

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

Tor Erik Brandrud¹, Egil Bendiksen¹, John Bjarne Jordal², Øyvind Weholt³, Bálint Dima⁴, Olga Morozova⁵, Machiel E. Noordeloos⁶

¹Norwegian Institute for Nature Research, Gaustadalléen 21, NO-0349 Oslo, Norway

²Biolog J.B. Jordal, Skrøvevegen 21, NO-6610 Øksendal, Norway

³Nord University, Nesna, NO-8700 Nesna, Norway

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

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

⁶Naturalis 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 rød-spore (Entoloma; Tricholomatinae, Basidiomycota) for Norge

Brandrud TE, Bendiksen E, Jordal JB, Weholt Ø, Dima B, Morozova O, Noordeloos ME, 2019. On some *Entoloma* species (Tricholomatinae, Basidiomycota) little known or new to Norway. *Agarica* 2019, vol. 39: 31-52.

KEY WORDS

rDNA ITS-sequencing, morphology, ecology, distribution

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 In addition, a few species taking a somewhat isolated position in our unpublished preliminary ITS tree are presented.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. sphagnetii*, 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) μm 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.

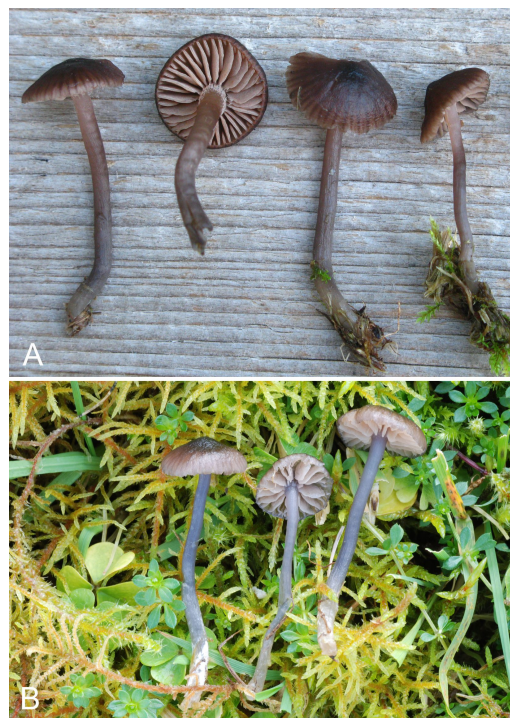


Figure 1. **A, B)** *E. caeruleopolitum*. **A)** KB&EB107-16; **B)** JBJ0251. Photos: **A)** E. Bendiksen; **B)** J.B. Jordal.

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 $8.0\text{--}10.0(-11.0) \times 6.5\text{--}8.0\ \mu\text{m}$, $Q = 1.1\text{--}1.3$, subisodiametrical, 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, $L = 10\text{--}25$, $l = 1\text{--}5(-7)$, (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. trachysporum*. 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 *Sphagneti*

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.

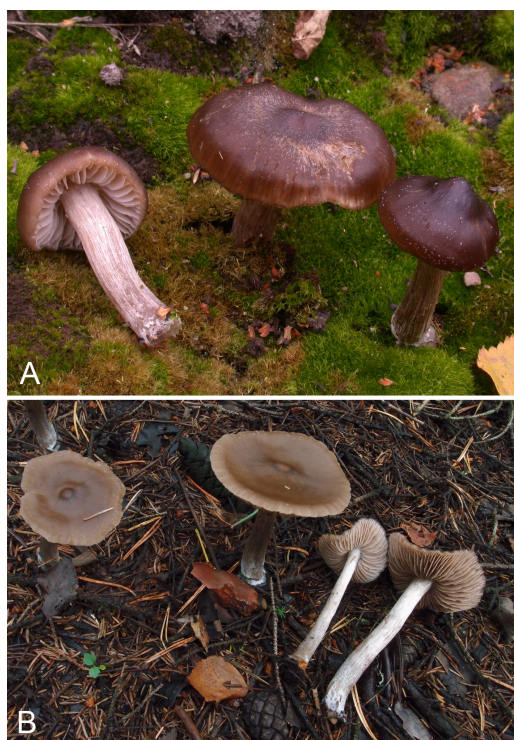


Figure 2. **A, B)** *E. sphagneti*. A) JV02-695; B) Ø. Weholt E2 14. Photos: A) J. Vesterholt. B) Ø. Weholt.

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 applanate, 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 $10\text{--}14 \times 7\text{--}10 \mu\text{m}$, 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, Opstad tjern, 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

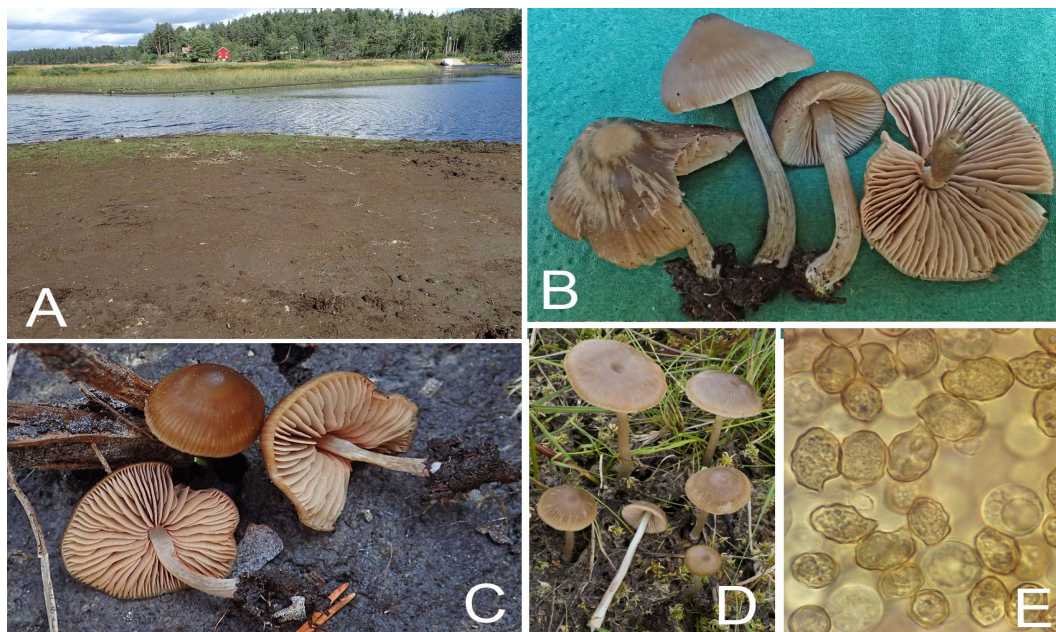


Figure 3. **A-E)** *E. pseudoconferendum*. A) (habitat), B), C) ILF 2018-001; D) AO 3-18; E) G.M. Jansen C1594394. Photos: A)-C) I.-L. Fonneland; D) A. Omberg; E) G.M. Jansen & M. Vegte.

(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 applanate 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

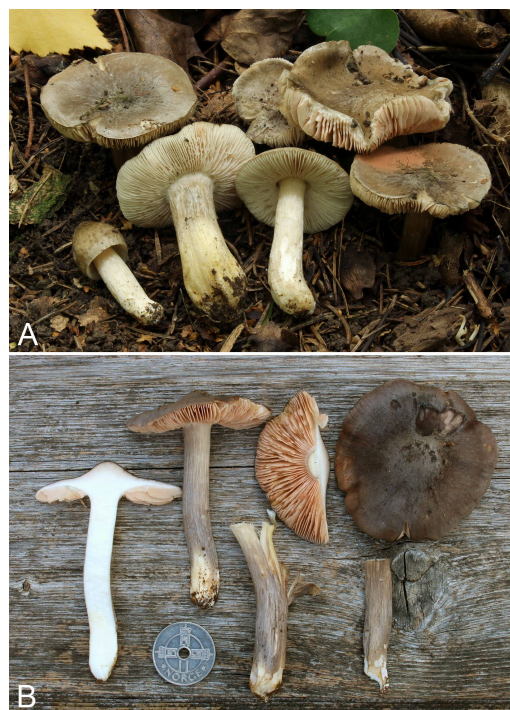


Figure 5. **A, B)** *E. luteobasis*. A). TEB363-14; B) TEB375-14. Photos: B. Dima.

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 (Noorde-loos 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 (Noorde-loos 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/).

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, Kongkleiv-åsen S, calcareous *Tilia* forest, 30 Aug 2019, 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 × 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.).

Acknowledgements

We appreciate the permission to use photographs provided by Tatiana Bulyonkova, Inger-Lise Fonneland, Felix Hampe, Gerrit Jansen, Anton Hausknecht, Thomas Laessøe, Henk Pras, Marjon van der Vegte, and Jan Vesterholt. We thank Tobias G. Frøslev for providing information on the type sequence of *E. caeruleopolitum*. The Norwegian *Entoloma* project 2015–2017 was financed by the Norwegian Taxonomy Initiative, with funding from the Norwegian Biodiversity

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. Blaallid, 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.

REFERENCES

- Ainsworth AM, Douglas B, Suz LM, 2018. Big Blue Pinkgills formerly known as *Entoloma bloxamii* in Britain: *E. bloxamii* s. str., *E. madidum*, *E. ochreoprunculoides* forma *hyacinthinum* and *E. atomadidum* sp. nov. *Field Mycology* 19: 5-14.
- Baroni TJ, Hofstetter V, Largent D, Vilgalys R, 2011. *Entocybe* is proposed as a new genus in the Entolomataceae (Agaricomycetes, Basidiomycota) based on morphological and molecular evidence. *North American Fungi* 6(12): 1-19. <https://doi.org/10.2509/naF2011.006.012>
- Brandrud TE, 2010. Kartlegging av jordboende sopp med vekt på rødlistearter i utvalgte vern-eområder i Telemark 2009. Kalkområdet i Bamble-Porsgrunn, samt Jomfruland, Kragerø. NINA rapport 593. 36 s.
- Brandrud TE, Dima B, 2017. Overvåking av jordboende sopp i Røsskleiva NR, Bamble 2016. NINA Kortrapport 80. Norsk institutt for naturforskning.
- Brandrud TE, Bendiksen E, Noordeloos ME, Dima B, Morozova O, 2017. *Entoloma*-arter funna i Jämtland och Medelpad 2016. *Entoloma* species found in Jämtland and Medelpad (Sweden) in 2016. *Svensk Mykologisk Tidskrift* 38(3): 25-35.
- Brandrud TE, Bendiksen E, Jordal JB, Weholt Ø, Eidissen SE, Lorås J, Dima B, Noordeloos ME, 2018. *Entoloma* species of the rhodopolioid clade (subgenus *Entoloma*; Tricholomatinae, Basidiomycota) in Norway. *Agarica* 38: 21-46.
- Brandrud TE, Evju M, Blaallid R, Skarpaas, O, 2016. Nasjonal overvåking av kalklindeskog og kalklindeskogsopper. Resultat fra første overvåkingsomløp 2013-2015. - NINA Rapport 1297. 128 s.
- Co-David D, Langeveld D, Noordeloos ME, 2009. Molecular phylogeny and spore evolution of Entolomataceae. *Persoonia* 23: 147-176. <https://doi.org/10.3767/003158509X480944>
- Gulde G, 2011. Three new agarics in Norway. *Agarica* 30:103-109.
- Horak E, 2008. The fungi of New Zealand. Vol. 5: Agaricales of New Zealand 1. Pluteaceae – Entolomataceae. *Fungal Diversity Research Series*, vol. 19: 1-305. Fungal Diversity Press, Hong Kong.
- Jordal, JB, Evju, M, Gaarder, G, 2016. Habitat specificity of selected grassland fungi in Norway. *Agarica* 37: 5-32.
- Kokkonen K, 2015. A survey of boreal *Entoloma* with emphasis on the subgenus *Rhodopolia*. *Mycol. Progress* 14: 1-116. <https://doi.org/10.1007/s11557-015-1135-y>
- Largent DL, 1994. Entomatoid fungi of the Pacific Northwest and Alaska. Mad River Press, USA.
- Morgado LN, Noordeloos ME, Lamoureux Y, Geml J, 2013. Multi-gene phylogenetic analyses reveal species limits, phylogeographic patterns, and evolutionary histories of key morphological traits in *Entoloma* (Agaricales, Basidiomycota). *Persoonia* 31: 159-178. <https://doi.org/10.3767/003158513X673521>
- Morozova OV, Noordeloos ME, Vila J, 2014. *Entoloma* subgenus *Leptonia* in boreal-temperate Eurasia: towards a phylogenetic species concept. *Persoonia* 32: 141-169. <https://doi.org/10.3767/003158514X681774>.
- Naveau P, 1923. Tweehonderd nieuwe zwammen voor de Antwerpse Kempen. *Natuurwetenschappelijk Tijdschrift* 5: 71-91.

- Noordeloos ME, 1981. *Entoloma* subgenera *Entoloma* and *Allocybe* in the Netherlands and adjacent regions with a reconnaissance of its remaining taxa in Europe. *Persoonia* 11: 153-256.
- Noordeloos ME, 1982. Studies in *Entoloma* 1–5. *International Journal of Mycology and Lichenology*. 1(1): 49-60.
- Noordeloos ME, 1992. *Entoloma* s.l. *Fungi Europaei*, vol. 5. Giovanna Biella, Saronno, Italy.
- Noordeloos ME, 2004. *Entoloma* s.l. *Fungi Europaei*, vol. 5a. Edizione Candusso, Italy.
- Noordeloos ME, 2012. *Entoloma* (Fr.) P.Kumm, in: Knudsen H, Vesterholt J (Eds) *Funga Nordica*. Nordsvamp, Copenhagen, pp. 517-576.
- Noordeloos ME, Gates GM, 2012. The *Entolomataceae* of Tasmania. *Fungal Diversity Research Series*. Vol. 22. Springer Dordrecht, Heidelberg, New York, London.
doi: /10.1007/978-94-007-4679-4
- Noordeloos ME, Dima B, Weholt Ø, Eidissen SE, Lorås J, Brandrud TE, 2017. *Entoloma chamaemori* (Entolomatacea, Basidiomycota) – a new, small-spored, boreal species, with isolated phylogenetic position. *Phytotaxa* 298(3): 289-295.
- Ratnasingham S, Hebert PDN, 2007. BOLD: The Barcode of Life Data System (www.barcodinglife.org). *Molecular Ecology Notes* 7: 355-364. doi: 10.1111/j.1471-8286.2006.01678.x
- Senn-Irlet B, Wöltsche H, 2002. *Entoloma excentricum*, eine Art mit Pleurozystiden. *Österreichische Zeitschrift für Pilzkunde*. 11: 29-33.
- Wickens GE, Legon NW, 2005. Checklist of the British and Irish Basidiomycota. Royal Botanic Gardens, Kew.