

New northern records of *Entoloma* with three new species of subgenus *Rhodopolia* and typification of *E. nidorosum*

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Abstract

Three hemiboreal or boreal species of *Entoloma* subg. *Rhodopolia*, *E. fluviale*, *E. quercetorum* and *E. uvidicola*, are described as new based on molecular and morphological data. *Entoloma nidorosum* is neotypified. New records of *E. boreale*, *E. caeruleopolitum*, *E. holmvassdalenense*, *E. lupinum*, *E. paragaudatum*, *E. pseudoconferendum*, *E. radicipes*, *E. rhodopolium* and *E. sphagneti* are presented from Finland and Sweden with ecological and morphological notices.

Introduction

The genetic research of boreal *Entoloma* subg. *Rhodopolia* (*Agaricales*, *Basidiomycota*) has revealed many more species than previously assumed (Kokkonen 2015; Brandrud et al. 2018). The species are morphologically difficult to distinguish from each other. The species around *E. rhodopolium* (Fr.) Quél. have been particularly difficult, which situation has been improved by the neotypification of *E. rhodopolium* (Kokkonen 2015). The aim of this study was to further clarify the species identities and stabilize the nomenclature. *Entoloma nidorosum* (Fr.) Quél. is neotypified, and two species genetically close to *E. rhodopolium* and *E. nidorosum*, as well as a species close to *E. sericatum* (Britzelm.) Sacc., are described as new. To provide data about distributions and habitats, new records of rarely reported *Entoloma* species are presented from Finland and Sweden.

Materials and Methods

For the typification of *E. nidorosum*, specimens of the herbarium of Museum of Evolution, Uppsala (UPS) were examined. Additionally, *E. nidorosum* and other *Rhodopolia* were searched from some forests around Uppsala during two days in the beginning of October, 2019. The descriptions of all new species are based on my own collections from 2006 to 2020. Vegetation was observed at the collection sites, and macroscopic features were noted from fresh fruitbodies. The colour codes refer to Küppers (1999). Few specimens of the herbarium of University of Turku (TUR) were among the material of *E. quercetorum* Kokkonen. The examined specimens are deposited in TUR, unless otherwise stated.

The microscopic and molecular methods follow Kokkonen (2015), except that both NucleoSpin Tissue XS and Plant II kits (Macherey-Nagel) were used for the DNA extraction. In addition to ITS (internal transcribed spacer) gene region, RPB2 (RNA polymerase II subunit) gene region was sequenced and analysed for *E. fluviale* Kokkonen and *E. quercetorum*. The sequences were submitted to European Nucleotide Archive (ENA). The ENA numbers are

provided in **Table 1**. All sequenced specimens have been marked with * along the descriptions.

For the phylogenetic analysis of *Rhodopolia* specimens, the ITS sequences were aligned by MAFFT 7.0 (Katoh 2013) and the alignments adjusted manually in AliView (Larsson 2014). The alignment is available as Electronic Supplementary Material 1. The maximum likelihood (ML) tree was run by raxmlGUI 2.0 (Stamatakis 2014; Edler et al. 2019) with thorough bootstrap, 1000 bootstrap replicates, and GTRGAMMA model. The Bayesian analysis was performed with MrBayes 3.2.6 (Ronquist and Huelsenbeck 2003) with GTR + I + Γ model, 500000 generations, samplefreq 500, printfreq 500 and diagnfreq 1000. The resulting tree was edited in TreeGraph 2 (Stöver & Müller 2010).

Taxonomy

Entoloma nidorosum (Fr.) Quél., Mém. Soc. Émul. Montbél., Sér. 2, 5: 119 (1872) –
Agaricus nidorosus Fr., Epicr. Syst. Mycol.
(Upsaliae): 148 (1838) – **Figures 1–3**

NEOTYPE (designated here): Sweden, Uppland, Knivsta, Nysätra, coniferous forest, 9.IX.1982 coll. & det. Svengunnar Ryman 7056 (UPS F-790006), MycoBank MBT10000874.

SPORES 7.0–8.2–9.0 × 6.0–6.9–7.7 μm , Q=1.07–1.18–1.32 (n=20), usually subisodiametrical. **BASIDIA** 36–47 × 8.5–11 μm (n=9), 4-spored. **CYSTIDIA** not observed. **PILEIPELLIS** hyphae smooth or slightly encrusted, with internal diffuse brown pigment; terminal cells cylindrical, somewhat clavate, or with a tapering apex, wall thin or at apex thickish. **CLAMPS** present in all structures.

COMMENTS: The herbarium UPS has two *E. nidorosum* collections and one *E. nidorosum?* collection from or near Uppsala, Sweden. All were conspecific according to ITS sequences, and one of them was selected as a neotype. They resembled morphologically both the protologue (Fries 1838) and the later drawn plate (Fries 1867, **Fig. 3**). Two of them were collected from coniferous forests, but in my experience, the species is connected with *Betu-*

Table 1. Accession numbers and origins of the specimens sequenced in this study.

Species	Specimen	Origin	Accession number	
			ITS	RPB2
<i>E. caeruleopolitum</i>	KK 246/18	Finland	OB998028	
<i>E. fluviale</i>	KK 8/19, holotype	Finland	OB998022	OB998320
<i>E. fluviale</i>	KK 10/19	Finland	OB998023	
<i>E. fluviale</i>	KK 1153/12	Finland	OB998024	
<i>E. fluviale</i>	KK 1603/12	Finland	OB998025	
<i>E. fluviale</i>	KK 190/20	Finland	OB998026	
<i>E. fluviale</i>	KK 191/20	Finland	OB998027	OB998321
<i>E. holmvassdalenense</i>	KK 489/18	Finland	OB998029	
<i>E. nidorosum</i>	S. Ryman 7056, neotype	Sweden	OB998030	
<i>E. nidorosum</i>	J. Ax. Nannfeldt 10526	Sweden	OB998031	
<i>E. nidorosum</i>	J. Ax. Nannfeldt 11356	Sweden	OB998032	
<i>E. pseudoconferendum</i>	KK 137/18	Finland	OB998033	
<i>E. quercetorum</i>	KK 117/19, holotype	Finland	OB998034	OB998322
<i>E. quercetorum</i>	KK 118/19	Finland	OB998035	
<i>E. quercetorum</i>	KK 122/19	Finland	OB998038	
<i>E. quercetorum</i>	KK 123/19	Finland	OB998036	
<i>E. quercetorum</i>	KK 124/19	Finland	OB998037	
<i>E. quercetorum</i>	KK 128/19	Finland	OB998040	
<i>E. quercetorum</i>	KK 129/19	Finland	OB998039	
<i>E. quercetorum</i>	KK 130/19	Finland	OB998042	OB998323
<i>E. quercetorum</i>	KK 132/19	Finland	OB998041	
<i>E. rhodopolium</i>	KK 258/20	Finland	OB998043	
<i>E. sericatum</i>	KK 1150/12	Finland	OB998044	
<i>E. sericatum</i>	KK 1152/12	Finland	OB998045	
<i>E. sphagneti</i>	KK 138/18	Finland	OB998046	
<i>E. uvidicola</i>	KK 112/19, holotype	Sweden	OB998047	
<i>E. uvidicola</i>	KK 113/19	Sweden	OB998048	



Fig. 1. *Entoloma nidorosum*, neotype.



Fig. 3. *Entoloma nidorosum*, number 3, plate in Fries (1867).

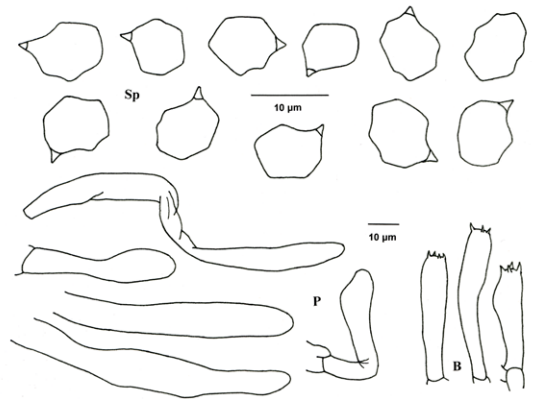


Fig. 2. *Entoloma nidorosum*, neotype, microscopic characters. *B* basidia, *P* terminal cells of pileipellis, *Sp* spores.

la and sometimes grows at moist sites with *Betula* in coniferous forests. In the protologue, Fries mentions deciduous forests around Uppsala. The neotype species grows also in deciduous forests. The species is rather common and likely represents the traditional view of *E. nidorosum* in Fennoscandia, which is supported by the *nidorosum* collections in UPS. The smell is typically distinctly nitrous, but at times faintly aromatic. A morphological description is provided in Kokkonen (2015). Due to the confusion with similar species, the distribution is yet incompletely known, but it extends at least from the hemiboreal zone of southern Sweden to the arctic zone in Europe, and to the temperate zone in Massachusetts, North America (Kokkonen 2015).

Another species resembling *E. nidorosum*, and the closely related *E. rhodopolium*, was found from a moist mixed forest in Uppsala. It was on average stouter (stipes ≥ 5 mm wide), its lamellae seemed more often decurrent, and the nitrous smell was fainter or absent, when compared with the *nidorosum* neotype species. According to Fries (1838), the stipe width of *Agaricus nidorosus* was under 5 mm and the lamellae were emarginate, never observed as subdecurrent. However, it is possible that Fries included both species in the protologue. Based on the ITS sequence, the above-mentioned *nidorosum*-like species is conspecific with *E. speculum* var. *microsporum* Armada & Lopez from France (Armada & Lopez 2017). Disagreeing with their identification, the species is described as a new below.

Brandrud et al. (2018) suggested some southern species for *E. nidorosum*, probably the same as in Noordeloos (1981, 1992). It was found once in Norway. Its identity remains open, since no genetic data was provided. They regarded it as similar to *E. rhodopolium*, which indicates a more robust species than the *nidorosum* neotype species. Also, the shape of the pileus in their photo differed from the pileus in the plate of Fries (1867).

ADDITIONAL SPECIMENS EXAMINED: SWEDEN. Uppland. Uppsala, Bondkyrka, Svinskinnskogen, about 1 km WSW of Berthåga, from rotten wood, moist forest, 28.VIII.1949 J. Ax. Nannfeldt 10526* (UPS, as *E. nidorosum*?), coniferous forest, 10.IX.1950 J. Ax. Nannfeldt 11356*, det. S. Lunden (UPS).

Entoloma uvidicola Kokkonen, sp. nov.

– Figures 4 and 5

Synonym *Entoloma speculum* var. *microsporum* Armada & Lopez, Bull. mycol. bot. Dauphiné-Savoie 226: 6 (2017) MycoBank MB839351

ETYMOLOGY: the epithet refers to the moist habitat.

HOLOTYPE: Sweden, Uppland, Uppsala, Vårdsåtra, SE of Norrtorpet, moist mixed forest, near *Betula*, *Picea abies*, *Alnus glutinosa* and *Rhamnus frangula*, further away *Pinus sylvestris*, *Fraxinus excelsior*, *Populus tremula* and *Salix caprea*, rich undergrowth with *Athyrium filix-femina*, *Filipendula ulmaria* and *Vaccinium myrtillus*, among leaf litter and hygrophilous mosses like *Mnium*, 6.X.2019 K. Kokkonen 112/19 (TUR; isotype UPS).

PILEUS 1.5–5.8 cm in diameter; campanulate when young, then applanate, low convex or depressed, umbo absent or low, at times margin undulate; greyish brown or yellowish brown ($S_{40}Y_{60}M_{40}$) with a darker centre ($S_{50}Y_{40}M_{30}$), or rather dark brown when old ($S_{50}Y_{70}M_{40}$), at times margin whitish; smooth or slightly radially rugulose when old, slightly viscid or dry, hygrophilous, margin translucently striate. **LAMELLAE** adnate to short decurrent; moderately or rather densely crowded; pale grey brown or pale grey when young, then with a pink tinge; edge slightly uneven or even, concolorous. **STIPE** 2.3–8.2 cm long, 0.5–1.2 cm wide; equal or narrowest in the middle, base often clavate or subbulbous, rarely flattened; whitish, pale grey or pale grey brown with a whitish apex; dry, faintly fibrillose, fistulose. **CONTEXT** fragile; dark brown grey in pileus, pale grey in stipe. **SMELL** weakly nitrous, “entolomaceous” (perhaps a mixture of faint nitrous and farinaceous) or indistinct, at times slightly farinaceous when crushed. **TASTE** indistinct or “entolomaceous”.

SPORES (7.4)7.7–8.5–9.8(10.5) × (6.0)6.3–7.0–8.0(8.3) μm , range of mean values 8.3–8.6 × 6.7–7.1 μm , $Q=(1.04)1.08\text{--}1.23\text{--}1.33(1.40)$, range of mean Q values 1.20–1.25 (60 spores from three collections); usually subsodiametrical or heterodiametrical, at times angles nodulose. **BASIDIA** 30–36–44 × 9–11–14 μm (n=21), 4- or 2-spored. **CYSTIDIA** not observed. **PILEIPELLIS** hyphae hyaline or brownish, some slightly to moderately encrusted; terminal

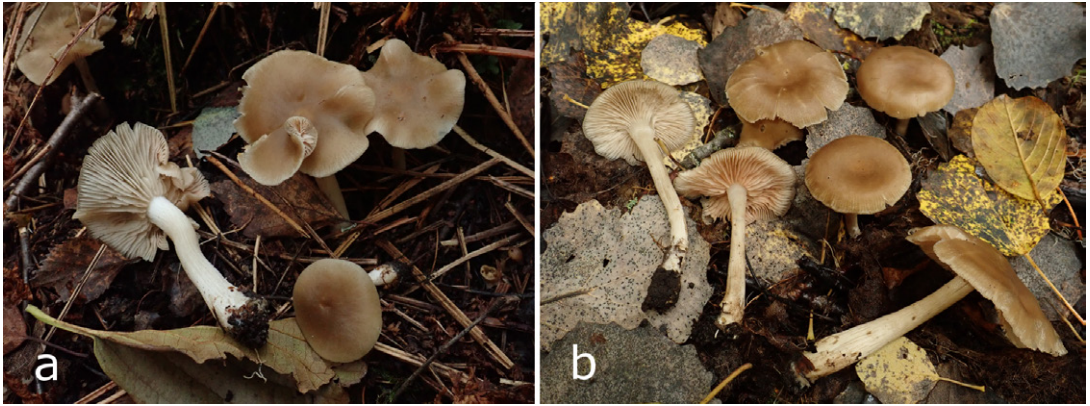


Fig. 4. *Entoloma uvidicola*. a holotype. b KK 113/19.

cells hyphoid, often with a tapering apex, wall thin or partially thickish. **STIPITIPPELLIS**: terminal cells cylindrical or clavate, thin-walled. **CLAMPS** present in all structures.

HABITAT AND DISTRIBUTION: Known from three sites in the type forest in Sweden, from Tartumaa and Saare in Estonia according to two sequences in UNITE (UDB025069; UDB018017, as *E. rhodopolium*), and from Meyzieu, Rhône in France according to a GenBank sequence (MF882927, Armada & Lopez 2017). The habitat was a moist mixed forest in Sweden and all sites included *Picea abies*, *Betula*, *Salix caprea*, *Populus tremula*, *Fraxinus excelsior* and *Rhamnus frangula*. The habitat of one Estonian collection is mentioned to be a temperate mixed forest, but the habitats of other collections are unknown.

COMMENTS: *Entoloma uvidicola* resembles morphologically species around *E. rhodopolium*. It is also genetically close to them. The nearest species *E. nidorosum* differed by 19 bases and 2 indels, when compared between the types. Two *uvidicola* collections deviated by 2 bases from the holotype but all are regarded as conspecific. The type sequence was identical with the type sequence of *E. speculum* var. *microsporum* (Armada & Lopez 2017) excluding ambiguous bases. The morphology of *E. uvidicola* partially agrees with the protologue of *E. speculum* (Fries 1836), but since *E. speculum* was characterized by a white, whitish or 'straw white' pileus when moist, turning silvery when dry, and emarginate lamellae,

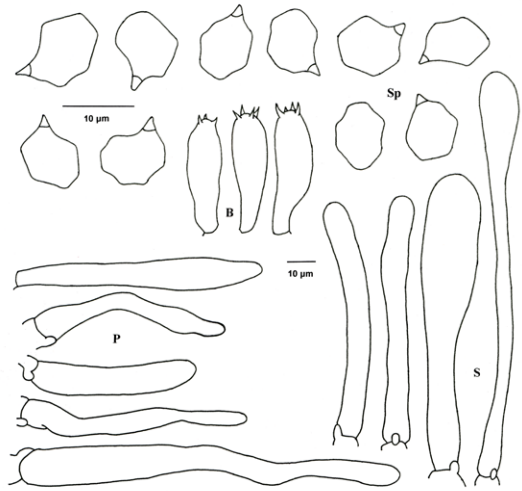


Fig. 5. *Entoloma uvidicola*, holotype, microscopic characters. For symbols see Fig. 2 and S terminal cells of stiptipellis.

the identification of Armada & Lopez is disagreed. The pileus of *E. speculum* var. *microsporum* was greyish or yellowish brown with a pink tinge, turning white when drying (Armada & Lopez 2017). Further, the habit of *E. speculum* is different in the plate of Fries (1867). *Entoloma speculum* was common around Femsjö according to Fries (1836), and it is thought to imply whitish forms of *E. sericatum* and maybe also whitish forms of other similar species by the author (Kokkonen 2015). The fungi of Armada &

Lopez (2017) resembled morphologically the Swedish *uvidicola* fungi, but they differed by the pink tinge and on average smaller spores. They were odourless.

Entoloma uvidicola is morphologically similar to *E. nidorosum* and *E. rhodopolium*, but it differs from them by having more often or stronger incrustations at pileipellis, and from *E. nidorosum* by a somewhat stouter habit and weaker smell. No species was found to match *E. uvidicola* by the author. *Entoloma roseoalbum* Arnolds & Noordel. is morphologically rather similar and it also grows in a wet habitat. However, it differs by a differently shaped white pileus, larger spores, and clamps observed only at the hymenium (Noordeloos 2004). *Entoloma leucocarpum* Noordel. differs by a differently shaped white pileus, larger spores, and presence of cheilocystidia (Noordeloos 1981, 1992). Their types were not obtained for loan.

ADDITIONAL SPECIMENS EXAMINED: SWEDEN. Uppland. Uppsala, Vårdsätra, SE of Norrtröpet, 8.X.2019 Kokkonen 113/19*, 114/19*.

Entoloma quercetorum Kokkonen, sp. nov

– Figures 6 and 7

Mycobank MB839352

ETYMOLOGY: the epithet refers to the habitat in *Quercus* forests; the type locality Tammimäki means Oak hill.

HOLOTYPE: Finland, Varsinais-Suomi, Turku, Ruissalo, Tammimäki, S slope, herb-rich forest with *Quercus robur*, *Tilia cordata*, *Acer platanoides*, *Corylus avellana* and *Pinus sylvestris*, among leaf litter, Grid 60° 255.668, 022° 09.437, alt. 9 m, 9.X.2019 K. Kokkonen 117/19 (TUR, isotype UPS).

PILEUS 1.7–9.2 cm in diameter; applanate, depressed, or low convex, rarely campanulate, umbo low or absent, margin usually even or weakly undulate, at times deflexed; yellow brown, grey brown or pale brown ($S_{40}Y_{50-60}M_{30}$, $S_{40}Y_{60}M_{40}$, $S_{50}Y_{70-80}M_{40}$, ca. $S_{50}Y_{50}M_{30}$, $S_{20}Y_{40}M_{20}$ – $S_{30}Y_{50}M_{30}$, ca. $S_{60}Y_{50}M_{40}$), centre usually darker (ca. $S_{50}Y_{50}M_{30}$, $S_{70}Y_{60}M_{40}$) and margin paler; smooth or rarely scarcely fibrillose, dry or slightly viscid, rarely centre rugulose or cracked to squamules, hygrophanous, margin translucently striate. **LAMELLAE** up to 9 mm, often rather broad; adnate, emarginate or subdecurrent; usually mod-

erately crowded; at times transverse; pale grey or pale grey brown when young, then with a pink tinge (ca. $S_{10}Y_{30}M_{10}$, ca. $S_{10}Y_{40}M_{20}$, ca. $S_{20}Y_{30}M_{20}$, ca. $S_{30}Y_{30}M_{20}$, ca. $Y_{30}M_{20}C_{00}$); edge slightly uneven or even, concolorous. **STIPE** 3.1–8.7 cm long, 0.35–1.0 cm wide; equal or broadening towards the base, base roundish, tapering or rarely subbulbous; white, pale grey brown, or grey brown, usually darker when old or down the stipe; dry, faintly fibrillose, often somewhat shiny especially when young, apex not or short pruinose, fistulose at least when old. **CONTEXT** fragile to rather firm; in pileus dark brown grey or dark grey brown; in stipe pale grey, pale grey brown or darker grey brown. **SMELL** spontaneously faintly aromatic especially when old, indistinct, or “entolomaceous”; when crushed slightly farinaceous or indistinct. **TASTE** indistinct, slightly farinaceous, or “entolomaceous”.

SPORES (6.8)7.4–8.1–9.2(10.2) × (6.0)6.4–7.2–8.0(8.6) μm, range of mean values 7.9–8.4 × 7.1–7.5 μm, $Q=(1.00)1.04$ – 1.13 – $1.24(1.30)$, range of mean Q values 1.10–1.16 (200 spores from 10 collections); mostly subisodiametrical with 5–6 angles. **BASIDIA** 27–36–67 × 8–10–12 μm (n=60), 4-spored. **CYSTIDIA** not observed. **PILEIPELLIS** hyphae hyaline or brownish, some slightly to moderately encrusted; terminal cells cylindrical, fusoid or clavate, usually long, wall thin or at apex thickish. **STIPITPELLIS:** terminal cells usually cylindrical or clavate, long to short, rarely short utriform, fusiform or roundish and forming chains, wall thin or thickish, often as tight bundles.

HABITAT AND DISTRIBUTION: Herb-rich forests with *Quercus robur*, likely connected at least with *Quercus*, also *Tilia cordata* and *Corylus avellana* often present in Finland, common in *Quercus* forests of south-west Finland. According to GenBank sequences, mycorrhizal with Mediterranean *Quercus ilex* (HQ204653, Richard et al. 2011) and with *Pinus sylvestris* from serpentine soil in Austria (EU046031, Urban et al. 2008).

COMMENTS: *Entoloma quercetorum* is genetically and morphologically close to *E. rhodopolium*. The types differed by 14 bases and 2 indels in ITS and 13 bases in RPB2 sequences from each other. They seem to have different hosts: *E. quercetorum* growing at least with *Quercus*, whereas *E. rhodopolium* with *Fagus* and some other deciduous trees. They were not found from the same sites. Morphologically, *E.*



Fig. 6. *Entoloma quercetorum*. **a** holotype. **b** KK 129/19. **c** KK 124/19. **d** KK 123/19.

quercetorum is distinguishable by the slight aromatic smell, when present, and the distinctly encrusted hyphae of pileipellis. *Entoloma nidorosum* is also close: the ITS sequences of the types differed by 19 bases and 2 indels from each other. It is also morphologically similar but usually has a depressed pileus with undulate margin, nitrous smell, and smooth or only very slightly encrusted pileipellis hyphae. It grows with *Betula* at moist sites. Generally, several large species of subg. *Rhodopolia* resemble each other, but none were found to grow with *E. quercetorum* in the same habitat.

ADDITIONAL SPECIMENS EXAMINED: FINLAND. Varsinais-Suomi. Kaarina, Vaarniemi nature reserve, W slope, herb-rich forest dominated by *Quercus robur*, near *Quercus* and *Acer platanoides*, 13.X.2019 Kokkonen 128/19*. Parainen, Lenholm,

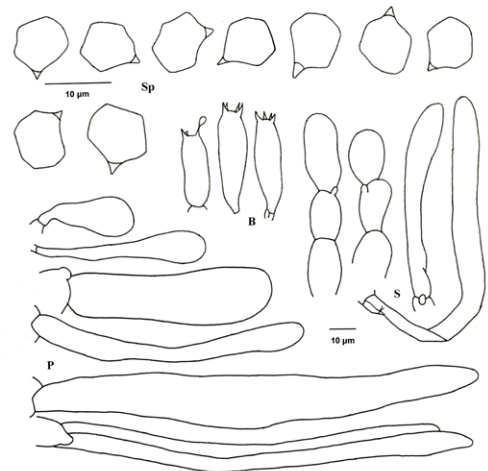


Fig. 7. *Entoloma quercetorum*, microscopic characters. Holotype: spores, basidia, terminal cells of pileipellis below the symbol, two terminal cells of stiptipellis on the right. KK 118/19: two terminal cells of pileipellis in the middle, two terminal cells of stiptipellis on the left. KK 120/19: two terminal cells of pileipellis above. For symbols, see Figs. 2 and 5.

21.VIII.1988 P. Heinonen 68-88*. Turku, Katariinanlaakso nature reserve, 3.IX.1960 P. Kallio*, herb-rich forest with *Quercus*, *Tilia*, *Acer*, *Betula* and *Picea*, 11.X.2019 Kokkonen 122/19*, 124/19*, 125/19, 126/19, 127/19, 12.X.2019 Kokkonen 123/19*, Muhuri nature reserve, herb-rich forest with *Quercus*, *Corylus*, *Acer*, *Pinus* and *Picea*, 15.X.2019 Kokkonen 129/19*, 130/19*, 131/19*, Ruissalo, Marjaniemi, herb-rich forest, near *Quercus* and *Acer*, 16.X.2019 Kokkonen 132/19*, old nature reserve, herb-rich forest with *Quercus*, *Tilia*, *Betula* and *Salix caprea*, 15.X.2006 Kokkonen 1364/06*, NE of the Pursiseura house, herb-rich forest with *Quercus*, *Corylus*, *Betula* and *Acer*, 9.X.2019 Kokkonen 118/19*, Tammimäki, 10.IX.2006 Kokkonen 684/06*, 28.VII.2007 Kokkonen 24/07*, 9.X.2019 Kokkonen 119/19, 120/19*.

Entoloma fluviale Kokkonen, sp. nov.

– Figures 8 and 9

MycoBank MB839353

ETYMOLOGY: the epithet refers to the habitat on riverbanks.

HOLOTYPE: Finland, Sompion Lappi, Savukoski, E of Maskaisenjärvi, S side of the river Värriöjoki, sandy riverbank beside a mixed heath forest, near *Salix phylicifolia*, *Pinus sylvestris*, *Picea abies*, *Betula*, *Sorbus aucuparia*, *Linnaea borealis* and *Vaccinium vitis-idaea*, 18.VIII.2019 K. Kokkonen 8/19 (TUR).

PILEUS 2.3–5.7 cm in diameter; applanate with a prominent obtuse umbo, margin at times undulate and recurved when old; pale grey brown to rather dark grey brown, at times with a yellowish hue (ca. $S_{10}Y_{40}M_{10}$, ca. $S_{20}Y_{40}M_{20}$, $S_{50}Y_{60}M_{30}$, $S_{60}Y_{50}M_{30}$), margin paler and umbo usually darker, up to black brown; delicately fibrillose or smooth, slightly viscid, hygrophanous, translucently striate. **LAMELLAE** up to 8 mm broad; adnate or emarginate; moderately or rather densely crowded, or rather distant; greyish or pale grey brown when young, then with a pink tinge; edge uneven or even, concolorous. **STIPE** 2.0–6.7 cm long, 0.3–1.1 cm wide; equal, slightly tapering, or slightly broadening towards base, base roundish or tapering, buried in sand; white, pale grey, or darkening to grey brown downwards; dry, faintly fibrillose,

often shiny, apex at times pruinose. **CONTEXT** concolorous with the surface, or dark grey in pileus and pale grey in stipe. **SMELL** indistinct or farinaceous when cut. **TASTE** indistinct or slightly farinaceous.

SPORES (7.2)7.6–8.5–9.5(9.9) × (6.1)6.6–7.4–8.0(8.5) μm, range of mean values 8.3–8.7 × 7.2–7.6 μm, Q=(1.01)1.06–1.15–1.27(1.29), range of mean Q values 1.12–1.19 (120 spores from six collections); usually subsisdiametrical. **BASIDIA** 28–38–52 × 10–12–14 μm (n=37), 4- or rarely 2-spored. **CHEILOCYSTIDIA** absent to abundant, 17–54 × 7–15 μm; flexuous, cylindrical, lageniform, utriform, fusoid, or subglobose; wall thin or at apex thickish, at times apex with scattered small crystals. **PILEIPELLIS** hyphae brownish or hyaline, rarely with internal pale brown flecks, slightly to strongly encrusted; terminal cells hyphoid, cylindrical, tapering at apex, constricted in the middle, or clavate, wall thin or at apex thickish, at times apex with small crystals or ‘mucus’. **STIPITPELLIS:** terminal cells similar to cheilocystidia. **CLAMPS** present in all structures.

HABITAT AND DISTRIBUTION: Known from two localities in the northern boreal zone of Finland. The habitats were sandy riverbanks.

COMMENTS: *Entoloma fluviale* is genetically and morphologically close to *E. sericatum*. The type deviated from the multiple *sericatum* sequences (Kokkonen 2015) by 9–12 bases and 2 indels. Due to the slight intraspecific genetic variation of both species, the close RPB2 sequences, and the similar morphologies, *E. fluviale* is distinguishable with difficulty. It may be regarded as a cryptic species. It is characterized by a pileus with a prominent umbo and sometimes having distinct cheilocystidia, but *E. sericatum* has also sometimes a prominent umbo. *Entoloma sericatum* has not been observed with cheilocystidia, although it may rarely have scarce, short cystidium-like structures at lamellar edge. *Entoloma fluviale* seems to be much rarer and has perhaps a restricted habitat in the north. Both species grew together at one site. Within the site, the two species deviated by 7–9 bases from each other. There existed partial intermediate specimens with ambiguous bases in two positions. Overall, the intraspecific variation of *E. fluviale* was up to 2 bases, the type being the most distant from *E. sericatum* and the other two specimens of the type site being intraspecific intermediates. The RPB2 sequences of



Fig. 8. *Entoloma fluviale*. **a** holotype. **b** KK 7/19. **c** KK 10/19. **d** KK 190/20.

E. fluviale deviated at least by 6 bases from all *sericatum* sequences.

Entoloma leucocarpum Noordel. resembles *E. fluviale* morphologically and by the habitat on sand (Noordeloos 1981, 1992). It differs by a paler pileus, a weaker umbo, a bulbous stipe base, on average larger spores, and absent incrustations at pileipellis. Its type was not obtained for loan.

ADDITIONAL SPECIMENS EXAMINED:

***E. fluviale*:** FINLAND. Sompion Lappi. Savukoski, E of Maskaisenjärvi, S bank of the river Värriöjoki, 18.VIII.2019 K. Kokkonen 7/19*, 10/19*. Koillismaa. Kuusamo, Oulanka National Park, S of Nurmisäärenrinne, bank of the river Oulankajoki, rich vegetation with scattered *S. phyllicifolia*, *S. myrsinifolia*, *Betula*, *Alnus incana*, *Prunus padus*, *Sorbus aucuparia* and *Picea abies*, 9.IX.2012 Kokkonen 1153/12*, 1603/12*, 27.VIII.2020 Kokkonen 189/20, 190/20*, 191/20*. ***E. sericatum*:** FINLAND. Koillismaa. Kuusamo, Oulanka National Park, S of Nurmisäärenrinne, bank of

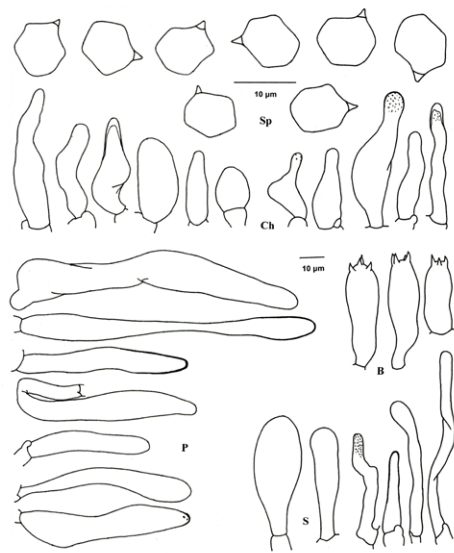


Fig. 9. *Entoloma fluviale*, microscopic characters. Holotype: spores, basidia, five terminal cells of pileipellis above, four terminal cells of stiptipellis on the right. KK 7/19: cheilocystidia left from the symbol. KK 10/19: cheilocystidia right from the symbol. KK 191/20: two terminal cells of pileipellis below. KK 1603/12: two terminal cells of stiptipellis on the left. For symbols, see Figs. 2 and 5.

the river Oulankajoki, 9.IX.2012 Kokkonen 1150/12*, 1152/12*.

New records of *Entoloma* from Finland or Sweden

Entoloma boreale Kokkonen, Mycol Prog 14: 116 (2015)

Common in *Picea abies* dominated rich forests of eastern Finland.

SWEDEN. Jämtland. Strömsund, near Torpen, moist herb-rich forest dominated by *Picea abies*, near *Picea*, *Betula*, *Oxalis acetosella*, *Equisetum sylvaticum*, *Rubus idaeus*, *Phegopteris connectilis*, *Dryopteris expansa*, *Gymnocarpium dryopteris* and *Viola palustris*, further away *Entoloma lupinum*, 20.VIII.2016 Kokkonen 294/16*. The first record from Sweden.

Entoloma caeruleopolitum Noordel. & Brandt-Ped., Persoonia 12(3): 221 (1984)

FINLAND. Kainuu. Hyrynsalmi, Pieni Mäntymäki, clearing, near seedlings of *Betula* and *Picea abies*, *Vaccinium myrtillus*, and *V. vitis-idaea*, among grasses, *Sphagnum* and other mosses, 4.IX.2018 Kokkonen 246/18*.

The first record from Finland. Pileus 1.6–2.0 cm in diam. Lamellae distant, brown. Stipe 4.0–4.1 × 0.3–0.6 cm, pale grey brown. Smell farinaceous when cut. Spores 7.8–9.2–11.0 × 6.7–7.6–8.9 μm with Q=1.04–1.21–1.38 (n=20), heterodiametrical or subsodiametrical, multi-angled with 7–11 angles. Pileipellis hyphae with abundant brown intracellular pigment.

Entoloma holmvassdalenense Eidissen, Lorås & Weholt, Öst. Z. Pilzk. 23: 58 (2014)

FINLAND. Kainuu. Paltamo, Kivesvaara-Keräsenvaara nature reserve, *Picea abies* dominated herb-rich forest, beside a brook, calcareous soil, 27.VIII.2018 Kokkonen 489/18*, eutrophic hardwood-spruce fen, among *Sphagnum*, 30.VIII.2018 Kokkonen 497/18*.

The first record from Finland. Pileus up to 3.9 cm in diam., brown or at margin violaceous grey, entirely blackish squamulose. Lamellae brownish with

a concolorous edge. Stipe up to 7.7 × 0.35 cm, brown grey, faintly dark flocculose. Smell faintly aromatic in one collection. Spores 9.2–10.8–12.8 × 7.0–8.0–9.5 μm with a range of mean values 10.5–11.1 × 7.9–8.1 μm, and Q=1.11–1.35–1.53 with a range of mean values 1.32–1.37 (40 spores from 2 collections), heterodiametrical with 6–7 angles. Lamellar edge sterile or heterogeneous. Cheilocystidia hyaline or brownish; fusiform, clavate, cylindrical, utriform, lageniform or mucronate. Basidia 1–4-spored, mostly 2-spored. Pileipellis with brown intracellular pigment.

Entoloma lupinum Kokkonen, Mycol Prog 14: 116 (2015)

FINLAND. Pohjois-Karjala. Juuka, Ruokolanvaara, mixed herb-rich forest, 29.VIII.2017 Kokkonen 62/17*. Nurmes, Valtimo, N of Haittalanmäki, pastured herb-rich forest, near *Picea abies*, *Betula*, *Alnus incana*, *Oxalis acetosella*, *Maianthemum bifolium*, *Gymnocarpium dryopteris*, *Rubus idaeus* and *Fragaria vesca*, 4.VIII.2020 Kokkonen 16/20*, 17/20*. Rautavaara, Pumpulikirkko nature reserve, herb-rich forest, near *Populus tremula*, *Picea*, *Sorbus aucuparia*, *Oxalis acetosella*, *Vaccinium myrtillus*, *Rubus saxatilis*, *Geranium sylvaticum*, *Gymnocarpium dryopteris* and *Athyrium filix-femina*, 6.VIII.2020 Kokkonen 24/20*. Kainuu. Paltamo, Yölinnunkuru nature reserve, moist and rich depression along slope with mixed forest, near *Populus*, *Picea*, *Betula*, *Alnus*, *Sorbus*, *Oxalis acetosella*, *Maianthemum bifolium*, *Vaccinium myrtillus*, *Phegopteris connectilis*, *Gymnocarpium dryopteris* and *Dryopteris expansa*, 8.VIII.2020 Kokkonen 28/20*. Sotkamo, Lauttolampi nature reserve, *Picea abies* dominated herb-rich forest, 18.VIII.2016 Kokkonen 289/16*. SWEDEN. Jämtland. Strömsund, near Torpen, *Picea abies* dominated moist herb-rich forest, near *Picea*, *Betula*, *Oxalis acetosella* and *Rubus saxatilis*, further away *Entoloma boreale*, 20.VIII.2016 Kokkonen 293/16*, 297/16.

The first record from Sweden. As an addition to the protologue (Kokkonen 2015), the pileus may have a prominent umbo (the Swedish collections and one Finnish fruitbody) and rarely a yellowish hue (another Swedish collection).

Entoloma paragaudatum Kokkonen, Mycol Prog 14: 116 (2015)

FINLAND. Etelä-Häme. Heinola, Läpiä, mixed herb-rich forest, 10.IX.2016 Kokkonen 669/16*. Pohjois-Karjala. Nurmes, Valtimo, Koppelovaara, moist

herb-rich forest, near *Betula*, *Picea abies*, *Alnus incana* and *Salix* spp., 4.IX.2016 Kokkonen 393/16*. Kainuu. Paltamo, Yöllinnunkuru nature reserve, herb-rich forest, near *Picea*, *Betula*, *Pinus sylvestris*, *Salix caprea*, *Oxalis acetosella*, *Maianthemum bifolium*, *Gymnocarpium dryopteris*, *Geranium sylvaticum*, *Vaccinium myrtillus* and *Rubus saxatilis*, 8.VIII.2020 Kokkonen 31/20*. Sotkamo, Lauttolampi nature reserve, mixed herb-rich forest, 18.VIII.2016 Kokkonen 292/16*, SE of Vuoriniemi, moist herb-rich depression in a mixed forest, near *Salix phylicifolia*, *Betula*, *Picea*, *Pinus*, *Juniperus communis*, *Filipendula ulmaria*, *Geranium sylvaticum*, *Epilobium angustifolium*, *Gymnocarpium dryopteris*, *Daphne mezereum* and *Crepis paludosa*, 16.VIII.2020 Kokkonen 53/20*.

As an addition to the protologue (Kokkonen 2015), the pileus was rarely scarcely fibrillose and extended to 6.8 cm in diameter. Two collections were from moist habitats but not from *Sphagnum*.

Entoloma pseudoconferendum Noordel. & Wölfel, In Noordel., *Entoloma* s.l., Suppl.: 955 (2004)

FINLAND. Keski-Pohjanmaa. Sievi, Pesäneva, mesotrophic – eutrophic fen, near *Rhynchospora fusca* and *Menyanthes trifoliata*, among *Sphagnum*, 1.IX.2018 Kokkonen 137/18*.

The first record from Finland. A solitary fruit-body. Pileus 1.7 cm in diam., rather dark brown. Stipe 4.4 × 0.4 cm, brownish. Smell farinaceous when cut. Spores 9.0–9.9–10.5 × 7.4–7.6–8.3 μm with Q=1.21–1.29–1.38, heterodiametrical with 7–8 angles. Pileipellis hyphae with brown intracellular pigment, rarely slightly encrusted.

Entoloma radicipes Kokkonen, Mycol Prog 14: 116 (2015)

FINLAND. Pohjois-Karjala. Juuka, margin of Koivikkola nature reserve, mixed herb-rich forest, near *Picea abies*, *Salix caprea*, *Alnus incana*, *Betula*, *Sorbus aucuparia* and *Lonicera xylosteum*, 5.IX.2017 Kokkonen 148/17*, Kusilampi nature reserve, herb-rich forest on a steep slope, near *Picea*, *Betula*, *Sorbus*, *Lonicera* and *Actaea spicata*, 5.IX.2017 Kokkonen 144/17*, Ruokolanvaara, mixed herb-rich forest, near *Picea*, *Alnus*, *Betula*, *Populus tremula*, *Oxalis acetosella*, *Equisetum sylvaticum*, *Geranium sylvaticum*, *Rubus saxatilis*, *Filipendula ulmaria*, *Gymnocarpium dryopteris* and *Vaccinium myrtillus*, 28.VIII.2017 Kokkonen 52/17*, near *Salix caprea*, *Picea*, *Populus* and *Lonicera*, 5.IX.2017 Kokkonen

143/17*. Nurmes, Valtimo, Koppelovaara, herb-rich forest dominated by *Picea*, near *Picea*, *Betula*, *Pinus sylvestris*, *Oxalis acetosella*, *Maianthemum bifolium* and *Gymnocarpium dryopteris*, 4.IX.2016 Kokkonen 389/16*.

Like the previous collections from one locality (Kokkonen 2015), all were characterized by a rooting or tapering stipe base and cheilocystidia.

Entoloma rhodopolium (Fr.) P. Kumm., Führ. Pilzk. (Zerbst): 98 (1871) – *Agaricus rhodopolius* Fr., Syst. Mycol. 1: 197 (1821)

FINLAND. Pohjois-Karjala. Juuka, Polvela, E of Valkealampi, herb-rich forest dominated by *Picea abies*, on a slope, near *Picea*, *Populus tremula*, *Betula*, *Sorbus aucuparia* and *Lonicera xylosteum*, calcareous soil, 19.IX.2020 Kokkonen 258/20*.

Entoloma sphagneti Naveau, Natuurw. Tijdschr. 5: 75 (1923)

FINLAND. Keski-Pohjanmaa. Sievi, Suihkonsalo, an overgrown pit in a ditch by the road, among *Sphagnum*, 2.IX.2018 Kokkonen 138/18*.

The second record from Finland. Macromorphology similar to the photos in Noordeloos 2004 (the first photo: Finland, Koski TL, a paludified depression between rocks, 24.IX.1997 M.-L. & P. Heinonen 961-97 F, photo P. Heinonen, J. Vauras pers. comm.) and Brandrud et al. (2018). Pileus 4.5–5.8 cm in diam. Stipe up to 7.9 × 1.1 cm, base dissolved in mosses. Smell and taste farinaceous. Spores 8.6–9.5–11.0 × 6.8–7.3–8.2 μm with Q=1.13–1.32–1.43, heterodiametrical with 6–8 angles. Pileipellis with brown intracellular pigment.

Phylogeny

The ML phylogenetic tree is presented in **Figure 10**. The clades of the new species were highly supported by the bootstrap and Bayesian BPP values.

Discussion

This paper provides new data about the occurrences

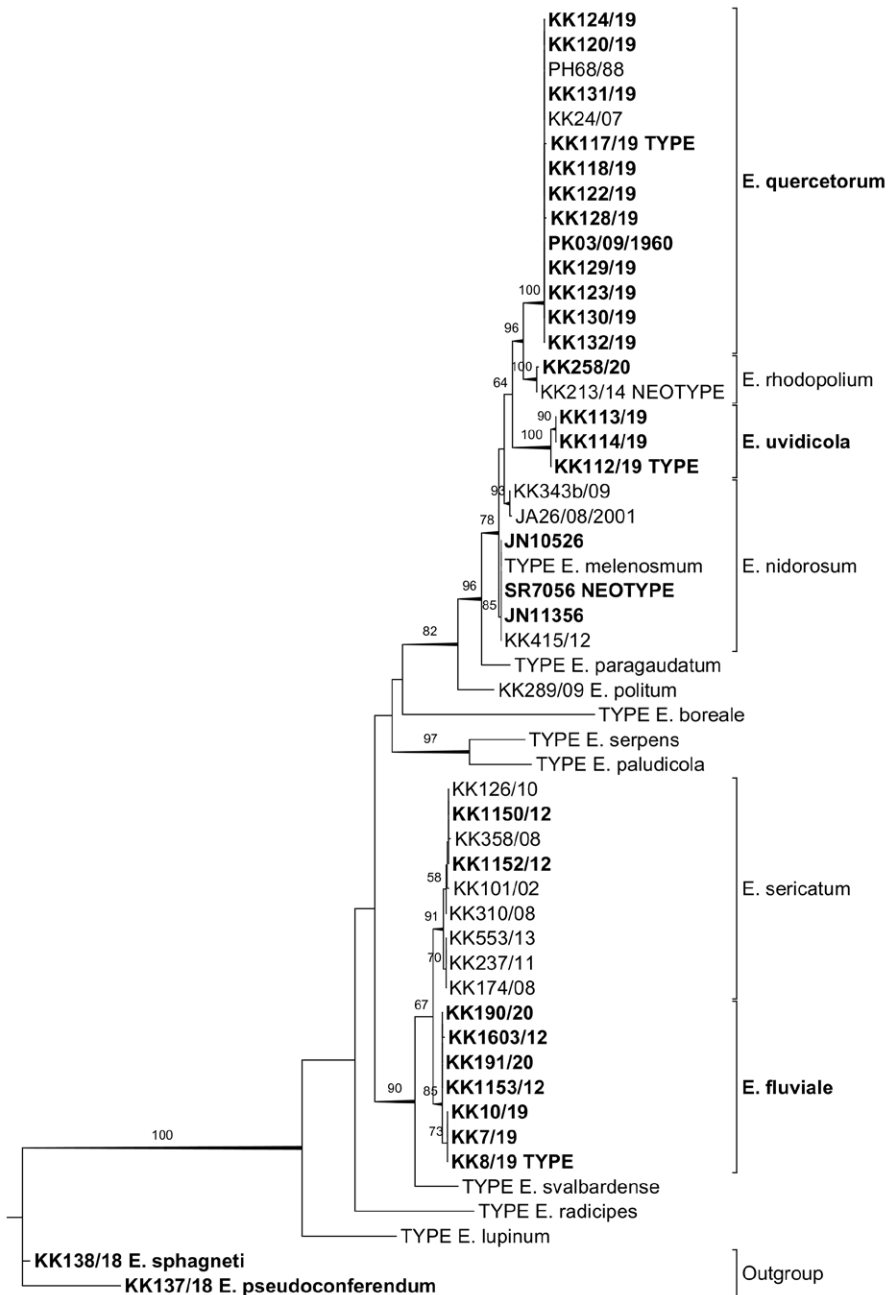


Fig. 10. A maximum likelihood tree of *Rhodopolia* ITS sequences. Part of the sequences originate from Kokkonen (2015). The new sequences and species are highlighted. ML bootstrap values ≥ 50 are given. Branches with Bayesian posterior probabilities ≥ 0.95 have thicker lines. Log likelihood -3690,93.

and distributions of boreal *Entoloma*, particularly of the species belonging to the subgenus *Rhodopolia*. Additionally, *E. quercetorum* is described as a new from the hemiboreal zone of Finland and *E. uvidicola* from the hemiboreal zone of Sweden. *Entoloma fluviale* is described as a new from the northern boreal zone of Finland.

Entoloma rhodopolium, which has previously been genetically confirmed only from one site in southern Finland (Kokkonen 2015), occurred as far north as in North Karelia, in the transition zone between southern and middle boreal zones. The soil was calcareous, and *E. rhodopolium* is probably associated there with *Populus tremula* or *Betula*, whereas it usually grows by *Corylus* or *Fagus* in south. It has been reported also near *Betula* from southern Norway (Brandrud et al. 2018).

All observations of *E. boreale*, *E. lupinum*, *E. paragaudatum* and *E. radicipes* were from rich or calcareous forests. *Entoloma boreale* is less demanding than the others, which concentrate on calcareous, often protected herb-rich forests, supporting the importance of these habitats for protection. *Entoloma lupinum* and *E. boreale* sometimes grow near each other, whereas *E. radicipes* seems to prefer different kind of herb-rich forests. It was often accompanied by the rare *Lonicera xylosteum* in eastern Finland. The habitat amplitude of *E. paragaudatum* was rather wide from dry to moist herb-rich forests, but it was not found growing among *Sphagnum*, as usual for the closely related but more common *E. nidorosum*.

The habitats of *E. holmvassdalenense*, *E. sphagneti* and *E. pseudoconferendum* resembled the previously reported habitats abroad (Naveau 1932, Noordeloos 1992, 2004, Brandrud et al. 2019), except that the site of *E. pseudoconferendum* was more nutritious compared with the oligotrophic bogs and ditches in Norway. *Entoloma caeruleopolitum* grew peculiarly in a clearing, but the previously reported sites have also been mainly oligotrophic (Noordeloos 1992, Brandrud et al. 2019).

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References

- Armada, F. & Lopez, F. 2017: *Entoloma speculum* Fr. (Quél.): espèce controversée. Bull. mycol. bot. Dauphiné-Savoie 226: 5-10.
- Brandrud, T.E., Bendiksen, E., Jordal, J.B., Weholt, Ø., Eidissen, S.E., Lorås, J., Dima, B. & Noordeloos, M.E. 2018: *Entoloma* species of the rhodopolioid clade (subgenus *Entoloma*; Tricholomatinae, Basidiomycota) in Norway. Agarica 38: 21-46.
- Brandrud, T.E., Bendiksen, E., Jordal, J.B., Weholt, Ø., Dima, B., Morozova, O. & Noordeloos, M.E. 2019: On some *Entoloma* species (Tricholomatinae, Basidiomycota) little known or new to Norway. Agarica 39: 31-52.
- Edler, D., Klein, J., Antonelli, A., Silvestro, D. 2019: raxmlGUI 2.0 beta: a graphical interface and toolkit for phylogenetic analyses using RAxML. bioRxiv, doi: <https://doi.org/10.1101/800912>.
- Fries, E.M. 1836: Spicilegium plantarum neglectarum. Decadem primam, Agaricos hyperhodios sistentem / praeside Elia Fries; p.p. Fransiscus Theodor. Noréus. Upsaliae.
- Fries, E.M. 1838: Epicrisis Systematis Mycologici. Upsaliae.
- Fries, E.M. 1867: Icon. Sel. Hymenomycetum nondum delineatorum. Holmiae.
- Katoh, S. 2013: MAFFT multiple sequence alignment software version 7: improvements in performance and usability. Molecular Biology and Evolution 30: 772-780.
- Kokkonen, K. 2015: A survey of boreal *Entoloma* with emphasis on the subgenus *Rhodopolia*. Mycological Progress 14: 116.
- Larsson, A. 2014: AliView: a fast and lightweight alignment viewer and editor for large data. Bioinformatics 30: 3276-3278.

Noordeloos, M.E. 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, M.E. 1992: *Fungi Europaei* 5, *Entoloma* s.l. Candusso, Saronno.

Noordeloos, M.E. 2004: *Fungi Europaei* 5A, *Entoloma* s.l., Suppl. Candusso, Alassio.

Richard, F., Roy, M., Shahin, O. et al. 2011: Ectomycorrhizal communities in a Mediterranean forest ecosystem dominated by *Quercus ilex*: Seasonal dynamics and response to drought in the surface organic horizon. *Annals of Forest Science* 68: 57-68.

Ronquist, F., Huelsenbeck, J.P. 2003: MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* 19: 1572-1574.

Stamatakis, A. 2014: RAxML. Version 8: A tool for Phylogenetic Analysis and Post-Analysis of Large Phylogenies. *Bioinformatics* 30: 1312-1313.

Stöver, B.C. & Müller, K.F. 2010: TreeGraph 2: Combining and visualizing evidence from different phylogenetic analyses. *BMC Bioinformatics* 11: 7.

Urban, A., Puschenreiter, M., Strauss, J. & Gorfer, M. 2008: Diversity and structure of ectomycorrhizal and co-associated fungal communities in a serpentine soil. *Mycorrhiza* 18: 339-354.

Electronic Supplementary Material
ESM1.fas. Alignment of ITS sequences.