population represents the first report of the species from Colorado.

Materials and methods

Field site scouting was conducted by the two authors in July and August 2018, across numerous sites throughout the Front Range Mountains and foothills of Colorado. These sites ranged from approximately 6,000-12,000 feet elevation on Boulder County Open Space property as well as U.S. Forest Service land. One such location is Caribou Ranch, a large tract of high quality subalpine forest, riparian corridors (including Boulder Creek Watershed), and fens that lies due N of the small community of Nederland and approximately 12 air miles west of Boulder. The basin consists of a large alluvial fan that originated approximated 2000 years ago with a breach of a cirque lake on Caribou Creek. This created extensive wetlands within the basin (Pineda et al. 1999). Much of this property is owned and protected by Boulder County Open Space, and prior work has found the area to host several rare species of plants (including species of *Botrychium*) and other organisms (Pineda et al. 1999).

Subsequent morphological and anatomical study of the field-collected specimen was conducted at The University of Colorado Herbarium (COLO; herbarium acronyms follow Thiers (2018)). Material was examined using an Olympus SZX10 stereomicroscope and an Olympus BX51 compound microscope, both coupled to a Retiga 2000R imaging system. Thin sections of basidiomata were cut by hand and then mounted in water. Sections were photographed using the Retiga imaging system except for macroscopic images, which were photographed using a Nikon D7100 digital SLR with a 105 mm 1:1 macrolens and ring flash. Second, all 52 collections of *Usnea perplexans* housed at COLO were searched for additional records of *Biatoropsis usnearum* in Colorado. Finally, four specimens from New Mexico annotated as *B. usnearum* and housed at the University of Minnesota Herbarium (MIN) were borrowed on loan and similarly studied at COLO. Queries were conducted of databases at The Canadian Museum of Nature (CANL), Arizona State University (ASU), New York Botanical Garden (NY), and Consortium of North American Lichen Herbaria (www.lichenportal.org) to survey other collections for potential material of *B. usnearum* from Colorado.

Given a suspected overlooking of specimens of *Biatoropsis usnearum* from throughout its range, we here refrain from generating a geographical distribution map in this study.

Results and discussion

During one of our collecting excursions at Caribou Ranch we traveled along the northern margins of Sherwood Creek and discovered of a small population of *Biatoropsis usnearum*, consisting of only a few thalli (Fig. 1). Given this small extent, we limited our field vouchering of the population. This population was parasitizing thalli of *Usnea perplexans*, growing along lower branches (approximately eye level) of a mature individual of *Pseudotsuga menziesii*. An additional specimen of *B. usnearum* was identified during analysis of *U. perplexans* specimens housed at COLO marking a second known population of the parasite in Colorado. This specimen was collected by the senior author during a trip to the Comanche Peak Wilderness, where it was found in a rich subalpine forest along a steep north-facing slope. Specimen records and numerous authors have noted that *U. perplexans* (previously referred to as *U. lapponica* in North America and Europe) is an important host lichen for *Biatoropsis usnearum* globally (Goward et al. 1994; Zhurbenko et al. 2012; Yazici & Etayo 2015).

Discovery of *Biatoropsis usnearum* in Colorado (Fig. 1) is not surprising considering (1) there are sporadic reports of this species from Arizona and New Mexico to the south, (2) that its diminutive size has almost certainly led to the overlooking of populations throughout North America and elsewhere, and (3) a relative lack of comprehensive lichen field studies in Colorado compared to other states. Nearest collection records of the species are from northern to central New Mexico, specifically, in Carson National Forest (vicinity of Taos, *Wetmore 100093!*, MIN) and Sante Fe National Forest (vicinity of Pecos, *Wetmore 98933!*, MIN; vicinity of San Miguel, *Wetmore 100018!*, MIN; vicinity of Santa Fe, *Wetmore 99096!*, MIN). These reports indicate a common occurrence at middle elevations (7600–9475 feet) in forested ecosystems, most frequently on *Pseudotsuga menziesii* but also on *Pinus ponderosa*. A collection earlier determined as *Biatoropsis usnearum* from Yellowstone National Park in Wyoming (*Wetmore 81350B!*, MIN) has dark black basidiomata and is more likely representative of *Biatoropsis minuta*.

Several other lichenicolous fungi parasitize species of *Usnea* in addition to *Biatoropsis usnearum*. *Cystobasidium usneicola* is distinguished by having morphologically dissimilar basidia (these consisting of two parts) and longer basidiospores (these 8.5–10 μm long vs. 4.5–8 μm long in *B. usnearum*; Diederich 2004, 2007; see Diederich & Christiansen [1994] as well as Millanes et al. [2016] for detailed descriptions of *B. usnearum*). *Tremella santessonii* has shorter basidia (these 16–21 μm long vs. 20–44 μm long in *B. usnearum*; Diederich 2004). *Tremella nashii* also has shorter basidia (these 8–20 μm long vs. 20–35 μm long in *B. usnearum*) and longitudinal or oblique septa that are often distinctly stalked (vs. transversely septate and not stalked in *B. usnearum*; Diederich 2007). *Tremella stevensiana* differs in having basidia with longitudinal septa (Diederich 2007). Finally, *Biatoropsis minuta* differs in consistently manufacturing dark brown to black galls (vs. pale pink to flesh-colored in *B. usnearum*; Millanes et al. 2016). In this study, all sectioned basidiomata of the Colorado specimens were found to be sterile, but macromorphology and ecology are consistent with *B. usnearum* (Fig. 1).

Vouchers for Colorado record. Boulder Co.: Caribou Ranch, Boulder County Open Space, margins of Sherwood Creek ~ 300m W of old mine, 8582 ft, 39.975776° -105.527867°, subalpine forest dominated by *Pseudotsuga menziesii*, lichenicolous on *Usnea perplexans*, 2 Jul 2018, Tripp & Kesler 9022 (COLO). Larimer Co.: Roosevelt National Forest, Comanche Peak Wilderness, Stormy Peaks Pass Trail, ~0.3 mi S of border with Rocky Mountain National Park, 9660 ft, rich subalpine forest on steep N-facing slopes above creek, lichenicolous on *Usnea perplexans*, 26 Aug 2017, Tripp 7687 (COLO).

ACKNOWLEDGEMENTS

We are grateful to Boulder County Open Space for their land preservation advocacy and activities, and for welcoming our fieldwork onto their property. We thank Daniel Stanton at University of Minnesota for facilitating a specimen loan. We are grateful to two anonymous reviewers whose

comments improved this manuscript. We thank an NSF Dimensions of Biodiversity award to EAT (Award #1542629).

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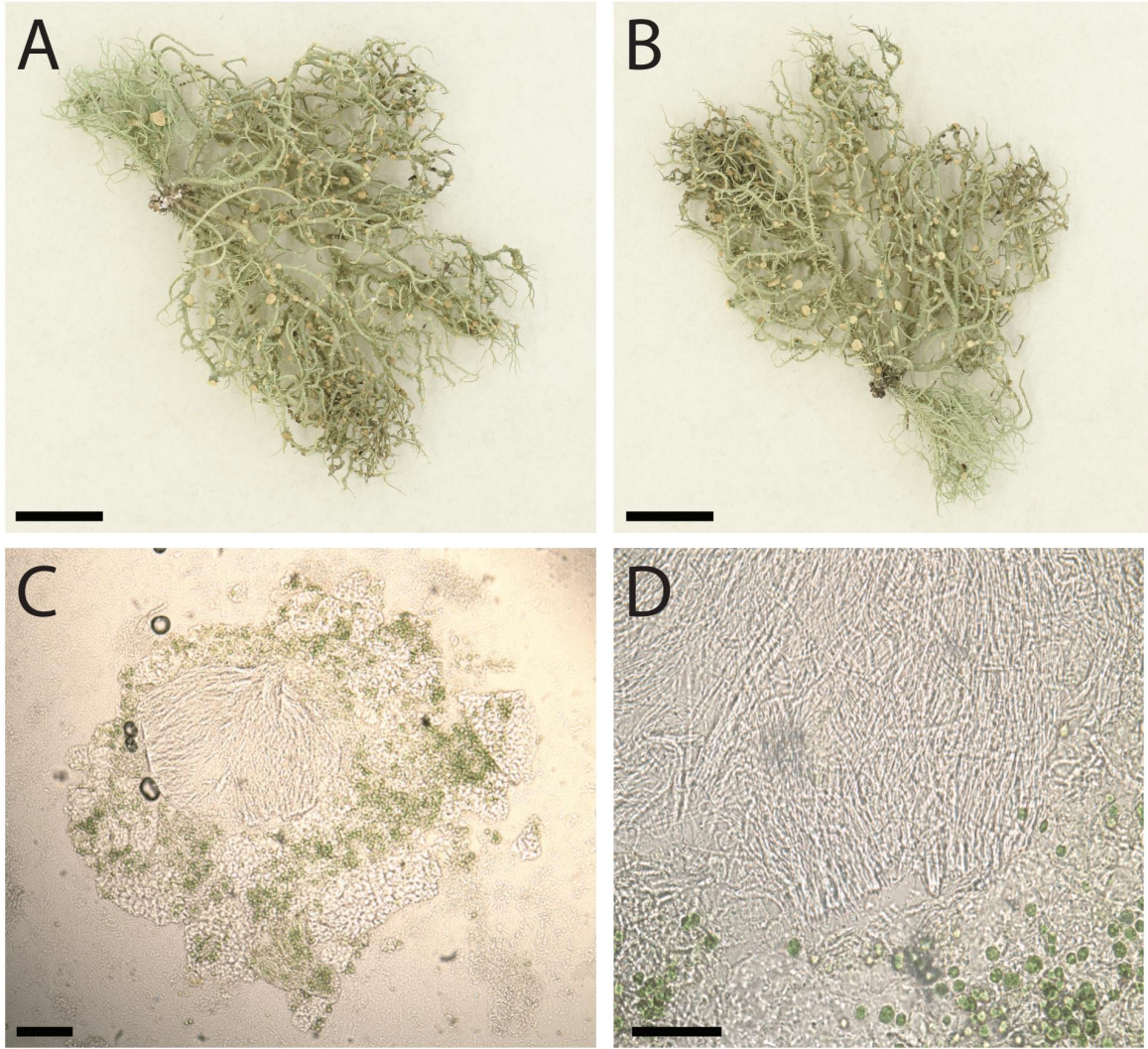


Figure 1. Macro- and micromorphology of *Biatoropsis usnearum* vouchered at Caribou Ranch Open Space in the Front Range Mountains of Boulder Co., Colorado. A. Thallus of *Usnea perplexans* showing infection with galls of *B. usnearum*, scale = 1 cm, Tripp & Kesler 9022. B. Other side of thallus of *Usnea perplexans* showing infection with galls of *B. usnearum* scale = 1 cm, Tripp & Kesler 9022. C. Section through gall of *Biatoropsis usnearum* [sterile, no spores seen] in 10% KOH, scale = 50 μ M, Tripp & Kesler 9022. D. Section through gall of *Biatoropsis usnearum* showing details of paraphyses [sterile, no spores seen] in 10% KOH, scale = 30 μ M, Tripp & Kesler 9022.