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A new species of *Halecania* (Leprocaulaceae, Lecanoromycetes) from eastern North America[1]

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Abstract. *Halecania robertcurtisii* is described as new to science from dry sandstone cliffs and overhangs in Ohio, USA, in eastern North America. It has a smooth and continuous to rimose-areolate thallus, pseudolecanorine apothecia with reddish to rust colored disks, and lacks lichen substances. The species is similar to *Halecania subsquamosa* but lacks the diagnostic unidentified terpenoid present in that taxon.

Key words: Biodiversity, crustose lichens, endemism, *Halecania punctata*

The state of Ohio in eastern North America is an example of a region that is both biologically diverse and heavily impacted by anthropogenic disturbances (Crooks *et al*. 2004). Although there has been much habitat destruction and fragmentation, it still hosts a plethora of unique and diverse habitats (Scheiring and Foote 1973). This diversity likely contributes to the large number of species that are known to occur in the state relative to the rest of North America (Tagliapietra and Sigovini 2010). Lichens are one group of organisms that have been largely overlooked even by naturalist and conservationist communities when compared to plants and vertebrates. This discrepancy of attention is likely due to their obscure nature.

Nevertheless, lichens in Ohio have been studied since the early 1800s, with a first baseline having been established for the Cincinnati area by Lea (1849). Most attention has focused on macrolichens, the larger foliose and fruticose species that regularly attract the attention of botanists and other naturalists (Andreas *et al*. 2007). In recent decades, study and outreach efforts for Ohio lichens have been led by Ray Showman, whose research on air pollution in the Ohio River Valley also concentrated on macrolichens (Showman 1972a, 1972b, 1975, 1981, 1997; Showman and Rudolph 1971; McClenahen *et al*. 2012).

Focus on macrolichens, rather than microlichens, was primarily due to microlichens being considered difficult to identify and there being very limited literature available (Thomson 1984, Wadleigh and Blake 1999). Recent increases in taxonomic and identification resources for microlichens, especially in temperate eastern North America, have made it possible to more fully document and describe this diverse part of the Ohio biota. Microlichens are more species rich than macrolichens, and extensive fieldwork has already led to the discovery of many rare and unreported species (Curtis 2019). Several species have been found that cannot be assigned to any taxon already known from Ohio or North America. One such species is an unusual crustose lichen growing on dry sandstone cliff faces and overhangs. Subsequent study led to the realization that it is an undescribed species of *Halecania* M. Mayrhofer, and as such it is described here.

Methods. This study is based primarily on specimens collected by the first author and deposited in the Tom S. and Miwako K. Cooperrider Herbarium at Kent State University (KE). The coordinate locations of these specimens were mapped using SimpleMappr mapping software (Shorthouse 2010). Material from The New York Botanical Garden (NY) was also consulted, largely for comparison with reference specimens of *Halecania subsquamosa* (Müll. Arg.) van den Boom & H. Mayrhofer and *H.* "*punctata*" ined. At

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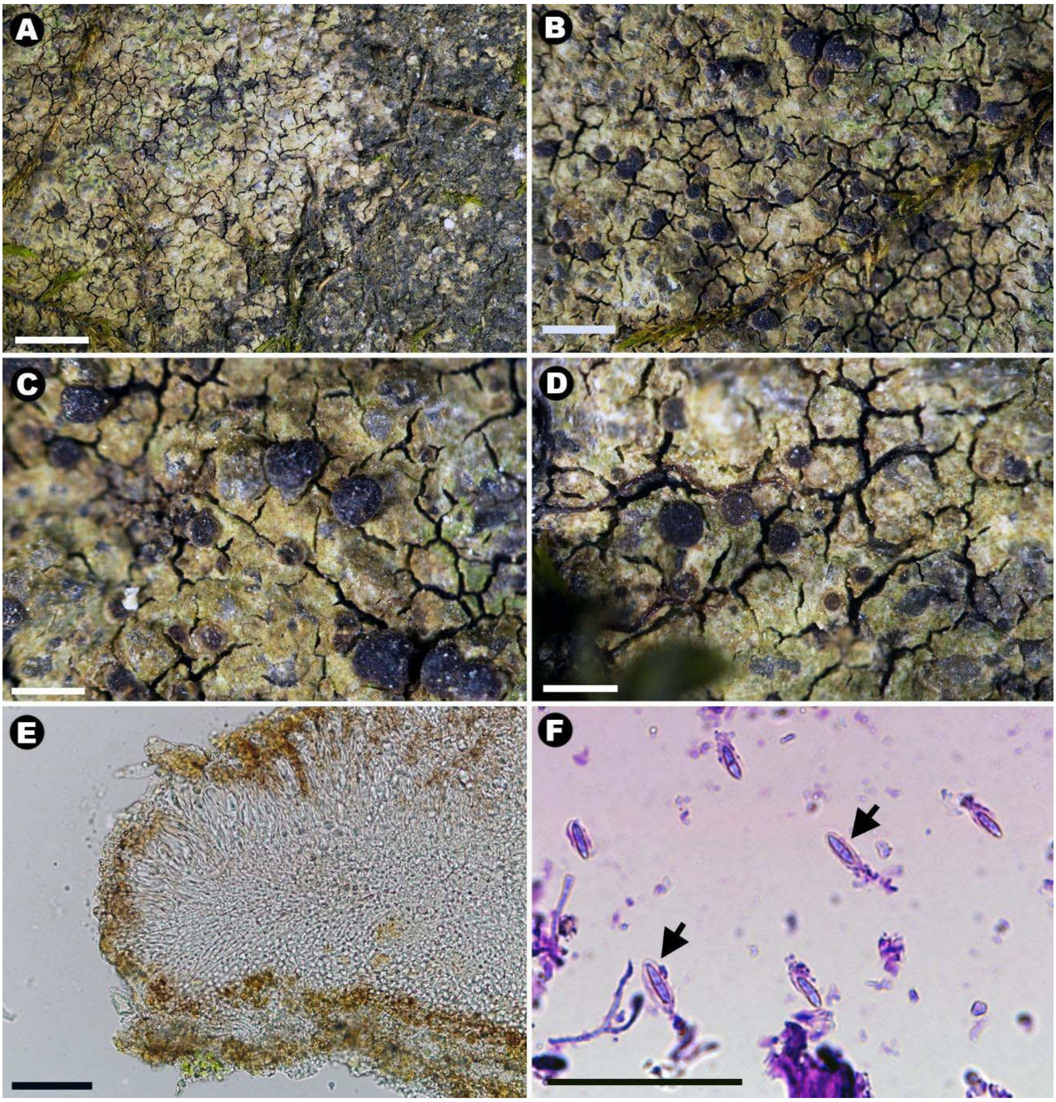

FIG. 1. Morphology of *Halecania robertcurtisii* (*Curtis s.n. [KE L4125]*, NY). (A) Gross morphology of the thallus illustrating thin continuous to rimose crust and thallus edge. (B) Gross morphology of the thallus illustrating cracked, rimose central portions. (C, D) Detail of apothecia illustrating young apothecia with pseudolecanorine margin that becomes almost excluded with age (disks typically not as blackish in fresh material). (E) Transverse section of apothecium mounted in water. (F) Detail of ascospores mounted in water and phloxine with arrows indicating gelatinous perispore. Scales = 2.0 mm in A, 1.0 mm in B, 0.5 mm in C and D, 50 µm in E and F.

KE, specimens were examined dry using a Fisher Scientific Stereomaster dissecting microscope, whereas mounted sections were examined with a Nikon Alphaphot YS2 compound microscope. At NY, specimens were dry examined using an Olympus SZ-STB dissecting microscope and mounted sections were examined with an Olympus BX53 compound microscope. Anatomy and tissue color reactions were studied from sections prepared by hand and mounted in water, iodine (I), or Lugols Solution (K/KI). Lichen substances were initially studied with spot tests using standard reagents (K, C, KC, P) and longwave UV following Brodo *et al*. (2001). The results of spot tests were then confirmed with thin-layer chromatography (TLC) which was performed following

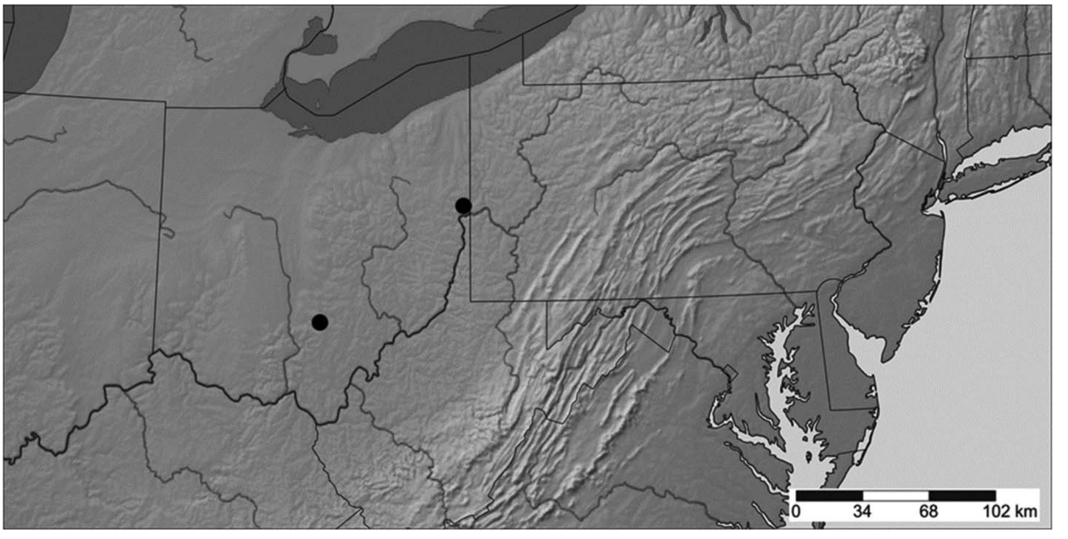

FIG. 2. Known distribution of *Halecania robertcurtisii* in eastern North America.

Culberson and Kristinsson (1970) as modified by Lendemer (2011) and using solvent C modified to a ratio of 200 ml toluene:30 ml glacial acetic acid.

The New Species

Halecania robertcurtisii T.J.Curtis & Lendemer, sp. nov.

MycoBank #MB842784.

Similar to *H. subsquamosa* but lacking the diagnostic unidentified terpenoid found in that species.

Type. USA. Ohio. Columbiana Co., Middleton Twp., Beaver Creek State Park, approx. 1.7 mi NE of the Bell School Rd./OH-7 jct, 40.7302, –80.6114, in a mature forest with mixed hardwoods (*Acer*, *Carya*, *Magnolia*, *Quercus*), *Tsuga canadensis*, and woody understory shrubs (*Asimina*, *Hamamelis*, *Hydrangea* on cliff), large cliff system with several seeps periodically flowing over bedrock, on sheltered SW-facing sandstone cliff face, 27 Nov. 2019, *T.J. Curtis s.n.* (KE L4125!, holotype; NY!, isotype).

COMMON NAME. Robert's Cliff Dots.

DESCRIPTION. Thallus saxicolous, smooth, thin, continuous to rimose or even areolate (especially near thallus border), olive green to olive brown; cortex present, up to 50 μm thick though typically much thinner; medulla white, up to 150 μm thick though typically much thinner; apothecia discoid, usually numerous, initially pseudolecanorine, but with the photobiont layer excluded in mature apothecia and causing them to appear biatorine, 0.1–5.0 mm in diameter; discs smooth, plane, reddish to rusty red-brown or dark brown, epruinose; margins smooth, even, initially also paler than the disc, but eventually becoming concolorous with the disc as the photobiont layer is excluded; exciple paraplectenchymatous, tapering, broader at base (25–50 μm thick), with a brown pigmented cortex, often disappearing under the hymenium of older apothecia; hypothecium hyaline, 125–150 μm tall; hymenium hyaline, not inspersed with oil or crystals, 50–70 μm tall, height approximately even throughout an apothecium; epihymenium thin, up to 5 μm thick, brown pigmented to almost hyaline; paraphyses abundant, thin, filamentous, mostly unbranched, septate, 30–40 μm tall, apically broadening but not markedly swollen, often brown pigmented at apices; asci cylindrical to somewhat clavate, (22.5)–39.8–(55) × (6.3)–11.8–(16.3) μm, 8-spored, *Catillaria*-type; ascospores hyaline, ellipsoid, 1-septate, (8.1)–10.1–(12.5) × (2.8)–3.5–(4.4) μm, smooth, with a visible perispore; pycnidia up to 0.2 mm in diameter, reddish to rust colored, concolorous with apothecial disks, mostly immersed, numerous to sparse or absent; conidia hyaline, simple, bacilliform or short rod-shaped, 3–4 × 1.5 μm.

CHEMISTRY. No substances detected. Thallus K-, C-, KC-, P-, UV-.

ETYMOLOGY. The epithet "robertcurtisii" honors Robert Curtis (b. 1971) who mentored the first author in the field of biology and whose work as a

Fig. 3. Sandstone bluff at the type locality where *Halecania robertcurtisii* was found growing on the basal, sheltered portions of the bedrock along with several other rare crustose lichens.

biologist has been instrumental in raising awareness and implementing protocols to conserve rare lichens and lichen habitat in northeast Ohio.

Distribution and Ecology. To date, *Halecania robertcurtisii* is known from only two sites in eastern Ohio, both within the Unglaciated Allegheny Plateau (Fig. 2). At both sites, it grew at the base of sheltered sandstone bedrock outcroppings (Fig. 3) and alongside both other *Halecania* species known from the Unglaciated Allegheny Plateau (*H*. "*rheophila*" ined. and *H. pepegospora* (H.Magn.) van den Boom). At the type locality, it occurred with *Polyozosia carlottiana* (C.J. Lewis & Śliwa) S.Y. Kondr., Lőkös & Farkas and *Rinodina siouxiana* Sheard, both of which are rare and also suspected to have a relatively narrow habitat preference (Śliwa *et al*. 2012, Sheard 2018). Whether or not *H. robertcurtisii* grows exclusively in these microhabitats is uncertain, but it is likely uncommon across its range. This is supported because the species was not found during other fieldwork in Ohio conducted by the first author, nor has it been found by the second author elsewhere in temperate eastern North America. Further study is needed before the total range of this species can be defined, though endemism to eastern North America seems likely as this region is known to host a high number of endemic species (Barr and Holsinger 1985).

Discussion. Species within other genera that resemble *Halecania robertcurtisii* morphologically can be difficult to distinguish without microscopic and chemotaxonomic examination. Some *Lecania* A. Massal. species can look quite similar, but the two genera are easily distinguished by the conidia, which are short and bacilliform in *Halecania* (vs. relatively long and filiform in *Lecania*; Mayrhofer 1987, Nash *et al*. 2004), and by the *Catillaria*-type ascus in *Halecania* (vs. *Bacidia*-type or *Biatora*-type in *Lecania*; Brodo *et al*. 2001, Næsborg *et al*. 2007). Some saxicolous species of *Catillaria* A. Massal. or *Rinodina* (Ach.) Gray can also resemble *H. robertcurtisii*, but both genera differ fundamentally from *Halecania. Catillaria* species differ from *Halecania* in having paraphyses with markedly swollen, heavily pigmented apices and ascospores that lack a perispore (Kantvilas and van den Boom 2013). Saxicolous *Rinodina* species can look quite similar to *H. robertcurtisii*, especially *R. oxydata* (A. Massal.) A. Massal., in which the apothecial margins are also known to be pseudolecanorine (Kaschik 2006), but *Rinodina* species differ most notably in having brown-pigmented, thick-walled ascospores (Sheard 2010, Sheard *et al*. 2017). Of the saxicolous *Catillaria* species, *C. patteeana* D.P. Waters & Lendemer, with its biatorine apothecia and thin, greenish, continuous to rimose thallus, can resemble older thalli of *H. robertcurtisii*, but it can easily be distinguished by the sorediate thallus (Waters and Lendemer 2019).

Currently there are seven other species of *Halecania* known from North America (Esslinger 2019, Spribille *et al*. 2020), two of which, *H*. "*punctata*" and *H*. "*rheophila*", have yet to be formally described. Of the North American taxa, these two undescribed species are most similar to *H. robertcurtisii* in having smooth, rimose to areolate, olive colored thalli. However, *H*. "*rheophila*" produces pannarin (thallus PD+) and *H*. "*punctata*" produces a series of three diagnostic unidentified terpenes, while *H. robertcurtisii* lacks both of these and instead does not produce any secondary compounds (Harris and Ladd 2005; Lendemer unpublished data). Both *H*. "*rheophila*" and *H*. "*punctata*" also have lecanorine apothecia (Harris and Ladd 2005) rather than the pseudolecanorine and superficially biatorine apothecia in *H. robertcurtisii* (Fig. 1). *Halecania pepegospora* is the only other *Halecania* known to be sympatric with *H. robertcurtisii* but differs markedly in its dark gray, blastidate thallus and the production of argopsin (thallus PD+; Zhdanov 2020). It also typically occurs in more disturbed and exposed habitats (Lendemer *et al*. 2013).

The other North American species of *Halecania* that are not presently known to be sympatric with *H. robertcurtisii* include *H. alpivaga* (Th. Fr.) M. Mayrhofer, *H. athallina* Fryday, *H. subsquamosa* (syn. *H. australis* Lumbsch), and *H. viridescens* Coppins & P. James. *Halecania alpivega*, *H. athallina*, and *H. subsquamosa* all differ from *H. robertcurtisii* in thallus morphology (thick and somewhat placodioid in *H. alpivega*, completely immersed in *H. athallina*, and subsquamulose in *H. subsquamosa*) and apothecia morphology (persistent lecanorine margins present in *H. alpivega* and *H. subsquamosa*, and lecideine apothecia in *H. athallina*; Fryday and Coppins 1996, Nash *et al*. 2004, Spribille *et al*. 2020). *Halecania subsquamosa* also differs chemically in the production of a diagnostic unidentified terpenoid (van den Boom and Mayrhofer 2007; confirmed for this study). *Halecania viridescens* is fundamentally different in that it is corticolous, the thallus is bright green, and abundantly sorediate, but it also produces argopsin, which reacts PD+ red (Coppins 1989).

Nineteen other species of *Halecania* have been described worldwide, most of which differ from *H. robertcurtisii* morphologically. *Halecania fuscopannariae* Etayo & van den Boom, *H. pannarica* M. Brand & van den Boom, *H. parasitica* Aptroot & K.H. Moon, *H. santessonii* M.P. Andreev, and *H. subalpivaga* S.Y. Kondr., Lőkös, & Hur all differ from *H. robertcurtisii* most notably in that they are lichenicolous (van den Boom and Etayo 2001, van den Boom 2009, Aptroot & Moon 2015, Kondratyuk *et al*. 2015, Kondratyuk *et al*. 2016). Other species are markedly different in thallus and/or apothecia morphology, such as *H. etayoana* Palice, van den Boom & Elix; *H. lobulata* van den Boom & Elix; *H. pakistanica* van den Boom & Elix; *H. rhypodiza* (Nyl.) Coppins; and *H. spodomela* (Nyl.) M. Mayrhofer, which have granular to squamulose or effigurate thalli; *H. laevis* M. Brand & van den Boom, which has black apothecial disks; and *H. giraltiae* van den Boom & Etayo, which is sorediate (Fryday & Coppins 1996, van den Boom & Elix 2005, van den Boom 2009). Some species differ from *H. robertcurtisii* in a combination of morphological and ecological characters, such as *H. bryophila* Fryday & Coppins and *H. lecanorina* (Anzi) M. Mayrhofer, which are bryophilous and have granular thalli; or *H. panamensis* van den Boom, which is corticolous and has black apothecial disks (Fryday and Coppins 1996, van den Boom *et al*. 2017). *Halecania tornensis* (H. Magn.) M. Mayrhofer differs from *H. robertcurtisii* most notably in its much larger ascospores (15–20 × 8–11 μm *fide* Fryday and Coppins 1996). *Halecania elaeiza* (Nyl.) M. Mayrhofer, *H. micaceae* Fryday & Coppins, and *H. ralfsii* differ in the production of pannarin and/or argopsin (Fryday and Coppins 1996, van den Boom 2009). *Halecania ralfsii* is very similar to *H. robertcurtisii* in its morphology and general ecology, but in addition to producing lichen substances, the ascospores in *H. ralfsii* are significantly larger than those of *H. robertcurtisii* (15–20 × 6–9 μm *fide* Mayrhofer 1987).

Additional Specimen Examined. **USA.** Ohio. Hocking Co., Crane Hollow Nature Preserve, central Hood Hollow, 39.487672, –82.570123, in a steep forested stream valley with mature hardwoods (*Quercus, Fagus, Acer, Liriodendron, Betula, Carya, Platanus*) and conifers (*Tsuga* and *Pinus*), woody shrubs (*Hamamelis, Carpinus*) in the understory, massive sandstone bedrock outcroppings lining the outer edges of the valley and large boulders throughout, on a lightly shaded sandstone boulder at the base of a large cliff, 11 Aug. 2019, *T.J. Curtis s.n.* (KE-L3581).

Reference Specimens of H. "punctata" *Examined*. **USA.** Missouri. Madison Co., Mark Twain National Forest, Rock Pile Mountain Wilderness, on shaded rhyolite in ravine, 3 Jun. 2004, *D. Ladd 26180-B* (NY); Amidon Memorial Conservation Area, Castor River Shut-Ins Natural Area, on granite along stream, 21 Oct. 2001, *W.R. Buck 40027* (NY). Shannon Co., Ozark National Scenic Riverways, Prairie Hollow, 24 Sept. 1990, on rhyolite along stream, *R.C. Harris 5837* (NY); Ozark National Scenic Riverways, Rocky Creek Shut-Ins ("Kelpzig Mill"), on rhyolite, 16 Apr. 1997, *W.R. Buck 31870* (NY).

Reference Specimens of H. subsquamosa *Examined*. **AUSTRALIA.** New South Wales, Oaky Creek, 37 km NE of Boorowa, on Reids Flat Rd., on eutrophic siliceous rocks in a river bed, 14 Aug. 1991, *H.T. Lumbsch s.n. & H. Streimann = Lecanoroid Lichens Exs. No. 22* (NY, isotype of *H. australis*). **BRAZIL.** Rio de Janeiro, on rock, *A.F.M. Glaziou s.n.* (NY, possible isotype of *Lecania subsquamosa* Müll.Arg.). **USA.** Arkansas. Franklin Co., Ozark National Forest, Boston Mountain Ranger District, Shores Lake, on sandstone, 17 Oct. 2005, *R.C. Harris 51781* (NY). Pope Co., Ozark National Forest, Kings Bluff, on sandstone, 7 Nov. 2002, *W.R. Buck 43047* (NY).

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