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The lichen genus *Rinodina* (Physciaceae) in New Brunswick, Canada

Stephen R. Clayden[1,*], Kendra E. Driscoll[1], and Hinrich Harries[2]

[1]Department of Natural History, New Brunswick Museum, 277 Douglas Avenue, Saint John, New Brunswick E2K 1E5 Canada
[2]23 Squire Street, Sackville, New Brunswick E4L 4K8 Canada
[*]Corresponding author: stephen.clayden@nbm-mnb.ca

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Abstract

Fifteen species of the crustose lichen genus *Rinodina* are confirmed in New Brunswick, Canada. We report four corticolous species, *Rinodina pachysperma*, *Rinodina populicola*, *Rinodina septentrionalis*, and *Rinodina tenuis*, and the saxicolous *Rinodina tephraspis* in the province for the first time. A previous report of *Rinodina granuligera* is based on a specimen that we have re-identified as *Rinodina cinereovirens*. We note distinguishing characteristics, habitats, substrata, relative abundance, and biogeographic relationships of each species and provide an identification key and distribution maps. The most frequently occupied phorophytes (tree substrata) are Sugar Maple (*Acer saccharum*), Yellow Birch (*Betula alleghaniensis*), and Eastern White Cedar (*Thuja occidentalis*). Some species are closely associated with particular habitats, phorophytes, or both. For example, we found *R. pachysperma* only in floodplain forests dominated by Silver Maple (*Acer saccharinum*), and *R. tenuis* only on Eastern White Cedar in wet cedar-dominated stands. In contrast, we recorded *Rinodina freyi* on numerous phorophyte species in a relatively wide range of habitats. Other than Eastern White Cedar and Balsam Fir (*Abies balsamea*), conifers are rarely colonized by *Rinodina* species in New Brunswick. Most *Rinodina* species are probably not currently of conservation concern in the province. However, *R. cinereovirens* is known from only two collections, one dating from 1902. The other, from 2007, was on Black Ash (*Fraxinus nigra*) in a swamp forest next to an active peat-mining operation. The expected devastation of ash species by the invasive Emerald Ash-borer (*Agrilus planipennis*) is a further threat to this occurrence and to any lichens for which ash may be an important phorophyte.

Key words: Biogeography; disjunct distribution; Atlantic Canada; Wolastoq (Saint John River); protected natural areas; phorophyte; conservation; seasonality of spore production

Introduction

The lichen-forming ascomycete genus *Rinodina* (Ach.) Gray includes species that share a crustose growth form, apothecia mostly with a thalline margin and unpigmented hypothecium, and brown, mostly 1-septate ascospores with unevenly thickened inner walls (Sheard 2010). Their green algal symbionts are species of *Trebouxia* Puym. (Helms *et al.* 2001; Sanders and Masumoto 2021). The name "Pepperspore Lichens" was introduced for the genus *Rinodina* by Brodo *et al.* (2001), but most of its species lack common names. Over the past few decades, molecular phylogenetic studies have shown that the combination of characters defining *Rinodina* is represented in several distinct lineages in the family Physciaceae (e.g., Helms *et al.* 2003; Nadyeina *et al.* 2010; Resl *et al.* 2016; Kondratyuk *et al.* 2021). Independent transitions between crustose and foliose or squamulose growth forms have occurred in some of these lineages. Although the polyphyletic character of the genus is clear from these findings, some clades including species of *Rinodina sensu lato* (*s.l.*, in the broad sense) are not yet well resolved within the Physciaceae, and the placements of many species remain uninvestigated. For these reasons, the genus is still widely treated in its broad sense.

Collectively, *Rinodina* species are distributed from subtropical to Arctic/subantarctic and alpine environments, and they occur on many substrata, including rock, tree bark, wood, bryophytes, plant debris, and soil. Knowledge of their species-level diversity and distributions has advanced greatly in recent decades. A monograph of the genus in North America north of Mexico by Sheard (2010), based on more than 40 years of study, recorded 96 species. Publication of this work catalyzed other investigations, bringing the number of species currently known in North America to 113 (Sheard 2018; Lendemer *et al.* 2019; Morse

and Sheard 2020). Comparable progress in the study of *Rinodina* in eastern Asia has led to further changes in the taxonomy and known distributions of several North American species (Sheard *et al.* 2017).

The regional diversity of *Rinodina* in North America is greatest in the cordilleran and coastal systems of the west. For example, 51 species are known in California and at least 37 in British Columbia (Sheard 2010, 2018). About half as many species occur in areas of roughly comparable size in eastern North America (Sheard 2010). Intensive recent studies of *Rinodina* in the southern Appalachian Mountains have recorded 22 species (Lendemer *et al.* 2012, 2014, 2019; Sheard *et al.* 2012). Five of these, including two regional endemics, had not been described previously, highlighting the significance of the southern Appalachians as a hotspot of lichen diversity (Tripp and Lendemer 2019). In New England and eastern Canada, state and provincial records of *Rinodina* species confirmed by Sheard (2010) have been supplemented in some cases by recent or updated general lichen surveys. For example, Seaward *et al.* (2017) reported 10 species from the coastal region of eastern Maine, and Brodo *et al.* (2021a,b) 15 species from the Ottawa region of Ontario and Quebec.

In this paper, we aim to assess the diversity, distributions, habitats, and relative abundance of *Rinodina* species in the maritime eastern Canadian province of New Brunswick. Eleven species were reported for the province by Sheard (2010, 2018): *Rinodina ascociscana* (Tuck.) Tuck., *Rinodina cinereovirens* (Vain.) Vain., *Rinodina efflorescens* Malme, *Rinodina freyi* H. Magn., *Rinodina gennarii* Bagl., *Rinodina granuligera* H. Magn., *Rinodina moziana* (Nyl.) Zahlbr., *Rinodina polyspora* Th. Fr., *Rinodina subminuta* H. Magn., *Rinodina subpariata* (Nyl.) Zahlbr., and *Rinodina willeyi* Sheard & Giralt. Most of these records are based on only a few specimens. An in-depth study of the lichens of Fundy National Park in New Brunswick by Gowan and Brodo (1988) detailed the local habitats and substrata of five species. Over the past few decades, wide-ranging surveys of lichen diversity in the province have yielded many new *Rinodina* collections. From this material, we have been able to gain a better understanding of the status of the species reported by Sheard (2010, 2018) and to add five species that were not previously known to occur in the province.

Study Area

New Brunswick is about 73 000 km^2 spanning 3.5 degrees of latitude and 5 degrees of longitude: 44.5° to 48°N, 64° to 69°W. It includes part of the northern Appalachian Mountain system, with elevations ranging from sea level along its coasts to 820 m in the northern interior. The climate is intermediate between continental and oceanic types, being dominated by airflows from the west but moderated by maritime influences (Hare and Thomas 1974). Conditions are most oceanic near the Bay of Fundy in the south, with January mean temperature −6° to −8°C, July/August mean 15° to 17°C, and precipitation 1300 to 1500 mm/yr. In the most continental areas, January and July means are −12° to −14°C and 16° to 19°C, respectively, and precipitation averages 1000 to 1200 mm/yr. Degree-days above 5°C vary from less than 1200 at elevations above 600 m in the highlands to more than 1900 in the middle Wolastoq (Saint John River) valley (Hassan *et al.* 2007; Clayden 2010; ECCC 2022).

The province falls largely within the Acadian Forest Region (Rowe 1972), which is the northeasternmost portion of the transition between temperate deciduous and boreal coniferous forests in North America. In the bioclimatic system of Tuhkanen (1984), New Brunswick is mainly in the hemiboreal zone, with some representation of the southern boreal zone in its northern highlands and of the north/cool temperate zone in the southern interior (Clayden 2010). Climatic and associated vegetation gradients in the province are not simply orientated along a south-north axis. Instead, topographic, coastal–inland, and latitudinal variation are reflected in a mosaic of ecoregions (Loucks 1962a; Clayden 2000, 2010; Zelazny 2007). The natural vegetation of the province has been much altered by settlement, agriculture, forestry, and invasive pathogens; however, about 85% of the land-area remained forested as of the early 2000s (Loo and Ives 2003). According to Global Forest Watch (2023), the net change in forest cover (gain versus loss) in New Brunswick between 2000 and 2020 was −6.8%, compared with a net change of −2.8% over the same period in Canada as a whole. As of 2022, 10% of New Brunswick has been allocated to biodiversity conservation in areas protected under provincial and federal legislation and by non-government organizations (NBDNRED 2022).

Methods

This study is based largely on collections made by the three authors and deposited in the herbarium of the New Brunswick Museum (NBM). We also cite selected specimens collected over the past few decades by our colleagues Frances Anderson, William Buck, Richard Harris, James Lendemer, and Steven Selva, among others. We examined and identified or confirmed 324 specimens from throughout the province (Figure 1). More precisely, the sample consisted of 324 species-occurrence records, as it included *Rinodina* species occurring as associates of other lichens in multi-species collections (in single

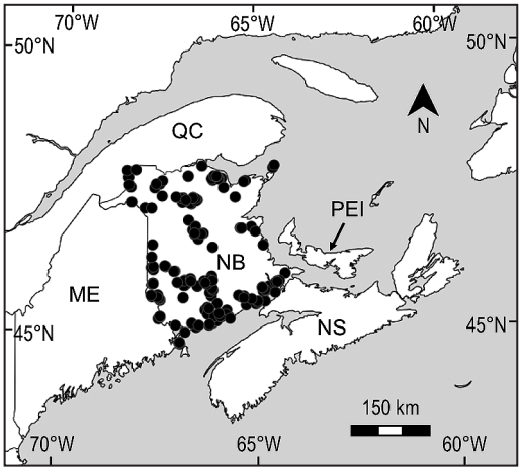

Figure 1. Map of New Brunswick and neighbouring areas, showing distribution of all *Rinodina* collections included in our study. Abbreviations: Canada: NB, New Brunswick; NS, Nova Scotia; PEI, Prince Edward Island; QC, Quebec. United States: Maine, ME. Basemap from SimpleMappr (Shorthouse 2010).

herbarium packets). Herbarium acronyms follow Thiers (2022+). Except as noted, specimens are in the herbarium of the NBM.

Most collections were made during general surveys of lichen diversity. Field work covered numerous representative examples of the province's range of forest community types and other environments (e.g., rocky coastal and river shores) that are known or potential habitats for *Rinodina* species (Figure 2). Mature upland deciduous and mixed forests and forested wetlands dominated by Eastern White Cedar (*Thuja occidentalis* L.) were especially well represented, as our early surveys indicated that these are species-rich habitats for *Rinodina* in the province. Recently wind-thrown trees or broken branches found on the forest floor were inspected for canopy-dwelling species.

We recorded the identities of the lichen phorophytes (tree or shrub species) wherever feasible and tallied the distributions and frequencies of *Rinodina* species by phorophyte in the sample. At least one specimen of each species is cited for each of the 15 counties of the province from which we have seen material. Lichen nomenclature follows Esslinger (2021). The scientific and common names of trees and shrubs follow Brouillet *et al.* (2010+). In descriptions of forest communities, short forms of common names are used for some tree species: fir for Balsam Fir (*Abies balsamea* (L.) Miller), beech for American Beech (*Fagus grandifolia* Ehrhart), hop-hornbeam for Eastern Hop-hornbeam (*Ostrya virginiana* (Miller) K. Koch), cedar for Eastern White Cedar, and hemlock for Eastern Hemlock (*Tsuga canadensis* (L.) Carrière). The full common names of these species are given where they refer to the phorophytes of *Rinodina* specimens and species.

Since 2009, S.R.C. and K.E.D. have made extensive collections in the larger protected natural areas (PNAs) of the province through the BiotaNB project led by the NBM (McAlpine 2022). All collection sites in provincial PNAs established as of 2022 are referred to by their current PNA names; however, some of these PNAs had not been established and named at the time the specimens were collected.

Methods for microscopic study of specimens followed Sheard (2010, 2018). Hand-cut sections of apothecia and thalli were mounted in water or Melzer's reagent and examined at 100× to 1000× magnification. Some sections were viewed in polarized light to assess the presence or absence of crystals of atranorin or sphaerophorin. To clear and highlight the internal structure of the spores of recently collected specimens, water mounts were gently heated over an alcohol lamp. Measurements of ascospores were made to the nearest 0.5 µm and are reported in the format: (minimum–) mean–SD – mean+SD (–maximum), followed by the number of measurements (*n*). The structure and developmental type(s) of ascospores occurring in each species are noted following standardized terminology (Sheard 2010). The characteristic medial swelling of spores of the *Dirinaria*-type was assessed by adding 10% potassium hydroxide (KOH) to the water mounts.

The occurrence of secondary chemical products in thalli was examined using standard reagents, following Brodo *et al.* (2001): sodium hypochlorite (C), 10% potassium hydroxide (K), and an alcoholic solution of para-phenylenediamine (P). Tests for the presence or absence of pannarin in the epihymenium of apothecia were made in microscopically examined thin sections. Selected specimens were analyzed with standardized thin-layer chromatography (TLC), using solvent system C and glass-backed plates (Culberson 1972; Orange *et al.* 2001).

Results

Fifteen species of *Rinodina* are confirmed to occur in New Brunswick. Five of these are reported here for the first time from the province: the corticolous species *Rinodina pachysperma* H. Magn., *Rinodina populicola* H. Magn., *Rinodina septentrionalis* Malme, and *Rinodina tenuis* Müll. Arg., and the saxicolous species *Rinodina tephraspis* (Tuck.) Herre. We found 14 species in the field, but not *R. moziana*. The latter is known from New Brunswick based on a single specimen that was identified and reported by Sheard (2010). A previous report of *R. granuligera* from the province (Sheard 2010) is based on a specimen that we re-examined and identified as *R. cinereovirens* (see below).

FIGURE 2. Habitats of selected *Rinodina* species in New Brunswick, Canada. a. Forest dominated by Silver Maple (*Acer saccharinum*) on floodplain of middle Wolastoq (Saint John River) valley, with Black Willow (*Salix nigra*) in foreground. *Rinodina pachysperma* is frequent on tree trunks in this type of community. b. Eastern White Cedar (*Thuja occidentalis*) at base of forested slope next to a river. *Rinodina tenuis* is present on the curving dead branch in the foreground. c. Damp siliceous rocks, with *Rinodina tephraspis*, next to a waterfall, Lepreau River. d. Late-successional hardwood forest dominated by Sugar Maple (*Acer saccharum*), American Beech (*Fagus grandifolia*), and Yellow Birch (*Betula alleghaniensis*), with *Rinodina ascociscana*, *Rinodina subminuta*, *Rinodina subpariata*, and *Rinodina willeyi* on the tree trunks. Photos: S.R. Clayden.

Three of the 15 recorded *Rinodina* species are saxicolous on siliceous (non-calcareous) rock: *R. gennarii* (rarely lignicolous), *R. moziana*, and *R. tephraspis*. The 12 corticolous species were found on 29 phorophyte species. The representation of corticolous *Rinodina* species and their main phorophytes in the set of specimens is shown in Figure 3. No phorophyte species had more than six associated *Rinodina* species. The most frequently collected species was *R. subminuta*. Its most frequent phorophyte, and the most frequent phorophyte species overall, was Sugar Maple (*Acer saccharum* Marshall).

Rinodina freyi and *R. subpariata* were found on the greatest number of phorophyte species (16). However, *R. freyi* was collected less frequently overall than several other *Rinodina* species. In contrast, *R. tenuis* was found on only one phorophyte, Eastern White Cedar, but was represented by 18 specimens from 14 localities. Although the sample of specimens collected and identified was loosely stratified by forest type and phorophyte species, it undoubtedly reflects collecting biases, e.g., an emphasis on mid- to late-successional stands. Also, parts of the province with fewer and/or smaller protected areas are under-represented. This is especially true of Carleton County and Victoria County in western New Brunswick, where most of the land is privately owned. Another gap centres on the lowlands of eastern New Brunswick, where extensive peatlands alternate with mostly early- to mid-successional coniferous and mixed forests (Clayden 2000; Crossland 2006). With these caveats, the distributions of specimens and species provide an approximation of the relative abundance and phorophyte associations of corticolous *Rinodina* species in New Brunswick. The distinguishing characteristics, distributions, habitats, and substrata of each species are described below.

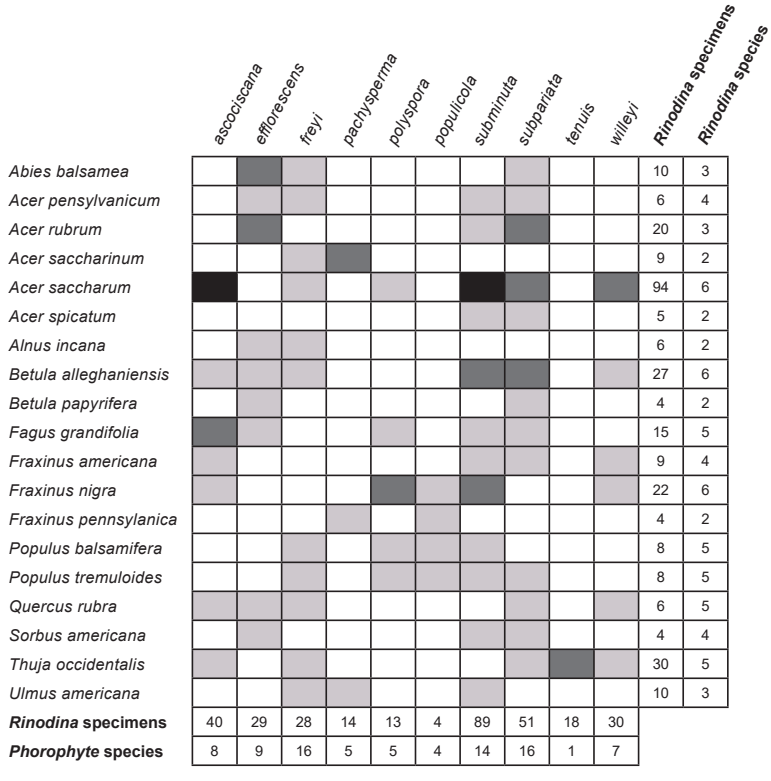

FIGURE 3. Principal phorophytes of corticolous *Rinodina* species in New Brunswick. The overall dataset included 318 specimens representing 29 phorophyte and 13 *Rinodina* species. Ten phorophyte species from which only one or two *Rinodina* specimens were collected, and two *Rinodina* species (*R. cinereovirens, R. septentrionalis*) represented by only one or two specimens, are not shown (see text for details). Shading indicates the number of *Rinodina* specimens from each phorophyte, in four arbitrary classes: white (no shading) = 0 specimens; light-grey = 1 to 5 specimens; medium-grey = 6 to 20 specimens; black > 20 specimens.

Key to *Rinodina* species known or expected to occur in New Brunswick

Eighteen species are included in the key. Three of these, *Rinodina bischoffii* (Hepp) A. Massal., *Rinodina buckii* Sheard, and *Rinodina oxydata* (A. Massal.) A. Massal. [enclosed in square brackets] have not been found in New Brunswick but are known from neighbouring Maine and/or Quebec. The key is based on those of Sheard (2010, 2018; Sheard *et al.* 2017).

1. On rock 2
1. On bark or wood, or on bryophytes over bark 6
2. On coastal rocks (rarely on rusted metal or wood) subject to salt spray and/or enrichment by guano; spores somewhat swollen at the septum (swelling more pronounced in KOH; *Dirinaria*-type) ..... ***R. gennarii***
2. On rocks near freshwater or in forested or open upland settings; spores swollen or not at the septum 3
3. On calcareous rock; spores with a broad dark-pigmented band around the septum, walls not thickened at the apices (*Bischoffii*-type) ..... [***R. bischoffii***]
3. On siliceous rock; spores with or without a thin dark-pigmented ring-structure ("torus") where the septum meets the lateral wall, walls thickened at the apices 4
4. Thallus K−, lacking atranorin (no crystals visible in the cortex of thallus and apothecium sections examined in polarized light), containing zeorin ..... ***R. tephraspis***
4. Thallus K+ yellow, containing atranorin (crystals visible in the cortex of thallus and apothecium sections examined in polarized light), lacking zeorin 5
5. Spores averaging 22.0–22.5 × 12.0–13.0 µm ..... ***R. moziana***
5. Spores averaging 18.5–19.5 × 10.5–11.5 µm ..... [***R. oxydata***]

6. Soredia present 7
6. Soredia absent 10

7. Thallus K+ yellow, P+ yellow, containing atranorin, lacking pannarin ..... ***R. subpariata***
7. Thallus K−, lacking atranorin, P+ red-orange, containing pannarin 8

8. Areoles convex, not uplifted at margins; soredia initially developing on the surface of the areoles, relatively coarse, 40–65 µm in diameter ..... [***R. buckii***]
8. Areoles ± plane, often slightly uplifted at margins; soredia developing at the margins or on the surface of the areoles, relatively fine, 15–30 µm in diameter 9

9. Areoles grey-brown to dark grey-green; prothallus thin and dark brown; soredia pale greenish-yellow, in discrete soralia developing at margins or on surface of areoles, soralia KC+ yellow-orange (reaction sometimes weak); thallus (in New Brunswick populations) not overgrowing bryophytes ..... ***R. efflorescens***
9. Areoles light to dark grey; prothallus not evident; soredia grey, developing at margins of areoles, KC−; thallus (in New Brunswick populations) sometimes becoming ± entirely sorediate and overgrowing *Frullania* and small pleurocarpous mosses ..... ***R. willeyi***

10. Spores more than 8 in most asci 11
10. Spores not more than 8 per ascus 12

11. Spores 12–16 per ascus, averaging 15.0–16.0 µm long, with persistent apical and septal wall thickenings (*Physcia*-type), not constricted at the septum; apothecia mostly scattered, discs becoming convex, thalline margins thin and becoming excluded; thallus thin and inconspicuous ..... ***R. polyspora***
11. Spores 16–32 per ascus, averaging 12.5–13.5 µm long, lacking wall thickenings at maturity (*Physconia*-type), often becoming slightly constricted at the septum; apothecia often becoming contiguous, discs remaining plane, margins distinct and not becoming excluded; thallus usually well developed, areolate ..... ***R. populicola***

12. On wood (typically on rock) in coastal habitats subject to salt spray and/or enrichment by guano; spores somewhat swollen at the septum (swelling increasing in KOH) ..... ***R. gennarii***
12. On bark or rarely wood, mainly of living trees, mostly in non-coastal habitats; spores not swollen at the septum 13

13. Thallus P+ red-orange, containing pannarin ..... ***R. tenuis***
13. Thallus P−, lacking pannarin 14

14. Medulla of apothecium margins densely filled with fine crystals of sphaerophorin (visible in polarized light); lower part of apothecial cortex expanded, 20–60 µm deep ..... ***R. cinereovirens***
14. Medulla of apothecium margins lacking sphaerophorin (no crystals evident in polarized light); lower part of apothecial cortex not or little expanded, <20 µm deep 15

15. Spores averaging >25 µm long; thallus usually thick and continuous, surface often waxy; margins of apothecia often becoming radially grooved ..... ***R. ascociscana***
15. Spores averaging <22 µm long; thallus inconspicuous or thin to moderately thick and areolate, surface matt; margins of apothecia smooth to rough, but not becoming radially grooved 16

16. Spores with thick lateral and apical walls, lumina ± rounded (*Pachysporaria*-type) ..... ***R. pachysperma***
16. Spores with apical walls thicker than lateral walls, lumina distinctly angular, at least in early stages of development (*Physcia*-type) 17

17. Apothecia initially immersed and erupting from the thallus, remaining broadly attached; spores averaging > 18.5 µm long; thallus often within the substratum or very thin and ± continuous, mainly on lower part of tree trunks ..... ***R. subminuta***
17. Apothecia not erupting from the thallus, broadly to narrowly attached; thallus superficial on substratum, usually consisting of discrete areoles, mainly on twigs and young branches; spores averaging <17 µm long 18

18. Thallus typically on and around axils and leaf scars of twigs and young tree branches; areoles ± plane and contiguous, up to 0.7 mm wide; apothecia crowded ..... ***R. freyi***
18. Thallus typically on ± smooth bark of twigs and young tree branches; areoles convex (especially when moist) and dispersed, <0.2 mm wide; apothecia dispersed ..... ***R. septentrionalis***

Annotated Checklist of *Rinodina* in New Brunswick

The list is sorted alphabetically by species, with the distribution map indicated. The lists of specimens are sorted alphabetically by **county** and by date (oldest to most recent). In cases where more than one specimen of a species was collected at, and cited from, a single locality, the abbreviation "*ibid.*" is used to minimize duplicated information on the locality, habitat, substrate, and date, as appropriate.

The Latin abbreviations *s.l.* and *sine numero* (*s.n.*, without number, when no collector number was given to the collection) also are used when relevant.

Rinodina ascociscana (Tuck.) Tuck. (Figure 4a)

Reported for New Brunswick by Gowan and Brodo (1988) and Sheard (2010). Characterized by its somewhat glossy, grey-brown, thin to thick thallus consisting of plane, coalescing areoles; apothecia with radially striate margins; and large *Physcia*- to *Physconia*-type spores measuring (25.0–)28.9–35.1(–38.0) × (13.0–)13.6–16.2(–17.5) µm (n = 37) in New Brunswick specimens. North American thalli of *R. ascociscana* lack secondary metabolites detectable with TLC (Sheard 2010). They thus lack crystals in the medulla, unlike *R. cinereovirens*, which contains sphaerophorin and which also has a different type of apothecial margin, smaller spores, and a thinner thallus. Zeorin is present rarely in populations of *R. ascociscana* in northeastern Asia (Sheard *et al.* 2017). We analyzed 12 New Brunswick specimens with TLC but did not detect zeorin in any of them.

The spores of *R. ascociscana* are the largest of those in any *Rinodina* species in eastern North America. In most specimens from New Brunswick (collected during the spring to fall months), the apothecia contain mainly overmature and deformed spores. However, a specimen collected in late December (*Clayden 27379*) has abundant, intact, well-developed spores releasing readily from the asci in water mounts. Sheard (2010) also noted what appeared to be seasonal variation among specimens of *R. ascociscana* in the representation of spores in different stages of development.

In North America, this species has a well-defined Appalachian–Great Lakes–Maritimes distribution (Brodo *et al.* 2001; Sheard 2010), coinciding largely with that of temperate deciduous forests dominated by Sugar Maple. It was long thought to be endemic to this region, but recent studies have shown that it also occurs in climatically similar areas of northeastern Asia (Sheard *et al.* 2017). Its distribution and habitats are similar to those of *R. subminuta*, but somewhat less extensive. For example, it has not been found in the Ozark Highlands of the south-central USA, where *R. subminuta* is present (Sheard 2010; Lendemer *et al.* 2014). In New Brunswick, it occurs mainly in closed forests of long historical continuity (e.g., Selva 1994), whereas *R. subminuta* can also occur on open-grown trees and at forest edges (Gowan and Brodo 1988; S.R.C. pers. obs.). It is less frequent in the province than *R. subminuta*, occurring mainly in mature hardwood and mixed forests in mesic sites, but also rarely on Eastern White Cedar in swamp forests, always in the understorey. *Rinodina ascociscana* occurs on Sugar Maple up to the elevational limit of this tree species in the northern interior (e.g., at 510 m on Gover Mountain, see below), but we did not find it in many hardwood stands in the northernmost areas of the province where *R. subminuta* is present (compare Figures 4a and 4i).

Among the specimens of *R. ascociscana* from New Brunswick examined for this study, 21 were on Sugar Maple, nine on American Beech, three on White Ash (*Fraxinus americana* L.), two on Black Ash (*Fraxinus nigra* Marshall), and one each on Yellow Birch (*Betula alleghaniensis* Britton), Eastern Hop-hornbeam, Red Oak (*Quercus rubra* L.), and Eastern White Cedar. The single occurrence on Red Oak is from a lakeshore forest where a species-rich epiphytic lichen community was present, apparently influenced by aerosol enrichment of the tree-bark resulting from wave splash on nearby shoreline rocks. The lack of records of *R. ascociscana* on Red Maple (*Acer rubrum* L.) matches the apparent absence or rarity of *R. subminuta* and *R. willeyi* on this maple species in New Brunswick. The substratum of a collection made by W.G. Farlow on Campobello Island in 1902 (not seen by us; examined and cited by Sheard [2010]) is unknown. Recent lichen surveys on the island have not detected *R. ascociscana*. (S.R.C. *et al.* unpubl. data).

Selected specimens examined—**Albert Co.:** Caledonia Gorge PNA, upland between Rhody Brook and Wells Brook, 45.7726°N, 64.8210°W, 323 m, old-growth hardwood forest dominated by Sugar Maple, Yellow Birch, and beech, on American Beech, 28 June 2011, *S.R. Clayden 22071*. **Carleton Co.:** Meduxnekeag River valley, terrace and E-facing slope between river and Plymouth Road, 46.18558°N, 67.68175°W, 140 m, mature hardwood forest dominated by Sugar Maple, on Sugar Maple, 7 May 2008, *S.R. Clayden 18189*. **Kings Co.:** Canadian Forces Base Gagetown, Nerepis Hills, ~3.8 km ESE of Welsford, 45.4413°N, 66.2978°W, 120 m, mature mixed forest of Red Spruce (*Picea rubens* Sargent), hemlock, Eastern White Pine (*Pinus strobus* L.), Yellow Birch, Heart-leaved Birch (*Betula cordifolia* Regel), and Red Maple, on SW-facing slope, on trunk of Yellow Birch, 7 September 2014, *S.R. Clayden 24840.* **Madawaska**

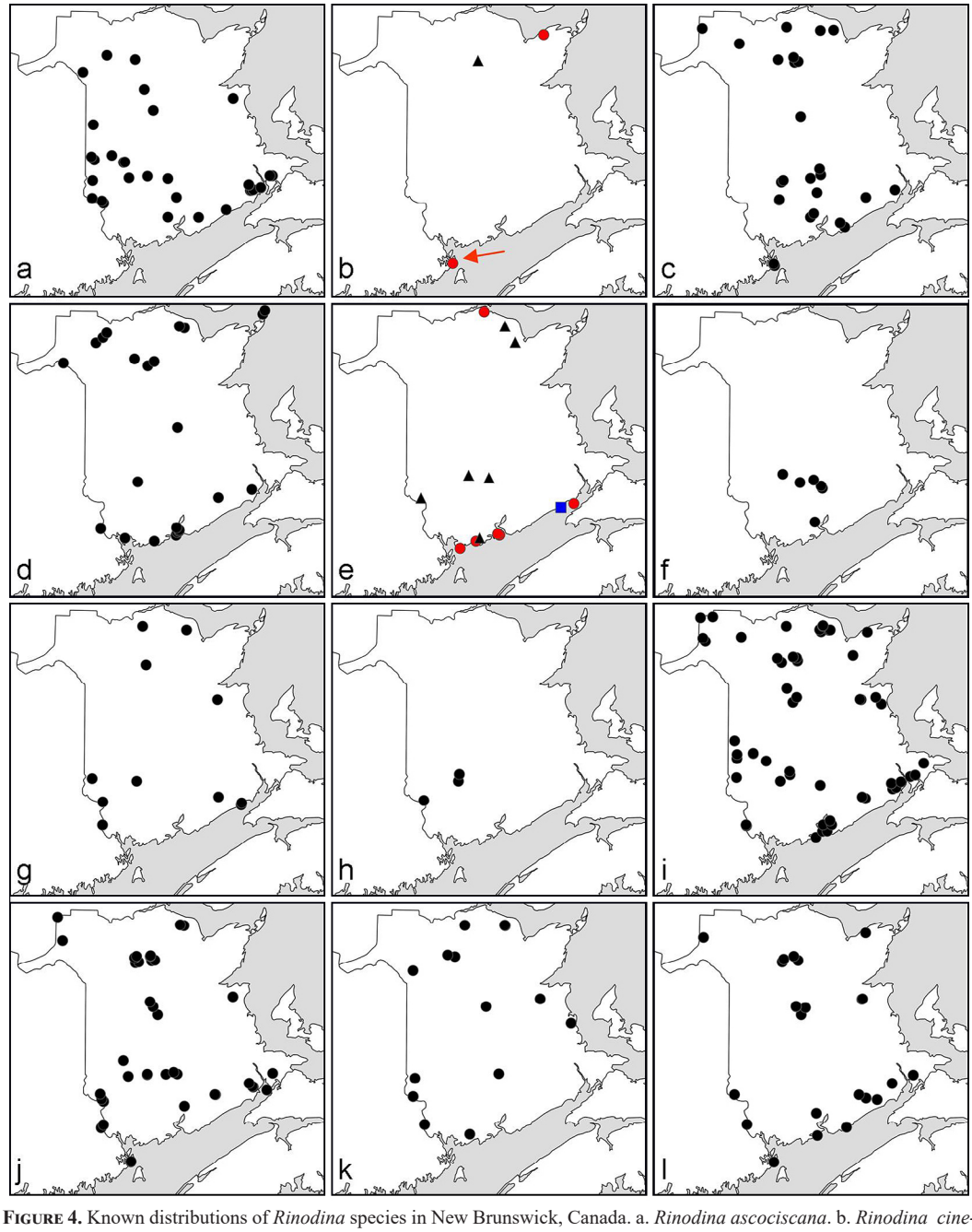

FIGURE 4. Known distributions of *Rinodina* species in New Brunswick, Canada. a. *Rinodina ascociscana*. b. *Rinodina cinereovirens* (circles, with arrow indicating historical occurrence on Campobello Island), *Rinodina septentrionalis* (triangle). c. *Rinodina efflorescens*. d. *Rinodina freyi*. e. *Rinodina gennarii* (circles), *Rinodina moziana* (square), *Rinodina tephraspis* (triangles). f. *Rinodina pachysperma*. g. *Rinodina polyspora*. h. *Rinodina populicola*. i. *Rinodina subminuta*. j. *Rinodina subpariata*. k. *Rinodina tenuis*. l. *Rinodina willeyi*. Basemaps from SimpleMappr (Shorthouse 2010).

Co.: "Black Brook District" of J.D. Irving Ltd, SW-facing hillside, ~5 km ENE of confluence of Harrison Brook with Grande Rivière, 47.24193°N, 67.86828°W, 266 m, mature hardwood forest dominated by Sugar Maple and beech, with scattered hophornbeam and Black Ash, on trunk of old Black Ash,

29 August 2008, *S.R. Clayden 19144*. **Northumberland Co.:** Gover Mountain PNA, plateau near mountain top, 47.036°N, 66.737°W, 510 m, mature deciduous forest dominated by Sugar Maple, with scattered Yellow Birch, Red Maple, and Red Spruce, on Sugar Maple, 20 October 1993, *S.R. Clayden 7914*; Kennedy Lakes PNA, along unnamed brook flowing S to SW off unnamed hill between Route 108 and Dungarvon River, 46.7782°N, 66.5704°W, 380 m, mature forest of Yellow Birch, Sugar Maple, beech, and Red Spruce, on trunk of Sugar Maple, 2 July 2019, *S.R. Clayden 27863B*; Hells Gate Hardwoods PNA, ~6.5 km ENE of Saint Margarets, 46.9232°N, 65.1121°W, 40 m, mature hardwood forest dominated by Sugar Maple, Red Maple, and Yellow Birch, on trunk of White Ash, 14 September 2019, *S.R. Clayden 27996*; **Queens Co.:** Wolastoq (Saint John River) valley E and S of Route 102 near Queenstown, ~1.5 km SW of E end of Otnabog Lake, "Nickerson Woodlot", 45.69034°N, 66.14550°W, 110 m, mature, mesic forest of Sugar Maple, beech, and Yellow Birch, with scattered ash (*Fraxinus* L.), hop-hornbeam, and Red Spruce, on Eastern Hop-hornbeam, 13 May 2008, *S.R. Clayden 18243*. **Restigouche Co.:** Mount Carleton Provincial Park, off the W side of the Mount Bailey trail, between 1 and 1.5 km from trailhead, 47.41°N, 66.91°W, hardwood stand dominated by Sugar Maple, with moderate amount of Yellow Birch, corticolous on Sugar Maple, 22 July 1989, *S.B. Selva 4059*. **Saint John Co.:** along woods road E of Little Salmon River, 6 km SE of Crawford Lake, 45.532°N, 65.256°W, small patch of selectively logged forest of Sugar Maple, beech, and Yellow Birch, on trunk of large *Nectria*-cankered American Beech, 2 September 1994, *S.R. Clayden 8907*. **Sunbury Co.:** Portobello Creek National Wildlife Area, French Island, NE shore, opposite Sand Point, 45.92417°N, 66.30011°W, 8 m, lakeshore with sandstone ledges and mixed conifer-hardwood forest including Red Oak, hemlock, White Spruce (*Picea glauca* (Moench) Voss), Silver Maple (*Acer saccharinum* L.), cedar, and Grey Birch (*Betula populifolia* Marshall), on trunk of large Red Oak, 9 August 2014, *S.R. Clayden 24562*. **Victoria Co.:** Highway 17, 3.2 km SW from Restigouche County line, on Sugar Maple, 24 May 1981, *W.S.G. Maass & B.L. Hoisington 81C-28a*. **Westmorland Co.:** Walker Road, ~6 km NW of Sackville, W side of Trans-Canada Hwy, 45.95°N, 64.42°W, mixed hardwoods, on American Beech, 18 June 1976, *S.R. Clayden 90*. **York Co.:** Spednic Lake PNA, between South Branch Mosquito Brook and McAllister Brook, 45.66670°N, 67.65411°W, 150 m, swampy forest of Red Maple, cedar, Speckled Alder (*Alnus incana* subsp. *rugosa* (Du Roi) R.T. Clausen), Black Spruce (*Picea mariana* (Miller) Britton, Sterns & Poggenburgh), and scattered Black Ash, with herb-rich understorey, on trunk of Eastern White Cedar, 14 August 2017, *S.R. Clayden 26733*; Crabbe Mountain, NE-facing slope, 46.12403°N, 67.10011°W, 240 m, hardwood forest dominated by Sugar Maple, Yellow Birch, beech, and Striped Maple (*Acer pensylvanicum* L.), with scattered fir, on trunk of Sugar Maple, 28 December 2018, *S.R. Clayden 27379*.

Also known from **Charlotte Co.:** Campobello Island, July 1902, *W.G. Farlow, s.n.* (Farlow Herbarium, Harvard University [FH 00478186]), cited by Sheard (2010); Grand Falls Flowage on St. Croix River, 45.2781°N, 67.4789°W, hardwood (maple [*Acer* L.], beech, birch [*Betula* L.]) forest, on maple, 30 April 2011, *J.C. Lendemer 27816* (William and Lynda Steere Herbarium, New York Botanical Garden [NY]).

Rinodina cinereovirens (Vain.) Vain. (synonym [syn.] *R. turfacea* var. *cinereovirens* (Vain.) H. Mayrhofer [Sheard *et al.* 2017; Sheard 2018]; Figure 4b)

Reported for New Brunswick by Sheard *et al.* (2017) without details of the single occurrence known at the time, which are provided here. Characterized by its thin, greyish, distinctly areolate, corticolous or lignicolous thallus containing sphaerophorin; narrowly attached apothecia; apothecial margins with the cortex expanded in its lower part (Figure 5a) and I+ blue; and large *Physcia*-type ascospores with a well-developed torus.

A second, previously overlooked, historical occurrence of *R. cinereovirens* in New Brunswick came to light during the present study. This is based on a specimen in the Farlow Herbarium (FH) collected by W.G. Farlow on Campobello Island in the Bay of Fundy in 1902 (Figure 4b). It was reported by Sheard (2010) as *R. granuligera* H. Magn., but we have re-identified the specimen as *R. cinereovirens* (corroborated by J.W. Sheard, 19 May 2023). Its morphology and chemistry (confirmed with TLC) are fully consistent with this species. *Rinodina granuligera* differs from *R. cinereovirens* in having a more continuous thallus containing atranorin, not sphaerophorin, a P+ red-orange epihymenium containing pannarin, and smaller *Dirinaria*-type ascospores that swell at the septum in KOH (Sheard 2010, 2018). It is endemic to the Piedmont and Coastal Plain regions of the southeastern United States (Sheard 2010; Lendemer *et al.* 2014).

In the two New Brunswick specimens of *R. cinereovirens*, the spores are (20.5–)23.8–28.5(–30.5) × (10.0–)11.2–12.8(–13.5) µm, with a length/width ratio of (1.8–)2.0–2.4(–2.6) (n = 46). Uncommonly for *R. cinereovirens*, some of the apothecia in both specimens have somewhat pruinose discs, the light-grey

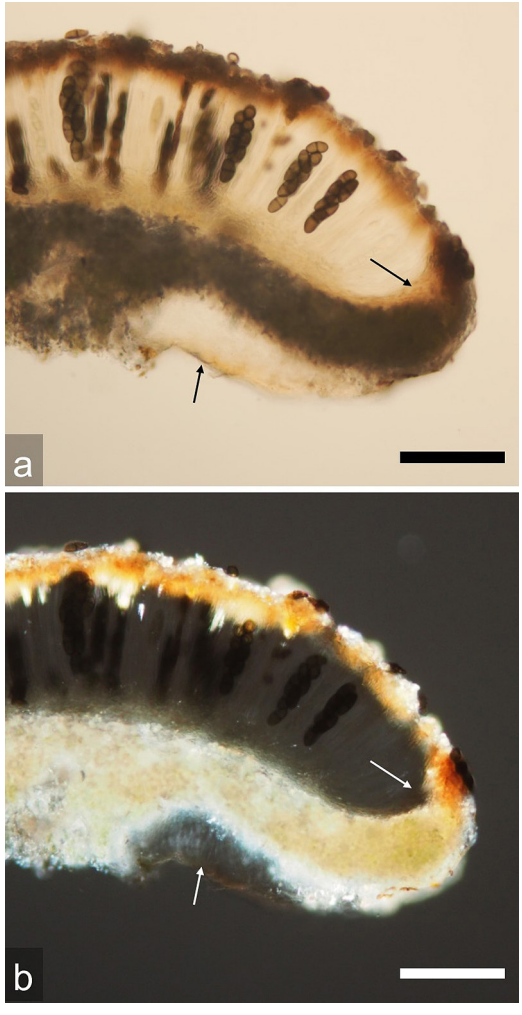

FIGURE 5. *Rinodina cinereovirens*, section of apothecium (*Clayden 18111*). a. In brightfield illumination. b. In polarized light. Arrows indicate expanded lower cortex of thalline exciple and proper exciple next to hymenium, both lacking sphaerophorin crystals. Dense deposits of birefringent sphaerophorin crystals are present in the medulla, and sparse streaks in the epihymenium. In brightfield, the medulla appears dark, but its opaqueness is due to the abundance of sphaerophorin crystals, which are colourless. Scale bars: 100 µm. Photos: S.R. Clayden.

pruina apparently consisting of crystals of sphaerophorin. Crystals are also present in scattered streaks extending into the upper part of the hymenium, distinct from the more diffuse red-brown epihymenial pigment (Figure 5b). The presence of sphaerophorin in the specimen from Campobello Island was confirmed by TLC.

Rinodina cinereovirens was treated by Mayrhofer and Moberg (2002) as a corticolous variety of *Rinodina turfacea* (Wahlenb.) Körb., and by Sheard (2010) as part of a continuum of variation within that species. However, Sheard *et al.* (2017) found that the ascospores of Arctic terricolous and boreal corticolous/lignicolous populations of *R. turfacea s.l.* differ subtly in average size, shape, and number per ascus, supporting the reinstatement of *R. cinereovirens* at species rank. Although the asci of *R. cinereovirens* often contain only four spores (Sheard *et al.* 2017), only eight-spored asci were observed in the New Brunswick specimens.

This species is widely but sparsely distributed in boreal forests around the Northern Hemisphere (Mayrhofer and Moberg 2002; Sheard *et al.* 2017; Galanina *et al.* 2021a,b). In North America, it has been documented to date from fewer than 20 localities scattered from Alaska to Newfoundland (Sheard *et al.* 2017; Sheard 2018). The historical occurrence on Campobello Island reported here is the southernmost on record. Farlow did not note its precise location on the island, which lies between 44.83°N and 44.96°N, or details of the habitat or substratum of the specimen. Ecologically, Campobello Island is in New Brunswick's Fundy Coast Ecoregion (Zelazny 2007), which has a hemiboreal rainforest climate and vegetation (Clayden *et al.* 2011). The other New Brunswick occurrence of *R. cinereovirens* is near the province's northern (Baie des Chaleurs) coast, about 350 km northeast of Campobello Island. However, this area has a more continental climate than the Bay of Fundy coast, with warmer summers, colder and snowier winters, lower annual precipitation, and much less fog (Clayden 2000, 2010).

Our examination of the bark characteristics of Farlow's specimen from Campobello Island indicates that it probably came from a mountain-ash, most likely American Mountain-ash (*Sorbus americana* Marshall), which is a frequent component of coastal spruce (*Picea* A. Dietrich)–fir–birch forests on the island. The specimen consists of several fragments of dark thin outer bark (periderm) typical of a mature or possibly senescent individual of this tree species. Several other lichens are present on the same bark fragments: an unidentified, small, poorly developed species of *Caloplaca s.l.* (probably *Athallia pyracea* (Ach.) Arup, Frödén & Søchting), *Leptogium cyanescens* (Rabenh.) Körb., *Parmelia* cf. *squarrosa* Hale (small immature lobes), *Rinodina subpariata* (Nyl.) Zahlbr., and possibly *Rinodina efflorescens* Malme (too fragmentary for chemical analysis).

Farlow made two visits to Campobello Island, in 1898 and 1902, during which he collected numerous specimens of several groups of cryptogams (Pfister 2016). Most notable among the lichens was the type material of the rare cyanolichen Boreal

Felt Lichen (*Erioderma pedicellatum* (Hue) P.M. Jørg.), and an accompanying fragment of Vole Ears (*Erioderma mollissimum* (G. Sampaio) Du Rietz; Jørgensen 1972). Conifer needles and bark present in the specimen envelopes indicate that the collections of these species were from Balsam Fir (Jørgensen 1972; Maass 1980). Neither *Erioderma* species has been found subsequently on the island, despite intensive searching (Maass 1980; Maass and Yetman 2002; COSEWIC 2009, 2014). Their presumed local extirpation was attributed by Maass (1980; Maass and Yetman 2002) to a combination of logging, human-caused forest fires, and acid precipitation. It is possible that *R. cinereovirens* has likewise disappeared from Campobello Island. However, there are several hundred hectares of relatively intact coastal forest protected within Roosevelt Campobello International Park and Herring Cove Provincial Park on the island. Further lichen surveys in these areas, including targetted searching of mountain-ash, should be carried out in order to assess the current local status of *R. cinereovirens*.

The occurrence of *R. cinereovirens* on Black Ash in northern New Brunswick was in an opening in a wet minerotrophic swamp forest dominated by cedar. The site is adjacent to a large (~300 ha) ombrotrophic bog where an extensive peat-harvesting operation began a few years before *R. cinereovirens* was found in the area. Drainage ditches from the bog are directed toward the swamp-forest community, and the current status of *R. cinereovirens* at the site is unknown. The diversity of lichens and lichenicolous fungi in this type of forest community in the province and region is generally high (Clayden 2010; S.R.C., K.E.D., and S.B. Selva unpubl. data). Ongoing studies demonstrate that it supports a number of rare and/or previously undescribed species occurring on various coniferous and hardwood trees, including Black Ash (e.g., Holien *et al.* 2015; Driscoll *et al.* 2016; Selva and Tuovila 2016; Haughian *et al.* 2018; Ertz *et al.* 2021).

Black Ash has a relatively high bark pH, reported by Nimis (1985) to be 7.2 ± 0.3 in the southern boreal Clay Belt region of Ontario, where it is likewise a component of swamp forests dominated by cedar. Lichens growing next to *R. cinereovirens* on Black Ash at the New Brunswick locality included *Lecidea erythrophaea* Flörke ex Sommerf., *Parmelia sulcata* Ach., *Ramalina dilacerata* (Hoffm.) Hoffm., and *Ramalina roesleri* (Hochst. ex Schaer.) Hue. The presence of several cyanolichens and species such as *Bacidia polychroa* (Th. Fr.), *Gyalolechia xanthostigmoidea* (Räsänen) Søchting, Frödén & Arup, and *Heterodermia speciosa* (Wulfen) Trevis. on neighbouring trees is indicative of locally base-rich conditions. The complex of swamp forests and fens in this area is associated with subsurface deposits of early postglacial, calcareous, marine silt and clay (Michalica *et al.* 2000). Several provincially uncommon to rare calciphilous vascular plants are present in the area, including Small Round-leaved Orchid (*Galearis rotundifolia* (Banks ex Pursh) R.M. Bateman) and Sage Willow (*Salix candida* Flüggé ex Willdenow; Blaney 2000).

The invasive non-native Emerald Ash Borer (*Agrilus planipennis* Fairmaire) now poses a threat to lichens and other biota, known and unknown, that occur on ash species in North America. Black Ash appears to be the most susceptible ash species (COSEWIC 2018). Emerald Ash Borer was first detected in New Brunswick and Atlantic Canada in the Edmundston area in 2018 and, soon after, further south in the province, eastward into Nova Scotia, and northeastward in the Gaspésie region of Quebec (CFIA 2022). In the Ottawa region, it has caused extensive mortality of Black Ash, and declines of several lichens locally restricted to this tree species are expected (Brodo *et al.* 2021a).

Specimens examined—**Charlotte Co.:** Campobello Island, July 1902, *W.G. Farlow, s.n.* (FH 00478 279). **Gloucester Co.:** North side of Lambert Barren, ~7.5 km SW of Pokeshaw, 47.7232°N, 65.3004°W, 55 m, swampy open woods dominated by cedar, Red Maple, fir, and Black Spruce, with scattered Black Ash, Yellow Birch, and Paper Birch (*Betula papyrifera* Marshall), on Black Ash, 7 October 2007, *S.R. Clayden 18111* (confirmed by J.W. Sheard).

Rinodina efflorescens Malme (Figure 4c)

Reported for New Brunswick by Sheard (2010), based on specimens collected by Emmanuël Sérusiaux in 1988 in Fundy National Park (Albert County) and Kouchibouguac National Park (Kent County). Characterized by its grey-brown areolate thallus containing pannarin (P+ red-orange, K−) and trace amounts of zeorin, with discrete, contrasting, often more or less punctiform, usually pale greenish-yellow soralia (Figure 6a) containing secalonic acid A (KC+ yellow-orange). *Rinodina willeyi*, like *R. efflorescens*, contains pannarin and zeorin, but its soredia are greyish and KC− and (in New Brunswick material) often spread diffusely, especially in thalli overgrowing bryophytes (Figure 6b). We have not found *R. efflorescens* growing on corticolous bryophytes, although it is reported to do so elsewhere (Tønsberg 1992; Mayrhofer and Moberg 2002). *Rinodina subpariata* has a light-grey thallus and contrasting, white soredia, both containing abundant atranorin (K+ yellow). These three species also differ in ascospore morphology and/or size; however, apothecia are lacking in most thalli. They are present in seven of the 30 New Brunswick specimens of *R. efflorescens*

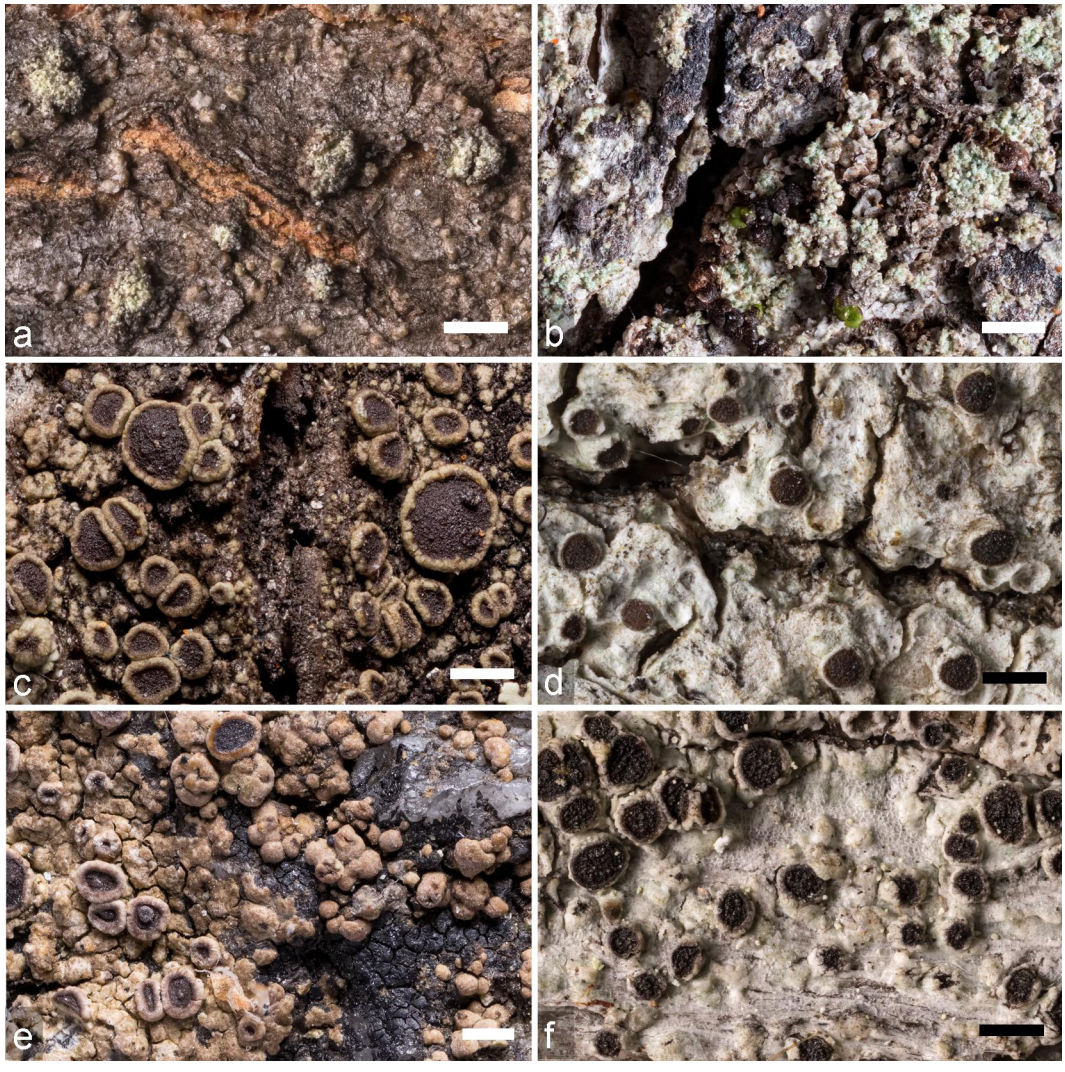

FIGURE 6. Thalli of selected *Rinodina* species occurring in New Brunswick. a. *Rinodina efflorescens* (*Clayden 28686*), with yellowish soredia. b. *Rinodina willeyi* (*Clayden 28931*), soredia concolorous with thallus. c. *Rinodina populicola* (*Clayden 28963*), with large and small apothecia. d. *Rinodina subminuta* (*Clayden 28773*), note two eroded apothecia at the extreme right. e. *Rinodina tephraspis* (*Clayden 26829*), thallus continuous at left to dispersed-areolate at right. f. *Rinodina tenuis* (*Clayden 28748*), with apothecia erumpent when young. Scale bars: 0.5 mm. Photos: Roger Smith.

examined for our study and have *Physcia*-type ascospores measuring (12.5–)14.6–18.9(–21.5) × (7.0–)7.6–9.5(–10.0) µm (n = 42). One specimen (*Clayden 26910*) is unusual in having numerous apothecia and only sparsely developed soralia, but its ascospore characters and chemistry (confirmed with TLC) are consistent with those of *R. efflorescens*. In most specimens, the dark colour of the thallus is imparted largely by the very thin prothallus, described by Tønsberg (1992: 146) as a "brown stain" between the usually dispersed, somewhat lighter-coloured areoles (Figure 6a).

Rinodina efflorescens is widely distributed in forested, north-temperate to hemiboreal, climatically humid areas of North America and Eurasia, with southward extensions in montane forests (Mayrhofer and Moberg 2002; Sheard 2010; Lendemer *et al.* 2014; Galanina *et al.* 2021a). Although it is frequent throughout New Brunswick, it has not yet been reported from the other provinces of Atlantic Canada, possibly because sorediate species are generally under-collected. In New Brunswick, it occurs in

a wide range of mesic to wet forest types; however, it is scarce or lacking in mature hardwood forests on relatively base-rich soils where *R. willeyi* is sometimes frequent. We have not found *R. efflorescens* on Sugar Maple, which is the most frequently recorded phorophyte of *R. willeyi* in the province. Conversely, *R. efflorescens* occurs commonly on several tree and shrub species with more acidic bark and on which *R. willeyi* is scarce or lacking. Among the specimens we examined, 10 were on Red Maple, six on Balsam Fir, four on Speckled Alder, two each on Yellow Birch and Paper Birch, and one each on Striped Maple, Mountain Maple (*Acer spicatum* Lamarck), American Beech, Red Oak, and American Mountain-ash.

Selected specimens examined—**Charlotte Co.:** Campobello Island, Roosevelt Campobello International Park, Liberty Point, trail to Lower Duck Pond, 44.832°N, 66.931°W, 40 m, coastal spruce–fir–birch woods with scattered American Mountain-ash, on mountain-ash, 24 September 2016, *K.E. Driscoll 1347*; *ibid*., along Fox Hill Drive, ~2 km W of Liberty Point Drive, at base of Fox Hill, 44.85344°N, 66.95304°W, mature forest dominated by Yellow Birch, on stem of Mountain Maple, 25 September 2016, *S.R. Clayden 26298*. **Gloucester Co.:** Jacquet River Gorge PNA, ~1.6 km E of Big Meadow, 47.7822°N, 65.8825°W, 175 m, forest of Red Maple, beech, fir, Paper Birch, and White Spruce, on smooth bark of American Beech, 8 August 2010, *S.R. Clayden 21033*. **Kings Co.:** Shippee Nature Reserve, near top of ridge between Cedar Camp and Chambers Settlement, 45.68733°N, 65.30949°W, 275 m, mainly deciduous forest with Red Oak, hop-hornbeam, Sugar Maple, beech, White Spruce, and Red Spruce, on trunk of Red Oak, 26 August 2017, *S.R. Clayden 26910*; Canadian Forces Base Gagetown, Nerepis Hills, near Askwith Brook, ~500 m ENE of end of Cochrane Lane, 45.4402°N, 66.3008°W, 70 m, moderately open young stand of Red Maple, poplar (*Populus* L.), and birch, on trunks of Red Maple, 7 May 2022, *S.R. Clayden 28686*. **Northumberland Co.:** Nepisiguit PNA, along unnamed brook SW of Popple Depot, 47.38678°N, 66.53639°W, 310 m, mixed forest of fir, Trembling Aspen (*Populus tremuloides* Michaux), Sugar Maple, and birch, on thin branches of Balsam Fir, 17 September 2015, *S.R. Clayden 25658*. **Queens Co.:** Grand Lake PNA, along forest road from Coy Road to East Branch Baltimore Stream, 45.97138°N, 66.11748°W, 50 m, young forest of fir, Paper Birch, and Red Maple, on smooth bark of Balsam Fir, 13 June 2013, *S.R. Clayden 23859*. **Restigouche Co.:** South side of lake at Summit Depot, 47.78125°N, 68.31897°W, 410 m, young forest dominated by fir and White Spruce, on trunk of Balsam Fir, 1 August 2012, *S.R. Clayden, 23537*. **Sunbury Co.:** Portobello Creek National Wildlife Area, French Island, NE shore, opposite Sand Point, 45.92677°N, 66.30252°W, 10 m, moderately open young forest of Grey Birch, cedar, and Red Maple, with scattered older/larger trees, on large broken Red Maple, 19 August 2014, *K.E. Driscoll 1054*. **York Co.:** Upper part of Kellys Creek, on N side, between Trans-Canada Hwy and Mazerolle Settlement Road, 45.87756°N, 66.82538°W, 95 m, wet forest of Red Maple, fir, Trembling Aspen, and Speckled Alder, on Speckled Alder, 8 June 2008, *S.R. Clayden 18530*.

Also known from Albert County and Kent County, as noted above.

Rinodina freyi H. Magn. (syn. *R. glauca* Ropin [Sheard 2010]; Figure 4d)

Reported for New Brunswick by Gowan and Brodo (1988), as *R. magnussonii* Sheard *ined*., and by Sheard (2010). Characterized by its non-erumpent, broadly to sometimes narrowly attached apothecia which are typically clustered on and around branch axils and leaf scars of twigs and thin branches; thin, green-grey to brownish, areolate to continuous/fissured thallus lacking secondary metabolites detectable by TLC; and eight-spored asci with *Physcia*-type spores measuring (12.5–)14.3–16.9(–19.0) × (6.0–)6.7–7.9(–8.5) µm (n = 86) in New Brunswick specimens. The habits of the apothecia and thalli can sometimes resemble those of *R. pachysperma* and *R. populicola*, but these species are readily distinguished by other characters: *R. pachysperma* by its *Pachysporaria*-type spores, and *R. populicola* by its 16–32-spored asci. *Rinodina subminuta* has more dispersed, erumpent apothecia, larger spores, and contains zeorin; it also occurs mainly on tree boles and large branches. The species most similar to *R. freyi* is *R. septentrionalis*. Their differences are noted under *R. septentrionalis*, below.

Rinodina freyi is widely distributed in the southern boreal and hemiboreal zones of North America and Eurasia (Sheard 2010, 2018; Brodo 2016; Sheard *et al.* 2017). Its circumscription, nomenclature, and distribution were first clearly resolved by Sheard (2010). In New Brunswick, it occurs on trees and shrubs in a wide range of habitats. However, its small thalli are often inconspicuous and scattered, and it is probably underrepresented in collections. It has been found, for example, on twigs of conifers on coastal headlands subject to salt spray, on planted trees in urban areas, and in openings, edges, or in the canopy of early successional to mature forests of varied composition. Shared features of these disparate microhabitats appear to be nutrient enrichment by external inputs or by leakage from the substrata, and relatively high light levels. The phorophytes of specimens examined

for our study or reliably identified by other collectors included Balsam Fir, Norway Maple (*Acer platanoides* L.), Silver Maple, Sugar Maple, Speckled Alder, Yellow Birch, ash (species not determined), Tamarack (*Larix laricina* (Du Roi) K. Koch), apple (*Malus* Miller), Balsam Poplar (*Populus balsamifera* L.), Trembling Aspen, Pin Cherry (*Prunus pensylvanica* L.), Red Oak, elderberry (*Sambucus* L.), cedar, and White Elm (*Ulmus americana* L.).

Selected specimens examined—**Albert Co.:** Caledonia Gorge PNA, along road to Canada Creek, 45.77275°N, 64.78191°W, 333 m, edge of young mixed forest along road, on branches of Pin Cherry, 17 August 2012, *S.R. Clayden 23652*. **Gloucester Co.:** Miscou Island, along boardwalk-trail E of Route 113 at Lac Chenière, 47.96458°N, 64.53225°W, 7 m, open, wet coastal bog with scattered thickets of Tamarack, Black Spruce, and tall shrubs, on branch of Tamarack, 10 July 2015, *S.R. Clayden 25330*. **Kings Co.:** Poley Mountain, just E of ski hill, 45.67478°N, 65.38319°W, 205 m, mixed forest of maple, birch, spruce, fir, hemlock, hop-hornbeam, and poplar, on N-facing slope, on thin young branch of Balsam Fir, 24 February 2017, *S.R. Clayden 26420*. **Madawaska Co.:** Saint-Basile, along Wolastoq (Saint John River), 47.342°N, 68.218°W, 140 m, forest of Silver Maple on levee and floodplain of river, on Silver Maple, 24 June 2010, *S.R. Clayden 20992*. **Northumberland Co.:** close to Doaktown, on elderberry near old saw mill, 5 May 1978, *I. Walker*, *s.n.* **Restigouche Co.:** Mount Carleton Provincial Park, off W side of Mount Bailey trail, between 1 and 1.5 km from trailhead, 47.41°N, 66.91°W, hardwood stand dominated by Sugar Maple, with moderate amount of Yellow Birch, corticolous on branches of Yellow Birch, 22 July 1989, *S.B. Selva 4064*; Kedgwick River, at confluence with Restigouche River, 47.665°N, 67.491°W, on Trembling Aspen, 29 July 1989, *S.P. Gowan 5663*; MacFarlane Brook PNA, ~5 km NW of confluence with Restigouche River, 47.602°N, 67.626°W, 290 m, broad, shallow brook valley with mesic to wet forest dominated by cedar, with Black Spruce, fir, and scattered Paper Birch, with wet openings dominated by Speckled Alder, on Speckled Alder, 25 May 2007, *S.R. Clayden 17247*. **Saint John Co.:** City of Saint John, Manawagonish Road between Centennial Drive and Hillcrest Drive, 45.241°N, 66.117°W, on elm (*Ulmus* L.), 25 September 1975, *H.R. Hinds 75-88,75-97* (det. J.W. Sheard); City of Saint John, Riverview Memorial Park, 45.26817°N, 66.08233°W, 30 m, city park with mature planted trees, mostly Norway Maple, on bark of Norway Maple, 2 June 2004, *M. Mildenberger 15*; *ibid*. on branches from crown of large Red Oak, 3 August 2004, *S.R. Clayden 12983*. **Westmorland Co.:** Fairfield Hills, Walker Road, 6.5 km NNW of Sackville, swampy mature Red Spruce–Red Maple forest, on canopy twigs of 110-year-old Red Maple, 28 June 1987, *H. Harries 870628-01*. **York Co.:** between Trans-Canada Hwy and upper part of Kellys Creek, SW of Mazerolle Settlement, 45.87232°N, 66.82954°W, 95 m, mesic to wet forest of cedar, fir, Red Spruce, Red Maple, and hemlock, on twigs of Eastern White Cedar, 28 April 2006, *S.R. Clayden 14318*.

Also known from **Charlotte Co.:** New River Beach Provincial Park, Barnaby Head Trail between Raspberry Cove and Chitticks Beach, 45.1306°N, 66.5253°W, wet coastal mixed conifer (fir, spruce) forest with scattered hardwoods (mountain-ash [*Sorbus* L.], alder [*Alnus* Miller], birch) and rock outcrops, on alder, 29 April 2011, *W.R. Buck 57639* (NY); Grand Falls Flowage on St. Croix River, peninsula N of parking area at terminus of NB 725, 45.28°N, 67.48°W, roadside and mixed forest of poplar and fir, on upper branches of fallen poplar, 30 April 2011, *R.C. Harris 56678* (NY); Caughey-Taylor Nature Preserve, E of NB 127, N and E of Sam Orr Pond, 45.1656°N, 67.0469°W, mixed conifer forest with rhyolite and basaltic outcrops, on apple, 2 May 2011, *R.C. Harris 56765-A* (NY).

Rinodina gennarii Bagl. (Figure 4e)

Reported for New Brunswick by Räsänen (1933: 15) as "*Rinodina demissa* (Flk.) Mass." and by Sheard (2010). Both reports are based on a specimen collected by Tapio Reijonen in 1930 at Dalhousie, Restigouche Co., near the north coast of the province. Characterized by its saxicolous (rarely lignicolous) grey-brown areolate thallus; lack of secondary metabolites detectable with TLC; relatively small ascospores tending to become swollen at the septum (Figure 7a), especially in KOH-mounts (*Dirinaria*-type); and occurrence on or near maritime shores (Sheard 2010).

Although it is locally frequent on coastal rocks along the Bay of Fundy, the only previously documented occurrence in the province was the one at Dalhousie, where it was found "on a field stone" (Räsänen 1933: 15). *Rinodina gennarii* is widely distributed in temperate to low-boreal regions of the Northern and Southern Hemispheres (Trinkaus *et al.* 1999). In North America, it occurs exclusively in maritime habitats, mainly in the spray (supralittoral) zone and on surfaces enriched by guano (Sheard 2010, 2018). It is one of the most abundant crustose lichens on rock at a large nesting colony of cormorants and gulls on Manawagonish Island near Saint John, where it is associated with lichens such as *Amandinea punctata* (Hoffm.) Coppins & Scheid., *Lecidella scabra* (Taylor) Hertel & Leuckert, *Myriolecis* species, *Physcia adscendens* (Fr.) H. Olivier, and *Xanthoria parietina*

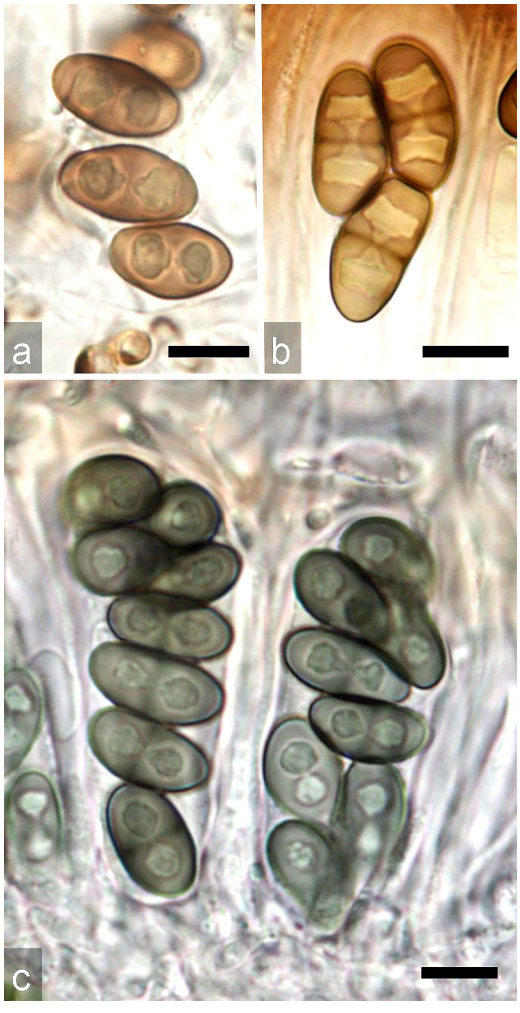

Figure 7. Ascospores of selected *Rinodina* species. a. *Rinodina gennarii* (*Dirinaria*-type, lacking a torus and with slight swelling at septum, in 10% KOH; *Bremner AB30*). b. *Rinodina subminuta* (*Physcia*-type, at intermediate stage of development, with strongly angular lumina, apically thickened walls and darkened torus; *Clayden 24853*). c. *Rinodina pachysperma* (*Pachysporaria*-type, with rounded lumina, laterally and apically thickened walls, and poorly defined torus; *Clayden 28971*). Scale bars: 10 µm. Photos: S.R. Clayden.

(L.) Th. Fr. It also occurs on driftwood logs at this site. An incidental occurrence on rusted metal at another coastal site (see below) probably also reflects localized nutrient enrichment. On Sable Island, Nova Scotia, *R. gennarii* is "common on cement and concrete" (Richardson *et al.* 2009: 568).

Specimens examined—**Albert Co.:** W side of Cape Enrage, coastal sandstone cliff, on HCl+ rock, with *Athallia holocarpa* (Hoffm.) Arup, Frödén & Søchting, *Flavoplaca flavocitrina* Arup, Frödén & Søchting, and *Myriolecis schofieldii* (Brodo) Śliwa, Zhao Xin & Lumbsch, 45.597°N, 64.781°W, 26 July 1992, *S.R. Clayden 7254*. **Charlotte Co.:** Pea Point Lighthouse, 1.7 km SW of Black's Harbour, 45.0392°N, 66.8069°W, on rusted steel plate on the ground, with *A. holocarpa*, *Candelariella aurella* (Hoffm.) Zahlbr., and *X. parietina*, 21 May 2008, *D. Malloch, s.n.*; New River Beach Provincial Park, Carrying Cove, near start of Barnaby Head trail, rocky coastal shore, 45.1298°N, 66.5277°W, 20 August 2018, *S.R. Clayden 27257*. **Saint John Co.:** Manawagonish Island, on rock, 45.209°N, 66.108°W, 1 July 1987, *S.R. Clayden 5772*; *ibid*., 45.2083°N, 66.1100°W, rocky beach, on driftwood, with *Lecanora xylophila* Hue, 16 October 2006, *A.M. Bremner AB30*; *ibid*., 45.20717°N, 66.11021°W, low siltstone rock-outcrops among thickets of North American Red Raspberry (*Rubus idaeus* subsp. *strigosus* (Michaux) Focke) in area with many nesting gulls and cormorants, 13 May 2021, *S.R. Clayden 28491, 28493*; *ibid*., 45.20969°N, 66.10654°W, low NW-facing siltstone bluffs at top of cobble beach, 3 to 5 m above mean high tide line, 13 May 2021, *S.R. Clayden 28501*; Saints Rest Marsh–F. Gordon Carvell Nature Preserve, at mouth of Manawagonish Creek, rocky coastal shore, on rock, 45.22309°N, 66.14230°W, 16 August 2013, *S.R. Clayden 24130 p.p.*

Also known from Restigouche Co., as noted above.

Rinodina moziana (Nyl.) Zahlbr. (syn. *Mischoblastia moziana* (Nyl.) S.Y. Kondr., L. Lőkös & J.-S. Hur [Kondratyuk *et al.* 2021]; *Rinodina destituta* Zahlbr. [Sheard *et al.* 2017]; Figure 4e)

Reported for New Brunswick by Sheard (2010) as *R. destituta*, based on a specimen collected by Sharon Gowan in Fundy National Park in 1980 (details below). Characterized by its areolate, grey, saxicolous thallus containing atranorin in the cortex (K+ yellow, crystals visible in polarized light), and lightly pigmented ascospores with strongly thickened apical walls and triangular to rounded lumina (*Mischoblastia*-type: Sheard [2010]). The New Brunswick specimen was originally reported as *Rinodina arenaria* (Hepp) Th. Fr. or *Rinodina iowensis* Zahlbr. (Gowan and Brodo 1988: 279, 305, 322). It was accurately described as having a K+ yellow thallus and spores 21–24 × 10–14 µm (Gowan and Brodo 1988); however, the taxonomy and nomenclature of these species were not well resolved at the time (Sheard 2010). *Rinodina arenaria* is a synonym of *Rinodina tephraspis* (Tuck.) Herre, which is distinguished from *R. moziana* by its K− cortex (lacking atranorin), among other characters; *R. iowensis* is a synonym of *Rinodina cana* Zahlbr., which also lacks atranorin and is

not known to occur in eastern Canada or northern New England (Sheard 2010).

Rinodina oxydata (A. Massal.) A. Massal. resembles *R. moziana* in having *Mischoblastia*-type spores and a saxicolous thallus containing atranorin. However, its thallus is typically thinner and more fissured ("rimose") than that of *R. moziana*, and its spores are smaller (Sheard 2010). Although it has not been found in New Brunswick, *R. oxydata* is to be expected in the province, as scattered occurrences are known in southern Ontario, Quebec, southeastern Newfoundland, and Maine (Sheard 2010; Lendemer *et al.* 2014; Seaward *et al.* 2017). In contrast, the record of *R. moziana* in Fundy National Park is isolated by more than 700 km from the closest known occurrences in Ontario (Sheard 2010; Brodo *et al.* 2021a) and southern New England (Sheard 2010; Lendemer *et al.* 2014). It has not been recorded elsewhere in Atlantic Canada, Quebec, or Maine. S.R.C. revisited the *R. moziana* locality in Fundy National Park in July 2022, but did not relocate the species during a ~2.5-hour search.

Specimen examined and cited by J.W. Sheard (Sheard 2010)—**Albert Co.:** Fundy National Park, Point Wolfe, below covered bridge, on south facing conglomerate cliffs above water, 19 June 1980, *S.P. Gowan 2456* (Canadian Museum of Nature Lichen Herbarium [CANL]).

Rinodina pachysperma H. Magn. (Figure 4f)

New to New Brunswick. Endemic to eastern North America, this species is readily distinguishable from other corticolous *Rinodina* species in Atlantic Canada with K− and P− thalli by its *Pachysporaria*-type ascospores with rounded lumina and both lateral and apical internal wall-thickenings (Figure 7c). The spores in the New Brunswick specimens are slightly larger, (13.5–)15.8–18.7(–21.5) × (6.5–)7.8–9.7(–11) µm ($n = 75$), and more variable in shape (length/width ratio (1.6–)1.7–2.3(–2.6)) than reported for this species by Sheard (2010, 2018). In *R. freyi* and *R. subminuta*, the spore lumina are angular (see Figure 7b) until overmature, and the apical walls are distinctly thicker than the lateral walls (*Physcia*-type). Thalli of *R. pachysperma* rarely form "consoredia" that break down into individual soredia 10–20 µm in diameter (Sheard 2010, 2018); however, we have not found sorediate thalli of *R. pachysperma* in New Brunswick. *Rinodina papillata* H. Magn. has *Pachysporaria*-type spores similar to those of *R. pachysperma*, but it has a glossier thallus with marginal, bulbous to cylindric, bud-like propagules ("blastidia") measuring ~200–300 × 150 µm (Sheard 2010, 2018). In Canada, *R. papillata* has been reported from a single locality in southern Ontario (Sheard 2010).

Rinodina pachysperma is locally abundant in bottomland hardwood forests dominated by Silver Maple on the floodplain of the Wolastoq (Saint John River) and its tributaries in south-central New Brunswick. The hydrology, climate, and biota of this area are exceptional in several respects. It includes the largest freshwater lake (Grand Lake) and wetland complex in Atlantic Canada; it has the warmest climate of any of New Brunswick's ecoregions; and it forms the northeastern limit of the ranges of several species of temperate North American hardwood trees and other vascular plants (Clayden 2000; Zelazny 2007).

In some stands we examined, *R. pachysperma* forms extensive cover on the trunks and lower branches of Silver Maple down to or below the spring high-water line. It also occurs on Red Ash (*Fraxinus pennsylvanica* Marshall), Black Willow (*Salix nigra* Marshall), Basswood (*Tilia americana* L.), and White Elm in or at the edge of the floodplain forests (Figure 2a). It is sometimes accompanied by species of *Phaeophyscia* and *Physcia*. However, epiphytic lichen species richness and coverage on Silver Maple in the floodplain forests, at least in the shaded understorey of stands with a continuous canopy, is generally much lower than on Sugar Maple and associated hardwoods in mesic upland settings in the province (S.R.C. unpubl. data). We did not find any of the characteristic *Rinodina* species of upland hardwoods (*R. asociscana*, *R. subminuta*, *R. willeyi*) on Silver Maple in the floodplain forests (Figure 3).

The floodplain habitat of *R. pachysperma* in New Brunswick is similar to that of an occurrence in Ontario reported by Brinker (2020). Records of this species posted on the website of the Consortium of Lichen Herbaria (2023) indicate, likewise, that seasonally flooded forests are its most common habitat. This association may account for a concentration of records of *R. pachysperma* along the upper Mississippi River and its major tributaries in the central United States (Sheard 2010). It is apparently rare or at least generally overlooked in upland settings in the Appalachian Mountains (Lendemer *et al.* 2014). Records from coastal pine–oak forests on Long Island (Brodo 1968) were revised by Sheard (2010) to *Rinodina maculans* Müll. Arg. The latter species has a mainly coastal distribution and reaches its northeastern range limit in southern New England (Sheard 2010).

The occurrences of *R. pachysperma* in New Brunswick fill a large gap in the reported distribution of this species in the Northeast. Previously, the only record east and north of southern Quebec was an anomalous outlier in boreal western Newfoundland, documented by a specimen (and duplicates) collected by A.C. Waghorne at Deer Lake in 1897 (Sheard 2010). This collection (*Waghorne 842*) was first reported by Arnold

(1899) as *Rinodina sophodes* f. *albana* A. Massal. (≡ *Rinodina albana* (A. Massal.) A. Massal.), a species with larger spores and differently shaped spore-lumina that is not known to occur outside Europe (Nadyeina *et al.* 2010). Waghorne did not record details of the habitat or substratum of the specimen. However, the authenticity of his late 19th-century collections of many uncommon and rare lichens has been validated by recent rediscoveries of a number of these species in Newfoundland (J.W. McCarthy pers. comm. 10 August 2022). A possible phorophyte for his collection of *R. pachysperma* could have been Balsam Poplar. Isolated occurrences of several temperate mosses are known from this tree species in western Newfoundland (Belland 1981; Belland and Brassard 1981). Waghorne collected at least one such moss, *Pylaisia selwynii* Kindb., at Deer Lake (Belland and Brassard 1981).

Selected specimens examined—**Kings Co.:** unnamed wooded island near mouth of Nerepis River, 1 km NW of Woodmans Point, 45.37°N, 66.24°W, 5 m, Silver Maple riparian forest on alluvial island, on exfoliating bark of large Silver Maple overhanging river, 30 August 1988, *S.R. Clayden 6500*. **Queens Co.:** Grand Lake PNA, between Raft Channel and Jemseg River, 45.79493°N, 66.10117°W, 5 m, floodplain forest of Silver Maple and Red Ash on deep alluvial soil, abundant on smooth bark of young Red Ash, 16 August 2014, *S.R. Clayden 24720 & K.E. Driscoll*. **Sunbury Co.:** Portobello Creek National Wildlife Area, along Route 690, 1 km SW of Lakeville Corner, 45.8999°N, 66.2585°W, 5 m, floodplain forest of Silver Maple along lakeshore, on trunk of Silver Maple, 15 June 2013, *S.R. Clayden 24101* (det. J.W. Sheard). **York Co.:** Lower Lincoln, between mouth of Oromocto River and Wolastoq (Saint John River), Thatch Road, ~800 m SE of junction with Route 102, 45.86586°N, 66.50396°W, 5 m, floodplain forest of Red Ash, Silver Maple, Basswood, and Butternut (*Juglans cinerea* L.), on Basswood, 22 September 2019, *S.R. Clayden 28073*; Upper Shores Island, 45.96925°N, 66.81758°W, mature riparian forest of Red Ash, Basswood, Butternut, and Silver Maple, on trunk of young Red Ash, 7 April 2022, *S.R. Clayden 28649*.

Rinodina polyspora Th. Fr. (Figure 4g)

Reported for New Brunswick by Gowan and Brodo (1988) and Sheard (2010). Characterized by its very thin thallus; scattered (not clustered) apothecia which are usually <0.5 mm in diameter and soon become convex, excluding the thalline margin; and 12–16-spored asci with *Physcia*- to *Physconia*-type ascospores (apical walls initially thick, but sometimes becoming thinner in mature stages). *Rinodina populicola* has a more conspicuous, distinctly areolate thallus, and larger, persistently marginate apothecia mostly containing 16–32 *Physconia*-type spores per ascus. In both species, eight-spored asci are also uncommonly present together with asci with higher spore numbers (Sheard 2010; our study).

Rinodina polyspora is known from eastern and western North America (Sheard 2010) and eastern and western Eurasia (Mayrhofer and Moberg 2002; Sheard *et al.* 2017). In eastern North America, it is distributed in a fairly narrow latitudinal band from the western Great Lakes region to the Maritime provinces (Sheard 2010). Records from the northeastern United States, including Maine, Massachusetts, New Hampshire, New York, Pennsylvania, and Vermont, all appear to date from the 19th and early 20th centuries (Consortium of Lichen Herbaria 2023). Declines or extirpations of *R. polyspora* in Europe are also inferred to have occurred (Mayrhofer and Moberg 2002; Wirth *et al.* 2013; Nimis *et al.* 2018; Wirth 2021), but the factors underlying these changes are uncertain (Wirth 2021). Owing to the limited extent and depth of lichen surveys in New Brunswick and the other Maritime provinces before recent decades, it is not possible to assess whether *R. polyspora* has declined in abundance in this region.

Gowan and Brodo (1988) reported this species from old field and roadside habitats in Fundy National Park, where it was found on Trembling Aspen. Another roadside occurrence near Sussex, Kings Co. (not "Sussex Co.") was reported by Sheard (2010). Our study documents eight further occurrences scattered throughout the province in forest habitats ranging from wet mixed-wood stands dominated by cedar to mesic upland hardwoods. Among the 13 specimens with phorophyte data, including those from Fundy National Park, seven were on Black Ash, three on Trembling Aspen, and one each on Sugar Maple, American Beech, and Balsam Poplar. The occurrences on ash were mostly on smooth bark of saplings in openings in cedar swamp forests.

Specimens examined—**Charlotte Co.:** St. Croix River, Clark Point PNA, ~0.5 to 1 km SE of point, 45.319°N, 67.442°W, 77 m, wet mixed forest dominated by cedar, Red Maple, and Black Ash, with scattered fir and Black Spruce, on young Black Ash, 27 May 2007, *S.R. Clayden 17502 p.p.* **Gloucester Co.:** Jacquet River Gorge PNA, between Antinouri Lake and Big Meadow, 47.771°N, 65.944°W, 215 m, young moderately open forest dominated by Sugar Maple, with scattered Paper Birch and White Spruce, on stems of young Black Ash, 15 August 2010, *S.R. Clayden 21181*. **Kings Co.:** Poley Mountain, ~11 km SE of Sussex, 45.67588°N, 65.37412°W, 265 m, forest of Sugar Maple, beech, White Ash, hop-hornbeam, Yellow Birch, and Paper Birch, on steep NE-facing slope, on smooth bark of American Beech,

branch from crown of recently fallen tree, 15 November 2013, *S.R. Clayden 24337*. **Northumberland Co.:** Goodfellow Brook PNA, between Lake Brook and Goodfellow Brook, ~16 km SSW of Miramichi, 46.896°N, 65.380°W, 35 m, wet mixed forest of Red Maple, Black Ash, cedar, spruce, fir, Speckled Alder, and Mountain Holly (*Ilex mucronata* (L.) M. Powell, V. Savolainen & S. Andrews), on Black Ash sapling, 23 May 2007, *S.R. Clayden 16930*; Nepisiguit PNA, at confluence of unnamed creek and Little South Branch Nepisiguit River, 47.3317°N, 66.6891°W, riparian forest with Balsam Poplar, spruce, Paper Birch, and fir, somewhat disturbed, on Balsam Poplar, 4 July 2015, *K.E. Driscoll 1218*. **Restigouche Co.:** Berry Brook PNA, headwaters area of Berry Brook, ~8 km S of Saint-Arthur, 47.81414°N, 66.75800°W, 310 m, mesic to wet forest of cedar, fir, and Black Spruce, with scattered Red Maple and Black Ash, on dead branch of Black Ash, 5 November 2006, *S.R. Clayden 16703 p.p.* **York Co.:** Eel River PNA, ~2 km SW of Browns Mountain, N side of large open peatland, 45.89629°N, 67.64210°W, 143 m, wet, moderately open forest of cedar and Tamarack, on Black Ash, 3 August 2006, *S.R. Clayden 15714 p.p.*; N side of Kellys Creek, ~1.7 km E of junction of Mazerolle Settlement Road and Mountain Road, 45.8723°N, 66.8414°W, 75 m, thicket of Speckled Alder, Black Ash, Red Maple, and Chokecherry (*Prunus virginiana* L.) near brook, on Black Ash, 7 June 2008, *S.R. Clayden 18479 p.p., 18481 p.p., 18490 p.p.*; Spednic Lake Provincial Park, Boulderwalk Trail, 45.60709°N, 67.44422°W, 145 m, mesic hardwood forest dominated by beech, Sugar Maple, and Yellow Birch, on trunk of large Sugar Maple, 16 June 2018, *S.R. Clayden 27081*.

Also known from Albert Co. (Gowan and Brodo 1988).

Rinodina populicola H. Magn. (Figure 4h)

New to New Brunswick. This species differs from *R. polyspora* not only in its greater spore number per ascus, smaller spore size, and lack of persistent apical spore-wall thickenings, but also in the external morphology of the thallus and apothecia (see above and Figure 6c). In one case (*Clayden 18490*), the two species were found growing together on a branch of Black Ash. The habit and colouration of the thalli of *R. populicola* can resemble those of some other *Rinodina* species, including *R. pachysperma* (Sheard 2010). Thus, field identification is not feasible.

Rinodina populicola is endemic to central and eastern North America (Sheard 2018). Much like *R. pachysperma*, it extends westward to the edge of the forest/prairie transition in the centre of the continent. East of the lower St. Lawrence River valley, it has been documented previously only from a few scattered localities in Quebec and Maine (Sheard 2010). The collections reported here date from 2008 to 2022 and are from four localities in south-central and southwestern New Brunswick. Two were from canopy branches of poplars (Balsam Poplar, Trembling Aspen), and all were in relatively humid settings near waterbodies, a set of general habitat characteristics that might guide future searches for this lichen in the province and elsewhere in eastern Canada.

Specimens examined—**York Co.:** N side of Kellys Creek, ~1.7 km E of junction of Mazerolle Settlement Road and Mountain Road, 45.8723°N, 66.8414°W, 75 m, thicket of Speckled Alder, Black Ash, Red Maple, and Chokecherry near brook, on Black Ash, 7 June 2008, *S.R. Clayden 18490 p.p.* (with *R. polyspora*); Spednic Lake PNA, Lower Palfrey Neck, 45.62548°N, 67.45639°W, mixed forest of beech, Red Maple, hemlock, spruce, birch, and poplar, on branch of Trembling Aspen fallen from crown of tree, 24 June 2018, *S.R. Clayden 27239*; S side of Wolastoq (Saint John River) at Island View, 45.95904°N, 66.82554°W, 10 m, forest of Red Ash, Butternut, and Black Willow, on river bank, on trunk of Red Ash, 23 May 2022, *S.R. Clayden 28693* (with *R. pachysperma*); French Village, Mactaquac Biodiversity Facility [Fish Hatchery], 45.95738°N, 66.84356°W, 10 m, line of tall Balsam Poplar along road adjoining mowed fields, on branches of Balsam Poplar from tree canopy, found on the ground, 25 September 2022, *S.R. Clayden 28963*.

Rinodina septentrionalis Malme (Figure 4b)

New to New Brunswick. This species is closely related to *R. freyi* (Nadyeina *et al.* 2010; Sheard 2010; Kondratyuk *et al.* 2021), differing in its more dispersed apothecia that are often more narrowly attached at maturity, and by its smaller, more convex, and likewise more dispersed areoles. There may also be a slight difference in mean ascospore size between the two species, at least in North American populations: "16.0–16.5 × ca. 8.0 µm" in *R. septentrionalis*, versus "15.0–15.5 × 7.5 µm" in *R. freyi* (Sheard 2018: 407). In the single specimen of *R. septentrionalis* reported here, the ascospores are (14.0–)15.1–17.9 (–20.0) × (7.0–)7.3–8.0(–8.5) µm (n = 44). The mean size is 16.5 × 7.6 µm, versus 15.6 × 7.3 µm in New Brunswick collections of *R. freyi* (see above), consistent with the difference noted by Sheard (2018).

The two species also differ ecologically and in their geographical distributions. *Rinodina septentrionalis* occurs on relatively smooth portions of tree branches, whereas *R. freyi* is mostly confined to branch axils and leaf scars (Sheard 2010; Sheard *et al.* 2017). Sheard (2010) suggested that this difference

reflects more rapid drying of areas of smooth bark than of axil and leaf-scar micro-niches. At the single known locality in New Brunswick, *R. septentrionalis* was found on branches of Balsam Poplar together with *A. pyracea*, *Caloplaca cerina* (Hedw.) Th. Fr., *Hypogymnia incurvoides* Rass., *Melanohalea septentrionalis* (Lynge) O. Blanco *et al.*, *Parmelia sulcata* Taylor, *Physcia aipolia* (Ehrh. ex Humb.) Fürnr., *Scoliciosporum chlorococcum* (Graewe ex Stenh.) Vězda, and the calicioid fungus *Phaeocalicium populneum* (Brond. ex Duby) A.F.W. Schmidt.

Rinodina septentrionalis has a more northerly distribution than *R. freyi*, occurring in the boreal to hemiarctic zones and their elevational counterparts in North America and Eurasia. In North America, it has been recorded widely in the western Cordillera, from Alaska to Colorado, and eastward to Hudson Bay, Lake Superior, and the Clay Belt region of western Quebec (Sheard 2010). The occurrence in northern New Brunswick reported here extends its known range eastward by about 900 km. The locality is in the bottom of a river valley in the Highlands ecoregion of the province, which has a strong representation of boreal plant communities and species (Loucks 1962a; Clayden 2000, 2010; Zelazny 2007). Although the local elevation of the valley floor is only ~250 m, species distributions in the area reflect the influence of night-time cold-air drainage off adjoining slopes during the growing season. The frost-free season is shortest in valley-floor, lower-slope, and hilltop positions, the latter locally above ~550 m. These situations are accordingly dominated by boreal conifers, whereas stands of temperate hardwoods are present on the warmer mid-slopes. Similar topoclimatic and associated vegetation gradients in northwestern New Brunswick were elucidated in a classic study by Loucks (1962b). It seems likely that *R. septentrionalis* is more frequent in valley-floor settings in northern New Brunswick than the single record reported here might suggest.

Specimen examined—**Northumberland Co.:** Nepisiguit PNA, Popple Depot, 47.39709°N, 66.51492°W, 250 m, edge of heathy forest of Black Spruce and Jack Pine (*Pinus banksiana* Lambert), with poplar, Paper Birch, and willow, adjoining a cleared and levelled (bulldozed) area, on branches of Balsam Poplar, 15 September 2015, *S.R. Clayden 25620* (confirmed by J.W. Sheard).

Rinodina subminuta H. Magn. (syn. *R. annulata* H. Magn. [Sheard 2010]; *R. halei* H. Magn. [Sheard 2010]; Figure 4i)

Reported for New Brunswick by Gowan and Brodo (1988) and Sheard (2010). Characterized by its usually inconspicuous thallus, which is partly to largely within the bark substratum, or else superficial, thin, and pale grey, green grey, or grey brown; apothecia initially immersed in the thallus or substratum, and remaining broadly attached, the discs often becoming eroded (Figure 6d); *Physcia*-type ascospores (Figure 7b) measuring (15–)17.4–20.9(–24) × (7.5–)8.7–10.5(–11.5) µm (n = 88) in New Brunswick specimens; and chemistry (K−, P−, containing zeorin only).

Sheard (2010) noted that ascospores are scarce in the apothecia of many specimens of *R. subminuta*, possibly due to physical inhibition of ascus development by dense gelatinization of the hymenium. While we, too, observed this tendency, a specimen collected in late winter (8 March 2021, *Clayden 28457*) is an exception. This contains numerous well-developed mature asci and spores. The question thus arises whether spore development and discharge in this species are also distinctly seasonal, as they appear to be in *R. ascociscana*.

This is the most common *Rinodina* species in New Brunswick. It is widely distributed in eastern North America, its range coinciding largely but not entirely with that of Sugar Maple, the tree species on which it has been recorded most frequently (Sheard 2010; Brodo 2016). It is also common in mixed and broadleaf deciduous forests in temperate northeastern Asia (Sheard *et al.* 2017; Galanina *et al.* 2021a). It is apparently less frequent in the southern Appalachians (Lendemer *et al.* 2014) than in the broad zone of Sugar Maple-dominated forests extending from the Great Lakes region to the Maritime provinces (Gowan and Brodo 1988; Wong and Brodo 1992; Selva *et al.* 2004; Harris 2015).

Among 89 specimens of *R. subminuta* from New Brunswick that we examined for this study, 48 were on Sugar Maple, 10 on Black Ash, nine on Yellow Birch, five on White Elm, four on Balsam Poplar, two each on Mountain Maple, American Beech, White Ash, and Trembling Aspen, and one each on Striped Maple, Red Maple, Butternut, Smith's Willow (*Salix* ×*smithiana* Willdenow), and American Mountain-ash. We did not find *R. subminuta* on Eastern White Cedar. Its apparent rarity on Red Maple and the lack of records from Silver Maple also stand out. Although most records are from forests, *R. subminuta* has also been found in New Brunswick on open-grown trees in fields and along roadsides in rural and suburban settings.

The type of *R. subminuta* is a 19th-century specimen collected by Edward Tuckerman in the White Mountains of New Hampshire, reportedly on *Acer* "*saccharinum*" (Magnusson 1947; Sheard 2010). However, the substratum noted on the label of the type specimen and isotypes (no. 88 in the exsiccata

Reliquiae Tuckermanianae) is "*Acer saccharinum* Wang." The latter name was widely misapplied to Sugar Maple in the 19th and early 20th centuries before it emerged that Linnaeus had validly described Silver Maple as *A. saccharinum* L. in 1753 in his Species Plantarum (Shaw 1977). Thus, the type of *R. subminuta* almost certainly originated from Sugar Maple, not Silver Maple. These two maple species occur in distinct environments, as noted above under *R. pachysperma*: Sugar Maple on well drained, mostly upland sites, and Silver Maple largely in seasonally flooded bottomlands. The type specimen of *R. halei* (= *Rinodina subminuta* [Sheard 2010]) is likewise from Sugar Maple (Magnusson 1953), not Silver Maple (Sheard 2010). These associations are consistent with the frequency of *R. subminuta* on Sugar Maple in eastern North America and with its apparent absence on Silver Maple, at least in New Brunswick, but possibly more widely.

Most records of *R. subminuta* in New Brunswick are from the lower part of tree boles. We have not found it on canopy branches in forests, although it sometimes occurs on small, thin, shade-suppressed hardwoods in the understorey of mature stands. Hinds (1970) documented a similar vertical distribution of *R. subminuta* (as *R. annulata*) on Balsam Poplar in northern Michigan: it was present only near the tree bases, not on smooth bark higher on the trunks. Tall deciduous shrubs such as Hobblebush (*Viburnum lantanoides* Michaux) and Beaked Hazel (*Corylus cornuta* Marshall) are common in the understorey of upland hardwood forests in New Brunswick, but we have not found *R. subminuta* on these species.

There is a single unusual New Brunswick record of *R. subminuta* (*Clayden 24853*) from American Mountain-ash. The collection is from the trunk of a dead tree that remained in a recently clearcut boreal forest dominated by fir. Mountain-ash was not among the phorophytes of North American specimens of *R. subminuta* examined by Sheard (2010). However, it occurs on mountain-ash in Japan and Russia (Sheard *et al.* 2017; Galanina *et al.* 2021b). The occurrence in New Brunswick is from an elevation higher than that of the local topoclimatic limit of Sugar Maple. Mean temperatures at a climate station (Upsalquitch Lake) at a similar elevation (625 m) about 12 km northeast of this occurrence are 15.9°C in July and −13.1°C in January, with annual growing-degree-days (5°C threshold) averaging 1204 (ECCC 2022). These values place the locality well within the (oro-)boreal zone (Clayden 2010). Associated lichens on the tree with *R. subminuta* included, e.g., *Buellia disciformis* (Fr.) Mudd, *Caloplaca borealis* (Vain.) Poelt, *Lobaria pulmonaria* (L.) Hoffm., and *Nephroma resupinatum* (L.) Ach., an assemblage indicative of a relatively high bark pH.

Rinodina subminuta has also been found on mountain-ash (Showy Mountain-ash [*Sorbus decora* (Sargent) C.K. Schneider]) in subalpine (upper oroboreal) fir–birch forest at ~900 m elevation on Mount Katahdin in neighbouring Maine, USA (Hinds *et al.* 2009). This occurrence and the record from montane northern New Brunswick indicate that the potential range of *R. subminuta* in northeastern North America is greater than that of its main phorophyte, Sugar Maple. However, it has not been recorded from the island of Newfoundland, or north of the Gulf of Saint Lawrence, where mountain-ash is a frequent component of fir-dominated forests. Sugar Maple is absent from Newfoundland, but outlying occurrences of a number of lichens characteristic of temperate deciduous forests are known on the island (Ahti 1983; McCarthy *et al.* 2015).

Selected specimens examined—**Albert Co.:** Lewis Mountain PNA, headwaters area of Turtle Creek, 45.8405°N, 64.8476°W, 345 m, old-growth hardwood forest dominated by Sugar Maple, beech, and Yellow Birch, on trunk of White Ash, 5 July 2011, *S.R. Clayden 22308*; Wilson Brook PNA, south side of Wilson Brook, ~1.3 km W of Albert Mines Road, 45.86034°N, 64.67532°W, 65 m, mixed forest of fir, birch, and maple near base of N-facing gypsum bluffs along brook, on stem of Mountain Maple, 21 September 2020, *S.R. Clayden 28356*. **Carleton Co.:** 250 to 400 m N of Southern Carleton Elementary School at Bedell, 46.14965°N, 67.62825°W, 160 m, mature forest of Sugar Maple with high canopy and rich understorey flora, on Sugar Maple, 7 May 2008, *S.R. Clayden 18172*. **Charlotte Co.:**; Pomeroy Ridge, ~4.1 km NW of intersection of Route 735 and Route 732, 45.3087°N, 67.4362°W, 65 m, moderately open, wet forest of Red Maple, Black Ash, fir, Balsam Poplar, Speckled Alder, and Common Winterberry (*Ilex verticillata* (L.) A. Gray), on Black Ash, 5 June 2008, *K. E. Driscoll 166*. **Gloucester Co.:** Bass River PNA, south side of East Branch Bass River, just W of Route 8, 47.4502°N, 65.524°W, 145 m, mature forest of Sugar Maple, Yellow Birch, beech, Striped Maple, and Beaked Hazel, on Sugar Maple, 27 May 1999, *S.R. Clayden 9889*. **Kent Co.:** Kouchibouguac National Park, N side of Black River, 1.4 km W of Route 117, 46.8387°N, 65.0102°W, 10 m, terrace of river, with mixed forest of Red Maple, Sugar Maple, fir, Black Spruce, Trembling Aspen, Yellow Birch, and scattered large dead White Elm, on trunk of White Elm, 5 July 2001, *S.R. Clayden 11059*. **Kings Co.:** McDermott Hill, ~5 km SE of Waterford, 45.65636°N, 65.31539°W, 330 m, old-growth hardwood forest dominated by Sugar Maple, Yellow Birch, and beech, on Sugar Maple, 3 May 2005, *S.R. Clayden*

13365. **Madawaska Co.:** Jalbert Brook, between forest road and First Lake, 47.647°N, 68.300°W, 230 m, mature forest of fir, White Spruce, Black Ash, and Mountain Maple, with a few large snags and small living trees of White Elm, corticolous on White Elm, 23 June 2010, *S.R. Clayden 20979*. **Northumberland Co.:** South of Chatham, along Lake Brook, tributary of Black River, Black Ash swamp forest near edge of marsh, on Black Ash, 26 August 1979, *I. Walker, s.n. (H. Harries 79104)*; Mount Carleton Provincial Park, off south side of Big Brook Trail, ~6.3 km from Pine Point, 47.36°N, 66.84°W, mixed hardwood forest dominated by Sugar Maple and Yellow Birch, corticolous on Yellow Birch, 1 August 1989, *S.B. Selva 4155*; ~4.7 km NW of Popple Depot, height of land just outside NE corner of Nepisiguit PNA, 47.41912°N, 66.56480°W, 680 m, clear-cut forest of fir, Heart-leaved Birch, and American Mountain-ash, on a hilltop, corticolous on trunk of dead mountain-ash, 18 September 2014, *S.R. Clayden 24853*; Hells Gate Hardwoods PNA, ~6.5 km ENE of Saint Margarets, 46.9232°N, 65.1121°W, 40 m, mature hardwood forest dominated by Sugar Maple, Red Maple, and Yellow Birch, on trunk of Sugar Maple, 14 September 2019, *S.R. Clayden 27998A*. **Queens Co.:** Grand Lake PNA, just south of Route 105 at Trout Creek, 1 km SW of Jemseg, 45.82332°N, 66.12413°W, 5 m, floodplain forest of Silver Maple and Red Ash, on trunk of White Elm, 13 August 2014, *S.R. Clayden 24691*. **Restigouche Co.:** Jacquet River Gorge PNA, upland between Winston Gulch and Cook Gulch, near forest road, 47.74908°N, 66.11139°W, 285 m, mixed mature forest of Sugar Maple, Yellow Birch, and White Spruce, abundant on smooth bark of Yellow Birch, 24 June 2008, *S.R. Clayden 18719*; *ibid*., W side of Jacquet River, at mouth of Big Hole Brook, 47.825°N, 66.077°W, 50 m, forest of Balsam Poplar, fir, and Black Ash on alluvial terrace next to river, on trunk of Balsam Poplar, 14 May 2010, *S.R. Clayden 21330*. **Saint John Co.:** City of Saint John, Seaside Park, 45.24746°N, 66.08243°W, 45 m, lawn with planted trees, on branch of Smith's Willow, 18 October 2020, *S.R. Clayden 28385*; City of Saint John, Red Head Road ¾ mile before Mispec Point Road, 45.250°N, 66.000°W, on roadside European Elms [probably Scotch Elm (*Ulmus glabra* Hudson): S.R.C. pers. obs.], 20 June 1975, *H.R. Hinds 75-98* (det. J.W. Sheard); **Westmorland Co.:** 3 to 4 km N of Cookville, on trunk of old elm trees in old field area, 16 August 1977, *H. Harries 77153*. **York Co.:** Between Williamstown and Lakeville, along NB Trail, 46.37033°N, 67.67613°W, 125 m, forest of Sugar Maple, Yellow Birch, beech, and fir, on Sugar Maple, 4 August 2006, *S.R. Clayden 15907*; Odell Park, 45.95428°N, 66.66842°W, 75 m, old mixed forest dominated by Sugar Maple, beech, hemlock, and Yellow Birch, on thin branch of sapling of American Beech, 8 March 2021, *S.R. Clayden 28457*.

Rinodina subpariata (Nyl.) Zahlbr. (syn. *Rinodina degeliana* Coppins [Resl *et al.* 2016; Sheard *et al.* 2017]; Figure 4j)

Reported for New Brunswick by Sheard (1995, 2010) and Resl *et al.* (2016, inadvertently spelled *R.* "*subparieta*"). Readily separable from the other two sorediate *Rinodina* species occurring in the province by its K+ yellow and P+ yellow thallus containing atranorin. *Rinodina efflorescens* and *R. willeyi* contain pannarin, not atranorin, and are K− and P+ red orange; *R. efflorescens* additionally contains secalonic acid A (soralia KC+ yellow orange). Both *R. subpariata* and *R. willeyi* have lighter-coloured thalli than *R. efflorescens*, in which the areoles usually have a brownish hue and are often distributed on a darker brown very thin prothallus. *Rinodina subpariata* and *R. willeyi* can usually be distinguished from one another in the field by the colour of their soredia: in *R. subpariata* they are persistently white, contrasting with the light-grey corticate portions of the areoles, whereas in *R. willeyi* both areoles and soredia are greyish. Well-developed thalli of *R. subpariata* with upturned areole-margins can sometimes superficially resemble the micro-squamulose lichen *Toensbergia leucococca* (R. Sant.) Bendiksby & Timdal. The light grey, marginally sorediate squamules of this species are K+ and P+ yellow, but also C+ pink. It contains alectorialic acid (not atranorin), and the thalli turn pinkish over time in herbarium specimens (Tønsberg 1992—as *Hypocenomyce leucococca* R. Sant.; S.R.C. pers. obs.). These two species also differ ecologically. In New Brunswick, *R. subpariata* occurs widely on a range of hardwood tree species, less frequently on Eastern White Cedar (Cupressaceae), and rarely on Balsam Fir and spruce (Pinaceae); *T. leucococca* is confined to pinaceous conifers and hardwoods with comparably acidic bark and is so far known only from the northern counties of the province (S.R.C. and K.E.D. unpubl. data).

Apothecia are sparsely present in 14 of the 51 New Brunswick specimens of *R. subpariata* that we examined. However, the ascospores are poorly developed or overmature in most of this material, a finding consistent with observations made by J.W. Sheard (Resl *et al.* 2016; Sheard *et al.* 2017). In *Clayden 28373A*, the spores are (17–)18.2–22.1(–23) × (9–)9.3–10.7(–11) µm, with a length/width ratio of (1.8–)1.9–2.2(–2.4) (n = 12). The type specimen of *R. subpariata*, from Japan, is fertile (with apothecia), but lacks soredia (Resl *et al.* 2016; Sheard *et al.* 2017). Other such thalli are known from high elevations in Japan, but

Resl *et al.* (2016) showed that these are nested phylogenetically in a clade that also includes sorediate thalli. We have not found fertile non-sorediate thalli of *R. subpariata* in New Brunswick.

The North American and global distributions of *R. subpariata* (including *R. degeliana*) are broadly similar to those of *R. efflorescens* (Sheard 1995, 2010; Lendemer *et al.* 2014; Sheard *et al.* 2017; Galanina *et al.* 2021b). In eastern North America, it occurs extensively in the Appalachian–Great Lakes–Maritimes region and was recently reported from Newfoundland (Sheard 2018). A study of the molecular phylogenetic relationships of collections of *R. subpariata* from several parts of its range in the Northern Hemisphere showed that material from eastern North America (including *Clayden 24048* from New Brunswick, cited below) groups most closely with collections from eastern Asia (Resl *et al.* 2016). Two other clades, one including material from western Europe and western North America, and the other western North American specimens only, are possibly species-level lineages, but on current evidence these are distinguishable only by molecular characters (Resl *et al.* 2016).

We have found *R. subpariata* throughout New Brunswick in mesic hardwood and mixed forests, as well as in wetter stands dominated by cedar. It occurs on a wide range of hardwood trees, on Eastern White Cedar, and rarely on Balsam Fir and spruce ("*Picea* sp.", *S.B. Selva 4089 p.p.* [NBM]). Among the specimens we examined in which the phorophytes were determined to species, nine were on Yellow Birch, eight on Red Maple, seven on Sugar Maple, five on Eastern White Cedar, three each on Striped Maple and Mountain Maple, two each on Paper Birch, American Beech, White Ash, and Red Oak, and one each on Balsam Fir, Butternut, Large-toothed Aspen (*Populus grandidentata* Michaux), Trembling Aspen, and American Mountain-ash.

Selected specimens examined—**Albert Co.:** Caledonia Gorge PNA, Crooked Creek valley, ~500 m NW of mouth of Caledonia Brook, 45.7992°N, 64.7782°W, 185 m, mixed forest dominated by Red Spruce and Yellow Birch, on steep slope, with scattered large Large-toothed Aspen, on Large-toothed Aspen, 2 July 2011, *S.R. Clayden 22219*. **Charlotte Co.:** Grand Falls Flowage on St. Croix River, at end of Route 725 NW of Upper Little Ridge, 45.278°N, 67.479°W, 80 m, mixed and hardwood forest dominated by Red Spruce, hemlock, fir, Red Maple, beech, and Yellow Birch, on trunk of Red Maple, *S.R. Clayden 21878*; Campobello Island, Roosevelt Campobello International Park, along Fox Hill Drive, 44.8544°N, 66.9453°W, wet spruce–fir woods with scattered Red Maple and pockets of birch and mountain-ash, on birch, 25 September 2016, *K.E. Driscoll 1365*. **Kings Co.:** Big Bluff, Rockville, SE of Sussex Corner, 45.70014°N, 65.44115°W, 170 m, forest of Sugar Maple, hop-hornbeam, and Red Oak, at top of bluffs, on trunk of Eastern Hop-hornbeam, 28 June 2018, *S.R. Clayden 27243*. **Madawaska Co.:** Gagné Brook, between forest road and Green River, 1.8 km south of First Lake, 47.608°N, 68.251°W, 225 m, forest of fir, White Spruce, Mountain Maple, and Speckled Alder, along brook, on Mountain Maple, 23 June 2010, *S.R. Clayden 20914*. **Northumberland Co.:** Nepisiguit PNA, upland between West Branch Portage Brook and headwaters of Pentland Brook, 47.4392°N, 66.6222°W, 470 m, mature forest of Sugar Maple and Yellow Birch, with scattered Heart-leaved Birch, fir, Red Spruce, and Red Maple, on smooth bark of Yellow Birch, 15 August 2016, *S.R. Clayden 25930*; Kennedy Lakes PNA, along road from Route 108 to Pratts Camp, ~2 km NW of Louis Lake, 46.86265°N, 66.62674°W, 505 m, forest of Sugar Maple, Yellow Birch, and beech, abundant on smooth bark of trunks of American Beech, 1 July 2019, *S.R. Clayden 27851A*; Hells Gate Hardwoods PNA, ~6.5 km ENE of Saint Margarets, 46.9232°N, 65.1121°W, 40 m, mature hardwood forest dominated by Sugar Maple, Red Maple, and Yellow Birch, over bark and lichens on trunk of Sugar Maple, 14 September 2019, *S.R. Clayden 28018*. **Restigouche Co.:** Mount Carleton Provincial Park, along the William's Falls trail, 47.426°N, 66.883°W, mixed conifer forest, corticolous on Eastern White Cedar, 17 August 1989, *S.B. Selva 4226 p.p.* **Sunbury Co.:** Grand Lake PNA, along forest road from Coy Road to East Branch Baltimore Stream, 45.96092°N, 66.12723°W, young mixed forest of fir, Red Maple, and Paper Birch, with scattered White Ash and hemlock, on trunk of White Ash, *S.R. Clayden 24048* (voucher for ITS sequence: Resl *et al.* 2016). **Westmorland Co.:** near site of Pink Rock wharf, coastal disturbance belt of forest, on trunk of scaly-barked old Red Maple, November 1979, *H. Harries 79206* (det. S.R. Clayden); Mount View Road between Trans-Canada Hwy and brow of hill, second growth forest with Red Spruce–fir tendency, on Red Maple, 29 March 1980, *H. Harries 80141* (det. S.R. Clayden). **York Co.:** N slope of Crabbe Mountain, 46.12365°N, 67.09935°W, 280 m, mixed forest of Sugar Maple, Red Spruce, fir, Yellow Birch, Heart-leaved Birch, and beech, on smooth bark of young Balsam Fir, 23 December 2016, *S.R. Clayden 26401*; Fredericton, Odell Park, ~450 m SSW of park lodge, 45.95354°N, 66.66621°W, 80 m, old mixed forest dominated by maple, beech, birch, and hemlock, on trunk of Butternut, 12 October 2018, *S.R. Clayden 27365*.

Also reported from Kouchibouguac National Park

in Kent Co. (Sheard 2010).

***Rinodina tenuis* Müll. Arg.** (syn. *Rinodina adirondackii* H. Magn. [Sheard *et al.* 2017]; Figure 4k)

New to New Brunswick and Atlantic Canada. Characterized by its light-grey, thin but continuous thallus containing pannarin (P+ red orange); apothecia initially immersed in the thallus and remaining broadly attached (Figure 6f); and large *Pachysporaria*-type ascospores measuring (24–)26.3–31.0(–33) × (10.5–)12.8–16.2(–19.0) µm (n = 55) in New Brunswick specimens. Magnusson (1947) described *R. adirondackii* based on a specimen collected on Eastern White Cedar in the Adirondack Mountains of northern New York state. Under this name, it was considered until recently to be endemic to the Appalachian–Great Lakes region (Sheard 2010; Lendemer *et al.* 2014).

Detailed studies of *Rinodina* in northeastern Asia led Sheard *et al.* (2017) to conclude that *R. adirondackii* is a synonym of *R. tenuis*, described from Japan by J. Müller Argoviensis in 1892. The two taxa are similar morphologically and both produce pannarin. However, specimens from Asia have longer spores: "(27.0–)32.0–35.5(–39.0) × (12.5–)14.5–17.0(–18.5) µm (n = 63)" [mean 33.8 × 15.8 µm] (Sheard *et al.* 2017: 659), versus "(21.5–)28.0–30.0(–36.5) × (9.0–)14.0–16.0(–20.5) µm" [mean 29.0 × 15.0 µm; n unknown] in North American specimens reported as *R. adirondackii* (Sheard 2010: 35). Sheard *et al.* (2017) suggested that this size-difference might be related to a difference in spore number per ascus. In Asian specimens, the asci sometimes contain four rather than eight spores (Sheard *et al.* 2017), whereas only eight-spored asci have been noted in North American specimens (Sheard 2010; our study). Spore size in the sample from New Brunswick (mean 28.7 × 14.5 µm; n = 55) is consistent with other North American material, and smaller than in collections of *R. tenuis* from Japan and the Russian Far East. Molecular evidence is needed to better assess the relationship of these widely disjunct populations. *Rinodina tenuis* has also been reported recently from the Western Caucasus region of southern Russia (Urbanavichus *et al.* 2020), an area known for disjunct occurrences of otherwise eastern North American–eastern Asian lichens (Otte 2004).

In New Brunswick and elsewhere in the northern part of its range in North America, *R. tenuis* has a striking fidelity to Eastern White Cedar as a phorophyte. All known occurrences in the province (14 localities documented by 18 specimens) are on this tree species. We and others have also found *R. tenuis* in swamp forests dominated by cedar in adjacent northern Maine and Gaspésie, Quebec (Lendemer *et al.* 2014; S.R.C., K.E.D., and S.B. Selva unpubl. data). It is typically present as scattered discrete thalli on tree trunks or on living or dead, corticate or decorticate, lower branches (Figure 2b). The occurrences in New Brunswick are in mature stands on wet sites at elevations ranging from 35 m to 275 m, especially on terraces near streams or rivers, but also on N- to NE-facing seepage slopes. Eastern White Cedar often hosts a species-rich assemblage of lichens in these settings, commonly including cyanolichens. Among the latter, *Fuscopannaria leucosticta* (Tuck.) P.M. Jørg., like *R. tenuis*, is strongly associated with cedar in New Brunswick (Haughian *et al.* 2018).

Records of *R. tenuis* posted on the website of the Consortium of Lichen Herbaria (2023) indicate that the known occurrences of *R. tenuis* in Quebec, Ontario, Maine, and the Great Lakes states are, likewise, mostly on Eastern White Cedar, with only a few on Balsam Fir, Tamarack, and hemlock. In the central and southern Appalachians, where Eastern White Cedar is very sporadically distributed or lacking, it occurs on hardwoods, especially oak (*Quercus* L.) species (Lendemer *et al.* 2014). The single collection reported from the Russian Caucasus by Urbanavichus *et al.* (2020) was on Oriental Beech (*Fagus orientalis* Lipsky).

The number and distribution of collections of *R. tenuis* reported here might suggest that it is a common species in New Brunswick. However, our findings reflect the emphasis we placed on locating and surveying old wet cedar forests. It appears that *R. tenuis* is infrequent throughout its range in North America (Sheard 2010; Lendemer *et al.* 2014) and that its extent of occurrence may have declined. The only record for Ontario is a specimen collected on Eastern White Cedar by R.F. Cain near Lake Temagami in 1945 (Sheard 2010; Consortium of Lichen Herbaria 2023). In Quebec, the only record outside Gaspésie is from Lac Clair near Quebec City, where it was collected on an unspecified substratum by W.G. Farlow in 1888 (Sheard 2010; Consortium of Lichen Herbaria 2023).

Specimens examined (all on Eastern White Cedar)—**Charlotte Co.:** Clark Point PNA, St. Croix River, ~0.5 to 1 km SE of Clark Point, NE of Clark Ridge, 45.32036°N, 67.43995°W, 70 m, wet mixed forest dominated by cedar, Red Maple, and Black Ash, with scattered fir and Black Spruce, 25 August 2006, *S.R. Clayden 16155*; Pennfield Parish, W and south of small lake at head of unnamed tributary of Love Lake Brook, 45.205°N, 66.635°W, 80 m, wet to mesic forest of cedar along brook, 16 April 2011, *S.R. Clayden 21754*. **Kent Co.:** Route 11, ~7 km south of Rexton, dense cedar forest along stream, 1 September 1979, *H. Harries 79364* (det. S.R. Clayden).

Madawaska Co.: "Black Brook District" of J.D. Irving Ltd., Little Beaver Brook, ~4.8 km NNW of confluence with Beaver Brook, 47.2423°N, 67.7003°W, 265 m, wet to mesic forest of cedar, with scattered Black Spruce and fir, along terrace adjoining brook, 29 August 2008, *S.R. Clayden 19073, 19122*. **Northumberland Co.:** Goodfellow Brook PNA, ~2 km E of Weldfield-Collette Road, 13 km W of Saint Margarets, 46.8991°N, 65.3666°W, 35 m, mature wet forest of cedar, fir, spruce, and Red Maple, with scattered Eastern White Pine and hemlock, 16 September 2019, *S.R. Clayden 28062*; Kennedy Lakes PNA, S side of North Branch Renous River, 250 m NW of mouth of Quigley Brook, 46.80440°N, 66.35524°W, 205 m, forest of Yellow Birch, Red Maple, fir, and cedar on NE-facing slope and terrace next to river, 13 August 2022, *S.R. Clayden 28748*. **Queens Co.:** Grand Lake PNA, SE of forest road, 1.6 km E of point where Coy Road crosses Baltimore Stream, 45.9641°N, 66.1209°W, swampy open forest of Black Spruce, cedar, and Red Maple, 13 June 2013, *S.R. Clayden 23880*. **Restigouche Co.:** Mount Carleton Provincial Park, N side of Nepisiguit Lakes Road near its junction with Little Tobique Road, just E of Little Tobique River, 47.425°N, 66.933°W, cedar swamp with moderate amount of spruce, 23 August 1989, *S.B. Selva 4256, 4263A*; Little Tobique River, 1 to 1.5 km NE of mouth of Red Brook, 47.44485°N, 67.06620°W, 232 m, mesic to wet forest dominated by cedar and fir, on river terrace, 13 June 2006, *S.R. Clayden 15161A, 15162*; Berry Brook PNA, headwaters of Berry Brook, ~8 km S of Saint-Arthur, 47.8177°N, 66.7561°W, 275 m, mesic to wet forest of cedar, fir, and Black Spruce, with scattered Red Maple and Black Ash, 14 June 2006, *S.R. Clayden 15285*; Jacquet River Gorge PNA, ~300 m W of Doyles Meadow, 47.816°N, 66.007°W, 184 m, mature wet forest of cedar, with scattered Black Spruce, fir, Black Ash, Red Maple, and Speckled Alder, 12 August 2010, *S.R. Clayden 21110*; *ibid*., S side of Antinouri Lake Brook, 47.8205°N, 66.0137°W, 180 m, old, mainly coniferous forest of cedar, fir, and Black Spruce, on N-facing slope toward brook, 16 August 2010, *S.R. Clayden 21283*. **York Co.:** Eel River PNA, ~1.5 km S of Browns Mountain, 7 km W of Hartin Settlement, 45.89725°N, 67.62759°W, 150 m, small patch of wet, mature, but disturbed cedar forest in a hollow traversed by a forest road, 13 May 2006, *S.R. Clayden 14480*; Spednic Lake PNA, ~1.5 km NE of McAllister Cove, 45.6679°N, 67.6548°W, wet mixed wood forest (cedar, fir, ash, maple), 14 August 2017, *S.R. Haughian 20170814.13*; *ibid*., between South Branch Mosquito Brook and McAllister Brook, 45.6667°N, 67.6541°W, 150 m, swampy forest of Red Maple, cedar, Speckled Alder, Black Spruce, and scattered Black Ash, 14 August 2017, *S.R. Clayden 26728*.

***Rinodina tephraspis* (Tuck.) Herre** (Figure 4e)

New to New Brunswick. Characterized by its saxicolous, grey to brown, areolate thallus (Figure 6e); broadly to narrowly attached apothecia with a persistent thalline margin; *Teichophila*-type ascospores with lumina varying from angular to rounded during development; and chemistry (zeorin present, atranorin lacking). The spores in New Brunswick specimens are (16.0–)18.2–23.5(–26.0) × (7.5–)9.0–12.1(–14.0) µm (n = 59). *Rinodina tephraspis* often contains 5-*O*-methylhiascic acid (± lecanoric acid) in addition to zeorin (Sheard 2010). However, four New Brunswick specimens (*Clayden 24666*, 26829; two thalli, *28403*) that we examined with TLC contained only zeorin. A specimen of *R. tephraspis* from Pennsylvania (*Lendemer 11843* [NBM]) containing both zeorin and 5-*O*-methylhiascic acid was used as a control.

The occurrences reported here, from scattered locations throughout New Brunswick, are apparently the first modern records of this species from Atlantic Canada. It was previously known in the region only from collections made by A.C. Waghorne in 1897 in the Bay of Islands area of western Newfoundland (Sheard 2010). A report (as *R. arenaria*) from Fundy National Park, New Brunswick (Gowan and Brodo 1988), is referable to *R. moziana*, as noted above. *Rinodina tephrasis* is a common species elsewhere in temperate eastern North America (Sheard 2010; Lendemer *et al.* 2014). It also occurs in Europe and neighbouring areas of Russia and the Caucasus region (Mayrhofer and Moberg 2002), and it was recently reported from Korea (Yakovchenko *et al.* 2018).

The substrata of the occurrences in New Brunswick include a range of hard, siliceous, sedimentary and metamorphic rocks. At five of the six sites, the rocks are subject to occasional immersion or splashing (Figure 2c). At the other site, in a mesic hardwood forest, *R. tephraspis* was found on a rock face with a northeast aspect and that appeared to be affected by seepage. A specimen from flat sandstone ledges on a well-lit open lakeshore has a brown hue. Those from shaded sites are light greenish-grey. There is wide variation in the form and density of areoles in the thalli (Figure 6e), with contrasting individuals sometimes occurring side by side.

Rinodina oxydata, like *R. tephraspis*, occurs on moist siliceous rocks, and the two species have generally similar distributions in the eastern North American portions of their ranges. However, *R. oxydata* has not yet been found in New Brunswick or the other Maritime provinces (see above under *R. moziana*). In contrast to *R. tephraspis*, both *R. moziana* and *R.*

oxydata contain atranorin and lack zeorin.

Specimens examined—**Charlotte Co.:** NW-facing bank of Lepreau River at Lepreau Falls, 45.16936°N, 66.46262°W, 15 m, edge of forest of Red Spruce, fir, and cedar, at top of waterfall, on humid shaded rock, 4 August 2022, *S.R. Clayden 28723*. **Gloucester Co.:** Tetagouche Falls, N-facing riverbank below falls, 47.6182°N, 65.8244°W (UTM zone 20T, 287768 m E, 5277729 m N), on shale rock, 1 August 2015, *F. Anderson, s.n.* (det. S.R. Clayden). **Restigouche Co.:** Jacquet River Gorge PNA, south side of Antinouri Lake Brook, 47.820°N, 66.014°W, 160 m, brook bed and N-facing slope above brook with old, mainly coniferous forest of cedar, fir, and spruce, on shaded vertical HCl– rock, ~1 m above water level of brook, 16 August 2010, *S.R. Clayden 21251* (det. J. W. Sheard). **Sunbury Co.:** Portobello Creek National Wildlife Area, French Island, NE shore, opposite Sand Point, 45.92461°N, 66.30010°W, 5 m, lakeshore with sandstone ledges and mixed conifer–hardwood forest, abundant on sandstone, 12 August 2014, *S.R. Clayden 24666 & K.E. Driscoll*. **York Co.:** Spednic Lake PNA, along Bolton Brook between Big Deadwater and Silas Cove, 45.66120°N, 67.51585°W, 120 m, bouldery brook and adjoining forest dominated by Yellow Birch, frequent on granitic boulders in brook, just above zone with *Dermatocarpon luridum* (With.) J.R. Laundon and *Ionaspis lacustris* (With.) Lutzoni, 18 August 2017, *S.R. Clayden 26829*; Fredericton, Odell Park, 45.95381°N, 66.66634°W, 75 m, mature hardwood forest dominated by Sugar Maple, beech, and Yellow Birch, with 1–3 m high sandstone outcrops, on rock, 27 October 2020, *S.R. Clayden 28403*.

Rinodina willeyi Sheard & Giralt (Figure 4l)

Reported for New Brunswick by Sheard (1995, 2010) as *R. willeyii*, based on collections made by Emmanuël Sérusiaux in 1988 in or near Fundy National Park, in Albert and Saint John Counties. The spelling of the epithet was modified by Sheard *et al.* (2012) to *willeyi* from the originally published *willeyii*. This species resembles *R. buckii* and *R. efflorescens* in having a sorediate thallus containing pannarin and zeorin. The soralia of *R. efflorescens* contain secalonic acid A (KC+ yellow orange), which is lacking in *R. buckii* and *R. willeyi*. *Rinodina buckii* is not yet known from New Brunswick or elsewhere in Canada, but it has been reported from neighbouring southeastern Maine (Sheard *et al.* 2012; Seaward *et al.* 2017). It has coarser soredia and more convex areoles than *R. willeyi*—see the key to species, above, and the detailed comparison and illustrations of these species in Sheard *et al.* (2012). *Rinodina buckii* and *R. willeyi* also differ in ascospore morphology but are usually sterile. Of 30 specimens of *R. willeyi* that we have examined from 19 localities in New Brunswick, seven have apothecia, with *Pachysporaria*-type spores measuring (17.5–)20.0–25.5(–28.0) × (9.0–)10.3–13.9(–17.0) µm (n = 37).

Our field and herbarium studies indicate that soredium development in *R. willeyi* is often more extensive than has been reported previously. Thalli with thin plane areoles forming soredia at their margins are found mainly on bark, but also on blackened senescent lobes of *Parmelia*. The thalli often spread from bark onto neighbouring bryophytes, especially the liverwort *Frullania eboracensis* Lehm. and small pleurocarpous mosses. They may then become largely sorediate, obscuring the originally corticate areoles (Figure 6b). In the field, such thalli often have a distinctive minutely grey-and-white speckled appearance.

When it was first described in 1995, *R. willeyi* was known globally from fewer than 10 localities in the southern Appalachians and northeastern coastal region of eastern North America, including the two in New Brunswick noted above (Sheard 1995). It is now known to occur more widely in the Appalachian and Great Lakes regions (Lendemer *et al.* 2014), northeastern Asia (Sheard *et al.* 2017), the Western Caucasus region of Russia (Urbanavichus *et al.* 2020), and Alaska (McCune *et al.* 2018). In New Brunswick, it is locally frequent throughout the province. However, it appears to be restricted to mature hardwood (Figure 2d) and mixed forests on relatively base-rich soils in mesic to wet sites. It occurs up to the elevational limit of hardwood forests dominated by Sugar Maple. Among the specimens we examined, 15 were on Sugar Maple, five each on Yellow Birch and Eastern White Cedar, two on Black Ash, and one each on White Ash, Eastern Hop-hornbeam, and Red Oak.

Rinodina willeyi is likewise an old-forest species in Nova Scotia, where it has been recorded on Red Maple, Sugar Maple, and Yellow Birch (McMullin *et al.* 2008, 2018).

Also known from **Colchester Co., Nova Scotia:** Economy River Wilderness Area, 45.522°N, 63.940°W, 230 m, N end and NE side of Simpson Lake, forest of Sugar Maple, Yellow Birch, and beech, on SW-facing slope above lake, on Sugar Maple, 17 May 2004, *S.R. Clayden 12624*). The only other published Canadian record of *R. willeyi* is a mapped occurrence in southern Ontario (Lendemer *et al.* 2014), based on collections made on Eastern White Cedar in an old-growth swamp forest (*J.C. Lendemer 28234, 28286 & R.E. Lee* [NY]; not seen by us).

Selected specimens examined—**Albert Co.:** Fundy National Park, East Branch Trail, 45.6369°N, 65.1176°W, 350 m, mature mixed forest dominated by Yellow Birch, Sugar Maple, and Red Spruce, corticolous and bryocolous on trunk of Sugar Maple, 15

October 2021, *S.R. Clayden 28621*. **Charlotte Co.:** Campobello Island, Roosevelt Campobello International Park, along Fox Hill Drive, ~2 km W of Liberty Point Drive, at base of Fox Hill, 44.8534°N, 66.9530°W, mature forest dominated by Yellow Birch, on bark and senescent thalli of *Parmelia* on trunk of Yellow Birch, 25 September 2016, *S.R. Clayden 26297*. **Gloucester Co.:** N side of Lambert Barren, ~7.5 km SW of Pokeshaw, S side of Pokeshaw River, 47.7238°N, 65.2994°W, 55 m, wet to mesic forest of cedar, Black Spruce, and Red Maple, overgrowing *Frullania* and lichens on upper side of leaning Eastern White Cedar, 7 October 2007, *S.R. Clayden 18161*. **Kings Co.:** McDermott Hill, ~5 km SE of Waterford, 45.65636°N, 65.31539°W, 330 m, old-growth hardwood forest dominated by Sugar Maple, Yellow Birch, and beech, on Sugar Maple, 3 May 2005, *S.R. Clayden 13368*; Big Bluff, Rockville, SE of Sussex Corner, 45.7001°N, 65.4412°W, 170 m, forest of Sugar Maple, hop-hornbeam, and Red Oak, at top of bluffs, corticolous on trunk of Eastern Hop-hornbeam, 28 June 2018, *S.R. Clayden 27242*; *ibid.*, on trunk of Red Oak, *S.R. Clayden 27243 p.p.* (with *R. subpariata*). **Madawaska Co.:** Jalbert Brook, between forest road and First Lake, 47.647°N, 68.300°W, 230 m, mature forest of fir, White Spruce, Black Ash, and Mountain Maple, on rich alluvial soil near stream, bryocolous and corticolous on Black Ash, 23 June 2010, *S.R. Clayden 20969*. **Northumberland Co.:** Mount Carleton Provincial Park, off the S side of the Big Brook Trail, ~6.3 km from Pine Point, 47.36°N, 66.84°W, mixed hardwood forest dominated by Sugar Maple and Yellow Birch, corticolous on Yellow Birch, 1 August 1989, *S.B. Selva 4156B* (det. S.R. Clayden) Nepisiguit PNA, E-facing slope in headwaters area of Pentland Brook, 47.43056°N, 66.62753°W, 510 m, mature moderately open hardwood forest dominated by Sugar Maple and Yellow Birch, with scattered fir and spruce, on trunk of Sugar Maple, 15 August 2016, *S.R. Clayden 25971*. **Saint John Co.:** City of Saint John, Lorneville, W of King William Road, 45.1895°N, 66.1860°W, 60 m, moderately open stand of Yellow Birch and Heart-leaved Birch on S-facing slope, with scattered fir, on bark and overgrowing *Frullania* on trunk of Yellow Birch, 9 December 2020, *S.R. Clayden 28427*. **Westmorland Co.:** ~600 m N of intersection of Lower Walker Road and King Street, NW of Sackville, 45.9381°N, 64.4635°W, 155 m, mature hardwood forest dominated by Sugar Maple and Yellow Birch, on trunk of Sugar Maple, 7 November 2019, *S.R. Clayden 28144*. **York Co.:** Spednic Lake PNA, near South Branch Mosquito Brook, ~1.5 km W of Musquash Lake, 45.69094°N, 67.67171°W, 140 m, mesic to wet coniferous forest dominated by cedar and fir, with scattered hemlock, on top of trunk of tipped-up Eastern White Cedar, 14 August 2017, *S.R. Clayden 26752*.

Discussion

Comparisons of the diversity and relative abundance of *Rinodina* species in New Brunswick and other areas of northeastern North America are limited by the unevenness of survey efforts and reporting. For example, only six species have been reported for Nova Scotia (McMullin *et al.* 2008, 2018; Sheard 2010), a number that is bound to grow with further study. The presence of 15 species in New Brunswick is consistent with the species richness recorded in several states of the northeastern USA: 13 species in Maine (Sheard 2010; Sheard *et al.* 2012), 18 in Massachusetts (Sheard 2010, 2018), and 17 in New York (Sheard 2010). Fifteen *Rinodina* species are known in the 7850 km^2 Ottawa region of southern Ontario and Quebec, where the lichen biota has been intensively explored over many years (Brodo *et al.* 2021a,b). Only two of the species reported here for New Brunswick, *R. cinereovirens* and *R. septentrionalis*, have not been found in any of the northeastern states or in the Ottawa region. Both of these species have boreal distributions.

In a broader context, the set of *Rinodina* species occurring in New Brunswick illustrates long-known similarities between the temperate biotas of eastern North America and eastern Asia. The biogeographic relationships of these two regions have been examined most intensively in their vascular plant floras (Wen 1999), but patterns of disjunction are also present in other major taxonomic groups, including lichens (e.g., Lendemer *et al.* 2014; Sheard *et al.* 2017). Thirteen of the 15 species of *Rinodina* found in New Brunswick, including the widely disjunct *R. asc-ociscana*, *R. subminuta*, *R. tenuis*, and *R. willeyi*, also occur in northeastern Asia (Sheard *et al.* 2017). In contrast, New Brunswick shares only three *Rinodina* species with the British Isles (Cannon *et al.* 2022), eight with Fennoscandia (Mayrhofer and Moberg 2002), and eight with British Columbia and Alaska (Sheard 2010, 2018). No *Rinodina* species with distinctly oceanic distributions are known in eastern North America, although several (e.g., *Rinodina disjuncta* Sheard & Tønsberg, *Rinodina stictica* Sheard & Tønsberg) occur in the more highly oceanic climates of western North America and western Europe (Sheard 2000; Mayrhofer and Moberg 2002).

Abundant fossil and molecular evidence indicate that disjunct eastern North American–eastern Asian distributions in vascular plants have had multiple origins from the Paleocene to the Pleistocene (Wen *et al.* 2010). A scenario of southward displacement and disruption of formerly more continuous higher-latitude

ranges by long-term cooling, mountain building, and changes in precipitation regimes is broadly supported by this evidence. However, long-distance dispersal may also underlie some species-level disjunctions and contribute to ongoing gene flow among widely separated populations occupying climatically similar niches (e.g., Xiang *et al.* 2015).

Among lichens, only a few studies have so far brought molecular evidence to bear on the origin and timing of eastern North American–eastern Asian disjunctions (Spribille 2011; Hoffman 2022). Resl *et al.* (2016) found that ITS sequences of specimens of *R. subpariata* from these two regions are more similar to one another than to sequences from western North American and western European specimens. However, the apparent lack of geographic structure in the eastern North American–eastern Asian clade was inferred by Sheard *et al.* (2017) to be suggestive of active gene flow via long-distance dispersal. Sampling of a wider range of localities, individuals, and DNA loci are needed to test this hypothesis.

Among the disjunct Asian(–Caucasian)–American *Rinodina* species represented in New Brunswick, *R. tenuis* may be an especially interesting candidate for phylogeographic analysis. Its American and Asian populations appear to have somewhat differentiated ascospore sizes, and the strong association of northern North American occurrences with Eastern White Cedar invites closer study. As recently as two million years ago, the range of this fossil tree species (*Thuja occidentalis*, the same as the modern species) extended to northernmost Greenland (Bennike and Böcher 1990), where it formed part of an open boreal-forest-like community (Kjaer *et al.* 2022). Although this community lacks any modern analogue, it seems likely that suitable contemporary niches for *R. tenuis* on Eastern White Cedar existed far north of its present range. The genus *Thuja* itself is disjunct between eastern Asia and eastern and western North America, with no fossil or other record of it having occurred in Europe at any time from the Paleocene to the present (Cui *et al.* 2015; Li *et al.* 2022). The three species of *Thuja* occurring in eastern Asia have extremely restricted distributions (Li *et al.* 2022), and none has been reported as a phorophyte of any *Rinodina* species (Sheard *et al.* 2017). However, in contrast to the relatively narrow phorophyte specificity of *R. tenuis* in North America, in the Russian Far East and Japan it occurs on a wide range of trees, including species of *Abies*, *Alnus*, *Betula*, *Picea*, *Prunus* L., *Quercus*, *Salix*, *Sorbus*, and *Ulmus* (Sheard *et al.* 2017; Galanina and Ezhkin 2019; Galanina *et al.* 2021a; note the east Asian species in these genera are all different from those occurring in Canada).

Although our study was not designed to critically assess the phorophyte specificity of *Rinodina* species in New Brunswick, the pooled collections data highlight a number of associations, besides that of *R. tenuis* with Eastern White Cedar (Figure 3). Our findings are largely in agreement with other reports on the phorophytes of these species in North America (e.g., Gowan and Brodo 1988; Wong and Brodo 1992; Sheard 2010; Lendemer *et al.* 2014; Harris 2015), but we provide new or more extensive region-specific data on species that were either unknown or poorly documented previously in New Brunswick and the Maritime provinces. For example, the three sorediate species, *R. efflorescens*, *R. subpariata*, and *R. willeyi*, appear to be distributed among broadly overlapping but differentiated sets of tree species, possibly reflecting in part a gradient of bark acidity. Conversely, the two most common maple species in the province, Red Maple and Sugar Maple, are shown to have more distinct complements of *Rinodina* species than documented in earlier studies. The association of *R. pachysperma* with Silver Maple and other hardwoods in floodplain forests, and its absence or rarity in mesic upland stands, appears to be a novel finding. On the other hand, the general rarity of *Rinodina* on pinaceous conifers and other strongly acidic, nutrient-poor substrata is characteristic of the genus as represented in New Brunswick. Its association with relatively base-rich habitats is not limited to the corticolous species. The three saxicolous *Rinodina* species known in the province occur on siliceous rocks, but their habitats are enriched to varying degrees by periodic immersion, wave splash, seepage, or guano deposition.

Despite these generalizations, we are aware of the limitations of our local observations. It is well known that the substratum specificity of corticolous lichens varies along climate and vegetation gradients (e.g., Hale 1955; Brodo 1973; Schmitt and Slack 1990; Ellis 2012). It was beyond the scope of our study to investigate the complex interacting factors contributing to variation in the diversity and abundance of *Rinodina* species on different phorophytes. Instead, we present basic descriptions of the ecological and geographical distributions of these and the saxicolous *Rinodina* species with the aim of encouraging further exploration and more specialized studies.

Author Contributions

Conceptualization: S.R.C. and K.E.D.; Investigation: S.R.C., K.E.D., and H.H.; Writing – Original Draft: S.R.C.; Writing – Review & Editing: S.R.C. and K.E.D.; Funding Acquisition: S.R.C.

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