OMPHALINA

FORAY NEWFOUNDLAND AND LABRADOR

Newsletter

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Foray Newfoundland and Labrador

is an amateur, volunteer-run, community, not-for-profit organization with a mission to organize enjoyable and informative amateur mushroom forays in Newfoundland and Labrador and disseminate the knowledge gained.

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CONTENT

Cover: *Melanohalea septentrionalis*, northern brown shield lichen, one member of the diverse community of lichens growing on a European larch in contributor Jim Cornish's backyard. Gorgeous, isn't it? Let this be the photo that convinces you to finally get that macro lens you've had your eye on. Then please drop us a note and share a few shots of your own backyard lichen community! Photo: Jim Cornish.

Message from the Editor

Hello again, friend of fungi!

To make up for lost time and missing issues, we've delivered a whopper of a double issue to you. Now, to protect you from the inevitable fatigue of reading this cover to cover, I recommend you approach it strategically—maybe take an intermission halfway through, or start at the end and work your way forward.

Love lichens? Start this issue with Felicity's introduction to some of their wonders on page 32, then take a deeper dive into Jim's backyard lichens in the following article. Want to meet some of our newest species of mushrooms? then starting at the front of this issue is the place for you! Stomach growling? Skip forward to page 57 , where Keerthi's got a delicious cure for what pains you.

Let's not keep you from it any longer. As always, Happy Hunting everyone!

Sara

ERRATUM

The photo of *Cortinarius violaceus* by Ian Gardiner in the last issue (Omphalina 12:107, Fig. 1A) was correctly attributed to Ian Gardiner in the caption, but unfortunately attributed to Jim Gardiner in the Acknowledgements. Both author and editor regret the error and thank Ian for his understanding. All parties involved may be pleased to know that the proof-reader and proofreading supervisor were dismissed with cause and without benefits.

Message from the President

Hello Foray NL members and friends,

Welcome to the first issue for 2022. You probably know that OMPHALINA is published by Foray NL, a wonderful little organization run entirely by volunteers. Our mandate is to organize one residential mushroom Foray somewhere in Newfoundland and Labrador each year, but we do more than that—in fact we haven't actually done that for almost three years. Before the pandemic and our additions of online activities, our membership used to be only those who have attended one of our forays, but we now have more members than ever. So I'd like to extend an extra welcome to those of you receiving your first OMPHALINA.

At our last AGM, we had some big changes in our Board. I'd like to sincerely thank our Directors who stepped down: Geoff Thurlow for his long and organized career as Foray NL's Treasurer; Shawn Dawson and Bill Bryden, who will continue to lend their mushroom expertise to our Forays; and Verle Harrop who deserves many thanks for guiding us through our series of online learning events in 2020 and spearheading the ongoing NL Hydnum project. We will miss each of them and the talents they brought to the Board. Happily, Kathleen Parewick, Glynn Bishop, Felicity Roberts, Hayley Paquette, Johanna Bosch and Nils Van Miltenburg have joined the Foray NL Board. We look forward to working as a team.

Other 'people news' is that Greg Thorn of Western University is joining Dave Malloch as an official mycological consultant for Foray NL. Greg has been Faculty on many of our Forays. He is a wonderful teacher and mentor and we are grateful for his contributions.

Here are our plans and hopes for 2022:

- We hope to hold a foray in Central Newfoundland in September. Foray NL members can take advantage of early registration, so keep up your membership if you hope to join us—we can only host 60 people. Membership forms are on our website: www.nlmushrooms.ca

- Online lecture opportunites continue for members. We are delighted to be part of a consortium of North American mycological clubs who share access to online mycological presentations. If you aren't a member, then these talks alone are worth the $20 membership, which also helps us pay our share of the speakers' honoraria.

- New and exciting: Glynn Bishop is offering monthly workshops online on painting mushrooms and lichens for identification. If you've ever attended one of our Forays, you'll know that Glynn's watercolour workshop is always relaxing and rewarding. Members receive the link to the workshops by email.

- Our citizen science aided research projects on lichen grazing and Hydnums of Newfoundland and Labrador continue—on the iNaturalist app, search for "Foray NL - All projects"

- We make no promises but will bring you OMPHALINA as time and energy permit. A million thanks to all the contributors and our editor who make this journal happen.

All the best for a happy and healthy mushroom year.

Helen Spencer

One birch, three boletes

Andrus Voitk

Way back in my naïve youth I described the year 2015 as the "edulis year", and showed a picture of *Boletus edulis** under birch, speculating about the validity of the species *B. betulicola*.[1]

Well, 2015 could not hold a candle to 2020. These days, declining health keeps our outings close to home, but even our limited sorties to nearby woods have revealed *B. edulis* in places never seen before. It seems to be an Island-wide phenomenon, because this year I got e-mails with photos of bags, baskets, buckets and banks (as in riverbanks, Figure 1E) overflowing with majestic *B. edulis* from the Avalon, central and western NL—even the Corner Brook Stream trail. And who can forget Shawn Dawson's presentation at our virtual learning series, with its dramatic display of gorgeous edibles, including mountains of *B. edulis*, followed a week later by Bill Bryden's video of a random walk in the woods, where he stubbed his toe on a patch of *B. edulis*?

The first ones I found this year (2020) were, as so often, pointed out to me by my wife Maria. On a trail in a primarily coniferous mixed forest that we had walked for twenty-one seasons without ever encountering a mushroom of scientific or culinary interest, this time we saw small groups of young boletes around the bases of birch trees right beside the trail. A closer look revealed that they were *Hemileccinum subglabripes*, a known birch associate. There were enough along the pathside to make collecting this tasty edible worthwhile. After a while, Maria said to me that one of them looked like *B. edulis*. I had not paid close attention, and had not expected *B. edulis* under birch, but indeed she was right, and on closer inspection, so were about half of the others we had picked! We returned a month later: *Hemileccinum subglabripes* had finished, and those *B. edulis* that we had left behind at our last visit were the size of dinner plates, but a new crop had appeared. Again, all boletes were under pathside birch in this primarily coniferous forest. While *Hemileccinum subglabripes* is a known birch associate, *B. edulis* is usually considered to be a conifer associate, so this was interesting. Ours was not an isolated observation, because some photos sent to me

*Although several *edulis*-like species have been described, here I use the name in its broad sense to include all, until we know more.

Figure 1. *Boletus edulis*. Mushrooms in primarily coniferous forests around birch, usually beside a path at the forest edge. Note the colour variation. **A**. Near Pasadena, at forest edge beside path. Photo: Henry Mann. **B–C.** Secret locations near Deer Lake, and central NL, respectively. Again, around birch, but these were found a bit into the forest from the trail. Photo: anonymous. **D.** Different location near Deer Lake. Under birch (not shown on photo). Photo: anonymous. **E.** How often do you pick mushrooms from your canoe from vertical riverbanks? Told you they appear in unusual places this year. Francine Lemire in the canoe (common habitat for her), *Boletus edulis* on the bank (unusual habitat for it). There are fallen birch leaves on the ground, and some small shrubby birch on the bank, as well as lots of alders. Imagine this organism quietly residing underground in that embankment, exchanging victuals with birch roots, for years, unbeknownst to us all. Then, suddenly anno Domino 2020, it takes into its head to fruit, and pushes mushrooms out from the perpendicular side of the embankment, where they turn gently upward, so that the cap can be parallel to the earth's surface and the tubes point straight down, allowing spores to float gently into the wafting breeze. Or maybe rivers are their main vectors and these mushrooms have the right idea?[5] Only canoeists and kayakers can see them. Wow! Photo: Jamie Graham.

from elsewhere in the province also clearly showed the boletes in coniferous woods, but under birch (Figure 1). This reminded me of the 2015 *B. edulis* under a big birch on the lawn of a neighbour.[1] We decided to look there again (title banner). Yes, the mushrooms were there (Figure 2). In fact, three bolete species: *B. edulis* (Figure 2A), *Hemileccinum subglabripes* (Figure 2B), and *Harrya chromapes* (the last genus named for the American mycologist Harry Thiers; Figure 2C).

All three are good edibles, especially in their youth. I am not aware of a look-alike to *Harrya chromapes*. The main look-alike in the province to *Hemileccinum subglabripes* is *Hemileccinum hortonii*, an oak associate on the mainland, but very rare here, as we have no oak. I found it only once, under birch on the Green Gardens trail in Gros Morne National Park (Figure 3A). It differs from *Hemileccinum subglabripes* by its wrinkled cap, and is equally edible, so a mistake here lets the mycophagist off unpunished. Another species, which might be mistaken for *Hemileccinum subglabripes* because of its yellow pores, flesh, and blue staining, is *Butyriboletus brunneus*, (formerly *Boletus speciosus* var. *brunneus*). I am aware of only two collections in the province: Michael Burzynski collected it from a mixed forest on Fogo Island in 2012, and Henry Mann collected it from an imported birch plantation in the Bottom Brook Arboretum this year (Figure 3D), so it is also not common. It should not be confused with the three boletes under discussion, because of its red stem base and different blueing reaction, but even if it does, it is a very good edible, so again the gods are protecting the careless mycophgagist.

However, read on to see that the above is not encouragement to be lax about identification, if you plan to eat these mushrooms, because the same gods can be very unforgiving.

Figure 2. Three species of boletes under the birch in the title banner. They may look similar at first glance, but most differences can be seen on these photos. **A.** *Boletus edulis*. Poremouths start white, become yellow, then olive, eventually olive-brown; do not stain blue on injury. Stem darker at the top, white at the bottom, with white reticulum. **B.** *Hemileccinum subglabripes*, somewhat worse for wear. Variable yellow outside and in. Yellow scales of stem become reddish brown with time, and eventually disappear leaving an almost entirely brownish stem, with a short yellow zone at the top. **C.** *Harrya chromapes*, also a bit past its best before date. Pinkish cap, white to brownish poremouths, stem covered with small pink scales going to a chrome yellow bottom.

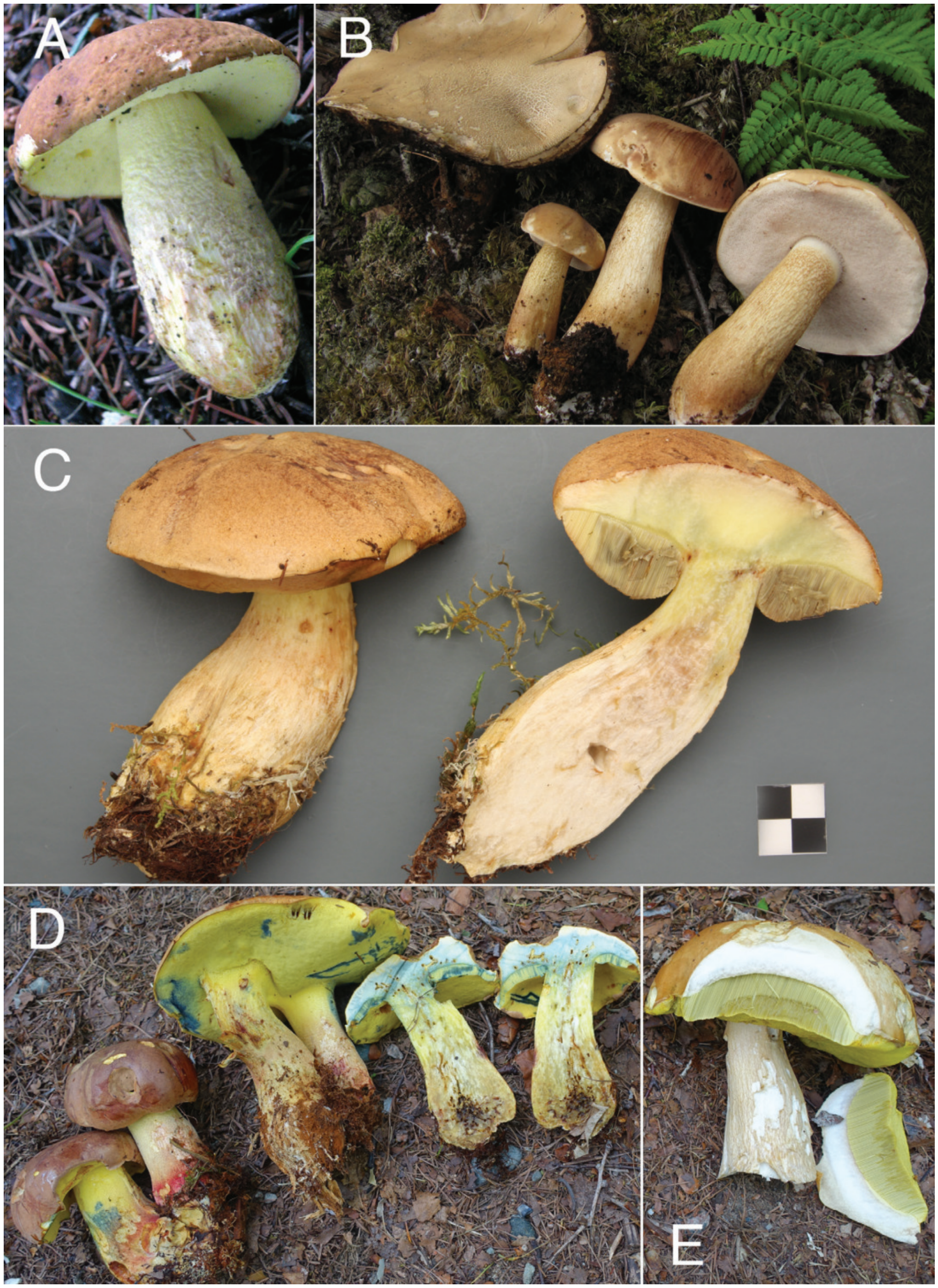

Figure 3. Look-alikes to the three species. **A.** *Hemileccinum hortonii*. Named after Charles Horton Peck, who first described the species as Boletus subglabripes var. corrugis. Other than the wrinkled-pitted cap, it is like Hemileccinum subglabripes, and tastes as good. Rare here, because it prefers oak to birch and we have no oak. The interesting observation is that *B. edulis* also has populations with smooth caps and others with wrinkled caps, increasing the odds that the latter may be confirmed as separate species. **B.** *Tylopilus felleus*. Grow on wood, usually conifer, which may be buried in the soil or covered with moss. Poremouths white, turning pink, then greyish, never yellow. Reticulum on stem brown, but may have short and sharply demarcated light area immediately under the cap. Photo: Maria Voitk. **C.** *Boletus huronensis*. Large mushroom, resembling meaty *B. edulis*. Conifer associate. Lacks reticulum, or it is very underdeveloped, tan. Usually flesh has at least some light yellow areas, often in the cap, but may be bright yellow throughout. Usually shows weak bluish discoloration on cut surface, but it must be looked for with care at the time, because at times it is very fleeting. Photo: Roger Smith. **D.** *Butyriboletus brunneus*, found growing with a Japanese birch, *Betula ermanii*. Bright yellow predominates, with yellow tubes, poremouth and flesh. Other distinguishing characters are the brown cap, an immediate and deep blueing reaction on the poremouths and stem, and a much slower blueing discoloration on the cut flesh, very small and low yellow-white reticulum at the top of the stem, and a red bottom of the stem. Should not be confused with the other species discussed. **E.** *Boletus edulis*, collected from the same plantation of *Betula ermanii*, at the same time. D and E are part of the same photograph therefore size and colour of the two specimens are comparable. Although *B. edulis* also has yellow pores in youth, the two are quite distinct from each other. Photo: Maria Voitk.

In our province two look-alike species to *B. edulis* are *Tylopilus felleus* (Figure 3B) and *B. huronensis* (Figure 3C). The former is relatively common, grows on wood, has pink spores (which turn the poremouths pink with time), has a dark brown reticulum, and is given away by its bitter taste. It is not toxic, so that tasting is safe, and the only damage it does is to make the meal intolerably bitter, should you add it to your dinner by mistake. *Boletus huronensis*, on the other hand, has caused several poisonings around Goose Bay, Labrador, including a memorable experience reported by this mycophagist.[2] It has also been identified in central Newfoundland, but is otherwise an uncommonly encountered conifer associate, a bit bigger than *B. edulis*. Stem adornment has been a good way to key out bolete genera, and indeed does provide a useful first step to separating these species from each other (Figure 4). In addition to the reduced or no reticulum on the stem, the flesh of *B. huronensis* is yellow, at least in places, varying from areas of partial light yellow to entirely bright yellow, and usually stains light blue on injury, at least transiently. It causes prolongued major gastrointestinal upset with fluid loss sufficient to threaten cardiovascular stability in persons at risk.

Apart from the pleasure of meeting three bolete species under one birch, the prime interest is the clear association of this member of the *B. edulis* complex with birch. European investigators (including FNL past faculty Tuula Niskanen and Kare Liimatainen) have supported the concept of *B. betulicola* as the species of the *B. edulis* complex growing with birch, on the basis of host association and microscopic differences, although so far phylogenetic differences between these two taxa have not been demonstrated.[3] Many species of the *B. edulis* complex have been described from North America. Table 1 shows some of these, described from eastern North America. Association with deciduous trees is not unusual in this group: two were described to grow with deciduous trees, one in mixed forests and for two the tree partner was not mentioned. The protologues (original descriptions) also list other character differences of these species: they differ in cap colour (yellow, ochre, brown, vinaceous red) and cap texture (smooth, woolly, cracked, scaly, pitted and wrinkled).

With so many appearing this year, we had a chance to see most of these characters (Figure 5). Although it is tempting to consider differences as different expressions

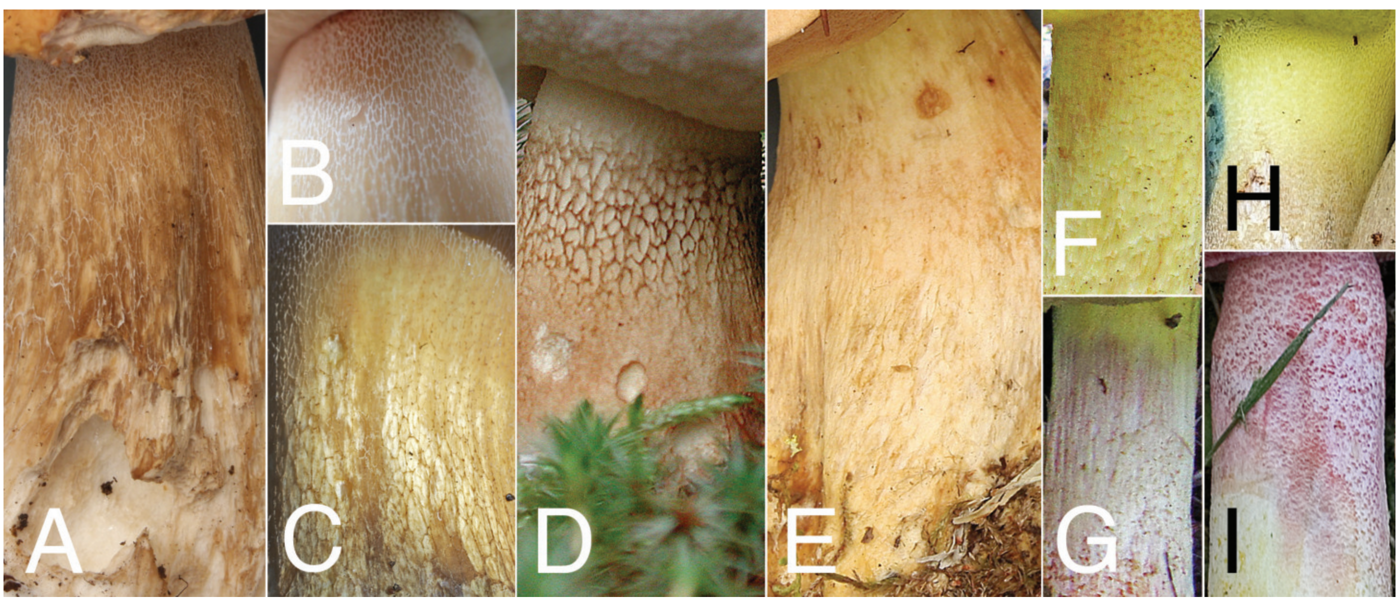

Figure 4. Stem ornamentation of the described species. **A–C**. *Boletus edulis.* **A.** White reticulation beginning at the cap-stem junction, obvious on a dark background. Photo: Roger Smith. **B.** Same less obvious on a light background. Photo: Henry Mann. **C.** With age the reticulation spreads downwards, where it widens out and may darken. **D.** Reticulum of *B. felleus* is always dark, usually with a very narrow and sharply demarcated light band immediately under the tubes. **E.** No obvious reticulation on *B. huronensis*, but on occasion minimal light brown reticulum has been described. Photo: Roger Smith. **F, G.** *Hemileccinum subglabripes.* **F.** Obvious to very fine yellow scales with yellow to reddish brown tips are evident in youth, over a yellow background. Photo: Maria Voitk. **G.** These darken with age and may disappear, leaving a smooth yellow background, which becomes streaked with longitudinal red fibers. Photo: Maria Voitk. **H.** *Butyriboletus brunneus.* Very small and low yellow to white reticulum almost always visible (loupe) at the top of the stem, enlarging slightly and disappearing toward the bottom. Photo: Maria Voitk. **I.** *Harrya chromapes.* Red scales to chevrons, widening out toward the bottom of the stem, exposing the chrome yellow lower tip.

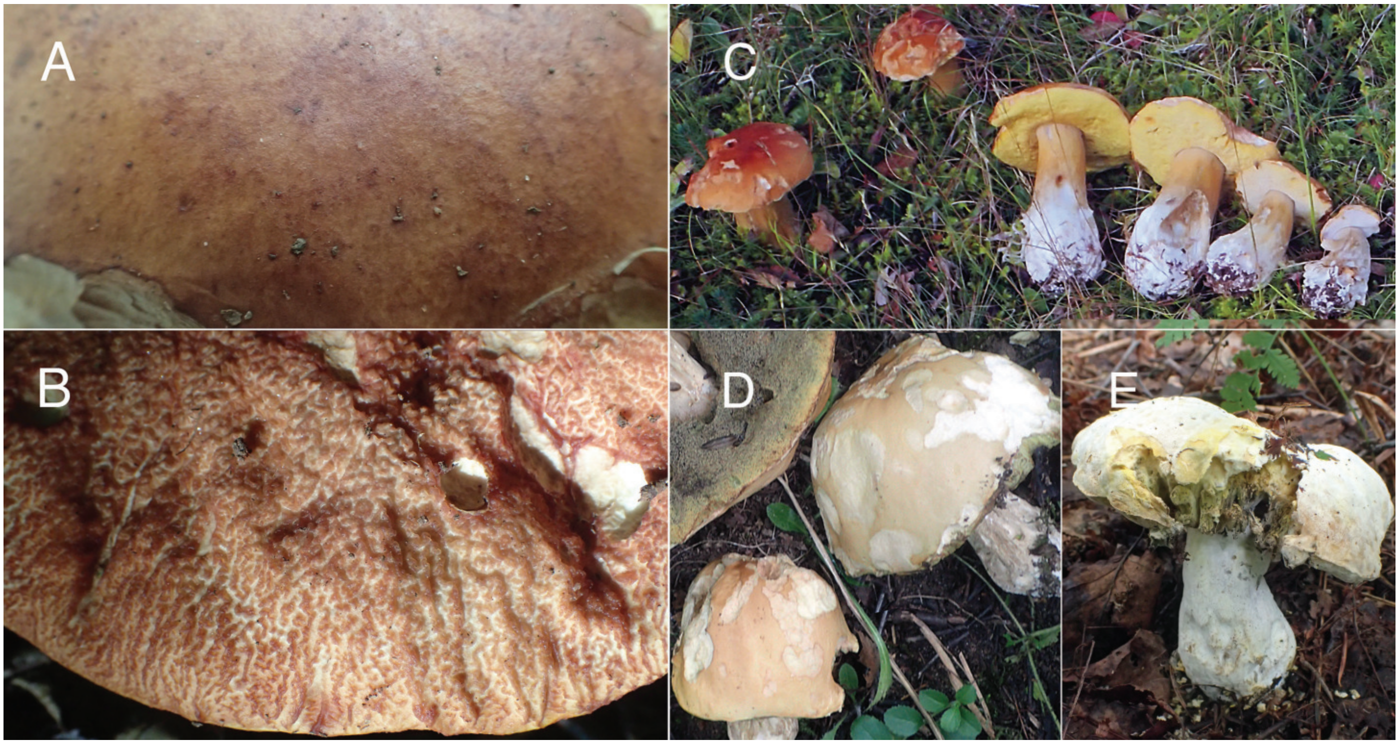

Figure 5. Range of cap colour and texture. **A.** Smooth cap, evenly brown. **B.** Pitted to wrinkled cap. Seems to be limited to discrete population, not mixed among populations with smooth caps. **C.** Reddish brown cap, darker in centre. See also Figure 1A. **D.** Pale ochre cap, again seemingly restricted within its population, not as a colour spectrum in several brown or red populations. **E.** Infection with presumed *Hypomyces chrysospermus*. Interestingly this infection only seen in populations (three) with ochre caps.

along a continuum for a single species, some of these differences seemed to be contained within separate populations (defined here as likely different individual organism, based on separation from others by both physical distance and around different tree), making it possible that they represent different species. For example, a population had either smooth caps or wrinkled (Figure 5A & B), but I did not see a mixture of both within a single population. Similarly, a population had either yellowish ochre caps (Figure 5D), or caps of other colours(Figure 5A, B, C), but no population seemed to have a mixture of yellow and brown or red caps. Also, I found what I presume to be *Hypomyces chrysospermum* (Figure 5E) infection in three separate populations: all were the yellowish ochre capped specimens. Admittedly the sample sizes are small in each case, but if these observations are representative, they suggest the possibility of more than one species in this complex.

An examination of this complex in eastern North America is overdue. Sequencing enthusiasts are reputed to maintain that once you identify a clade that enjoys statistical support, it reflects a true natural grouping, not a rumour. However, without typification, names applied to these clades are no better than idle tittle-tattle. Types need to be sequenced or new sequenced types declared for both North American and Eurasian species. Only then can we begin to apply names in a meaningful way. An excellent start was made by Dentinger and collaborators, sequencing several North American and other types,[4] and I hear that Dentinger is in the process of additional type studies and retypification, where type tissue is not available or does not yield amplifiable DNA, so that many of the old names can be placed in the context of current ranking. I hope to read which old species remain "good" and which need to be synonymized with older description. Keaton Tremble, from the depths of Dentinger's laboratories, is also involved with whole-genome sequencing of this complex, where we were pleased to contribute specimens, so we should expect to learn much more about this wonderful species in a year or two.

A macroscopic description (I have not examined them microscopically) with additional photos of the three species found under the one birch follows.

Boletus edulis

Macroscopic. Large, robust bolete, cap up to 25+ cm diameter, about equal to stem height. Mushrooms on upper photo associated with white spruce, and on lower photo with birch. **Cap** convex, broadening to near-flat, smooth, lubricious when wet, yellow-tan to reddish brown, darker in centre, mature diameter at or above 10 cm. Some populations with granular-cracked or pitted-wrinkled caps. Colour relatively evenly distributed in some populations, and darker toward the centre in others. Occasional populations with a lighter yellowish cap that does not seem to darken much with age. **Poremouths** in all these species of the complex begin "stuffed", that is covered with a sheet of white material. This slowly opens up to expose the pores, whose surface is white at first, then yellow, turning olive to olive-brown in age, and does not stain blue with injury. **Stem** firm, often enlarged to bulbous toward bottom, up to 7+ cm diameter in old large specimens, cream to tan or reddish brown, with prominent white reticulation. **Flesh** white, does not stain blue with injury, but all tissues may develop brownish stains in old injured areas. Pungent "edulis odour", concentrated on drying.

Habitat sandy soil in mixed woods, associated with both conifers (primarily white spruce) and birch. No macroscopic differences noted between populations growing with either host. **Distribution** throughout boreal NL.

Hemileccinum subglabripes

Macroscopic. Medium-sized early-season birch associate, with yellow poremouths, stems and flesh. Upper photo: Henry Mann, lower left: Maria Voitk.

Cap convex, broadening to near-flat, smooth, tacky to slimy when wet, yellow-tan to reddish brown, mature diameter seldom above 10 cm. **Poremouths** bright yellow at first, then lighter, turning olive in age, do not stain blue with injury. **Stem** firm, cylindrical, up to 10–12 mm diameter in mature specimens, light to bright yellow, covered with prominent yellow scales, which disappear toward the bottom, exposing yellow surface. With age scales vanish and stem becomes longitudinally streaked reddish to reddish brown. **Flesh** very pale to bright yellow, stains weakly blue with injury, at least fugaciously. Odour unremarkable.

Habitat birch associate, often in mixed woods. **Distribution** throughout boreal NL.

Description Sheet

Harrya chromapes

Macroscopic. Medium-sized bolete of mixed woods, with a pink cap and chrome yellow bottom of the stem.

Cap convex, broadening to near-flat, smooth, covered with thin whitish powder, pink to reddish under the powder, ages brownish, mature diameter at or above 6 cm. **Poremouths** white at first, then pinkish, turning brownish in age; do not stain blue with injury. **Stem** firm, cylindrical or slightly narrowed at both ends, seldom more than 12 mm in diameter, white but covered with red-pink scales of variable density, that thin out to reveal the chrome yellow lower part. **Flesh** white, does not stain blue with injury. Odour unremarkable.

Habitat in mixed woods, seemingly associated with both conifers and birch. **Distribution** throughout boreal NL.

Acknowledgments

I gratefully acknowledge the help of Keaton Tremble in reviewing the story, and the contribution of photographs by Jamie Graham, Henry Mann, Roger Smith, Maria Voitk, and two contributors who preferred to remain anonymous. Above all, I owe much to the collaboration, support and companionship of Maria in these adventures.

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Edulis epilogue

The discussion of *Boletus edulis*, so bounteous that year, told you that for over 100 years there have been all kinds species in the *B. edulis* group described in eastern North America with various combinations of yellow caps, from bright to ochre, with or without variable amounts of red or reddish brown, smooth, woolly, cracked, scaly, pitted and wrinkled, with stems ranging in colour from white to dark brown, decorated with reticulations from small and sparse to prominent and covering the entire stem, and growing with conifers or deciduous trees, the latter both Fagaceae and Betulaceae. You will have noticed that in recent years for *B. edulis* we found some populations that fit some of these early descriptions. For the most part, our finds have fit some particular description reasonably well.

Going over our recent photos, I found one of an intriguing specimen from coniferous woods not far from our house (**A**, photo: Maria Voitk). The mushroom had many of the characters mentioned in some of the early descriptions, but no description had them in the combination seen on this photo. By this time, well at the end of the *edulis* season, we had seen most of the characters, and no longer paid that close attention to this single young specimen. Maria took a hurried snap of it, after which it was tossed it into the food basket without another thought. You may ask, "Well, didn't you see the yellow wrinkled cap with red ridges?" Indeed, we did, but a) we had seen caps, both yellowish and reddish, and smooth and wrinkled, and b) to our casual glance the wrinkles were passed off as slug damage.

Now, that I have read more about them and see the photo in peaceful contemplation, I realize that it is the only specimen we have of those characters in that combination—well worthy of further investigation, and totally different from the standard issue *B. edulis* in our area (**B**, photo: Henry Mann). We have reliably narrowed down the place it was found to about 50 m along a trail, and you can believe that we have scoured that area repeatedly, but naturally, no more were be found in that location. The one we had, we ate.

It happens.

– Andrus Voitk

Cuphophyllus bondii

another new species of *Cuphophyllus* for Newfoundland

Renée Lebeuf and Irja Saar

It is amazing how the discovery of one small mushroom fruitbody, all alone in the grass, can lead to the description of a new fungal species. That's what happened in 2018 during the Faculty Foray of Foray NL in Sir Robert Bond Park on the central Avalon Peninsula of Newfoundland. Looking for small, overlooked fungi in the grass, one of us (Renée) happened to find a small mushroom with a brownish-pink cap and a pale-yellow stem base reminiscent of the genus *Cuphophyllus*, but a species that she did not recognize. Having a long-time interest in waxcaps, Renée knew this was an interesting basidiome and tried to find morefruiting bodies, but there was none to be found. She showed it to Andrus Voitk, who was nearby and who, like her, recognized it as something unknown to him but interesting. Even though it was a singleton, it was brought back and went through the usual process of photographing and drying.

Renée had often heard from well-recognized mycologists that it was not worth collecting a single basidiome because it does not give a good indication of the species variation. But now, with modern tools for genetic analysis, this is no longer true; it is possible for a single specimen to provide valuable information.

At the time, Andrus, leading a team of international mycologists, was working at untangling the grey and brown species of the genus *Cuphophyllus* in NL. Renée's discovery fit perfectly into their project, but material was insufficient to describe a new species. Nevertheless, Andrus sent it for sequencing to Irja, a long-time collaborator, and it proved to be an undescribed species of *Cuphophyllus*. Even though Renée's find was not included in the paper Andrus and his team published on the genus *Cuphophyllus* in North America,[1] a preliminary description of what was referred to as "Bond's mushroom" was provided in the follow-up paper they published in *Omphalina*[2] to introduce to NL mushroom community the novelties in the genus *Cuphophyllus*.

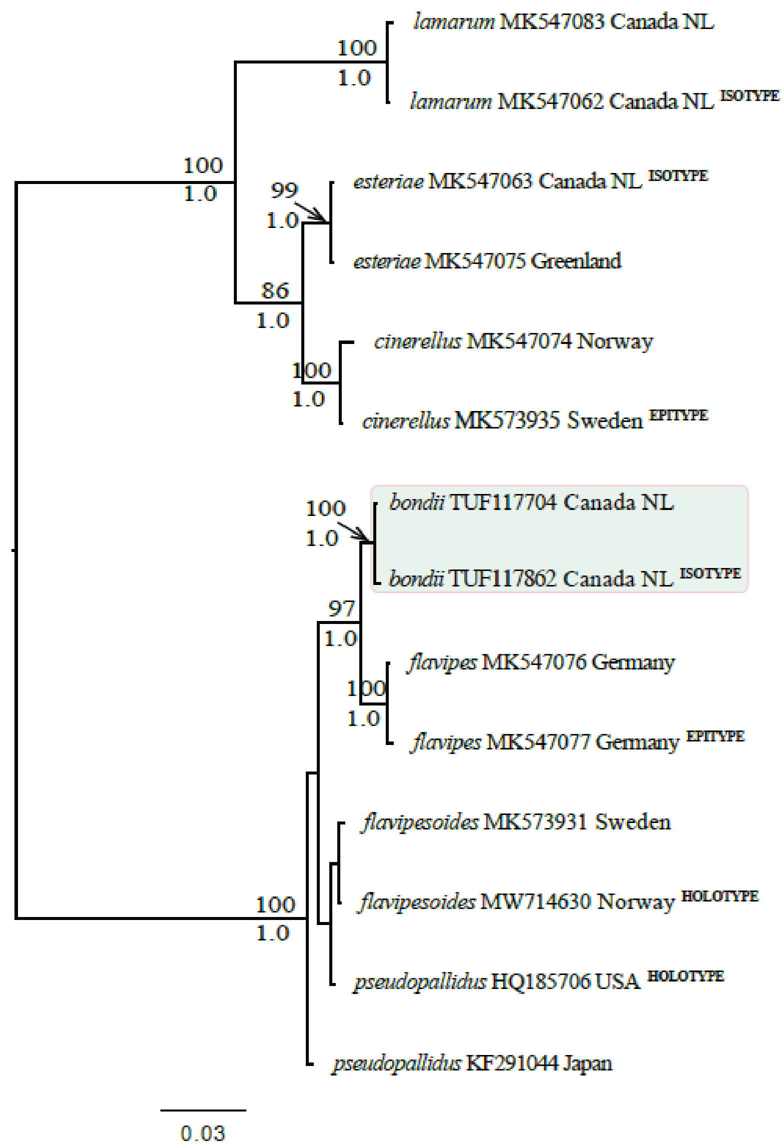

Figure 1. Phylogenetic tree produced for the description of *C. bondii*. *C. bondii* is in the green box. It groups with three other species of *Cuphophyllus* with yellow stem base (*C. flavipes, C. flavipesoides, C. pseudopallidus*). *C. lamarum* and *C. esteriae* are the two new species of *Cuphophyllus* that were described by Voitk et al. in 2020[1].

In the fall of 2020, we received the exciting news from Andrus that a good number of Bond's mushrooms in perfect shape had been found again at Sir Robert Bond Park by Don Spencer and Helen Spencer, Foray NL President, thanks to the preliminary report published in *Omphalina*. With that new collection and the many pictures Helen had taken (Figure 2), we finally had enough material to publish the new species. Part of the fruitbodies were sent to Irja for sequencing, which confirmed that the collection was identical to the 2018 collection, and Renée got the rest of the collection for microscopic study. We quickly completed microscopic study, constructed a phylogenetic tree, drafted the description, and, in the spring of 2021, we submitted our paper to Fungal Planet for publication. The paper is now published[3] (*see* description sheet # 1345), and we can introduce another new species of *Cuphophyllus* for NL: *Cuphophyllus bondii*, in honour of Sir Robert Bond.

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Figure 2. *Cuphophyllus bondii* (holotype) in situ. Photo Helen Spencer.

Cuphophyllus bondii Lebeuf & I. Saar

Macroscopic. Cap 12–35 mm, convex then applanate to slightly depressed at the disk with a low umbo, smooth, lubricous, brownish pink, with the margin incurved then straight, completely upturned with age.

Gills decurrent, arcuate at first, distant, increasingly intervenose with age, whitish to very pale orange. Stem 36–64 × 3.5–10 mm, equal, straight or curved, smooth, dry, with age fibrillose-striate and developing small scales in the upper third, whitish or concolourous with the lamellae in the upper half, with increasing yellow tones towards the base. Odour and taste not recorded. Spore print white.

Microscopic. Spores 6–8 × 4.5–6.5 µm, broadly ellipsoid to ellipsoid, subamygdaliform, inamyloid, smooth. Basidia 40–60 × 6.5–9 µm, 4-spored, more rarely 2-or 3-spored. Clamp connections present in all tissues.

Habitat, substrate, season, distribution. Solitary or gregarious, in the fall. Currently only known from the type location, on the Avalon Peninsula. Even though the first collection had been made in grass under maple and oak, the second collection (type) was made in grass, without any trees nearby. Of note was the presence of *Pilosella* sp., plant often found in the vicinity of hygrocyboid fungi.

Cantharellus betularum,
the "purple chanterelle" of NL

Greg Thorn, Alicia Banwell, Jee In Kim, Renée Lebeuf, Andrus Voitk

Several years of study of our chanterelles[1,2] resulted in the publication in 2017 of three species native to our province. Of these, our commonest species is the new species that we named after our province, *Cantharellus enelensis*. The two less common species are *C. camphoratus*, previously reported from Nova Scotia, and *C. amethysteus*, a European species previously undocumented in North America—this in a genus with no other known European species among the 29 reported in North America.[3,4] Our population of *C. amethysteus* differed from the European one by: a) growing at a higher latitude (i.e., under more slanted sunlight of shorter duration); b) thriving in a 10°C cooler average temperature; and c) associating with birch, not oak or beech as preferred by the European population. Although we have not seen the European *C. amethysteus*, reports and online photos suggest that amethyst scales on its cap are consistent and more prominent (Figure 1), not occasional and subtle, as with ours (Figure 2 & title banner), and its average spore width is almost 20% greater.[5] At the time, we considered these differences as good indicators of ongoing evolutionary divergence of separate populations on two continents, presenting an impediment to continued genetic mixing. As a result we were prepared to accept even weakly supported phylogenetic divergence as further evidence of this, without a need for high statistical support, and speculated that future sampling of more markers from more specimens would support the phylogenetic divergence better. For this reason we initially treated our population of *C. amethysteus* as a new species, sister to the European *C. amethysteus*. However, one of the pre-publication reviewers thought that the likelihood that the divergence was due to chance was not low enough to support this claim, so we reported ours as conspecific with the European one.[6]

Since then we sequenced more collections of our species and sampled three sites (ITS, LSU, Tef-1) for an analysis of the known amethyst-coloured chanterelle species. We can now confirm that our population is a separate and hitherto unknown species.[7] The purpose of this article is to report this finding to readers of **Omphalina**, a readership likely to have the most interest in this, given that the species is hitherto only known from the Island. We named the species *betularum* (Latin: "of birches") because, as opposed to our two other chanterelle species, which are found with conifers, this one has only been found in birchwoods (Figure 3).

Figure 1. The European *Cantharellus amethysteus*. Note the more prominent amethyst scales. Photo: 2008-08-12_Cantharellus_amethysteus_19170.jpg by Gerhard Koller at Mushroom Observer; CC BY-SA 3.0 via Wikimedia Commons.

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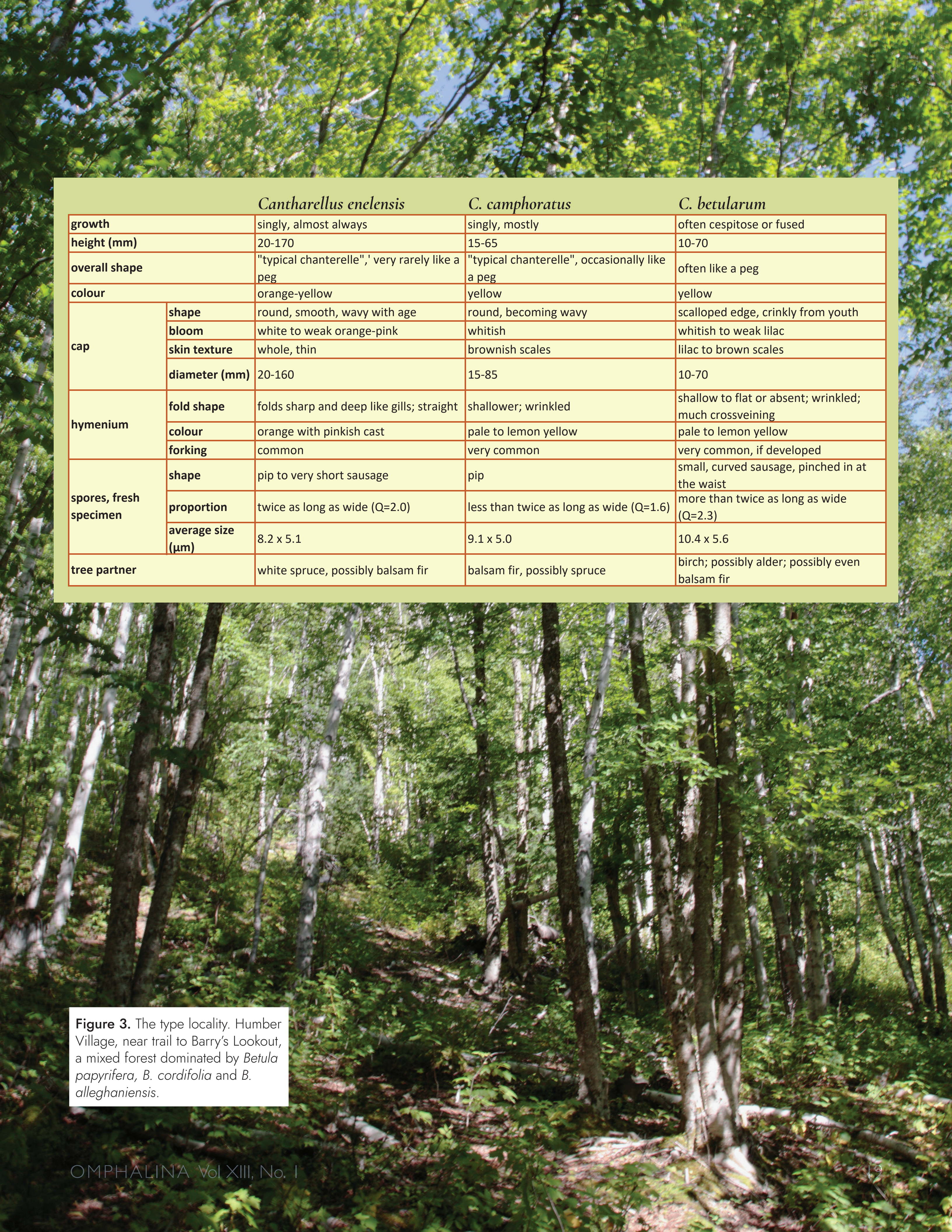
Figure 2 (left). Two collections of *C. betularum* from two sites (about 25 km apart), collected within 10 days of each other. The upper group comes from the same location as the type collection, where mushrooms grow on the soil with an exposed hymenium, which seems to encourage various peg and fused multicephalic shapes. Mushrooms in the lower collection (photo: Maria Voitk) grew in moss covering the hymenium, producing more "normal" chanterelle shapes. We have observed a similar response to exposed hymenium with our other chanterelle species as well.[3] Note also the lighter, blunted hymenial folds, almost absent on the peg form, and brownish orange staining.



		Cantharellus enelensis	*C. camphoratus*	*C. betularum*
growth		singly, almost always	singly, mostly	often cespitose or fused
height (mm)		20-170	15-65	10-70
overall shape		"typical chanterelle",' very rarely like a peg	"typical chanterelle", occasionally like a peg	often like a peg
colour		orange-yellow	yellow	yellow
cap	**shape**	round, smooth, wavy with age	round, becoming wavy	scalloped edge, crinkly from youth
	bloom	white to weak orange-pink	whitish	whitish to weak lilac
	skin texture	whole, thin	brownish scales	lilac to brown scales
	diameter (mm)	20-160	15-85	10-70
hymenium	**fold shape**	folds sharp and deep like gills; straight	shallower; wrinkled	shallow to flat or absent; wrinkled; much crossveining
	colour	orange with pinkish cast	pale to lemon yellow	pale to lemon yellow
	forking	common	very common	very common, if developed
spores, fresh specimen	**shape**	pip to very short sausage	pip	small, curved sausage, pinched in at the waist
	proportion	twice as long as wide (Q=2.0)	less than twice as long as wide (Q=1.6)	more than twice as long as wide (Q=2.3)
	average size (µm)	8.2 x 5.1	9.1 x 5.0	10.4 x 5.6
tree partner		white spruce, possibly balsam fir	balsam fir, possibly spruce	birch; possibly alder; possibly even balsam fir

Figure 3. The type locality. Humber Village, near trail to Barry's Lookout, a mixed forest dominated by *Betula papyrifera*, *B. cordifolia* and *B. alleghaniensis*.

Cantharellus betularum Voitk, Thorn, Lebeuf, Kim

Cap: 20–70 mm diameter, edges evenly round and inrolled, becoming plane, then funnel shaped, with an irregularly wavy margin; opaque; variously covered with thin coating that breaks up into small scales, which often disappear; yellow, scales amethyst, turning violet-brown, then brown; amethyst color not always present. **Hymenium**: flattened, blunt, sinuous, moderately spaced folds, forked and cross-veined, deeply decurrent, but may be almost absent; light yellow to almost white. **Stem**: Up to 65 mm tall, narrowing downwards, solid; yellow. **Flesh**: whitish yellow; odour sweet and fruity. All tissues stain reddish-brown with injury or prolonged exposure. Fruitbodies relatively immune to invertebrate parasites, remain over a month in good condition.

Spores: 7.7–14.0 × 3.9–7.7 µm (average 10.4 × 5.6), Q_{ave}=2.3; elliptical to oblong, usually narrower at the apex, often with an asymmetrically placed constriction, frequently slightly bent; content homogeneous. **Basidia** 7.7–11.6 × 65–90 µm; 4–6-spored; clavate. Clamp connections in all tissues. Wide range in micromorphology between collections and individual sporocarps within a single collection.

Habit: Grows in colonies among leaf litter with *Betula*, end of August to beginning of October, most plentiful Sept. So far documented from three sites in the Bay of Islands region of western Newfoundland.

Comment: Development is "normal" when the hymenium is protected from drying by moss or a high layer of leaf litter. If the hymenium is exposed (no moss or a low layer of leaf litter) abnormal development is seen: fruitbodies may fuse to make polycephalic or single massive fruitbodies, cap development may be arrested beyond the stipe to make peg-like fruitbodies, and the hymenial folds become markedly underdeveloped as mere short, flat, undulating ribs with multiple anastomoses, or even absent. Habitus in exposed habitats varies from solitary pegs, to connate, cespitose or fused fruitbodies. Lighter and flatter hymenial folds and frequent aberrant forms distinguish it from *C. enelensis*. Amethyst scales, if present, association with birch, and markedly longer spores separate it from *C. enelensis* and *C. camphoratus*. Note: the balsam fir branch behind the photo is misleading. It was the only small fir we have seen around these mushrooms, which grow with birch. The photo was chosen to show well-developed amethyst scales on the cap, not too common here.

The Arrhenia acerosa complex in Newfoundland & Labrador

Andrus Voitk, Irja Saar, Robert Lücking, Pierre-Arthur Moreau, Gilles Corriol, Irmgard Krisai-Greilhuber, Greg Thorn, Chris Hay, Bibiana Moncada, Gro Gulden

In a preliminary DNA survey of NL species of *Arrhenia*, we noted that the species that had been consistently identified as *Arrhenia acerosa* formed a sister clade with the only collection bearing the same name available in GenBank® at the time. Anxious to identify our species and learn which of the two was the "real" *A. acerosa*, we set out to study other collections identified as this species. This led to a surprising discovery: the name "acerosa" had been applied to species arising from over 20 different phylogenetic lineages, varying widely in appearance, habitat, and substrate.[1] Only five of these had been described previously: the "real" *A. acerosa*; *A. glauca*; *A. latispora*; *A. subglobisemen*; and *Rhodocybe tillii*—the last we recombined as *A. tillii*. The remainder were species new to science. Of these, we described four: *A. fenicola* from Canadian prairie grasslands; *A. juncorum* and *A. leucotricha*, both on live and dead herbaceous material in European wetlands; and *A. svalbardensis* from the high Arctic. We were not sufficiently familiar with the other species to describe them: either we had not encountered these species ourselves, or were unable to appreciate them as separate from *A. acerosa* at the time. Now that the diversity in the complex is known, we hope that in time further encounters with them will lead to their formal description.

Please go online to <http://sydowia.at/syd73/T12-Voitk-2900.pdf> and download our article—free, and worth every penny. You can largely ignore the text (a very long version of the above paragraph) and appreciate the four full-page colour plates of specimens from this complex. You will be amazed to see not only grey-brown, but dark violet, pink and near-white, small, medium and large fruiting bodies, a wide range in substrate, habitat and distribution. In addition, there is one page of the omphalinoid ("ordinary" cap-and stem mushrooms with an umbilicate cap on a central stem) species found amongst the acerosa-like pleurotelloid (gilled mushroom caps attached to their substrate by the side with no stem or a rudimentary eccentric or lateral one) species.

That various pink species with pink spores were nestled among this grey-brown, white-spored group was interesting. In addition to an undescribed pink species collected by Yves Lamoureux in Québec, we identified two other pink-spored species in Europe, one of them being the *Rhodocybe tillii*, mentioned above, which required transfer to *Arrhenia*. Another unsuspected finding was to discover among this group of pleurotelloid species, several omphalinoid ones. One of these was found by Renée Lebeuf in northern Québec, which is close and similar enough to NL that it may occur here as well. These all await further investigation and definitive identification.

We set out on this adventure because we wanted to know which of the two sequences available in 2014 and identified as *A. acerosa* was the "real" acerosa, and learn the identity of "our acerosa", if it was not the "real" one. Well, the sequence deposited in GenBank came from Svalbard and fell in a clade with the new species *A. svalbardensis*. The only species of the complex identified in this province so far, found both on the Island and Labrador, is *A. subglobisemen* (title banner, Figures 1 & 2), which had been reported on these pages[2] a year after it was first described in Europe.[3] It seems to be the most widely distributed taxon of this complex in the Northern Hemisphere, known widely from Europe, as well as North America.

Arrhenia svalbardensis may grow in the arctic parts of NL because it has been found to the east of us in the high Arctic of Svalbard and to the west of us on Prince Patrick Island in the NWT. One of the new species we reported was *A. fenicola*, from Ontario tall grass prairie, also recorded from the Prairies of western Canada. It might also be found in tall grass here, making a mycological census of the Grassy Place, in the Long Range Mountains at the source of Robinsons River, highly overdue. With sufficient funding, we might even toss in the grassy Sable Island as an extraprovincial add-on.

Federal, NL, NS, governments and other funders of our natural science heritage, take note—an opportunity to use your coffers for productive work.

Does this sort of research matter? Well, if certain work gives you satisfaction, that is its principal reward and meaning. But if you look for meaning of your work beyond your own satisfaction, then one of the real rewards of research is if others find it sufficiently interesting to participate or continue. After our work was published, Pieter van Heerden sent along a photo of a small stemless species growing on moss that he had seen in central NL this summer (Figure 1H_{1-2}), which looked like it might differ from our *A. subglobisemen*. Irja Saar sequenced it and found that it was a very small and young specimen of the same species. Fine, we did not find a new species, but did gain a more complete picture of our species. Then Sara Jenkins sent in a weird, multicephalic specimen from Robert Bond Park (Figure 1F_{1-2}). It looked like the multicephalic forms of *A. subglobisemen* that Gilles Corriol had found in the Pyrenées and was confirmed as such by Greg Thorn's sequences. Until then we thought this complex form was a European phenomenon, so again we learned something about our species.

Interest and participation was not limited to NL. Gro Gulden, our Norwegian collaborator and long-time student of these species, was sent a specimen from Bente Rian (Figure 3), a Norwegian mycophile who had read the acerosa article and wondered where her find might fit in. The specimen also looked like *A. subglobisemen*, which we knew to grow in Norway. However, Bente also sent microscopic pictures and measured the spores. These turned out to be a little smaller than the measurements we had for this species. Although there is considerable overlap in spore size, the difference is small, and there is such a thing as interobserver variation, because we had found a sister species to *A. subglobisemen* in Norway, it was worth pursuing. Indeed, sequencing showed it to be the undescribed sister species. Additional specimens were found the next year, and as you read this, Gro, Bente and Irja are putting final polish on a report about this new species before submission to be published. A very satisfying and worthwhile sequel to our study.


A
B
C
D
F1
H1
E
F2
H2
G1
G2

Figure 1 (preceding page). The face of *A. subglobisemen* in NL. A: Makkovik Bay, Labrador (photo: Aare Voitk). B: Happy Valley-Goose Bay, Labrador (photo: Roger Smith). C: Gros Morne National Park (GMNP), McKenzie's Brook. D & E: GMNP, McKenzie's Brook. (photo: Roger Smith). F1, F2: Sir Robert Bond Park (photo: Sara Jenkins). G1, G2: Lockston Path Provincial Park (photo: Roger Smith) H1, H2: Central NL (photo: Pieter van Heerden). See also title banner and illustration for the description, both by Roger Smith from the Killdevil Camp grounds, GMNP.

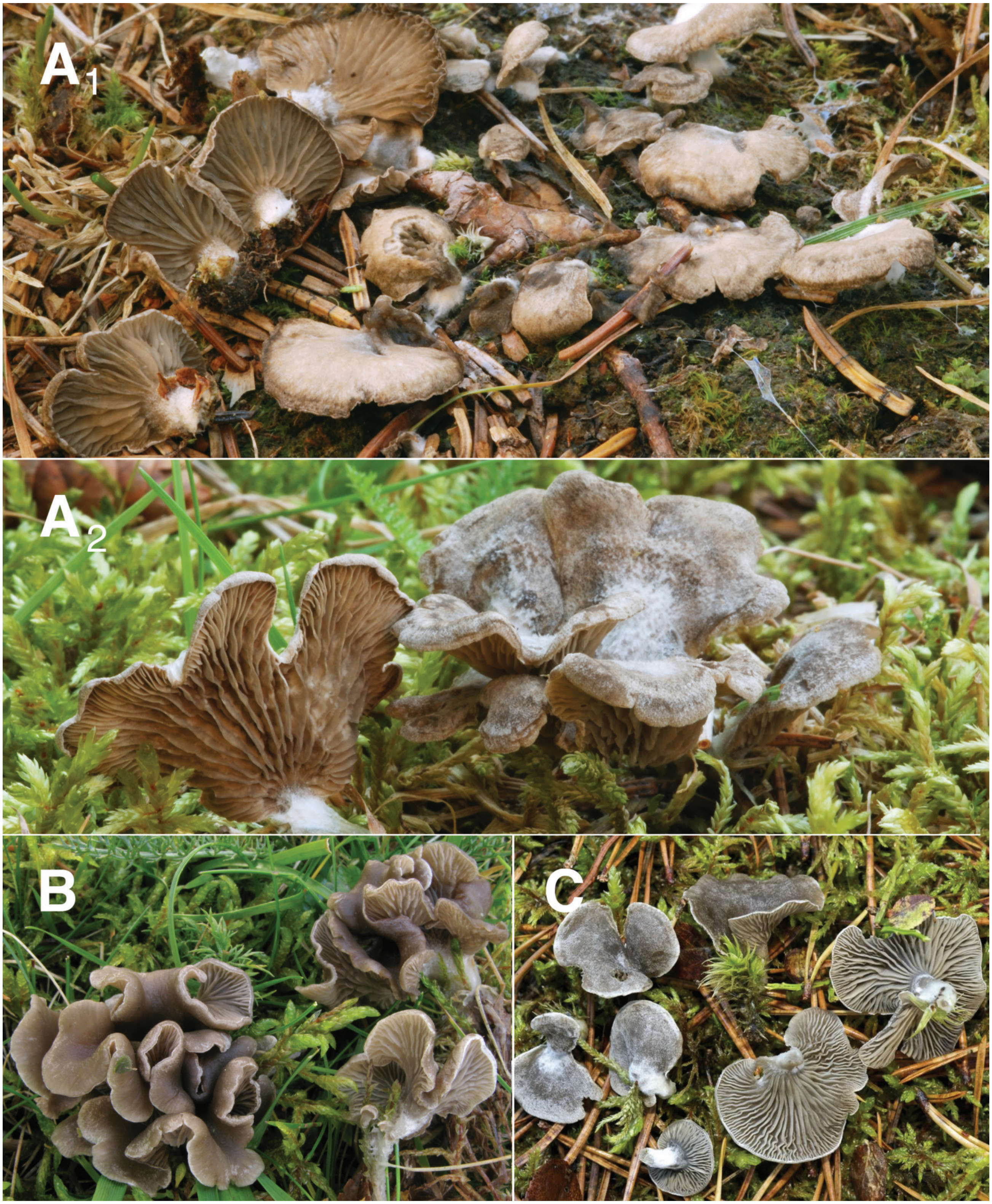


Figure 2. Extraprovincial *Arrhenia subglobisemen*. A1, A2: Québec (photo: Renée Lebeuf). B: French Pyrenées (photo: Gilles Corriol). C: Estonia (photo: Vello Liiv).

Figure 3. Unidentified subglobisemen-like species from Norway sent to Gro from Bente Rian. Being sequenced, as it may be the unknown Norwegian sister species to *A. subglobisemen*. The response to their work was a nice reward to the investigators.

Figure 4. Andrus Voitk, grinning with absolute delight over receiving a bound and signed special edition of this work, proudly displayed on a trophy shelf in his study, immediately to the left of his Covid-era autocoiffed head. Photo: Maria Voitk.

While on the subject of nice rewards, a little while after Christmas 2021, the first author was surprised with a package in the mailbox. His collaborators had gotten together and sent him a special edition bound and signed version of their work (Figure 4), which arrived a little belated, as we have noticed in these Covid times. With all these rewards, you, dear reader, will not be left out: your reward will be a description of our known species, *A. subglobisemen*, at the end of this article.

Acknowledgements

In addition to the people thanked in our original report,[1] we wish to thank Pieter van Heerden, Sara Jenkins and Bente Rian for sending along additional collections, and them as well as Renée Lebeuf, Vello Liiv, Roger Smith, Aare Voitk and Maria Voitk for permitting use of their photos.

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Description Sheet

photo: Renée Lebeuf

Arrhenia subglobisemen Corriol

Macroscopic. Basidiomes up to 25 × 25 mm, with eccentric to lateral rudimentary stem, at times forming complex multilobular or polycephalic structures up to 30 × 30 mm. Cap rugulose, soft, with fine white tomentum becoming dense near stem; initially dark grey-brown with paler margin. Gills long decurrent, straight, occasionally forked; with time and in complex basidiomes may become wavy, narrow, crowded, with numerous lamellulae; grey-brown, a little lighter than context. Stem broad and short, covered with white tomentum as on the pileus; in complex structures reduced to a barely differentiated mass, only a few millimetres high, its upper part covered by decurrent lamellae, and lower part by white tomentum, which may partially cover the base of the hymenium; grey. Context dark grey, lightening when drying; distinct *Pelargonium* smell and taste. Spore-print white.

Microscopic. Spores 4.8–7.8 × 4.3–6.7 µm, average 6.5 × 5.5 µm; Q_{avg} 1.3; pip-shaped to subglobose, with prominent apiculus reaching 1 µm, hyaline, smooth, inamyloid, acyanophilous. Basidia 23–35 × 6–8 µm, clavate, 4-spored. Cystidia absent. Clamp connections abundant in all tissues.

Habitat, substrate & distribution. Growing in sheltered grassy areas or grassy patches in woodland, in both alpine and lowland settings. Terricolous, ± gregarious, often on cottony mycelium mantles encompassing living stems of mosses and surrounding litter. Known from Europe and North America.

Our angel wings are not alone, but which ones are poisonous?

Greg Thorn, Andrus Voitk

photo: *Pleurocybella porrigens*, taken in Pippy Park, St. John's, NL, by S. Jenkins

Pleurocybella porrigens, known as angel wings, is a beautiful and easily recognized species (Figure 1), common in Newfoundland and Labrador.[1] Although it looks too small to be considered a significant edible, it was consumed regularly until Japanese reports of toxicity appeared in 2004 and 2009, where multiple people died from encephalopathy up to three weeks after eating what was identified then as *P. porrigens*. The symptoms are described in a bit more detail by Michael Beug on these pages[2] (as well as elsewhere). Amounts consumed were repeated and extraordinarily copious, and affected people on haemodialysis, suggesting that the toxin is excreted by the kidneys, and compromised kidney function may be a factor in toxin build-up. The toxin was a mystery at the time but was later identified as an unusual and unstable amino acid named pleurocybellaziridine.[2]

In early November, 2020, Quebec mycologist Roland Labbé asked Greg whether *P. porrigens* has caused poisonings in eastern North America, and whether the species here differed genetically from seemingly identical Asian representatives.

The answer to the first part of his question is, "Probably not." Greg found two records of poisoning involving *P. porrigens* in the NAMA Toxicology Reports and Poison Case Registry from 2006 to 2016 (https://namyco.org/toxicology_reports.php). The first, from British Columbia in 2013, caused dizziness, itching, a feeling of being "stoned", hot and cold, and vomiting, followed by recovery. Because a species of *Crepidotus* may have been involved, the case is not considered definite. The other, from Oregon in 2016, caused gastrointestinal distress, and the mushroom eaten, thought to be *Pleurotus ostreatus* by the victim, was identified from a photograph as *Pleurocybella* by the toxicology expert. In addition, there is an earlier report from Washington State in 1979, causing nausea, sweating, disorientation and diarrhoea, and apparently specimens from that episode have been preserved. None of the North American (or European) reports resemble the serious poisonings in Japan, but there also seem to be no biochemical studies of the toxicity, or lack thereof, of any North American specimens named *P. porrigens*.

The answer to the second part of Roland's question is also quite interesting, and something Greg feels better equipped to tackle. He found quite a few DNA sequences identified as *P. porrigens* in publicly available databases—but only one from eastern North America. Foray Newfoundland & Labrador to the rescue! From our collections of angel wings from past forays we selected nine from different parts of the province,

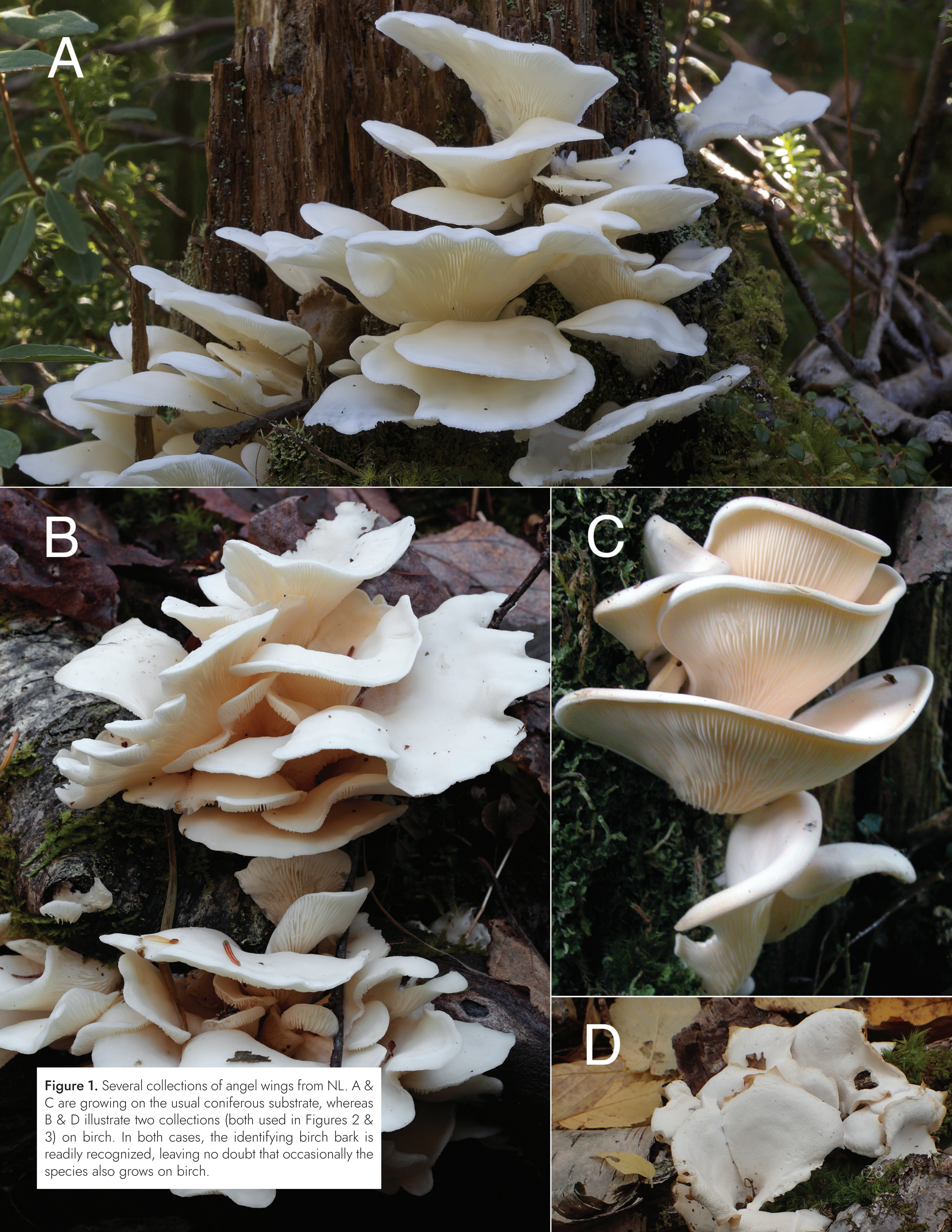

Figure 1. Several collections of angel wings from NL. A & C are growing on the usual coniferous substrate, whereas B & D illustrate two collections (both used in Figures 2 & 3) on birch. In both cases, the identifying birch bark is readily recognized, leaving no doubt that occasionally the species also grows on birch.

including Labrador, and also collections from known conifer and hardwood substrates. Yes, angel wings are usually reported growing on rotting coniferous wood, but we have collections from brown-rotted white and yellow birch (Figure 1B & D).[1] Some obvious questions arose:

1. Are the collections on hardwoods and conifers the same or different species?
2. Are our angel wings the same or different from the species in Europe, where it was first described?
3. Are ours the same as those in Asia?
4. If they are different, are all (equally) toxic?

Comparison of our two collections from birch with two similar collections from coniferous woods in the same area showed no macroscopic difference. Microscopically all had 4-spored basidia of the same size with very occasional 2-spored ones, and many variably shaped cystidia. The spores were of similar size and shape (Figure 2), but because at times we have seen closely related species with almost as close spore sizes, molecular studies seem required to confirm or exclude their conspecificity. Such studies should also answer questions 2 and 3.

While COVID-19 has wrought illness, death and misery world-wide and caused closures and cancellations of our usual activities, it actually permitted and enhanced this small project, in which a few mushroom samples travelled by mail to London, Ontario, and then small parts of them were ground up and their DNA extracted and amplified for sequencing in a lab that was otherwise eerily quiet and empty. As it happens, angel wings give up their DNA much more readily than many mushrooms, so within a few weeks the task was done, revealing a tree brought to you in Figure 3. The angels decorating the tree tell the story: angel wings from Newfoundland & Labrador, whether from coniferous, deciduous or unknown woody substrates, are nearly identical in their DNA sequences (the internal transcribed spacer, or ITS region) to samples from western Europe. So, while there is no type specimen, let alone a sequence of a type specimen, for the European *P. porrigens*, it seems most likely that our angel wings are that species. A single available sequence stretches the confirmed range of this species in North America west to Wisconsin. This is one case in which it appears that a separate name for the species in eastern North America coined by Charles Peck (*Pleurotus albolanatus* Peck) is not necessary—but read on.

The next western sequences, from British Columbia (and a single large ribosomal subunit, or LSU, sequence from Washington state, not shown), cluster with a few sequences from northern Japan (Hokkaido and Aomori provinces) in the group on the green panel named "pacific" on our tree. This is most likely a separate, unnamed species, obviously called *P. porrigens* by mycologists who collected and sequenced it, and as the only species of angel wings there, had to be the species associated with the 1979, 2013 and 2016 events, described above. Japan also hosts what appear to be two other

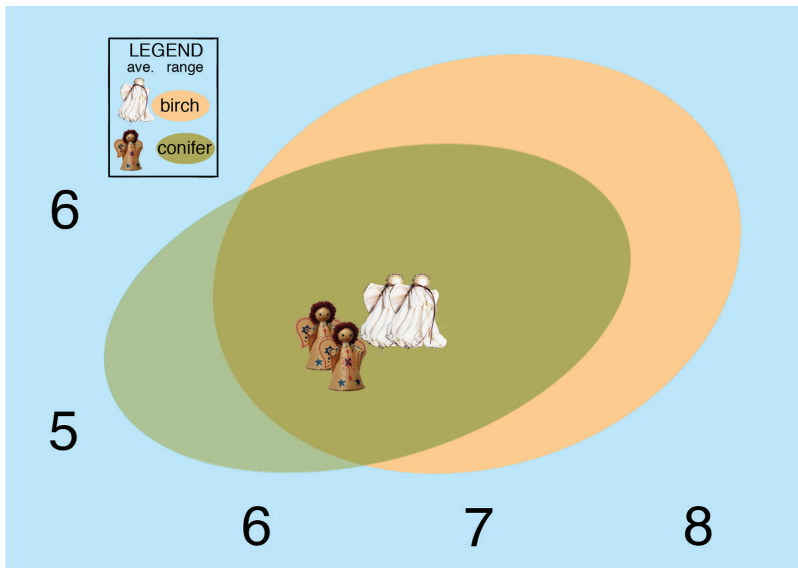

Figure 2. Spore sizes of two collections each of NL *P. porrigens* from birch and coniferous wood, measured in µm, length on the x-axis and width on the y. Averages of each collection represented by angels and ranges of both by coloured ovals.

unnamed species of *Pleurocybella*,[3] with the commoner one, which we label "eastasian 1", being most distantly related to the species in Europe. However, the authors of the Japanese study reported that there were no obvious morphological characters by which their specimens could be distinguished from one another. Unfortunately, no samples from the poisoning cases of 2004 and 2009 were sequenced, so we do not know which of the three species was responsible.

These preliminary data have exposed huge gaps in our knowledge. We do not know yet whether and how these species differ from each other macro- or microscopically,

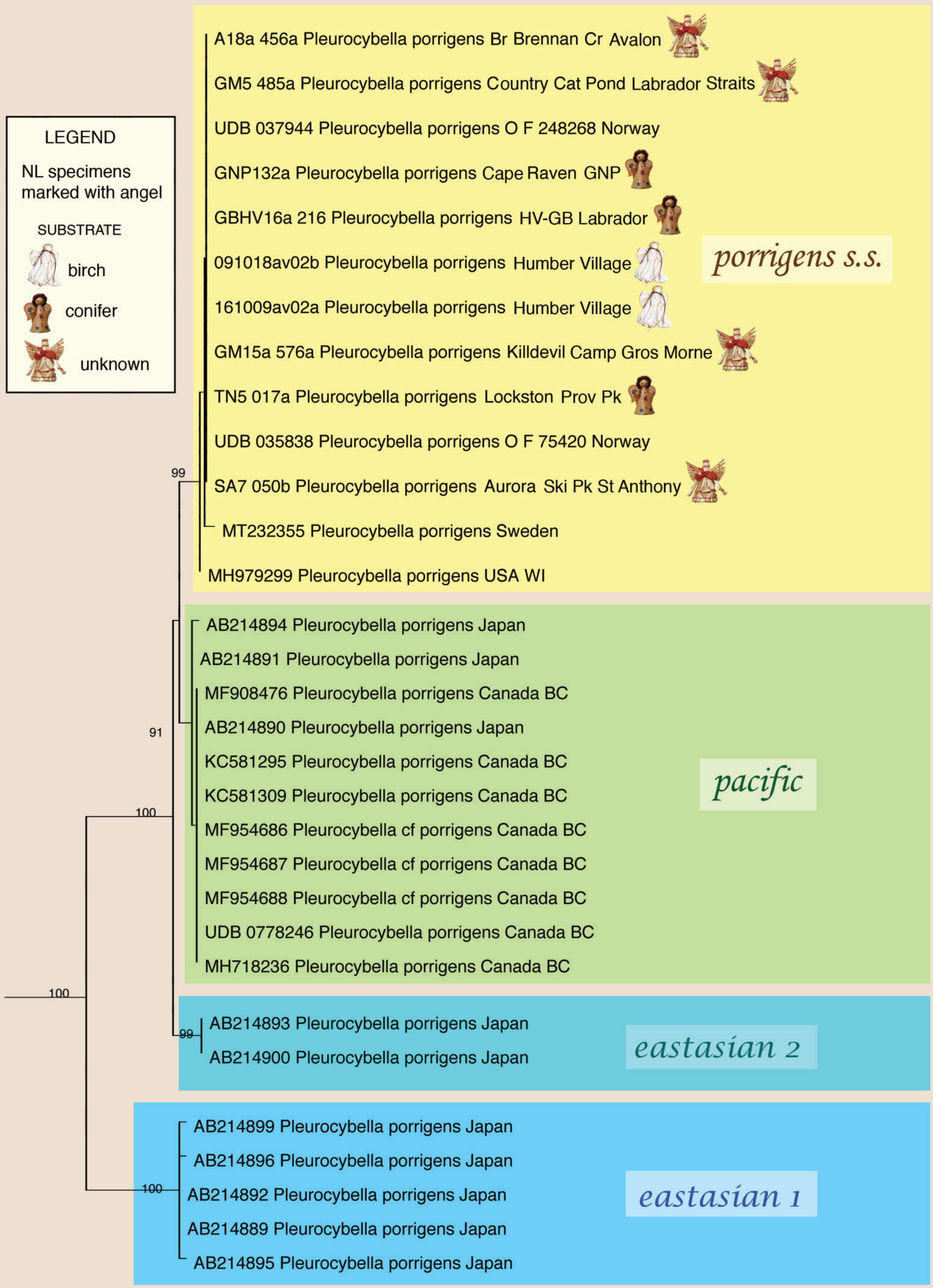

Figure 3. The *Pleurocybella porrigens* complex, made up of ITS sequences of NL collections (marked with angels) added to sequences from elsewhere deposited in GenBank and UNITE databases, on a segment from a neighbour-joining tree originally rooted in *Henningsomyces candidus*. Four species clusters can be seen, each on a different colour panel. The tree does not show time, but does indicate the order of appearance, from left to right. Because the most ancestral species, as well as three of the four species are all found in Japan, one can speculate that the complex originated in Asia, and spread from there across the world—more speculation to check with future research.

their full distribution, or whether one or more species is/are toxic. The toxin must be present in at least one of the species known from Japan ("eastasian 1", "eastasian 2", or "pacific") because the confirmed toxicities were reported from there, but may be present in more than one species, including *P. porrigens* sensu stricto (the "real" *P. porrigens*), which we have here. If only one species is toxic, it could be "eastasian 1" because so far, only this species is known from all the prefectures (provinces) of Japan where poisonings have been reported. Or, it could be "eastasian 2", because it is a much less common species and the poisonings are rare. Or it could be "pacific", because there are three presumptive *Pleurocybella* poisonings reported from western North America, and this is the only species found in both Japan and western North America. However, the case here is made rather weak, because the symptoms described in the North American events are mild, somewhat non-specific, and not characteristic of encephalopathy. Lots of room for investigation.

Caution

As you can see, significant doubt about the toxicity of the species exists. *Pleurocybella porrigens* has been eaten for decades with no hint of harmful effects until 2004. Could they be due to some other factor, like a more aggressive form of dialysis encephalopathy? If poisoning is limited to haemodialysis patients, is the mushroom safe for others? If all poisonings were related to the repeated consumption of large amounts, are less frequent meals of smaller amounts safe? If there are several species of the complex, and no poisoning reported in eastern NA, is our species safe to eat? And so on. Should you look it up on the net, you will find these questions and more bandied about by professional skeptics, expressing many thomasine* opinions that reports of toxicity have not demonstrated causality and the species is/may be safe to eat, or at least for some. If you are swayed by these opinions and are tempted to try some, we ask you seriously, "**WHY?**" What have you to gain? Not a worthwhile taste sensation, that much we can guarantee. One of us (AV) ate angel wings twice in the early 2000s, before the poisoning report came out, and found them insipid. With so many more flavourful species to choose from, he gave up collecting these for food, but still likes to photograph them because of their striking visual beauty. Michael Beug reports a similar experience and also quit collecting the species (likely the species we labelled "pacific") early on because they offered no worthwhile culinary experience. Trust these tasters! On the other hand, what have you to lose? Well, the odds are probably very small that you'll suffer, but if you do, the consequences are major: encephalopathy is a very bad way to go and fatality is often irreversible. Eating them under these conditions just because you think you are right and the experts are wrong is for idiots.

*neologism meaning doubting, referring to doubting Thomas. You read it here first.

Future

As is so common in mycology, a "simple question" about a "well-known species" has revealed how little we know. Thanks to Roland, we now have our work cut out for us, because motivated by the same curiosity, we cannot help pursuing these questions in a scientific way, to learn some more definitive answers. You heard it here first. Stay tuned for more in a few years.

Acknowledgments

We are glad that Roland Labbé is curious and thank him for the question, which started this quest. We also thank Michael Beug for reviewing this article, suggesting improvements and contributing precise information about North American poisonings.

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photo: Roger Smith

Link it to LICHENS

by Felicity Roberts

Lichens are truly ubiquitous creatures. It is estimated that they cover up to 8 percent of the earth's surface, and they are found on every continent including Antarctica.[1] Their extremophile nature makes even the most barren deserts and frigid tundras habitable. Some lichens, including *Rhizocarpon geographicum*, a common species here in Newfoundland and Labrador, have even survived zero gravity and exposure to cosmic rays in space.[2,3]

Lichens are incredibly complex and new and exciting discoveries about them are made all the time! In fact, a few years ago, when scientists decided to have a look at the DNA of the lichen *Dictyonema glabratum,* once considered to be a single species, they discovered there are actually 126 different species of this lichen, maybe even more.[4]

Link It to Lichens is a new Omphalina column exploring the myriad ways lichens entwine with our daily lives that aims to provide basic and fun 'infotainment' for the lichen-lovers among us. Full of ideas that will spark an interest in lichens in newbies and nature-oriented kids alike, and widen the scope of those who already love lichens, we also welcome feedback on topics you would like to see linked to lichens.

First, let's explain a little bit about what a lichen is, in simple terms, for those new to the subject. Lichens don't work like other things you know, and that's exactly what makes them so fascinating. Luckily for those of us reading from here in Newfoundland and Labrador, we are a lichen hotspot.

A great introductory definition of a lichen is simply: *fungi that has learned to farm*. "What?" you say. Well, a lichen is not just one species. It is a composite organism made up of a *photobiont*, (algae or cyanobacteria) which makes food for the organism through photosynthesis, and a *mycobiont* (the fungal partner) which provides protection and shelter. Together, they can and have conquered almost every corner of the world. Sometimes there's a yeast in the picture too.... but that's a story for another time.

Back to extreme environments: in deserts, with limited water and plant life, lichens play a key role in the webs of life found there. And that web is tangly! For example, in some parts of Australia (another great spot for lichen), there are lichens that live on bugs, but also bugs that live within that lichen. Many insects depend on lichen for food and camouflage, and some larger animals also graze them. Biological soil crusts, bastions of cryptic diversity, are composed of mosses, lichens, cyanobacteria and algae. They help hold down the soil, prevent erosion, and conserve soil moisure.

Let's shift our focus now to Central Asia, which is also rich with lichens (and mountains, and sheep). This region has an exquisite tradition of weaving with the wool of those sheep, often still dyed with locally-produced natural dyes, some sourced from lichens. Lichens are powerful natural dyes with a long history; they were one source of the coveted color purple before aniline (coal based) dyes were invented.

But dyes are not the only use for lichens: in some regions of the Himalayas, lichens are also used medicinally. One herder in Nepal has even described lichens used for veterinary medicine. The herder was taught by his grandfather to use a lichen found growing on rocks to treat open wounds on his sheep. He told a researcher that his father had seen injured sheep rubbing themselves on rocks covered in that lichen, and upon trying it as a veterinary treatment, he believed that it speeded their healing.[5]

Central Asia is punctuated by many mountain ranges, from the Tian Shan to the Himalayas, the Pamir to the Hindu Kush. Earthquakes are an ever-present danger in many areas. One way that scientists can track the frequency of earthquakes is by using a method called lichenometry, that involves—you guessed it—lichens.

Lichenometry is a method of dating surfaces that cannot be radiocarbon dated, like carvings on rocks, or gravestones, or the time since a rockfall exposed a fresh rock face. It works on the premise that if you know the annual growth rate of a lichen, you can measure the lichens growing on a surface to determine how long it has been exposed. Lichenometry has been used to measure the ages of avalanches from earthquakes,[6] and the frequency of rebuilding sacred sites after earthquakes,[7] among other things. And which lichen do we find playing the starring role in those studies? Why, our old friend, *Rhizocarpon geographicum*!

As you might guess from this whirlwind global tour of lichens and some of their unique uses, if you look carefully enough at just about anything, you'll find a link to lichens.

Tune in next issue when we'll link the fashion industry to lichens. You'll learn about lichen perfumes, lichen ceremonial suits, and more.

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Sphaerophorus sp., photo: S. Jenkins

The Corticolous Lichens In My Backyard

Jim Cornish

About thirty years ago, my then eight-year-old son and I planted a larch seedling in our backyard. The seedling—and later sapling—survived many brushes with the lawnmower in summer and the deep snowdrifts of Gander winters. Today, at 10 m tall with a 143-cm girth, the tree's trunk stands as straight as a schooner's mast and come mid-November, when most other trees are bare, it is the showiest tree in the neighbourhood!

A few years ago, I noticed that after a period of steady rain, patches of bark scattered over the tree's trunk and branches turned a bright grey-green, an unmistakable sign of lichens I learned many years ago. A casual look revealed the lichens were mostly of the shield variety that commonly grow in our forests. A closer look through a 10x hand lens revealed more, much, much more. On just a half-metre section of one of the lowest and hence oldest branches, I discovered a dozen or more **corticolous** (bark-dwelling) lichen species and on the trunk and younger branches above, even more. What began as casual observations of lichens in my backyard became a macro photoshoot and this article, both great distraction during the covid-19 restrictions. I hope the photographs and text will serve as a reference should you also explore for lichens in your backyard too.

What are Lichens?

Lichens are enigmatic lifeforms![1,2] When the Florentine botanist Pier Antonio Micheli began the systematic study of lichens in 1729, there was little agreement on the true nature of lichens or their classification. Carl Linnaeus, the 18th century inventor of taxonomy, was so frustrated by lichens, he described them as "rustici pauperrimi", the "poor trash" of vegetation but did manage to separate them from plants, algae, and mosses in his classification scheme.[3] In 1869, Swiss botanist and microscopist Simon Schwendener published a paper advancing the radical idea that lichens were dual organisms, a fungus (the **mycobiont**) living with an alga (the **photobiont**). At first, Schwendener's contemporaries vigorously rejected his proposal. Evolution, they argued, was divergent, not convergent as his hypothesis suggested. But, through the efforts of German botanists Anton de Barry and Albert Frank, the founders of the concept of symbiosis, by the end of the 19th century, the lichen's duality and its mutualistic lifestyle was widely accepted.[3]

Since Schwendener's 1869 discovery, cyanobacteria (called cyanobionts) have been added as the lone or second photobiont in some 1500 lichen species.[4] More recently, yeast and other fungi, as well as various types of bacteria and other microbes, have been identified as additional partners in a growing number of lichens collected worldwide.[5] Today, Earth's ~20,000 known lichen species are often called "lichenized fungi" and viewed as a consortium of lifeforms from multiple kingdoms living together in a stable and self-sustaining mini ecosystem.[6] And while the lifestyle is still considered mutualistic in some respects, how lichens gain their nutritional requirement from their photobiotic partners is now considered an example of "controlled" or "balanced parasitism".[7,8]

Lichen Structure

Lichens are extremophiles—they can live in places their partners cannot possibly survive on their own. Lichens live in every terrestrial habitat from pole to pole, and from sea level to 7500 m on mountain peaks. Their symbiotic relationship, stratified structure, and unique ability to dehydrate and suspend all biological activity, enable lichens to survive dormancy measured in days and in some cases, hundreds of years. And when rehydrated, dormant lichens amazingly spring back to life virtually unscathed.

The unique association between a fungus and a photobiont partner gives rise to a vegetative body (**thallus**) unlike any of the partners. Multicellular and differentiated, most thalli are stratified into three or four layers (Figure 1). In the absence of pigmentation, thalli often appear greyish green when dry and usually greener and brighter when wet. The top thalline layer (a), called the **upper cortex**, is composed of tightly bound fungal hyphae, after which the lichen is named, that give lichens their structural strength and characteristic shapes. The upper cortex is water absorbent during wet periods and slows evaporation during dry spells. Secondary metabolites, produced solely by the mycobiont and stored in crystalline form in the upper cortex, act as sun blockers, antioxidants, anti-herbivores, and antipathogens. Below the upper cortex lies the **photobiont layer** (b). Composed of algae or cyanobacteria and

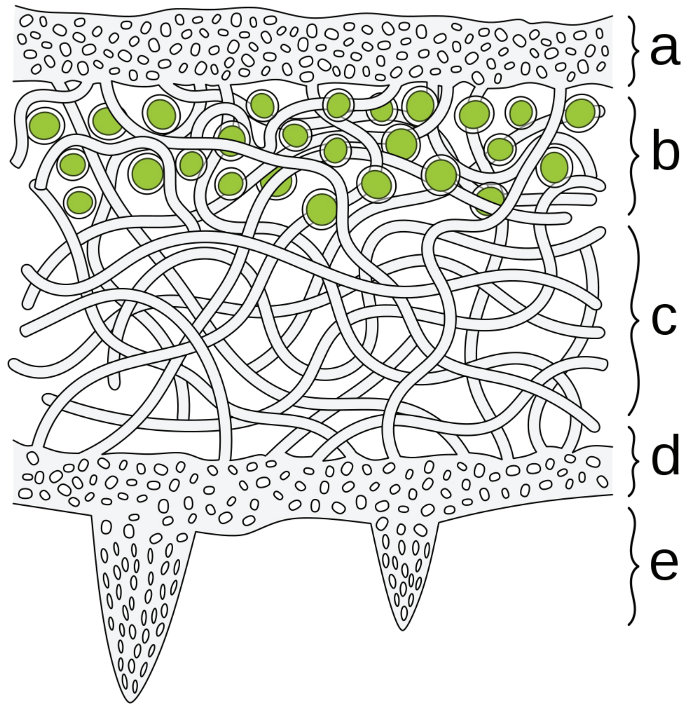


Figure 1: A typical lichen thallus: a) outer cortex; b)photobiont layer with algae and enveloping medullary hyphae; c) medulla; d)lower cortex; and e) rhizines. Photo public domain.

sometimes both, each photobiont cell is enveloped by hyphae that originate in the third layer, the **medulla** (c). The medulla, the thickest layer, is composed of loosely arranged hyphae, an assemblage that creates plenty of air spaces for the exchange of gases by the photosynthetic algae. Secondary metabolites produced in the medulla coat medullary hyphae in a crystalline hydrophobic (water-repellant) layer that helps the fungus move water and minerals passively to the photobiont for photosynthesis and then move photosynthates converted to sugar alcohols by the fungus from the photobiont to all parts of the lichen thallus where it is used for maintenance, growth, and reproduction. The hydrophobic coating also helps the medulla stay dry even when the upper cortex is saturated. This protection of the algae by the fungus and the give-and-take of nutrients and carbohydrates by the algae is the essence of lichen symbiosis. When present, the fourth layer is called the **lower cortex** (d). Also composed of tightly woven hyphae, the lower cortex is often melanized (black or dark brown in colour) and sometimes covered by hanging strands of hyphae called **rhizines** (e) that anchor lichens to their substrates.[6,9,10]

The Substrate

The larch in my backyard is *Larix decidua,*[11] commonly called European larch. Grey-brown twig bark, shorter trunks and a northeast leaning treetop distinguish our native *Larix laricina* from the European variety.[11] *L. decidua* was introduced to Newfoundland and other parts of eastern North America from Europe for silviculture research and plantation planting in the mid-1960s[12] (Figure 2). Often called a deciduous conifer, larch's tufted needles look coniferous but like deciduous leaves, they change colour and shed in the fall. *L. decidua* is a fast growing tree that can reach 45 metres in height under optimal growing conditions. It is shade-intolerant which makes it a great substrate for phototrophic lichens.

Figure 2: *Larix decidua,* a European larch species introduced to eastern North America in the 1960s.

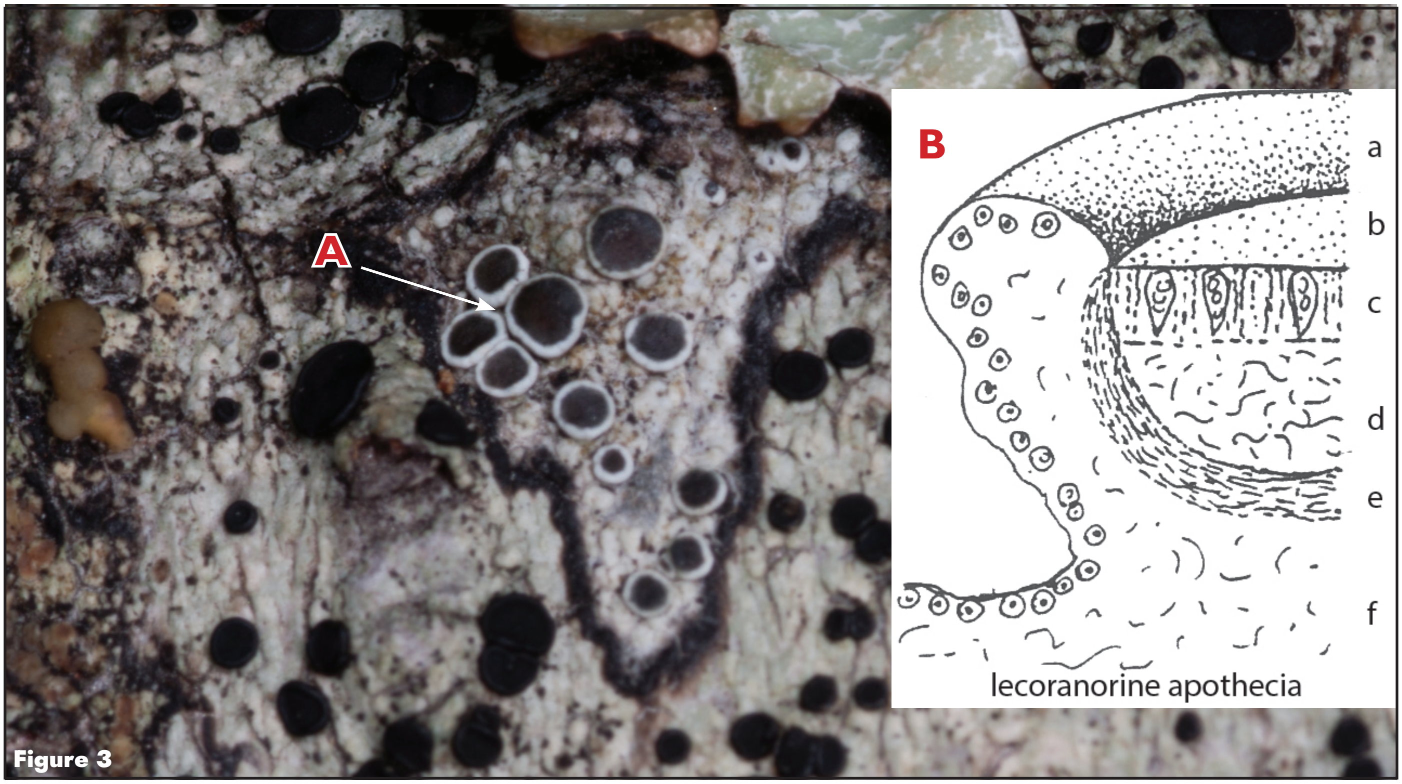
THE LICHENS

Crustose Group

Lichens are often grouped based on thallus morphology (crustose, foliose, fruticose, squamulose and leprose) and substratum type (rocks, bark, dead wood, and soil). Crustose lichens, the largest of the five morphological groups, grow particularly slowly (1 mm/yr in many cases) and appear as thin crusts on natural surfaces and on undisturbed manmade objects including glass, plastic and rubber.[10] Crustose thalli can be continuous, cracked, smooth, or granular in texture and are often the most colourful lichens, sometimes looking more like paint than anything alive. Collecting crustose lichens is a challenge and not recommended. Because they lack a lower cortex, medullary hyphae fasten the whole crustose lichen to the substrate, making it almost impossible to separate the two without damaging one or both.[13,14]

Three of four crustose lichens species found on my larch tree (Figures 3–6) belong to *Lecanora*, a large genus with 1000+ species worldwide and at least 170 in North America.[14] *Lecanorae* often look alike superficially, and many species require chemical tests and microscopic study of their sexual reproductive structures and spores for identification. The three *Lecanorae* described here are common in our province. The distinctive features described here can be seen easily with the naked eye or a 10x hand lens. Detailed descriptions for all lichens in this article are available from the sources cited.

Lecanora circumborealis (black-eyed rim lichen)

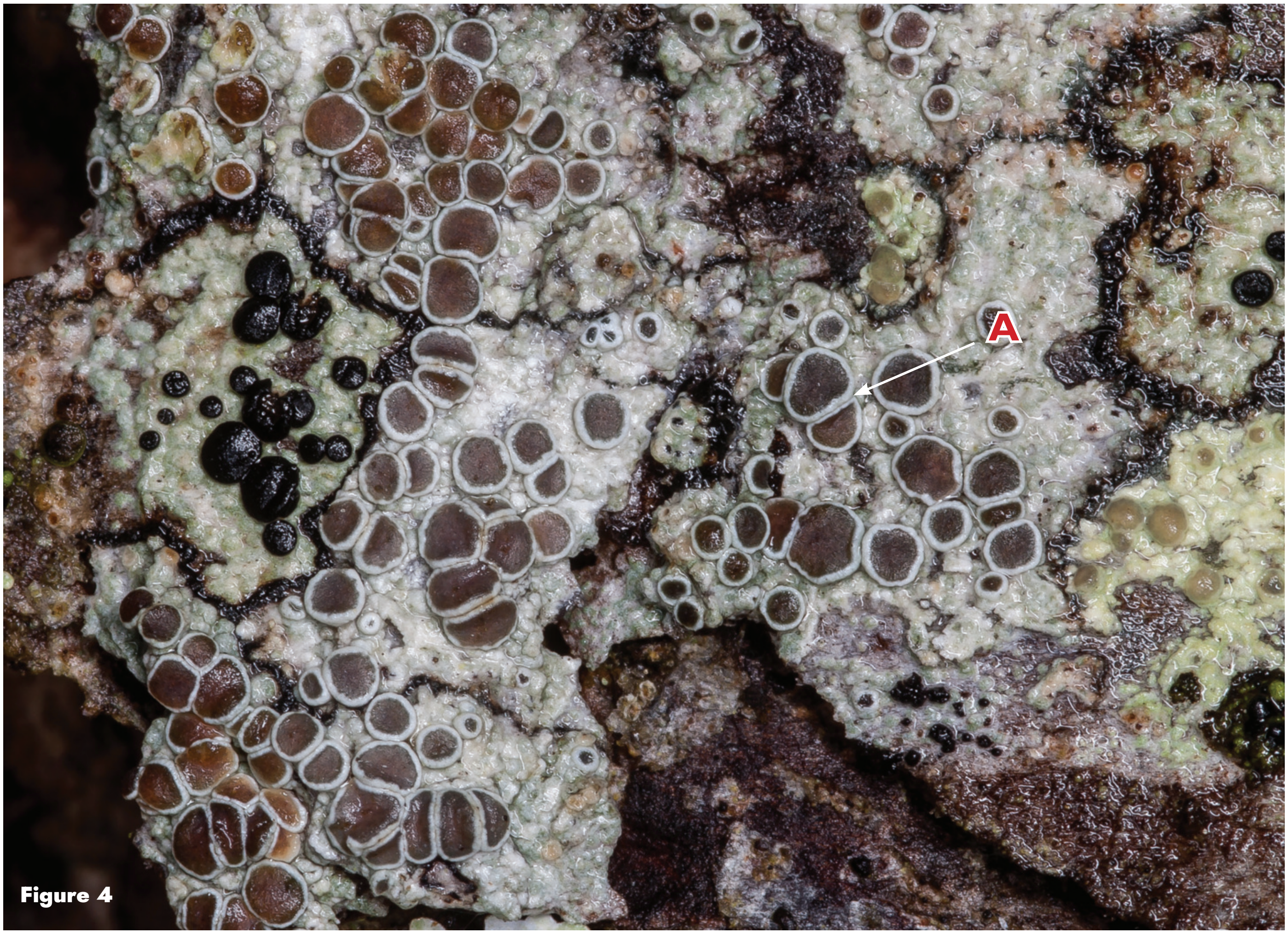


Lecanora circumborealis has a pale grey, thin, patchy, single layered thallus dotted with mm-scale **apothecia** (see Figure 3A). Each apothecium has a black to very dark brown epihymenium (disc) surrounded by a prominent rim (parathecium) similar in colour to the thallus. An "individual" thallus is often delineated by a black line called a **prothallus** (Figure 3B). *L. circumborealis* is distributed throughout the Boreal Forest Biome in both North America and Eurasia, and commonly grows above the height of the winter snowpack on both coniferous and deciduous trees. The name *Lecanora* comes from the Greek "lekanon" meaning a small bowl and "ora" meaning beauty; both are apt descriptions of the lichen's often lightly coloured apothecial rim. [14,15]

Figure 3A: Lecanorine apothecia. Like other ascomycetes, lichens produce sexual spores in sacs called asci which are bundled into stalked or sessile globose, cup or disc-like apothecia. Cup-like apothecia typically contain multiple parts: (a) the **parathecium**, the rim composed of upper cortical tissue containing both hyphal and algal cells; (b) the **epithecium**, the tips of sterile asci-supporting hyphae (paraphyses), that give the apothecium its characteristic colour and convex, concave, or flat shape; (c) the **hymenium** with spore-bearing asci and paraphyses; (d) the **hypothecium** composed of sterile hyphae; (e) the **subhypothecium** and (f) the **medulla.** The rim is typically the same colour as the cortical hyphae on lecanorine apothecia. Lichen apothecia are often perennial features, capable of producing spores for some years. In temperature climatic zones such as ours, lichen apothecial spore development and dispersal are often timed with the air temperatures and relative humidity levels during the spring and fall. The colour, shape, size, and placement of apothecia are all diagnostically important features in species identification.[14,16,17]

Figure 3B: Prothallus. A prothallus forms when thalline fungi grow beyond the lichenized portion of the lichen thallus as an unlichenized (i.e. containing no photobiont cells), and often dark pigmented (melanized)[18] or white fringe that separates "individual" lichens of the same or different species from one another. A prothallus may also act as a barrier preventing individuals from overtaking one another's space. The presence or absence of a prothallus is diagnostically important in identifying many crustose species.[19,20] As Figure 3B shows, *L. circumborealis* has a distinct and defining prothallus that clearly separates it from the adjacent *Buellia disciformis*, a crustose species discussed later in this article.

Lecanora allophana (brown-eyed rim lichen).



Lecanora allophana has a somewhat large, thick, white to pale grey, smooth or wrinkled to **areolate** (cracked) thallus. Apothecia are lecanorine, often large (up to 2.5 mm in diameter) with distinct, thick, reddish-brown pigmented epithecium and white rims that appear contorted when apothecia are crowded on the thallus (Figure 4A). Like many other *Lecanorae*, an individual *L. allophana* is separated from other crustose lichens by a robust prothallus. The lichen commonly grows on poplars but also colonizes the barks of other trees. *L allophana* is restricted in distribution to the northeast in North America.[14] The specific epithet *allophana* means "appearing differently", probably a reference to the apothecia which are larger in this species than in other *Lecanora*.[15]

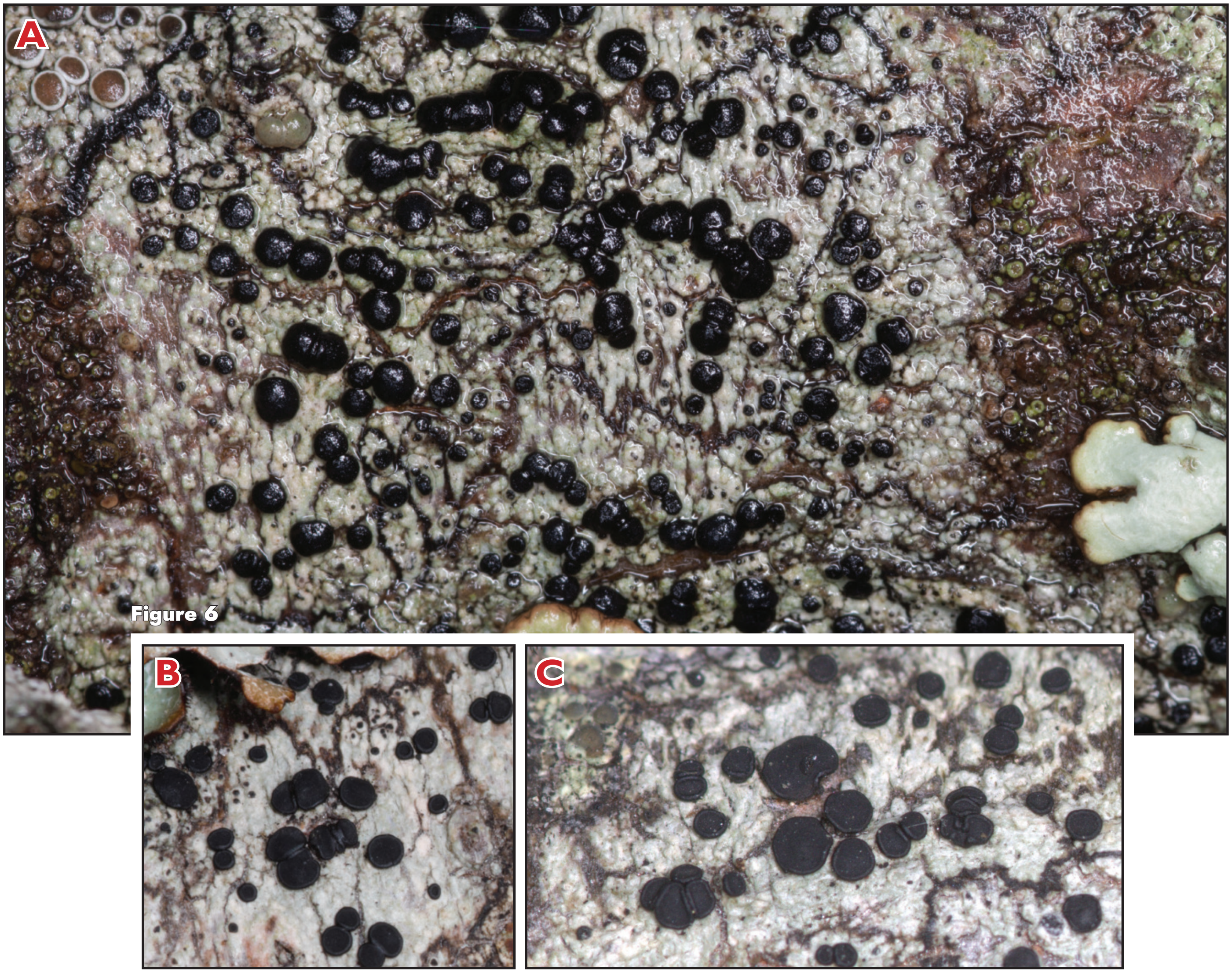
Figure 4A: Apothecia. Depending on the species, lichen apothecia can be spread apart or crowded on a thallus. In *L. allophana*, characteristic crowding often distorts the typically circular shape of apothecia in this genus. Since *L. allophana* apothecia are relatively large, a hand lens will easily show this distinguishing feature.[14]

Lecanora symmicta (fused rim-lichen)

Lecanora symmicta has a greenish yellow to gray-green or pale green thallus that is often thin and granular. The lichen's apothecia are waxy and pale yellowish-brown, the latter a result of usnic acid, a pigment that gives many lichens their yellowish colour. Usnic acid is one of over 1000 unique secondary metabolites (also known as "lichen acids") produced solely by the mycobiont of lichens.[10] Usnic acid also acts as a UV screen and has antibacterial, antimycotic, antimicrobial, and antifeedant properties that have long interested pharmaceutical researchers.[21] *L. symmicta* apothecia are less than 1 mm in diameter, flat to slightly swollen (convex) and when crowded, often fuse with their neighbours (Figure 5A). Only young apothecia show a rim. White prothallus often delimits the thallus margins. *L. symmicta* grows on coniferous and deciduous tree bark and deadwood and is widely distributed across Canada and the northeast and Great Lakes region of the USA. The species epithet *symmicta* means "comingled", a reference to its fused apothecia.[14,22,23]

Figure 5A: Fused Apothecia. A defining feature of *L. symmicta* is the fusing of crowded apothecia on the thallus. Fusion of hyphae occurs in other species of lichenized and nonlichenized (mushroom) fungi. In crustose lichen varieties, individual thalli sometimes fuse to form large patches of lichen of the same species.

Buellia disciformis (boreal button lichen)



Buellia disciformis has a thin and pale grey to ivory areolate thallus (Figure 6A) Individual lichens are often bounded by a black or grey prothallus. Apothecia are only a millimetre in diameter and appear as raised buttons on the thallus (Figure 6B) *B. disciformis* grow on coniferous and deciduous tree bark and are cosmopolitan, i.e. distributed world-wide. The lichen is widespread in the Boreal Forests of Canada and Europe, and in similar forests at higher elevations further south on both continents.[14] The genus name *Buellia* acknowledges Esperanzo Buelli, a friend of famous Italian lichenologist and taxonomist Giuseppe De Notaris, who pioneered the use of microscopy in lichen identification.[21] The species epithet *disciformis* refers to the disc-shaped apothecia.

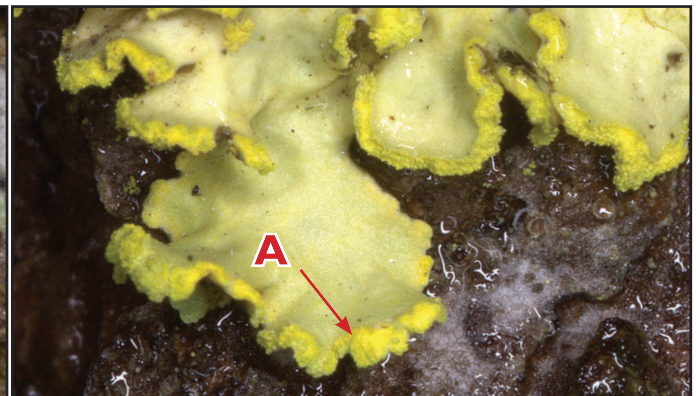
Figure 6B: Areoles. Crustose lichen thalli can be cracked **(rimose)** or extremely cracked **(areolate)**. **Areoles** form when lower layer hyphae grow faster than the rest of a thallus, forcing it to split into pieces. When surrounded by a prothallus, areoles can make a lichen thallus appear tiled. Often diagnostically important, areoles are easily seen on some **saxicolous** (rock dwelling) crustose lichens, but a hand lens is often needed to see them on corticolous varieties.[14]

Figure 6C: Lecideine apothecia. Unlike lecanorine apothecia, the tissue forming the rims of *B. disciformis* apothecia contain hyphae derived from apothecial tissues and not the upper cortex of the thallus. Consequently, the perithecium of *lecideine* apothecium lacks photobiotic cells. In species like *B. disciformis*, perithecium is carbonized, making it appear black and sometimes barely distinguishable from disc portion of the apothecium, even with a hand lens.

Foliose Group

Foliose lichens have leafy thalli with upper and lower surfaces usually different in colour and texture. Foliose thalline lobes can be flat or tubular with margins that are rounded or angular and slightly upturned or curled, features that are important in species identification. Most foliose lichens are stratified into four layers (Figure 1). The upper cortical layer has thick-walled hyphae that protect the lichen from environmental stresses. Depending on genera, foliose lichens have algae or cyanobacteria as photobionts. Some have both. Many foliose lichen species are generalists and grow on rocks, soils, and headstones. They are the most common lichen group found on trees. Corticolous foliose thalli are often loosely attached to the bark substrate by rhizines or by a single holdfast. Some foliose lichens rise above the substrate, and are considered intermediaries called subfruticose.[14,24] Seven foliose species from seven different genera grow on the larch in my backyard.

Vulpicida pinastri (powdery sunshine lichen)



Vulpicida pinastri has a bright to dull yellow upper cortex and a dull yellow to white lower cortex that is often covered in rhizines. Thallus lobes are 1–2 cm wide with upturned margins that are a brighter yellow than the rest of the thallus and rimmed with **soredia** (Figure 7). *V. pinastri* grows on conifers, often within a metre or two of the ground, possibly using the snowpack as protection from harsh winter weather. It is a species threatened by climate change and habitat loss. The lichen has been studied for its vulpinic, pinastric and usnic acids, all ultraviolet blocking secondary metabolites.[25] *V. pinastri* is found across temperate regions in the northern hemisphere. The genus name *Vulpicida* means "fox killer", a reference to the toxicity of its vulpinic acid to wolves. The specific epithet *pinastri,* refers to its growth on *Pinaceae*, the pine family of trees.[14,15]

Figure 7A: Soredia. Many lichens reproduce asexually via vegetative structures called soredia. Unique to lichens, soredia are powdery or granular bundles of algal cells enveloped by hyphae, essentially making them lichens without a cortex. Soredia appear on ruptures (**soralia**) that form along lobal margins and along ridges on the upper cortex. Soredia are water-repellent and are actively discharged and dispersed by chance, often by the force of wind and falling raindrops or by contact with passing insects or trampling birds and animals. Heavier than spores, soredia are less likely to be dispersed great distances by wind. Soredia have an advantage over ascospores in synthesizing new lichens; because the alga and fungus are dispersed together, they can easily find one another after separating and relichenize (come back together) to form a new lichen. Spores, on the other hand, often contain only mycobiont cells; their germ tubes must find a compatible photobiont partner before a lichen can form, a requirement that is thought to have a lesser chance of succeeding.[13,17]

Parmelia sulcata (hammered shield lichen)

Parmelia sulcata has a grey-green, radial, and branching lobed thallus that is partially attached to the substrate by bottlebrush-like black rhizines (Figure 8A). The upper cortex has a distinct network of white ridges that help give the lichen's upper cortex a furrowed or hammered metal look. *P. sculata* reproduces mainly via soredia (Figure 8B) which on older specimens occur on cracked ridges and/or on lobe margins. Apothecia are rare on this species. *P. sculata* grows on well-lit coniferous and deciduous trees, on rocks and on undisturbed wooden surfaces. Often considered "weedy", the lichen is distributed throughout all of Canada and in the northern states across the USA. It is also widespread in temperate and subboreal regions in the southern hemisphere. The genus name *Parmelia* means "shield-like" while the specific epithet *sulcata* means furrowed.[14,15] When growing on the narrow branches and branchlets of my larch, the lichen is often elongated and far less shield-like in appearance.

Figure 8A: Rhizines. Rhizines of foliose lichens are linear, multi-cellular root-like bundles of hyphae that grow from the lower cortex. Typically using a disk-like holdfast, rhizines clasp substrate particles such as mineral grains in rocks and cork cells in bark to anchor a lichen in place. Often melanized, rhizines come in many shapes (branched, unbranched, forked, straight or tomentose) and often vary in density over the lower cortical surface. While rhizines may hold water, unlike roots they have no vascular mechanism to transport water or nutrients to the thallus. Foliose lichens without rhizines typically use a single central peg or holdfast to fasten the lichen to the substrate. Rhizines are diagnostically important in species identification and their shapes are more easily identifiable under a compound microscope.[13,14]

Figure 8B: Soredia. Soredia appear along the margins of *Parmelia sulcata*. *Parmelia* primarily reproduce in this manner.

Melanohalea septentrionalis (northern brown shield)

Figure 9

Melanohalea septentrionalis has a small, smooth to slightly wrinkled (matted) and appressed thallus often varying in shades of olive-green on the upper cortex and dark brown underneath. The broad and flat apothecia are abundantly clustered in the center of the thallus. The lichen lacks soredia and other asexual reproductive structures. The lower cortex is covered with brown unbranched rhizines. *M. septentrionalis* grows on a variety of coniferous and deciduous trees. It is distributed through the Boreal Forest of North America and Eurasia. The genus *Melanohalea* refers to the dark brown to melanin-rich thallus (*melano*) and to the American lichenologist Mason Hale, Jr. (*halea*). The specific epithet *septentrionalis*, means "northern regions" and refers to its boreal distribution.[14,15]

Lichenization:

Trees provide ideal environments for the wind dispersal of spores from apothecia rich lichens like *M. septentrionalis*. With few exceptions, spores contain no photobiotic cells, so they must land and germinate in the vicinity of a compatible partner and lichenize. Fortunately for many lichen-forming fungi, a variety of algae can be suitable partners. Once lichenized, the fungus can choose a new partner if a more compatible one becomes available or swap partners with another lichen or it can steal a more suitable partner from an adjacent lichen.[26]

Hypogymnia physodes (hooded tube lichen)

Figure10

The genus *Hypogymnia* contains most of the tube-like arboreal lichens common in our woods. *H. physodes* has a thallus of branching flattened tubes about 1-5 mm in width and variable in length. These tubes are smooth and pale greenish gray, often turning pale brown along their upturned and inflated lobe tips. Tube margins may be covered in soredia. The lower surface is wrinkled and typically brown at the margins and black towards the centre. *H. physodes* has a circumpolar distribution across boreal and temperate forests in the northern hemisphere. Preferring acidic bark, the lichen grows abundantly on coniferous trees but can also be found on deciduous ones. Because of its sensitivity to sulphur dioxide and heavy metals, *H. physodes* is often used as a **bioindicator** of air quality. The genus name *Hypogymnia* means "naked", a reference to its lack of rhizines on the lower cortex. The specific epithet *physodes* means "tubes".[14,27]

Bio-monitors:

Lichens are sensitive to air pollution because they have no way to regulate or rid themselves of airborne chemicals. Pollutants like sulphur dioxide and heavy metals tend to accumulate in lichens and affect thallus size, apothecial development, and overall survival. Consequently, the form and presence or absence of lichens are bioindicators of air quality. Individual lichens and whole lichen communities are often used to biomonitor the changing health of the environment and to evaluate the rate of recovery of areas where air pollution has been reduced or its sources eliminated.[8,28] The presence of *Bryoria*, *Hypogymnia* and *Ramalina* on the larch is an indication of the good air quality in my town.

Xanthoria polycarpa (pin-cushion sunburst lichen)

Figure 11

Xanthoria polycarpa has a bright yellow orange to orange pigmented thallus that appears as small irregular-shaped cushions (2.5 mm diameter) on the substrate. Near coastlines, the lichen tends to form large colonies. The thalline lobes are narrow, abundantly branched, and irregular. Apothecia are abundant, dark orange with bright orange rims, that are often contorted when crowded in the center of the thallus. *X. polycarpa* grows on nutrient rich bark, twigs, branches, wood, and rocks. The presence of this lichen is an indication of nitrogen-rich substates commonly associated with bird excrement. Distribution is scattered but common in Atlantic Canada, along the shores of the Great Lakes, and along the Pacific coast of BC and western USA. The genus name *Xanthoria* refers to the pigmented secondary metabolites that give the lichen its yellow colour. The specific epithet *polycarpa* means "many fruits", referring to its many apothecia. [14,28]

Lichen Pigmentation:

Many lichens lack pigments and appear as shades of green or grey-green when dry, then greener when wet. The rest are colourful because some of the secondary metabolites deposited in the upper cortex are pigmented. Yellowish colours come from usnic acid or pulvinic acids and from xanthones. Bright yellow, orange and red colours come from anthraquinones. Browns and blacks come from melanin. The brightest lichens often grow in areas of greatest direct exposure to the sun. Intraspecific changes in colouration are common because pigment concentrations can change depending on thallus age, exposure to sunlight, genetics, and various environmental factors.[14]

Physcia aipolia (hoary rosette lichen)

Physcia aipolia has a pale to dark grey thallus with narrow radiating lobes and upturned tips. The thallus is conspicuously spotted with white **maculae** (Figure 12A) Lower surface is white to pale brown and thickly covered in rhizines. Cilia may be present on lobal margins. The apothecia have black discs with grey rims, are up to 3 mm in diameter and typically scattered over the thallus. Sometimes apothecia are covered in a fine "frosting" called **pruina**, not present in Figure 12, maybe because the lichen has not yet matured. *P. aipola* grows on many tree types and dead wood in open habitats and is widely distributed across North America. The genus name *Physica* means "inflated" and refers to the appearance of its lobes. The specific epithet *aipolia* means "hoary" and refers to its pruinose apothecia. Its look-alike *Physcia stellaris* has about the same range but has flat or somewhat convex lobes that lack maculae.[14,22]

Figure 12A: Maculae. In some lichens the photobiont is not always continuous. Since the photobiont layer does contribute to the overall colour of the thallus, areas free of photobiont will show as a paler spots or lines called maculae, on the upper cortex.[14] Maculae textures resemble painting done by dabbing a sponge.

Platismatia glauca (ragbag lichen)

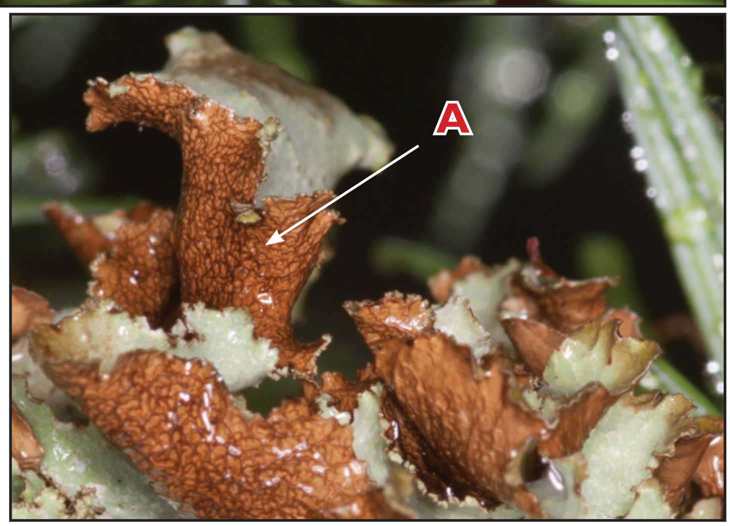


Figure 13A: Reticulation. In some foliose lichens, the upper or lower cortex may appear wrinkled or ridged. Called reticulations, these ridges are caused by the bundling of cortical hyphae. Lower cortical reticulation is characteristic of *P. glauca*, although it might appear differently from specimen to specimen.

The thallus of *Platismatia glauca* is more erect on the substrate that most foliose lichens and is considered an intermediary species. *P. glauca* has a ruffled and ragged looking thallus with wide, leafy, floppy lobes often pale green to white in colour on top but **reticulated** (interlaced lines) and pale brown below (Figure 13A) In older specimens, the margins are often divided into small rounded or angular brown lobes with isidia or soredia occurring abundantly, usually on different specimens. In the image above, isidia are beginning to appear on the margins of some lobes. Apothecia are rare and rhizines are scarce. *P. glauca* grows spruce and fir and is commonly found in the eastern section of Canada's boreal forest and in the mountain ranges of southern British Columbia and Alberta. The genus name *Platismatia* means "broad-lobed" while the specific epithet *glauca* means "pale grey", a reference to the colour of its upper surface.[14,15]

Tuckermannopsis orbata (variable wrinkle-lichen)

Figure 14

Tuckermannopsis orbata has a variable olive-brown to pale green thallus that typically darkens in colour when exposed to sunlight. The subfruticose thallus has wrinkled and irregular shaped lobes with black finger like projection called **isidia** (Figure 14A) and black hairs called **cilia** (Figure 14B) along its margins. Apothecia are common, flat, brownish, and usually develop near the lobe margins on both the upper and lower cortical layers. *T. orbata* grows on conifers and occasionally hardwoods but is limited to northeastern North America, British Columbia, and the upper western states of the USA. The genus is name after lichenologist Edward Tucker, while the specific epithet *orbata* refers to its circle-like apothecia.[15]

Figure 14A Isidia: Like soredia, isidia are unique to lichens. They appear as minute, finger-like outgrowths, usually on crustose, foliose, and fruticose lichen thalli. Isidia contain both lichen partners and a cortical layer. Because isidia increase the surface area of the lichen thallus, they likely contribute to photosynthetic output of the whole lichen. Brittle when dry, isidia are easily detached and dispersed by wind and/or animal vectors. Once they find a suitable habitat, isidia can grow into new lichen thalli.[8,13]

Figure 14B Cilia: Cilia are algae-free eyelash-like extensions of hyphae from the margins or apothecia of certain lichen thalli. Black or white in colour, they often vary in length and branching. Cilia might play a role in anchoring a lichen to its substrate, but their real purpose is unknown. Like many thallus features, cilia are diagnostically significant in species identification.[14,20]

Fruticose Group

Fruticose lichens are shrub- or hair-like in appearance and are believed to be the last lichen form to evolve. Missing a lower cortex, the three remaining layers of fruticose lichens are arranged concentrically to form cylindrical or flattened tubular stems (**podetia**) that grow singly or in tufts on soils, trees, and rocks.[8] Some podetia are hollow while others are filled with medullary hyphae. Fruticose lichens grow erect and keep their shape via long thick-walled cortical cells. Some hair-like fruticose species that hang like tresses from trees, have an elastic central cord for mechanical strength. Most fruticose lichens are attached directly to the substrate via a holdfast. Some hair-like varieties are simply draped over their tree branch substrates.[14] Three fruticose species from three separate genera were found growing on the lower trunk and branches of my larch tree.

Evernia mesomorpha (boreal oakmoss lichen)

Figure 15

Evernia mesomorpha thalli are composed of pale yellow-green tufts with divided, angular, wrinkled and uneven branches 4–8 cm long and around 3 mm wide. Branch margins are typically covered in coarse soredia. (Figure 15A). The lichen grows on the trunks and branches of both coniferous and deciduous trees. *E. mesomorpha* has a circumboreal distribution and is common throughout most of boreal North America and the continent's northern central plains.[14,15] The lichen is pollution tolerant, being one of the first species to recover after pollution damage.[26] The genus name *Evernia* means "many branches" while *mesomorpha* refers to it ridged branches. [15]

Figure 15A: Soredia. Apothecia are rare on *E. mesomorpha*, so the lichen's branch ridges are abundantly covered in coarse soredia,[26] only visible under magnification.

Ramalina dilacerata (punctuated ramalina)

Figure 16

Ramalina dilacerata has a pale greenish yellow, thin, flat, smooth and hallow thalli. The lichen appears as dense, and highly branched tufts and grows on coniferous tree trunks and branches. Immature specimens often lack the apothecia that form on the branch tips, so young *R. dilacerata* can easily be mistaken for some *Usnea* and *Alectoria* species. *R. dilacerata* is limited in distribution to most of Atlantic Canada, New England and the Great Lakes region and northern coastal mountain ranges of western North America. The genus name *Ramalina* means "twigs" while the specific epithet *dilaceratae* means "twice torn", a reference to its perforated branches.[14,15]

Epiphytes:

Corticolous lichens are epiphytes, organisms that grow on other organisms but gain their nutrition from the surrounding environment. Epiphytes must attach themselves to their bark hosts by holdfasts, formed of basal hyphae that extend deeper into the bark than rhizines, in some cases going all the way to the cambium layer. *E. mesomorpha*, *Ramalina dilacerata* and other fruticose lichens typically use a single or relatively few holdfasts. These attachments are not used as roots to gain nutrients from the tree nor do they directly harm the tree. However, some research suggests that holdfasts may open the inner bark to infectious microbes that can lead to tree health problems.[14]

Bryoria trichodes (horsehair lichen)

Bryoria trichodes is the only living hair lichen represented on the larch. Another hair lichen, likely an *Usnea*, was too young and possibly dead and could not be positively identified. *B. trichodes* has a dull, pale to dark brown pendant thallus that can hang up to 15 cm from the substrate. *B. trichodes* is held in place by a single holdfast or appears draped over a branchlet, suggesting it originated elsewhere and was snared by the branch. Apothecia and soredia are uncommon and are scattered over the thallus when present. Whitish **pseudocyphellae** (pores; Figure 17A) are short, oval and tend to bend the branches. *B trichodes* often grows on the twigs and branches of conifers particularly near rivers, lakes, and marshlands. The lichen is widely distributed in northeastern North America from the Great Lakes to Newfoundland. *Bryoria* is a combination of two older names of this group of hair lichens, *Bryopogon* and *Alectoria*, and *trichodes* meaning hairy.[14,15]

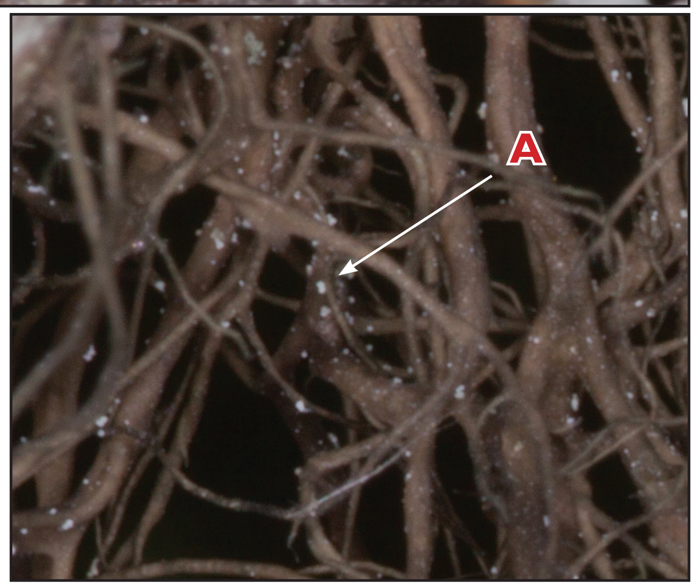


Figure 17A: Pseudocyphellae: If there is inadequate gas exchange in specific regions on the thallus, the lichen's upper cortex can break down, forming 0.1–2 mm diameter pores called pseudocyphellae that can help restore the equilibrium between gas exchange and the metabolic needs of the lichen. Pseudocyphellae can be filled by ascending medullary hyphae and often appear as white spots on the upper cortex.[29]

Figure 18: The species diversity on this eight cm section of the lowest branch contains over half of the lichens found.

Corticolous lichen ecology

While studying and photographing the lichens featured here (e.g. Figure 18), I thought about the biotic and abiotic factors that influenced the selection, growth, and colonization of the earliest lichen propagules to reach the larch years ago. My explanations of the lichen ecology (the study of the relationships between lichens and their environments and the places where they live and the relationships that sustains them) are based on observations of the tree during 2019 and on the books and open-source papers cited throughout this article.

Propagule Capture and Dispersal

Other than their relatively small size, lichen spores, soredia and isidia lack the wings, parachutes and burrs that aid dispersal in plants, yet they take advantage of the same dispersing vectors as plants to disperse. The larch in my backyard is isolated and exposed to the wind. The tree's rough bark can easily capture locally and regionally sourced propagules carried over them by the wind. Once established, the new lichen colonists can take further advantage of wind to dislodge new propagules and move them to the young and older surfaces of the fast-growing larch.[17,24,30–32]

Throughout 2020, I observed many birds and the occasional squirrel visit the larch (Figures 19, 20) Lichens propagules were likely dispersed from local and/or regional lichen populations by birds and small mammals who use the tree as a perch and as source of insectivorous food and nest building materials. Birds and animals are known to trample dry brittle lichens and dislodge their propagules, some of which get caught in their feet, fur, and feathers and to later deposit the propagules while perching and preening on the branches of the same or other trees. The presence of *Xanthoria,* a genus commonly associated with nitrogen-rich bird excrement, is an indication of the importance of birds in lichen dispersal.[14,32]

Corticolous Lichen Succession and Substrate Specificity

One of the oldest challenges in ecology is understanding the co-existence of species and explaining their community composition.[33] Of the hundreds of arboreal lichens

Figure 19: While photographing the lichens on my larch, a rather curious squirrel scampered down the tree trunk to within a metre of my camera. I was lucky to capture this image before it dashed away.

Figure 20: This boreal chickadee, photographed within two kilometres of my home, is perched on lichen covered branches. Birds like this are known participants in lichen propagule dispersal. Photo David Brophy.

identified in Newfoundland, why these fourteen species were selected to co-exist on my larch at the exclusion of others can be explained by a variety of factors including the nature of the resident lichens, the age of the tree, and the characteristics of larch bark as a living substrate.[24]

The diverse species growing on the backyard larch likely did not arrive and colonize the tree at the same time. Lichen succession on bark substrates suggests that widely distributed species capable of growing on a wide variety of substrates (generalists) were likely the first lichens to appear. These generalists would include circumboreal species such as the fast-growing *H. physodes*, and *P. sulcata* that seem to dominate the surface area of the tree, particularly the trunk. Corticolous lichen succession also suggests that fruticose species followed leaving the crustose lichens from *Lecanora* and *Buellia* as the climax species.[14,34] Presently, the last six to eight years of growth on the lower and branches appear lichen-free.

Corticolous lichen diversity can be influenced by the age of a tree, by bark characteristics such as texture, stability, chemistry, pH, and moisture retention, and by environmental factors such as light availability, air quality and temperature, and humidity levels.[35–38] Planted 30 years ago, the larch has had plenty of time to become colonized by lichens. Even as a sapling, the tree's widely spaced branches, scattered needled whorls and sparse branchlets left plenty of bark exposed to rainwater and sunlight, creating the alternating wet-dry cycles lichens seem to prefer for growth and survival. Over the years, wind dispersed propagules snagged by the tree's exposed and rough bark likely gave rise to the first lichens.[24] Resins in the bark's cork layer likely make the substrate acidic which likely favoured some lichen species while excluding others. The scaly and porous outer trunk bark also enabled the tree to absorb and retain water directly from rainfall and stem flow and as the water slowly evaporated humid microenvironments provided enough moisture to extend their growth periods for some time after a good rain.[24,39] Even moisture transpired through cracks in the bark and sap and gum residues in dissolutions that trickled down the branches and trunk may have favoured some species over others.[40]

Conclusion

We plant trees in our back yards to beautify our property, to celebrate the birth of a child, to pay tribute to a departed family member, to enjoy the shade it provides on a sunny day, or to provide shelter against winter winds. With time, that tree will likely have many roles: a holdfast for hammock, a support for a swing and a center beam for a treehouse. Ecologically, the tree will likely serve many more roles. As the larch on my property demonstrates, backyard trees, and the ones planted in community parks, provide important habitats in degraded urban landscapes and in suburban sprawl stripped of its trees for housing. Planted trees also have the potential to preserve biodiversity by providing a refuge for species across many Kingdoms as they help to bridge gaps in ecosystems fragmented by our towns and cities. While that seems so obvious now, it is something I had not considered when I planted the larch many years ago.

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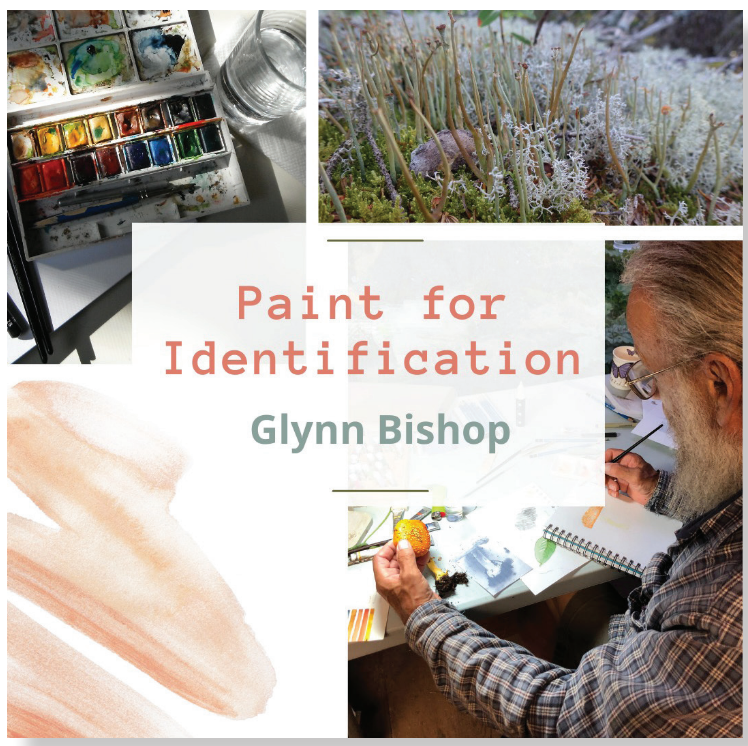

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The Empty Skillet

Keerthi's Wild Mushroom and Potato Stir-Fry

Recipe and images by Keerthika Ashokkumar

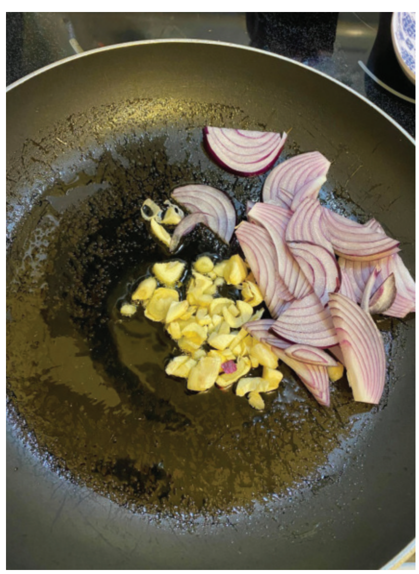
Ingredients:

– Wild mushroom mix (3-5 cups), cleaned and halved. Keerthi is using a mix of chanterelles, russulas, oyster, and hedgehog mushrooms here.
– 3-4 small potatoes
– 1/2 red onion, thinly sliced
– 5 cloves of garlic, coarsely chopped
– soy sauce
– Hoisin sauce
– black pepper to taste
– vegetable oil

Preparation:

1. Add oil, sliced red onion and chopped garlic to a heated frying pan. Cook together over medium heat until fragrant, about 5 minutes.

2. Add mushroom mix. Crowding the pan is OK in this recipe, since you will be cooking with the water from the mushrooms. Cook until mushrooms soften, about 2-3 minutes.



3. Add 1 tbsp soy soyce and 1 tbsp hoisin sauce. Add black pepper and continue to cook as mushrooms dewater, about 4-5 minutes.

4. Add sliced potatoes to the pan. Cover pan and cook over medium heat until potatoes soften.

5. Remove lid from pan. Turn heat to high, and stir-fry until sauce thickens and most of water is boiled off.

6. Serve hot with bread or rice.

Tip: To make a delicious soup, simply blend the cooked potato & mushroom stir-fry with some broth and serve!

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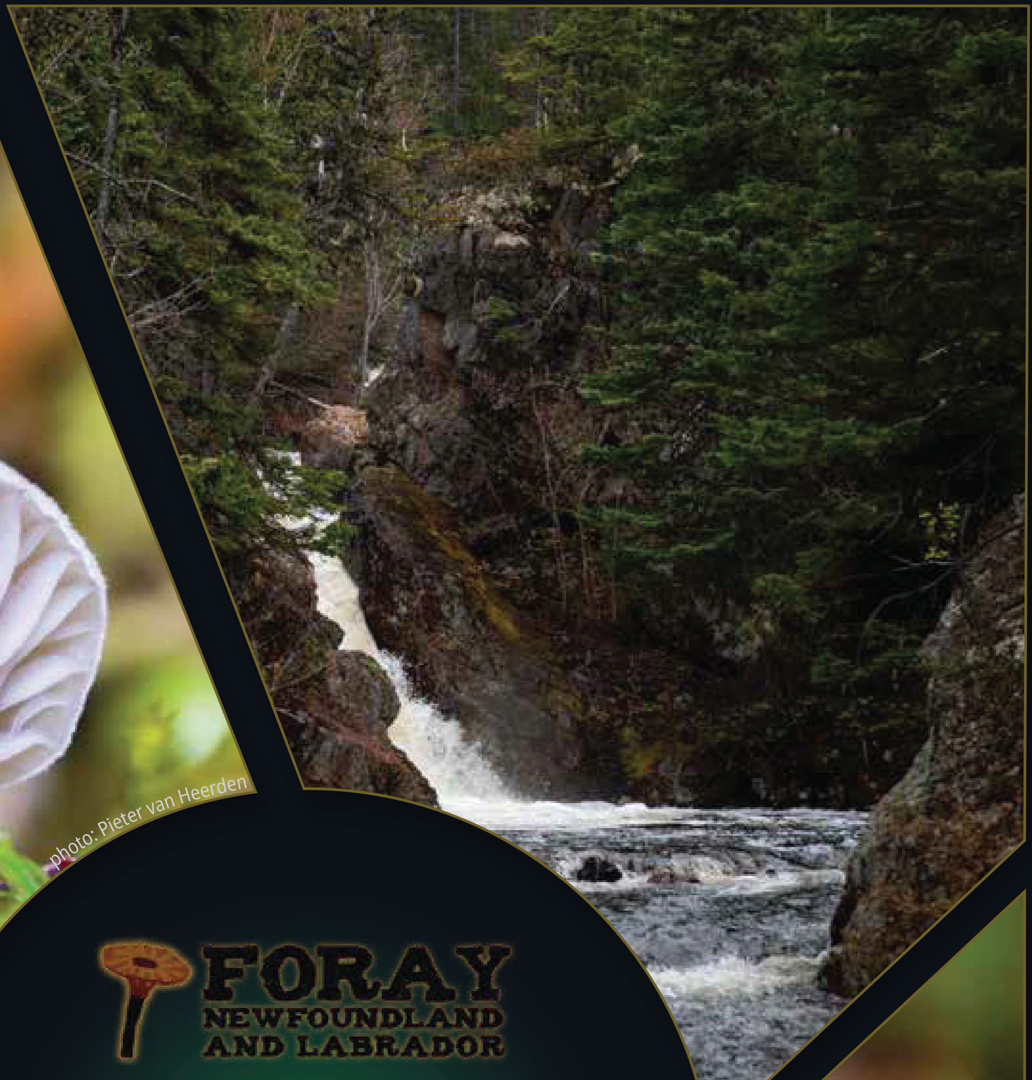

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