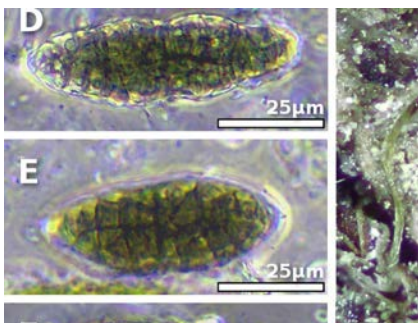


# AGARICA

Mykologisk tidsskrift utgitt av Norges sopp- og nyttevekstforbund



2019 vol. 39



# AGARICA

Mykologisk tidsskrift utgitt av Norges sopp- og nyttevekstforbund / A mycological journal published by Agariplantus norvegicus.

Tidsskriftet AGARICA publiserer originalartikler med hovedfokus på mykofloristikk og taksonomi og tar dessuten sikte på å formidle god populærviten-skap. Ulike typer manuskript mottas, herunder regu-lære artikler, mindre kommentarer (notes), over-siktsartikler (reviews) eller populariserte utgaver av mer omfattende forskningsartikler. AGARICA pub-liserer norsk-, svensk-, dansk-, og engelskspråklige bidrag. Tidsskriftet har fagfellelvurdering og artik-lenes endelige utforming gjøres i samarbeid mellom forfatter og redaksjonen. I utgangspunktet utkom-mer et årlig nummer av AGARICA (men ved større tilstrømming av artikler utkommer to).

Redaktører:

Anders K. Wollan, anders.wollan@nhm.uio.no

Gry Alfredsen, gry.alfredsen@nibio.no

Redaksjonssekretær:

Jon-Otto Aarnæs, jaarnas@broadpark.no

Redaksjonsmedlemmer:

Even W. Hansen, even.w.hansen@sabima.no

Gro Gulden, gro.gulden@nmh.uio.no

Håvard Kausrud, haavarka@bio.uio.no

Klaus Høiland, klaus.hoiland@bio.uio.no

Lone Ross Gobakken, lone.ross.gobakken@nibio.no

Volkmar Timmermann,

folkmar.timmermann@nibio.no

Norges sopp- og nyttevekstforbund  
Schweigaards gate 34, 0191 Oslo  
soppognyttevekster.no  
E-post: post@soppognyttevekster.no

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Forsidebilde: *Morchella-exuberans*. Foto: Gro Gulden

I venstre kolonne denne siden fra toppen:

*Entoloma chytrophilum*

*Entoloma porphyrocephalum*

*Lycoperdon mammiforme*

*Julella macrospora*

## Kjære lesar

Fagartiklene i Agarica volum 39 inkluderer to *Entoloma* arbeider: en ny *Leptonia* for Norge beskrives og den andre artikkelen omhandler noen lite kjente eller nye rødsporer for Norge. I tillegg presenteres en omfattende gjennomgang av spissmorkler i Norge inkludert ny informasjon om tre *Morchella* arter som opprinnelig er beskrevet fra Norge.

Er det mulig å forestille seg norsk og nordisk mykologi og sopp-miljø uten de tre jubilantene Gro Gulden, Klaus Høiland og Trond Schumacher? Umulig spør du oss. Alle som har vært en del av vår kjære norske og nordiske sopp-familie har et forhold til dem; som kursledere, læremestere eller veiledere, som forfattere av sopp-håndbøker, læremateriell og artikler, som inspiratorer og artseksperter og - ikke minst - som trivelige folk å være i lag med. Leser du Klaus sin beskrivelse av Trond, Trond sin beskrivelse av Klaus og Anne-Elise (Lillemor) sin beskrivelse av Gro, så har du lest deg opp på en vesentlig del av nyere norsk mykologihistorie, og sikkert også fått de små grå til å finne frem egne historier om og med de tre.

Det skjer stadig rekruttering også, og du kan også lese om fire nye doktorgrader innen mykologi i dette volumet. På en workshop i Hordaland i mai 2019 ble det funnet 13 ascomycetarter nye for Norge og disse presenteres i et popularisert bidrag med bilder og notater vedrørende mikroskopering. Til sist må vi slutte oss til forfatterne av de to bokanmeldelsene, og gratulere Mikael Jeppson med en etterlengtet bok om røyksopper, og Thomas Læssøe og Jens H. Pettersen med det gjennomillustrerte tobinds praktverket om macromycetene i Nord-Europa.

Det er ellers en glede for å meddele at vi har fått rekruttert en ung mykolog til Agarica redaksjonen, Ella Thoen.

God lesing!

Anders K. Wollan & Gry Alfredsen  
Redaktører Agarica

## Dear reader

The research articles in Agarica volume 39 include two *Entoloma* papers: a new *Leptonia* for Norway is described and the second paper deals with a number of *Entolomas* little known or new for Norway. In addition, a comprehensive overview of *Morchella* in Norway is presented, including new information about three *Morchella* species originally described from Norway.

Is it possible to imagine the Norwegian and Nordic mycology community without the three jubilants Gro Gulden, Klaus Høiland and Trond Schumacher? Impossible if you ask us. Everyone who has been part of our Norwegian and Nordic mycology community has a relationship with them; as course leaders, teachers or tutors, as authors of mushroom manuals, teaching materials and scientific articles, as inspirers and species experts and - not least - as great people to hang out with. If you read Klaus's description of Trond, Trond's description of Klaus and Anne-Elise's (Lillemor) description of Gro, then you are updated on a significant part of recent Norwegian mycology history, and it probably also triggered you to think about your own stories about and with the three.

Recruiting is ongoing and you can also read about four new PhDs in mycology in this volume. At a workshop in Hordaland in May 2019, 13 ascomycet species were found new to Norway and these are presented in a popular contribution with images and notes on microscopy. Finally, we must join the authors of the two book reviews, and congratulate Mikael Jeppson on a long-awaited book on puffballs, and Thomas Lessøe and Jens H. Pettersen with the brilliant two-volume book on macromycetes in Northern Europe.

We are also happy to announce that we have recruited a young mycologist to the editorial board of Agarica – Ella Thoen.

Enjoy!



# *Entoloma chytrophilum* (Basidiomycetes, Agaricales) – a new *Leptonia* to Norway

Øyvind Weholt<sup>1</sup>, Morten Pettersen<sup>2</sup>

<sup>1</sup>Høyåslia 9, NO-1657 Torp, Norway

<sup>2</sup>Vestengt. 48 D, NO-1656 Torp, Norway

Corresponding author:  
oyvind.weholt@fredfiber.net

Norsk tittel: *Entoloma chytrophilum* Wölfel, Noordel & Dähncke (Basidiomycetes, Agaricales) – en ny *Leptonia* for Norge

Weholt Ø, Pettersen M, 2017. *Entoloma chytrophilum* Wölfel, Noordel & Dähncke (Basidiomycetes, Agaricales) – a new *Leptonia* to Norway. *Agarica* 2019 vol. 39: 3-8.

## KEYWORDS

Agaricales, *Leptonia*, Norway, *Entoloma chytrophilum*

## NØKKELOD

Agaricales, *Leptonia*, Norge, *Entoloma chytrophilum*

## SAMMENDRAG

*Entoloma chytrophilum*, subgenus *Leptonia*, ble først beskrevet fra La Palma, Kanariøyene i 2001 i en blomsterpotte. Første funn ble gjort i Tyskland i 1985, men da som en varietet av *E. lepidissimum*. Den er senere dokumentert fra seks europeiske land, de fleste funn i Russland, og også i Canada. Det første funn i Norge ble gjort i 2014 i Fredrikstad. Så langt vi er kjent med, ble det første funnet fra Skandinavia gjort i Danmark i 2012. Artikkelen gir en beskrivelse av det norske funnet og en grov oversikt over kjent geografisk utbredelse.

## ABSTRACT

*Entoloma chytrophilum*, subgenus *Leptonia*, was first published from La Palma, Canary

Islands, growing in a flower pot in a greenhouse in 2001. It has subsequently been reported in six European countries, most records are from Russia, and later from Canada. The species was first found in Germany in 1985, but was then considered a variety of *E. lepidissimum*. The only record in Norway, was made in 2014. As far as we know, the first collection from Scandinavia was made in Denmark in 2012. This article gives a description of the Norwegian record and a rough survey of the geographical distribution.

## INTRODUCTION

March 8, 1995 a beautiful blue *Entoloma* was found in an orchid pot with wood chips in a greenhouse in La Palma, Canary Islands. Nineteen years later, August, 18, 2014 the second author found a beautiful blue *Entoloma* growing in an old pile of wood chips outside Fredrikstad in South Norway. When the first author saw the pictures, he realized immediately that this was something very special. Association went to some photos he had seen of a very conspicuous species called *Entoloma chytrophilum*. This was considered less likely since the Norwegian habitat had little in common with greenhouses, orchids and La Palma.

The genus *Entoloma* is currently undergoing great changes, demonstrated by recent finished as well as ongoing molecular studies. Several new species have been described based on a combined morphological and phylogenetic species concept (Vila et al. 2013, Morozova et al. 2014, Kokkonen 2015).

Fortunately, in some groups of *Entoloma* the phylogenetic studies have largely confirmed the established taxonomy based on morphology, with mainly well-delineated species that may be identified with sufficient certainty (without DNA sequencing). One of the studies is on the subgenus we now call *Leptonia*. After it was concluded that subgenus *Leptonia* as described by Noordeloos (Noordeloos 2004) was polyphyletic (Co-David et al. 2009), the majority of the *Leptonia* species was separated into the new subgenus *Cyanula*, and subgenus *Leptonia* now includes considerably fewer species than before. The species in subgenus *Leptonia* s.s. str. are easily morphologically distinguished from those in subgenus *Cyanula* by their clamped hyphae.

Using the updated subgenus *Leptonia* key, based on DNA studies (Morozova et al. 2016), the Norwegian specimens were identified as *E. chythrophilum*. The material was later included in the Norwegian *Entoloma* project (funded by the Norwegian Biodiversity Information Centre), where the DNA analysis (ITS) confirmed perfect match with *E. chythrophilum* as shown in the phylogenetic tree of Morozova et al. (2016), where its position proves it is a sister species *E. subleavisporum*. Therefore, it has definitely been confirmed that our material represents the first finding of *E. chythrophilum* in Norway.

#### MATERIALS AND METHODS

Dried material was studied microscopically, after soaking in 10% NH<sub>4</sub>OH, using Olympus CX31 light microscope. Spore drawings were made by hand. DNA sequences were generated in collaboration with the Norwegian Barcode of Life Network (NorBOL) as part of The Barcode of Life Data System (BOLD). For BOLD methods, see Ratnasingham and Herbert (2007, 2013).

The material is deposited in the herbarium at the University in Oslo (herb. O).

#### TAXONOMIC PART

##### ORIGINAL DESCRIPTION

The original description is cited from Wölfel et al. 2001, Österr. Z. Pilzk. 10 (2001):

*Hut:* 2-10 mm breit, schon jung tellerartig abgeflacht mit niedergedrückter Mitte, nicht hygrophan, undurchsichtig, auf hellerem Untergrund (stellenweise schaut das beige Hutfleisch durch), feinschuppig blau, stahlblau, graublau. Rand etwas eingeschlagen. *Lamellen:* etwas entfernt stehend, bauchig, teils miteinander verwachsen, Lamelletten auch gegabelt, am Grunde aderig. Breit angewachsen bis leicht herablaufend, jung weiss, alt lachsrosa, Schneide glatt, gleichfarbig. *Stiel:* bis 2 cm lang, bis 3 mm (Basis bis 4 mm) breit, schwach keulig. Spitze hellgrau, sonst wie der Hut gefarbt, dicht mit feinsten Schüppchen bekleidet, Basis mit weissem Tomentum. *Fleisch:* Geruch stark pilzig, fruchtig-pilzartig wie *Cantharellus cibarus* Fr.Fr.

*Sporen:* 8,5-11,5 x 6-7,0 µm, Q= 1,35-1,75, stark eckig-knotig (ohne ausgeprägte Einzel-ecken, deutlich heterodiametrisch. *Basidien:* keulig, 4-sporig, selten 2-sporig. *Schnallen:* an Fuss der Basidien, nirgends häufig. *Cheilocystiden:* fehlen, Lammellenschneide fertil. *Huthaut:* ein Trichoderm, endzellen zugespitzt, zylindrisch oder leicht keulig, bis 15 µm breit, Pigment bläulich, rein intracellulär. *Stieloberfläche:* ein Trichoderm ähnlich der Huthaut. *Standort:* auf gehäckselter Kiefferrinde im Topf von *Cymbidium* im Orchideenhaus.<sup>1</sup>

##### Description of the Norwegian material

At the verge of a gravel track which is used as an exercise track for horses. Scraped material is piled along the track. Thus the substrate consists of soil, sand, horse manure, wood chips, twigs, leaf and moss. Close to the site

1 A find of *E. chythrophilum* was pictured and reported on the Swedish Facebook portal Svampnördarna in the autumn 2017.





Figure 1. *E. chytrophilum* in the substrate. Photo: M. Pettersen.

grows *Picea*, *Pinus*, *Salix*, *Betula*, *Alnus* and *Populus*.

*Locality:* Norway, Østfold County, Fredrikstad municipality, near Vettatoppen, in old pile of conifer chips mixed with other organic refuse, August 18, 2014.



Figure 2. White gills with blue spots and diffusely striate pileus. Photo: M. Pettersen



Figure 3. Chip pile where *E. chytrophilum* was found. Photo: Morten Pettersen

*Macromorphology:*

*Pileus:* 10-20 mm wide with broad umbo, some with slightly depressed centre, slightly striate margin when very wet and mature, shining when moist, smooth to slightly fibrillose, not viscid, dark blue to deep purple, not hygrophanous. *Gills:* pure white, but in some places slightly blue spotted on one individual, adnate somewhat adnexed, distant, about 30 reached the stipe. *Stipe:* smooth (in very moist weather), elongate striped (probably fibrillose when not water soaked), concolorous with pileus, length 30-35 mm, width 3-5 mm, base with white tomentum.

Odour acidic. Taste mild, slightly farinaceous.

*Micromorphology:*

Spores heterodiametrical, nodulose, not or only few slightly angled, 8.0-10.2 x 5.1-6.1  $\mu\text{m}$ , av 9,3 x 5.8  $\mu\text{m}$ ,  $Q_{\text{av}} = 1.6$ , no cheilocystidia, 4-spored, clamped present at base of basidia. Pigmentation in pileus hyphae intracellular.

*Molecular identification:*

Results showed a 100% similarity in the ITS region with the *E. chytrophilum*-sequence in Morozova et al. (2014).

COMMENTS

*Entoloma chytrophilum* differs primarily from other species in subgenus *Leptonia* on habitat that always seems to be associated with lignicolous, especially coniferous, substrate. Both pileus and stem are furthermore strongly and beautifully blue and gills are completely white as young. Microscopically the spores are heterodiametrical and conspicuously nodulose without real angles. Another differentiating feature from close relatives is the lack of cheilocystidia. The species should easily be possible to identify in the field exclusively from its appearance and habitat.

The Norwegian collection agrees reasonably well with both the original description and the description of Morozova (2014). It shows that the species can be somewhat larger than previously reported, up to 30 mm vs. 20 mm. As seen from the from figure 2 and 3 the



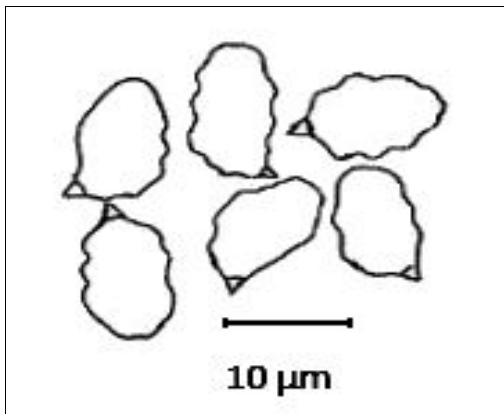


Figure 4. Spores of *Entoloma chytrophilum*. Del. Ø. Weholt

pileus may be distinctly translucently striate and rather smooth, opposed to previous descriptions, and opposed to typical habit in sect. *Leptonia* s. str. as a whole (with pileus fine scaly-fibrillose). Also the stipe was more smooth than described and depicted elsewhere, at least in adult specimens. However these deviations might be explained by the very wet weather on collecting.

*Entoloma chytrophilum* is often reported growing on decaying and mossy stumps, and seems to have a special preference for pine, although it is also reported from spruce cones, spruce needles, and in one case it is said to grow on beach cupules (but in a mixture with conifer needles). It is also noteworthy that the holotype was reported to grow in a pot together with an orchid, but also with chips of pine branches.

However, since only the holotype is reported from Canary Island and most records from Russia and other northern latitudes, could it possibly be "imported" to La Palma, and even to entire Western Europe? Maybe it is as Tatiana Bulyonkova (Flickr 2008) writes about the species on a web page:

«The explanation could be simple: The species travelled to the Canary Islands with poorly sterilized orchid substrate, which is wooden pine bark. Trains and trucks loaded

with pine logs and heading west are a too-common sight here [in Russia]».

So maybe the true, primary habitat of the species is coniferous forest regions of boreal-montane zones from eastern parts of Eurasia. However, according to the land owner who has deposited the wood chips in Fredrikstad, they originate from the local tree chopping, and therefore are assumed not to have been "infected" by bark substrate from exotic origin.

In the article of Morozova et al. (2014) 14 records of *E. chytrophilum* are mentioned from the four countries: Germany, Poland, Russia (most) and Spain (only holotype, Canary Islands).

It appears that the first record and only German record of *E. chytrophilum* was made in Germany in 1985, i.e. nine years before the discovery in La Palma, but then named as a variety of *E. lepidissimum* (var. *pauciangulatum*; Gminder and Enderle 1996). The other records so far reported in Europe were made during the period 2004-2012. The collection from Fredrikstad is apparently the first one in Europe since 2012. In 2014, two finds of *E. chytrophilum* were reported from Canada (Mycology Collection Portal). It may be argued that the species is rare in Scandinavia despite its apparently high dispersal ability.

Such a beautiful species, despite its small size, would hardly have been overlooked for so long, given both the alertness of professional mycologists and, not the least, the numerous avid mushroom amateurs in Norway. The authors of this article have collected and studied *Entoloma* for decades, but never found anything like it.

#### BRIEFLY ON OTHER SPECIES IN SUBSECTION LEPTONIA IN NORWAY

Morozova et al. (2014) describes 13 phylogenetic species, and the key also included eight species based on morphology, i.e. species not

studied molecularly, but documented morphologically in the literature. A new species, *Entoloma kruticianum*, was recently described in subsection Leptonia (Morozova et al. 2016), so 22 species are presently included in subgenus Leptonia. One species, *E. tjallingiorum* is described with 3 varieties. This species is quite common in Norway, but few of the Norwegian findings are sequenced, so it remains to see how many species are found in Norway. A check with the herbarium at the Natural History Museum, University of Oslo showed that 12 species in the revised subgenus Leptonia up to now have been reported. In addition, *E. sublaevisporum* was found and described as new for Norway in 2014 (Weholt et al. 2014), not included in the above 12. Thus, after the discovery of *E. chytrophilum*, 14 species in subgenus Leptonia are known (but not genetically verified) from Norway.

Based on the reported findings the most common species in Norway are *E. euchroum*, *E. tjallingiorum* and *E. lamprous*, while there are few records of *E. lepidissimum*, *E. callichroum*, *E. coelestinum* and *E. percoelestinum*.

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# The genus *Morchella* section *Distantes* in Norway and new information on three *Morchella* species described from Norway

Øyvind Weholt<sup>1</sup>, Pablo Alvarado<sup>2</sup>, Roy Kristiansen<sup>3</sup>, Gro Gulden<sup>4</sup>

<sup>1</sup>Høyåslia 9, NO-1657, Torp, Norway

<sup>2</sup>ALVALAB, Av. Bruselas 2 3B, 33011 Oviedo, Spain

<sup>3</sup>P.O. Box 32, NO-1650 Sellebakk, Norway

<sup>4</sup>Natural History Museum, University of Oslo, P.O. Box 1172  
Blindern, NO-0318, Norway

Corresponding author:  
oyvind.weholt@fredfiber.net

Norsk tittel: Spissmorkler i Norge og ny informasjon om tre spissmorkelarter som opprinnelig er beskrevet fra Norge

Weholt ØW, Alvarado P, Kristiansen R, Gulden G, 2019. The genus *Morchella* section *Distantes* in Norway and new information on three *Morchella* species described from Norway. *Agarica* 2019, vol. 39: 9-30.

KEY WORDS: Ascomycetes, *Morchella* sect. *Distantes*, clade Elata, *Morchella conicopapyracea*, *Morchella eximioides*, *Morchella norvegiensis*, multigene analysis, phylogeny.

NØKKELOD: Ascomyceter, *Morchella* sect. *Distantes*, *Morchella conicopapyracea*, *Morchella eximioides*, *Morchella norvegiensis*, multigenanalyse, fylogeni.

## SAMMENDRAG

Ved å analysere ITS rDNA, tef1, rpb1 og rpb2 sekvenser i vel 70 innsamlinger av spissmorkler samlet av amatørmykologer i Norge har vi funnet 10 distinkte genetiske enheter hvorav syv svarer til de allerede kjente artene *Morchella conifericola*, *M. deliciosa*, *M. eximioides*, *M. exuberans*, *M. importuna*, *M. norvegiensis* og *M. purpurascens*. For de resterende tre fins ingen artsbeskrivelser. Data om funnsteder for de påviste artene fins i Tabell 1; omtale

av habitatstyper og utbredelse er gitt under de enkelte artene.

*Morchella eximioides*, *M. norvegiensis* og *M. conicopapyracea* er tre arter av spissmorkler som opprinnelig ble beskrevet på grunnlag av norsk materiale av den franske mykologen E. Jacquetant. Forskjellige uheldige omstendigheter knyttet til typematerialet for disse artene er gjort rede for (under Material and Methods). Epityper fra typelokalitetene for *M. norvegiensis* og *M. conicopapyracea* er utpekt. Sekvenser fra holotyper og epityper tyder på at *M. norvegiensis* er identisk med den nylig beskrevne arten *M. eohespera* Beug, Voitk & O'Donnell og førstnevnte får dermed prioritet, mens *M. conicopapyracea* synes å tilsvare den tidligere beskrevne *M. purpurascens* (Boud.) Jacquet. Formen *M. eximia* f. *schizocostata*, også beskrevet fra Norge, antar vi er en litt avvikende utgave av *M. norvegiensis*.

## ABSTRACT

Following the analysis of ITS rDNA, tef1, rpb1 and rpb2 sequences from about 70 collections of *Morchella* sect. *Distantes* collected by Norwegian amateur mycologists we found 10 distinct genetic lineages occurring in Norway, seven of them matching the already known species *M. conifericola*, *M. deliciosa*, *M. eximioides*, *M. exuberans*, *M. importuna*, *M. norvegiensis*, and *M. purpurascens*, as well as three lineages lacking suitable species names. Information on habitats and distribution for these is provided.

Three of these *Morchella* species were originally described from Norway: *Morchella eximoides*, *M. norvegiensis* and *M. conicopapyracea* by the French mycologist E. Jacquetant, and circumstances around the type designation and type material for these species are discussed (under Material and Methods). Epitypes from the original localities for *M. norvegiensis* and *M. conicopapyracea*, are selected, and their genetic profile suggests that *M. norvegiensis* is a priority synonym over *M. eohespera* Beug, Voitek & O'Donnell, while *M. purpurascens* (Boud.) Jacquet. has priority over *M. conicopapyracea*. *Morchella eximia* f. *schizocostata* is seen to represent a deviating form of *M. norvegiensis*.

## INTRODUCTION

True morels, members of the genus *Morchella* Dill. ex Pers., are among the world's most palatable and sought mushrooms, representing a multimillion dollar business. In some countries concerns about their conservation are pertinent (Pilz et al. 2007, O'Donnell et al. 2011, Taşkin et al. 2012, Du et al. 2012a, 2012b) and cultivation has recently scaled up in China (Qizheng et al. 2017). Some true morels may be saprotrophs but most species are now believed to form facultative endophytic or mycorrhizal relationships with vascular plants, herbs and trees (Loizides et al. 2016). Many morel species seem to be associated with specific trees (Clowez 2012, Richard et al. 2015, Loizides 2017).

Before the introduction of genetics, the knowledge of species diversity of *Morchella* was vague in most countries, mainly limited to a distinction between black morels and yellow morels. In Norway, black morels ('spissmorkler') were usually identified as *M. conica* Pers. or *M. elata* Fr. while the rarer yellow morels ('rundmorkler') were named *M. esculenta* (L.) Pers. A few attempts to update morel taxonomy were conducted by Jacquetant (1984) and Clowez (2012), but

still identification of species was problematic because morel fruitbodies are highly variable, changing considerably in shape and colors with maturity and lacking easily observable microscopic characters. Genetic studies based on multiple loci were first conducted by Taşkin et al. (2010), O'Donnell et al. (2011), and later Du et al. (2012a), Richard et al. (2015) and others, suggesting the existence of nearly 70 genetic lineages of *Morchella* worldwide, many of them matching already existing names. So far, 34 of these lineages have been shown to be present in Europe, 18 of them belonging in section *Distantes* Boud. (Loizides 2017). Genetic evidence suggests the existence of three main clades of *Morchella*: the *Rufobrunnea* clade being the older one, and two younger ones, the *Elata* clade and the *Esculenta* clade (O'Donnell et al. 2011, Du et al. 2012a). These lineages correspond to the three sections of *Morchella* already established in traditional taxonomy: sect. *Rufobrunnea* Clowez & Courtec. (= clade *Rufobrunnea*), sect. *Distantes* Boud. (= clade *Elata* with the 'black morels'), and sect. *Morchella* Dill. ex Pers. (= clade *Esculenta* with the 'yellow morels'). Within the *Elata* clade the subclade *Elata* is especially diverse and known to include more than one-third of all described *Morchella* species (Du et al. 2012a). Supposedly, the genus *Morchella* originated in western North-America and there split into the three lineages before an expansion to other continents took place (O'Donnell et al. 2011, Du et al. 2012a). This hypothesis on origin, including theories on historical evolution, routes and ways of expansion and dispersal, is currently under debate in view of results from recent studies on *Morchella* in many countries and continents (see f. inst. Du et al. 2012a, Clowez et al. 2015, Loizides et al. 2016, Loizides 2017).

While genetic studies help to group morels, species recognition is still difficult, and a review of morphological, ecological and



chorological traits to discriminate species is critically needed (Loizides et al. 2016, Loizides 2017). For the eight European species of section *Morchella* a key already exists (Clowez et al. 2015). (A monograph dealing with the European morels by Clowez and Moreau has been announced and is expected in 2020.)

In Norway the genus *Morchella* has mainly been studied by Roy Kristiansen (RK), who collected several *Morchella* species in the Fredrikstad region (SE Norway) in the late 1970s – early 1980s (Kristiansen 1981, 1982). Dried samples together with photographs of the fresh mushrooms were sent to the French mycologist Emile Jacquetant, who, from this Norwegian material, described three new species and one new form of *Morchella* in section *Distantes*: *M. eximioides* Jacquet., *M. norvegiensis* Jacquet., *M. conicopapyracea* Jacquet., and *M. eximia* f. *schizocostata* (Jacquetant 1984). The taxa are described in Kristiansen (1982) in Norwegian with accompanying line drawings.

Samples from Kristiansen's private herbarium were included in an early phylogenetic study conducted by O'Donnell et al. (2011). Results showed that three genetic lineages, informally named Mel-16, Mel-20, and Mel-23, occurred in Norway. Later, Richard et al. (2015) showed that Mel-16 matches the species *M. eximioides*, and Mel-20 matches *M. purpurascens*. Mel-23 still appears to lack a published name. Richard et al. (2015) also obtained ITS rDNA sequences from Kristiansen's holotype collections of *M. norvegiensis* and *M. conicopapyracea*, at that time kept in the fungarium of the Natural History Museum in Oslo (O), which suggested that these species belong in the subclade *Elata*, but not allowing a full identification of the exact genetic lineage. The names were accordingly discussed under the heading “*Doubtful names in sect. Distantes*”, where also the traditional names *M. conica* Pers.: Fr and *M. elata* Fr.: Fr. appear.

In recent years, Kristiansen again collected morels in the Fredrikstad region together with Morten Pettersen. In addition, multiple samples of *Morchella* and images have been sent to Øyvind Weholt (ØW) by numerous Norwegian amateur mycologists for the present study. We selected around 70 of these collections, along with type material of the three species described from Norway, for sequencing, in order to (i) gain a rough overview of species diversity of *Morchella* section *Distantes* in Norway, and (ii) clarify the identity of *M. norvegiensis* and *M. conicopapyracea*. We had no ambition at this stage to provide descriptions of the Norwegian species, since we have, primarily, studied dried material. However, we present pictures of most species to illustrate some of the variability of the species.

#### MATERIAL AND METHODS

*Material studied*: Representative collections of Norwegian species of *Morchella* sect. *Distantes* were selected for genetic analyses. They are from all parts of the country, but there is a bias towards collections from the surroundings of the town Fredrikstad in SE Norway, and very few collections are from SW Norway (Vestlandet). Voucher numbers were constructed when needed for early collections by RK in analogy with the method introduced in Jacquetant and Bon (1985). All samples are kept at the Oslo fungarium (O), and sequences were deposited in GenBank under accession numbers specified in Table 1. The table also provides data on localities, habitats, dates of collection and the genes studied. Samples sequenced in other studies, but pertinent to our project, are shown in Table 2.

**Table 1**

<b>A. Data for collections sequenced in this study</b>									
Voucher nos in Herb O (Herb(O))	Sequence- ID	Species	Country, Location	Habitat	Date of collection	ITS	TEF	RPB2	RPB1
O-F-255621	ALV15967	<i>M. conicopapyracea a epytype</i>	Norway: Østfold, Fredrikstad	In moss on burnt ground	26-May-1982				
O-F-270651	ALV14315	<i>M. conifericola</i>	Norway: Akershus, Bærum		6-May-2002	MK629434	MK639482		MK639563
O-F-255587	ALV7844, ALV16059	<i>M. deliciosa</i>	Norway: Akershus, Asker	Lawn under <i>Pinus silvestris</i> .	20-Apr-2016	MK629386	MK639442	MK639493	MK639534
	ALV8121	<i>M. eximioides</i>	Norway: Nord-Trøndelag, Leksvik	Bark bed	May-2016	MK629391	MK639447	MK639498	MK639539
O-F-255593	ALV8188	<i>M. eximioides</i>	Norway: Troms, Tromsø	Lawn with old bark bed	8-Jun-2016	MK629398	MK639453	MK639504	MK639545
O-F-255599	ALV12011	<i>M. eximioides</i>	Norway: Buskerud, Ringerike	Open forest area, previously dominated by <i>Pinus silvestris</i> .	19-May-2017	MK629409	MK639459	MK639511	MK639551
	ALV12015	<i>M. eximioides</i>	Norway: Sør-Trøndelag, Trondheim	Mixed forest with <i>Picea</i> , <i>Betula</i> and possibly other tree species.	12-May-2017	MK629413	MK639463	MK639515	MK639555
O-F-255597	ALV8394	<i>M. exuberans</i>	Norway: Buskerud, Drammen	Burnt forest with <i>Pinus silvestris</i> and some <i>Betula</i> and <i>Picea</i> trees	May-2009	MK629402	MK639456	MK639508	MK639549
	ALV5336	<i>M. importuna</i>	Norway: Sør-Trøndelag, Trondheim	Verge of <i>Picea</i> forest, thick moss, moist	19-Apr-2015	MK629379			
O-F-255586	ALV7778	<i>M. importuna</i>	Norway: Østfold, Fredrikstad	Not bark, open deciduous forest		MK629385	MK639441		
O-F-255589	ALV8123	<i>M. importuna</i>	Norway: Østfold, Sarpsborg	Bark in garden	22-May-2016	MK629393	MK639449	MK639500	MK639541
O-F-255590	ALV8125	<i>M. importuna</i>	Norway: Østfold, Sarpsborg	Bark in garden	22-May-2016	MK629394		MK639501	
O-F-255591	ALV8126	<i>M. importuna</i>	Norway: Østfold, Hvaler	Cultivated on bark	May-2016	MK629395	MK639450		MK639542
	ALV8794	<i>M. importuna</i>	Norway: Sør-Trøndelag, Trondheim	In gravel, roadside near a <i>Picea</i> forest	22-May-2016	MK629405			

O-F-255592	ALV8128	<i>M. importuna</i>	Norway: Sør-Trøndelag, Trondheim	On a bark cloth	18-May-2016	MK629396	MK639451	MK639502	MK639543
	ALV8137	<i>M. importuna</i>	Norway: Oslo	Bark	May-2016	MK629397	MK639452	MK639503	MK639544
	ALV8191	<i>M. importuna</i>	Norway: Akershus, Ås	Bark in garden	30-May-2016	MK629400	MK639455	MK639506	MK639547
O-F-255595	ALV8193	<i>M. importuna</i>	Norway: Østfold, Hvaler	Bark	May-2016	MK629401		MK639507	MK639548
	ALV8795	<i>M. importuna</i>	Norway: Sør-Trøndelag, Trondheim	In grass along roadside	27-May-2016	MK629406			
O-F-255603	ALV12111	<i>M. importuna</i>	Norway: Oslo	Terrain with some moss, grass and flowers.	16-May-2017	MK629414			
	ALV9517	<i>M. importuna</i>	Norway: Nordland, Bodø	Bark		MK629407			
O-F-255604	ALV12112	<i>M. importuna</i>	Norway: Østfold, Fredrikstad	Barkbed	20-May-2017	MK629415	MK639464	MK639516	MK639556
O-F-255611	ALV12337	<i>M. importuna</i>	Norway: Vest-Agder, Kristiansand	Barkbed		MK629422	MK639471	MK639523	
O-F-22466	ALV14313	<i>M. importuna</i>	Norway: Oslo		4-Jun-2015	MK629432	MK639481	MK639528	
O-F-255577	ALV4999	<i>M. norvegiensis</i>	Norway: Østfold, Fredrikstad	Among waste from old paper industry.	Apr-2015	MK629374	MK639431	MK639488	MK639530
O-F-255578	ALV5000	<i>M. norvegiensis</i>	Norway: Sør-Trøndelag, Trondheim	On the edge of <i>Pinus silvestris</i> forest, thick moss, moist and open landscape	15-Apr-2015	MK629375	MK639432	MK639489	MK639531
O-F-255580	ALV5327	<i>M. norvegiensis</i>	Norway: Østfold, Våler	Bark	18-May-2015	MK629378	MK639435	MK639490	MK639532
O-F-255581	ALV5487	<i>M. norvegiensis</i>	Norway: Østfold, Fredrikstad	Old industrial area, on soil and waste disposal	27-Apr-2014	MK629380	MK639436	MK639491	
O-F-255585	ALV6994	<i>M. norvegiensis</i>	Norway: Oppland, Sel	In gravel by road side in a <i>Picea abies</i> forest.	6-Jun-2015	MK629384	MK639440		
O-F-255588	ALV8016	<i>M. norvegiensis</i>	Norway: Oppland, Sel	Among hedge plants ( <i>Rosa rugosa</i> and <i>Potentilla</i> ).	10-May-2016	MK629387	MK639443	MK639494	MK639535
	ALV8119	<i>M. norvegiensis</i>	Norway: Sør-Trøndelag, Trondheim	In a flower bed on bark among newly planted fruit trees.	22-May-2016	MK629389	MK639445	MK639496	MK639537
	ALV8122	<i>M. norvegiensis</i>	Norway: Nord-Trøndelag, Leksvik	Among grass and gravel, along a farm road near forest with some <i>Picea</i> trees.	May-2016	MK629392	MK639448	MK639499	MK639540
O-F-255594	ALV8189	<i>M. norvegiensis</i>	Norway: Sør-Trøndelag, Røros	Roadside of a gravel road near <i>Betula</i> .	5-Jun-2016	MK629399	MK639454	MK639505	MK639546

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O-F-255596	ALV8393, ALV15968	<i>M. norvegiensis</i>	Norway: Sør-Trøndelag, Røros	Among grasses with various other plants/herbs	9-Jun-2016				
O-F-255598	ALV8395	<i>M. norvegiensis</i>	Norway: Troms, Harstad	Flowerbed with bark		MK629403		MK639509	
	ALV8396	<i>M. norvegiensis</i>	Norway: Troms, Harstad	Flowerbed with bark		MK629404	MK639457	MK639510	MK639550
	ALV11548	<i>M. norvegiensis</i>	Norway: Østfold, Fredrikstad	Among waste material from old paper industry, <i>Alnus</i> sp.	17-Apr-2017	MK629408		MK639458	
O-F-255600	ALV12012	<i>M. norvegiensis</i>	Norway: Sør-Trøndelag, Melhus	Bark bed	3-May-2017	MK629410	MK639460	MK639512	MK639552
O-F-255601	ALV12013	<i>M. norvegiensis</i>	Norway: Sør-Trøndelag, Melhus	Weedy slope without bark	15-May-2017	MK629411	MK639461	MK639513	MK639553
O-F-255602	ALV12014	<i>M. norvegiensis</i>	Norway: Sør-Trøndelag, Melhus	In garden, short moss, no bark.	17-May-2017	MK629412	MK639462	MK639514	MK639554
O-F-255605	ALV12113	<i>M. norvegiensis</i>	Norway: Nord-Trøndelag, Frosta	Near rhubarb, in garden with hedges and apple trees.	27-May-2017	MK629416	MK639465	MK639517	MK639557
O-F-255606	ALV12114	<i>M. norvegiensis</i>	Norway: Buskerud, Flesberg	Near wood chips, no bark, 650 m asl	27-May-2017	MK629417	MK639466	MK639518	MK639558
O-F-255607	ALV12116	<i>M. norvegiensis</i>	Norway: Østfold, Fredrikstad	Old industrial area, among soil and waste disposal	Apr-2017	MK629418	MK639467	MK639519	MK639559
O-F-255608	ALV12126	<i>M. norvegiensis</i>	Norway: Hedmark, Løten	Near compost heap, 230 m asl		MK629419	MK639468	MK639520	MK639560
O-F-255610	ALV12336	<i>M. norvegiensis</i>	Norway: Nord-Trøndelag, Frosta	Near rhubarb, in garden.	21-May-2017	MK629421	MK639470	MK639522	
O-F-255612	ALV12338	<i>M. norvegiensis</i>	Norway: Troms, Tromsø	Bark bed with <i>Picea</i>	15-Jun-2017	MK629423	MK639472	MK639524	MK639561
O-F-255613	ALV12339	<i>M. norvegiensis</i>	Norway: Oppland, Sel	On soil with a thin grass cover, 700 m asl	21-Jun-2017	MK629424	MK639473	MK639525	
O-F-255614	ALV12340	<i>M. norvegiensis</i>	Norway: Sør-Trøndelag, Trondheim	Mixed forest with <i>Picea abies.</i> , <i>Betula</i> sp., and possibly other trees.	12-May-2017	MK629425	MK639474	MK639526	MK639562
	ALV12341	<i>M. norvegiensis</i>	Norway: Sør-Trøndelag, Trondheim	In gravel overgrown with grass	25-May-2017	MK629426	MK639475	MK639527	
O-F-255615	ALV12569	<i>M. norvegiensis</i>	Norway: Oppland, Øyer	Road side in <i>Picea</i> forest, 650 m asl.	23-May-2017	MK629427	MK639476		
O-F-255616	ALV12570	<i>M. norvegiensis</i>	Norway: Oppland, Øyer	Edge of a spruce forest clearcut, partly pasture with grass and flowers cut the year before, 250 m asl.	Jun-2017	MK629428	MK639477		
O-F-255617	ALV13090 ALV15969	<i>M. norvegiensis</i>	Norway: Finmark, Porsanger	In garden		MK629429	MK639478		



O-F-255618	ALV13095	<i>M. norvegiensis</i>	Norway: Finmark, Berlevåg			MK629430	MK639479		
O-F-255619	ALV14265	<i>M. norvegiensis</i> <i>epitype</i>	Norway: Østfold, Fredrikstad	Old waste site	24-May-1987	MK629431	MK639480		
O-F-300354	ALV14314	<i>M. norvegiensis</i>	Norway: Buskerud, Hurum		30-May-1979	MK629433		MK639529	
O-F-302305	ALV14568	<i>M. norvegiensis</i>	Norway: Buskerud, Ringerike		23-May-2015	MK629435	MK639483		
O-F-255620	ALV15353	<i>M. norvegiensis</i>	Norway: Akershus, Bærum	Flowerbed with bark	27-May-1983		MK639484		
O-F-76270	ALV16731	<i>M. norvegiensis</i>	Norway: Oppland, Lom	1100 m asl	8-Jun-2018	MK629438	MK639487		
O-F-255579	ALV5325	<i>M. purpurascens</i>	Norway: Møre og Romsdal, Rindal	Flowerbed	28-May-2015	MK629376	MK639433		
	ALV5326	<i>M. purpurascens</i>	Norway: Møre og Romsdal, Rindal	Flowerbed	21-Jun-2015	MK629377	MK639434		
O-F-255582	ALV5488	<i>M. purpurascens</i>	Norway: Østfold, Fredrikstad	Open <i>Populus tremula</i> forest, moss, leaves.	12-May-2014	MK629381	MK639437		
O-F-255584	ALV5490	<i>M. purpurascens</i>	Norway: Østfold, Fredrikstad	Open <i>Populus tremula</i> forest, moss, leaves.	13-May-2015	MK629383	MK639439		
	ALV8118	<i>M. purpurascens</i>	Norway: Sør-Trøndelag, Trondheim	Among grass in tractor road, forest with <i>Ulmus glabra</i> , <i>Populus tremula</i> , <i>Corylus</i> <i>avellanea</i> and <i>Picea abies</i> .	21-May-2016	MK629388	MK639444	MK639495	MK639536
	ALV8120	<i>M. purpurascens</i>	Norway: Nord-Trøndelag, Leksvik	In courtyard	21-May-2016	MK629390	MK639446	MK639497	MK639538
O-F-255609	ALV12335	<i>M. purpurascens</i>	Norway: Telemark, Siljan	Flowbed	5-May-2017	MK629420	MK639469	MK639521	
O-F-255583	ALV5489	<i>M. sp.1</i>	Norway: Østfold, Fredrikstad	In heap of soil	9-May-2014	MK629382	MK639438	MK639492	MK639533
	ALV16216	<i>M. sp.2</i>	Norway: Oslo	Flowerbed	19-Apr-2018	MK629437	MK639486		MK639564
HMAS 57629(S)	ALV15535	<i>M. sp.</i>	China: Shandong, Linqu			MK629436	MK639485		

**Table 2.**

B. Data for collections sequenced in other studies					
Specimen voucher (Herb(O))	ID (O'Donnell)	Species	Country, Location	Habitat	Date of collection
O-72836		<i>M. conicopapyracea</i> (holotype)	Norway: Østfold, Fredrikstad	In <i>Bryum</i> -moss on burnt cellulose balls, among crushed brickstones and pieces of concrete.	16-May-1981
	M-487	<i>M. purpurascens</i>	Norway: Østfold, Fredrikstad	With <i>Salix</i> , <i>Tussilago</i> , on extreme calcareous soil introduced by man.	19-May-1987
	M-492	<i>M. purpurascens</i>	Norway: Østfold, Hvaler	With <i>Corylus</i> , <i>Malus</i> , ferns, calcareous ground.	21-May-1982
O-76269	M-489	<i>M. eximioides</i>	Norway: Østfold, Fredrikstad	Industrial waste and garbage.	19-May-1982
O-76268	M-494	<i>M. eximioides</i>	Norway: Østfold, Fredrikstad	Industrial waste and garbage.	22-May-1982
O-72834		<i>M. eximioides</i> (holotype)	Norway: Østfold, Fredrikstad	Old leaves and twigs with charcoal from old sawmill, <i>Salix</i> , <i>Alnus</i> , <i>Populus</i> , <i>Betula</i> , <i>Aesculus hippocastaneum</i> .	17-May-1981
O-255729	M-495	<i>Morchella</i> sp. (Mel-23)	Norway: Østfold, Fredrikstad	On burnt pulp and paper balls just outside a old burnt store house for paper and pulp from paper mill, under <i>Salix</i> .	4-June-1981
O-72835		<i>M. norvegiensis</i> (holotype)	Norway: Østfold, Fredrikstad	Near <i>Salix</i> , burnt stockyard, among Leca spheres.	23-May-1981

*Names, numbers and type material of M. norvegiensis, M. conicopapyracea, and M. eximioides*

- Unfortunately, Jacquetant (1984) did not designate holotype specimens for *M. norvegiensis*, *M. conicopapyracea*, and *M. eximioides* and hence the names were considered invalid. Trying to remediate this, Jacquetant and Bon (1985) constructed and published numbers (based on the collecting dates) for the holotypes but made no reference to the original latin diagnoses, and therefore the names remained invalid. The names were finally validated by Kristiansen (1990) who assembled names, latin diagnoses, and holotype numbers for these species.
- The holotype numbers constructed by Jacquetant and Bon (1985) obviously refer to the collecting dates, but are correct

- only for *M. norvegiensis* (230581) that was collected on 23 May 1981. The number for *M. conicopapyracea*, 260581, should have been 160581, since it was collected on 16 May 1981 (the wrong date had already been given by Jacquetant in his book from 1984, p. 100), and *M. eximioides*, assigned no. 290579, was collected 24 May, not 29 May 1979. However, the material of *M. eximioides* from 1979 has been destroyed, see below.
- In Richard et al. (2015) the accession number in the Oslo fungarium for the holotype of *M. conicopapyracea* is given as O-72834 while the correct number is O-72836. The number for *M. eximioides* is correctly given as O-72834. The collecting date for the holotype of *M. norvegiensis* is said to be 23 April 1981, while it was collected in May (23 May 1981).

- Richard et al. (2015, p. 373) supposed that Jacquetant had intermixed the pictures (and descriptions) of *M. conicopapyracea* and *M. eximioides* in his book, because they held the shape of the pieces deposited in Oslo as the holotype of *M. conicopapyracea* to look more like the picture of *M. eximioides* than that of *M. conicopapyracea* and vice versa. (Pictures of the samples in O were published by Richard et al. (2015) as SUPPLEMENTARY FIG. 1.). However, this scenario is most unlikely since Jacquetant never saw or illustrated the samples deposited in (O); his paintings are based on in situ photographs he received from RK and samples (typically half ascomata) that had been extracted from the original collections. Jacquetant kept those in his private fungarium which has now been lost (P.-A. Moreau, in letter to RK of 9 May 2014 and Loizides 2017 p. 42). The main parts of the collections were kept in RK's private fungarium until they were finally sent to Oslo.

*Morchella eximioides* – The species was first collected in 1979 at Nabbetorp in Fredrikstad 24 May 1979, but the specimens from 1979 are unfortunately lost. Two dried specimens from 1979 were sent to Jacquetant (without an accompanying photograph) and the remaining material was stored in a freezer by RK. Jacquetant's fungarium has been lost and the material in the freezer was destroyed shortly after it was taken out. A low-quality newspaper picture of this material was printed in the newspaper Fredriksstad Blad (10 May 1980). However, Jacquetant also received one dried specimen from a new collection of the species collected in 1981 from the same site accompanied by an in situ photograph. The description of *M. eximioides* in Jacquetant (1984) is based on both the 1979 and the 1981 collections (loc. cit. p. 100). The voucher

material designated as holotype in (O) - O-72834 - is actually from 1981. Since Jacquetant's description was based on material from both years and his illustration was based exclusively on material from 1981, we conclude that it is appropriate to accept this material as the holotype. Alternatively, this material could be designated a lectotype.

#### *Molecular biology and phylogenetics*

##### *DNA extraction, amplification and sequencing:*

Total DNA was extracted from dry specimens employing a modified protocol based on Murray and Thompson (1980). PCR amplification was performed with the primers ITS1F and ITS4 (White et al. 1990, Gardes and Bruns 1993) for the ITS region, while LR0R and LR5 (Vilgalys and Hester 1990, Cubeta et al. 1991) were used to amplify the 28S rDNA region, EF1-526F, EF1-983F, EF1-1567R and EF-2218R (Rehner and Buckley 2005) for the translation elongation factor 1a (*tef1*) gene, bRPB2-9F and bRPB2-3AR for the RNA polymerase II second largest subunit (*rpb2*) gene (Taşkın et al. 2010), and RPB1-Af (Stiller and Hall 1997) and RPB1-Cr (Matheny et al. 2002) for the RNA polymerase II largest subunit (*rpb1*) gene. PCR reactions (Mullis and Faloona 1987) included 35 cycles with an annealing temperature of 54 °C. PCR products were checked in 1% agarose gels, and positive reactions were sequenced with one or both PCR primers. Chromatograms were checked searching for putative reading errors, and these were corrected.

*Phylogenetic analyses:* BLAST (Altschul et al. 1990) was used to select the most closely related sequences from the International Nucleotide Sequence Database Collaboration (INSDC) public databases. Sequences came mainly from O'Donnell et al. (1997, 2011), Taşkın et al. (2010, 2012, 2016), Du et al. (2012a, 2012b), Richard et al. (2015), Voitk et al. (2016), Loizides et al. (2016), and

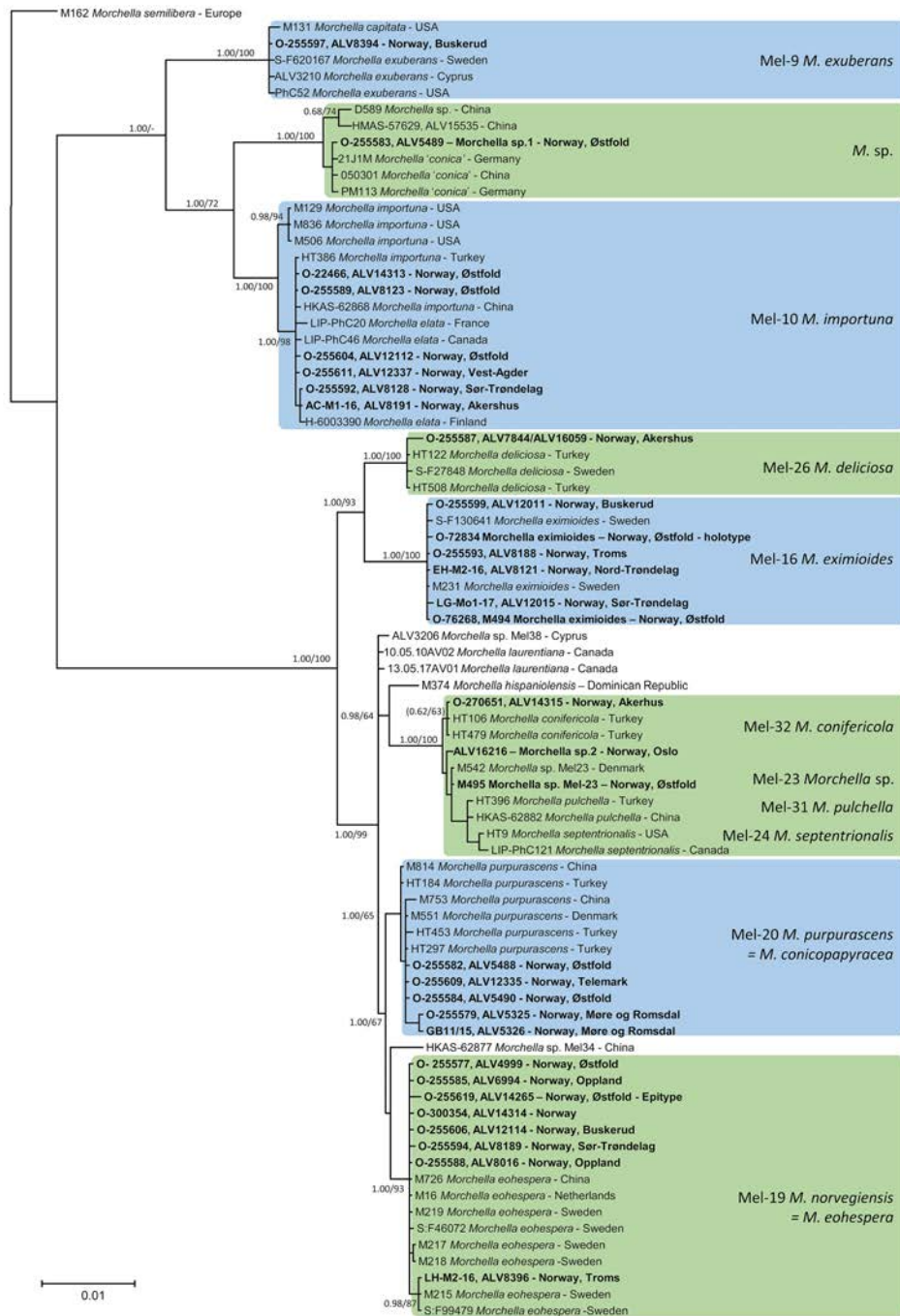


Figure 1: Phylogenetic tree. 50% majority rule consensus phylogram obtained in MrBayes from 9375 trees after the analysis of ITS rDNA, tef1, rpb2 and rpb1 sequences of selected species of *Morchella* section *Distantes*. Nodes were annotated if supported by > 70% ML BP or > 0.95 bayesian PP, but non-significant support values are exceptionally represented inside parentheses. Bold names represent Norwegian samples.



Baroni et al. (2018). Sequences were first aligned in MEGA 5.0 (Tamura et al. 2011) software with its Clustal W application and then corrected manually. The final alignment included 200/669 (ITS rDNA), 178/945 (*tef1*), 54/403 (*rpb2*), and 101/760 (*rpb1*), variable sites from 80 distinct individuals. A Bayesian analysis (data partitioned, GTR+G model, two simultaneous runs, six chains, temperature set to 0.2, sampling every 100th generation) was performed in MrBayes 3.2.6 (Ronquist and Huelsenbeck 2003) until convergence parameters were met after 1.25M generations, standard deviation having fallen below 0.01. Finally, a full search for the best-scoring maximum likelihood tree was performed in RAxML (Stamatakis 2006) using the standard search algorithm (data partitioned, GTRMIX model, 2000 bootstrap replications). Significance threshold was set above 0.95 for posterior probability (PP) and 70% bootstrap proportions (BP).

## RESULTS AND DISCUSSION

Phylogenetic analysis (Figure 1) produced a phylogeny consistent with other studies of *Morchella* section *Distantes* (Richard et al. 2015). Norwegian samples seemed to represent at least 10 distinct genetic lineages, matching already known species, such as *M. conifericola*, *M. deliciosa*, *M. eximoides*, *M. exuberans*, *M. importuna*, *M. norvegiensis*, and *M. purpurascens*, as well as one lineage not associated to any known species (Mel-23), and two unnamed lineages (ALV5489 and ALV16216). *Morchella importuna* was composed of two genetically independent but geographically overlapping lineages. The species-rich *Elata* subclade contained several closely related species

which could not be significantly discriminated in the present analysis, including the known *M. conifericola* (Mel-32), Mel-23 and ALV16216.

***Morchella conifericola*** Taşkın, Büyükalaca & H.H. Doğan, 2016, (Mel-32)

A single collection of the recently described *M. conifericola* (Mel-32) found in SE Norway (Akershus) in an unknown type of habitat was identified in the analyses. The species was originally reported from the Black Sea region in Turkey, growing under conifers (*Pinus*, *Cedrus* and *Abies*; Taşkın et al. 2016). The present finding is the first record from another country, and suggests a much broader distribution.

*Morchella deliciosa* Fr. 1822, (Mel-26) – Fig. 2  
One collection of *M. deliciosa* (Mel-26) from SE Norway (Akershus) was identified among the specimens studied in the present work. Several ascomata were found on a lawn under an *Abies* sp. in a spot where it had been observed for many years. Richard et al. (2015) linked the genetic lineage Mel-26, with *M. deliciosa*. *Morchella deliciosa* is an old Friesian name



Figure 2. *Morchella deliciosa*, O-255587. ALV7844. Photo: Kristin Vigander.

(Fries 1822) which has been rarely used in Scandinavia, but rather frequently in southern Europe. Clowez (2012) used the name *M. conica* for this species, but this name is now considered illegitimate (Richard et al. 2015).

Fries (1822) reported that *M. deliciosa* grows in grassy deciduous woods in Sweden, but no authentic material remains in the Swedish herbaria. Clowez (2012) described it (as *M. conica*) as very common, growing under various species of conifers (*Picea*, *Pinus* and *Abies* spp), and also often with hazel (*Corylus*). Also Loizides (2017) reported that *M. deliciosa* is associated with conifers, mostly *Larix*, *Picea* and *Pinus*. It appears, from current information, to be a strictly European species with a wide distribution, ranging from Turkey to France and Sweden.

***Morchella eximioides*** Jacquet. ex R. Kristiansen, 1990, (Mel-16) – Fig. 3

**Holotype:** NORWAY: Østfold: Fredrikstad, Nabbetorp, near Glomma, 59.21811° N, 10.97272° E, among old newspapers (overgrown), under *Salix*, with *Alnus*, *Populus*, *Acer* a. o., 17 May 1981, leg. Roy Kristiansen, det. E. Jacquetant, O-72834, (Bon & Jacquetant no. 290579).

According to Kristiansen (1982 p. 72 as 9. *Morchella* sp. and Fig. 7) *M. eximioides* was found among old leaves and twigs, at base of a *Salix* where at the time of collecting other deciduous trees including *Ulmus*, *Populus*, *Acer*, *Betula*, and *Aesculus* were growing; the ground mainly consisted of charcoal from a saw mill burnt in the 1920s.

O'Donnell et al. (2011) sequenced two Norwegian collections identified by Jaquetant as *M. eximioides* (RK82-44/250482 and RK 82-69/RK190582) and O'Donnell nos. M489 and M494, Oslo nos. O-76268 and O-76269), both of them found at Torp in Fredrikstad in 1982, reporting that they match the genetic lineage Mel-16. Later, Richard et al. (2015) sequenced the holotype in O (O-72834), with a similar result.

One of the two collections from Torp sequenced by O'Donnell was found among *Rubus* in a site with industrial waste, the other in a nearby site growing on burnt cellulose balls. Other, more recent samples were found

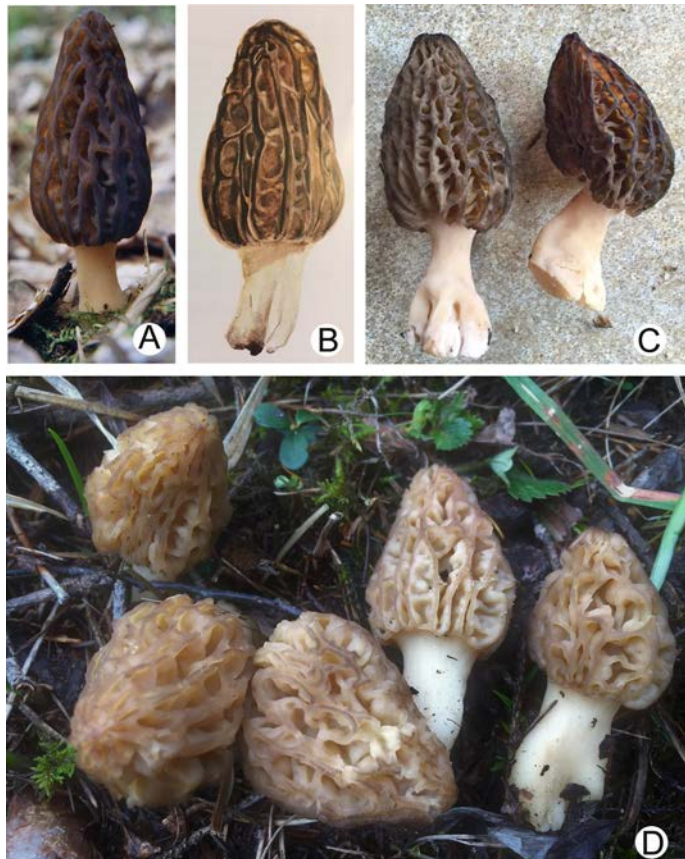


Figure 3. *Morchella eximioides*. A) Holotypus, O-72834, found 17.05.1981; B) Water colouring of holotype (Jaquetant, 1984); C) O-255593, ALV8188; D) O-255599, ALV12011. Photos: A) Roy Kristiansen; C) Eva Espeland; D) Øyvind Weholt.



in various habitats: an open logged site formerly dominated by pine (*Pinus sylvestris*), bark beds (two collections), a mixed forest with spruce (*Picea abies*) and birch (*Betula*) where no bark was observed. *Morchella eximioides* is known in Norway from Østfold in the South to Troms in the far North, and is up to now only known from northern Europe (O'Donnell et al. 2011, Richard et al. 2015), and China (Du et al. 2012a).

*Note:* The legacy of the holotype is described above, under the Material and Methods section.

***Morchella exuberans*** Clowez, Hugh Sm. & Sandi Sm., 2012, (Mel-9) – Fig. 4

Syn.: *M. capitata* M. Kuo & M. C. Carter (2012)

Du et al. (2012b) demonstrated that ITS rDNA data alone can be employed to discriminate *M. exuberans* (Mel-9) from all other morels.

This is an obligate post-fire morel and the only species in Norway reported to produce ascomata abundantly shortly after a wild fire (Gulden 2013). In Europe, *M. exuberans* and *M. eximia* are the only two obligate post-fire species hitherto recognized (Loizides 2017). *Morchella importuna* is often considered a

facultative post-fire species (Du et al. 2012a), but this grows more often in non-burnt sites. Some other species of *Morchella* may occur on burnt substrates, e.g. *M. norvegiensis* and *M. eximioides*, but mostly on older burnt remains or charcoal, not on recent burns.

The forest in S Norway where *M. exuberans* was found had mainly pines in addition to some spruce and birch. A massive fruiting occurred exactly one year after a wild-fire in June. Such massive fruiting of morels in burnt forest has been documented only from this one occasion in Norway, but presence of a few black morels in recently burnt forests has sometimes been reported (Gulden 2013). The phenomenon of massive fruiting of morels following forest fires is well known in southern Europe (see f. inst. Moser 1949, where a total of more than 20,000 kg of morels - not identified to species - were estimated to fruit during one year in a small area, 500 ha). In North-America where at least four post-fire morels occur (Kuo et al. 2012) commercial harvesting of post-fire morels is a significant business (see f. inst. Pilz et al. 2007).

*Morchella exuberans* is a vernal morel able to fruit also in autumn. In Oregon (USA), massive fruiting of this species was observed



Figure 4. *Morchella exuberans*. O-255597, ALV8394; Photos: Gro Gulden.

in August the year after a summer fire (Kuo et al. 2012), and a similar event took place in Lule Lappmark (Sweden) in September (Richard et al. 2015). Moser (1949) reported ascomata of post-fire morels from spring to middle September with occasional ascomata occurring as late as November. *Morchella galilaea* Masaphy & Clowez (Taşkin et al. 2016) and *M. rufobrunnea* Guzmán & F. Tapia (Loizides 2017) are the only other species known to occur in autumn so far.

*Morchella exuberans* is also known from northern Sweden, Turkey, Cyprus, eastern and western USA, and southern China (Kuo et al. 2012, Richard et al. 2015, Miller et al. 2017).

***Morchella importuna*** M. Kuo, O'Donnell & T.J. Volk, 2012, (Mel-10) – Fig. 5

Our phylogenetic analysis based on 4 genes (Figure 1) suggests that collections identified as *M. importuna* (Mel-10) fall in two closely

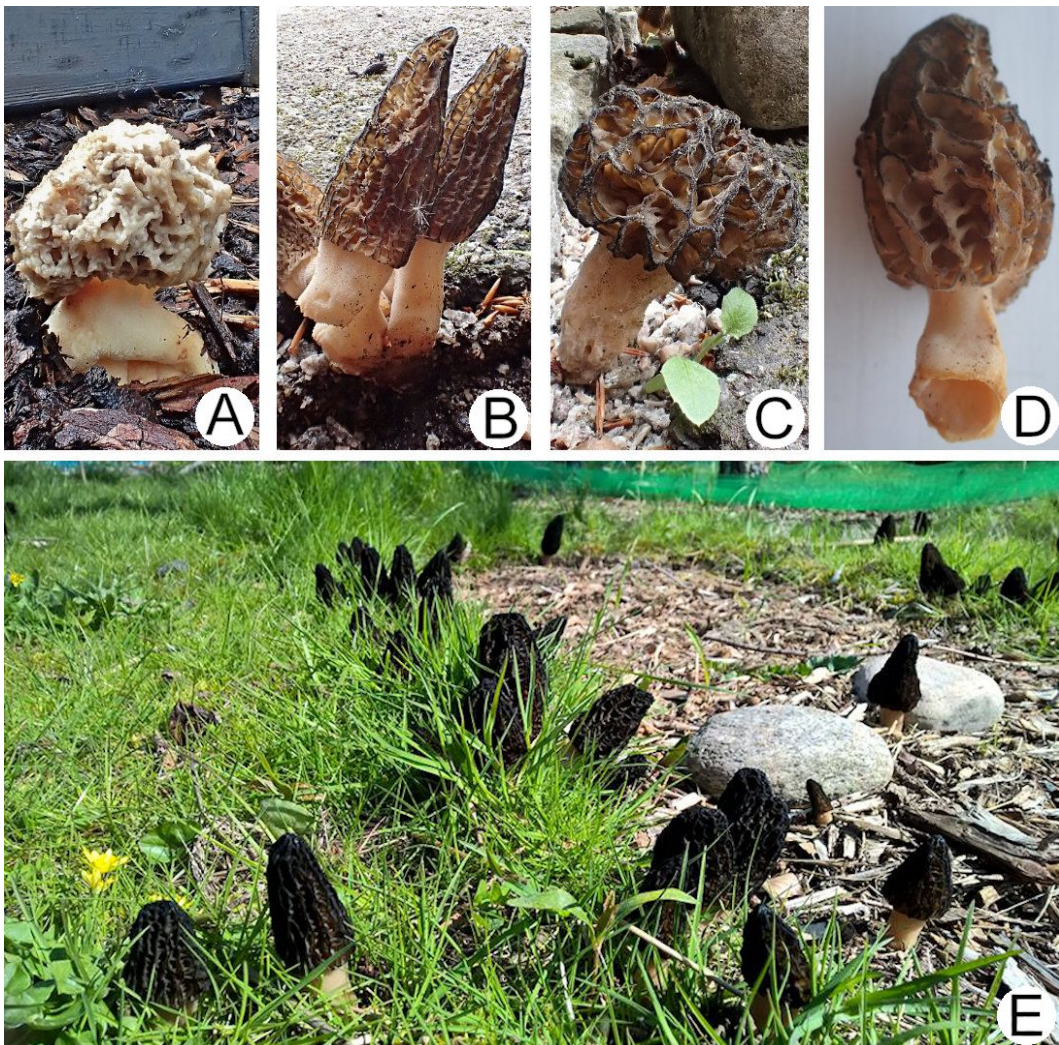


Figure 5. *Morchella importuna*. A) O-255590, ALV8126; B, C) O-255589, ALV8123; D) O-255611, ALV12337; E) O-255591, ALV8126. Photos: A, B, C) Ingvild Rokseth; D) Andreas K. Svendsen; E) Claus Larsen



related clades: one of them known, until now, only from North-America, and another one found in Europe, Canada, and China. These possibly represent distinct species and are presently studied in another project in order to provide a taxonomic solution. Richard et al. (2015) pointed at *M. importuna* (Mel-10) as the most probable match to *M. elata* Fr.: Fr., but refrained from proceeding with a typification process for *M. elata*, partly because they had no Scandinavian collections at that time identified as Mel-10/*M. importuna*.

*Morchella importuna*, however, we found to be one of the most common morels in Norway, found throughout the country. Most collections are from bark fillings and flowerbeds with bark. A few collections are apparently from other types of habitats, e.g. gravelly road-sides, among grass and weeds, and in open deciduous forest. Until now it is only known from lowland sites, up to approximately 100 m asl.

Kuo et al. (2012) found that *M. importuna* showed a preference for urban sites, such as planters, woodchip beds and gardens; no bark mentioned. With bark apparently being a favored substratum for the Norwegian collections, also an ecological distinction may be seen between North-American *M. importuna* and European *M. importuna*. *Morchella importuna* is sometimes thought to be a facultative pyrophilous species (Taşkin et al. 2012, Du et al. 2012a, Loizides 2017), but none of the Norwegian collections were found in burnt sites.

*Morchella importuna* has been reported from several European countries (Finland, France, Germany, Spain, Switzerland, Turkey), as well as Canada, USA, and China (Richard et al. 2015, Loizides 2017), and is believed to be a worldwide saprotroph (Richard et al. 2015).

***Morchella norvegiensis*** Jacquet. ex R. Kristiansen, 1990, (Mel-19) – Fig. 6 A, B

Syn.: *M. eohespera* Beug, Voitk & O'Donnell (2016).

**Holotype:** NORWAY: Østfold: Fredrikstad: Torp Bruk, close to river Glomma, but not a flooded site, lat./long.: 59.1985° N, 10.8735°

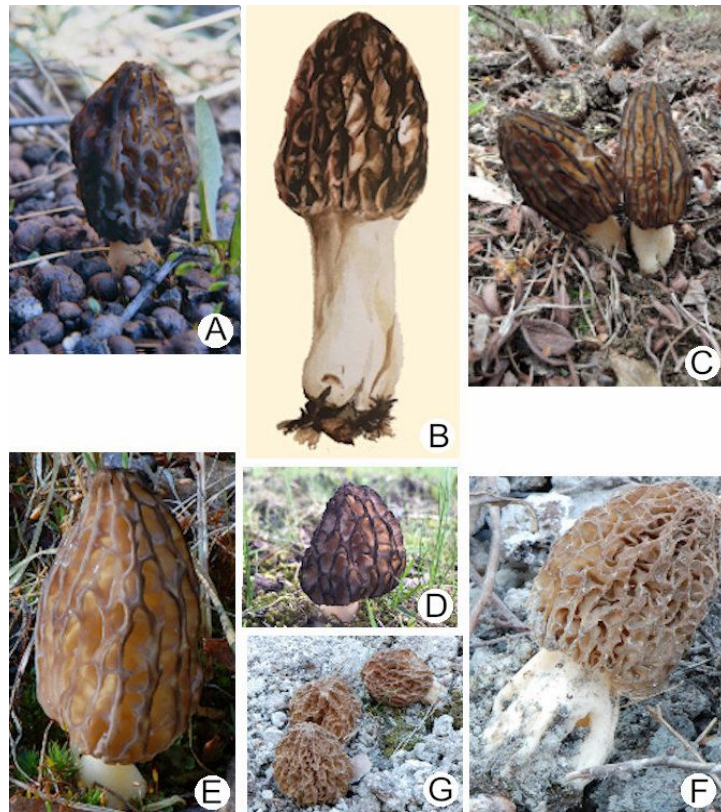


Figure 6A. *Morchella norvegiensis*. **A)** Holotype, O-72835, found 23.05.1981; **B)** Water colouring of holotype (Jaquetant, 1984); **C)** O-255588. ALV8016; **D)** O-255602. ALV12014; **E)** O-255581. ALV5487; **F-G)** O-255577, ALV4999. Photos: A) Roy Kristiansen; C) Hans Schwencke; D) Jim-Andre Stene; E, F, G) Morten Pettersen.

E, among Leca-spheres where the old (down burned) storehouse of Torp Bruk stood, 23 May 1981, leg. R. Kristiansen, det. E. Jacquetant, O-72835 (Bon & Jacquetant no. 230581). **Epitype** designated here: topotype material, collected 24 May 1987 by R. Kristiansen, RK-87-07, ALV 14265, O-255619.

According to Kristiansen (1982 p. 70, as 5. *Morchella* sp. and Fig. 3) the holotype of *M. norvegiensis* was found in a shady, moist dike edge with twigs and other plant debris, burnt paper remains, grass and moss, under *Salix*, with *Tricholoma cingulatum* (in the same spot in autumn).

Richard et al. (2015) succeeded to obtain ITS and LSU rDNA sequences from O-72835, the holotype of *M. norvegiensis* which suggested that this species belongs in the clade of Mel-17-19-20-34, where an accurate identification cannot be achieved without additional genetic markers. In the present work we selected an epitype of *M. norvegiensis* coming from the original locality in order to clarify the concept of this taxon. Additional tef1 data from the epitype showed no significant differences from sequences obtained from *M. eohespera* (Mel-19), a species recently described from Canada and USA and thought to be cosmopolitan as it seems to be present also in southern Europe and China (Voitk et al. 2016). Accordingly, we consider the two species conspecific. This was also suggested by Loizides (2017).

In Norway, *M. norvegiensis* competes with *M. importuna* in being the most common species of *Morchella*. It has been collected throughout the country except for SW Norway; in central Norway it enters the northern boreal zone with finds up to 1100 moh. Samples were found in a wide range of manmade or human-disturbed sites. Some collections are from calcareous ground, some from nitrogen-rich habitats, and some from flower beds with or without bark; gravely road-sides and borders of logged coniferous forests also

seem favorable for the species. Old burnt remnants were present in the site where the type was collected. On a few occasions it was collected in sites that may have natural, undisturbed vegetation. Voitk et al. (2016) wrote that the majority of the collections of their *M. eohespera* in Canada and USA were found in natural vegetation where soil, gravel, and sand periodically shifted because of wind and cryogenic cycles.

Jacquetant (1984) also identified a form of *M. eximia* Boud., f. *schizocostata* Jacquet. (RK-290580), but due to contamination we were unable to obtain DNA data from this sample. A description and illustration in Kristiansen (1982, p. 72, Fig. 6) depicts a morel with an almost globose cap recalling species of section *Morchella* (“rundmorkler”), with a small depression at the top. Jacquetant, in a letter to RK (14 January 1981), found that the material was immature, and supposed the apical depression, actually a hole, might represent an acute apex that was lost. Just like *M. norvegiensis*, it was found among burnt paper and in the same place as *M. norvegiensis*, and most probably it should be referred to this species. *Morchella eximia* is a post-fire morel not yet known to occur in Norway.



Figure 6B. *Morchella eximia* f. *schizocostata*. Photo: Roy Kristiansen.

***Morchella purpurascens*** (Boud.) Jacquet. 1985, (Mel-20) - Fig. 7 A, B

Syn.: *M. conicopapyracea* Jacquet. ex R. Kristiansen, 1990.

**Holotype** of *M. conicopapyracea*: NORWAY: Østfold: Fredrikstad, near Torp stadium, in a waste site under *Betula* and *Alnus*, 16 May 1981, leg R. Kristiansen, det. E. Jacquetant, RK-160581, O-72836 (Bon & Jaquetant no. 260581). **Epitype** designated here: NORWAY: Østfold: Fredrikstad, near Torp stadium, in moss on burnt ground, 26 May 1982, leg. R. Kristiansen, det. E. Jacquetant, RK-260582, ALV15967, O-255621.



Figure 7A. *Morchella purpurascens*, **A**) O-255584, ALV5490; **B**) ALV8119; Photos: A) Morten Pettersen; B) Tijana Gajjik.

O'Donnell et al. (2011) obtained ITS rDNA sequences from two Norwegian collections from Østfold, one found at Torp collected on 19 May 1997 (O'Donnell no. 487, RK 97-58), and another one found at Hvaler on 21 May 1982 (O'Donnell no. 492, RK 82-82), suggesting they represented an independent lineage that they labeled Mel-20. Later, Richard et al. (2015) defined Mel-20 as *M. purpurascens*.

*Morchella purpurascens* is a relatively common morel in Norway. Most of the Norwegian collections are from sites influenced by human activity, for instance flowerbeds, some however are from natural habitats such as shell-banks, and the species may grow in extremely calcareous soils. There is no mention

of bark as substrate. A few times deciduous forests are indicated, never conifer forests. All our samples are from lowland sites in south and central Norway.

*Morchella purpurascens* is considered a common morel in Europe (Jacquetant 1984). In contrast to the Norwegian observations, *M. purpurascens* is known to be associated with *Pinus* and other conifers (Loizides 2017), preferably growing in moist, boggy or swampy habitats. The species is known in Europe from the Mediterranean area to Sweden and Norway (Loizides 2017), as well as southern China (Du et al. 2012a) and Taiwan (O'Donnell et al. 2011).

*Morchella conicopapyracea* –Richard et al. (2015) were able to obtain only ITS sequences from the holotype of this species. By renewed efforts to obtain quality DNA from the holotype of *M. conicopapyracea*, employing the Pezizales-specific primer LR3-Pez (Teder-soo et al. 2011), we were able to reconstruct a partial 28S/LSU rDNA sequence (MN017027). The consensus LSU sequence (about 455 bp), was different from those of *M. exuberans* (by 5 bp), *M. importuna* (5 bp), *M. deliciosa* (2 bp), *M. eximoides* (2 bp), as well as *M. conifericola*, *M. pulchella*, *M. septentrionalis* and Mel-23 (1 bp). The consensus LSU sequence we obtained from the holotype had also 12 sites which could not be determined unambiguously because of a mixed signal, while the remaining sites matched 100% *M. norvegensis* (Mel-19), *M. purpurascens* (Mel-20), and other lineages such as Mel-17. Therefore, an epitype for *M. conicopapyracea* from the same site as the holotype (O-255621, RK-260582) was selected to get a more accurate





Figure 7B. *Morchella conicopapyracea*. A) Holotype, O-72836; B) Water colouring of holotype (Jaquetant 1984). Photo: A) Roy Kristiansen.

identification. The 28S/LSU rDNA sequence obtained from this specimen is genetically more similar to Mel-20 than to Mel-19 (1bp different) or any other lineage of *Morchella*, and therefore, we conclude that *M. conicopapyraea* is probably a later synonym of *M. purpurascens* (Mel-20).

Kristiansen (1982, p. 71, as 7. *Morchella* sp. and fig. 5) described the habit and habitat of *M. conicopapyraea* more in detail as a species growing gregariously, partly fasciculate, on mats of *Bryum* covering burnt cellulose balls in places where *Betula*, *Alnus* and *Salix* were growing.

**Lineages not associated to any known species**

Finally, several collections did not match any lineage with a confirmed species name, and therefore need additional study to ascertain if they match an existing taxon or need to be described as new.

One of these unnamed samples matched the lineage Mel-23 (Figure 8). There are two collections of this taxon found in the same place in Fredrikstad in 1980 and 1981, described and illustrated by Kristiansen (1982,

p. 70, as *M. distans* ss. Boudier, fig. 4). Jaquetant (1984) identified these samples as *M. distans* Fr. ss. Boud., and one of them (O'Donnell no. 495) was later shown to represent an independent genetic lineage by O'Donnell et al. (2011), which they named Mel-23. The other collection is apparently lost. *Morchella distans* is an old, obscure taxon, very briefly and vaguely described by Fries (1849) from Sweden. The species is the type of section *Distantes* Boud. Lineage Mel-23 has been reported up to now only from Norway, Denmark and Finland (O'Donnell et al. 2011). It belongs in the highly variable Elata subclade, together with other species, such as *M. conifericola* (Mel-32) discussed above, *M. pulchella* (Mel-31) and *M. septentrionalis* (Mel-24). No significant values supporting the monophyletic status of these lineages were found, perhaps because of a too recent or incomplete reproductive isolation or perhaps because of lack of data.

One collection (*Morchella* sp. 1, Figure 9, ALV5489, O-255583), also from Fredrikstad, appears to represent an unnamed lineage closely related with *M. importuna* (Mel-10) and *M. exuberans* (Mel-9), already observed



Figure 8. Mel-23: Kerry O'Donnell no. 495. Photo: Roy Kristiansen.

by Du et al. (2012a). This lineage is composed of some ITS rDNA sequences obtained from environmental or spore samples (PBM113, GenBank KJ744351; 21J1M, GenBank AJ544196), as well as some herbarium specimens identified as *M. conica* from China

(39739, GenBank DQ257343; 050301, GenBank DQ257344). Its taxonomic identity needs to be clarified, and compared with known species and genetic lineages.

Another collection, (*Morchella* sp. 2, Figure 10, ALV16216) from a garden in Akershus (SE Norway) appears to represent yet another independent lineage within the same group as *Morchella* sp. 1. Further studies are clearly needed in order to check if this complex is truly formed by isolated species, or whether a different taxonomic arrangement is in order.

### Summary

All in all, true morels are far from common in Norway, but at least 10 different phylogenetic species occur here. Most collections come from flower beds, lawns, bark deposits, ruderal sites, roadsides with sand or gravel and other human-influenced habitats. We have experienced that the species occurring on lawns and in bark fillings tend to produce ascomata in great numbers the first year, but they are only present in small numbers the one or two years following, if at all. The two most frequent and widespread species are *M. norvegiensis* and *M. importuna*, but there are very few collections occurring in natural sites. *Morchella norvegiensis* grows from the low-



Figure 9. *Morchella* sp. 1, O-255583, ALV5489. Photo: Morten Pettersen.





Figure 10. *Morchella* sp. 2, ALV 16216; young specimens (about two weeks). Photo: John Sandve.

lands up almost to the treeless alpine level, while the other relatively common species, *M. importuna*, seems to be restricted to lowland sites. The third most common species is *M. purpurascens*, also predominantly found in manmade habitats. Considering that practically all finds also of *M. eximioides*, a species apparently rare but widely distributed in Norway, and all other species represented by single collections come from human influenced habitats, it seems that the whole group of black morels in Norway represents anthropogenic introductions.

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## On some *Entoloma* species (Tricholomatinae, Basidiomycota) little known or new to Norway

Tor Erik Brandrud<sup>1</sup>, Egil Bendiksen<sup>1</sup>, John Bjarne Jordal<sup>2</sup>, Øyvind Weholt<sup>3</sup>, Bálint Dima<sup>4</sup>, Olga Morozova<sup>5</sup>, Machiel E. Noordeloos<sup>6</sup>

<sup>1</sup>Norwegian Institute for Nature Research, Gaustadalléen 21, NO-0349 Oslo, Norway

<sup>2</sup>Biolog J.B. Jordal, Skrøvegen 21, NO-6610 Øksendal, Norway

<sup>3</sup>Nord University, Nesna, NO-8700 Nesna, Norway

<sup>4</sup>Department of Plant Anatomy, Institute of Biology, Eötvös Loránd University, Pázmány Péter sétány 1/c, H-1117 Budapest, Hungary

<sup>5</sup>Komarov Botanical Institute of the Russian Academy of Sciences, 197376, 2 Prof. Popov Str., Saint Petersburg, Russia

<sup>6</sup>Naturalis Biodiversity Center, section Botany, P.O. Box 9517, NL-2300 RA Leiden, The Netherlands

Corresponding author: tor.brandrud@nina.no

Norsk tittel: Noen lite kjente eller nye rødsporer (*Entoloma*; Tricholomatinae, Basidiomycota) for Norge

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### NØKKEWORD

rDNA ITS-sekvensering, morfologi, økologi, utbredelse.

### SAMMENDRAG

Dette er den andre artikkelen med resultater fra det norske *Entoloma*-prosjektet 2015-2017. I denne artikkelen presenterer vi arter som er nye for Norge eller lite kjent, fra følgende mindre grupper/klader; *Caeruleopolitum*, *Claudopus*, *Entocybe*, *Leptonia*, *Prunuloides*

og *Sphagneti*. I tillegg tar vi med enkelte arter som plasserer seg noe isolert i de foreløpige fylogenetiske analysene basert på ITS. Følgende arter rapporteres her nye for Norge: *E. cuboidoalbum*, *E. jahnii*, *E. percoelestinum*, *E. pseudoconferendum*, *E. ritae* og *E. venustum*. Den svært lite kjente *E. juniperinum* og synonymi med *E. mirum* blir også diskutert. *Entoloma porphyrocephalum* er tidligere beskrevet som en varietet, men blir her endret til artsnivå basert på DNA-analyser.

### ABSTRACT

This is the second paper reporting major results from the Norwegian *Entoloma* project 2015-2017. Here we present species that are new to Norway or little known, from the following smaller clades: *Caeruleopolitum*, *Claudopus*, *Entocybe*, *Leptonia*, *Prunuloides* and *Sphagneti*. In addition, a few species taking a somewhat isolated position in our unpublished preliminary ITS tree are presented. The following species are here reported new to Norway: *E. cuboidoalbum*, *E. jahnii*, *E. percoelestinum*, *E. pseudoconferendum*, *E. ritae*, and *E. venustum*. The synonymy of *E. mirum* with the older *E. juniperinum*, is also discussed. *Entoloma por-*

*phyrocephalum*, formerly described as a variety, is now raised to species level based on its phylogenetic position.

## INTRODUCTION

The present paper is the second in a series of papers in *Agarica* reporting results from the Norwegian *Entoloma* project 2015–2017. The Norwegian *Entoloma* project has been a part of The Norwegian Taxonomy Initiative, funded by The Norwegian Biodiversity Information Centre (NBIC). In the first paper, results on the *Rhodopolia* clade were reported (Brandrud et al. 2018). In this second paper, some small, basal clades in *Entoloma* are emphasized, including the clade *Entocybe*, often distinguished as a separate subgenus, by some even as a separate genus (Baroni et al. 2011). Furthermore, the present paper also treats some taxa from the *Claudopus* and *Prunuloides* groups/clades (in the sense of e.g. Noordeloos 1992) and *Leptonia* s. str. (in the sense of Morozova et al. 2014), as well as some taxa with uncertain phylogenetic affinity, which are new to Norway or at least little known. A third paper, on the large clade *Cyanula* (= *Leptonia* s. lat.) is in preparation for a later issue of *Agarica*. All results presented here are based on samples being verified by rDNA ITS sequencing, mainly through NorBOL (Norwegian Barcode of Life Network; see Ratnasingham and Hebert 2007).

*Entoloma* is one of the most species-rich genera within Agaricales, well characterized by many-angled spores that leave a pinkish brown spore print. As commented more deeply in the first paper (Brandrud et al. 2018), we consider that *Entoloma* should still be kept as one single, very large genus and not split into several smaller genera, due the fact that variability in *Entoloma* is complex and still not fully understood. This is mainly due to incomplete sampling and the fact that large regions

are still underexplored (e.g. Africa, S. America, Asia) and the fact that many clades in recent phylogenetic analyses show low support with the genetic markers applied so far (see e.g. Morgado et al. 2013).

## MATERIAL AND METHODS

Altogether approx. 700 samples of *Entoloma* species have been collected during the Norwegian 2015–2017 *Entoloma* project, and 1080 samples were verified by ITS-sequencing. The latter number also includes many herbarium collections. In addition, sequences were obtained of numerous type specimens and some important reference material from outside Norway studied in connection with the present project. All sequenced material from Norway are listed under material sequenced. Collections labelled NOBAS or CAFUN are sequenced through NorBOL, those labelled ALV are sequenced by Pablo Alvarado (ALVALAB, Spain), and those with no sequence label are sequenced by us (BD, in Eötvös Loránd University, Budapest). All sequences are analysed by us (see below). All material is deposited or will be deposited in herb. Oslo (the Oslo fungarium).

## Morphology and molecular study

The macromorphological observations are based on the field notes and photographs of the available material. Microscopical observations were made using standard methods (see e.g. Morozova et al. 2014), and the molecular study was likewise performed according to standard methods, described in detail in the first paper in this series (Brandrud et al. 2018).

## RESULTS AND DISCUSSION

During our NBIC *Entoloma* project 2015–2017, we could distinguish 194 well-supported, phylogenetic species (Operational Taxonomic Units, OTU's). Of these, 87 species were new to Norway. In the following, we will present

in more detail some of our results on a number of small clades.

### 1. The basal *Entoloma* clades

The basal *Entoloma* lineages (the basal *Entoloma* grade as defined by Baroni et al. (2011) and Co-David et al. (2009)), includes several distantly related clades, among others the apparently polyphyletic (sub)genus *Entocybe*. Many species in this basal group are characterized by a peculiar spore morphology, being rather small, thin-walled, often rounded and weakly angular, almost nodulose-warted, resembling a type of spores that is also found in the *Rhodocybe* clade. There are, however, exceptions, like in the case of *E. sphagneti*, which has more elongate-heterodiametrical spores, which at the same time also have a wavy-nodulose outline instead of being sharply angled as in most *Entoloma* species. A macromorphological feature found in this basal *Entoloma* clades is the occurrence of blue and/or violaceous pigments in many species, a character shared with the *Cyanula* and *Leptonia* clades, but otherwise a rare feature in the genus *Entoloma*. Many species in these clades also have a characteristic shape of the stipe, which is distinctly swollen just above the often rather distinctly tapering base. Members of the basal clades occur widespread all over the world, with several species recently described from Australasia, and America (Horak 2008, Largent 1994, Noordeloos and Gates 2012). Many European species prefer oligotrophic habitats, such as *Sphagnum* peat bogs and heathland on poor, acidic soil.

#### 1.1. Clade *Caeruleopolitum*

This small clade consists of two, morphologically rather similar species, characterized by having relatively large spores, up to 10 (11)  $\mu\text{m}$  long, and with normally thick walls and well-developed angles. Both species may have blue-violaceous tinges in the basidiocarp or not. The more common of the two, *E. caeruleopolitum*

occurs widespread in Norway, while *E. juniperinum* is more rarely recorded, but seems locally not infrequent.

#### *Entoloma caeruleopolitum* Noordel. & Brandt-Ped. Fig. 1 A, B.



Figure 1. **A, B)** *E. caeruleopolitum*. **A)** KB&EB107-16; **B)** JBJ0251. Photos: **A)** E. Bendiksen; **B)** J.B. Jordal.

**Characteristics:** Pileus up to 30 mm broad, conical at first, soon convex or applanate, umbonate or slightly depressed at centre, hygrophanous, when moist deeply translucently striate, reddish or porphyry brown, as young often tinged blue or more greyish brown, darker at centre, pallescent on drying, glabrous. Lamellae rather distant, broadly adnate or emarginate, sometimes with decurrent tooth, segmentiform to ventricose, pallid creamy-beige or tinged brownish, then with pink tinge. Stipe 20–60  $\times$  2–5 mm, cylindrical or compressed with longitudinal groove, sometimes tapering towards base, blue, violaceous-

brown or greyish brown, smooth, polished. Context dark grey in pileus, in cortex of stipe with blue tinge. Smell and taste indistinct. Spores 8.0–10.0(–11.0) × 6.5–8.0 μm, Q = 1.1–1.3, subspherical, 5–6-angled in sideview. Basidia 4-, and occasionally also 2-spored, clamped. Cystidia absent. Pileipellis an ixocutis of narrow, cylindrical, 3–8(–11) μm wide hyphae, subpellis usually well differentiated, made up of inflated elements, up to 25 μm wide. Pigment brown, intracellular in pileipellis. Clamps abundant in all tissues.

*Habitat & distribution:* In SE and E Norway the species has been found in poor grasslands, mainly abandoned but pastured summer farms on oligotrophic bedrock. Along the W Norwegian coast it is found in similar habitats, but there is also a few finds in calcareous soils. It is recorded up to 965 m a.s.l. Oppdal, South Trøndelag. The species is found mainly in sites poor in *Entoloma* species (only with *E. conferendum*, *E. clandestinum* and *E. sericeum*) and it also occurs much later in the season (together with a.o. *Hygrocybe* spp.) than most *Entoloma* species.

*Collections sequenced:* NORWAY. Hedmark: Rendalen, Grøndalen, old summer farm pasture, 3 Sept 2016, K. Bendiksen, E. Bendiksen KB EB 107/16 (O-254028). Hordaland: Bømlo, Holme, in semi-natural pasture, 9 Oct 2008, leg. A. Knutsen, J. B. Jordal (O-287891). Bømlo, Tverborgvika ved Lykling, in semi-natural pasture, 10 Oct 2008, leg. A. Knutsen, J. B. Jordal (O-287897). Møre og Romsdal: Averøy, Vågsholmen by Kårvåg, in semi-natural pasture, 30 Sep 1994, leg. G. Gaarder, J. B. Jordal (O-178137). Oppland: Sel, Ottadalen, Rustmo, leg. H. Schwencke, pasture, 22 Sep 2016, HS-E1-15 (ALV7294). Sør-Trøndelag: Oppdal, Losfjellet, Medlisætrene, in semi-natural pasture, 30 Aug 2016, leg. J. B. Jordal, JB16994 (O-304665). DENMARK. Jutland: Silkeborg, Høvild forest,

18 Oct 1982, leg. Brandt-Pedersen 82.268 (C 67093 holotype *E. caeruleopolitum*, ITS2 T. G. Frøslev, pers. comm.).

*Comments:* *Entoloma caeruleopolitum*, originally described from Jutland, Denmark, has a wide distribution in Northwestern Europe, but it is often overlooked because of its small, inconspicuous basidiocarps. Distinctive characters are the glabrous, translucently striate pileus, polished stipe, bluish colours, (sub-)isodiametrical spores, clamped hyphae and simple ixocutis. Like in other species in this clade, the colour of the basidiocarps varies a great deal. Typically, the pileus is bluish tinged as young, soon turning moderately dark reddish or porphyry brown; the stipe is blue or violaceous-blue, but in some collections, the stipe lacks blue tinges. *Entoloma reae*, also with blue pileus and stipe, may appear to be conspecific with *E. caeruleopolitum* as discussed by Noordeloos (1992). A type sequence is needed to prove the synonymy. *Entoloma juniperinum* is closely related, but it differs by having a darker, inconspicuously translucently striate pileus and normally less bluish tinges.

### ***Entoloma juniperinum* Barkman & Noordeloos**

Syn.: *Entoloma mirum* Kokkonen

*Emended description* (incl. features of *E. mirum*): Pileus 5–20 mm broad, convex or applanate, with weak central depression or with small papilla, with deflexed then straight margin, hygrophanous, when moist translucently striate at margin up to 2/3 of radius, dark brown to grey-brown, especially at centre, sometimes when young with blue tinges near margin, occasionally pinkish with darker centre, pallescent on drying, opaque, almost glabrous or covered with fine whitish fibrils, at centre sometimes minutely squamulose. Lamellae, L = 10–25, l = 1–5(–7), (moderately) distant, adnate sometimes emarginate with or without decurrent tooth, segmentiform, rarely



ventricose, up to 6 mm broad, sometimes transvenose, white, or pale grey-brown then with pink tinge. Stipe 15–45 × 1–5(–8) mm, cylindrical, sometimes slightly to distinctly swollen at base, brown or pink, more or less concolorous with pileus or with blue or steel-grey tinge, fading to brown with age, smooth, polished or covered with fine fibrils lengthwise. Smell indistinct to subfarinaceous. Taste often distinctly farinaceous, sometimes absent. Spores 8–10(–11) × 6–8 μm,  $O = 1.1–1.2$  (–1.25), subisodiametrical, 5–7-angled in side-view. Basidia 4-spored. Cheilocystidia absent. Pileipellis a cutis with transitions to a trichoderm, made up of cylindrical to slightly inflated hyphae, 5–20 μm wide, subpellis well-differentiated, made up of inflated elements, 20–45 × 15–35(–45) μm. Pigment brown, intracellular in pileipellis, especially in subpellis. Caulocystidia scattered, simply cylindrical to subclavate. Clamps abundant in all tissues.

*Habitat & distribution.* The Norwegian collections are from eutrophic *Rubus idaeus* thickets on clear-cuttings, where it seems locally not infrequent, as well as from a semi-natural pasture and *Alnus incana* floodplain (delta) woodland.

*Collections sequenced:* NORWAY. Oppland: Lunner, S. Oppdalen, Mørkomdalen, 27 Aug 1979, E. Bendiksen, EB 266/79 (O; as *E. juniperinum*, conf. M.E. Noordeloos), 9 Sept 1990, E. Bendiksen (O). Lunner, Brovoll, semi-natural forest pasture, 6 Oct 2000, E. Bendiksen (O). Nordre Land, Dokka, Dokkadeltaet nature reserve, Bergsrønningen, floodplain *Alnus incana*–*Prunus padus* woodland, 15 Sept 1989, K. Bendiksen, E. Bendiksen, KB EB 269/89 (O).

*Comments:* This species, normally being less bluish tinged than its sister species *E. caeruleopolitum*, is very little known and seldom col-

lected. Nevertheless, it seems in Norway to be locally rather frequent in eutrophic *Rubus idaeus* shrublands after clear-cutting of low-herb spruce forest. Unfortunately, the nomenclature of this taxon is still somewhat unsettled. Kokkonen (2015) published *E. mirum* as a new species, with normally pink or sometimes rather dark brown basidiocarps and small, more or less isodiametrical or slightly heterodiametrical spores. All three known collections were found in the type locality. She noted the remarkable differences in colour between the specimens, some being pink, others dark brown. The type sequence appeared to be similar to some earlier collections from Norway identified by one of us (MEN) as *E. juniperinum*, as well as another one from the Netherlands, identified as such (J. Schreurs 892, L).

Especially the latter should be regarded as a representative reference collection for the original concept of *E. juniperinum*. *Entoloma juniperinum*, also known from juniper heaths in Denmark, Germany and the Netherlands, has similar morphological features as those described by Kokkonen for *E. mirum*, but a still larger range of colours, including forms with distinct blue tinges in the stipe. This phenomenon occurs also frequently in the related taxa *E. vinaceum*, *E. caeruleopolitum*, and the North American *E. trachyosporum*. Unfortunately, the holotype of *E. juniperinum* did not produce usable DNA sequence for analysis. We are convinced, however, based on the morphological similarities, and match with reference material, that *E. mirum* is a later synonym of *E. juniperinum*. More material will be sequenced and studied morphologically to support the supposed synonymy.

### 1.2. Clade *Sphagnetii*

So far, three members of this clade are known from Europe, all of which occur in Norway, and seem preferably to be associated with *Sphagnum* in peaty areas in more or less

acidic environments. The spores are thin-walled, and more or less nodulose-bumpy in outline, heterodiametrical in *E. sphagneti* and *E. pseudoconferendum*, isodiametrical in *E. chamaemori*. *Entoloma sphagneti* is a relatively large, stout fungus, almost tricholomatoid, the other two are more slender, mycenoid or collybioid. At present, these are verified from only two collections each. Whether these are truly rare in a frequent habitat, or just overlooked, remains to be seen.

*Entoloma sphagneti* Naveau. Fig. 2 A, B.



Figure 2. **A, B**) *E. sphagneti*. A) JV02-695; B) Ø. Weholt E2 14. Photos: A) J. Vesterholt. B) Ø. Weholt.

**Characteristics:** A fairly stout, tricholomatoid (-mycenoid) fungus. Pileus up to 120 mm broad, conical, expanding to convex with broad umbo, dark red-brown, slightly translucently striate, glabrous, but with fibrillose patches along the margin. Lamellae deeply adnate-emarginate, ventricose, reddish pink.

Stipe 35–150 × 3–17 mm, from, brown, paler than pileus, strongly fibrillose striate lengthwise. Smell indistinct or farinaceous. Spores 9.5–12.5 × 6.5–9.0 μm, distinctly heterodiametrical with a wavy-nodulose, many-angled outline. Basidia 4-spored. Cystidia absent. Pileipellis an ixocutis or cutis of narrow, cylindrical hyphae, 2.5–9 μm wide. Pigment very abundant, brown, intracellular, in some collections also encrusting. Clamps present in all tissues.

**Habitat & distribution:** In Norway the species is verified only from two collections, one (ALV5672) in a muddy dried-out “pond”, with needle litter in an oligotrophic spruce forest, the other one (ALV14353) in a recently (1 year) dug muddy ditch on peaty ground.

**Collections sequenced:** NORWAY. Østfold: Fredrikstad, Hystad, near Prestmyra, 11 Aug 2014, Ø. Weholt, OW E2 14, ALV5672 (O). Fredrikstad, Blåkollen, 13 Oct 2017, M. Pettersen, MP-3.131017, ALV14353 (O; as *E. aff. turbidum*).

**Comments:** *Entoloma sphagneti* is a rare species, mainly confined to (Atlantic) *Sphagnum* bogs in Northwestern Europe. The species was originally described from Belgium (Naveau 1923). The type is not sequenced, but fits in all other respects, and since this is morphologically and ecologically a quite well defined species, we choose to apply this name. Most records of *E. sphagneti* are from the Netherlands (<https://www.verspreidingsatlas.nl/00041140>) where it is usually found at the margin of peat bogs, often in dry summers in places where the *Sphagnum* is dying, sometimes it grows on dried out peat, and occasionally it is also found in swamp forest with *Salix aurita*. The two Norwegian sequence-verified collections are from more or less dried-out ditches and pond-like depressions, probably with *Sphagnum* peat. It is also

recorded from Britain (Wickens and Legon 2005) and was published from Norway and Denmark by Noordeloos in Knudsen and Vesterholt (2012).

***Entoloma pseudoconferendum* Noordel. & Wölfel** Fig. 3 A-E.

Syn. *Entoloma dolosum* Noordel. & Wölfel, non *Entoloma dolosum* Corner & Horak.

**Characteristics:** Habit slender, mycenoid. Pileus up to 3 cm broad, convex with umbo soon appanate, dark reddish-greyish brown, deeply translucently striate, hygrophanous, pallescent on drying, glabrous. Lamellae moderately distant, deeply adnate-emarginate, brownish pink. Stipe much paler than pileus, silvery-fibrillose striate, base with white tomentum. Smell slightly farinaceous. Spores 10–14 × 7–10 μm, heterodiametrical, weakly angular-nodulose in outline. Basidia 4-spored. Cystidia absent. Pileipellis a cutis of cylindrical hyphae with intracellular pigment. Clamps present.

**Habitat & distribution:** Found in (very) moist oligotrophic bogs and ditches, apparently fruiting mainly in very dry summers with a lowered water table.

**Collections sequenced:** NORWAY. Aust-Agder: Risør, Opstadtjern, A. Omberg, AO 3-18, ALV18069. Froland, Øynaheia, I.-L.- Fonneland & D. Pettersen, ILF 2018-001 (O-76265). THE NETHERLANDS. Prov. Gelderland: Bronckhorst, Kruisbergsebossen, 25 Sept 2016, G.M. Jansen C1594394 (L).

**Comments:** *Entoloma pseudoconferendum* was described in 1995 based on a single collection from Germany, and have never been recorded afterwards until 2016, when it was found in the Netherlands in September and in Eastern Germany in October, in both occasions in the margin of peat bogs where the *Sphagnum* had been dried out. The species was found in a number of dried-out bogs, ditches and exposed lakeshores during the very dry summer of 2018 in southernmost Norway

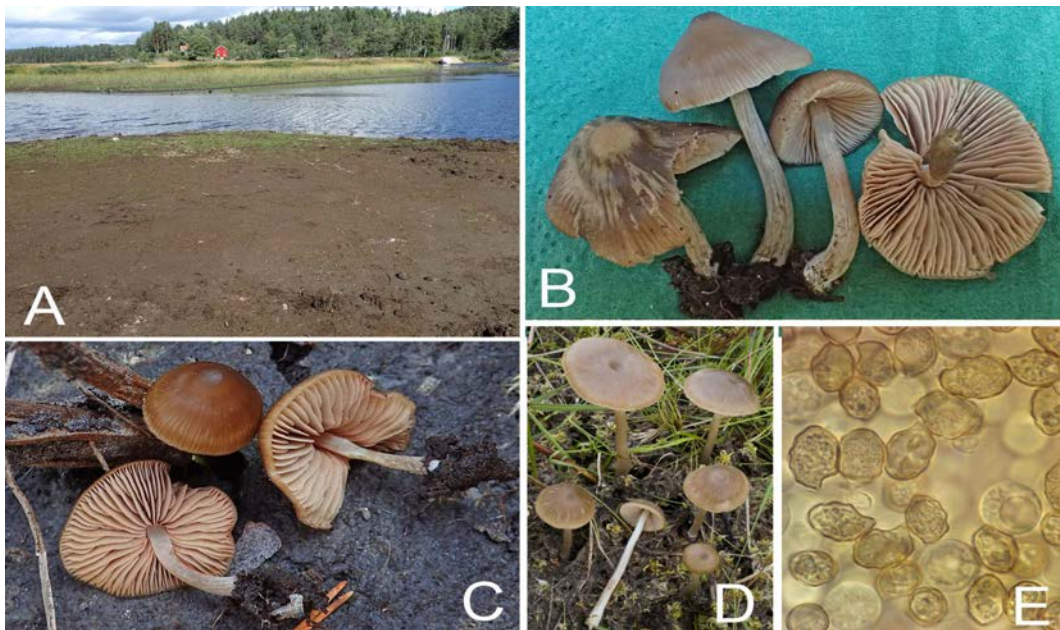


Figure 3. **A-E)** *E. pseudoconferendum*. A) (habitat), B), C) ILF 2018-001; D) AO 3-18; E) G.M. Jansen C1594394. Photos: A)-C) I.-L. Fonneland; D) A. Omberg; E) G.M. Jansen & M. Vegte.



(Agder; I.-L. Fonneland, pers. comm.), and these represents the first finds in Norway. *Entoloma pseudoconferendum* has strong similarities with *E. conferendum*, which is not infrequent in bog habitats during summer in Norway. The latter has, however, completely different spore morphology. Microscopically, this species is similar to *E. sphagneti*, but it can readily be distinguished on the slender, mycenoid habit, and the glabrous, deeply translucently striate pileus, and possibly also on a more extremely seasonally inundated habitat.

***Entoloma chamaemori* Noordel., Weholt, Eidissen & Lorås. Fig. 4 B.**

**Characteristics:** Habit mycenoid, with 25–40 mm wide, conico-convex, expanding pileus, (reddish) brown with darker centre, glabrous. Lamellae distant to moderately crowded, narrowly adnate-emarginate to (almost) free, greyish white, becoming pinkish tinged, with concolorous edge. Stipe 50–70 × 3–5 mm, greyish white, apex pruinose, silvery striate lengthwise. Smell farinaceous. Spores 6.0–8.0 (–8.5) × 5.5–7.0(–7.5) μm, isodiametrical to subisodiametrical, with 6–8 rather weak angles, thin-walled. Basidia 4-spored. Cystidia absent. Pileipellis a differentiated (ixo-) cutis of thin hyphae, with scattered clavate to cystidiform terminal elements, 20–35 × 4–12 μm and brown intracellular pigment. Clamps present.

**Habitat and distribution:** Collected in an oligotrophic bog, among *Sphagnum papillosum* and *S. tenellum* in open, sub-exposed, site with predominantly *Rubus chamaemorus*. So far only known from two collections from one locality in Holmvassdalen, Northern Norway.

**Collections sequenced:** NORWAY. Nordland: Grane, Holmvassdalen Nature Reserve, 10 Aug 2014, S. E. Eidissen & J. Lorås, JL69-14 (holotype, O). GenBank: KX928955; 10 Aug 2014, S. E. Eidissen & J. Lorås, JL70-14 (O). GenBank: KX928956.

**Comments:** The species was described quite recently, based on Norwegian material from a poor *Sphagnum* bog in Holmvassdalen, Nordland (Noordeloos et al. 2017). The small, nodulose weak-angled spores of *E. chamaemori* resemble those of *E. vinaceum* and *E. turbidum*, but the angles are slightly more pronounced and the walls slightly thicker, whereas those of the other two resemble *Rhodocybe* spores. In the phylogeny, *E. chamaemori* is rather isolated and clusters basally with *E. sphagneti* and *E. pseudoconferendum* (Noordeloos et al. 2017), both of which have more elongate, nodulose-angular spores.

**1.3. Clade *Vinaceum/Entocybe***

This clade more or less fits with the concept of *Entocybe*, and contains species with small, thin-walled, often rounded-nodulose or bumpy spores, resembling those found in the *Rhodocybe* clade. In Norway, it is represented with



Figure 4. **A)** *E. turbidum*. J. Vesterholt (not sequenced). **B)** *E. chamaemori*, JL69-14 (holotype). Photos: A) J. Vesterholt, B) J. Lorås.

four species: *Entoloma nitidum*, well known by its splendid blue basidiocarps, *E. vinaceum*, *E. turbidum*, and a fourth taxon, probably referable to *E. turbidum* var. *pachylamellatum*. Due to uncertainties on nomenclature, morphological variation and circumscription, the latter is not treated here.

***Entoloma vinaceum* (Scop.) Arnolds & Noordel.**

Syn.: *Entoloma vinaceum* var. *fumosipes* Arnolds & Noordel.; *Entoloma vinaceum* var. *violeipes* Arnolds & Noordel.

*Characteristics*: Pileus 20–40 mm broad, convex, often with slightly depressed centre, sometimes vaguely umbonate with deflexed margin, hygrophanous, deeply translucently striate when moist, moderately dark horn brown with darker centre, of grey- to reddish brown, paler towards margin, pallescent on drying, glabrous. Lamellae moderately distant, adnate-emarginate, segmentiform, greyish then with pink tinge, with entire, concolorous edge. Stipe 20–60 × 1–3 mm, cylindrical, often flexuous, and distinctly tapering towards base, sometimes rooting, variably coloured, typically yellowish to yellow brown, but frequently also grey or with violaceous tinges, glabrous, polished, base white tomentose. Smell and taste indistinct. Spores 6.0–8.0 × 5.5–7.5 µm, isodiametrical, very thin-walled and weakly angled, sometimes appearing almost nodulose, reminiscent those of *Rhodycybe* species. Basidia 4-spored. Cystidia none. Pileipellis a simple, thin (ixo)cutis of narrow, cylindrical hyphae. Pigment brown, intracellular. Clamps present in the entire basidiocarp.

*Habitat & distribution*: The species is in Europe mostly confined to nutrient poor, acidic habitats, like dry, poor *Pinus* forests of *Vaccinium vitis-idea-Calluna* type, *Picea* forests of *Vaccinium myrtillus* type, heathlands, peat bogs and very poor grasslands. In Norway, the verified finds so far are from oligotrophic

*Pinus-Picea* forests in the Oslo-Hadeland region. Probably widespread, but little known.

*Collections sequenced*: NORWAY. Oppland: Lunner, Øståsen, Morstadhaugen (study plot 15-19), oligotrophic, xeric (lichens, *Calluna*) pine forest, 4 Oct 2001, E. Bendiksen EB 204/01 (O-169164). Lunner, Øståsen, Morstadhaugen, oligotrophic, subxeric pine(-spruce) forest, 29 Sept 2004, E. Bendiksen 246/04 (O-165807). Lunner, Øståsen, S. Korsvatnhaugen, old *Vaccinium myrtillus-Picea* forest, 9 Oct 2015, E. Bendiksen EB 279/15 (O-252032). Oslo: Grorud, Frankrig N, mixed forest, 26 Sept 1984, E. Bendiksen EB 362/84 (O-F-169415) (O-169415).

*Comments*: *Entoloma vinaceum* is morphologically rather variable species, with a yellow, grey or vinaceous stipe. Accordingly, varieties have been published with greyish stipe (var. *fumosipes*) and violaceous-blue stipe (var. *violeipes*). Our molecular studies indicate, however, that these varieties should be considered phenotypic variation rather than worthy of taxonomic rank, like in species with similar colour variation discussed above. Sometimes the species can be confused with *E. turbidum*, which is also widespread in oligotrophic-acid habitats. However, *E. turbidum* is usually a stouter fungus found in somewhat moister spruce forests, whereas *E. vinaceum* is more frequent in drier pine forests and heathlands.

***Entoloma nitidum* Quél.**

*Characteristics*: Habit mycenoid or slenderly tricholomatoid. Pileus 20–40(–50) mm broad, conical or campanulate then expanding to convex with broad, low umbo, not hygrophanous, not translucently striate or at margin only, bright blue, sometimes blackish blue at centre, silky shining, glabrous or radially fibrillose. Lamellae moderately distant, adnate-emarginate, white then pink. Stipe

30–100 × 2–5(–7) mm, cylindrical with attenuated, sometimes even rooting base, blue, concolorous with pileus or paler, with distinct yellow tinge near base, innately fibrillose striate. Spores 7–9 × 6–7 μm, isodiametrical, thin-walled, poorly angled. Basidia 4-spored. Cystidia absent. Pileipellis an ixocutis of 2–6 μm wide, hyphae with blue, intracellular pigment. Clamps abundant.

*Habitat & distribution:* The species is in Norway rare but widely distributed in mossy, oligotrophic(-mesotrophic) *Picea abies* forests of *Vaccinium myrtillus* type. Sometimes it is recorded also in oligotrophic *Pinus* or *Quercus* forests.

*Collections sequenced:* NORWAY. Akershus: Ski, Svartoren, under spruce and pine, 12 Sept 2014, S. Hansen (O-75603). Hordaland: Bømlo, Totland, in margin of pasture, among moss and needles under *Pinus sylvestris*, moist, 29 Sept 2009, A. Knutsen, J. B. Jordal (O-291246). Oppland: Lunner, S. Oppdalen, Mørkomdalen, Solbakken; open spot in low herb *Picea* forest, *Vaccinium myrtillus*, grass, 19 Aug 2014, A. Molia (O-75140).

*Comments:* *Entoloma nitidum* is one of the species in the genus that can easily be identified in the field by its mycenoid to slenderly tricholomatoid, bright blue basidiocarps and the ecology in oligotrophic, acidic coniferous and deciduous forests. Although these habitats are among our most frequent forest types, this beautiful species is everywhere rare, at least based on basidiocarps, which are not seen every year. *Entoloma bloxamii/madidum* differs in a more stout tricholomatoid stature, strong farinaceous smell and habitat in calcareous grasslands and forests.

***Entoloma turbidum* (Fr.) Quél.** Fig 4 A.

*Characteristics:* Pileus 20–80 mm, conical or campanulate, then convex with pronounced

umbo, not hygrophanous, not translucently striate, grey-brown or sepia brown, glabrous, slightly sticky in moist weather. Lamellae deeply emarginate-adnate, crowded, white or greyish, then pink. Stipe 30–90 × 4–10(–12) mm, fusiform, usually broadened just above the tapering base, greyish white, densely covered with silvery fibrils, at base often tinged yellow. Smell and taste indistinct to rancid-farinaceous. Spores 6.5–8.5(–9.0) × 6.0–7.0(–7.5) μm, Q= 1.0–1.2, thin-walled and many-angled with weak angles, appearing almost nodulose. Basidia 4-spored. Cystidia absent. Pileipellis an ixocutis of 2.5–5 μm wide, cylindrical hyphae. Pigment brown, intracellular in pileipellis. Clamps present in all tissues.

*Habitat & distribution:* In Norway rather frequent in oligotrophic-mesotrophic *Picea abies* forests, sometimes in *Sphagnum*, more rarely in oligotrophic pine forests and grasslands. Distributed in all parts of Norway.

*Collections sequenced:* NORWAY. Møre og Romsdal: Skodje, Skodjereitane, alt. ca. 100 m, under pine and spruce, 02 Aug 2007, P. G. Larsen (O-75994). Oppland: Lunner, S. Oppdalen, Hellerud NE, old *Picea* forest of *Vaccinium myrtillus* type, 19 Aug 2014, E. Bendiksen (O-75256). Rogaland: Rennesøy, Bø-Asmarvik, alt. 20 m, 30 Sept 2008, J. B. Jordal (O-287732).

*Comments:* *Entoloma turbidum* can be distinguished from *E. vinaceum* by the more robust stature with a conical pileus and firm stipe, but they may occur in similar habitats. However, the latter is more frequent in dry pine forests and heathlands, whereas the former prefers moister spruce forests. *Entoloma turbidum* is one of the most frequent *Entoloma* species in our boreal spruce forests (together with *E. cetratum* and *E. conferendum*) and should be familiar to those looking

for red-spored fungi. We have nevertheless included it for comparison with the less frequent or new taxa within the basal clades treated here.

## 2. The *Prunuloides* clade

The *Prunuloides* clade/group is a small, well-supported lineage according to Morgado et al. (2013), including strongly farinaceous smelling, calciphilous grassland/forest species with small, isodiametric spores. Three taxa are so far recognized in the *Prunuloides* clade in Norway, of which *E. luteobasis* is presented here, and some new data on *E. bloxamii* s. l. are commented. *Entoloma prunuloides*, a widespread species well known from grasslands (Jordal et al. 2016), are not treated here.

***Entoloma luteobasis* Ebert & E. Ludw.** Fig. 5 A, B.

Syn.: *Entoloma ochreoprunuloides* Morgado & Noordel.; *E. prunuloides* var. *obscurum* Arnolds & Noordel.

**Characteristics (emended description):** Pileus 20–60 mm broad, conical soon expanding to plan-convex with low umbo, with initially deflexed, then straight margin, expanding with age to appanate with weak umbo and undulating margin, hardly hygrophanous, medium to fairly dark (grey)brown, uniformly coloured or with dark, greyish brown centre, possibly sometimes with a bluish grey reflex when very young, not entirely glabrous but, particularly at central part with an aeriferous covering of fine, silvery hairs, sometimes also radially wrinkled. Lamellae fairly crowded to moderately distant, adnate-emarginate, ventricose, sordid white then pink with entire, concolorous edge. Stipe 30–50 × 5–15 mm, cylindrical, straight or flexuous, sometimes slightly broadened towards base, off white to pale grey-brown, at base sometimes, but not frequently with distinct yellow tinges, innately fibrillose lengthwise, often with a metallic shine. Context concolorous, rather firm. Smell

and taste farinaceous. Spores: 6.0–7.0 × 5.5–7.0 μm, Q = 1.0–1.05, isodiametric with normally thick walls, with 5 to 6 angles in side-view. Basidia 4-spored. Cystidia absent. Pileipellis a thin ixocutis of narrow, cylindrical up to 6.5 μm wide hyphae. Pigment brown intracellular. Clamps abundant.

**Habitat & distribution.** In Norway, most records are from calcareous *Tilia-Corylus* forests, mainly in the inner Oslofjord (Oslo, Bærum, Asker, Røyken), but also in the outer Oslofjord (Porsgrunn-Bamble), a few finds also from calcareous *Pinus* forests including transitions to open shrubland and from rich *Quercus-Tilia* forests. Altogether more than 20 localities are known so far (including non-sequenced material too). Outside Norway, this species has been recorded only a few times from North-western Europe (Netherlands, Germany, Great Britain), from calcareous

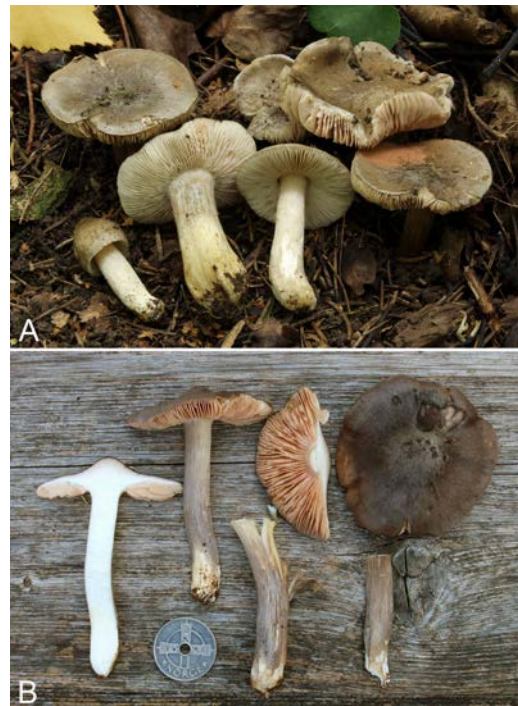


Figure 5. **A, B)** *E. luteobasis*. A). TEB363-14; B) TEB375-14. Photos: B. Dima.



*Quercus-Carpinus* and *Fagus* forests, and from calcareous grasslands.

*Collections sequenced:* NORWAY. Akershus: Asker, Vettre, 8 Sept 2011, E. Bendiksen, EB 713-11 (O-253930). Bærum, Dælivann, Langenga east, 6 Sept 2014, T.E. Brandrud, B. Dima, TEB 363-14 (O); Laenga west, 6 Sept 2014, T.E. Brandrud, B. Dima, TEB 375-14 (O). Buskerud: Røyken, Bøsnipa, 13 Sept 2011, K. & E. Bendiksen, T. E. Brandrud & I. Kytövuori, TEB 819-11 (O-248443); 11 Sept 2014, T. E. Brandrud, B. Dima, Høstsopptreff (foray) no. 1462 (O-F-75440). Oslo: Bygdøy, Reinsdyrlia, 13 Sept 2014, T.E. Brandrud, B. Dima, Høstsopptreff (foray) no. 14780 (O-75787). Oslo, Gressholmen/Rambergøya, 24 Sept. 2008, E. Bendiksen, EB 259-08 (O-254030).

*Comments:* We have for some time called this *E. ochreoprunuloides* (see e.g. Brandrud et al. 2016), according to the phylogeny of Morgado et al. (2013). However, our molecular study revealed that the type of *E. luteobasis* is identical with that of *E. ochreoprunuloides*. This throws a new light on the morphological variability of this species. The type of *E. luteobasis* showed a very striking yellow stipe base, but apparently, this character is rather variable, and may be present or absent. However, the dark coloured pileus separates it clearly from the related *E. prunuloides*, as well as the lack of blue/violaceous tinges differentiate this species from *E. bloxamii* s. l.

The species was first reported from Norway by Gulden (2011) under the name *E. luteobasis*, found in a calcareous, mixed forest along the Oslofjord. Then the species was found several times in connection with our *Entoloma* project and a monitoring program for calcareous *Tilia* forests in the Oslofjord region (see e.g. Brandrud et al. 2016; as *E. ochreoprunuloides*). It is not infrequent in this forest type, and

seems in Norway to be a more or less habitat-specific calcareous lime forest species. However, a few finds are documented also from margins of calcareous pine forest-shrublands, and from rich (but not calcareous) oak-lime forests. Possibly it can occur also in calcareous grasslands in Norway, as do the related *E. prunuloides* and *E. madidum* (*E. bloxamii* coll.). Also outside Norway, this species seems to be bound to calcareous habitats, including loamy soils, and preferentially grows in deciduous forests (*Quercus robur*, *Q. cerris*, *Fagus*, *Carpinus*, *Populus*), but is also recorded in calcareous grasslands. So far, it has been recorded from Norway, Germany, Great Britain and Italy (Noordeeloos 2004). Morgado et al. (2013) described a variety with violaceous tinges in the pileus as *E. ochreoprunuloides* var. *hyacinthinum* from a calcareous grassland in Wales. We have never seen such distinctly bluish variants in Norway.

#### ***Entoloma bloxamii* s. l. in Norway**

*Entoloma bloxamii* in its traditional morphological concept is an iconic species with its blue, tricholomatoid basidiocarps. This morpho-species is fairly easy to recognize in the field. In Europe it appears to be a signal species for various types of ancient and mycologically valuable, poorly managed pastures on calcareous soils (Noordeeloos 2004), and it has a red-list status in many countries. *Entoloma bloxamii* sensu lato is also reported from North America and Australasia, and was furthermore placed recently on the Global Fungal Red List ([http://iucn.ekoo.se/iucn/species\\_view/221900/](http://iucn.ekoo.se/iucn/species_view/221900/)).

However, *E. bloxamii* sensu lato consists of several, molecularly and morphologically well-separated species (Morgado et al. 2007, Ainsworth et al. 2018). Occurrences outside Europe refer invariably to a range of similar, but different species (Morgado et al. 2013). In

Europe at least four blue taxa can be recognized, viz. *E. bloxamii* s. str., *E. madidum*, *E. atromadidum*, and *E. ochreoprunuloides* var. *hyacinthinum*. They are morphologically separated, and identifiable. So far, only three collections have been sequenced from Norway, two from forests and one from grassland, and they all belong to *E. madidum*. Likewise, one grassland collection from Sweden was sequenced, and appeared to be *E. madidum* (Brandrud et al. 2018). More studies are necessary to see if we have more taxa in the Nordic countries. And furthermore, if they have different ecological preferences, since the collective species *E. bloxamii* shows a wide range of habitats from calcareous, (semi)natural grasslands-shrublands to calcareous lime- and pine forests.

*Collections sequenced:* NORWAY. Nord-Trøndelag: Steinkjer, Litl-Gaulstad, margin of calcareous pine forest, 09 Sept 2009, H. Holien, U.-B. Bøe, (O-69505). Oppland: Nord-Fron, Syltebakkane, calcareous, dry, semi-natural meadow, 6 Sept 2005, J. B. Jordal, JBJ3025 (O-158205). Telemark: Porsgrunn, Kongkleivåsen S, calcareous *Tilia* forest, 30 Aug 2919, T.E. Brandrud, TEB 280-19 (O). SWEDEN. Jämtland: Åre, Alsen NØ, Glösa, TEB 327-16 (O).

### 3. The *Claudopus* clade

The *Claudopus* clade, more or less referable to subgen. *Claudopus* in Noordeloos (1992), includes a number of small to very small, pleurotoid, more or less lignicolous species with reduced, lateral stipe (referable to sect. *Claudopus* in Noordeloos 1992). In Norway, *E. byssisedum* seem to be the only widespread species within this group. However, the species might sometimes have been treated collectively, and all the Norwegian material of this should have been revised, which unfortunately was not possible within the frames of our *Entoloma* project.

### *Entoloma jahnii* Wölfel & Winterh.

*Characteristics:* Habit pleurotoid. Pileus 1–15 mm broad, membranaceous, hemispherical to convex then applanate, with involute margin, not hygrophanous, not translucently striate, white to pale pink, densely and finely white hairy-tomentose all over. Lamellae, adnate-emarginate to almost free, distant, white then purely pink with entire, concolorous edge. Stipe well developed in young specimens only, soon lateral and reduced to almost lacking, white tomentose. Context very thin, smell and taste indistinct. Spores (9–)10–14(–15) × 7.5–11(–11.5) µm, very variably shaped, iso- to heterodiametrical, 5–6 angular in side-view with pronounced angles. Basidia 4-, rarely also 2-spored. Pileipellis a cutis with transitions to a trichoderm of cylindrical to inflate, 5.0–15 µm wide hyphae, with abundant capitate terminal elements. Similar capitate cystidia are found on stipe surface. Clamps present.

*Habitat and distribution:* Usually found on rotten wood and bark of deciduous trees (*Alnus*, *Fraxinus*, *Betula*, *Quercus*) in moist and dry woods and copses. Distribution in Europe poorly known. The Norwegian, verified find was from swampy *Carex* vegetation.

*Collection sequenced:* NORWAY. Aust-Agder: Arendal, Tromøy (v/Alvekilen), on the base of *Carex* sp., 30 July 2003, T. H. Dahl, 87/03 (O-66534).

*Comments:* *Entoloma jahnii* is a very small and inconspicuous species within the group of pleurotoid *Entoloma*, which to the present day is poorly understood. The species is characterized by white, hairy-tomentose pileus and stipe with capitate cystidia, and large spores. There are indications that more species occur with capitate pileo- and/or cheilocystidia, but with different spores. The Norwegian collection, however, fitted with the type-sequence, so its occurrence is confirmed. The species

are here reported new to Norway. The Norwegian material was originally identified to *E. albotomentosum*, which might superficially resemble our species, but *E. albotomentosum* is fibrillose, not hairy-scaly, and lack the capitate pileo- and caulocystidia of our species. Moist habitats in ditches, rather similar to the Norwegian find, are reported for *E. jahnii* from Denmark (J. Heilman-Clausen, pers. comm.), and the species are nicely illustrated in <https://svampe.databasen.org/taxon/13637>.

The identity of the Danish material should however been verified by sequencing, since apparently more taxa are hidden in this complex.

#### 4. The Leptonia clade

Leptonia s. str. comprises species with often vivid lilac-violaceous colours, a strongly fibrillose pileus and fibrillose to squamulose stipe, hyphae with clamp connections and habitat on organic debris, litter-layer or on rotten wood (Morozova et al. 2014). The group forms a very distinct, well-supported clade, and was by Morozova et al. (2014) treated as an own subgenus. In the latter study, new phylogenetic evidence was shown not to alter much the morphology-based taxonomy of Leptonia s. str. Formerly, however, Leptonia was used in a wide sense, also covering many grassland species without clamps, now included in subgenus or clade Cyanula (see e.g. Noordeloos 1992). Clade Cyanula will be treated in the third, forthcoming paper in Agarica. Two Leptonia species new to Norway are presented below. Another member of the Leptonia clade new to Norway, *E. chytrophilum*, is treated in another paper in the present volume of Agarica. In addition to these three new ones, the following species from Leptonia s. str. are ITS-verified from Norway: *E. dichroum*, *E. euchroum*, *E. lampropus*, *E. sublaevisporum* and *E. tjallingiorum* (*E. placidum* probably also occurs, but is so far not verified).

#### *Entoloma percoelestinum* O.V. Morozova, Noordel., Vila & Bulyonk. Fig. 6 B.

*Characteristics:* Pileus 5–12 mm broad, conical or hemispherical with umbo, not hygrophanous, not translucently striate, with straight margin, radially fibrillose, squamulose at centre, uniformly dark blue, blackish blue or black. Lamellae moderately distant, adnate-emarginate, ventricose, white, becoming pinkish, with entire concolorous edge. Stipe 20–40 × 1–2 mm, cylindrical, longitudinally fibrillose striate or almost smooth, concolorous with pileus, whitely tomentose at base. Context thin, concolorous with the surface. Smell indistinct. Spores 6.5–8.5(9.0) × 5.0–6.5 µm, heterodiametrical, with 7–9 blunt angles in side-view, almost nodulose. Basidia 4-spored. Cheilocystidia absent. Pileipellis a trichoderm of cylindrical to slightly inflated hyphae 10–20 µm wide with blue intracellular pigment. Clamps present.

*Habitat and distribution:* The only collection from Norway was collected in a rather exposed coastal habitat with drifting sand, in a heath-like grassland. The Spanish material was collected in montane *Quercus pubescens*-*Fagus* forest and a (planted) coniferous forest, the Russian collections are from either coniferous forest (*Pinus*; also planted), mixed forest or *Fraxinus* copses (Morozova et al. 2014).

*Collection sequenced:* NORWAY. Rogaland: Sola, Vigdelstranda, in coastal, grazed sandy pasture/heath, 23 Sept 2010, leg. John Bjarne Jordal, John Inge Johnsen (O-294539).

*Comments:* *Entoloma percoelestinum* is a species, as the name suggests, similar to *E. coelestinum*, differing mainly by the almost nodulose spores and longitudinally fibrous stipe. It belongs to the Leptonia clade on account of the clamped hyphae and trichodermal pileipellis. The species was described as new in Morozova et al. (2014), and in all



Figure 6. **A)** *E. venustum*. Holotype; **B)** *E. percoelestinum*, T. Bulyonkova (LE254327); **C)** *E. cuboidoalbum*. Holotype; **D)** *E. ritae*. TEB 134-14. Photos: A) F. Hampe; B) T. Bulyonkova; C) A. Hausknecht; D) T. E. Brandrud.

phylogenetic analyses, it comes out as a sister species to *E. coelestinum*. It is so far known from five sites, indicating a very wide distribution; two in Russia, two in Spain (incl. type) and the one here reported from SW Norway. The ecological preferences of *E. percoelestinum* are apparently also very broad, since it has

been found in habitats ranging from exposed heath-like grasslands to damp forests. It should be noted that both in Siberia and in Norway, it is found in sandy soils.

***Entoloma venustum* Wölfel & F. Hampe.**

Fig. 6 A.

Syn.: *Entoloma callichroum* var. *venustum* (Wölfel & F. Hampe) O.V. Morozova, Noordel. & Vila.

*Characteristics*: Pileus up to 30 mm, conico-convex to convex with small umbo, not hygrophanous, not translucently striate, brightly pinkish-lilac, finely squamulose. Lamellae distant, emarginate-adnate, lilacinous, or whitish with bluish tinges towards edge, then pinkish. Stipe 20-50 x 203, cylindrical, steel blue, fibrillose, not polished. Spores 11.5–13.0 (–16.0) × 5.7–8.6 μm, heterodiametrical, with 6–8 moderately pronounced angles in side view. Cheilocystidia present. Pileipellis a trichoderm with intracellular pigment. Clamps present.

*Habitat & distribution*: We have just one confirmed sequenced collection from Norway, and it was found in a pasture with *Juniperus* on calcareous soil. According to Morozova et al. (2014) the species is elsewhere recorded in moist *Alnus* and *Betula* forests, park-like secondary habitats and once also in grasslands. *E. venustum* is so far known from Norway, Germany, Belarus, Western Siberia, and the Russian Far East.

*Collection sequenced*: NORWAY. Rogaland: Rennesøy, Brimse, middle of the island, in pasture, 2 Oct 2006, J. I. Johnsen, J. B. Jordal (O-361255).

*Comments*: This is a striking species with bright lilac tinges. Morozova et al. (2014) considered *E. venustum* a variety of *E. callichroum*. Both species are indeed very similar morphologically, and might in many cases only be distinguishable with the help of molecular markers. However, on average, the spores seem narrower and more distinctly angled in *E. venustum*, and the cheilocystidia seem more pronounced. The degree of morphological differentiation needs further study,

but the differences in ITS are significant, and justify recognition on specific level. *Entoloma callichroum* is so far not ITS-verified from Norway.

With five finds from Russia (mainly Siberia and Far East) and one from Belarus, *E. venustum* seems to be a mainly eastern species within the boreal-boreonemoral Eurasian range. Like many of its relatives *E. venustum* apparently has a wide range of habitats, so far recorded in *Alnus-Betula* forests, parks and grasslands. It is noted on wood or probably leaf litter, - in grasslands probably on grass litter or woody remnants.

**5. Species of uncertain phylogenetic position new to Norway**

**5.1. *Entoloma excentricum* and *E. porphyrocephalum***: an example of semicryptic speciation.

***Entoloma porphyrocephalum* (Noordel. & Wölfel) Noordel., Brandrud & Dima, comb. & stat. nov.** Fig. 7 B, C and 8

Basionym: *Entoloma excentricum* var. *porphyrocephalum* Noordel. & Wölfel in Int. J. Mycol. Lich. 1(1): 54 (1982)  
Mycobank MB# 83376

*Characteristics*: Pileus up to 60 mm broad, convex with depressed centre, not hygrophanous, not translucently striate, when young very finely fibrillose-tomentose, soon almost glabrous; initially whitish, soon pale greyish brown, ivory-grey, becoming more ochraceous to pale pinkish brown or porphyraceous brown. Lamellae broadly adnate to slightly decurrent, purely white then pink with serrulate, concolorous, often developing a (spotwise) brownish edge. Stipe 65 × 4–6 mm, cylindrical, slightly twisted, slightly swollen at base, sometimes slightly eccentrically attached to pileus, entirely densely white pruinose, some with small drops exudated at apex; more or



less concolorous with pileus, becoming leather-brown to porphyry brown tinged, white tomentose at base. Smell faint to somewhat farinaceous. Taste farinaceous. Spores  $10\text{--}13.5 \times 7\text{--}8.5 \mu\text{m}$ , very large and heterodiametrical. Conspicuous fusiform to lecithiform cystidia, up to  $100 \mu\text{m}$  long occur on sides and edge of the lamellae, as well as on the stipe surface. The basidia often develop brown pigment with age (necropigment). Clamps present.

*Habitat & distribution:* In Norway ITS-verified from three sites; two from outer Oslofjord (Bamble) from shallow-soil limestone plateau; in near-shore grassland-shrubland near sea-shore and grassland-like opening (old track) in calcareous *Pinus sylvestris* forest. The third verified collection is from a coastal shell-bed, grazed meadow in Brønnøy, Nordland.

*Collections sequenced:* NORWAY. Nordland: Brønnøy: Urdstabbvika, UTM 33W UN 73818,64534, calcareous shore meadow (shell-bed) which was partly mown, 3 Sept 2009, Geir Gaarder 5738 (O-293670). Telemark: Bamble, Eikstrand, limestone with shallow soil (grassland-shrubland), 20 Aug 2012, T. Læssøe, A. Molia AM-196c-2012 (O-245576). Bamble, Røsskleiva nature reserve, calcareous, semi-open pine forest, along track, 12 Aug 2016, T. E. Brandrud, B. Dima, TEB 197-16 / DB6047 (O; CAFUN090-17).

*Comments:* Morphologically, *E. excentricum* s.l. takes a rather isolated position in the genus *Entoloma* with its large spores, prominent and large cystidia, and dark granular pigment (necropigment) in the hymenial elements. For this reason, Noordeloos (1981) created the subgenus *Allocybe* for it. Noordeloos and Wölfel described an aberrant collection with more porphyry brown cap and stipe with caulocystidia, as *E. excentricum* var. *porphyrocephalum* (Noordeloos 1982). An interesting study by Senn-Irlet & Woltsche (2002), how-

ever, demonstrated that the variability in *E. excentricum* can be very large, particularly with respect to pileus colour and presence of caulocystidia. They observed a population over several years and concluded that the differences indicated as diagnostic/differential between the two varieties was seen as gradual variation within the population studied, and therefore must be considered as phenotypic variation rather than of taxonomic significance.

However, during our recent studies we successfully amplified and sequenced the ITS region of the holotype of *E. excentricum* var. *porphyrocephalum*, which appeared to be different from typical *E. excentricum* (where no type exists). In addition, several collections of *E. excentricum* from Norway fit with this type sequence. Morphologically, some have slightly more brown coloured basidiocarps, others were, however, rather similar to typical *E. excentricum*. So it appears that within the complex of *E. excentricum* two semi cryptic species can be distinguished, one of them sometimes differing also by having porphyry-brown tinges in the pileus. This calls for a larger scale study on many collections from whole Europe.

*Entoloma excentricum* and *E. porphyrocephalum* have very similar habitat-preferences, based on the Norwegian, ITS-verified collections of the two taxa. They both occur mainly in dry grassland-shrublands of coastal shallow-soil limestone plateaus, and coastal, grazed, calcareous shell-beds and dune slacks. So far, three samples are sequenced and verified of *E. porphyrocephalum* (outer Oslofjord, Nordland) and four of *E. excentricum* s. str. (inner and outer Oslofjord, and a steppe-like site in continental Gudbrandsdal). There seems to be a core area for both taxa at Porsgrunn-Bamble, Telemark county, outer Oslofjord (cf. Brandrud 2010, Brandrud and Dima 2017, as *E. excentricum*). Here the two might be co-occurring and seem to have exact the



Figure 7. **A)** *E. excentricum* TEB 189-16 / DB6044; **B, C).** *E. porphyrocephalum*; B) AM-196c-2012; C) TEB 197-16 / DB6047. Photos: A) B. Dima; B). A. Molia ; C) B. Dima.

same ecological requirements. In Porsgrunn-Bamble they occur on almost barren limestone between seashore and adjacent calcareous pine forests (also in openings in the forests),

often together with *E. fridolfingense* and *E. mougeotii*. Furthermore, they are collected from calcareous, semi-natural, grazed meadows, especially near the seashore on



Figure 8. *Entoloma porphyrocephalum*. TEB 210-19. [Røsskleiva nature reserve.] photo: B. Dima.

shell-beds and dune slacks, of coastal Nordland north to Bodø (the northernmost records of *E. excentricum* coll. in the world). In fact, a rather large population of *E. excentricum* coll. is documented from coastal Nordland. So far, only one of those are verified by sequencing, appearing to be *E. porphyrocephalum*. More sequencing is needed to see if both taxa, or only *E. porphyrocephalum* are occurring in North Norway. Outside Norway, *E. porphyrocephalum* is so far ITS-verified only from Germany (Bayern, type).

**5.2. *Entoloma ritae* Noordel. & Wölfel Fig. 6 D.**

*Characteristics*: Pileus up to 20 mm broad, convex to applanate, slightly undulating due to concentric depression, with blunt or slightly depressed centre, not hygrophanous, not translucently striate, tomentose; rather uniformly pinkish to vinaceous brown. Lamellae adnate-emarginate, whitish, then pink. Stipe 40–60 × 2 mm, cylindrical, yellowish pink to pale

brownish yellow, paler than pileus, more or less polished, base with some white tomentum. Smell and taste indistinct. Spores 8.0–12 × 6.5–9 μm, (5–8 angled with pronounced angles. Basidia 4-spored. Lamella edge heterogeneous. Cheilocystidia pronounced, rendering the lamellae edge more or less sterile (Norwegian collection), or in groups among basidia (holotype), 25–55 × 5.0–20 μm, cylindrical to clavate. Pileipellis a cutis with transitions to a trichoderm of up to 17 μm wide hyphae with intracellular pigment. Clamps abundant.

*Habitat & distribution*: In calcareous, semi-natural grasslands; recorded in middle boreal, mown meadow (Norway) and subalpine meadow (Italy). So far only known and sequence-verified from two localities; in SE Norway and N Italy (Trentino), respectively. The Norwegian collection was from a calcareous district near the lake Randsfjord.



*Collection sequenced:* NORWAY. Oppland: Lunner, S. Oppdalen, T. E. Brandrud, TEB 134-14 (NOBAS604-15; O-247988; originally identified as *E. indutoides*).

*Comments:* The Norwegian collection represents the first report from N Europe and the second known collection of this species (ITS verified with the type sequence). It was originally described from a calcareous meadow of N Italy (Noordeloos and Wölfel 1997). The species is a characteristic one with its vinaceous brown, undulate, fibrillose pileus, and must be one of our most rare *Entoloma* taxa. *Entoloma ritae* resembles a *Cyanula* species on account of the general habit and combination of fibrillose pileus and polished stipe, but micro morphologically it does not fit there because of the clamped hyphae and simple, cutis-like pileipellis structure. Noordeloos (2004) suggested therefore that it would be better placed in section *Roseicaules* of subgenus *Alboleptonia*. Our preliminary phylogeny analysis suggest that it is indeed nested within the *Alboleptonia* clade, but apparently with a rather isolated position, not very close to typical representative of *Alboleptonia*, such as *E. sericellum*. For the time being, its phylogenetic and taxonomic position remains obscure.

### 5.3 *Entoloma cuboidoalbum* Noordel. & Hauskn., Fig. 6 C.

*Characteristics:* Basidiocarps collybioid. Pileus about 10 mm broad, applanate, white not translucently striate, opaque, subfelted; lamellae adnate to slightly decurrent, whitish, then pink; Stipe cylindrical, white to pale yellow, polished, cartilaginous, stiff, swollen at base; smell of honey. Spores 9–12 × 7.5–11 μm, 4–5 angled in side-view. Cystidia absent.

*Ecology and distribution:* In Norway recorded in (base-)rich, steep, thermophilous deciduous forest with *Quercus* and *Corylus* (W Norway) and in semi-open, calcareous *Pinus sylvestris*-

*Corylus avellana* forests along track (under pipeline). The type and the Netherlands collection were found in a moist, deciduous forest (type with *Alnus incana*) on wet, heavy soil.

*Collections sequenced:* NORWAY. Rogaland: Hjelmeland, Hetlandsbygd below Kvittefjell, westfaced deciduous forest, on the ground, 26 Sep 2009, O. Førland, J. B. Jordal (O-252008). Telemark: Porsgrunn, Frierflogene northeast (under pipeline), T.E. Brandrud, B. Dima, 21 Sept 2015, TEB 452b-15 (O).

*Comments:* The Rogaland collection was first thought to be *E. sericellum* (noted in the field), but the spores had 4–5 angles, and was then labelled *E. aff. rhombisporum*. The Telemark collection was in the field identified to *E. aff. neglectum* due to the adnate-decurrent lamellae. The ITS sequences, however, matched 100% with the holotype of *E. cuboidoalbum*, a species recently described from Austria and recently also recorded from the Netherlands. It differs from *E. sericellum* and other taxa in the *Alboleptonia* group mainly by the 4-5-angled spores. *Entoloma cuboidoalbum* seems, according to the available data, to be a more strict forest species than *E. sericellum*, which is more frequent in heathlands and pastures. *E. cuboidoalbum* was however, co-occurring with *E. sericellum* in Porsgrunn as well as with another white taxon in the group (*E. percanidum* coll.).

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Information Centre (NBIC). The majority of our material was sequenced through NorBOL, and we thank G. Marthinsen and K. Bendiksen, NHM, University of Oslo, as well as R. Blaalid, NINA Bergen for performing the barcoding work. Furthermore, we thank Pablo Alvarado (ALVALAB, Santander, Spain), for sequencing another, substantial part of our material (collections labelled ALV). Sequencing of *E. chamaemori* material from Holmvassdalen nature reserve (Nordland) was financed by Nord University. The foundation Rijksherbariumfonds Dr. E. Kits van Waveren supported the sequencing of type- and other valuable material for this study and enabled the necessary travelling for MEN.

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## Popularisert bidrag

### Ascomycetes new to Norway found at workshop in Hordaland, 13 -16 May 2019

Björn Nordén, Roger Andersson, Mathias Andreasen, André Aptroot, Putarak Chomnunti, Gernot Friebes, Walter Jaklitsch, Edvin Johannesen, John Bjarne Jordal, Hermann Voglmayr.

#### SAMMENDRAG

På en workshop i Hordaland med inviterte internasjonale eksperter fant vi 13 ascomycetarter som var nye for Norge. Disse artene er presentert med bilde og notater vedrørende mikromorfologi, økologi og utbredelse i Skandinavia. I tillegg rapporteres funn av den sjeldne artene *Melaspileella proximella* og av «*Dothiorina tulasnei*» (den asexuelle morph av *Chlorociboria aeruginascens*).

#### ABSTRACT

During a workshop in Hordaland with invited international experts, we found 13 ascomycete species new to Norway. These are presented with photos and notes on their micromorphology, ecology and occurrence in Skandinavia. In addition, the rarely collected species *Melaspileella proximella* and “*Dothiorina tulasnei*” (the asexual morph of *Chlorociboria aeruginascens*) are reported.

#### INTRODUCTION

Ascomycota is the most abundant and diverse fungal phylum, but its members are still poorly known in most countries. There are new country records of ascomycetes, and even new species to science, waiting to be



Figure 1. The participants in the workshop in front of Ørredalsfossen in Kvam, Hordaland. From the left: André Aptroot, Putarak Chomnunti, Björn Nordén, Walter Jaklitsch, Hermann Voglmayr, Gernot Friebes, Edvin Johannesen, John Bjarne Jordal, Roger Andersson, Mathias Andreasen. Foto: BN.

discovered in almost any forest. The problem is 'just' to find them and to identify them, something that requires long training and experience. Working with the few experts available is the best way to get forward in learning new taxa. As part of a biodiversity mapping project financed by the Norwegian Biodiversity Information Centre, the first author invited leading experts to a workshop in Norheimsund, Hordaland 13 May-16 May 2019 (Figure 1). The results in terms of new country records identified by morphological methods are presented below.

#### MATERIALS AND METHODS

The presented species were encountered in temperate deciduous forests on short excursions from Norheimsund, Hordaland. The area is situated on the northern side of the Hardanger fjord and has a temperate oceanic climate. The bedrock in the area ranges from acidic gneiss and granite to ultrabasic rock types, with according differentiation in deciduous forest types from poor oak forest to herb-rich elm forest. All collection sites were situated below 150 m a.s.l. Each forenoon was spent in the field where we surveyed twigs and branches and bark on living and dead trees, and the rest of the day was spent in the lab. We used the middle of each site as coordinates for all collections from that site.

The species were determined by studying the morphology of the sexual morph (teleomorph) or/and asexual morph (anamorph) under the microscope. Species distributions in Scandinavia were checked using the following sources: for Norway Artskart (2019), The Norwegian Mycological Database (NMD 2019), and Aarnæs (2002); for Sweden Eriksson (2014), Santesson et al. (2019) and Artportalen (2019), and for Denmark Atlas of Danish Fungi (2019).

Collectors, identifiers and photographers are designated by: BN: Björn Nordén, RA: Roger Andersson, MA: Mathias Andreasen,

AA: Andre Aptroot, PC: Putarak Chomnunti, GF: Gernot Friebes, WJ: Walter Jaklitsch, EJ: Edvin Johannesen, HV: Hermann Voglmayr. The nomenclature follows Eriksson (2014) for species occurring in Sweden, and otherwise MycoBank (mycobank.org) if not otherwise stated and should be treated as preliminary in several cases.

#### RESULTS

*Cucurbitaria pulveracea* P. Karst. (Pleosporales, Dothideomycetes)

This species, originally described from Finland, is new to Norway and is not known from Sweden or Denmark. It grows on dead corticated branches of *Prunus padus* and is characterized by reddish, thyridaria-like stromata, differing from the latter by muriform ascospores, which agree with type material - in contrast to the protologue, which only stated 3-5-septate ascospores.

Material: Hordaland, Kvam, Barlindflaten, UTM32 356860/6702450, on *Prunus padus* bark in mixed low-herb forest with *Taxus baccata*, 14 May 2019, leg. HV, det. WJ.

*Dothidotthia ramulicola* (Peck) M.E. Barr (Botryosphaeriales, Dothideomycetes)

This species occurs on branches of various trees and has not been recorded from Sweden or Denmark. It has two-celled ascospores approximately  $26 \times 13 \mu\text{m}$  that slowly become dark brown, often develop secondary transverse and longitudinal septa (Barr 1989) and germinate from several cells. Material: Hordaland, Kvam, Barlindflaten, UTM32 356860/6702450, on *Prunus padus* bark in mixed low-herb forest with *Taxus baccata*, 14 May 2019, leg. & det. HV, WJ.

*Dothiorina tulasnei* (Sacc.) Höhn., the asexual morph of *Chlorociboria aeruginascens* (Helotiales, Leotiomyces), Fig. 2

This is not a new species to Norway but the asexual morph of the well-known disco-

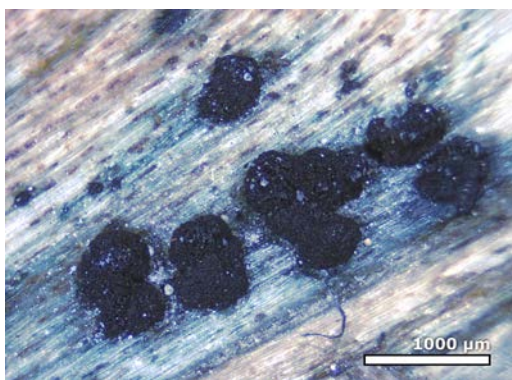


Figure 2. *Dothiorina tulasnei* conidiomata on stained wood of *Alnus glutinosa*. Photo: MA.

mycete *Chlorociboria aeruginascens*. It deserves to be mentioned since it is rarely collected and we are not aware of previous finds in Scandinavia. The genetic connection between an asexual and sexual morph was demonstrated by Tudor et al. (2014). Although the genus *Dothiorina* is older than *Chlorociboria*, the latter has been protected, and *Chlorociboria aeruginascens* remains the valid name to be used for the species (see <https://www.iapt-taxon.org/nomen/main.php>, Appendices I-VII). The asexual morph shares the blue-green wood stain of the teleomorph, which makes it relatively easy to identify in the field. The conidia measure  $3-7 \times 2-3 \mu\text{m}$ . Material: Hordaland, Kvam, Berge, UTM32 343420/6689460, on *Alnus glutinosa* wood in mixed blueberry forest, 15 May 2019, leg. PC, det. GF.

*Dothivalsaria megalospora* (Auersw.) Petr. syn. *Massariovalsa megalospora*. (Dothideomycetes incertae sedis), Fig. 3

Further probable synonyms are *Cryptovalsaria americana* and *Cryptovalsaria rossica*, described from other species of *Alnus*.

This species is new to Norway and has not been found in Sweden or Denmark. In Europe it is so far only known from bark of living trunks of *Alnus incana* and has perithecia covered by thick stromatic tissue which

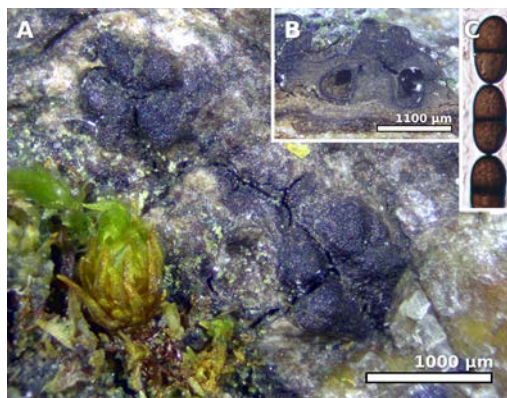


Figure 3. *Dothivalsaria megalospora* ascomata are formed under thick stromatic tissues on branch of *Alnus incana*; the conspicuous inversely stellate crests are characteristic for the species. Photo: MA.

typically forms inversely stellate crests around the inconspicuous ostiolar openings. The ascospores are dark brown, ellipsoid, 2(-3) septate,  $28-45 \times 15-20 \mu\text{m}$ , with densely granular contents. Its systematic affiliation is yet unclear; while Müller & von Arx (1962) considered it to be closely related to *Massariovalsa sudans* (Diaporthales, Sordariomycetes), Barr (1987, 1990) placed it in Massariaceae (Pleosporales, Dothideomycetes). Material: Hordaland, Kvam, Barlindflaten, UTM32 356860/6702450, on *Alnus incana* in mixed low-herb forest with *Taxus baccata*, 14 May 2019, leg. BN, WJ, det. WJ, HV; Hordaland, Kvam, Berge, UTM32 343420/ 6689460, on *Alnus incana* close to a small rivulet, 15 May 2019, leg. & det. WJ.

*Julella macrospora* Döbberler (Ostropales, Lecanoromycetes), Fig. 4

This species grows on various bryophytes and is not lichenized. It is new to Scandinavia and is characterized by having brown muriform ascospores and by lacking a hamathecium. This means that it is not a *Julella* in the sense it is now known, but without sequence data it cannot be easily determined what genus it is related to. Material: Hordaland, Kvam, Ørre-



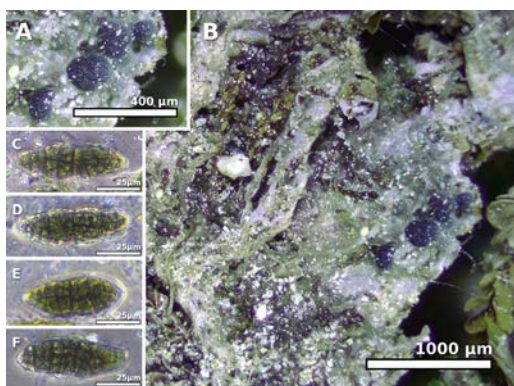


Figure 4. *Julella macrospora* growing on *Jungermannia*. A-B. perithecia. C-F. Muriform ascospores. Photo: MA.

dalsfossen, UTM32 344400/6699290, on *Jungermannia* sp. on soil in river gorge with deciduous forest (“lågurtskog”), weak low herb forest, 14 May 2019, leg. & det AA.

*Lentomitella investita* (Schwein.) Réblová (Xenospadicoidales, Sordariomycetes)

*L. investita* is new to Scandinavia and macroscopically looks like the more well-known *L. cirrhosa* with long black perithecial necks protruding from single perithecia sunken in wood. However, *L. investita* has longer and wider ascospores and longer asci (Réblová et al. 2018). Material: Hordaland, Granvin, Uraneset, UTM32 362780/6704090, on *Tilia* (?) in *Ulmus/Tilia* low-herb forest, 14 May 2019, leg. & det. EJ, conf. WJ.

*Melaspileella proximella* (Nylander) Ertz & Diederich (Eremithallales, Dothideomycetes), Fig. 5

*M. proximella* is not new to Norway but has not been collected since 1865, and this material should be checked. It is known from Sweden but not from Denmark. It is characterized by the unusual whorl of cilia at the apices of the ascospores. It's not lichenized. Material: Hordaland, Granvin, Uraneset, UTM32 343420/6689460, on dead twigs of *Juniperus communis* in broadleaved forest dominated by *Ulmus* and *Tilia*, 15 May 2019, leg. GF, det. GF & AA.

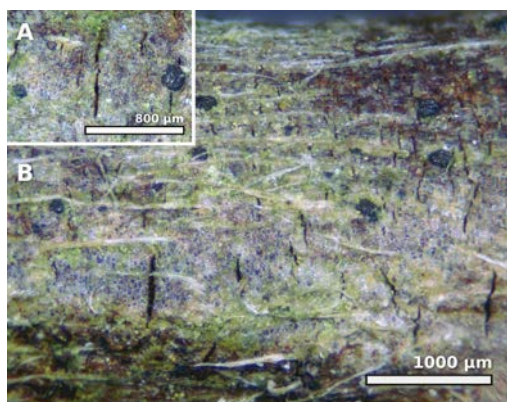


Figure 5. *Melaspileella proximella* on *Juniperus* branch. Photo: MA.

*Mycoporum sparsellum* Nyl. (Pleosporales, Dothideomycetes)

This non-lichenized species is new to Scandinavia and has irregularly shaped ascomata with several locules and two-celled clavate, 16-19 × 6-7 µm large ascospores. It typically grows on bark of *Corylus avellana* and can be confused with *Tomasellia gelatinosa*, which however has slender fusiform ascospores. Material: Hordaland, Kvam, Barlindflaten, UTM32 356860/6702450, on *Corylus avellana* in weak low-herb forest with *Taxus baccata*, 14 May May 2019, leg. & det. AA.

*Nigrograna mycophila* Jaklitsch, Friebes & Voglmayr (Pleosporales, Dothideomycetes)

This species forms 200-350 µm wide globose ascomata close to or on old ascomata of Diaporthales, and has fusoid to narrowly ellipsoid two-celled ascospores measuring ca 14-17 × 5.5-6.5 µm. The species is not known from other Sandinavian countries. Material: Hordaland, Kvam, Barlindflaten, UTM32 356860/6702450, on *Diaporthe impulsa* on *Sorbus aucuparia* in *Taxus baccata* forest, weak low-herb forest, 14 May 2019, leg. & det. WJ. A similar species, *N. norvegica* Jaklitsch & Voglmayr, was described from material collected at a previous workshop and is only known from the holotype location in



Aust-Agder, Arendal kommune, Nedenes, Langevoll. It has a similar ecology and was found in association with a *Diaporthe* sp. on a twig of *Tilia* lying on the ground, 4 Oct. 2014. *N. norvegica* differs from *N. mycophila* by faintly verruculose ascospores that are slightly smaller ( $13.0\text{-}17.0 \times 4.5\text{-}5.8 \mu\text{m}$ ). The two species were described in Jaklitsch and Voglmayr (2016).

*Ptychographa xylographoides* Nyl. (Trapeliales, Lecanoromycetes), Fig. 6

This weakly lichenized species is new to Scandinavia. It grows on dead wood on living trees and has an indistinct granulate thallus with narrowly elongate, usually unbranched apothecia measuring  $0.3\text{-}1.4 \times 0.1\text{-}0.3 \text{ mm}$ . The ascospores are ellipsoid and measure  $8.5\text{-}13 \times 4.5\text{-}6.5 \mu\text{m}$ . Material: Hordaland, Kvam, Berge, UTM32 343420/6689460, on old oak in mixed blueberry forest, 15 May 2019, leg. & det. BN, conf. AA



Figure 6. *Ptychographa xylographoides* showing lirellate apothecia or hysterothecia. Photo: MA.

*Rutstroemia tiliacea* (Fr.) K. & L. Holm (Helotiales, Leotiomyces)

This large discomycete with leathery apothecia is new to Norway but was previously reported from Sweden and Denmark. It grows in small groups on twigs, mainly on *Tilia* but has also been found on *Salix*, *Ulmus* and *Pinus* (Pärtel et al. 2016). The apothecia are 4–8 mm

in diameter and ochraceous- to dark chestnut-brown, the ascospores are cylindrical-subellipsoid, and about  $13\text{-}18 \times 3\text{-}4 \mu\text{m}$ , when over-mature two-celled and forming microconidia at both ends (Pärtel et al. 2016). Material: Hordaland, Granvin, Uraneset, UTM32 362780/6704090, on *Tilia cordata* in *Ulmus/Tilia* low-herb forest, 14 May 2019. leg. & det. WJ.

*Saccardoëlla canadensis* Ellis & Everh. (Sordariomycetes incertae sedis), Fig. 7

The species appears to be new to Scandinavia. Mathiassen (1993) argued that *S. canadensis*, *S. kanderana* and *S. transylvanica* probably represent a single taxon, but *S. canadensis* differs from the two other species by the shape of the papilla, ascus length, and ontogeny, shape, septation and size of the ascospores. The ascospores are cylindrical,  $40\text{-}70 \times 9\text{-}12 \mu\text{m}$ , 12–15 celled, hyaline, and slightly constricted at the septae, with ends not or only slightly attenuated (Petraik 1961). Ascospores of *S. transylvanica* and *S. kanderana* do not exceed  $50 \mu\text{m}$  in length and are only constricted at the middle septa. Material: Hordaland, Kvam, Skeianeset, UTM32 351870/6698600, on *Salix* sp. in low-herb forest, 13 May 2019, MA19-061, leg. MA, det. WJ. Material of *S. canadensis* was previously found by BN in 2014 and 2018, but was only identified with certainty together with the new material.

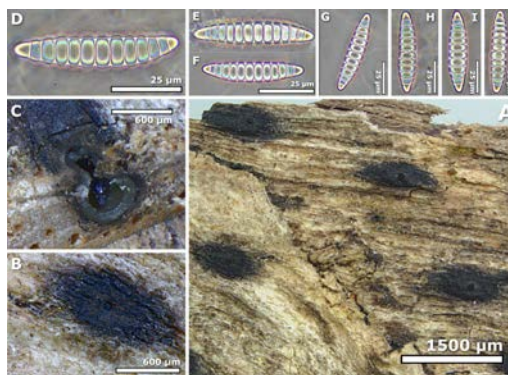


Figure 7. *Saccardoëlla canadensis*. Photo: MA.

*Splanchnonema britzelmayrianum* (Rehm) Boise (Pleosporales, Dothideomycetes)

This aquatic species is new to Norway but was previously reported from Sweden. The ascospores are mostly 7-septate (but up to 10-septate) and characteristic in shape and size (ca 40 × 10 µm). Material (en route to Bergen): Hordaland, Oppland, Grønlistølen, UTM32 451002, 6783177, on deciduous wood (bark-less twig, probably *Salix* sp.) in a stream, 12 May 2019, leg & det. RA, conf BN.

*Strigula taylorii* (Carroll ex Nyl.) R.C. Harris. (Strigulales, Dothideomycetes)

This lichenized species is not known from Norway or Sweden but there is an old find from Denmark. It has a brownish thallus and has conical ascomata that are 0.2-0.3 mm in diameter. The ascospores are two-celled and 19-24 × 4-5 µm, and typically break in two part-spores at early stage of development. Material: Hordaland, Kvam, Skeianeset, UTM32 351870/ 6698600, on deciduous tree in low-herb forest, 13 May 2019, leg & det. BN, conf. AA. It was previously found by BN and JBJ in Hordaland, Bømlø, Spissøy, Stølsvika sør, 295859/6626507, on an old *Ulmus* tree, 11 May 2013.

*Thyronectria coryli* (Fuckel) Jaklitsch & Voglmayr (Hypocreales, Sordariomycetes), Fig. 8

This species is new to Norway but was previously reported from Sweden. Its yellow scurf on the reddish cupulate ascomata is diagnostic for the genus *Thyronectria*, within which it is characterized by hyaline, uniseptate, narrowly fusiform to oblong ascospores budding within the asci. Unlike many other species of *Thyronectria*, *T. coryli* shows little host specificity, and it is known from various different broadleaf trees and shrubs (Jaklitsch and Voglmayr 2014). Material: Hordaland, Kvam, Barlindflaten, UTM32 356860/6702450, on *Prunus padus* in mesic low-herb forest with



Figure 8. *Thyronectria coryli*. Clusters of perithecia breaching the bark of *Prunus padus*. Photo: MA.

*Taxus baccata*, 16 May 2019, leg. & det. WJ & HV.

## DISCUSSION

The results of the workshop show that many interesting species can be found by a team of experts during just a few brief excursions. As identification of ascomycetes can be laborious, and may in many cases require advanced microscopy, cultivation and/or sequencing, many specimens from the workshop remain to be identified. We found several species that appear to be undescribed. Some of these are currently under processing, but describing new species is often a very time-consuming process so publishing the new names may take a long time.

## ACKNOWLEDGMENTS

The workshop was financed by the Norwegian Biodiversity Information Centre (Artsdatabanken), project 'Bitunicate ascomycetes (Dothideomycetes and Chaetothyriomycetidae) on bark and wood of selected hosts in Norway' lead by BN.

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## Doktorgrad

### Anvendte og fundamentale perspektiver på nedbrytningsmekanismer hos brunråtesopp

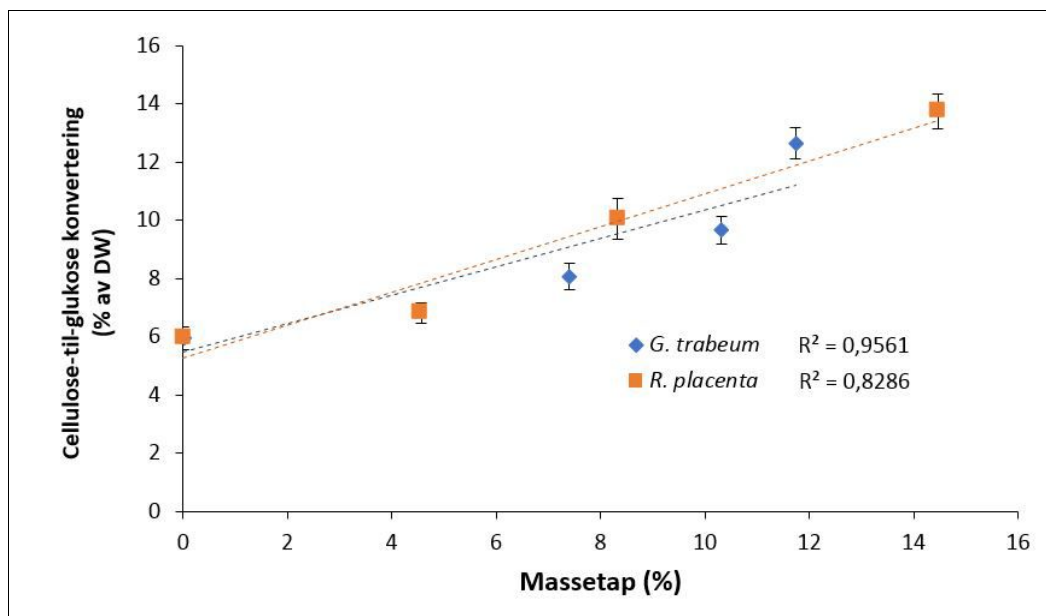
*Applied and fundamental perspectives on brown-rot fungal decay mechanisms*

Olav Aaseth Hegnar Philosophiae Doctor (PhD) avhandling ved Norges miljø- og biovitenskapelige universitet (NMBU), 2019:14. Fakultet for kjemi, bioteknologi og matvitenskap.

Avhandlingen består av en sammenstilling på 81 sider samt tre vitenskapelige artikler. Hvis

du ønsker en kopi av avhandlingen kontakt Dr. Olav Aaseth Hegnar, [olav.aaseth.hegnar@nmbu.no](mailto:olav.aaseth.hegnar@nmbu.no)

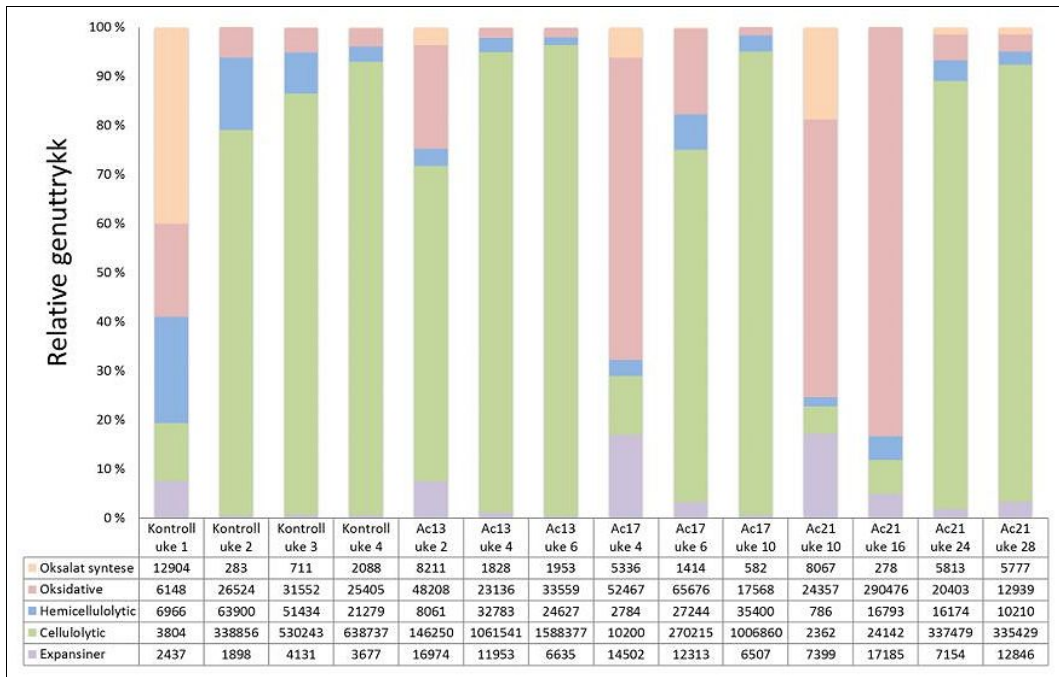
Biomasse fra tre er et viktig materiale for den gryende bioøkonomien, og har tiltrukket seg betydelig oppmerksomhet som et råstoff for 2. generasjons bioraffinerier. Tre har tradisjonelt blitt brukt som byggemateriale i årtusener, men er på grunn av sitt biologiske opphav utsatt for angrep av vednedbrytende sopp.



Figur 1. Forbehandling av gran med brunråte. Oppmalt trevirke ble inokulert med enten *R. placenta* eller *G. trabeum* for opptil 45 dager og massetap ble målt. Prøvene ble nedbrutt med enzym cocktailen Cellic CTec2, og en nær lineær sammenheng ble funnet mellom massetap og frigjort glukose. Termen «DM» på y-aksen refererer til tørrvekten. Cellulose-til-glukose konverteringen ble regnet ut på basis av w% før forbehandling.

*Brown-rot pretreatment of Norway spruce. Milled spruce wood was inoculated with either *R. placenta* or *G. trabeum* for up to 45 days and mass loss of the samples was monitored. Samples where then saccharified with Cellic CTec2, and a close to linear relationship between mass loss and glucose release was established. The term "DW" on the y-axis refers to the dry weight. Cellulose-to-glucose conversion calculated on the basis on w% before pretreatment. Based on Hegnar et al. 2019, Wood Science and Technology 53(2): 291-311.*





Figur 2. Relative uttrykk av 22 *R. placenta* gener under nedbrytning av umodifisert og acetylet (13, 17 og 21% WPG) *Pinus radiata* trevirke. Enhetene er arbitrære genuttrykk enheter, relativt til det kontinuerlig uttrykte beta-tubulin genet med uttrykksnivåer gitt som  $10^4$ . Vær oppmerksom på at den totale summen av genuttryknivå varierer mellom høstetidspunkt og behandlingsnivå.

*Relative expression of 22 R. placenta genes during decay of unmodified and acetylated (13, 17 and 21% WPG) Pinus radiata wood. The units given are arbitrary gene expression units, relative to the constitutively expressed beta-tubulin gene with the expression level given as  $10^4$ . Note that the sum total expression level varies between harvesting points and treatment levels. Based on Beck et al. 2018, International Biodeterioration and Biodegradation 135: 39-52.*

Biokjemien benyttet av disse soppene til å bryte ned tre er av interesse, både fra et trebeskyttelsesperspektiv, og som potensielle bioprosesseringsverktøy. I naturen er basidiomycete brun- og hvitråtesopp de eneste som bryter ned alle polysakkaridene i lignifisert plantemateriale. Brunråtesoppene er unike i at de fjerner holocellulose uten å mineralisere lignin, mens hvitråtesoppene bryter ned både lignin og holocellulose. Målet ved denne avhandlingen er å studere fundamentale brunråtesoppmekanismer for anvendte øyemed.

Denne avhandlingen beskriver brunråte-nedbrytning fra tre perspektiver: 1) oksidative ikke-enzymatiske nedbrytningsmekanismer

som forbehandling av tremasse, 2) genuttrykk av nedbrytningsassosierte gener under vekst på modifisert tre, og 3) samspillet mellom celluloseoksidierende lytisk polysakkaridmonooksygenaser, hydrogenperoksid og reduktanter.

I artikkel I var de tidlige nedbrytningstrinn hos brunråtesopp studert som en potensiell forbehandling for gran (*Picea abies*). Vi viser at ved å forbehandle gran med to brunråtesopparter, kan enzymatisk hydrolyse med en kommersiell enzymcocktail forbedres, og fikk en over 250% økning i glukosefrigivelse. Vi utførte deretter en rekke eksperimenter, hvor målet var å mimikere brunråteforhåndsbehandlingen, ved bruk av en modifisert

Fenton reaksjon. Her fikk vi en marginal økning i fordøyelighet etter forhåndsbehandling, hvor hensikten var å generere reaktive oksygenarter inne i treets cellevegg. Videre eksperimenter ble utført for å undersøke mulighetene for å gjøre forhåndsbehandling og sakkarifisering i ett og samme system, og resultatene her indikerer et behov for komplett separasjon av forhåndsbehandling og sakkarifisering, da kjemikaliene i forhåndsbehandlingen viste seg å være skadelige for enzymene. Vi konkluderer med at en biomimetisk tilnærming til forhåndsbehandling av gran er teoretisk mulig, men at systemet trenger optimalisering før videre arbeid kan gjøres.

I artikkel II var målet å bestemme hvordan acetylering (trebeskyttelse) av *Pinus radiata* påvirket uttrykk av nedbrytningsgener hos brunråtesoppen *Rhodonia placenta*. Genuttrykk ble analysert ved bruk av qRT-PCR og fanget både tidlige og sene nedbrytningstrinn. Initieringen av nedbrytning ble forsinket som et resultat av acetylering. Når nedbrytningen først var etablert i acetylert tre var raten sammenlignbar med umodifisert tre, noe som indikerer en hemning av nedbrytning og ikke en total beskyttelse. I samsvar med tidligere studier var det oksidative nedbrytnings-systemet hos *R. placenta* mer aktivt i tre med høy grad av acetylering, og uttrykk av hydrolytiske gener var forsinket sammenlignet med umodifisert tre. Vi studerte uttrykk av gener involvert i hemicellulose og pektin nedbrytning som ikke tidligere er beskrevet i studier på nedbrytning av acetylert tre. Vi observerte at en karbohydratesterase (CE16) som er antatt å være involvert i deacetylering av hemicellulose var nedregulert i acetylert tre, og fremsetter en hypotese om at dette genet er regulert via en negativ feedback mekanisme. Oppreguleringen av to expansin-gener i acetylert tre indikerer at denne modifiseringen øker behovet for å løse cellevegginteraksjoner som en konsekvens av økte massetettheten. I denne studien demonstrerer vi at acetylering

påvirker uttrykk av en rekke gener ikke tidligere studert under disse forholdene, og resulterer i forsinket nedbrytning.

I artikkel III har vi rensert og karakterisert en rekombinant familie AA9 lytisk polysakkaridmonooksygenase (LPMO, *GtLPMO9B*) fra brunråtesoppen *Gloeophyllum trabeum*, som er aktiv på både cellulose og xyloglucan. Enzymaktivitet ble testet med tre forskjellige reduktanter: ascorbic acid (AscA), gallic acid (GA) og 2,3-dihydroxybenzoic acid (2,3-DHBA). Under reaksjonsforhold vanligvis brukt i LPMO reaksjoner, var enzymet katalytisk aktivt med AscA og GA, men var det ikke med 2,3-DHBA. I samsvar med den nylige oppdagelsen at LPMO-katalyse kan drives av H<sub>2</sub>O<sub>2</sub>, viser vi at gradvis tilføring av H<sub>2</sub>O<sub>2</sub> tillater LPMO aktivitet ved svært lave, sub-støkiometriske (relativt til produkt) reduktantkonsentrasjoner. Viktigst, så vi viser at, mens 2,3-DHBA ikke kunne drive LPMO reaksjonen under standard aerobe forhold, så kan den det i nærvær av tilført H<sub>2</sub>O<sub>2</sub>. Ved alkalisk pH (8.0-9.0), ble aktivitet med *GtLPMO9B* observert med 2,3-DHBA (uten ekstern tilførsel av H<sub>2</sub>O<sub>2</sub>), noe som overlappet 100% med endogen H<sub>2</sub>O<sub>2</sub> produksjon via *GtLPMO9B*-katalysert oksidering av 2,3-DHBA. Disse funnen støtter teorien om at H<sub>2</sub>O<sub>2</sub> er et kosubstrat for LPMOer, og tilfører ny kunnskap om hvorledes LPMO reaksjoner er avhengige, og potensielt kan kontrolleres med bruk av forskjellige reduktanter.

Olav Aaseth Hegnar

## Doktorgrad

### Forståelse av fuktighetens rolle ved brunråtedbrytning av acetylert tre

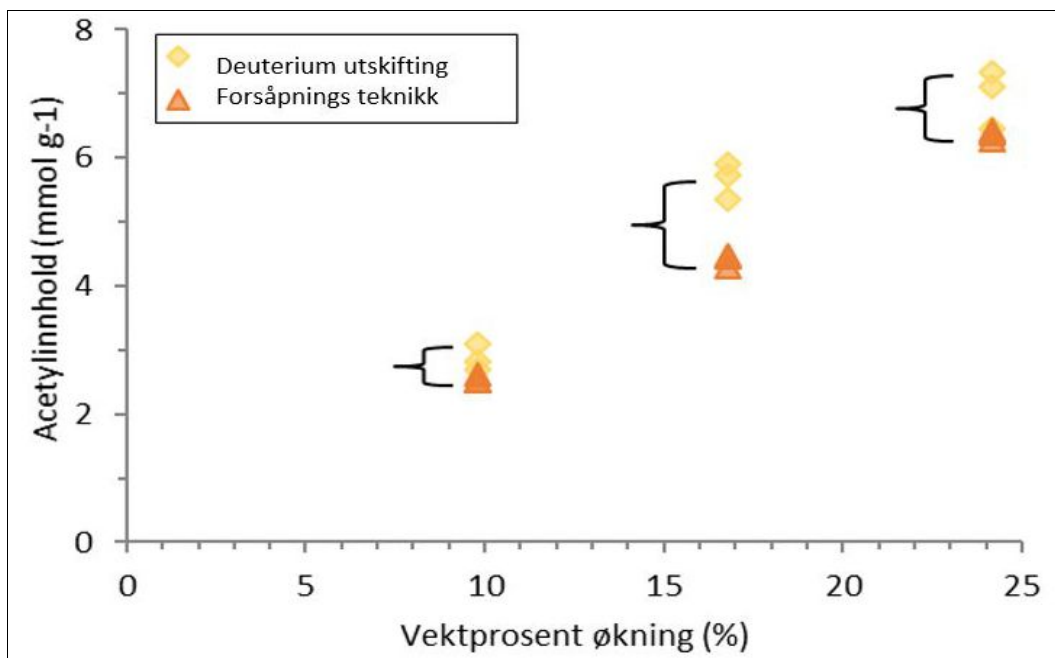
*Understanding the wood-water relationship in brown-rot degradation of acetylated wood*

Dr. Greeley Beck, greeley.beck@nibio.no

Harold Greeley Beck Philosophiae Doctor (PhD) avhandling ved Norges miljø- og biovitenskapelige universitet (NMBU), 2018:41. Fakultet for miljøvitenskap og naturforvaltning.

Målet med doktorgraden var å klargjøre rollen vann har i forbindelse med brunråtedbrytning av acetylert tre. Acetylering er en kjemisk tremodifisering som gir økt holdbarhet mot vednedbrytende sopp. Den økte holdbarheten skyldes hovedsakelig at vann ekskluderes fra den acetylte celleveggen, men den eksakte mekanismen for hvordan vann ekskluderes er fortsatt uklar. De to første

Avhandlingen består av en sammenstilling på 55 sider samt fire vitenskapelige artikler. Hvis du ønsker en kopi av avhandlingen kontakt



Figur 1. Acetylinnhold i acetylert *Pinus radiata* vårved som en funksjon av økning i vektprosent (behandlingsgrad). Verdier i oransje er bestemt direkte ved forsåpning mens verdiene i gult er bestemt indirekte ved å anta at en nedgang i hydroksyltilgjengelighet bestemt ved deuterium utskifting kun er et resultat av acetylsubstitusjon. Forskjellen mellom verdiene (illustrert med parentes) indikerer at antagelsen ikke er gyldig og at hydroksyltilgjengelighet også reduseres ved andre mekanismer i tillegg til acetylsubstitusjon.

*Acetyl content of acetylated Pinus radiata earlywood as a function of weight percentage gain. Values in orange are determined directly with saponification, while values in yellow are determined indirectly by assuming decreases in hydroxyl accessibility determined with deuterium exchange are entirely the result of acetyl substitution. The difference between the values (illustrated with brackets) indicates that the assumption is invalid and hydroxyl accessibility is also reduced by another mechanism in addition to acetyl substitution. Adapted from Beck et al. 2017, Holzforschung, 72, 12-23.*

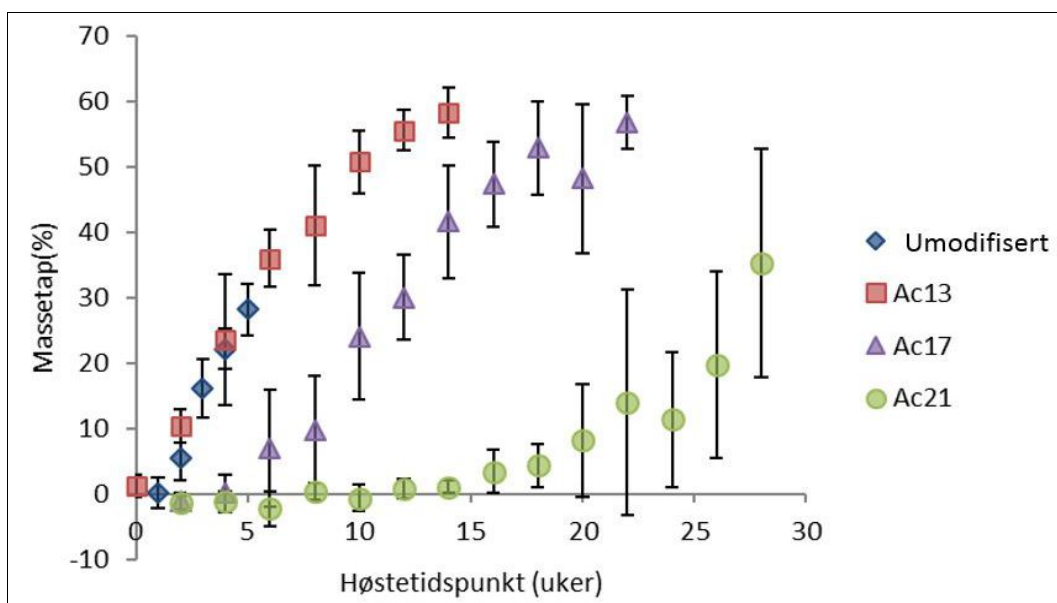
artiklene i avhandlingen belyser mekanismen bak ekskluderingen av vann. I artikkel 1 blir det for første gang bevist at tilgjengelige hydroksylgrupper i acetylt tre er redusert på to måter: 1) ved direkte substitusjon av hydroksylgrupper med acetylgrupper og 2) ved at acetylgrupper fyller opp celleveggen og på grunn av sin størrelse vil acetylgruppene hindrer tilgang til hydroksylgrupper i deler av celleveggen som ikke er modifisert. Det ble benyttet en kombinasjon av to metoder, deuterium utskifting for å fastslå hydroksyltilgjengelighet og forsåpning med natrium hydroksid for å fastslå acetylinnholdet.

Artikkel 2 viser effekten av acetylering på  $T_2$  relaksasjon av vann i ulike delene av vedcellene i vannmettede acetylte treprøver. Acetylering gjør at vannet gradvis blir mer

mobilt på grunn av den reduserte affiniteten til den acetylte celleveggen, samtidig som den totale mengden av vann inne i celleveggen reduseres. Begge disse studiene sammenligner også fuktighetsegenskapene til acetylte tre med tre som er modifisert med propansyreanhydrid. Målet var å vise effekten av fysisk bulking sammenlignet med direkte hydroksyl substitusjon ved å modifisere trevirket med et større anhydridmolekyl.

Resultatene indikerte at den propansyreanhydrid modifiserte celleveggen ble ødelagt under denne reaksjonen.

Acetylt tre nedbrutt av brunråtesoppen *Rhodonía placenta* ble undersøkt i de to siste artiklene. Ved å bruke små prøver av radiatafuru (vårved) og lang inkubasjonstid, viste de acetylte prøver med høy acetylerings-



Figur 2. Massetap som en funksjon av høstetidspunkt for umodifisert og acetylt *Pinus radiata* vårved nedbrutt av brunråtesoppen *Rhodonía placenta*. Økning i vektprosent (behandlingsgrad), som et resultat av kjemisk modifisering (acetylering) er angitt med nivå etter Ac. Økende grad av acetylering forsinket initieringen av råtenedbrytning, men selv prøver med høyt acetyleringsnivå blir kraftig nedbrutt hvis de eksponeres for råtesoppen over lang tid.

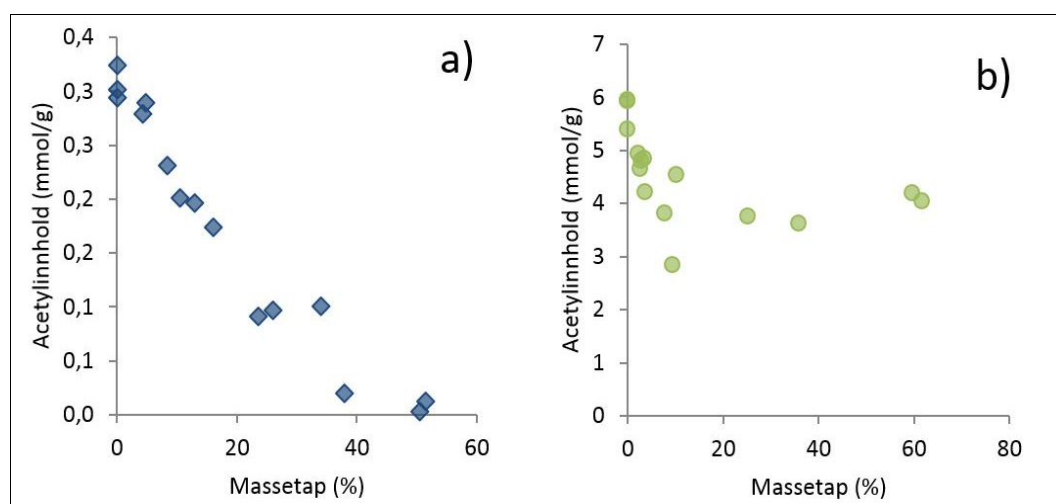
Mass loss as a function of harvest time for unmodified and acetylated *Pinus radiata* earlywood degraded by the brown-rot fungus *Rhodonía placenta*. The weight percent gain due to chemical modification for the acetylated samples is denoted by the number after Ac. Increasing levels of acetylation delay the onset of decay, but even highly acetylated samples are severely degraded if given enough time.

grad (21 % vektprosent økning) mye høyere nivå av nedbrytning enn det som tidligere har blitt rapportert i litteraturen. Artikkel 3 undersøker forholdet mellom tre og vann i soppnedbrutte acetylte prøver ved bruk av LFNMR (lavfelt kjernemagnetisk resonans) og avklarer kjemiske endringer i acetylt tre ved bruk av deuterium utskifting og acetylinnhold målt med en forsåpnings teknikk samt ATR-FTIR (Attenuated total reflectance-Fourier transform infrarødt spektroskopi). Endringer i kjemisk sammensetning i prøvene og  $T_2$  relaksasjonen av vann i de ulike delene av vedcellen indikerte at det i acetylt tre foregår en substansiell deacetylering ved lave massetap. Det ser ut som at så snart deacetylering opptrer, så brytes acetylt tre ned med

samme nedbrytningsrate som ubehandlet tre.

Artikkel 4 ser på nedbrytning av tre fra soppens sitt perspektiv og viser hvordan acetylt tre påvirker genuttrykket til enzymer som er involvert i oksidativ nedbrytning og polysakkarid hydrolyse. Økende grad av acetylering forårsaker oppregulering av enkelte genene involvert i det oksidative systemet og nedregulering av gener involvert i depolymerisering av polysakkarider. Dette kan bety at soppen er mer avhengig av det oksidative systemet ved nedbrytning av acetylt tre, og muligens brukes det oksidative systemet til å deacetylere materialet.

Harold Greeley Beck



Figur 3. Acetylinnhold i umodifisert *Pinus radiata* vårved (a) og *P. radiata* vårved med høy acetyleringsgrad (b) som en funksjon av massetap etter nedbrytning av *Rhodonia placenta*. Den lineære nedgangen i acetyl innhold for umodifiserte prøver antyder at hemicellulose brytes ned med en konstant hastighet og er totalt fjernet ved 50% massetap. Den bratte nedgangen i acetyl innhold for acetylte prøver ved lave massetap indikerer at deacetylering forekommer ved tidlige nedbrytningsstadier, mens det resterende acetylinnholdet ved høye massetap kan skyldes gjenværende acetylgrupper på modifisert lignin.

*Acetyl content of unmodified (a) and highly acetylated (b) Pinus radiata earlywood as a function of mass loss due to degradation by Rhodonia placenta. The linear decrease in acetyl content for unmodified samples suggests that hemicellulose is degraded at a constant rate and completely removed by 50% mass loss. The steep decline in acetyl content for acetylated samples at low mass loss indicates deacetylation occurs during initial decay, while residual acetyl content at high mass loss may be due to acetyl groups remaining on modified lignin. Adapted from Beck et al. 2018, International Biodeterioration and Biodegradation, 135, 62-70.*



## Doktorgrad

### Svertesoppvekst som en bidragsyter til visuelle endringer av utvendige trekledninger

*Surface mould growth as a contributor to visual changes of exterior wooden claddings*

Solrun Karlsen Lie Philosophiae Doctor (PhD) avhandling ved Norges miljø- og biovitenskapelige universitet (NMBU), 2019:21.

Fakultet for Miljøvitenskap og naturforvaltning, Ås.

Avhandlingen består av en sammenstilling på 62 sider samt fire vitenskapelige artikler. Hvis du ønsker en kopi av avhandlingen kontakt Dr. Solrun Karlsen Lie, skl@erichsenhorgen.no.

Utseendet til umalt utvendig trekledning endrer seg over tid avhengig av klima og materialfaktorer (Figur 1). Slike visuelle endringer kan være ønsket eller uønsket, og endringene kan til og med brukes for å oppnå et bestemt uttrykk og design. Det er nødvendig med mer kunnskap om faktorene som forårsaker visuelle endringer av utvendig trekledning for å sikre at man oppnår et vellyk-

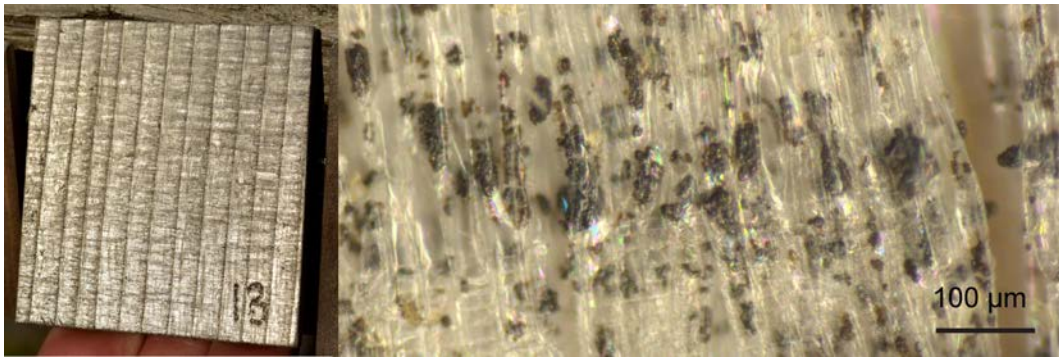
ket resultat og en tilfredsstillende ytelse. Svertesoppvekst er en viktig bidragsyter til de visuelle endringene. Med sine mørke hyfer og sporer kan vekst av svertesopp gi trevirket et mørkere utseende. Derfor er svertesoppvekst en viktig faktor for det grå utseendet som trekledninger ofte utvikler. Det overordnede målet med denne avhandlingen var å undersøke svertesoppvekst på umalt tre for å gjøre det mulig å predikere visuelle endringer av utvendige trekledninger. Dette kan gjøre det enklere å oppnå vellykket bruk av tre som kledningsmateriale.

Tidligere forskning på svertesopp har hovedsakelig fokusert på å forhindre svertesoppvekst innendørs eller på malte substrater uten-dørs. Det finnes mindre kunnskap om hvordan svertesoppvekst forårsaker visuelle endringer av umalte utvendige kledninger. Derfor gjennomførte vi fire studier for å få en bedre forståelse av klimafaktorer og materialfaktorer som påvirker vekst av svertesopp og for å gjøre det enklere å modellere, screening-teste og evaluere svertesoppveksten.



Figur 1. Eksempler på utendørs eksponert trekledning. Venstre: kledning i Oppdal, Norge. Midten: kledning på Ås videregående skole. Høyre: kledning på fjellhytte i Telemark.

*Examples of claddings that have developed a varying colour. Left: Cladding in Oppdal, Norway. Middle: Cladding on Ås high school, Norway. Right: Cladding on a cabin in the mountains in Telemark, Norway. Photos: S. K. Lie.*



Figur 2. Værdret treprøve og forstørret foto av overflaten som viser mørkfargede sopphyfer og –sporer.  
*Grey wood specimen and magnified photo taken of its surface showing the dark-coloured hyphae and spores of the surface mould growth. Photos: S. K. Lie.*

I tilpassede klimarom ble effekten av temperatur, relativ luftfuktighet og lengde av våttid på svertesoppvekst testet på forskjellige umalte trematerialer. Alle klimafaktorene hadde signifikante effekter på svertesoppveksten og signifikante forskjeller mellom materialene ble påvist. Data fra denne testen ble videre benyttet til å avgjøre om eksisterende svertesoppmodeller kan brukes til å predikere svertesoppvekst på trekledninger som er utsatt for periodisk oppfukning med flytende vann. Frem til nå har ikke eksisterende modeller inkludert effekter av oppfukning med flytende vann. Den originale VTT-modellen ga resultater som hadde bemerkelsesverdig godt samsvar med eksperimentelle data i dr. grads-studiet så lenge tilpassede klimatiske inngangsdata ble benyttet. Best samsvar ble funnet ved å bruke relativ luftfuktighet i treoverflaten (estimert fra elektriske motstandsmålinger) som inngangsdata i modellen.

Videre ble bruken av screeningstester (agarplattetest og vannopptakstest) for å predikere svertesoppvekst på umalte utvendige trekledninger undersøkt. Det ble påvist at inokuleringsmetode og inkuberingsstemperatur hadde signifikant effekt på mengde svertesopp i agarplattetesten, men ingen av testkombinasjonene ga gode indikasjoner på utendørs ytelse. Vannopptakstesten klarte imidlertid delvis å forutse utendørs ytelse og er derfor en mer lovende screeningmetode.

Som en del av studiet, ble visuelle endringer av tre eksponert utendørs undersøkt. Utvikling av svertesopp ble evaluert ved å studere mørkhet og jevnhet i farge på ulike umalte trematerialer eksponert utendørs i 62 uker (Figur 2). Resultatene viste hvordan svertesoppvekst kan gi trevirket et mørkere utseende, og hvordan evaluering av svertesoppvekst kan forbedres ved å tilleggsevaluere mørkhet og fargejevnhet (homogenitet).

Solrun Karlsen Lie

## Doktorgrad

### Functional versatility and diversity in the plant root mycobiome

Ella Thoen Philosophiae Doctor (PhD) Avhandling ved Universitetet i Oslo (UiO), nr. 2090, 2019. Det matematisk-naturvitenskapelige fakultet.



Selv om de er best kjent som nedbrytere av dødt organisk materiale i skog, finner vi ofte DNA av hettesopp (*Mycena* spp.) i friske planterøtter, hvor de kan ha viktige funksjoner som biotrofe symbionter eller endofytter. Avbildet her er rosehette (*Mycena rosella*). Foto: E. Thoen

Sopp er viktige komponenter i alle økosystem, som nedbrytere av dødt organisk materiale, som patogener og som nyttige symbionter i planterøtter. Flere nyere studier antyder at skille mellom ulike økologiske grupper innen soppriket ikke er like skarpt avgrenset som tidligere antatt, og i sin avhandling ser Ella Thoen nærmere på dette.

Studiene i denne avhandlingen fokuserer på sopp som er assosiert med planterøtter, og deres allsidige økologiske roller. Avhandlingen viser hvordan ulike faktorer er med på å struk-

turere soppfunn på forskjellige skalaer, og at empiriske funn fra feltstudier kan bekreftes av *in vitro* laboratoriestudier. I en omfattende studie, undersøkte Ella Thoen og kolleger en klimatisk gradient på Vestlandet i Norge, og fant at rot-assosierte soppfunn var mer påvirket av klimavariabler enn sopp i jord generelt. Mengden karbon og soppbiomasse var lavest i den våteste enden av gradienten, hvilket kan indikere at det fremtidige varmere og våtere klimaet i denne regionen kan føre til endring av soppfunnet og mindre potensiell lagring av karbon i jordsmonnet her.

Blant de mest vanlige slektene i den nevnte studien, var de antatte nedbrytersopper i slekten *Mycena* (hettesopper). Disse har nå blitt rapportert fra friske planterøtter i mange studier, som kan indikere at disse kan opptre som biotrofe sopp. Ella Thoen og kolleger undersøkte dette ved hjelp av veksteksperimentet og fluorescerende mikroskopi, og dokumenterte de fysiske interaksjonene mellom planterøtter og *Mycena*. Alle *Mycena*-artene inkluderer i studien assosierte tett med levende planterøtter. Ved å bruke radiokative isotoper, viste de at noen av artene også kunne overføre næring til plantene. Arter innen denne slekten er muligens mer økologisk allsidige enn tidligere antatt, og kan befinne seg i et overgangsstadium mellom saprotrof og biotrof økologi.

Fordi sopp for det meste lever skjult, vet vi veldig lite om hvordan soppfunn er strukturert på veldig små skalaer. Ella Thoen og kolleger undersøkte romlig struktur på fin skal i et rotsystem fra harerug (*Bistorta vivipara*). Selv på en så liten skala, fant de høy diversitet og romlig struktur i soppfunnet.

Ella Thoen

## En mykolog runder 70!!

**Klaus Høiland har rundet 70 år, tro det den som vil! Det understreker bare hvor fort årene går.**

En mykolog og botaniker som har gjort seg gjeldene i 'miljøet' i mer enn 50 år!



Klaus i blomstereng på Lista, der han hentet inspirasjon til sitt karriereløp.

Helt fra studiedagene har Klaus hatt sin hovedinteresse i botanikk. Men også før det – tilbake på 60-tallet - da han foruten å lytte til Beatles-musikk, samlet og bestemte han planter, moser, alger, sopp og lav av alle slag. Materialet ble sendt til Botanisk museum i Oslo, hvor han kom i kontakt med fagpersoner som Gro Gulden, Finn-Egil Eckblad og Leif Ryvarden. Det var da interessen for sopp virkelig tok av. Klaus sikret seg hovedoppgave i mykologi om temaet "sopp på sanddyner på Lista" (hvor han har familie på farssida) med Gro Gulden som veileder. Ut av det ble han cand. real. i 1974, og ti år senere, etter inngående studier av kanelslørsoppene (*Dermocybe*), ble det også doktorgrad og Dr. philos. tittel. Interessen for planter forsvant ikke på grunn av mykologien, den har alltid vært levende, om etterhvert i noe mindre omfang enn soppene. Etter en periode som vitenskapelig assistent ved Botanisk hage og museum 1976-1982, ble Klaus tilsatt i Øko-forsk/NINA som forsker fra 1987-1994, og i 1994 kom han til Biologisk institutt – nå

Institutt for Biovitenskap - hvor han var professor inntil han 'falt for aldersgrensen' i 2018. Nå vandrer han rundt i gangene som emeritus professor på Institutt for biovitenskap og trives fortreffelig med det.

Karriereløpet til Klaus inneholder mange detaljer. I NINA arbeidet han først og fremst med høyere planter og vegetasjonsøkologi. Studier av forekomster, vern og forvaltning av truede karplanter i Norge ble en viktig oppgave som har engasjert professoren siden. I NINA-tiden utviklet han også interesse for numerisk vegetasjonsøkologi, noe han tok med seg inn i mykologien. Klaus har også en utpreget sans for antropokorene, dvs. alle ugressene som dukker opp på gater, jordhauger, vegkanter, ved møller osv. og som drar nytte av menneskelige aktiviteter. Professoren går fortsatt på bytur med kamera rundt halsen for å fotografere disse innvandrerne. Han har fortsatt et levende samarbeid med amatørbotanikere i Norsk Botanisk Forening, en forening hvor han også har vært formann (1986-1988) og redaktør (1990-1997) for tidsskriftet *Blyttia*.

I 1985 arbeidet Klaus på et prosjekt (ledet av Gro Gulden) om virkningen av forurenset nedbør på fruktlegemedannelse hos ektotrofe mykorrhizasopper. Tre områder ble valgt ut, i Høylandet i Nord-Trøndelag (uforurenset), Gjerstad i Aust-Agder (litt forurenset) og i Schwarzwald i Tyskland (sterkt forurenset). Det ble funnet klare forskjeller i soppfloraen, dvs. minst arter i Schwarzwald og flest i Høylandet. En naturlig hypotese var at forurensetningene hadde skadet soppene, noe som igjen kunne forklare skogdøden. Senere gjøv Klaus løs på omfattende undersøkelser av soppfunn i barskog i Gjerstad og i Sør-Trøndelag sammen med Egil Bendiksen. Senere også på



Finse, hvor han har veiledet flere hovedfagstudent.

Faget kjemi har interessert Klaus helt siden guttedagene. Etter eget sigende utmerket han seg med å lage krutt, knallgass og smørsyre til klassens (og lærerens!!) store begeistring. Det falt derfor helt naturlig for Klaus å interessere seg for soppkjemi, eller rettere soppenes sekundærmetabolitter, hvor han også i sin tid innledet et samarbeid med undertegnede. På midten av 70-tallet ble vi oppmerksomme på at spiss giftslørsopp (*Cortinarius rubellus*), som var kjent å gi forgiftninger i Finland, faktisk også var ganske så vanlig i Norge. Det gikk da heller ikke lang tid før de første forgiftningstilfeller med soppen dukket opp her hjemme. Og enda verre, - soppen sto ikke avbildet eller omtalt i en eneste norsk soppbok! Her måtte det revisjoner til, hvor Klaus ble en viktig pådriver. Giftstoffet orellanin ble testet ut på kloroplastene i grønne planter og viste seg å være vel så toksisk som ugrasmidlene dikvat og parakvat. I et senere arbeid kunne Klaus påvise at orellanin også kan binde og ufarliggjøre oppløst aluminium i jordvann (oppløst aluminium er giftig og frigjøres ved forsuring). Dette kan muligens forklare hvorfor spiss giftslørsopp er så vanlig på steder med høy luftforurensning. Fleinsoppene (*Psilocybe*) hører også med til hjertebarna, og Klaus mottok i mange år pakker fra KRIPOS med mystisk innhold av potensielle narkotiske sopper til identifikasjon.

Siden vi står overfor en professor i biologi med spesiell forkjærlighet for sopp, blir ikke bildet av fagligheten komplett før vi også trekker fram at en av særinteressene hans, nemlig taksonomi og fylogeni hos hatsopper. Her er det slørsoppene (*Cortinarius*) som har fått mest oppmerksomhet, men også mosekantarellbeger (*Arrhenia*), fleinsopper (*Psilocybe*), bittersopper (*Gymnopilus*) og grupper av rørsopper (Boletales) har fått gjennomgå. Doktorgraden ble som nevnt utført på kanel-slørsoppene (*Cortinarius* subgen. *Dermocybe*)

i Norden. Kjemotaksonomi på anthrakinoner spilte her en sentral rolle, men også fenetiske og kladistiske metoder ble utprøvd på denne soppgruppen, metoder som den gang hadde liten innpass i mykologien. Studier av ektotrof mykorrhiza og samfunnsstudier av sopp har også vært viktige arbeidsfelter. Som professor ved Biologisk institutt og senere Institutt for Biovitenskap har Klaus de seneste årene igjen tatt fatt på slørsoppene, denne gang ved hjelp av DNA-studier. I øyeblikket er han heltidsansatt på et artsdataprojekt om slørsoppene på Svalbard!

Det er få norske botanikere og mykologer som har holdt flere turer, foredrag og kurs om sopp enn Klaus. Alt fra nybegynnerkurs om matsopp til avanserte kurs om slørsoppenes



Klaus på fotograferingsrunde med sitt første kamera.



Klaus som godt voksen foredragsholder i Botanisk hage

systematikk, økologi og kjemi er en del av kursporteføljen. Klaus sine evner som foredragsholder og popularisator av bio-faget i vid forstand er viden kjent. En titt i forrige århundres årganger av Blekksoppen, Våre Nyttevekster, Naturen og Blyttia, og nå på nettstedet som 'spør en biolog' bekrefter mine ord.

Til lykke, Klaus, med dine første 70 år og din nye tilværelse som emeritus!

Trond Schumacher

## Trond Schumacher 70 år

Plutselig ble Trond 70 år!

At Trond Schumacher fylte 70 år er en begivenhet som ble skikkelig feiret i sommer, først med internasjonalt seminar om sekksporesopper, Ascomycota, på Tøyen hovedgård, deretter i hans kjære Grimsdalen, dit han inviterte familie og venner til Grimsdalen festival med natursti, musikk, foredrag, middag og mye attåt – i virkeligheten en 130 årsfeiring fordi hans livsledsager, Kirsten, også fylte år (60) i 2019.

Men la meg ta historien tilbake til begynnelsen. I 1960-årene startet Tronds vitenskapelige karriere, iallfall uti botanikken. Da ville han begynne på et universitetskurs i systematisk botanikk, men hadde ikke tilstrekkelig studiekompetanse til å melde seg på. Men etter å ha vist professor Rolf Y. Berg sitt velfylte

herbarium, med mange gode funn fra indre Troms, ble Berg så begeistret at han fikk begynne på kurset uten flere motforestillinger.

Trond begynte å studere medisin i 1968, og mange, meg med, regnet ham som tapt for botanikken.

Men nei da, ikke før var medisinstudiene overstått, fullførte han sitt biologistudium og tok sin master (da hovedfag) på en forskningsoppgave om begersopper Pezizales på elvekanter langs Grimsa. Den vakre Grimsdalen har alltid stått Tronds hjerte nær. Han har beskrevet flere nye sopper for vitenskapen derfra, f.eks. *Iodophanus hyperboreus*, som han alltid viser fram på feltkurs med studentene – en sjokolade til den som finner den først! Du må bare kravle ned i elveslammet og bli våt på buksa! Men Grimsdalens generelle



Grimsdalsfestivalen 2019



økologi og natur har engasjert ham nesten like mye som soppene. Hans omfattende rapport til Vassdragsforsk på tidlig 80-tall bidro sterkt til at Grimsdalen ble varig vernet mot utbygging og nå er blitt landskapsvernområde.

Sin kunnskap om medisin har han kombinert med mykologien ved å ta opp temaet giftsopper og soppforgiftninger. Dette er det blitt bok, flere artikler og foredrag ut av. Til glede og nytte for allmennheten ved å formidle sikre kunnskaper med rot i dagens moderne medisin.

Tronds viktigste mykologiske felt er Ascomycota, spesielt Pezizales og Helotiales (begeropper, morkler og trøfler). Det begynte allerede i 1976 med en omtale av *Vibrissea* og dens slektninger. Og deretter gikk det slag i slag med *Ciboria*, *Boudiera*, *Sarcoleotia* osv.

Denne interessen ble kronet med hans doktorgrad i 1988 over slekten *Scutellinia*, en verdensmonografi med bl.a. nybeskrivelse av flere arter. Denne ble publisert i *Opera Botanica* i 1990. Her er viktige ting om taksonomi, økologi, utbredelse og nomenklatur omtalt. Trond har alltid tatt nomenklatur svært høytidelig og slår raskt ned på arbeider som ikke følger nomenklaturens irrganger. Noe som er viktig i dagens forskning fordi altfor mange artikkelforfattere slomser i vei og kan gjøre stor skade omkring navnsetting av arter.

Samtidig hadde Trond begynt å utvide sitt kontaktnett, og dette er blitt så vidtfavnende og involverer så mange personer at jeg bare kan nevne de aller mest sentrale. En av hans tidligste og viktigste makkere er Linda Kohn fra Toronto, Canada. Trond tilbrakte et sab-



Trond elsker å formidle, og her demonstrerer han sopp på sopptur arrangert for de ansatte ved UiO. Turen gikk til Slattum i Nittedal.





Trond som leder av master-feltkurset i Grimsdalen i en liten rasmark ved Tverråa. Til venstre, Einar Timdal, lavspesialist ved NHM. For ordens skyld: Lav er også sopp.

batsår i Toronto (1993) for å studere Ascomycota sammen med Linda. Hun arbeider mye med de planteparasittiske Sclerotiniaceae og Rutstroemiaceae (en familie opprettet av Kohn, Schumacher og Arne Holst-Jensen) og deres systematikk, livssyklus og økologi. Linda, og hennes mann James Anderson, som for øvrig er sopp-genetiker, kom hele den lange veien fra Canada for å holde foredrag på Tøyensemiaaret og for å være med på Grimsdalen-festivalen.

Da de molekylære metodene ble tatt i bruk i mykologien mot slutten av 1980-årene, var Trond den som var tidligst ute. Dette nedfelte seg i studier av *Monilinia* (Sclerotiniaceae), som parasitterer frukter både av bærlyng og epler og eplenes nærstående slekter. Arne Holst-Jensen tok Cand. Scient.-oppgave på dette og ble en viktig medarbeider. Siden tok Arne doktorgrad i samme område og er nå forsker ved Veterinærinstituttet.

I 1990 skjedde det «heldige» at flere mål skog brant opp i Maridalen. Her fikk Universitetet i Oslo fritt leide til å drive forskning. Da mange sopp er tilpasset brann, var det naturlig å knytte til seg mykologene. Det ble til flere masteroppgaver. Trude Vrålstad var en av dem som studerte soppene i brannfeltet. Hun konsentrerte seg om *Geopyxis carbonaria* og viste at den danner ektomykorrhiza med røttene til gran ganske dypt nede i jordsmonnet. Når det har brent, danner soppen fruktlegemer i «dødens stund» for å få spredd avkommet dvs. sporene. Dette elegante arbeidet ble kronet med en fin artikkel, og siden arbeidet Trond og Trude med mykorrhiza i kopperforurenset furuskog rundt Follidal gruver og påviste at mykorrhiza med Helotiales gjorde at furu-plantene ble beskyttet mot de giftige tungmetallene. Dette ledet til Trudes doktorgrad, og nå er også hun forsker ved Veterinærinstituttet.

*Neolecta* er en sekksporesopp med frukt-



Finner vi *Iodophanus hyperboreus*? Åling i lendet langs Grimsa, alle ble våte. Trond er nummer 2 fra venstre.

legemer som likner på en gul jordtunge, en gruppe Trond alltid har interessert seg for. I samarbeid med den svenske mykologen Sara Landvik, nå ansatt som Science Manager hos Novozymes, København, fant de ut at *Neolecta* ikke tilhører jordtungene, og overraskende slett ikke er i slekt med de andre ekte sekksporesoppene, Pezizomycotina. På bakgrunn av morfologi (f.eks. åpningsmekanismen til asci), ultrastruktur og molekylære analyser, påviste de at *Neolecta* grupperte seg med ursekksporesoppene, Taphrinomycotina, som inntil da hadde omfattet bare planteparasitter uten fruktlegemer (f.eks. bjørkeheksekost) og gjærliknende sopper. Sannsynlig er *Neolecta* en ur gammel slekt, en «soppdinosaur», som kan peke bakover til sekksporesoppenes opprinnelse.

Videre har Trond interessert seg for snylteklubbene, *Cordyceps* s.l. og levert viktige fylogenetiske bidrag om dette temaet. Her viste det seg at både *Claviceps* og *Epichloë* ligger godt inne i fylogenen til denne artige soppgruppen. Og selvfølgelig ble det også veiledning av et par hovedfagstudenter på dette emnet.

Hans interesse for mykorrhiza gjorde at han ble veileder for mange master- og PhD-

prosjekter der rotsonen i ulike vegetasjonstyper ble undersøkt, særlig vegetasjon på Finse og Svalbard. I det hele tatt har Trond forkjærlighet for kalde strøk, og hans bidrag til fungaen i arktisk-alpine-strøk er omfattende med mange bøker og artikler, også populære.

Det er verdt å legge til at Trond har stadig utvidet sin kompetanse i molekylære metoder etter hvert som de ble stadig mer avanserte. Han og medarbeidere har skrevet viktige arbeider av mer generell natur innen molekylærbiologi, f.eks. om tolkning av gensekvenser og metagenomikk. Dette har gjort at han også har bidratt som veileder eller medarbeider i prosjekter som omfatter molekylære problemstillinger hos stilksporesopper (Basidiomycota).

Sammen med kollegaen Håvard Kausrud har han arbeidet med reproduktive strategier, artsdannelse, evolusjon og populasjonsbiologi til *Serpula lacrymans*, *S. himantioides*, *Phellinus nigrolimitatus*, *Trichaptum abietinum* og *Fomitopsis rosea*. Og med undertegnede er det blitt et par samarbeid om *Cortinarius*.

Tronds engasjement i mykologien har ikke bare bestått i publikasjoner og forskningsprosjekter. Han er også en fantastisk formidler av faget, både på forelesninger, foredrag,

feltkurs og soppturer. Jeg minnes for eksempel alle de flotte masterfeltkursene i Grimsdalen med klatring i rasmarka opp Tverrgjelet for å finne *Balsamia aestivales* (med alltid like sterke gledesutbrudd når det første apotheciet dukker opp) eller åling på magen i mudderet langs Grimsa for å studere de små begersoppene der, f.eks. den nevnte *Iodophanus hyperboreus*. Og etterpå mikroskopering på «intimlabben» som ble rigget opp på Grimsdalshytta mellom sokker til tørk og soveposer stuet bort for å gi plass til vitenskapen!

Trond elsker det kalde, men også det varme. Han har deltatt på tre større regnskogsprosjekter i Nord-Thailand og på Sumatra. I Thailand studerte han etnomedisin, blant annet ved å intervju lokale leger og studere de plantene de bruker. Dette ble til en viktig bok om tradisjonell urtemedisin i Nord-Thailand, skrevet sammen med dansken Viggo Bruun. Men det ble også litt tid til mykologiske studier i felt, hvor undertegnede ble invitert til to uforglemmelige uker i jungelen. To forskningsprosjekter gikk til Sumatra (Indonesia) hvor han også studerte plantene lokale leger bruker, samt biodiversitet og bevaringsbiologiske aspekter ved regnskogen. Et interessant botanisk bidrag som nedfelte seg fra disse prosjektene er et arbeid om slekten *Rafflesia* (ekstreme parasitter med like ekstreme blomster), hvor han var med på å utrede fylogeni og evolusjon innenfor denne merkelige plantefamilien, Rafflesiaceae, sammen med Mika Bendiksby, botaniker ved NTNU og tidligere student av Trond.

Med sitt verdensomspennende engasjement for mykologien har han blant annet vært president i International Mycological Association (IMA) i perioden 2002 til 2006. Og i 2018 mottok han fra IMA «Fellow Medal For Research And Service To Global Mycology», på verdenskongressen i mykologi som ble arrangert i Puerto Rico. På det mer lokale plan nevner jeg at han var instituttleder ved Institutt for biovitenskap (IBV) UiO i ni år.

Hvis noen tror at Trond begynte å legge inn årene når pensjonsalderen nærmet seg, så tro om igjen! I 2017 kom et viktig arbeid om *Helvella* i Europa, sammen med Inger Skrede, forsker ved IBV, og Tor Carlsen, seksjonssjef ved Naturhistoriske museer UiO. Her blir alle *Helvella*-artene i Europa beskrevet, typifisert, nomenklatur gjennomgått og fylogeni basert på flere gensekvenser satt opp. Og, ikke nok med det, i år (2019) kom en artikkel om slekten *Pindara* (Helvellaceae), sammen med blant annet Inger Skrede og Karen Hansen, Naturhistoriska riksmuseet, Stockholm.

På vegne av Agarica ønsker jeg Trond lykke til med den mykologiske innsatsen i årene som kommer.

Gratulerer!

Klaus Høiland



## Gro Gulden fylte 80 år 30. oktober 2019

Professor emerita Gro Gulden har hatt en meget lang fartstid ved Universitetet i Oslo, Naturhistorisk museum. Etter avlagt cand. real. eksamen i 1965, ble hun ansatt som vitenskapelig assistent og senere som universitetsstipendiat. Hun hadde dessuten et studieopphold i tidligere Tsjekkoslovakia. I 1967 ble hun konservator ved Botanisk museum i Oslo i den første konservatorstilling som er opprettet i mykologi i Norge.

Senere professor fra 2001, til hun ble pensjonist i 2006. Ved museet har hun holdt mykologiens fane høyt. Hun skaffet soppene et skikkelig herbarium med forsvarlig oppbevaring og forbehandling for insektangrep. En krevende omlegging av soppherbariet tok mange arbeidstimer. Hun sørget for innkjøp av nødvendig faglitteratur og bygget opp et mindre «bibliotek» i herbariesalen. Hun er en faglig klippe i vår mykologiske forskning, og uhyre grundig og samvittighetsfull i sitt arbeid. Hun har gode internasjonale kontakter og høster nasjonal og internasjonal anerkjennelse. Hun har hatt flere sabbatsår og forskningsopphold i utlandet, i Frankrike, Østerrike, USA og Canada. Hun ledet fra 1985 et forskningsprosjekt (Høylandet, Gjerstad og Schwartzwald) for å se om sur nedbør hadde innvirkning på fruktlegemedannelse hos ektotrofe mykorrhizasopper. Hun var engasjert i prosjektet Overvåking av radioaktivitet i sopp og bær, ledet av Direktoratet for strålevern og atomsikkerhet i 1988. Det



Gro på fjellet

skulle samles sopp og bær og tas gressprøver fra de mest rammete områdene i Norge etter Tsjernobylulykken i 1986. Resultat av målingene fra de tidligste innsamlede prøvene er satt sammen og publisert i flere artikler, men resultatene viser at det er behov for at prosjektet og innsamlingene fortsetter.

Hovedfagsoppgaven, et arbeid om musseronger i gammel klassisk tradisjon, førte til utgivelsen av boken «Musseronflora» i 1969. Et meget verdifullt tilskudd til sopp-litteraturen som på den tiden var mangelfull i Norge. Senere fulgte vitenskapelige artikler og soppbøker på rekke og rad. Vitenskapelig arbeider publisert alene eller sammen med andre mykologer har gitt henne en meget lang publikasjonsliste som omfatter artikler innen systematikk, økologi, soppgeografi og giftopper. Gro har veiledet mange hovedfagsstudenter med oppgaver spredt innen flere grener av mykologien. Flere av oppgavene er publisert i samarbeid med studentene. Hun har foruten musseronger, behandlet slektene *Strobilurus*, *Galerina*, *Squamanita*, *Lepista*, *Phaeocollybia* og andre i Funga Nordica – Agacioid, boletoid and cyhelloid genera.

Gro har utgitt populære soppbøker for voksne og barn i løpet av en 50 års periode. Soppboka fra 2018 med fotografier av Per Marstad har hun høstet gode kritikker for, og



den er foreløpig den siste i rekken. Tidligere bøker er Giftsopper og soppforgiftninger sammen med Trond Schumacher (1977), Fjellsopper (1985), og Norsk lommessoppbok (1989), begge med Kolbjørn Mohn Jenssen og Jens Stordal, Sopp på Svalbard (2013) med Tor Carlsen, Pernille Bronken Eidissen og Klaus Høiland. Soppbok for barn (1998), Soppbok for begynnere (2004). Oversettelse og bearbeidelse av Cappelens soppbok (4 utgaver: 1978, 1986, 1993, 2000) av Olle Persson, Sven Nilsson & Bo Mossberg, som er en meget god og flittig brukt soppflora. Arctic and Alpine Fungi 1-3 (1985, 1988, 1990) sammen med Kolbjørn Mohn Jenssen, Jens Stordal og Beatrice Senn-Irlet er viktige bidrag om fungaen i arktiske og alpine områder, med vekt på Norge, Svalbard og Sveits.

Gro har hatt og har fortsatt verv i organisasjoner, i komiteer og utvalg. Allerede i studietiden var hun styremedlem både i Norsk soppforening og i Nyttevekstforeningen. Da de to foreningene etter mange års «forhandlinger» gikk sammen til Norges sopp- og nyttevekstforbund i 2005, var hun styreleder i årene 2006-09. Det var travle og til tider slitsomme år hvor mye skulle gå seg til i en ny organisasjon. I 2009 ble hun utnevnt til æresmedlem i NSNF. Andre verv er medlem i «Den norske soppnavnkomiteen av 1968», fra 1995 leder av komiteen, medlem i Eksamenkommisjonen (nå Faglig mykologisk råd) fra 1969, leder i rådet fra 2018, og mangeårig medlem av redaksjonskomiteen for Nordic Macro-mycetes Flora og redaksjonen i Agarica. I sin periode som redaktør av Agarica, sørget Gro for at tidsskriftet ble godkjent som en poeng-



Gro underviser studenter.

givende fagfelleverdert journal. Innen Norsk faglig forfatter- og oversetterforening har hun også hatt verv.

Et sterkt engasjement innen mykologien har ført til forskningsprosjekter og publikasjoner, men hun har også brukt av sin tid til formidling av soppkunnskap og kontakt med amatører og sopplukkere. De fleste sopp- og nyttevekstforeningene våre har gjennom årene hatt gleden av å ha Gro som foredragsholder og kursleder. Hun har vært aktiv i utdanning av soppkontrollører, først for Nyttevekstforeningen og etter 2005 for NSNF. Hun har holdt Kurs for utdanning av sopp-sakkyndige på mange forskjellige steder i landet, deltatt i arbeidet som eksaminator og sensor ved Prøve for sopp-sakkyndige samt ledet viktige Etterutdanningskurs og Mikroskopingskurs. Kompendiet Rørsopper og skivesopper under mikroskopet som ble laget til sistnevnte kurs, er kommet i flere utgaver og en ny foreligger snart. Formidlingsarbeidet deltar hun fremdeles aktivt i, se foto fra årets kurs for «Ung mykolog». Det viktige arbeidet som soppkontrollør for Oslo kommunes soppkontroll på Youngstorvet i 1970-årene skal heller ikke glemmes.

Gro er en ivrig og habil bridgespiller som ikke sitter ved bridgebordet bare i Drammen, men bridgeturer til Spania har vært faste innslag i mange år. Gro er et utpreget friluftsmenneske og glad i naturen. Det er en fordel

når forskning, jobb og hobby kan forenes og har ført henne til studier av fungaen på Svalbard, Finse og i Rondane for å nevne noen. I tillegg er hun en ivrig fotturist og går fortsatt i fjellet og har besøkt mange DNT-hytter.

Jeg arbeidet sammen med Gro på Botanisk museum og i noen år da konservatorstillingen i soppherbariet var delt hadde Gro hånd om basidiomycetene og jeg om ascomycetene. Dessuten har vi sittet i de samme utvalg og råd i mange år, og vi samarbeidet utmerket om nasjonale, nordiske og internasjonale kongresser og kurs som mykologimiljøet har hatt ansvaret for. Vi har mottatt gode tilbakemeldinger på arrangementene samt at vi har høstet erfaringer som kommer til nytte i videre samarbeid og diskusjoner.

Merittlisten til Gro er lang, og blir ganske sikkert lenger. Hun ønskes mange gode år fremover, så forskere, amatører og venner kan ha glede og nytte av hennes enorme soppkunnskaper.

Gratulerer!

Anna-Elise Torkelsen, Lillemor

## Puffballs of Northern and Central Europe

Mikael Jeppson, Mykologiska publikationer 8, Sveriges Mykologiska Förening och miljövetenskap Göteborgs universitet, 2018. ISSN: 1654-546x

Mikael Jeppson is one of the world's leading specialists on gasteromycetes. The actual book deals with the puffballs, i.e. the genera *Apioperdon*, *Bovista*, *Bryoperdon*, *Calvatia* sstr., *Disciseda*, *Langermannia*, *Lycoperdon*, and *Mycenastrum*. The geographical area in this book encompasses the northern, central and east central parts of Europe, including Iceland, excluding Russia and Belarus.

Much has happened in the phylogeny of Basidiomycota, and the group gasteromycetes is split to several independent evolutionary lines. The “puffballs” belong to Agaricaceae together with mushrooms as *Agaricus* and *Macrolepiota*.

The book gives first chapters on distribution, ecology and morphology. The morphology part offers good photographs, microphoto-

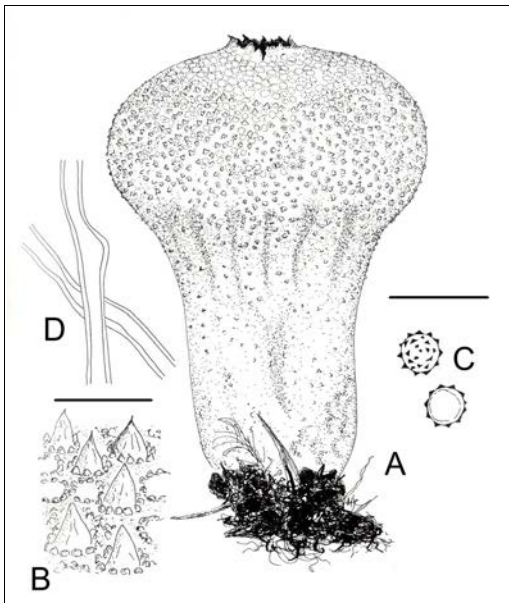


*Lycoperdon mammiforme*.

graphs and drawings of important diagnostic characteristics as basidiocarp structures, capillitium and spores – details that are very important for determination of puffballs.

The taxonomy and nomenclature are up to date: *Apioperdon* is elevated to a separate, monotypic genus, containing *A. pyriforme* (former *Lycoperdon*); genus *Bovista* encompasses the “*Bovista*-like” subgenus *Bovista* and the “*Lycoperdon*-like” subgenus *Globaria*; all Nordic *Calvatia* are now joined with genus *Lycoperdon*, except two rare and south continental species. The former genera *Morganella* and *Vascellum* are likewise merged into *Lycoperdon*.

However, the main part of the book is the keys, descriptions, drawings and photographs of the various species, ca 55. Every species is



*Lycoperdon perlatum*



*Lycoperdon excipuliforme*.



*Lycoperdon lividum.*

precisely presented, including nomenclature, description, habitat and distribution, and notes considering variation, taxonomy and other details of interest. Maps are showing the species' distribution both in the Nordic countries and in the book's geographical area. The photographs are exceptionally good. To be honest, I have never seen better and more explaining pictures of puffballs in any other book.

All species are photographed in various stages from unripe and white to mature and gray-brown and fissured. This is very important because a reliable determination can only rely on ripe material with mature spores. However, pictures of several stages of maturity are helpful if the material of hand is not fully ripen.

At the end, there is a very long reference list to all citations in the text – very important if one want to consult the actual literature concerning the species.

Puffballs have notoriously been a problem for students, amateurs and professionals in mycology, because the literature either is outdated or too fragmentary – or both. This beautiful book is therefore highly wanted by mycologists working in field and on field courses.

Klaus Høiland







og artsgrupper i boken. Forfatterne fraviker prinsippet om lange og omstendelige beskrivelser av artenes morfologi, noe forfatterne begrunner med at den type beskrivelser er tungt leselige og opptar mye plass. Bilder vil ofte være bedre dokumentasjon enn mange ord. Det er mye sant i det, og spesielt når omfanget og kvaliteten på bildene er av en så høy standard som i dette bokverket.

Mens oppbygningen av boken tar utgangspunkt i soppenes morfologi (formgrupper), er artene gruppert og plassert i sine fylogenetiske slekter med korrekte vitenskapelige navn bestemt utfra fylogenetisk slektskap. Dette gjør at en soppsekt som oppviser stor formvariasjon og dekker over flere formgrupper, vil få artene presentert på forskjellige steder (sider) i bøkene. Litt uvant å finne arter som hører hjemme i samme slekt på ulike steder i boken, men selv om gammel vane er vond å vende, er det snakk om en tilvenning som i mitt tilfelle tok et par timer. Deretter gikk det greit.

Forfatterne anslår at det finns ca. 15-20.000 sopparter i det de definerer som temperert Europa. Det tempererte Europa definerer forfatterne som 'alt som ligger mellom det nordlige Norge til Alpene og det nordlige Frankrike og Spania, med unntak av subalpine og arktisk-alpine strøk'. Med en slik definisjon vil soppene i lavlands-Norge også være inkludert i bokverket, men det skurrer noe når forfatterne sjonglerer med begreper som temperert Europa i det ene øyeblikk og temperert og boreale klimasoner i det neste øyeblikk. For dem som er opptatt av soppenes utbredelse er denne sjongleringen med begrepene 'temperert Europa' og tempererte og boreale klimasoner uryddig og i noen tilfelle misvisende. Men det påvirker i liten grad anvendeligheten av boken også i Norge og Sverige ettersom bøkene dekker artsinventaret i både lavereliggende løvskogsområder i temperert sone og høyereliggende barskogsområder i boreal sone.

Soppverkets store styrke - utover det enorme omfanget av arter som behandles - er forfatternes solide taksonomiske kunnskaper innen så å si alle soppgrupper og slekter som er representert. Det er sjelden å se et så komplett og oppslukende verk om sopp som til de grader har klart å fange opp nødvendige navneendringer og omplussinger av arter og slekter som har funnet sted gjennom de siste tiårene som følge av nyervervet kunnskap om hva en art er og hva den bør hete. Her har forfatterne klart å plukke opp korrekte navn også på arter hvor navnene først er blitt klargjort til bruk i løpet av de siste par årene. Noen stikkprøver fra slekter som undertegnede har spesielt greie på ga et svært oppløftende resultat; så å si alle beskrivelser og avbildninger er forsynt med korrekte navn. Det er ingen liten prestasjon og forteller at forfatterne er dedikerte mykologer. Tusen takk, og gratulerer Thomas og Jens! med et grundig og etterlengtet høykvalitetsprodukt om soppdiversiteten i naturen som omgir oss. Den engelske utgaven av soppverket hører så absolutt hjemme i bokhyllen til alle soppinteresserte – ikke bare i Europa – men også i boreale og tempererte klimasoner i verden forøvrig!

Trond Schumacher



*Papegøje-vokshat* (*Gliophorus psittacinus*)

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