

Nya fynd av marina svampar i Sverige

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Sammanfattning

En översikt av forskningen om och en beskrivning av det internationellt starka intresset för marina svampar presenteras. Det dåliga kunskapsläget om dessa svampars förekomst i Sverige noteras. Nya fynd av marina svampar har erhållits såväl från studier av herbariematerial vid Evolutionsmuseet i Uppsala samlat av Rolf Santesson i mitten av 1900-talet som genom studier av nyinsamlat material, delvis genom identifiering via DNA-sekvensering. I allt behandlas 18 arter från Sverige och ytterligare två från Danmark. *Amphitrite annulata* och *Corollospora borealis* beskrivs som nya för vetenskapen. Vidare uppges fem arter som nya för Sverige och ytterligare redovisas fynd som medför ökad kunskap om marina svampars utbredning i Sverige. Den svenska texten följs av en engelsk version som också innehåller en kommenterad artlista.

Inledning

Trots att de marina svamparna under de senaste decennierna tilldragit sig stort intresse i forskningen på många håll i världen förblir de fortfarande dåligt kända jämfört med de landlevande svamparna. Vi har länge känt till att de landlevande svamparna har en nyckelroll i de flesta terrestra ekosystem, både som nedbrytare, symbionter och parasiter. Landlevande svampar är i allmänhet känsliga för uttorkning och UV-strålning. För vattenlevande svampar saknas dessa negativa ekologiska faktorer. Vatten är deras livsmedium och vatten skyddar väl mot UV-strålning. Under 1900-talet påvisades en ganska stor diversitet av svampar i sötvatten, där svamparna har likartade ekologiska roller som på land. Något senare fick mykologerna upp ögonen för den rika förekomsten av svampar också i haven. Den rika förekomsten i haven är måhända inte så förvånande om vi betänker att fylogenetiskt basala svampgrupper i första hand är vattenlevande, t ex Chytridiomycota. Av dessa svampar finner vi också fossil redan från tidig Devon i Rhynie chert-lagren. Chytridsvamparna utgör sannolikt en systergrupp till en gren som omfattar sporsäckssvampar, basidsvampar och zygomyceter. Chytriderna har externa gissel, en anpassning till vattenliv, och finns mestadels i vatten, såväl i sötvatten som i oceanerna. Intresset bland mykologer för marina

svampar ökade dramatiskt under 1900-talet, särskilt under dess andra del, och gradvis försköts intresset från de tidiga undersökningarnas fokus på marin ved och på växtlämningar i haven till marina svampars förekomst i alger, marina svampar (Porifera; Höller m fl 2000, Rozas m fl 2011), musslor (Grovel m fl 2003) och sediment. Således rapporterade Zuccaro m fl (2008) inte mindre än 45 arter av marina svampar från sågtång (*Fucus serratus*), och parallellen till landsvamparnas förekomst som endofyter är uppenbar. Även djuphavssediment har visat sig innehålla en stor mångfald av svampar (Edgcomb m fl 2011). Antalet kända hyfbildande marina svampar sammanfattades av Jones (2011) till cirka 550 arter, en bråkdel av det totala antalet, som samma källa uppskattar till runt 10 000. Mörkertalet är alltså stort!

Trots mykologins långa och rika historia i Sverige har de marina svamparna rönt ganska litet intresse. Det internationella intresset för dem manifesterades under 1960- och 70-talen i publikationer av t ex Kohlmeyer (1969, 1984) och Kohlmeyer & Kohlmeyer (1979). Under denna period beskrevs många arter, främst från marin ved (drivved eller utplacerade träskivor fungerande som beten), men även från marina alger, marina djur och marina växter, inte minst mangrove (Jones & Hyde 1988, Jones m fl 1997). Som en följd av detta har förståelsen av

de marina svamparnas roll resulterat i ny och delvis ganska sensationell kunskap och vår bild av deras roll i haven har radikalt förbättrats och förändrats, såväl med avseende på deras ekologiska betydelse som deras evolutionära historia. Några av dessa rön finner vi i publikationer av Kohlmeyer (1969, 1984), Kohlmeyer & Kohlmeyer (1979), Kohlmeyer & Volkmann-Kohlmeyer (1991), Hyde m fl (1998, 2000), Hibbett & Binder (2001), Jones m fl (1997), Hyde m fl (1998, 2000), Kis-Papo (2005), Richards & Bass (2005), Loque m fl (2010), Pang m fl (2011), Raghukumar (2012) och Singh m fl (2012). Från vårt närområde rapporterade Rämå m fl (2014) flera nya arter från Norge.

När det gäller utforskandet i svenska vatten rapporterade Erneholt (1972) i sin avhandling fyra arter av marina svampar från alger, marin ved och *Zostera* (bandtångsläktet). Den enda mer omfattande inventeringen av hyfbildande marina svampar i Sverige publicerades av Henningsson (1974). Uppsatsen koncentrerades till vedlevande arter och rapporterade 25 teleomorfa (fruktkroppsbyggande) ascomyceter och sex anamorfer ("Fungi imperfecti"). I listan över svenska ascomyceter inkluderade Eriksson (2014) 31 marina arter. Redan under tidigt 1950-tal samlade Rolf Santesson marina svampar från ved, huvudsakligen på svenska västkusten. Detta material finns bevarat i Evolutionsmuseets i Uppsala samlingar (UPS) och har delvis undersökts i föreliggande arbete. De flesta kollektionerna tillhör den intressanta marina svampfamiljen Halosphaeriaceae, som har perithecier som fruktkroppar och sporer som ofta är försedda med karaktäristiska bihang. Dessa antas ge sporer en bättre flytförmåga och underlätta att de fastnar på ett lämpligt substrat. Förutom de från Sverige kända marina svampar som växer på ved, är nio arter kända från alger, mestadels stora brunalger som *Ascophyllum*, *Fucus*, och *Laminaria*. Endast en marin basidsvamp är hittills känd från svenska vatten.

En intressant frågeställning kring de marina svamparna vi finner idag är huruvida de är överlevare från en tid då dessa utvecklades i marina miljöer (primärt marina svampar) eller har

övergått till ett liv i haven från landliv (sekundärt marina arter). Kanske inte helt oväntat tycks svaret här vara "både och"! Några grupper, t ex Halosphaeriaceae (med sina egenartade sporbihang), tycks vara primärt marina (Spatafora m fl 1998), medan andra är sekundärt marina (Kohlmeyer 1986).

De marina svamparnas ekologi

Vi är väl förtrogna med att svampar spelar en mycket viktig roll i terrestra ekosystem, men minde välkänt är att svamparna i vattenmiljöer spelar en kanske lika viktig - om inte viktigare roll. Kanske viktigare därför att vattensystem dominerar vår planet både till yta och biomassaproduktion. Liksom på land spelar de marina svamparna en huvudroll som nedbrytare av organiskt material och därmed också i kol- och syre- och näringscyklarna. Svampar har enzymatisk kompetens att bryta ned nästan alla biologiska material och även t ex spillolja, och utgör därmed en viktig städpatrull i hav och sjöar. En del av de strikt marina arterna saknas möjligen i Östersjöns brackvatten, men flera av de marina svamparna tolererar låga salthalter och utgör sannolikt även där, tillsammans med bakterier, de viktigaste nedbrytarna, vilket gör dem till såväl ekologiskt som ekonomiskt viktiga. Så har svampar t ex enzymatisk kompetens för att bryta ner både cellulosa och lignin, de viktigaste beståndsdelarna i fiberbankarna och döende växter, samt alger, inte minst efter algbloomingar. Östersjöns döda botten är ett stort ekologiskt problem där syre-bristen orsakas av syrekonsumerande nedbrytning. En del marina svampar kan dock bryta ner organiska produkter även i frånvaro av syre och de bidrar därför inte till syrereduktionen. Även organiskt avfall från jordbruket och vattenreningsverk kan brytas ned av marina svampar och de bidrar därmed till den biologiska reningen av Östersjön. Kanske finns här utrymme för att pröva 'bioremediation', biologisk rening av ekosystemen i likhet med de metoder som använts för att befria ekosystem från t ex avfall, oljespill och tungmetaller. De marina svamparnas aktiviteter är ytterligare ett exempel på oftast förbisedda ekosystemtjänster.

Marinarkeologi

Marina svampar kan i haven även vara delaktiga i från vår synpunkt mindre positiva skeenden. För marinarkeologin utgör givetvis svamparnas nedbrytning av träföremål ett hot, och så har t ex åtminstone två arter isolerats från regalskeppet Wasas skrov. Bevarandet av museiskepp och de många träföremålen från marina fyndplatser kräver kunskaper om de marina svamparnas ekologi och fysiologi.

Oceanbottnarnas myka

Det kom nog som en överraskning för många biologer att djuphavsbottnar hyser en rik myka, inte minst i närheten av vulkanisk aktivitet i plattgränserna. I dessa miljöer förekommer en mängd jästartade svampar (Bass m fl 2007), och en del av dem synes ha utvecklats från landlevande former. Detta ifrågasätter också vår traditionella syn på att djuphavsvulkaniska områden bebos av livsformer som funnits där mycket länge och är starkt isolerade från andra organismer – inte minst finns det en hypotes om att livet på vår planet uppstod där. I djuphavsbottnarnas sediment finns även många mycelbildande svampar (Burgaud m fl 2009). I dessa bottnar har man också funnit ett flertal svampar vars DNA inte liknar några av de landlevandes. De kan mycket väl vara hittills obeskrivna arter och grupper. En DNA-baserad studie (Edgcomb m fl 2011) fann att svamparna utgör en majoritet bland de eukaryota mikroorganismerna i marina bottensediment.

Lista över fynd av marina svampar

Denna studie baseras till stor del på en revision av material av vedlevande marina svampar insamlat av Rolf Santesson på 1950-talet, mest på svenska västkusten. Materialet förvaras nu på Evolutionsmuseet i Uppsala (UPS). Det består av åtskilliga kollektorer och identifierades delvis av Santesson. Det studerades inte av Henningsson i samband med hennes arbete från 1974. Ännu är materialet således opublicerat, undantaget ett fåtal fynd som har tagits med i Erikssons förteckning av svenska ascomyceter (Eriksson 2012). När Santesson samlade materialet var kunskapen om marina

vedlevande svampar ganska fragmentarisk och de identifieringar som Santesson gjorde förefaller kanske i efterhand en smula förhastade och schematiska. Namnsättningen tycks ofta ha baserats endast på peritheciernas stormorfologi. Oftast har materialet identifierats som *Ceriosporopsis*, *Peritrichospora integra* (= *Corollospora maritima*) eller *Halosphaeria appendiculata*. Understudium blev jag en smula besviken vid studiet av Santessons material då inga fertila fruktkroppar kunde hittas. Detta må ha berott på att materialet ursprungligen var mycket sparsamt så att inte mycket återstod efter Santessons undersökningar. Det kan också hänga samman med en förmodad kort och årstidsberoende sporulationstid. Tomma fruktkroppar sitter kvar ganska länge och kan hittas med endast en handlupp. Materialet har kanske ibland samlats men sedan ej undersökts mikroskopiskt och fått utgöra en kollekt och alltså måhända varit utan sporer redan vid insamlings-tillfället.

Artlistan ger ny information om förekomst, utbredning, namngivning och ekologi för marina svampar i Sverige. Det har utförts inom projektet 'MARFUS - Marine Fungi of Sweden' som stötts av ArtDatabanken. Ett fåtal kollektorer från Danmark samlade av Santesson har också inkluderats.

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Sanja är forskare vid Uppsala universitet och har disputerat på lavars fylogeni och taxonomi (Verrucariaceae). Numera omfattar hennes forskning även icke-licheniserade svampar, basid- och sporsäckssvampar - med en koncentration på marina svampar. Denna senare forskning stöds av ett anslag från ArtDatabanken.

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New records of marine fungi from Sweden

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ABSTRACT

A review of the currently strong interest in marine fungi is presented and the scarcity of records from Swedish waters is noted. New records of filamentous marine fungi resulted both from the revision of material collected by Rolf Santesson in the mid-20:th century and identifications via sequencing. In all 18 species from Sweden and two further species from Denmark are reported on. *Corollospora borealis* and *Amphitrite annulata* are described as new and further records of five species new to Sweden and records extending the known distributions are given.

Introduction

In spite of a strongly increased interest in them during the recent decades, marine fungi are poorly known as compared to the terrestrial ones. We have since long known that fungi have a key role in terrestrial ecosystems, both as degraders, symbionts and parasites. Terrestrial fungi are sensitive to draught and UV radiation. For water living fungi these ecological aspects are not a problem. Water is their medium and it also offers good UV protection. During the 20:th century a considerable diversity of fungi was demonstrated to occur in fresh water. In fresh water the fungi have similar ecological roles as on land. Only in the latter part of the century it was shown that there is also a rich diversity of fungi in the oceans. Like terrestrial fungi, marine fungi are important components in their ecosystems and have similar roles as terrestrial fungi, not least on the ocean floor. Given the phylogeny of the fungi this is perhaps not so surprising, since early fungal lineages, like the Chytridiomycota, mostly occur in water including in the oceans. Chytrids have been found as fossils back to early Devon in the Rhynie chert deposit and possibly form the sister group to a clade containing ascomycetes, basidiomycetes and zygomycetes. They have a flagellum and live mostly in water, fresh water as well as in the oceans. The interest in marine fungi increased

dramatically during the 20:th century and gradually the focus shifted from early investigations of fungi on wood and plant remains to their occurrence in algae, marine sponges (Höller et al. 2000, Rozas et al. 2011), mussels (Grovel et al. 2003) and sediments. Thus Zuccaro et al. (2008) reported no less than 45 marine fungi from just one species of brown algae, *Fucus serratus*, and the parallel to the occurrence of fungal endophytes in land plants is obvious. Even deep bottom sediments have been shown to harbor a rich diversity of fungi (Edgcomb et al. 2011). The number of species of marine fungi has been summarized to about 550 by Jones (2011), but at the same time he estimated that this is just a small proportion of the total number of species, that he estimated to some 10.000.

Although mycology in Sweden has a long and rich history, comparatively little interest has been devoted to the marine fungi. The international upsurge in interest in marine fungi was manifested in the 60ies and 70ies by publications i.e. by Kohlmeyer (1969, 1984), Kohlmeyer & Kohlmeyer (1979). Several species were discovered and described as new, particularly from marine wood (driftwood or baiting panels) but also from algae, marine animals and plants, not least mangrove (Jones & Hyde 1988, Jones et al. 1997). During the past few decades, and partly facilitated by the advancement of molecular methods,

the interest in marine fungi has increased strongly and rather sensational results have emerged as to the role of fungi in the oceans. These findings have very much altered our view, both of the ecological importance and evolutionary history of marine fungi, see for example Kohlmeyer (1969, 1984), Kohlmeyer & Kohlmeyer (1979), Kohlmeyer & Volkmann-Kohlmeyer (1991), Hibbett & Binder (2001), Jones et al. (1997), Hyde et al. (1998, 2000), Kis-Papo (2005), Richards & Bass (2005), Loque et al (2010), Pang et al. (2011), Raghukumar (2012) and Singh et al. (2012). Rämä et al. (2014) reported several new species from Norway.

From Sweden, Erneholt (1972) in a dissertation reported four species of marine fungi, from algae, wood and *Zostera*. The only more comprehensive paper on marine fungi from Swedish waters was published by Henningsson (1974). Here was a concentration on wood-inhabiting species, and 25 teleomorphic ascomycetes and six anamorphs ('fungi imperfecti') were reported. In a list of Swedish ascomycetes (Eriksson 2014) 31 species of marine fungi were included. Earlier on, already in the fifties, Rolf Santesson collected marine fungi on wood mainly from the Swedish west coast. These collections are kept in the Botanical museum in Uppsala (UPS) and have partly been re-investigated in this study. Most belong to the interesting marine family Halosphaeriaceae. The fruit bodies are perithecia and in this family the spores are often provided with characteristic appendages supposed to render the spores a better buoyancy and also to facilitate their adherence to wood. Nine species of marine fungi have been reported to grow on algae, mainly on large, brown algae like *Ascophyllum*, *Fucus*, and *Laminaria*. Only one basidiomycete is known from Swedish waters.

One interesting question pertains the evolution of the marine fungi – are the marine fungi we find today survivors from a time when these fungi evolved in a marine habitat (i. e. 'primary marine fungi') or have they secondarily colonized the seas from land ('secondary marine fungi')? Not unexpectedly the answer seems to be both and! Some groups, for example Halosphaeri-

aceae (with their unusual appendages) seem to be 'primary marine' (Spatafora et al. 1998), whereas others seem to be secondarily marine (Kohlmeyer 1986).

The ecology of marine fungi

As we know fungi play an important role in terrestrial ecosystems, but their importance in aquatic environments may well be comparable. Also here perhaps mainly as degraders tidying up organic matter in the ecosystems and releasing nutrients for recirculating. Fungi have the ability to degrade almost all organic matter, even oil spill, and may thus work tidying up also in the oceans. In the Baltic some species adapted to ocean water are probably lacking because of the low salinity, but even here marine fungi (many of them tolerant to low salinities) along with bacteria may well be the most important degraders and thus both ecologically and economically quite important. Ecologically because fungi have the enzymatic competence to degrade leftovers from the pulp mill industry and decaying algae originating from algal blooms. 'Dead bottoms' with oxygen depletion is a major and rapidly increasing problem in the Baltic, but interestingly some marine fungi have the ability to occur even under anoxic conditions. Also organic emissions from agriculture and water management plants may be degraded by fungi. Economically because the purifying the water of the Baltic is an enterprise that already today costs enormous amounts of money and in situ bioremediation using marine fungi is a still unexplored (but possibly comparatively cheap) opportunity. The activity of the fungi is thus a good example of an unquantified and neglected but important ecosystem service.

Marine archeology

Marine fungi are also interesting for the area of marine archeology. Thus were two species isolated from wood of the Swedish warship 'Wasa' that went down in Stockholm in 1628. This ship is now in a museum and the rescue and preservation of it and other sunken wood artifacts require knowledge about the marine fungi.

Fungi of the ocean floors

It came as a surprise that deep sea bottoms of the oceans harbor many marine fungi, not least in the vicinity of volcanic activity. Here many yeast-like fungi are found (Bass et al. 2007), and some of them seem to be derived from terrestrial lineages, questioning the assumption that deep-sea vents hold an ancient and isolated biota. Many mycelial fungi have also been found in deep sea bottoms (Burgaud et al. 2009). It is also interesting that in these bottoms several fungi were found for which no similar DNA-sequences are known. They may thus represent undescribed taxa. Another DNA-based study (Edgcomb et al. 2011) found fungi to form a majority among the eukaryotic microorganisms of marine bottom sediments.

List of records

This study is to a large extent based on a revision of a material of mainly wood-inhabiting marine fungi made by Rolf Santesson in the 1950ies and kept in the Uppsala herbarium (UPS). The material included many collections and they were given preliminary identifications by Santesson. It was not included in the treatment by Henningsson (1974) and also not elsewhere. It has so far remained unpublished. The knowledge of the marine fungi at the time when Santesson collected and identified the material was still rather fragmentary and the identifications by Santesson in hindsight often seem a bit careless and schematic, possibly identifications were made only from gross perithecium morphology. The collections were most often identified as *Ceriosporopsis*, *Peritrichospora integra* or *Halosphaeria appendiculata*. My investigations of the material were sometimes a bit disappointing since no sporulating ascomata could be found. This might depend on scarcity of material in the original collection, so that little or no material remained after the initial investigation. It might further be caused by short sporulation periods associated with seasonality. Since the empty ascomata remain and may be detected with a hand-lens, the material might have been collected after just a macroscopic discovery of ascomata.

The list below includes new information on the distribution, nomenclature and ecology of marine filamentose fungi of Sweden. It is part of the project 'Marine fungi in Sweden (MARFUS)', supported by the Swedish Species Initiative. A few Danish collections by Santesson have also been appended.

Amphitrite annulata S. Tibell, sp. & gen. nov.
- Fig. 1

Mycobank nrs MB 817492, MB 817480.

Etymology: *Amphitrite* is the name of a sea-goddess; *annulata* refers to the ring-shaped spore ornamentation.

Ascomata (fig. 1A, B) 140 – 195 µm in diameter, globose to subpyriform, superficial, black, solitary, ostiolate, on driftwood. Ascoma wall (fig. 1C) 15 – 20 µm thick, consisting of an inner pale part formed by 5 – 7 layers of strongly flattened, hyaline, thick-walled concentrically arranged cells, the outermost, blackish brown part is formed by 1 – 2 layers of elongated hyphae that connect with a dark surrounding tissue reaching into the substrate, surrounding tissue consisting of branched and intertwined hyphae, ostiolum central. Asci eight-spored, thin-walled, ellipsoidal, 52 – 68 x 16 – 19 µm with spores 2 – 3-seriately arranged; spores at maturity ellipsoid, 1-septate, 18 – 21 x 5.5 – 8 µm, hyaline, with rounded apices without spines and appendages, a 1 – 2 µm thick ring-like collar encloses the spore at the septum, the collar is strongly light refractive, and seems to be located within the outer surface of the spore wall.

Sweden: **Bohuslän**, SKAFTÖ, Kristineberg, (S)W side of Blåbärsholmen, on driftwood (oak) in a dark crevice 20 – 30 cm above mean water level, 1955-07-04 Santesson 10870 (holotype, UPS), as *Halosphaeria appendiculata*.

No young or semi-mature ascomata were found and the description is therefore in this respect incomplete. This, and the lack of molecular information, makes the placing of the genus difficult. Many of the marine filamentous ascomycetes belong in Halosphaeriaceae, where a variety of spore appendages occur. Some genera have ap-

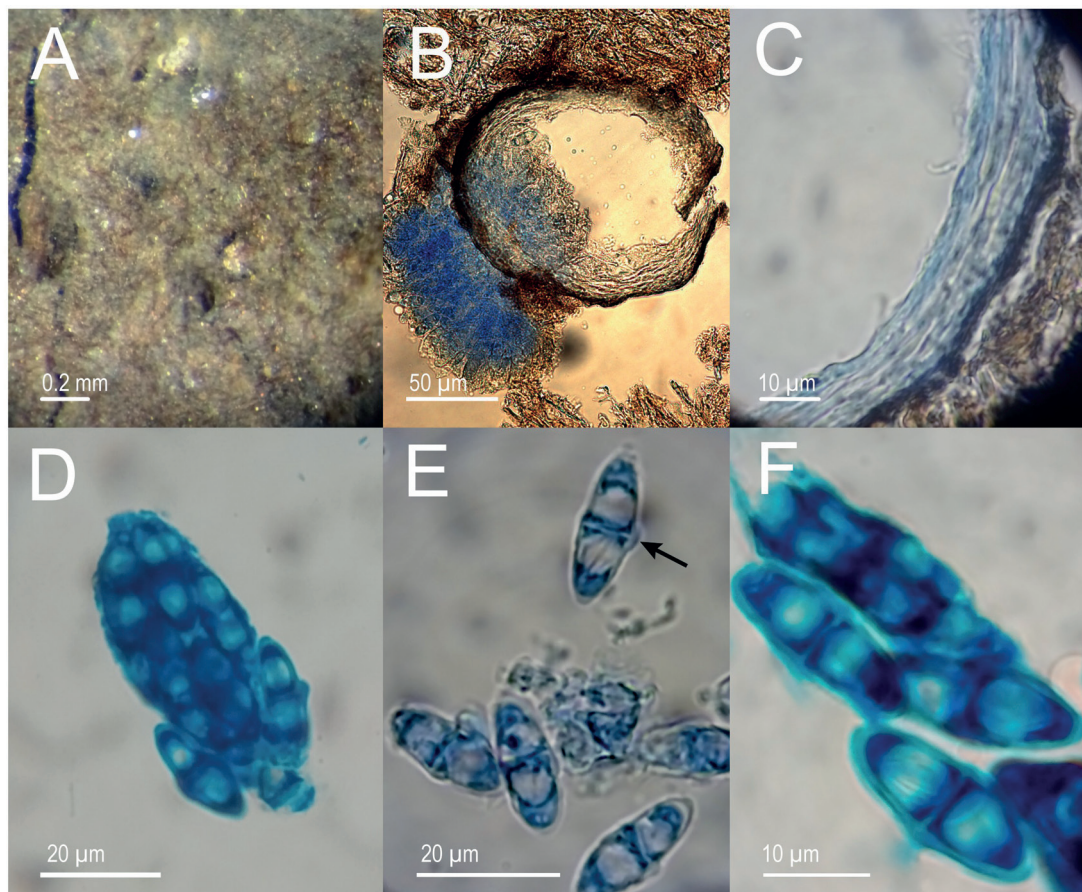


Fig. 1. *Amphitrite annulata*. A. Ascomata on driftwood. B. Section of perithecium. Hamathecium partly inverted and positioned in the lower left corner of the figure. C. Perithecium wall. D. Ascus with semi-mature spores and two spores with annulus adhering to it. E–F. Mature spores released from asci. The annulus is indicated with an arrow in Fig. E. A–C: Holotype. D–F: Santesson 12934.

pendages at the median septum, but they are, e.g. in *Corallospora*, formed in a very distinctive ontogenetic process and/or are morphologically characteristic and quite different from the ring of *Amphitrite*. An annular appendage is, however, found in *Ondiniella torquata* (Kohlm.) E.B.G. Jones, R.G. Johnson & S.T. Moss, but this species differs in having apical spines. Spore morphology would thus give an indication for placing *Amphitrite annulata* in *Ondiniella*, but in the absence of molecular data this is just a tenuous speculation.

Further material studied: **Bohuslän**, SKAFTÖ, Kristineberg, SW side of Blåbärsholmen, on driftwood (oak) in a dark crevice 20 – 30 cm

above mean water level, 1955-07-04, Santesson 10869 (UPS), as *Halosphaeria appendiculata*; Buholmen N of Gåsö, on driftwood, 1959-08.13, Santesson 12934 (UPS), as *Ceriosporopsis halima*.

Amylocarpus encephaloides Curr.

Bohuslän, SKAFTÖ, Kristineberg, Råttholmen, on driftwood below present mean-water level, 1953-08-01, Santesson (UPS), confirmed. Recorded by Henningsson (1974: 411) from Öland and Ångermanland. Eriksson (2014) further mentions it from Västerbotten. New to the Swedish West coast.

Calycina marina (Boyd) Rämä & Baral

Gotland, FÄRÖ, Digerhuvud, sea shore, on *Fucus vesiculosus*, 1994-06-11 leg. & det. O. Eriksson (UPS), confirmed; VÄSKINDE, Skälsö, sea shore, on *Fucus vesiculosus*, 1994-06-10, leg. & det. O. Eriksson (UPS), confirmed. First reported from Sweden by Eriksson (1973) as *Orbilina marina*, later (Eriksson 2014) as *Laetenevia marina* (Boyd) Spooner. Included in *Calycina* by Baral & Rämä (2015).

***Corollospora borealis* S. Tibell, sp. nov. - Fig. 2**
Mycobank nr. MB 817481.

Etymology: *borealis* refers to northern.

Ascomata (fig. 2A, B) 300 – 440 µm in diameter, globose to subglobose, superficial, black,

solitary, ostiolate, on driftwood. Ascoma wall (fig. 2C) 15 – 24 µm thick, consisting of an inner pale part formed by 3 – 5 layers of strongly flattened, polygonal or irregularly rounded, thick-walled concentrically arranged cells, outer layer forming a dark brown textura angularis (fig. 2C). A mid-part is formed by 2 – 3 layers of shorter, dark brown cells c. 2 – 3 µm diam. The outermost part consist of 2 – 7 layers of pale brown, elongated hyphae that individually or in bundles partly reach out into the surrounding substrate and merge with the black subiculum. Ostiolum (fig. 2D) central, c. 16 µm wide at the base and narrowing to c. 10 µm at the top, c. 20 µm high, at the base with a dark separation layer a few hyphae thick; asci (fig. 2E) eight-spored, thin-walled, ellipsoidal, 104 – 140 x 20 – 25 µm with

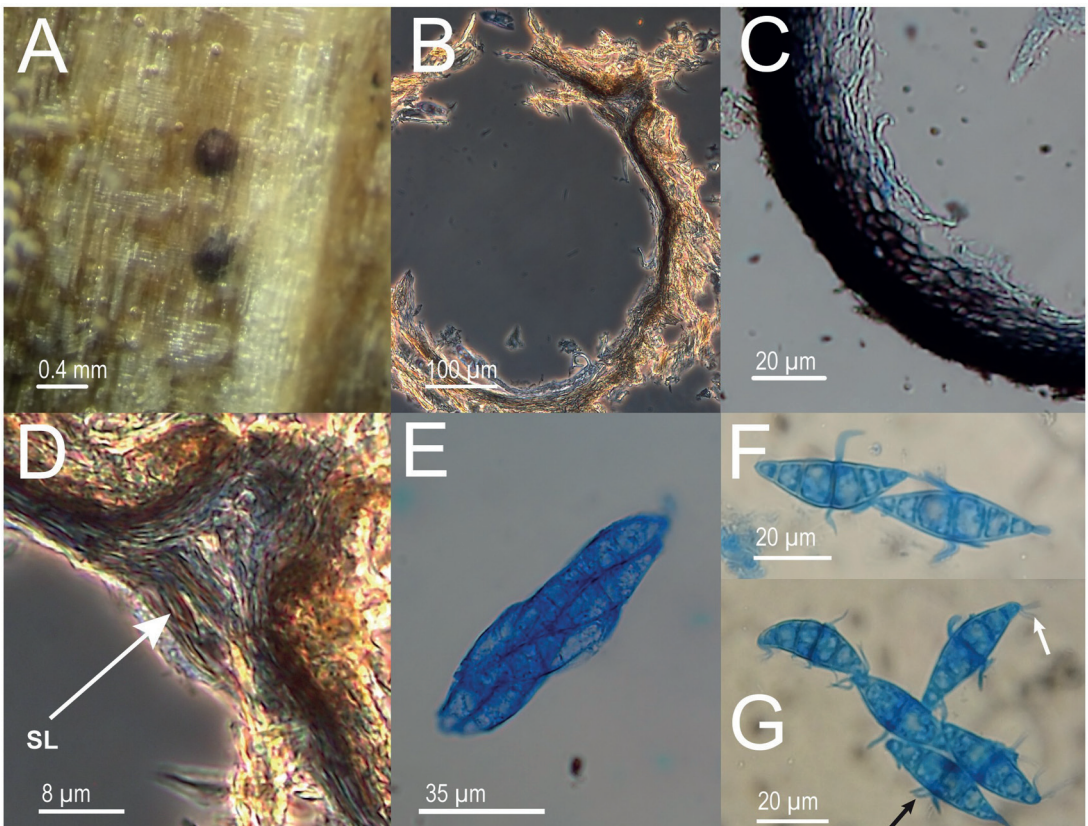


Fig. 2. *Corollospora borealis*. A. Ascomata on driftwood. B. Section of perithecium. C. Perithecium wall. Note the textura angularis as seen in surface view of the upper surface of the section. D. Ostiolum, note the separation layer (SL). E. Ascus. F–G: Mature spores with meridional (black arrow) and apical (white arrow) appendages. A–G: Holotype.

2-3-seriately arranged spores; spores (Fig. 2F) at maturity fusiform, 5-septate, 33 – 44 x 8 – 11 μm , hyaline, without constrictions at septa; cells adjacent to the median septum distinctly enlarged as compared to the penultimate cells, without spines formed from the spore wall, but with usually two, sometimes just one or three appendages at the spore apices and the central septum surrounded by two whirls of flattened appendages formed by the recurved fragments of the exospore; semi-mature spores with a distinct longitudinal striation delimiting the parts of the exospore that later will split up and release the recurring appendages.

Sweden: **Bohuslän**, SKAFTÖ, Kristineberg, Blåbergsholmen, in the S part of the island (Humerhållet), on driftwood in dark crevice, 10 – 30 cm above the mean-water level, 1956-10-09, Santesson 11510 (holotype, UPS), as *Nereiospora comata*.

Further material examined: **Bohuslän**, SKAFTÖ, Islandsberg, on driftwood below big boulders, c. 50 cm above mean-water level, 1955-07-08, Santesson 10897 (UPS), as *Peritrichospora integra*.

Corollospora has spores provided with appendages formed from a fragmented exospore and the genus was recently found to be monophyletic in a molecular phylogeny (Sakayaroj et al. 2011). Most species in *Corollospora* have non-pigmented spores provided with spines as extensions of the spore wall. The exospore fragments rather close to the end cell into ribbon-like fragments that recurve in two directions: towards the median septum and the apices of the cell. Thus the septum is ornamented by two sets of skirt-like fragments and the apices with an exospore remain that is sometimes inverted to form a tube-like ornament or several shorter ribbons. This ontogeny was well described and illustrated by e.g. Kohlmeyer & Volkmann-Kohlmeyer (1987). Further notes on and illustrations of *Corollospora* were provided by Hsieh (2004). *Corollospora borealis* has no spines, but both apical and equatorial ornaments occur, and in semi-mature spores the longitudinal striation indicates the outlines of the developing ribbon

ornamentations. Thus *C. borealis* displays the spore ontogeny characteristic of *Corollospora*. No young or semi-mature ascomata were found and the description is therefore in this respect incomplete. In connection with the description of *Corollospora armoricana* Kohlm. & Volkm.-Kohlm., a distinctive structure at the base of the ostiolum named ‘separation layer’ was described and illustrated (Kohlmeyer & Volkmann-Kohlmeyer 1989b). The authors also suggested this structure to be characteristic of *Corollospora* and to be included in an emended description of the genus. A separation layer (SL) was also observed in *C. borealis* (Fig. 2D).

Among the species without spines the following species all have quite large spores (> 50 μm long): *C. colossa* Nakagiri & Tokura, *C. filiformis* Nakagiri, *C. luteola* Nakagiri & Tubaki, *C. pseudopulchella* Nakagiri & Tokura and *C. pulchella* Kohlm., I. Schmidt & N.B. Nair. Of these only *C. luteola* has 5-septate spores, the other species mentioned have more than five septa. The spores of *C. borealis* are somewhat similar to those of *C. lacera* (Linder) Kohlm., but the latter differs in having pigmented cells adjacent to the central septum and also in having spores provided with rather long spines. A review of *Corollospora* was given by Hsien (2004).

Corollospora maritima Werderm.

Bohuslän, SKAFTÖ, 1.5 km SE of Grundsund, Islandsberg, on driftwood in the *Verrucaria maura* zone, 1955-07-06, Santesson 10892 (UPS), two collections, confirmed, as *Peritrichospora integra* and *C. maritima*; Skällholmen, N of Tjällsö, on driftwood (cork) in a dark and deep crevice, 40 – 60 cm above the mean-water level (coast very exposed), 1955-07-30, Santesson 11031 (UPS), confirmed, as *P. integra*; Islandsberg, on driftwood below big boulders, c. 50 cm above mean-water level, 1955-07-08, Santesson 10900 (UPS), confirmed, as *P. integra*; Usholmen (Ullsholmen), on grain of sand in a piece of driftwood in a crevice about 20 – 30 cm above mean-water level, 1955-07-19, Santesson 10948, confirmed, as *P. integra* (UPS); Kristineberg, in the harbor of the Zoological Station, on a test

board, c. 40 – 50 cm below mean water level, 1955-08-03, Santesson 11056b, confirmed, as *P. integra* (UPS); In the harbor of the Zoological Station, on a test board of oak, ca 15 cm below the mean-water level, 1956-10-08, Santesson 11539, 11544 (UPS), confirmed, both as *P. integra*; Kristineberg, S side of Blåbärsholmen, on driftwood in a crevice, 20 – 30 cm above the mean-water level, 1955-07-05, Santesson 10871 (UPS), confirmed, as *P. integra*.

Recorded by Henningsson (1974: 413) from Skåne and Bohuslän. In one of the specimens perithecia were formed on minute sand grains attached to a piece of driftwood. Several species of marine fungi (the arenicolous marine fungi) are known to occur like this, and some seem to develop ascomata only on sand grains in contact with wood, e.g. *Arenariomyces*, and *Lulworthia lignoarenaria* mentioned below. Although several species in *Corollospora* are sand-dwelling (Jones et al. 2009) in *C. maritima* occurrence on sand grains is facultative and seems to be rather rare.

Didymella fucicola (G.K. Sutherl.) Kohlm.

Bohuslän, SKAFTÖ, northern part of Blåbergholmen, on *Fucus vesiculosus*, 1953-05-14, Santesson 10017 (UPS), confirmed; Kristineberg, Råttholmen, in the uppermost part of the *Fucus vesiculosus* belt, in *F. vesiculosus*, 1953-08-06, Santesson (UPS), confirmed.

The spores of these collections differ slightly from the illustrations and description in Kohlmeyer & Volkman-Kohlmeyer (1991). They are neither asymmetric nor constricted at the septum. They are also quite narrow and the collections thus may represent an undescribed species. Recorded from Bohuslän by Eriksson (2014).

Halokirschsteiniothelia maritima (Linder) Boonmee & K.D. Hyde

Bohuslän, SKAFTÖ, Kristineberg, in the harbour of the Zoological Station, on a test board of oak, ca 5 – 40 cm below the mean-water level, 1956-10-08, Santesson 11525, 11570, 11572 (UPS), as *Peritrichospora integra*, *Leptosphaeria oraemaris* and *Ceriosporopsis halima* respectively

and also Santesson 1955-03-06, 11063 (UPS) as *Leptosphaeria oraemaris*; Dragsmark, Lindholmen, on driftwood, 1955-07-22, Santesson 10966b, as *Nereiospora comata*; Kristineberg, between Smalsund and Gåsevik, on driftwood in a crevice about 30 – 50 cm above the mean-water level, 1955-07-14 Santesson 10924 (UPS), as *Halosphaeria appendiculata*. **Gotland**, GAMMELGARN, Sandviken, on driftwood, 2013-08-15 S. Tibell 2013/8. (UPS). Earlier known from Bohuslän and Skåne (Eriksson 2014). New to the Swedish East Coast.

Leptosphaeria orae-maris Linder

Bohuslän, SKAFTÖ, Kristineberg, in the harbor of the Zoological Station, on test board of oak, 1956-10-08, Santesson 11557 (UPS), confirmed. Reported by Henningsson (1974) from Skåne, Bohuslän, Södermanland and Ångermanland.

L. pelagica E. B. G. Jones

Bohuslän, SKAFTÖ, Kristineberg, in the harbor of the Zoological Station, on test board of oak 0 – 10 cm below the mean-water level, 1956-10-08 Santesson 11529 (UPS), as *Ceriosporopsis halima*. As noted by Kohlmeyer & Volkman-Kohlmeyer (1991), 4-septate spores occur along with the more frequent 3-septate ones. New to Sweden.

Leucosporidium scottii Fell, Statzell, I. L. Hunter & Phaff

Uppland, VÄDDÖ, Nothamn, among stranded brown algae, 2014-12-02, S. Tibell 2014/15.

Several isolations from decaying brown algae yielded cultures of this basidiomycetous yeast. The cultures were thin, pale and irregular. Nine (9) isolations of total DNA and amplification with ITS1f /ITS4 and LROR/LR5 yielded nine nuITS sequences and three nuLSU sequences that were blasted against GenBank sequences. A nuITS sequence from GenBank (AF444496) of *L. scottii* was obtained as a best match (coverage and identity of 100% for all nine nuITS sequences). Interestingly, the source of the sequence of *L. scottii* from GenBank was Strain No CBS 5932 (origin: Antarctica, sea-water, at depth 155m,

salinity 34,6%, temp. 2.6°C). The best match for nuLSU was GenBank AY646098.1 (coverage and identity of 100% for all three nuLSU sequences); source: Strain No CBS 614, with origin from soil, near meatworks, Queensland, Australia.

Two sequences have been submitted to GenBank under the numbers **KX452944** (nuITS), **KX452945** (nuLSU). *Leucosporidium scottii* is a widely distributed yeast, reported as psychrophilic (cold-adapted) in marine habitats (in Sweden the material was collected in December 2014), particularly in association with brown algae, and has been reported e.g. from Norway, Germany, the Netherlands, North America, Australia, New Zealand and Antarctica. New to Sweden.

Lignincola laevis Höhnk

Bohuslän, SKAFTÖ, Kristineberg, between Smalsund and Gåsevik, on driftwood in a crevice about 30 – 50 cm above the mean-water level, 1955-07-14, Santesson 10925 (UPS), as *Halosphaeria appendiculata*; SKAFTÖ, 1.5 km SE of Grundsund, Islandsberg, on driftwood in the *Verrucaria maura* zone, 1955-07-06, Santesson 10892, as *Corollospora maritima* (UPS); Kristineberg, S. side of Blåbärsholmen, on driftwood, 1955-07-05, Santesson 10873, 10876 (UPS), as *Peritrichospora integra* and *Ceriosporopsis halima* respectively; Blåbergsholmen, on driftwood, 1959-08-11, Santesson 12894 (UPS), as *C. halima*; Kristineberg, in the harbor of the Zoological Station, on test board of oak, 1956-10-08, Santesson 11526, as *C. halima*; Gåsö, on the NW side of Tjällsö (c. 4 km W of Kristineberg), on driftwood, 1959-08-16, Santesson 12941, as *Ceriosporopsis*. **Gotland**, GAMMELGARN, Sandviken, on driftwood, 2013-08-15 S. Tibell 2013/6 (UPS). **Småland**, DÖDERHULT, near the mouth of River Emån, 1957-07-16, Santesson 12027 (UPS), as *Ceriosporopsis*. Reported by Henningsson (1974: 418) from Skåne, Bohuslän and Södermanland. New to Gotland.

Lulwoana uniseptata (Nakagiri) Kohlm., Volkm.-Kohlm., J. Campb., Spatafora & Gräfenhan

Bohuslän, SKAFTÖ, Skällholmen, (anamorphic material, i.e. '*Zalerion maritima*'), N. of Tjällsö, on driftwood in a crevice, 40 – 50 cm above the mean-water level, 1955-07-30, Santesson 11034 (UPS), as *Peritrichospora integra*; Skällholmen, on driftwood below boulders, 20 – 30 cm above mean-water level, 1955-08-30, Santesson 11028b (UPS) as *Ceriosporopsis halima*.

This is the teleomorph (sexual stage) of *Zalerion maritima* (Linder) Anastasiu. Parallel names for anamorphs have been abolished and hence the name *L. uniseptata* has to be used. The connection between *Zalerion maritima* and *L. uniseptata* was provided by Nakagiri (1984). The anamorphic stage (*Zalerion*) was first reported from Sweden by Gustafsson & Fries (1956). Henningsson (1974) mentioned the occurrence in 13 localities. The teleomorph *L. uniseptata* has as yet not been reported from Sweden.

Lulworthia longirostris (Linder) Cribb & J.W. Cribb

Bohuslän, SKAFTÖ, Kristineberg, in the harbour of the Zoological Station, on a test board of oak, ca 5 – 40 cm below the mean-water level, 1956-10-08 Santesson 11532, 11533, 11534 (UPS), all as *Peritrichospora integra*; Kristineberg, in the harbour of the Zoological Station, on a test board c. 20 – 40 cm below mean water level, 1956-10-08, Santesson 11540 (UPS) as *Peritrichospora integra*. New to Sweden.

The Swedish material has longer spores (280 – 460 µm) than indicated in the original description (155 – 200 µm). The long, protruding necks of this species are quite striking and make it easy to spot. The necks are often 2 – 3 times as long as the perithecia. A variation in neck length has often been observed in *Lulworthia* and the importance of this feature as a species characteristic has been questioned (Meyers 1957). The difference in spore length may indicate that our material belongs to a different species, but given the problems of morphological identification in *Lulworthia* this remains an open question until sequence data become available.

Lulworthia medusa (Ellis & Ever.) Cribb & J.W. Cribb

Bohuslän, SKAFTÖ, Kristineberg, in the harbor of the Zoological Station, on test board of birch, 50 – 60 cm below the mean-water level, 1955-08-06, Santesson 11061 (UPS), as *Ceriosporopsis halima*; Kristineberg, in the harbour of the Zoological Station, on a test board of oak in mean-water level, 1960-02-10, Santesson 13668 (UPS), as *L. floridana*; Kristineberg, in the harbor of the Zoological Station, on test board of oak, c. 83 cm below mean-water level, 1956-10-08, Santesson 11500 (UPS), as *Ceriosporopsis halima*; Kristineberg, the NE side of Blåbärsholmen, on driftwood in a crevice about 20 – 30 cm above the mean water level, 1955-07-13 Santesson 10918 (UPS), as *Ceriosporopsis halima*; East of small islet N of Tjällsö, on driftwood in very deep and dark crevice, 10 – 20 cm above mean-water level, 1955-07-25, Santesson 10990 (UPS), as *Lulworthia opaca*; Usholmen (Ullsholmen), on driftwood in a deep crevice about 10 – 30 cm above mean-water level, 1955-07-19, Santesson 10943 (UPS), as *Halosphaeria appendiculata*; Islandsberg, on driftwood below big boulders, c. 30 cm above mean-water level, 1955-07-06, Santesson 10885 (UPS), as *Ceriosporopsis halima*.

The identification here is tentative. *Lulworthia* species are hard to identify by morphological features (Kohlmeyer & Volkmann-Kohlmeyer 1989, Campbell et al. 2005) and we most probably need molecular markers for a safe identification. *Lulworthia medusa* has earlier been reported from Sweden (Bohuslän and Ångermanland by Henningson 1974: 418, observing spores up to 280 µm long), but the material studied here differs from the original description (200 – 400 µm) in having longer spores in the range of 390 – 500 µm. The material (Santesson 10990) recorded as *L. opaca* (Linder) Cribb & J.W. Cribb by Eriksson (2014) is here considered to belong to *L. medusa*.

Naïs inornata Kohlm.

Bohuslän, SKAFTÖ, Buholmen (Lilla Buholmen), on driftwood, 1955 Santesson 11021 as *Halosphaeria appendiculata*, UPS; Kristine-

berg, in the harbor of the Zoological Station, on oak wood just above the mean-water level, 1955-08-11, Santesson 11093 (UPS), as *Peritrichospora integra*; Kristineberg, the NE side of Blåbärsholmen, on driftwood in a crevice about 20-30 cm above the mean water level, 1955-07-13 Santesson 10918 (UPS), together with *Lulworthia medusa*. (see above), as *Ceriosporopsis halima*; Buholmen (Lilla Buholmen NE of Tjällsö), on driftwood of oak in a crevice 20 – 30 cm above the mean-water level, 1955-07-30, Santesson 11038 (UPS), as *H. appendiculata*; Gåsö, NW side of Tjällsö, on driftwood, 1959-08-16, Santesson 12940 (UPS), as *Ceriosporopsis*. New to Sweden.

The spores have a diffuse and irregular gelatinous coat surrounding the spore. This appendage is best visible in Indian ink, and seems previously to have been overlooked.

Piricauda pelagica T. Johnson

Bohuslän, SKAFTÖ, Kristineberg, Råttholmen, on driftwood, 1959-08-1, Santesson 12910 (UPS), as *Ceriosporopsis*. The record refers to the anamorph [*Monodictys pelagica* (T. Johnson) E.B.G. Jones], a synonym of *P. pelagica*. Recorded by Henningson (1974: 411) as *M. pelagica* from 13 localities. The teleomorph has not been reported from Sweden.

Saagaromyces glitra (J.L. Crane & Shearer) K.L. Pang & E.B.G. Jones

Bohuslän, SKAFTÖ, Blåbergsholmen, Hummerhålet, on driftwood, 1959-08-16, Santesson 12946 (UPS), as *Ceriosporopsis halima*. New to Sweden.

Sphaerulina orae-maris Linder

Bohuslän, SKAFTÖ, Kristineberg, in the harbour of the Zoological Station, on a test board, c. 60 – 80 cm below the mean-water level, 1956-10-08, Santesson 11542 (UPS), as *Peritrichospora integra*; Kristineberg, and on test board of oak, 1956-10-08, Santesson 11571b (UPS), as *Lepetosphaeria oraemaris*; Buholmen (Lilla Buholmen), driftwood, 1955-07-25, Santesson 10983 (UPS), as *Nereiospora cristata*; V. Gåsö, N point

of Tjällsö, on driftwood, 1955-07-28, Santesson 11012, 11016 (UPS), as *N. cristata* and *Halosphaeria appendiculata* respectively.

This species was not included by Henningsson (1974), but Eriksson (2014) recorded it from Skåne and Bohuslän.

Enclosed some further records from Denmark from Santesson's collections that were noted:

Corollospora maritima Werderm.

Denmark, **Jylland**, W om Örnbjerg, c. 7 km SW of Lökken, on sand attached to a piece of driftwood (oak) on the sandy seashore (reached by storm waves), 1956-07-23, Santesson 11420 (UPS), confirmed, as *Peritrichospora integra*.

Lulwoidea lignoarenaria (Jørg. Koch & E.B.G. Jones) Kohlm., Volk.-Kohlm., J. Campb., Spatafora & Gräfenhan

Denmark, **Jylland**, W om Örnbjerg, c. 7 km SW of Lökken, on sand attached to a piece of driftwood (oak) on the sandy sea shore (reached by storm waves), 1956-07-23, Santesson 11418b (UPS), as '*Arenariomyces trifurcatus*' Höhnk. Originally described from Denmark as *Lulworthia lignoarenaria* Jørg. Koch & E.B.G. Jones.

Lignincola laevis Höhnk

Denmark, **Jylland**, Skagen, on driftwood among big boulders, 1956-07-25, Santesson 11432 (UPS), as *Halosphaeria appendiculata*; NE of Hulsig, c. 10 km SW of Skagen, on driftwood, 1956-07-18, Santesson 11371 (UPS), as *Peritrichospora integra*.

Nereiospora comata (Kohlm.) E.B.G. Jones, R.G. Johnson & S.T. Moss

Denmark, **Jylland**, Skagen, Nordstranden, on driftwood, 1956-07-21, Santesson 11398 (UPS), confirmed.

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