*The Lichenologist* (2023), **55**, 107–114
doi:10.1017/S0024282923000233

Standard Paper

# *Lecanora caledonica* – a new species in the *Lecanora intumescens* group (*Lecanoraceae*) from north-western Europe

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## Abstract

*Lecanora caledonica* is described as new to science. Molecular analyses show that it belongs to the *L. intumescens* group. It is also rather similar in appearance to *L. intumescens*, but differs mainly chemically in containing only atranorin and an unknown UV+ ice blue substance. There are also anatomical and morphological differences to the other species of the group. The new species has a pronounced oceanic distribution and is so far known only from western Norway and Scotland.

**Keywords:** corticolous; DNA; *Lecanora albella*; lichen; molecular; Norway; oceanic; Scotland

(Accepted 17 May 2023)

## Introduction

*Lecanora intumescens* (Rebent.) Rabenh. and closely related species were for a long period of time regarded as belonging to the *L. albella* group (Imshaug & Brodo 1966; Brodo *et al.* 2019). However, during the past two decades there have been several studies showing that this group can be divided into three separate phylogenetic lineages (Grube *et al.* 2004; Zhao *et al.* 2016; Malíček *et al.* 2017): the *L. albella/subcarnea* group, *L. rupicola* group and the *L. intumescens* group. The result of these studies leaves *L. intumescens* and allies in a rather small group comprising *L. intumescens*, *L. cateilea* (Ach.) A. Massal. and *L. excludens* Malme. The last is regarded here as the correct name for the taxon *L. septentrionalis* H. Magn. (see Brodo *et al.* (2019) for an explanation). Based on morphological, chemical and molecular studies, we here describe *L. caledonica*, a fourth species of the group, as new to science.

## Materials and Methods

Fresh material of the new species was collected in Norway (HH) and Scotland (UA); this was complemented with material of related species, mainly from Sweden and Norway but to some extent also from Alaska and Austria. Collections of the new species are deposited in E, TRH and LD. A small number of old specimens was found in the herbaria of O and TRH, mostly hidden under *Lecanora subfusca* auct.

The specimens were examined by interference contrast and light microscopy. Anatomical features were measured on hand-cut sections or squash preparations mounted in water. Morphological characters were measured on dry material using a dissecting microscope (×40). Chemical reagents used were 10% potassium hydroxide (K), undiluted standard bleach (C), and paraphenylenediamine in ethanol (Pd). Crystals were studied in polarized light (POL). Spore dimensions are calculated from ten measurements per specimen. Data on spore dimensions are presented in the following way: (min. extremes) 85% of the variation with a mean in italics (max. extremes). Specimens were studied by TLC according to standard methods (Orange *et al.* 2001).

New sequences for this study (Table 1) were produced using direct PCR according to Arup *et al.* (2015). Amplifications were made of the internal transcribed spacer regions (nrITS) and the large subunit (nrLSU) of the nuclear ribosomal RNA genes, and the small subunit of the mitochondrial ribosomal RNA gene (mtSSU). Primers used for amplification were ITS1F (Gardes & Bruns 1993), ITS4 (White *et al.* 1990), AL1R (Döring *et al.* 2000), LR5 or LR6 (Vilgalys & Hester 1990), mrSSU1 (Zoller *et al.* 1999) and mrSSU7 (Zhou & Stanosz 2001). The PCR parameters included an initial hold at 94 °C for 5 min, then denaturation at 94 °C for 1 min, annealing at 50 °C or 54 °C (mtSSU) or 53–56 °C (nrITS and nrLSU) for 1 min, decreasing 1 °C per cycle for the first six of the 39 cycles (touchdown), and an extension at 72 °C for 3 min. The sequencing was carried out by Macrogen Inc., South Korea, using the same primers as for the PCR. The two resulting strands of each gene were assembled using Geneious v. 11.1.5. Subsequent alignments were performed in the same program and adjusted manually. Sequences have been submitted to GenBank as indicated in Table 1.

Two alignments were prepared: one three-gene alignment combining data from the nrITS, nrLSU and mtSSU genes, including 23 representatives of the genus *Lecanora* s. lat., 2238 bases long, and a second one with 27 taxa, 525 bases long, of only ITS sequences of the *L. intumescens* group and close relatives. *Protoparmelia memnonia* Hafellner & Türk was used as an outgroup in the first

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**Cite this article:** Arup U, Holien H and Coppins BJ (2023) *Lecanora caledonica* – a new species in the *Lecanora intumescens* group (*Lecanoraceae*) from north-western Europe. *Lichenologist* 55, 107–114. https://doi.org/10.1017/S0024282923000233

**Table 1.** Sequences of *Lecanora* and allied species, newly produced (in bold) or downloaded from GenBank used in the analyses, with voucher information and Accession numbers.

| Species | Country, collector, collector number, herbarium | nrITS | nrLSU | mtSSU |
|---|---|---|---|---|
| *Lecanora allophana* | Austria, *Arup* L98005, LD | AF159939 | **OQ946442** | KY502459 |
| *L. argentata* | Sweden, *Arup* L97562, LD | **OQ945701** | **OQ946443** | **OQ945755** |
| *L. bicincta* | Unknown, *Trinkhaus* 102, GZU | AY412264 | | |
| *L. caledonica* 1 | Scotland, *Arup* L10182, LD 2292600 | **OQ945702** | | |
| *L. caledonica* 2 | Norway, *Holien* 12577c, TRH L-13956 | **OQ945703** | | |
| *L. caledonica* 3 | Norway, *Holien* 10546, TRH L-13958 | **OQ945704** | | |
| *L. caledonica* 4 | Norway, *Holien* 14122, TRH L-19013 | **OQ945705** | | |
| *L. caledonica* 5 | Norway, *Holien* 7782a, TRH L-13959 | **OQ945706** | | |
| *L. caledonica* 6 | Norway, *Holien* 16072, TRH L-19431 | **OQ945707** | **OQ946444** | **OQ945756** |
| *L. campestris* | Sweden, *Arup* L97370, LD | AF159930 | DQ787361 | DQ787362 |
| *L. carpinea* | Austria, *Arup* L97007, LD (ITS, LSU); Sweden *Arup* L03192, LD (mtSSU) | AF070043 | DQ787363 | DQ787364 |
| *L. cateilea* 1 | Unknown, *Goward* & *Poelt*, GZU | AY541250 | | |
| *L. cateilea* 2 | Alaska, *Tønsberg* 44295, BG | **OQ945708** | | |
| *L. cenisia* | Austria, *Malíček* 5869 (ITS, mtSSU); *Bushbom* 3015, F (LSU) | KY548047 | AY532992 | KY502425 |
| *L. chlarotera* | Netherlands, *Sparrius* 9312, hb. Sparrius | **OQ945709** | **OQ946445** | **OQ945757** |
| *L. epibryon* | Austria, *Wilfling* 1289, GZU | AY541251 | | |
| *L. excludens* 1 | Norway, *Palice* 21929 | MK541647 | | |
| *L. excludens* 2 | Norway, *Arup* L18248, LD | **OQ945710** | **OQ946446** | **OQ945758** |
| *L. excludens* 3 | Alaska, *Tønsberg* 45033, BG | **OQ945711** | | |
| *L. glabrata* | Sweden, *Fritz*, LD (ITS, LSU); *Arup* L011200 LD (mtSSU) | **OQ945712** | DQ787359 | DQ787360 |
| *L. intricata* | Austria, *Arup* L97370, LD | AF070022 | DQ787345 | DQ787346 |
| *L. intumescens* 1 | Norway, *Holien* 16084f, TRH L-19685 | **OQ945713** | **OQ946447** | **OQ945759** |
| *L. intumescens* 2 | Norway, *Holien* 12577b, TRH L-19014 | **OQ945714** | | |
| *L. intumescens* 3 | Norway, *Holien* 12577a, TRH L-19015 | **OQ945715** | | |
| *L. intumescens* 4 | Austria, *Zeiner* 453, GZU | AY541253 | | |
| *L. intumescens* 5 | Austria, *Hafellner* 51153, GZU | AY541254 | | |
| *L. intumescens* 6 | Ukraine, *Malíček* 8203 | KY548039 | | |
| *L. lojkaeana* | Unknown, *Grube* s. n., GZU | AY398709 | | |
| *L. orosthea* | Sweden, *Arup* L97364, LD (ITS, LSU); Czech Republic, *Vondrák* JV24522, PRA (mtSSU) | AF070035 | U244 | OK465589 |
| *L. polytropa* | Austria, *Grube*, GZU (ITS, LSU); Sweden, *Arup* L93568, LD (mtSSU) | AF070017 | DQ787347 | DQ787348 |
| *L. pulicaris* | Sweden, *Arup* L22109, LD | **OQ945716** | **OQ946448** | **OQ945760** |
| *L. rupicola* | Austria, *Grube* s. n., GZU (ITS, LSU), Czech Republic, *Vondrák*, PARA (mtSSU) | **OQ945717** | **OQ946449** | OK465591 |
| *L. salicicola* | Sweden, *Arup* L20564, LD | **OQ945718** | **OQ946450** | **OQ945761** |
| *L. sulphurea* | Sweden, *Arup* L96006, LD (ITS, LSU); Sweden, *Arup* L01823, LD (mtSSU) | AF070030 | DQ787355 | DQ787356 |
| *L. swartzii* | Austria, *Arup* L97114, LD | AF070036 | | |
| *Myriolecis perpruinosa* | Austria, *Wilfling* 1224, GZU (ITS, LSU); *Arup* L97320 LD (mtSSU) | AF070025 | DQ787343 | DQ787344 |
| *Protoparmelia memnonia* | Sweden, *Arup* L97388, LD (ITS, LSU); *Arup* L01841, LD (mtSSU) | AY541276 | DQ787366 | DQ899312 |
| *Protoparmeliopsis achariana* | Sweden, *Hafellner* 30569, GZU (ITS); *Arup* L03216, LD (LSU, mtSSU) | AF070019 | DQ787341 | DQ787342 |
| *P. macrocyclos* | Sweden, *Arup* L97570, LD | AF159933 | **OQ946451** | |
| *P. muralis* | Austria, *Wilfling* 2536, GZU (ITS, LSU); Sweden, Arup L03196, LD (mtSSU) | AF159922 | DQ787339 | DQ787340 |

(*Continued*)

https://doi.org/10.1017/S0024282923000233 Published online by Cambridge University Press

**Table 1.** (*Continued*)

| Species | Country, collector, collector number, herbarium | nrITS | nrLSU | mtSSU |
|---|---|---|---|---|
| *Rhizoplaca chrysoleuca* | Kazakhstan, *Moberg & Nordin* 190, GZU (ITS, LSU); Norway, *Arup* L03454, LD (mtSSU) | AF159940 | DQ787353 | DQ787354 |
| *R. melanophthalma* | Austria, *Obermayer* 2701, GZU (ITS, LSU); Chile, *Arup* L01500, LD (mtSSU) | AF159935 | DQ787351 | DQ787352 |

alignment, and *Protoparmeliopsis muralis* (Schreb.) M. Choisy in the second. Introns in all the aligned genes and ambiguously aligned parts were excluded from the alignment. The alignments of the three different genes were first analyzed separately to check for incongruence between genes, but none was detected. A conflict was assumed to be significant if two different relationships were both supported with posterior probabilities ≥ 0.95.

Data were analyzed using the program MrBayes v. 3.2.4 (Ronquist *et al.* 2012). A suitable model of molecular evolution was selected using the Bayesian Information Criterion (BIC) as implemented in jModelTest v. 2.1.4 (Guindon & Gascuel 2003; Darriba *et al.* 2012), evaluating only the 24 models available in MrBayes v. 3.2.0 (Ronquist *et al.* 2012). For the combined analysis, the SYM + I + G model was found to be optimal for the nrITS, K80 + I + G for nrLSU and HKY + I + G for the mtSSU data set. For the ITS only data set, HKY + G was found to be optimal. No molecular clock was assumed. Three parallel runs with 2 000 000 generations starting with a random tree and employing six simultaneous chains were executed, five of which were incrementally heated with a temperature of 0.10. Analyses were diagnosed every 1000 generations in the last 50% of the tree sample and automatically halted when convergence was reached. Convergence was defined as a standard deviation of splits (of frequency 0.1) between runs below 0.01. Every 1000th tree was sampled. A majority-rule consensus tree was constructed from the post-burn-in tree samples. The consensus trees were visualized using FigTree v. 1.4.4 and redrawn in Adobe Illustrator.

## Results

The results of the molecular studies are presented in two phylogenetic trees (Figs 1 & 2). The three-gene tree (Fig. 1), resulting from analysis of nrITS, nrLSU and mtSSU sequences, shows the position of the new species *L. caledonica* within *Lecanora* s. lat., where it clearly belongs to the *L. intumescens* clade that is fully supported. In this rather limited analysis of the genus *Lecanora*, the *L. rupicola* group is situated in a sister position to the *L. intumescens* group but without support. The second tree (Fig. 2), based on nrITS sequences of *Lecanora*, further supports the position of the new species inside the *L. intumescens* clade, with *L. excludens* at the base of the clade and *L. caledonica* as sister to the two species *L. intumescens* and *L. cateilea*. Its independence as a species separate from others in the group is also clearly demonstrated, with all terminal clades in the group fully supported.

*Lecanora caledonica* is also clearly different from the other species in the group in morphological and chemical characters.

## Taxonomy

### *Lecanora caledonica* Holien, Coppins & Arup sp. nov.

MycoBank No.: MB 848677

Similar to *Lecanora intumescens* but differs chemically in containing atranorin, zeorin and an unknown UV+ ice blue substance versus atranorin, psoromic acid, ±2-*O*-demethylpsoromic acid, chloratranorin and zeorin. It further differs in the non-pruinose apothecium disc and shorter ascospores (9–14 μm versus 11.5–18 μm).

Type: Norway, Nord-Trøndelag, Flatanger, Lauvsnesodden, along the old church trail, corticolous on young *Sorbus* in deciduous forest, 64.50592°N, 10.88914°E, alt. *c.* 12 m, on *Sorbus aucuparia*, 13 December 2020, *H. Holien* 16072 (TRH L-19431—holotype; LD—isotype). GenBank nos: OQ945707, OQ946444, OQ945756.

(Fig. 3)

*Thallus* 0.05–0.25(–0.45) mm thick, up to several cm wide, continuous, smooth to finely cracked or areolate; areolae 0.3–1.3 mm diam., irregular in outline, even and smooth to uneven or occasionally slightly verruculose or squamulose, of different shades of pale grey, sometimes yellowish grey; margin clearly delimited, sometimes by a thin black line against other thalli or as a white, slightly fimbriate prothallus.

*Apothecia* normally present and abundant, 0.4–1.5(–2.0) mm diam., adnate to sessile, round to irregular to often angular from compression in dense aggregates; *disc* varying greatly in colour from pale beige-orange to dark brown or almost black, normally matt, without pruina, slightly concave to somewhat convex, sometimes flexuous; thalline margin prominent and persistent, (30–)50–150(–240) μm thick (dry, seen from above), level with or slightly raised above disc, even to uneven or somewhat ridged, of thallus colour or paler; *epihymenium* beige-grey to brown-blackish, with small, POL+ granules on top and between the paraphyses (*pulicaris*-type), dissolving in K but not in N, when dark pigment is present N+ red, K+ olive; *hymenium* 60–80 μm thick; *hypothecium* hyaline, 125–400 μm thick; *paraphyses* 1.5–2 μm wide, simple to slightly branched, straight to flexuous, with tips to 3 μm wide; *amphithecium* usually filled with small POL+ crystals dissolving in K but not in N, and the pseudocortex with varying amounts of medium coarse crystals, to 8 μm large, not dissolving in K or N, and a layer of algae just below the hypothecium; pseudocortex indistinctly delimited from the medulla, up to 200 μm thick at base; *asci* 50–68 × 11–17 μm, with eight spores; *ascospores* simple, narrowly to broadly ellipsoid or ovoid, ends round or slightly pointed, (9.0–) 10.0–*11.46*–13.0(–14.0) × (4.8–)5.0–*6.78*–8.0(–9.5) μm, ratio spore length/width = 1.18–*1.72*–2.30 ($n$ = 100), spore wall 0.8–1.0 μm.

*Pycnidia* sometimes present, immersed, as dark brown to blackish dots; *conidia* filiform, curved to almost straight, 18–25 × 0.8 μm.

*Chemistry.* Atranorin, zeorin and an unknown substance ($R_f$ values A5, B4, C5) that turns UV+ ice blue before charring (Fig. 4) and an additional substance in minor concentration (best seen on the A-plate, $R_f$ value 6). The unknown substances are colourless after treatment with sulphuric acid and heat. Thallus and apothecial margin K+ yellow, C−, KC+ yellow, Pd+ pale yellow, UV−.

https://doi.org/10.1017/S0024282923000233 Published online by Cambridge University Press

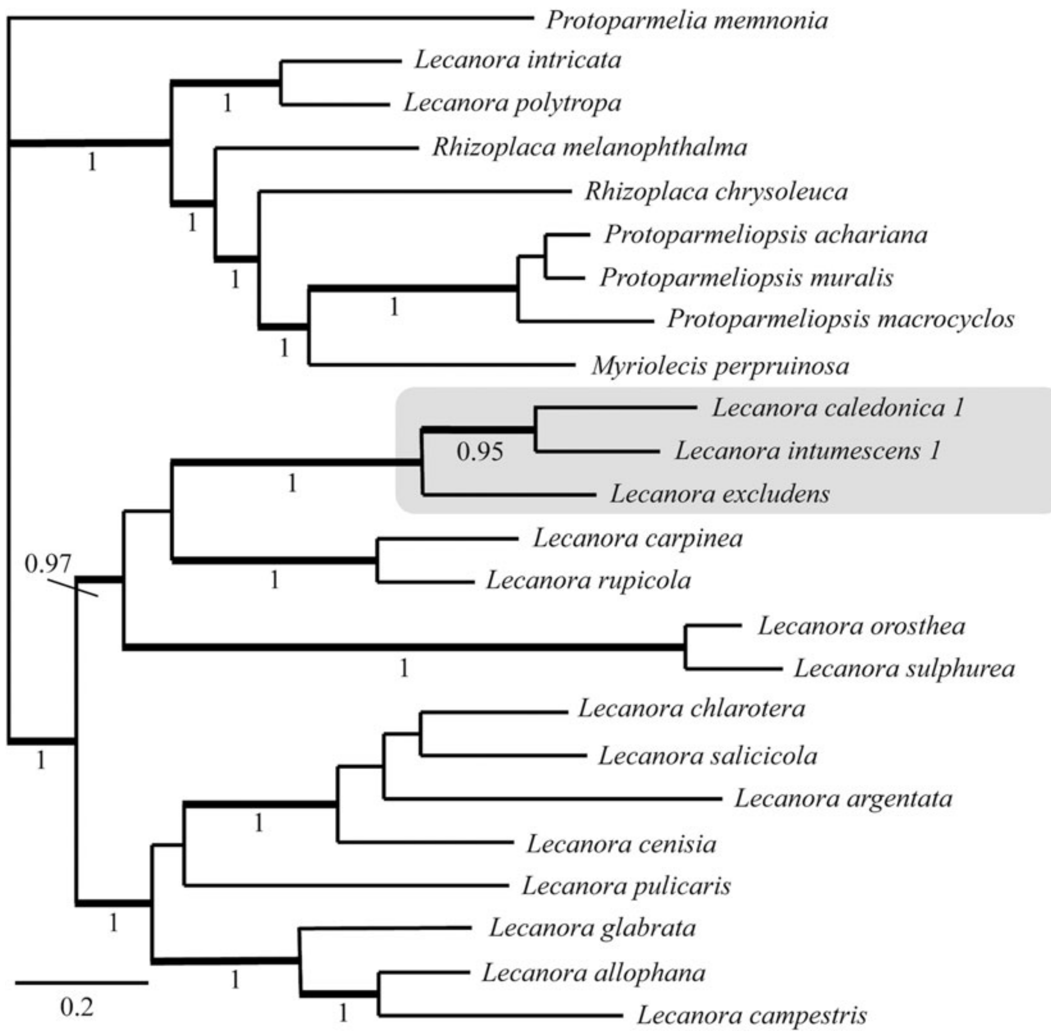


**Figure 1.** Majority-rule consensus tree based on a Bayesian MCMC analysis of a combined data set of the ITS, LSU and mtSSU genes showing the position of *Lecanora caledonica* (shaded area) well inside the *L. intumescens* group. Branches with posterior probabilities ≥ 0.95 are shown in bold.

*Etymology.* The name *caledonica* refers to Scotland, where the species was first discovered.

*Ecology and distribution.* *Lecanora caledonica* is corticolous, occurring on deciduous trees with smooth bark. It is most often found on the trunks, but also on coarse branches. In Norway it is most commonly found on *Alnus incana* and *Sorbus aucuparia*, but it has also been found on *Populus tremula*, *Salix aurita* and *S. caprea*. In Trøndelag it is particularly frequent in secondary forests along the coast, dominated by deciduous trees developed after logging. It is also quite common in open forest close to the tree limit, for example in the Fosen peninsula in Trøndelag, or along rivers, streams and mires.

The species is part of a lichen community dominated by crustose species that is overgrown later in the succession by parmelioid foliose lichens in particular. Among accompanying species on the trunks are *Arthonia radiata* (Pers.) Ach., *Arthopyrenia analepta* (Ach.) Massal., *Biatora toensbergii* Holien & Printzen, *Buellia disciformis* (Fr.) Mudd, *B. griseovirens* (Turner & Borrer ex Sm.) Almb., *Fuscidea arboricola* Coppins & Tønsberg, *Lecanora argentata* (Ach.) Malme, *L. carpinea* (L.) Vain., *L. farinaria* Borrer, *L. intumescens*, *L. symmicta* (Ach.) Ach., *Lecidella elaeochroma* (Ach.) Choisy, *Melanelixia glabratula* (Lamy) Sandler & Arup, *M. subaurifera* (Nyl.) O. Blanco *et al.*, *Melanohalea exasperata* (De Not.) O. Blanco *et al.*, *Micarea peliocarpa* (Anzi) Coppins & R. Sant., *Parmelia saxatilis* (L.) Ach. s. lat., including *P. ernstiae* Feurerer & Thell/*P. serrana* A. Crespo *et al.*, *P. sulcata* Taylor, *Platismatia glauca* (L.) W. L. Culb. & C. F. Culb., *Ramalina farinacea* (L.) Ach. and *Usnea* spp.

*Lecanora caledonica* seems to be an oceanic species and is so far known only from north-western Scotland (Fig. 5) and from coastal regions of Norway, from the areas around Bergen in the south, north to the surroundings of Tromsø (Fig. 6). Most Norwegian collections are from Trøndelag and Nordland counties and all localities in Norway, except the most northern one, are within the markedly oceanic section O2 (see Moen 1999). Its vertical distribution ranges from around sea level to *c.* 400 m. Since the species has been known in Scotland for quite some time, the distribution there is fairly well known (Fig. 5). In Norway, it is expected to also occur more frequently south of Trøndelag.

Lichen species with a similar distribution in Europe include, for example, *Arthothelium norvegicum* Coppins & Tønsberg (Coppins & Tønsberg 1984), *Bacidia caesiovirens* S. Ekman & Holien (Ekman & Holien 1995), *Biatora toensbergii* (Printzen 1995) and *Hypogymnia hultenii* (Degel.) Krog (Westberg *et al.*

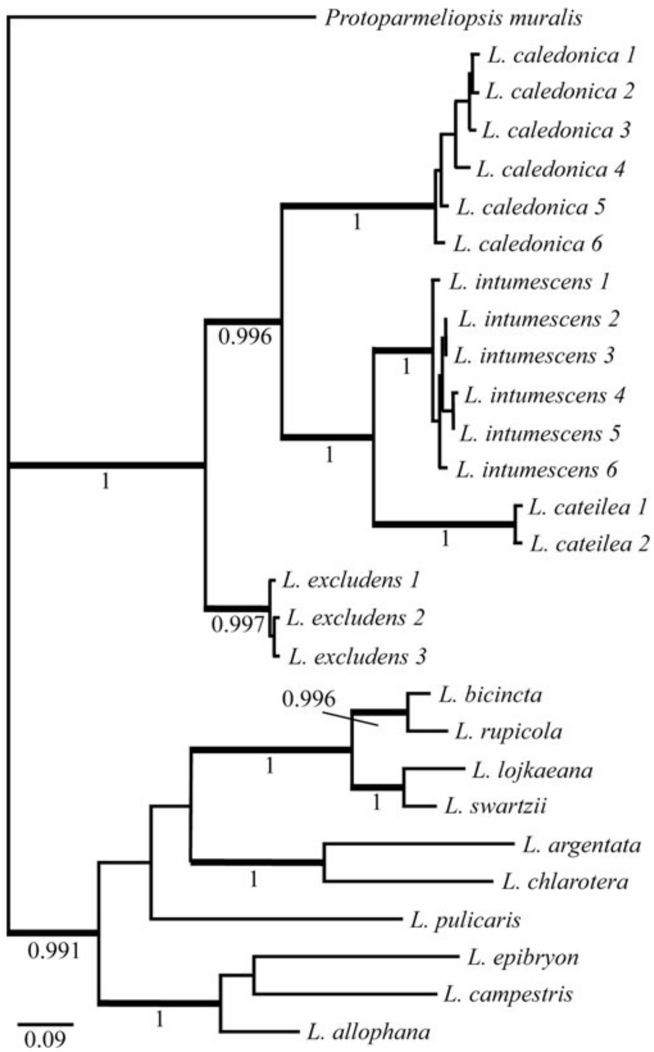


**Figure 2.** Majority-rule consensus tree based on a Bayesian MCMC analysis of ITS data of the *Lecanora intumescens* group and allies showing the position of *L. caledonica* in relation to the other species of the group. Branches with posterior probabilities ≥ 0.95 are shown in bold.

2011) which fit into the so-called Trøndelag phytogeographic element in the European lichen flora (Holien & Tønsberg 1996).

In Scotland, *Lecanora caledonica* has a very similar habitat ecology and altitudinal range, with *Alnus glutinosa* replacing *A. incana* as one of the main phorophytes. It has also been recorded more rarely on *Acer pseudoplatanus*, *Crataegus* sp., *Fraxinus excelsior*, *Prunus padus* and *Ulmus glabra*. On one occasion (*Coppins* 21574) it was found parasitized by *Skyttea lecanorae* Diederich & Etayo, a common parasite on *Lecanora chlarotera* Nyl., *L. pulicaris* (Pers.) Ach., and more rarely *L. farinaria*, in the Scottish Highlands.

*Remarks.* There is a considerable variation in disc colour, from pale beige to dark brown. A large part of this variation can sometimes be found within a single specimen and even within a single apothecium (Fig. 3B & C). This variation is due to a dark pigment in the epihymenium occurring in varying amounts. In cross-section it can be visualized as it reacts with N (pale red), and K (olive). Normally, the new species can be recognized by the uneven, rather thick, but smooth margin similar to the one usually found in *L. intumescens*. These two species are similar but *L. caledonica* differs chemically, which can be seen in the Pd reaction (Pd− instead of Pd+ deep yellow) and in the non-pruinose discs. According to Brodo *et al.* (2019), a small number of specimens of *L. intumescens* from southern Europe lacked psoromic acid based on TLC, although they reacted Pd+ yellow on the apothecial margin. Such specimens most certainly represent variations in the amount of psoromic acid in this species. The spores in *L. caledonica* also appear to be shorter, 9–14 µm long rather than 11.5–18 µm in *L. intumescens*. Another difference is the geographical distribution that is pronounced oceanic in *L. caledonica* whereas *L. intumescens* has a much wider distribution. *Lecanora caledonica* differs from *L. excludens* mainly in the much thicker thalline margin, generally smaller spores, larger apothecia and in the different secondary chemistry. *Lecanora cateilea* differs from the new species in having 12–16 spores per ascus, a different chemistry, in slightly pruinose apothecium discs and in smaller spores. Occasionally, the POL+ crystals in the epihymenium of *L. caledonica* are very few or even entirely absent, giving the disc a more shiny appearance (Fig. 3D) and making it more similar to *L. allophana* Nyl.; however, this species has a very different ecology, occurring on trees with higher pH and coarse bark (i.e. *Populus*, *Fraxinus* and *Acer*), and has more raised apothecia with a more narrow base and a different chemistry.

*Selected material studied.* **Norway:** *Hordaland*: Moster, viii 1915, *Havaas* & *Lynge* (O L-110198). *Nordland*: Brønnøy, ad Saulas paroch, Velfjord, undated, *J. M. Norman* (O L-110896); Leirfjord, N side of Lake Svartdalsvatnet, on *Alnus incana*, 66.18330°N, 13.27540°E, alt. 40 m, 2006, *H. Holien* 10689 (TRH L-19438); Rødøy, W of Kilboghamn, on *Sorbus aucuparia*, 66.49010°N, 13.21130°E, alt. 35 m, 2013, *H. Holien* 14122 (TRH L-19013); Gildeskål, Storvikvatnet W, on *Alnus incana*, 66.95810°N, 13.84509°E, alt. 210 m, 2022, *H. Holien* 16536 (TRH L-33525); Gildeskål, Inndyr, Lauvvatnet, on *Alnus incana*, 67.04031°N, 14.06149°E, alt. 105 m, 2022, *H. Holien* 16480 (TRH L-33518); Gildeskål, Kjellingelva, on *Alnus incana*, 67.05989°N, 14.35477°E, alt. 85 m, 2022, *H. Holien* 16618c (TRH L-33524); Gildeskål, Følvikelva, on *Alnus incana*, 67.13203°N, 14.20378°E, alt. 45 m, 2022, *H. Holien* 16608 (TRH L-33521); Bodø, Godøystraumen, on *Salix caprea*, 67.23817°N, 14.70939°E, alt. 5 m, 2022, *H. Holien* 16413 (TRH L-33527); Steigen, in Stegen ad Præstkontind, undated, *J. M. Norman* (O L-110845); Vestvågøy, Stamsund church, on *Sorbus aucuparia*, 68.14410°N, 13.83990°E, alt. 20 m, 2011, *H. Holien* 13031a (TRH L-19435); Sørfold, Aspfjorddalen, on *Alnus incana,* 67.4836°N, 15.6008°E, alt. 40 m, 2014, *H. Holien* 14499 (TRH L-19571). *Nord-Trøndelag*: Flatanger, Lake Honnavatnet NE, on *Alnus incana*, 64.41262°N, 10.92026°E, alt. 160 m, 2021, *H. Holien* 16336a (TRH L-19889); Flatanger, Lauvsnes, N end of Lake Lauvsnesvatnet, on *Sorbus aucuparia*, 64.49573°N, 10.91524°E, alt. 25 m, 2021, *H. Holien* 16084 (TRH L-19682); Flatanger, Vollan SE, Buknotten, on *Sorbus aucuparia*, 64.49909°N, 10.96098°E, alt. 25 m, 2022, *H. Holien* 16690 (TRH L-33617); Namsos (Namdalseid), between Skardbergfjellet and Lakshølhaugen, on *Populus tremula*, 64.38490°N, 11.17460°E, alt. 85 m, 2001, *H. Holien* 8778a (TRH L-19440); Nærøysund (Vikna), Kalvøya, S of Kalvøyskardsfjellan, on *Salix aurita*, 64.97140°N, 10.83880°E, alt. 10 m, 2011, *H. Holien* 13452 (TRH L-19430); Nærøysund (Nærøy), Kolvereid, the churchyard, 24 vii 1931, *O. A. Høeg* (TRH L-40662). *Sør-Trøndelag*: Osen, SW

https://doi.org/10.1017/S0024282923000233 Published online by Cambridge University Press

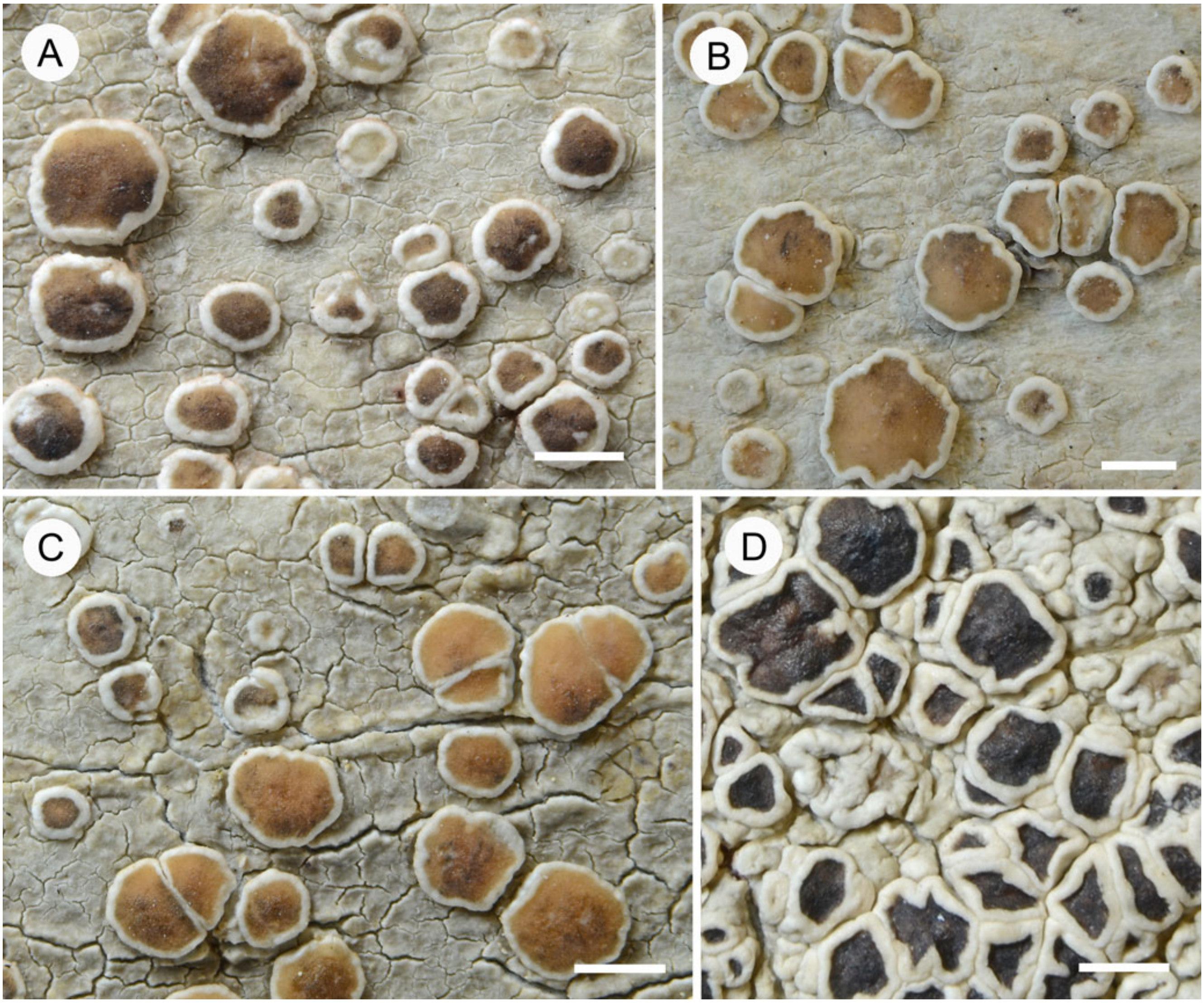


**Figure 3.** Habitus of *Lecanora caledonica*. A, common form with medium brown apothecium discs; holotype (TRH). B, another common form with paler beige discs; L-19682 (TRH). C, a form showing the variation that is commonly seen in the disc colour, from beige to brown, and often somewhat mottled; L-19429 (TRH). D, a less common form with dark brown, slightly glossy discs; L-13959 (TRH). Scales = 1 mm. In colour online.

of Storkangsen, N of Essen lakelet, on *Sorbus aucuparia*, 64.21280°N, 10.78110°E, alt. 375 m, 2010, *H. Holien* 12623 (TRH L-13957); Åfjord, by Lake Måmyrvatnet, Nesodden, on *Sorbus aucuparia*, 64.098364°N, 10.549687°E, alt. 260 m, 1999, *H. Holien* 7782a (TRH L-13959); Åfjord, Roan, Inner Vargfossnessa Nature Reserve, along River Lonelva, corticolous on *Alnus* in humid forest, 64.127540°N, 10.66370°E, alt. 310 m, 2006, *H. Holien* 10520 (TRH L-19439). *Troms*: Tromsø, in insula Tromsø ad Fredriksberg, undated, *J. M. Norman* (O L-110900); Tromsø amt, Ramfjorden, 5 vi 1910, *B. Lynge* (O L-115132).—**Great Britain:** *Scotland*: **V.C. 96,** Easterness, Drumnadrochit, Divach Cottage by Divach Burn, on *Salix*, NH4927, *c.* 100 m, 1975, *B. J. Coppins* 3854 (E); Glen Strathfarrar. between Dunmaglass and Coille Gharbh, on *Salix*, NH33, alt. *c.* 100 m, 1975, *B. J. Coppins* et al. 2250 (E); Dundreggan, near Dundreggan Lodge, on twigs of fallen *Populus tremula*, NH32611457, *c.* 130 m, 29 viii 2014, *J. R. Douglass* s. n. (hb. Douglass); **V.C. 97,** Westerness, Loch Arkaig, S side, Aird Nòis, on *Alnus glutinosa* by mouth of burn, NN081907, alt. 50 m, 2018, *B. J. Coppins* (25979) & *A. Acton* (E); **V.C. 104,** North Ebudes, Skye, Kyleakin, South Obbe to Caisteal Maol, on *Sorbus aucuparia*, NG7526, 2010, *U. Arup* L10182 (LD); **V.C. 105,** West Ross, Beinn Eighe NNR, Allt a'Chuirn, on *Sorbus aucuparia*, NH0060, 1984, *B. J. Coppins* 10864 (E); Beinn Eighe NNR, Coille na Glas-leitir, upper part of forest, N of Cnoc na Gaoithe, on old *Sorbus aucuparia*, NG9964, alt. 150–200 m, 2001, *A. M.* & *B. J. Coppins* 19739 (E); Dundonnell, S of Dundonnell House, E side of river, on *Fraxinus* branches, NH11658537, alt. 50 m, 2007, *A. M.* & *B. J. Coppins* 22462 (E); *ibid.*, on *Alnus glutinosa* branches by river, NH1185, alt. 50 m, 2007, *A. M.* & *B. J. Coppins* 22449 (E); Dundonnell, N of Dundonnell House, E side of river, on large *Acer pseudoplatanus*, NH110859, alt. 30 m, 2007, *A. M.* & *B. J. Coppins* 22470 (E); **V.C. 108,** West Sutherland, Inchnadamph, Allt a'Chalde Mòr, on *Ulmus glabra* branch, NC24972362, 120 m, 2004, *B. J. Coppins* 21574 (E, sub *Skyttea lecanorae*); Altnaharra, Loch Naver, N side, on *Betula*,

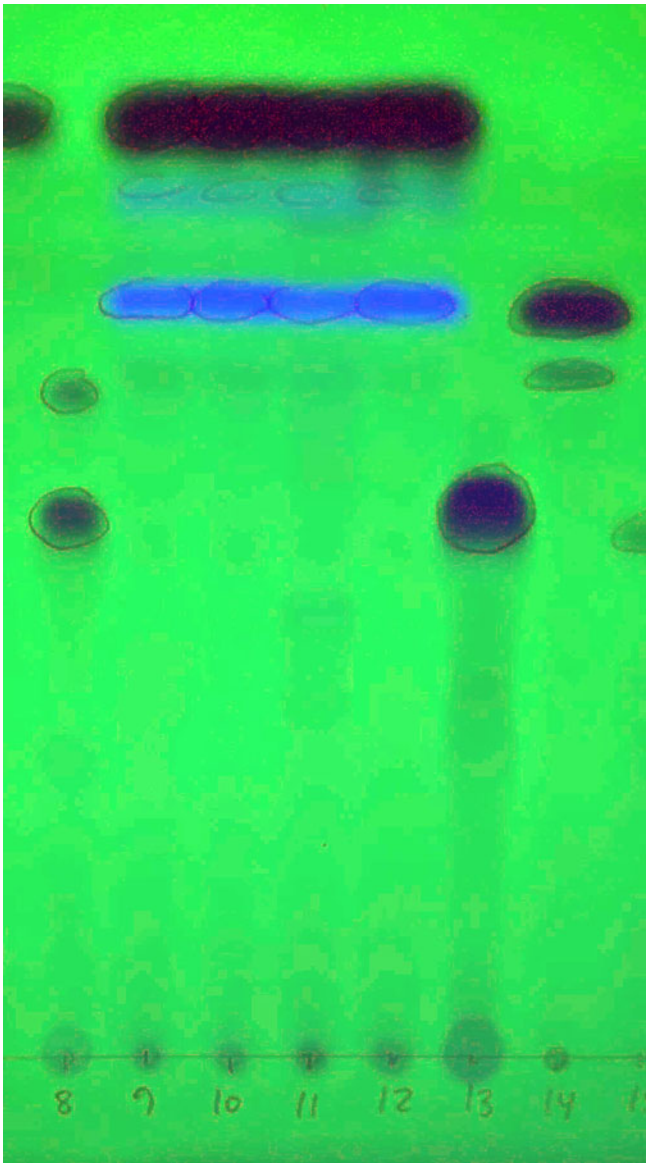


**Figure 4.** Chromatogram in solvent A under short-wave UV (254 nm), before charring with sulphuric acid and heat. *Lecanora caledonica* is shown on lanes 9–12. References are gyrophoric acid and psoromic acid (8), gyrophoric acid (13) and confluentic acid (14). In colour online.

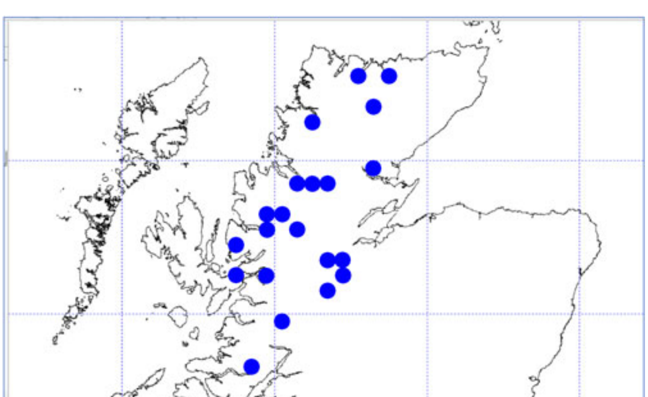

**Figure 5.** Map showing the known distribution of *Lecanora caledonica* in Scotland. In colour online.

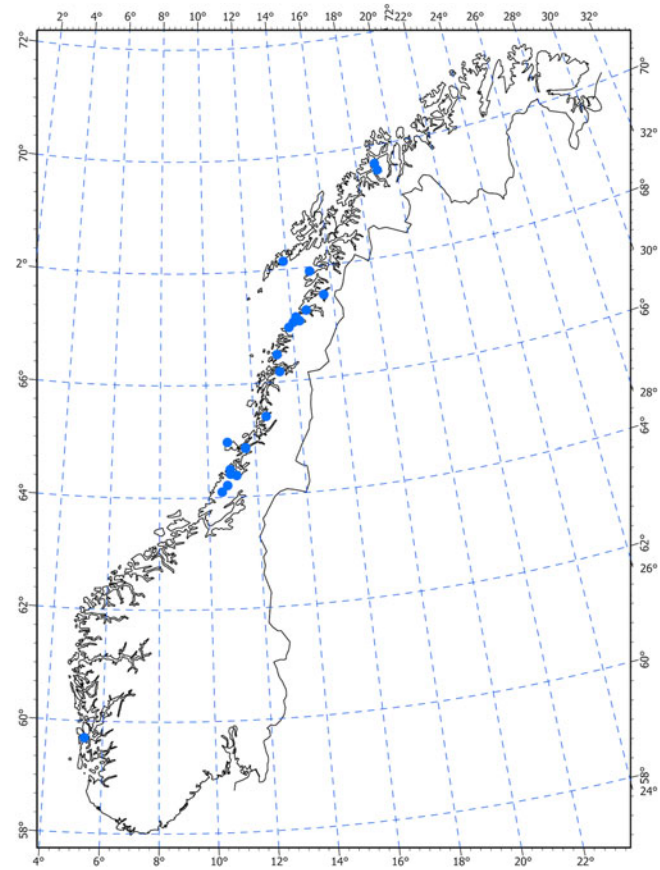

**Figure 6.** Map showing the known distribution of *Lecanora caledonica* in Norway. In colour online.

NC6137, 75 m, 1984, *B. J. Coppins* 10348 (E); Tongue, woods between An Garbh-chnoc and Creag an t-Tralghean, on *Salix*, NC5754, alt. *c.* 60 m, 1984, *B. J. Coppins* 10410 (E).

**Acknowledgements.** UA is grateful to the Swedish Taxonomy Initiative (grant no. Dha 150/2011) and to Ove Almborn's donationsfond for financial support. HH is grateful to Torgrim Sund for technical assistance. BJC belatedly thanks Dr Irwin Brodo for generous comments, some 37 years ago, on his early collections of our 'new' species!

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**Competing Interests.** The author(s) declare none.

## References

**Arup U, Vondrák J and Halıcı MG** (2015) *Parvoplaca nigroblastidiata*, a new corticolous lichen (*Teloschistaceae*) in Europe, Turkey and Alaska. *Lichenologist* **47**, 379–385.

**Brodo IM, Haldeman M and Malíček J** (2019) Notes on species of the *Lecanora albella* group (*Lecanoraceae*) from North America. *Bryologist* **122**, 430–450.

**Coppins BJ and Tønsberg T** (1984) A new species of *Arthothelium* from Norway. *Nordic Journal of Botany* **4**, 75–77.

**Darriba D, Taboada GL, Doallo R and Posada D** (2012) jModelTest 2: more models, new heuristics and parallel computing. *Nature Methods* **9**, 772.

**Döring H, Clerc P, Grube M and Wedin M** (2000) Mycobiont-specific PCR primers for the amplification of nuclear ITS and LSU rDNA from lichenized ascomycetes. *Lichenologist* **32**, 200–204.

**Ekman S and Holien H** (1995) *Bacidia caesiovirens*, a new lichen species from western Europe. *Lichenologist* **27**, 91–98.

**Gardes M and Bruns TD** (1993) ITS primers with enhanced specificity for basidiomycetes – application to the identification of mycorrhizae and rusts. *Molecular Ecology* **2**, 113–118.

**Grube M, Baloch E and Arup U** (2004) A phylogenetic study of the *Lecanora rupicola* group (*Lecanoraceae*, *Ascomycota*). *Mycological Research* **108**, 506–514.

**Guindon S and Gascuel O** (2003) A simple, fast, and accurate algorithm to estimate large phylogenies by maximum likelihood. *Systematic Biology* **52**, 696–704.

**Holien H and Tønsberg T** (1996) Boreal rain forest in Norway – the habitat for lichen species belonging to the Trøndelag phytogeographical element. *Blyttia* **54**, 157–177.

**Imshaug HA and Brodo IM** (1966) Biosystematic studies on *Lecanora pallida* and some related lichens in the Americas. *Nova Hedwigia* **12**, 1–59.

**Malíček J, Berger F, Palice Z and Vondrák J** (2017) Corticolous sorediate *Lecanora* species (*Lecanoraceae*, *Ascomycota*) containing atranorin in Europe. *Lichenologist* **49**, 431–455.

**Moen A** (1999) *National Atlas of Norway: Vegetation*. Hønefoss: Norwegian Mapping Authority.

**Orange A, James PW and White FJ** (2001) *Microchemical Methods for the Identification of Lichens*. London: British Lichen Society.

**Printzen C** (1995) Die Flechtengattung *Biatora* in Europa. *Bibliotheca Lichenologica* **60**, 1–275.

**Ronquist F, Teslenko M, van der Mark P, Ayres DL, Darling A, Höhna S, Larget B, Liu L, Suchard MA and Huelsenbeck JP** (2012) MrBayes 3.2: efficient Bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology* **61**, 539–542.

**Vilgalys R and Hester M** (1990) Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. *Journal of Bacteriology* **172**, 4239–4246.

**Westberg M, Ahti T and Thell A** (2011) *Hypogymnia*. In Thell A and Moberg R (eds), *Nordic Lichen Flora Vol. 4*. Uppsala: The Nordic Lichen Society, pp. 56–62.

**White TJ, Bruns TD, Lee S and Taylor J** (1990) Application and direct sequencing of fungal ribosomal DNA for phylogenetics. In Innis MA, Gelfand DH, Sninsky JJ and White TJ (eds), *PCR Protocols: a Guide to Methods and Application*s. San Diego: Academic Press, pp. 315–322.

**Zhao X, Leavitt SD, Zhao YT, Zhao LL, Arup U, Grube M, Pérez-Ortega S, Printzen C, Sliwa L, Kraichak E, *et al.*** (2016) Towards a revised generic classification of lecanoroid lichens (*Lecanoraceae*, *Ascomycota*) based on molecular, morphological and chemical evidence. *Fungal Diversity* **78**, 293–304.

**Zhou S and Stanosz GR** (2001) Primers for amplification of mt SSU rDNA, and a phylogenetic study of *Botryosphaeria* and associated anamorphic fungi. *Mycological Research* **105**, 1033–1044.

**Zoller S, Scheidegger C and Sperisen C** (1999) PCR primers for the amplification of mitochondrial small subunit ribosomal DNA of lichen-forming ascomycetes. *Lichenologist* **31**, 511–516.