

## *Parmotrema perforatum* new to Canada from Kejimikujik National Park and National Historic Site in Nova Scotia, Canada

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**ABSTRACT.** – *Parmotrema perforatum* is a large macrolichen that is common in southeastern North America. We report the first Canadian records from Kejimikujik National Park and National Historic Site in Nova Scotia, Canada. The taxon was located during surveys of the nationally rare Atlantic Coastal Plain habitat in southern Nova Scotia where many disjunct species of vascular plants, bryophytes, and other lichens reach their northern limit in eastern North America.

**KEYWORDS.** – Conservation, biogeography, temperate.

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### INTRODUCTION

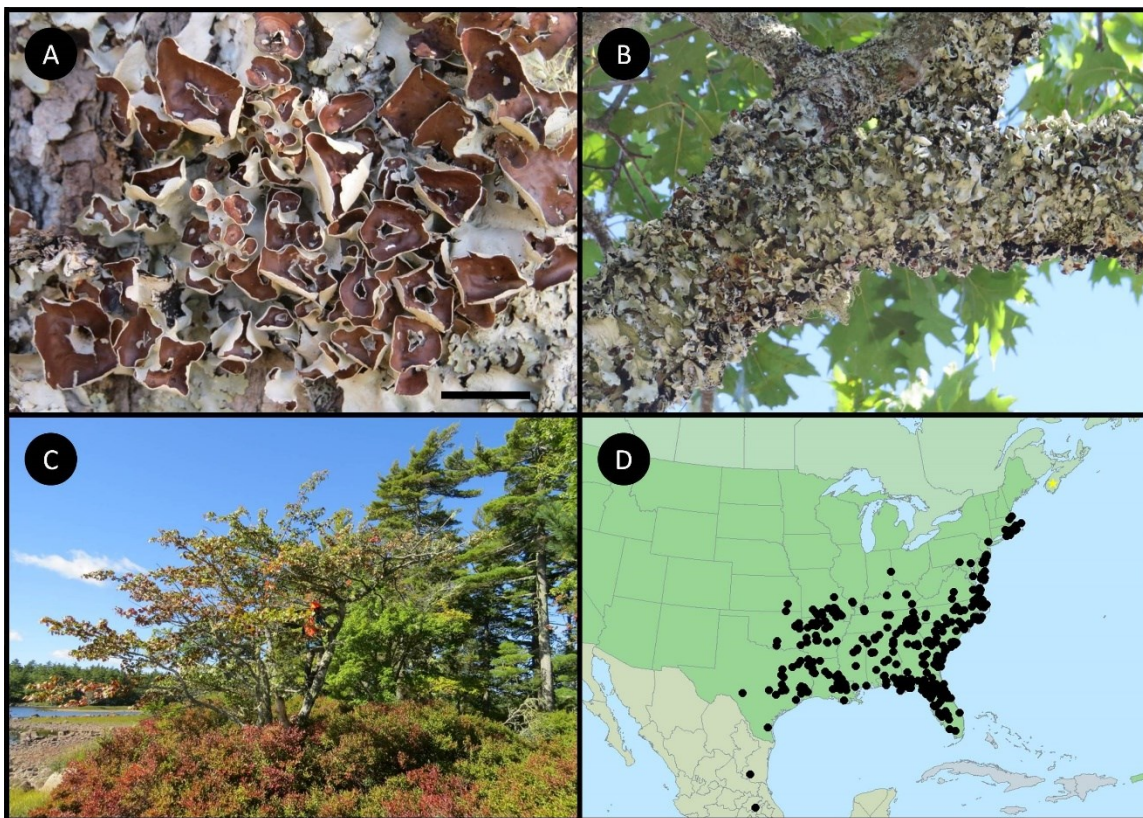
*Parmotrema perforatum* (Jacq.) A. Massal. is a large foliose lichen (thalli 2–15 cm in diameter) that is characterized by 10–20 mm wide lobes with ciliate margins and a mostly green-grey upper surface; substipitate and perforated apothecia that are <20 mm in diameter with brown disks and thalline margins; and a lower surface that is centrally rhizinate and black and brown with mottles of ivory near the periphery (Nash & Elix 2002, Widhelm et al. 2016). The taxon typically occurs on upper branches and trunks of trees in open and exposed habitats (Flenniken 1999, Hinds & Hinds 2007, Nash & Elix 2002). The upper cortex is KOH+ yellow, C-, KC-, PD- due to the presence of atranorin and the medulla is K+ yellow turning red, C-, KC-, P+ orange due to the presence of norstictic acid (Harris 1995; Harris & Ladd 2005; Lendemer et al. 2013, 2016; Nash & Elix 2002; Widhelm et al. 2016). Its global distribution includes eastern North America, Mexico, southern Africa, and Ireland (Hinds & Hinds 2007). In North America, the species distribution is closely affiliated with the Southeastern Coastal Plain, ranging from eastern Mexico to Florida, and north to Massachusetts (Lendemer et al. 2015). Its North American distribution also includes non-coastal plain regions such as the Ozark Mountains, the southern Appalachian Mountains, and the Piedmont (Brodo et al. 2001; Harris & Ladd 2005; Lendemer et al. 2013, 2015).

The Southeastern Coastal Plain contains many endemic bryophyte, lichen, and vascular plant species (Estill & Cruzan 2001, Fleming 2012, Lendemer et al. 2016, Noss et al. 2015, Sorrie & Weakley 2001). Some Coastal Plain plant species, such as *Drosera filiformis* Raf. and *Hydrocotyle umbellata* L., *Sphagnum cyclophyllum* Sull. & Lesq., and *S. macrophyllum* Brid., are known to occur as far north as easternmost Atlantic Canada, which is over 300 kilometers north of the Coastal Plain physiographic region (Fenneman 1938, Noss et al. 2015, Thorne 1993). In Atlantic Canada, this northern extension is most prominent in southern Nova Scotia, where climatic conditions are suitable and Coastal Plain habitats are locally abundant, and where approximately 100 Coastal Plain vascular plant species occur (Crowley et al. 2011; Fernald 1921, 1922; Keddy & Wisheu 1989; Wisheu 1994). Some lichen species, such as *Coccocarpia palmicola* (Sprengel) Arv. & D. J. Galloway, *Fuscopannaria leucosticta* (Tuck.) P. M. Jørg., *Parmelinopsis horrescens* (Taylor) Elix & Hale, *Trypethelium virens* Tuck., and *Usnea strigosa* (Ach.) A. Eaton, exhibit similar distribution patterns north into Nova Scotia and provide strong evidence for the potential of additional discoveries of lichen species with Coastal Plain affinities in southern Nova Scotia (Brodo et al. 2001). Here,

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**Figure 1.** Morphology, habitat and geographic distribution of *Parmotrema perforatum*. **A**, Gross morphology (*A. Belliveau* AGB00500.1, CANL, ACAD), scale = 1 cm. **B**, habit of *P. perforatum* on branch of tree. **C**, habitat where the species was located in Canada. **D**, Geographic distribution of *P. perforatum* in North America, with the Canadian population indicated by a yellow star.

we report the first occurrence of *Parmotrema perforatum* in Canada from Kejimikujik National Park and National Historic Site on the southern peninsula of Nova Scotia.

#### MATERIALS AND METHODS

*Study Site.* – Our study area included lakeshores and adjacent wetlands, riparian zones and forest of 36 lakes in six counties (Annapolis, Digby, Yarmouth, Shelburne, Queens, Lunenburg) of southern Nova Scotia (Fig. 1D), totalling a linear distance of approximately 800 km of lakeshore (B. Toms, pers. comm.). Studied lakes ranged from <1 km from the Atlantic Coast of Nova Scotia, to as far as 55 km away from the coast, with a maximum elevation of 120 meters. They were located within the Acadian Forest Ecozone (Rowe 1972) and the Western Ecoregion of Nova Scotia (Neily et al. 2003). Five of the six counties are also within the UNESCO Southwest Nova Biosphere Reserve (UNESCO, 2001). These lakes were deemed high-priority for conservation efforts by the Atlantic Coastal Plain Flora Recovery Team (Environment Canada and Parks Canada Agency 2016), and each includes at least one of 11 Coastal Plain species federally and legally listed as species at risk of extinction by the Committee on the Status of Endangered Wildlife in Canada (Government of Canada 2017). The determination and updating of information on species population abundance and distribution, habitat availability and suitability, and threats, on these lakes is an objective stated in federal recovery documents (Environment Canada and Parks Canada Agency 2010).

*Surveying.* – From 2009 to 2016, surveys for federally protected vascular plant species were conducted by five professional botanists, of which one was considered a capable lichenologist for the entire duration of the surveys, and another became one near the end of the survey period. Surveys were predominantly carried out on foot, except for some portions of generally narrow and/or steep shoreline which

were examined by slow canoeing close to shore. Survey effort was concentrated along lakeshores and shoreline peatlands, but also included some floodplain and uplands adjacent to lakeshores. Areas covered were documented using a GPS unit set to save position coordinates every 20 seconds. For federally or provincially listed species, provincially rare species (those species with provincial status ranks [S-ranks] of S1 to S3S4 and/or provincial General Status Ranks of At Risk, May Be At Risk, or Sensitive) or non-field-identifiable species, we recorded locations by GPS (accurate to 10 m or less), along with information on population size and extent, habitat, and associated species. For these rarer taxa, we also collected specimens. All data collected through these lakeshore surveying efforts have been incorporated into the Atlantic Canada Conservation Data Centre database for permanent storage. Maps for fieldwork and reporting were produced in Esri ArcMap 9 or 10.

*Identification.* – Specimens were identified using a stereo microscope and standard chemical spot tests with paraphenylenediamine in ethyl alcohol, 10% potassium hydroxide, and alkaline iodine (Brodo et al. 2001). Chemistry was further examined using an ultraviolet light chamber and thin-layer chromatography following Culberson and Kristinsson (1970) and Orange et al. (2001) in solvents A, B, and C. Images were captured using an Olympus OM-D E-M1 Mirrorless Micro Four Thirds Digital Camera. Specimens are housed at the Canadian Museum of Nature (CANL) in Ottawa, Ontario, and the E.C. Smith Herbarium (ACAD) at Acadia University in Wolfville, Nova Scotia.

## RESULTS

Between 100 and 1000 thalli of *Parmotrema perforatum* were observed at two localities on Kejimikujik Lake in Kejimikujik National Park and National Historic Site (Fig. 1D). The first location was on an unnamed 0.4-hectare island (herein called “*Parmotrema* Island”) between Freeman Island and Dark Island, and the second location was approximately 350 meters to the northwest on the 1.3-hectare Dark Island. *Parmotrema* Island is forested with mature *Acer rubrum*, *Picea mariana*, *Pinus strobus*, and *Quercus rubra*, with dense shrubs (*Gaylussacia baccata*, *Ilex verticillata*) along the island’s upland periphery (Fig. 1C). Dark Island is forested with an old-growth *Tsuga canadensis* forest, with *A. rubrum* and dense *G. baccata* along its upland periphery. Thalli were most abundant throughout the upland portion of *Parmotrema* Island, on various substrates including the living bark of *A. rubrum*, *I. verticillata*, *P. mariana*, *P. strobus*, and *Q. rubra*, and on decaying *P. mariana* woody debris (Fig. 1B). Thalli were especially prolific over five meters high in tree canopies, or on the most exposed tree trunks and branches closer to the ground. Smaller numbers of thalli were found scattered on lower, less exposed trunks, branches, and a few shrubs. On Dark Island, one occurrence was observed on the larger limbs of the upper canopy (>10 m) of an *A. rubrum* between open, east-facing lakeshore and old-growth *T. canadensis* forest.

The specimens of *Parmotrema perforatum* that we examined were distinguished by a lower surface with dark coloration in the central portions and with a ~1 cm white zone along the margins, a maculate upper cortex, abundant perforated apothecia that were occasionally as wide as 20 mm, and norstictic acid in the medulla (Fig. 1A). The material matches well the many published accounts of this species (e.g., Harris 1995; Harris & Ladd 2005; Lendemer et al. 2013, 2016; Nash & Elix 2002).

We also searched the following databases for existing Canadian occurrences of this species: Canadensys, Canadian Museum of Nature, Consortium of North American Lichen Herbarium, Global Biodiversity Information Facility, and the New York Botanical Garden. This search led to six previously collected Canadian specimens that were labelled as *Parmotrema perforatum*. After examination of the vouchers we found that that all of them represented other taxa. Four collections from British Columbia (Goward 83-39b, 83-83, 83-166, and Noble & Crane 5361, all at UBC) appear to have been entered into Canadensys and the Global Biodiversity Information Facility incorrectly. On the packets, they were all labelled as *P. perlatum* (Huds.) M. Choisy and we confirmed that as the correct identification. One collection from Ontario (Macoun 27, FH) proved to represent the sorediate species *P. margaritatum* (Hue) Hale, and another specimen from Québec (Lepage 143, QFA) represented a mixture of to *Hypogymnia physodes* (L.) Nyl. and *Parmelia sulcata* Taylor.

## DISCUSSION

The two *Parmotrema perforatum* localities that we discovered are the first confirmed occurrences of the species in Canada. We distinguished *P. perforatum* from other non-sorediate and non-isidiate

*Parmotrema* and *Parmotrema*-like species with marginal cilia or cilia-like marginal rhizines in eastern North America using the key provided in Appendix II. Several species from this group can be difficult to separate and may require mature specimens and/or chemical analyses for identification. Our results suggest that similar species with a more southern-affinity might also be present in southern Nova Scotia, including taxa from the key in Appendix II.

Our survey in Nova Scotia suggests that *Parmotrema perforatum* warrants a provincial conservation rank of S1 (Critically Imperilled). Lichen surveys have been particularly extensive in southern Nova Scotia, largely due to ongoing efforts to detect and monitor *Erioderma pedicellatum* (Hue) P.M.Jørg., a lichen federally-listed as endangered (COSEWIC 2014) and supported by provincial policy requiring targeted lichen surveys before the occurrence of forestry activities. Other surveys have included efforts to monitor Atlantic Coastal Plain vascular plant species along 36 high-priority lakes. In addition to the lakeshore surveys, at least 1906 kilometers of focused lichen surveys by experienced lichenologists have occurred in the six southern Nova Scotia counties where broadly similar vegetation communities (shrubby forests with *Acer*, *Quercus*, and/or *Pinus*) to the ones found on Kejimikujik Lake are known to occur (B. Toms, pers. comm.). Based on lichen records in the area (Atlantic Canada Conservation Data Centre 2017, CNALH 2017), many other unpublished surveys have also occurred in southern Nova Scotia. This relatively extensive coverage, along with the comparative ease of recognizing *P. perforatum* suggests that it is indeed rare. In addition, the possibility of tree blow-down in its only known localities is high. Given the high likelihood of rarity, and the high potential for significant site disturbance, this species warrants provincial conservation concern. The new discovery of this large macrolichen species in a relatively well-surveyed region also highlights the importance of continuous survey efforts to better understand the rare and threatened species in south-western Nova Scotia, and their status in Canada, North America, and globally (Atlantic Canada Conservation Data Centre 2017, Cameron & Toms 2016, Government of Canada 2017, McMullin 2012).

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#### APPENDIX I – SPECIMENS EXAMINED

*Specimens of Parmotrema perforatum examined.* – **CANADA. NOVA SCOTIA.** QUEENS CO.: Kejimikujik National Park and National Historic Site, Kejimikujik Lake, Parmotrema Island, 24.viii.2016, on bark and woody debris, *A. Belliveau AGB00500.1* (ACAD, CANL), 15.xi.2016, *T. McMullin 18650* (CANL).

*Specimens previously identified as Parmotrema perforatum that belong to other taxa.* – **CANADA. BRITISH COLUMBIA.** CAPITAL REGIONAL DIST.: Vancouver Island, Botanical Beach Provincial Park, 4 km SW of Port Renfrew, near sandstone beach fringed by *Picea sitchensis*, on *Picea*, 14.viii.1975, *W.J. Noble & A. Crane 5361* (UBC = *Parmotrema perlatum*). ALBERNI-CLAYOQUOT REGIONAL DIST.: Vancouver Island, harbour area adjacent to Ucluelet, at water’s edge on shady side of N-facing open area, on branches of *Picea sitchensis*, 20.ii.1983, *T. Goward 83-166* (UBC = *Parmotrema perlatum*); Vancouver Island, edge of town of Ucluelet, 30.i.1983, on rock over bird-lined rock above upper tide line, *T. Goward 83-83* (UBC = *Parmotrema perlatum*); Vancouver Island, road edge near town of Ucluelet, 28.i.1983, on branches of wind-felled *Pinus contorta*, near crown, *T. Goward 83-39b* (UBC = *Parmotrema perlatum*). **ONTARIO:** location uncertain, 2.v.1905, *J. Macoun III 27* (FH = *Parmotrema margaritatum*). **QUÉBEC:** Ste-Anne, 11.v.1935, on rock, *E. Lepage 143* (QFA = *Hypogymnia physodes* and *Parmelia sulcata*).

#### APPENDIX II – IDENTIFICATION KEY

Below we provide an identification key for mature, non-sorediate, non-isidiate *Parmotrema* and *Parmotrema*-like species with marginal cilia or cilia-like marginal rhizines in eastern North America. Note that small or immature *Parmotrema* thalli (typically those <1 cm in diameter) with norstictic acid can be either *P. hypotropum* (Nyl.) Hale or *P. perforatum*, as young thalli of *P. hypotropum* can be esorediate (Harris & Ladd 2005).

1. Upper surface reticulately cracked to the lobe margin (best seen under 10× or greater magnification) creating a pattern of ± isodiametric polygons 0.1–0.2 mm broad, the reticulations developing into a pattern of cracks in older portions of the thallus; lower surface dark and rhizinate to the lobe margin; apothecia up to 10 mm in diameter; medulla KOH+ yellow to red (salazinic acid)..... ***P. cetratum*** (Ach.) Hale (≡ *Rimelia cetrata* (Ach.) Hale & Fletcher)
1. Upper surface not cracked; lower surface variable; apothecia up to 20 mm in diameter; salazinic acid present or absent..... **2**
  2. Cortex emaculate; lower surface dark brown to black throughout; lobes 1–8 mm in diameter; apothecia up to 14 mm in diameter and never perforate ..... **3**
    3. Medulla PD-, K+ purple-brown (lividic acid), KC+ purple-brown or red; lobes 1–4 mm in diameter; apothecia 1–5(–8) mm in diameter..... ***Hypotrachyna livida*** (Taylor) Hale
    3. Medulla PD+ red or red-orange, K+ dirty yellow-brown, or K-, KC+ pink or red (protocetraric acid); lobes 2–8 mm in diameter; apothecia up to 14 mm in diameter..... ***P. submarginale*** (Michx.) DePriest & B. Hale (= *P. michauxianum* (Zahlbr.) Hale)
  2. Cortex maculate (except occasionally in *P. eurysacum* or *P. despectum*); lower surface brown throughout or dark brown to black with pale or mottled marginal region; lobes up to 20 mm in diameter; apothecia up to 20 mm in diameter and often perforate..... **4**
  4. Lower surface dark brown throughout ..... **5**

5. Lobe margins crenate to erose; subpalmately divided lacinae absent; upper cortex sometimes faintly maculate; thallus coriaceous, 260–300  $\mu\text{m}$  thick; marginal cilia rare to sparse, 1–3 mm long; ascospores 10–14  $\times$  6–10  $\mu\text{m}$  ..... *P. despectum* Kurok.
5. Lobe margins subentire to broadly crenate; long, subpalmately divided lacinae present; upper cortex emaculate; thallus membranaceous, 150–160  $\mu\text{m}$  thick; marginal cilia frequent, often divided, 1.5–5 mm long; ascospores 14–16  $\times$  7–9  $\mu\text{m}$ ..... *P. eurysacum* (Hue) Hale
4. Lower surface black with a pale mottled marginal region ..... 6
6. Medulla UV+ bright blue-white, KC+ pink (alectoronic acid)..... 7
7. Medulla, especially near the apothecia, KOH- (norstictic acid absent) .....  
..... *P. subrigidum* Egan s. str.
7. Medulla, especially near the apothecia, KOH+ yellow turning red (norstictic acid present)  
..... *P. subrigidum* Egan s. lat.
6. Medulla UV-, KC- (alectoronic acid absent)..... 8
8. Medulla AI+ blue, KOH+ yellow (constictic and stictic acids, occasionally with traces of norstictic acid); Louisiana and Texas..... *P. preperforatum* (W.L.Culb.) Hale
8. Medulla AI-, KOH+ yellow turning red (connorstictic and norstictic acids); mostly the southeastern coastal plain and southern Appalachians..... *P. perforatum* (Jacq.) A.Massal.