DOI: 10.5617/agarica.11686

A comparison of aboveground sporocarps and belowground ectomycorrhizal structures of Agaricales, Boletales and Russulales in a sand dune ecosystem on Lista, South-western Norway

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Norsk tittel: En sammenlikning av sporokarper over bakken og ektomykorrhizastrukturer under bakken for Agaricales, Boletales og Russulales i et sanddyneøkosystem på Lista, Sørvest-Norge

Høiland K, Botnen S, 2016. A comparison of above ground sporocarps and below ground ectomycorrhizal structures of Agaricales, Boletales and Russulales in a sand dune ecosystem on Lista, South-western Norway. Agarica 2016 vol. 37: 67-77.

KEY WORDS
Ectomycorrhiza, molecular identification, sand dunes, sporocarps

NØKKELORD
Ektomykorrhiza, identifikasjon, molekylær, sanddyner, sporokarper

SAMMENDRAG
I dette arbeidet fokuserer vi på ektomykorrhizasopper i Agaricales, Boletales og Russulales, som alle har iøynefallende sporokarper. Dette gir oss en mulighet til å sammenlikne diversitet av ektomykorrhiza med diversitet av sporokarper av ektomykorrhizasopper. I sanddyneområdene på Lista, i Sørvest-Norge, ble det lagt ut ni plot med diameter 3 m i vegetasjon dominert av *Salix repens* (krypvier). Tre plot på dynetrau, tre plot på kuppeldyner og tre plot på eroderte dyner. I 2009 ble ektomykorrhizarøtter av *Salix repens* samlet i hvert av plottene. Taksa av ektomykorrhizasopper ble identifisert ved hjelp av pyrosekvensering. I perioden 2008 til 2014 ble sporokarper samlet og identifisert i de samme plottene. Tretti taksa av de ektomykorrhizasoppene vi fokuserte på ble identifisert på røttene, 10 av dem ble også funnet sammen med sporokarper (i det minste i ett av plottene). I tillegg ble 11 taksa bare registrert som sporokarper. Det vanligste takson var *Hebeloma* spp. (reddiksopper), funnet i alle ni plottene. Det vanligste takson på artsnivå var *Cortinarius saniosus* (branngul slørsopp), som imidlertid bare ble registrert som ektomykorrhiza på røttene, mens sporokarper ble funnet utafor plottene. De vanligste ektomykorrhizaartene med sporokarper i det minste i ett plot var *Cortinarius casimiri* (storsporeslørsopp) og *Russula laccata* (skarp vierkremle). Av taksa typiske for sanddyner med *Salix repens* fant vi *Lactarius controversus* (rosaskiveriske), *Russula persicina* (aprikoskremle), *Tricholoma cingulatum* (grå ringmusserong), *Inocybe impexa* (strandtrevlesopp), *I. dunensis* (dynetrevlesopp) og *Laccaria maritima* (dynelakssopp). De to siste taksa var bare representert ved sporokarper. Vi konkluderer med at en kombinert registrering av ektomykorrhiza på røtter og sporokarper er en optimal tilnærming hvis vi ønsker å dekke diversiteten av de ektomykorrhizasoppene vi har fokusert på.

ABSTRACT
In the present work we put focus on ectomycorrhizal Agaricales, Boletales and Russulales, all with conspicuous sporocarps, giving us an opportunity to compare the below ground ectomycorrhiza diversity with the aboveground sporocarp diversity. In the sand dune area on Lista, South-west Norway, nine plots of 3 m diameter were established in *Salix repens* (creeping willow) dominated vegetation; i.e. three plots on dune slacks, three plots on hummock dunes, and three plots on eroded dunes. In 2009 ectomycorrhizal *Salix repens* roots were sampled in each plot. Ectomycorrhizal taxa were identified by pyrosequencing. From 2008 to 2014 fungal sporocarps were collected and identified in the same plots. Of the 30 actual ectomycorrhizal taxa identified on the roots, 10 of them were also accompanied by aboveground sporocarps. In addition, 11 taxa were only recorded as sporocarps. The most frequent ectomycorrhizal taxon was *Hebeloma* spp, recorded in all nine plots. The most frequent taxon on species level was *Cortinarius saniosus*, however, only recorded on ectomycorrhizal roots while sporocarps were found outside the plots. The most frequent ectomycorrhizal species with at least one plot housing accompanied sporocarps were *Cortinarius casimiri* and *Russula laccata*. Some of the ectomycorrhizal taxa belong to the typical inventory of *Salix repens* dominated dune vegetation: *Lactarius controversus*, *Russula persicina*, *Tricholoma cingulatum*, *Inocybe impexa*, *I. dunensis* and *Laccaria maritima*; the two last taxa only represented by sporocarps. We conclude that a combination of sampling below ground ECM and monitoring aboveground sporocarps seems to be an optimal approach if we want to cover the diversity of conspicuous ECM fungi in an area.

INTRODUCTION
The sand dune area on the Lista peninsula (Farsund municipality, Vest-Agder County, SW Norway) consists of an approximately 10 km long beach-line from SE to NW, interrupted by short stretches of boulders or rocks (Figure 1) (Høiland 1978a). It houses a very interesting funga, encompassing many specialised species (Høiland 1974, 1975, 1977, 1978b, 2006). These registrations have been performed by monitoring visible sporocarps, where basidiomycetes belonging to Agaricales and Russulales are the most conspicuous and frequent, together with some few from Boletales. Of these the following genera are ectomycorrhizal (ECM): *Amanita*, *Tricholoma*, *Laccaria*, *Entoloma* (at least some), *Cortinarius*, *Inocybe*, *Hebeloma*, *Naucoria*, *Boletus*, *Leccinum*, *Paxillus*, *Russula* and *Lactarius*.

In the actual sand dune area, creeping willow *Salix repens* L. is the only ECM plant, as also documented from similar sand dune areas in the UK and The Netherlands (Watling and Rotheroe 1989, Rotheroe 1993, Arnolds and Kuyper 1995, van der Heijden and Vosatka 1999, van der Heijden et al. 1999). In *Salix repens* both ECM and arbuscular mycorrhiza coexist (Heijden and Vosatka 1999). A survey of ECM fungi on roots of *S. repens* in the sand dune area on Lista has newly been published by Botnen et al. (2015). The results, obtained by 454 pyrosequencing, identified ECM from many of the above-mentioned genera, but also from genera with no or inconspicuous sporocarps, like Thelephorales, Sebacinales and Cantharellales. Approximately one quarter was Agaricales, Boletales and Russulales; the other quarter Thelephorales; the third quarter Sebacinales and Cantharellales; and the fourth quarter Glomeromycota (arbuscular mycorrhiza) and Ascomycota.

Monitoring of sporocarps is a straightforward method if we want a survey of ECM species in an area, although we realise that the visible sporocarps represent roughly one quarter of the total ECM diversity below ground. The aim of the present work is to compare records of ECM taxa of Agaricales,

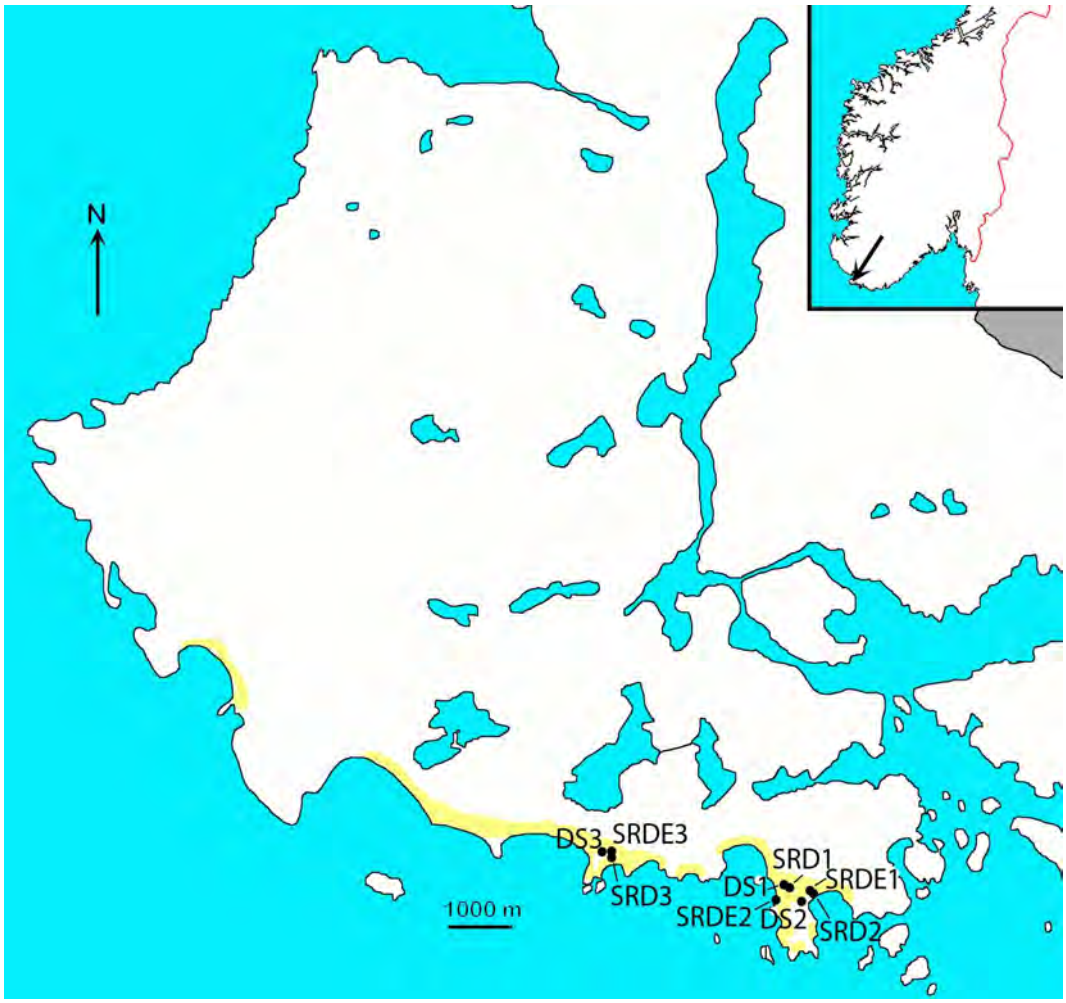


Figure 1. Sketch map of the Lista peninsula, Vest-Agder County, Farsund municipality. DS1, DS2, and DS3 are study plots from dune slacks; SRD1, SRD2, and SRD3 are study plots from hummock dunes; SRDE1, SRDE2, and SRDE3 are study plots from eroded dunes. The sand dune investigation area is marked with yellow.

Boletales and Russulales from aboveground sporocarps with records of ECM from the same group based on below ground *Salix repens* root samples. Moreover, the ecology of the actual species or genera will be commented.

MATERIALS AND METHODS

Collection of root samples and metagenomics of mycorrhizal fungi

Field work was carried out on the Lista peninsula in SW Norway (Figure 1, Table 1). In October 2008, nine circular study plots of 3 m diameter including *S. repens* were established in the sand dune areas on the S and SE parts of the Lista peninsula; encompassing (1) dune slacks: DS1, DS2, DS3, (2) hummock dunes: SRD1, SDR2, SRD3, and (3) eroded dunes: SRDE1, SRDE2, SRDE3 (see Botnen et al. 2015). In 2009 two independent samples of approximately 10 cm continuous *S. repens* root were collected in each plot by excavating the individual roots. These samples were

Table 1. Description of the study plots, 3 m diameter, all positioned on Lista peninsula, Vest Agder County, SW Norway (see Figure 1).

Locality	Plot	Degrees N	Degrees E	Vegetation
Einarsneset-Husebysanden	DS1	58.06612	6.78315	Dune slack, relatively dry and rich
Einarsneset-Husebysanden	SRD1	58.06580	6.78369	Hummock dune in E end of DS1
Einarsneshalsen	DS2	58.06372	6.78761	Dune slack, wet
Lomsesanden	SRD2	58.06559	6.79160	Hummock dune 200 m W of a camping toilet
Lomsesanden	SRDE1	58.06562	6.79136	Eroded dune 220 m of the same toilet
Einarsneset	SRDE2	58.06488	6.78339	Eroded dune, blow out in *Ammophila* dune ridge
Havik	DS3	58.06754	6.73032	Dune slack, wet, E of parking place
Havik	SRD3	58.06717	6.73048	Hummock dune in SE end of DS3
Havik	SRDE3	58.06749	6.73075	Eroded dune in E end of DS3, N of SRD3

collected in April, July and October, altogether 54. Metagenomics with fungal specific ITS primers were performed by 454 pyrosequencing. For details about sampling, pyrosequencing and biostatistics, see Botnen et al. (2015). Fungi were considered ECM if they were listed by Tedersoo et al. (2010).

A list of all mycorrhizal OTUs from the 454 pyrosequencing is given by Botnen et al. (2015), Online Resource 2.

Monitoring of ECM sporocarps, DNA-methods, data mining and taxonomy

The fungal study group was ECM Basidiomycota belonging to Agaricales, Boletales and Russulales. From 2008 to 2014, each of the nine study plots was visited for monitoring sporocarps twice a year, July and October. Sporocarps outside the study plots were also collected. They were dried in a 20 °C air current from a standard air to air heat pump.

DNA was extracted from dried, crushed sporocarps following the 2% CTAB miniprep method (Murray and Thompson 1980). Primer pairs used in the PCR reactions included ITS5/ITS4 for the complete ITS1-5.8S-ITS2 region (White et al. 1990). PCR products were purified using ExoSAP-IT (Amersham Biosciences) prior to sequencing. Sequences were generated with an ABI 3730 high-throughput capillary electrophoresis sequencer using the PCR primers as sequencing primers.

The taxonomic identification was based on sporocarp morphology using standard keys (Vesterholt 2005, Knudsen and Vesterholt 2008), combined with searches on the ITS sequences done in the NCBI nt/nr using BLASTN.

Information about occurrence, ecology and distribution of all actual species recorded in the Lista sand dune area was obtained from Høiland (1974, 1975, 1977, 1978b, 2006, 2012), Høiland and Elven (1980), and The Norwegian Mycological Database, NMD (2010), as of April 2015.

In the present work all fungi are considered at species level, except *Hebeloma* and *Entoloma*, which are treated at genus level. The reason is difficulties to relate species identifications based on the morphology of sporocarps with species suggestions from BLASTN on ITS sequences from the same sporocarps. The term taxon is therefore used to include either species or genera.

The nomenclature follows Index Fungorum (http://www.indexfungorum.org/Names/Names.asp, as of April 2015).

RESULTS AND DISCUSSION

Altogether 30 taxa of ECM Agaricales, Boletales and Russulales were recorded from root samples of *Salix repens* in the nine study plots (Table 2; see also Botnen et al. 2015, Online Resource 2). Of these, 20 taxa have been reported previously from the Lista sand dune area, based on sporocarp recordings. Ten taxa were represented by ECM sequences from root samples accompanied by aboveground sporocarps in at least one of the plots. Ten of the 30 ECM taxa have not been recorded from the area before. Two of them, *Inocybe chelanensis* D.E. Stuntz and *I. straminipes* Romagn., are new to Norway. In addition, sporocarps, but no belowground ECM, of 11 taxa were found in at least one of the plots (Table 2).

The most frequent ECM taxon was *Hebeloma* spp., recorded in all nine plots, even in the plots from eroded dunes, which were scarce in other ECM taxa (Botnen et al. 2015). Sporocarps were found in three plots, one from dune slack, two from hummock dunes. *Hebeloma* species are regarded as generalist ECM builders on *Salix* (van der Heijden 1999, Aanen et al. 2000); some having a short life span adapted to pioneer situations, such as nutrient-poor, unstable sand dunes (Gryta et al. 1997). In the dune areas of Lista, sporocarps of various *Hebeloma* species have been reported by Høiland (1974, 1978b, Høiland and Elven 1980), mostly from dune slacks.

On species level, the most common ECM taxon was *Cortinarius saniosus* (Fr.) Fr. (Figure 2A) found in seven plots. However, no sporocarps were recorded in any plot, and the species fructified rather seldom in the investigation area (Høiland 1980). *Salix* is reported a common host for *C. saniosus* (Høiland 1980, Høiland and Elven 1980, van der Heijden et al. 1989, Niskanen et al. 2008). ECM of *C. casimiri* (Velen.) Huijsman was also frequent, recorded in six plots, with sporocarp in one, a hummock dune. This is a very common species, both under deciduous and coniferous trees, but also under *Salix* (Brandrud et al. 1990-2013, Niskanen et al. 2008), and may be regarded as a generalist. *Cortinarius illuminus* Fr. was also frequent as ECM, in 6 plots, including two in eroded dunes. However, the species was not found with sporocarps, not even outside the plots, and it belongs to the most frequent of the "hidden" Agaricales in our area. According to Brandrud et al. (1990-2013) and Niskanen et al. (2008), it is common in mesic and acidic *Picea* forests, but is not mentioned under *Salix*. *Cortinarius parvannulatus* Kühner found as ECM in two plots, both hummock dunes, had a similar "hidden" appearance. This species is reported from *Salix*, preferably in alpine environments Brandrud et al. (1990-2013). *Cortinarius croceus* (Schaeff.) Gray, having a broad ecology, but preferring open environments (Høiland 1984), was found in 5 plots with sporocarps in one of them, here together with sporocarps of the closely related *C. cinnamomeus* (L.) Fr. ECM of *Cortinarius trivialis* J.E. Lange was found in two plots, both dune slacks, with sporocarps in one of them. This species has *Salix* as important host (Brandrud et al. 1990-2013, Niskanen et al. 2008), and has been reported from *Salix repens* by Watling and Rotheroe (1989), van der Heijden et al. (1999), van der Heijden and Kuyper (2003). It is rather common in dune slacks on the Lista peninsula (Høiland 1974, 1978b, Høiland and Elven 1980). Six species of *Cortinarius* were not recorded from the root samples, only as sporocarps. Sporocarps of *C. saturninus* (Fr.) Fr. was found in one plot, a hummock dune, but the species is common in all *Salix repens* dominated dune vegetation on Lista (Høiland 1974, 1978b, Høiland and Elven 1980). *Cortinarius uliginosus* Berk. found in plot DS3 was locally common also outside the wet dune slacks surrounding this plot.

Species of *Inocybe* are frequent in dune areas, especially on less acidic sand with none

Table 2. Records of both ectomycorrhiza (ECM) and sporocarps of the same species *# green; only ECM * yellow; or only sporocarps # blue in the study plots (Table 1). Fungi in concern are Agaricales, Boletales and Russulales. ECM was sampled in 2009, sporocarps from 2008 to 2014. ECM and sporocarps sampled together in 2009 are marked with ! For further explanation of plot codes, see Table 1.

Plot	DS1	DS2	DS3	SRD1	SRD2	SRD3	SRDE1	SRDE2	SRDE3
Vegetation type	Dune slacks			Hummock dunes			Eroded dunes		
Amanita muscaria	-	-	-	-	-	#	-	-	-
Cortinarius albovariegatus	-	-	-	-	-	-	-	-	#
Cortinarius anomalus	-	-	-	-	-	#	-	-	-
Cortinarius casimiri	-	*	*	-	*	*#	*	-	*
Cortinarius cinnamomeus	-	-	-	-	#	-	-	-	-
Cortinarius croceus	-	*	*	*	*#	*	-	-	-
Cortinarius illuminus[2]	-	*	*	-	*	*	*	-	*
Cortinarius obtusus	-	-	-	-	-	#	-	-	-
Cortinarius parvannulatus[2]	-	-	-	*	-	*	-	-	-
Cortinarius saniosus	*	*	*	*	*	-	-	*	*
Cortinarius saturninus	-	-	-	#	-	-	-	-	-
Cortinarius trivialis	-	*	*#	-	-	-	-	-	-
Cortinarius uliginosus	-	-	#	-	-	-	-	-	-
Entoloma spp.	-	-	-	-	-	*	*	-	-
Hebeloma spp.	*#	*	*	*#	*	*#	*	*	*
Inocybe acuta	-	*	-	#	-	-	-	-	-
Inocybe chelanensis[1]	-	-	-			-	-	-	*
Inocybe dulcamara	*	-	-	-	-	-	-	-	-
Inocybe dunensis	#	-	-	-	-	-	-	-	#
Inocybe impexa	-	-	*	-	-	-	*	-	-
Inocybe jacobi	-	-	-	-	*	-	-	-	-
Inocybe lacera	#	*	*	-	-	-	-	-	-
Inocybe napipes[2]	-	-	-	*	-	-	-	-	-
Inocybe obscurobadia[2]	*	-	-	*	-	*	-	-	-
Inocybe ochroalba[2]	*	-	-	-	-	*	-	-	*
Inocybe paludinella	-	*#	-	*	-	-	-	-	-
Inocybe straminipes[1]	-	-	*	-	-	-	-	-	-
Inocybe subcarpta	-	-	*	-	-	-	-	-	-
Inocybe whitei[2]	-	-	-	-	-	*	-	-	-
Laccaria laccata	-	*	-	*	*	*#	-	-	*
Laccaria maritima	-	-	-	-	-	-	#	-	-
Laccaria proxima	-	*	-	-	*	*	-	-	*
Lactarius controversus	-	-	*	-	-	#	-	-	!*#
Leccinum scabrum	-	-	-	#	-	-	-	-	-
Naucoria aff. *bohemica*[2]	-	-	*	-	-	-	-	-	-
Naucoria tantilla[2]	-	-	-	-	-	*	-	-	-
Paxillus involutus	-	-	-	-	-	-	-	-	*
Russula laccata	-	*	*#	*	*	*	*	-	#
Russula pascua	-	-	#	-	-	-	-	-	#
Russula persicina	-	-	*#	-	*	#	-	-	*#
Tricholoma cingulatum	-	-	-	*#	-	*#	-	-	*

[1]Not recorded from Norway before. [2]Not previously recorded from the investigation area.



Figure 2. Common or typical ECM fungi on sand dunes with *Salix repens* on Lista peninsula, Vest-Agder county, Farsund municipality. A. *Cortinarius saniosus* found in seven of the nine study plots; all as ectomycorrhiza (ECM) on roots. B. *Lactarius controversus* found in three of the nine study plots; one as ECM accompanied by sporocarps, one as ECM, and one as sporocarp. C. *Russula persicina* found in four of the nine study plots; two as ECM accompanied by sporocarps, one as ECM, and one as sporocarp. D. *Tricholoma cingulatum* found in three of the nine study plots; two as ECM accompanied by sporocarps, one as ECM. (See Table 2.). Photo: K. Høiland.

or scarce amounts of organic matter (Andersson 1950, Høiland 1974, 1975, 1978b, 2006, Watling and Rotheroe 1989, van der Heijden et al. 1999). Typical sand dune species were *I. impexa* (Lasch) Kuyper (ECM on hummock dune and eroded dune) and *I. dunensis* P.D. Orton (sporocarps on dune slack and eroded dune). The other *Inocybe* species (Table 2) are not exclusively sand dune species, but many of them, e.g. *I. lacera* (Fr.) P. Kumm. and *I. dulcamara* (Pers.) P. Kumm., prefer sand or open soils and are therefore frequent in sand dune vegetation (Høiland 1974, 1978b, Jacobsson 2008). *Inocybe dulcamara* prefers calcareous soils (van der Heijden et al. 1999, van der Heijden and Kuyper 2003) and may be favoured by shell fragments in the sand. *Inocybe paludinella* (Peck) Sacc. is typical for wet soils (Jacobsson 2008). Plot DS2, in which both ECM and sporocarps were found, is situated on a very moist dune slack, which is flooded from autumn to spring, and even in rainy summers. *Inocybe obscurobadia* (J. Favre) Grund & D.E. Stuntz and *I. ochroalba* Bruyl. have not been recorded from Lista before. ECM of both was detected in three plots. According to Jacobsson (2008) the two species prefer calcareous soils under conifers. They may be favoured by shell fragments in the sand, especially in the nutrient rich plots DS1 and SRD1 (Botnen et al. 2015, Online Resource 1). The rest of the *Inocybe* species will not be commented on since they were too infrequent, but, as mentioned, two of them are new for Norway.

Sporocarps of the variable *Laccaria laccata* (Scop.) Cooke are frequent in dune slacks on Lista (Høiland 1974, 1978b, Høiland and Elven 1980). ECM was recorded in five plots, with sporocarps in one of them (a hummock dune). *Laccaria maritima* (Theodor.) Singer ex Huhtinen, one of the most noticeable sand dune species (Andersson 1950, Høiland 1974, 1975, 1976), was found as sporocarps in one plot from an eroded dune, SRDE1. Eroded dunes are the most important habitat for this rare and threatened species (Høiland and Elven 1980, Høiland 2006). However, no ECM was detected.

Tricholoma cingulatum (Almfelt ex Fr.) Jacobashch (Figure 2D) is a well-known associate with *Salix* (Gulden 1969, Watling and Rotheroe 1989, Watling 1992, Rotheroe 1993, van der Heijden et al. 1999). Sporocarps are rather frequent on *Salix repens* hummock dunes on Lista (Høiland 1974, 1978b, 2006, Høiland and Elven 1980). ECM and sporocarps were recorded in two plots, SRD1 and SRD3, from hummock dunes, and one ECM in SRDE3, an eroded dune in vicinity of SRD3.

Russula laccata Huijsman, which is most frequent under *Salix* in arctic and alpine environments (Gulden et al. 1985, Knudsen et al. 2008), is also common in dunes with *Salix repens* (Watling 1992). ECM was recorded in root samples from six plots, spanning from dune slacks to eroded dunes, one of them with sporocarps. In addition sporocarps, but no ECM, were found in one plot, an eroded dune. Sporocarps of *R. laccata* are common in the dune areas on Lista (Høiland 1974, 1978b, Høiland and Elven 2008). ECM of *Russula persicina* Krombh. (Figure 2C) was found in three plots, two of them with sporocarps, from dune slack, hummock dune and eroded dune, respectively. Additional sporocarps, but no ECM, were found in one plot, a hummock dune. The species is associated with deciduous trees (Knudsen et al. 2008) including *Salix repens* (Rotheroe 1993, van der Heijden et al. 1999, Taylor 2001). On Lista sporocarps were reported from various *Salix repens* vegetations, but preferably on hummock dunes (Høiland 1974, 1978b, 2006, Høiland and Elven 2006). The last species, *R. pascua* (F.H. Møller & Jul. Schäff.) Kühner, was only found as sporocarps in two nearby plots, DS3 and SRDE3, dune slack and eroded dune, respectively. This species is also reported under *Salix* in the UK (Watling and Rotheroe 1989).

The peculiar, nearly subterranean *Lactarius controversus* Pers. (Figure 2B) is typical under *Salix* or *Populus* (Heilmann-Clausen et al. 1998, Kalamees 2011), and sporocarps are recurrently found beneath *Salix repens* in sand dunes (Høiland 1974, 1978b, 2006, Høiland and Elven 1980, Watling and Rotheroe 1989, Rotheroe 1993, Heilmann-Clausen et al. 1998, van der Heijden et al. 1999, van der Heijden and Kuyper 2003). ECM and/or sporocarps were recorded from three nearby plots, DS3, SRDE3 and SRD3, dune slack, eroded dune and hummock dune, respectively. *Lactarius controversus* was the only species recorded both as ECM and sporocarps in the same year (2009) in the same plot (SRDE3) (Table 2). (However, 2009 was a bad year for sporocarps in the investigation area.)

The rest of the fungal taxa were found too seldom to be commented on.

Taxonomic remarks

Hebeloma is for reasons mentioned above only treated at genus level. Sequences from sporocarps gave by BLASTn: *Hebeloma cavipes* Huijsman (syn. *H. lutense* Romagn.), *H. crustuliniforme* (Bull.) Quél. (syn. *H. longicaudum* (Pers.) P. Kumm.) and *H. leucosarx* P.D. Orton (syn. *H. velutipes* Bruchet) together with an undetermined species. ECM sequences from root samples gave by BLASTn the

following species (Botnen et al. 2014, Online Resource 2): *Hebeloma alpinum* (J. Favre) Bruchet, *H. cavipes* and *H. kuehneri* Bruchet together with an undetermined species.

The name *Cortinarius trivialis* J.E. Lange is used in this investigation, although the BLASTN results turned up with *C. alpinus* Boud. for both ECM and sporocarps (except one sporocarp identified as *C. trivialis*). However, Peintner (2008) showed that ITS sequences gave very little (or no) resolution between species determined *C. trivialis* or *C. alpinus*. Moreover, the material from Lista is morphologically closer to *C. trivialis* than to *C. alpinus* (Brandrud et al. 1990-2013, Niskanen et al. 2008). Therefore we prefer to consider it *C. trivialis*.

Inocybe impexa (Lasch) Kuyper is the correct name (Kuyper 1986) for *I. maritima* P. Karst. (Høiland 1975, Høiland and Elven 1980).

Inocybe dulcamara (Pers.) P. Kumm. was shown to be the correct determination for specimens previously named *I. caesariata* (Fr.) P. Karst. sensu Heim (now *I. heimii* Bon) (Høiland 1974, 1978b, 2006, 2012, Høiland and Elven 1980).

Russula laccata Huijsman was misinterpreted as *R. fragilis* Fr. by Høiland (1974, 1978b) and Høiland and Elven (1980).

Russula persicina Krombh. (Figure 2C) was repeatedly named *R. exalbicans* (Pers.) Melzer & Zvára (syn. *R. depallens* Cooke sensu auct.) by Høiland (1974, 1978b, 2006, 2012) and Høiland and Elven (1980). However, sequences of both ECM and sporocarps gave evidence by BLASTN for *R. persicina*, a species which in Norway previously was found in Sør-Trøndelag, Trondheim (NMD 2010). Also, the morphology of the material from Lista matches this species better than that of *R. exalbicans* (Knudsen et al. 2008).

CONCLUSION

Our investigation of ECM Agaricales, Boletales and Russulales in nine plots showed that 24% of the taxa were represented by below ground ECM accompanied by aboveground sporocarps (in at least one of the plots); 49% of the taxa were represented by below ground ECM not accompanied by aboveground sporocarps (but sporocarps may be found without below ground ECM in some other plots); and 27% of the taxa were represented only by aboveground sporocarps. To cover the total diversity of conspicuous ECM fungi, a combination of sampling belowground ECM and monitoring aboveground sporocarps seems to be an optimal approach.

ACKNOWLEDGMENT

The county governor of Vest-Agder is thanked for granting permission to collect samples in the nature-protected areas on the Lista peninsula. Moreover, we will thank Cecilie Mathiesen (IBV, UiO) for DNA sequencing of sporocarps, and The Department of Biosciences, UiO, for a generous financial support.

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