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LIGNOTROPHIC BASIDIOMYCETES FROM PIONEERING MICROSITES IN BOREAL FORESTS OF THE WHITE SEA REGION

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Observations of lignotrophic basidiomycetes in chronically pioneering microsites in boreal forests of White Sea Region (North European Russia) reveal some causal and sporadically distributed species, namely *Niemelaea consobrina*, *Hyphoderma roseocremeum*, *Peniophora junipericola*, *Thelephora caryophyllea*, *Xanthoporus syringae*. The morphology, substrate preferences and the distribution of the species revealed are discussed in the connection with community characteristics.

Key words: boreal forests, North European Russia, pioneering microsites, lignotrophic basidiomycetes, sporadic species.

The forests dominating in boreal placores are characterized by rather rigid coenological environment which blocks an invasion of irradiating species and species assemblages. They dominated monotonously by 1–3 stand-formers of maximum age differentiation and exist in thin balance with surrounding mires (Fedorchuk et al., 1998; Zmitrovich, 2011). Within a non-placore environments (alluvial and diluvial processes, sandy and stone substrates) some elements of forest mosaics are characterized by dynamic updating – a «chronically pioneering» microsites are reproducing here. These microsites can give a shelter to species and species complexes rejected by placore communities. All aforementioned is quite applicable to lignotrophic basidiomycetes, the group of fungi bearing considerable ecosystem loading. These fungi are incorporated into all the stages of wood humification and humus degradation with production of fulvic acids; some species are capable to ectomycorrhizal formation (Zmitrovich et al., 2014).

In forest ecosystems of European Russian North the pine forests of Cladonio-Pinetum boreale and Arctoparmelio-Cladino-Pinetum types are rich by "chronically pioneering" microsites. These associations represent a topo-edaphic subclimax characterized by pyrogenous dynamics (Kucherov et al., 2009; Kucherov, Zverev, 2014). Another quickly updating communities range is associated to complex association Salicetum triandro-viminalis which associated with a river coasts and characterized by unstable litter and herb-moss cover.

The purpose of the present paper is observation of "chronically pioneering" microsites in boreal forests of White Sea Region (North European Russia) and revealing of certain causal and sporadically distributed species of lignotrophic basidiomycetes. As a rule, such species are characterized by wide distribution, but everywhere have a sporadic occurrence. The revealing of substrate range of such species as well as accumulation of information about their typical habitats in a global scale would give a key for understanding of species' distributional patterns. The knowledge on causal and ephemerous species of fungi is important for understanding of biological invasions (Woewoda, Karasiński, 2010; Mułenko et al., 2010) and some regularities in communities formation in the north boreal zone (Zmitrovich, 2011, 2014).

Materials and Methods

The field work was carried out during 2014–2016 in the Pinega Reserve, Kotlas and Plesetsk areas, and Kiy island of White Sea (Arkhangelsk Region, northern boreal zone). Lignotrophic basidiomycetes were collected from standing trees, fallen logs and branches, and wood debris of forest litter. The living and dry standing trees, fallen logs, stumps, wood debris and forest litter were observed. In total, 7500 trees were involved into this study. The specimens collected were dried and examined in the laboratory.

The collection and conservation of fungal material is supposed to be in concordance of recom-

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mendations by Ryvarden and Gilbertson (1993) and Lodge et al. (2004).

The material collected is supposed to check in Laboratory of systematics and geography of fungi of the Komarov Botanical Institute (Russia). The following microscopic technique is was used: AxioScope.A1 (Zeiss), Micmed-6, Micmed-2 (LOMO).

The material kept in the herbarium of the Pomory University (AR); the duplicates were placed at mycological herbarium of the Komarov Botanical Institute RAS (LE) (Ezhov & Zmitrovich 2015).

Results

The basic species list of north boreal species revealed was published recently (Ezhov, 2013; Ezhov et al., 2012; Ezhov, Zmitrovich, 2015). Only non-characteristic for placore environments records will be discussed here.

Niemelaea consobrina (Bres.) Zmitr., Ezhov et Khimich var. *balaenae* (Niemelä) Zmitr., Ezhov et Khimich (Fig. 1, *a*)

The resupinate fungus of porioid morphotype having annual whitish basidiomata 1–3 mm thick which prostrate up to 5 cm in largest dimension. Margin bolster-like in young basidiomata, whitish, slightly fimbriate, at the maturity substituted by tubes. Hymenophore as single ceraceous tube layer, up to 2.5 mm thick, whitish; pore surface whitish, then cream with lemon-yellow, honey-yellow or salmon tints at the tube margins; pores angular and thin-walled at the maturity, 2–4 per mm, more or less irregular and slightly lacerate. Subiculum thin (up to 0.5 mm thick), cottony, purely white. Hyphal system monomitic. Hyphae thin-walled or (near the subiculum) with prominent walls, clamped, 2–4.5 μm in diam., obscurely amyloid (P53 according to Zmtrovich, 2008). Cystidia none. Basidia clavate with a basal clamp, (9–25) × (4–5) μm. Basidiospores ellipsoid, (3.6–4.2) × (2.6–3.2) μm, rather thin-walled, non-amyloid.

Material studied: Russia, Arkhangelsk Region, Kiy island, Salicetum triandro-viminalis, on fallen trunk and branches of *Salix cinerea*. Coll. O.N. Ezhov, A.V. Ruokolainen 17.08.2014 (AR 1880).

General substrate range: *Quercus boissieri*, *Q. calliprinos* (Ţura et al., 2008), *Salix planifolia* (Niemelä, 1985), *Salix* spp., *Populus tremula* (Ryvarden, Gilbertson, 1993).

General distribution: North America (Canada, Puerto Rico), Europe (Finland, France, Sweden, Russia, Czech Republic, Slovakia), Asia (Israel, Russia) (Ţura et al., 2008).

Note. This fungus is associated to small fallen twigs of *Salicaceae* and *Fagaceae* trees and has a certain distribution in the Northern Hemisphere. The data for conclusion on its ecological preferences are incomplete. Old shrubs curtains in southern maquis and northern floodlands where fresh branch debris is not merged into humic layer seem to be core nishe of this species.

Hyphoderma roseocremeum (Bres.) Donk (Fig. 1, *b*)

The resupinate subceraceous corticioid fungus with annual basidiomata with adhering margin which prostrate up to 5.5 cm in the longest dimension. Margin white, finely fibrillose, up to 2 mm when young, later stays substituted by hymenophore. Subiculum white, wooly, very thin (up to 0.1 mm thick). Hymenophore smooth to obscurely papillose at the center, as thin (up to 1 mm thick) subceraceous layer, white, then creamish with dull rose to rose-ochraceous tints. Hyphal system monomitic. Hyphae 3–4.5 μm in diam., clamped, thin-walled, regularly branched at sharp angle; loosely arranged into subiculum and parallelly arranged near the subhymenium. Leptocystidia abundant, cylindrical or tubular, non-septate, originating from subicular zone, (40–130) × (5.5–9) μm, hyaline, without incrustation. Basidia utriform-clavate, (25–35) × (6–8.5) μm, 4-spored, with oildrops in the protoplasm, in deeply packed clusters. Basidiospores cylindrical, adaxially flattened and often slightly curved, (9–12.5) × (3–4.5) μm, with numerous oildrops into protoplasm, thin-walled, smooth, inamyloid, acyanophilous.

Material studied: Russia, Arkhangelsk Region, Kiy island, Salicetum triandro-viminalis, on fallen trunk of *Salix* sp. Coll. O. N. Ezhov, A.V. Ruokolainen 17.08.2014 (AR 1882).

General substrate range: *Alnus incana*, deciduous trees, rarely conifers (Eriksson & Ryvarden, 1975), *Thuja occidentalis*, *Salix* sp. (Zmitrovich, 1997), *Fagus sylvatica* (Wojewoda, 2003), *Picea*, *Quercus* (Shiryaev et al., 2010), *Abies alba*, *Pinus laricio*, *Quercus ilex*, *Q. pedunculata*, *Q. pubescens* (Bernicchia, Gorjón, 2010).

General distribution: Europe (Belarus, Belgium, Bosnia and Herzegovina, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Italy, Macedonia, Norway, Poland, Russia, Serbia, Slovenia, Spain, Sweden, Switzerland, the Netherlands, Turkey, Ukraine, United Kingdom) (Bernicchia, Gorjón, 2010), North America (Canada) (Roskov et al., 2013).

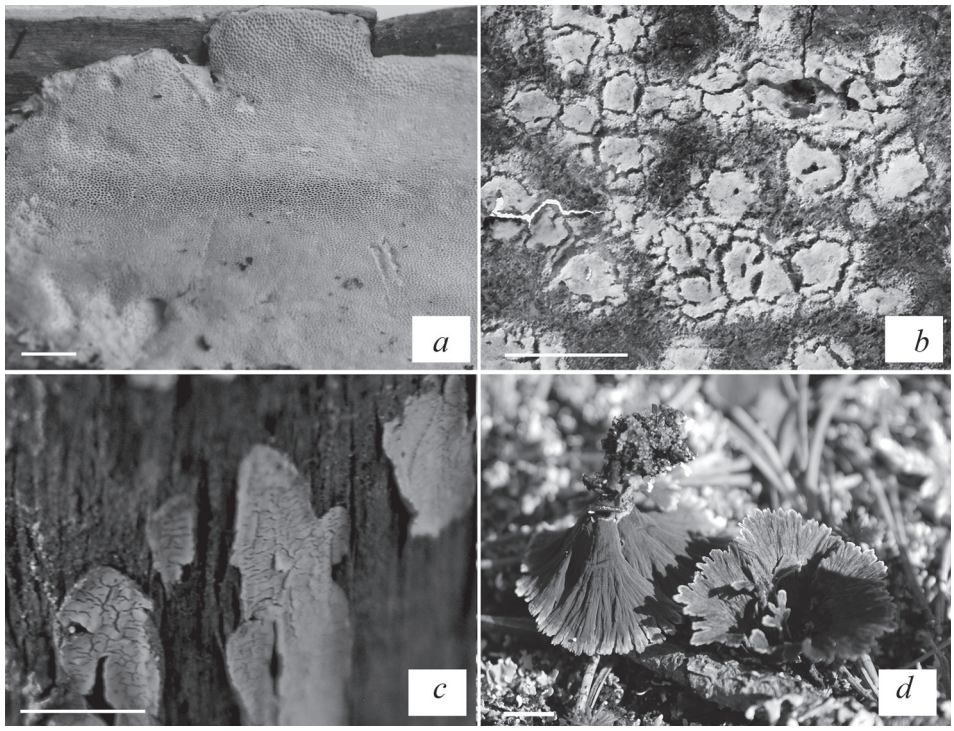

Fig. 1. Lignotrophic basidiomycetes from pioneering microsites in boreal forests of the White Sea Region: *a – Ceriporiopsis consobrina*, *b – Hyphoderma roseocremeum*, *c – Peniophora juniperi-cola*, *d – Thelephora caryophyllea*. Scale bar – 5 mm

Note. The oil-rich basidia and spores as well as non-septate tubular leptocystidia are characteristic to the species. Prostrate rosaceous forms of *Hypho-derma setigerum* (Fr.) Donk are similar, but differs by septate and often encrusted septocystidia and rougher hyphae with prominent walls. *H. mutatum* at young stages can be confused with *H. roseo-cremeum*, but first one has quite different basidio-spores (12–16) × (3–4) μm. The species seems to be distributed over Northern Hemisphere, but rather sporadically. The fructifications are associated as a rule with even and non-cavernose surfaces, e.g. an even bark or decorticated areas. The cavernose fragments of the same substrates in many cases are colonized by closely related, but more adaptive due to formation of septocystidial stroma species, *H. setigerum*. Still attached or fallen decorticated twigs seem to be main niche for this species.

***Peniophora junipericola* J. Erikss. (Fig. 1, *c*)**

This resupinate fungus of typical peniophoroid appearance which prostrates up to 20 mm in longest dimension and develops a perennial basidiomata with thickening hymenium and adnate, but loosen-ing together with thin outer bark layer margin. The last one up to 1 mm wide, thinning out, sharp, pink-ish-gray to brown, initially adhere the substrate, then loosening together with thin outer bark layer. Subiculum corky, hyaline-brownish, substituted by thickening yellowish-brown subhymenium 0.1–0.3 mm thick. Hymenophore initially tuberculate, then smoothening, overbuilding during 1–6 seasons, horneous, pinkish gray when fresh, grayish-brown when dry. Hyphal system monomitic. Hyphae 2.5–4.5 μm in diam., with clamps and prominent walls; in the subiculum packed parallelly to the substrate, in the subhymenium form a *textura porrecta*. Gloe-ocystidial stage is accelerated and imperceptible. Lamprocystidia fusoid to subovoid, (10–40) × (6–15) μm, hyaline to yellowish, heavily encrusted. Basidia subcylindrical, (15–25) × (4–5) μm, 4-spored, with a basal clamp, densely packed. Basidiospores cy-lindrical or suballantoid with a minute apiculus, (6.5–10) × (2.1–3.1) μm, smooth, thin-walled, in-amyloid, acyanophilous.

Material studied: Russia, Arkhangelsk Region, Kiy island, the dry trunk of *Juniperus communis* in Arctoparmelio-Cladino-Pinetum. Coll. O.N. Ezhov, A.V. Ruokolainen 17.08. 2014 (AR 1943), Plesetsk area, the dry trunk of *Juniperus com-munis* in Arctoparmelio-Cladino-Pinetum. Coll. O.N. Ezhov 14.07.2015 (AR 2311).

General substrate range: *Cupressus*, *Platycla-dus*, *Juniperus communis*, *J. excelsa*, *J. oxycedrus*, *J. semiglobosa*, *J. virginiana*, *Pinus pallasiana* (Yurchenko, 2010; Sell et al., 2011).

General distribution: Asia (Kyrgyzstan), Europe (Estonia, Latvia, Finland, Sweden, France, Austria, Ukraine, Russia), North America (USA) (Belomesyatseva, 2004; Yurchenko, 2010; Shiryaev et al., 2010; Sell et al., 2011).

Note. The first record for European North and White Sea Region, particularly. This is highly characteristic species, easily distinguished from other *Peniophora* species (Eriksson, 1950, 1958). *P. piceae* (Pers.) J. Erikss. is rather similar, but differs by thick-walled pigmented hyphae in subhymenial tissues, conical (not fusoid or ovoid) lamprocystidia and slightly larger basidiospores in median. The preference to *Cupressaceae* trees by *P. junipericola* is prominent, too. According to E. Parmasto and I. Parmasto (1992), this is xerothermic species, however its finding in Russian North allow to interpret its distribution rather as juniper-associated. Moreover, Sell et al. (2011) revealed that overwhelming finds number of this species is associated with a sea coastal zone. The juniper in pine forests of coastal zone has more xeromorphic habit than in the *Vaccinium myrtillus*-pine forests, where its wood is faster colonized by boreal species suite.

Thelephora caryophyllea (Schaeff.) Pers. (Fig. 1, *d*)

The fungus forms annual-biennial minute mesopodal thelephoroid basidiomata. Pileus infundibuliform, lacerate to lobate, 4–45 mm in diam.; upperside radially-fibrillose, or rugulose, purplish-brown, drying paler, obscurely zonate. Stipe 13–35 mm long and 1–5 mm in diam., central to somewhat eccentric, brownish and uneven. Margin sinuose, deeply lacerate, uneven, creamish to tan. Context 1–3 mm thick, fuscous to fuscous-purple, unchanged in KOH. Hymenophore basically smooth with thickening hymenium, radially streaked, decurrent on the stipe, fuscous-violaceous, paler near the margin, slightly cyanescent in KOH. Hyphal system monomitic. Hyphae 3–8 μm in diam., clamped, with prominent to slightly thickened walls, hyaline in subhymenium and brownish in the context. Cystidia none. Basidia (45–80) × (7.5–12) μm, utriform, with 2–4 sterigmata 7–8 μm long. Basidiospores (6.5–8.5) × 4.5–7.5) μm, moderately lobate with ellipsoid outline, angular, verrucose-echinulate with processes up to 1 μm, thick-walled, uniguttulate, umber-yellowish.

Material studied: Russia, Arkhangelsk Region, Russia, Arkhangelsk Region, Plesetsk area, on soil in Cladonio-Pinetum boreale. Coll. O.N. Ezhov 01.09.2014 (AR 1859), Kotlas area, on soil in Cladonio-Pinetum boreale. Coll. O.N. Ezhov 12.08.2016 (AR 2598).

General substrate range: mycorrhizal with *Bistorta* (Mühlmann et al., 2008), mycorrhizal with *Dryas octopetala* (Ryberg et al., 2009), mycorrhizal with *Kobresia* (Gao, Yang, 2010), on sandy soils in open *Pinus* forests (Corner, 1968; Zmitrovich, 2000), mycorrhizal with *Salix retusa*, *S. reticulata* (Jamoni, 2008; Ryberg et al., 2009).

General distribution: Africa (Algeria), Asia (India), Europe (Finland, Germany, Italy, Iceland, Norway, Russia, Spain, Sweden, United Kingdom), North America (USA, Canada) (Gao, Yang, 2010; Roskov et al., 2013).

Note. The closest relative is *Th. antocephala* (Bull). Fr. which, however, differs by larger basidiomata with lobes division reaches a stipe. A lobate variants of *Th. palmata* (Scop.) Fr. differ by strong tissue reaction with KOH and also by fetid garlic odor. The distribution pattern of this rare fungus seems to be associated to azonal elements of plant cover connected with dry sandy soil. It is possible that it is non-specialized mycorrhizal partner of pine seedlings and herbaceous or small shrubs plants of soil cover in open sandy habitats, like dunes, alvares, river terraces, pine islands in a desert zone (Algeria).

Xanthoporus syringae (Parmasto) Audet

This stipitate polypore of scutigeroid morphotype forms a clustered or single annual basidiomata attached to open or buried wood or homogeneous forest litter. Pileus round or crispate, 2–8 cm in diam., plane when young, staying infundibuliform at the maturity, upperside citrine-brownish, with obscure zonation, darker at the center, glabrous, fibrous to matted. Stipe central to lateral, (1–3.5) × (0.5–1) cm, sometimes give rise from a bulb 1–2 cm in diam. Margin inrolled, citrine to honey-yellow. Context 3–5 mm thick, homogeneous, whitish-citrine, of fleshy to sponge consistency. Hymenophore as a single tube layer 1–4 mm thick, fleshy when fresh, staying fragile; pore surface citrine to honey yellow; pores 3–5 per mm, rather thin-walled, angular and often irregular in size. Hyphal system monomitic with gloeoplerous hyphae, all hyphae with clamps; in subhymenium and tube trama 2.5–3.5 μm in diam., more or less parallelly arranged and densely packed, thin-walled; in context 3–10(25) μm in diam., varying in walls thickness and content's refraction, regularly inflated, often coiled and rather freely arranged. Cystidia none. Basidia clavate with moderately expressed medi-

al constriction, (15–25) × (5–7) μm. Basidiospores (4–5.2) × (3–4.5) μm, ovoid with opaque subapicular region, with prominent walls, smooth, inamyloid, cyanophilous.

Material studied: Russia, Arkhangelsk Region, Pinega Reserve, on soil in Cladonio-Pinetum boreale. Coll. O.N. Ezhov 06.09.2014 (AR 1945).

General substrate range: sandy soil near *Syringa* (Parmasto, 1962), lawn of graveyard (Niemelä, 1970), pine forests (Svetlova, Zmitrovich, 2012).

General distribution: North America (Canada, USA), Europe (Estonia, Finland, Sweden, Russia, Italy), Asia (Russian Far East) (Granmo, Mathiassen, 2001).

Note. The characteristic features of the fungus are infundibuliform scutigeroid basidiomata with citrine pores and brownish obscure upperside zonation. Microscopically, the cyanophilous spores with opaque subapicular region are characteristic. A merulioid affinity of the fungus and a separate generic position was recognized some time ago (Audet, 2010). This fungus is distributed seemingly thorough whole Northern Hemisphere, but data on its ecological preferences rather incomplete. The association of the fungus to *Syringa* seems to be occasional. More evident is connection of *X. syringae* with a sandy soil. This is a white-rot fungus.

Discussion

The phenomenon of causal species occurrence in communities is connected not least with presence of chronically pioneering elements of vegetation mosaics, somehow sandy sites of pine forests of various genesis as well as rather dynamic vegetation updating in alder and willow river galleys. This is a single common feature of all the species mentioned here, whereas their coenotic gravitation and substrate preferences are diverse. In contrast to the placore boreal communities, where generations flow is extremely regulated, the non-placore communities are characterized by spontaneous opening of free nishes.

Particularly, the *Niemelaea consobrina* represents a marginal walley willows-associated analogous of *Ceriporiopsis aneirina* and *C. resinascens* which exercise a control of *Populus tremula* and *Salix caprea* debris in placore boreal communities.

The *Hyphoderma roseocremeum* seems to be basically a nemoral species irradiating into boreal zone via willow- and alder-associated elements of vegetation cover, where it is a marginal analogous of *H. setigerum* and *H. mutatum*.

The *Peniophora junipericola* is associated to juniper which, in turn, is associated with various types of azonal pine forests, as a rule dry and open; this is seemingly a marginal kin of *Amylostereum laevigatum* (Fr.) Boidin, which controls a juniper in wider range of habitats, including the ones of *Vaccinium myrtillus*-type (Bondartseva et al., 1998).

The *Thelephora caryophyllea* seems to be associated to a poor sandy soils on warm habitats and represents a marginal analogous of *Th. terrestris*.

The *Xanthoporus syringae* seems to be marginal species, too. A chronically pioneering elements of oligotrophic communities as Pineta cladinosa are suitable for the fungus colonization, also cemeteries and other anthropogenically transformed variants of pioneering communities with wood debris and sandy soil can be infested by this ephemerous species.

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ЛИГНОТРОФНЫЕ БАЗИДИОМИЦЕТЫ ПИОНЕРНЫХ МИКРОСАЙТОВ ТАЕЖНЫХ ЛЕСОВ БЕЛОМОРЬЯ

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Изучение лигнотрофных базидиомицетов в «хронически-пионерных» микросайтах северотаежных лесных сообществ Беломорья (Северо-Запад Европейской части России) позволило выявить целый ряд малоизвестных спорадически распространенных видов, а именно: *Niemelaea consobrina*, *Hyphoderma roseocremeum*, *Peniophora junipericola*, *Thelephora caryophyllea*, *Xanthoporus syringae*. В статье приводятся биоморфологические особенности выявленных видов, характер их распространения и субстратные предпочтения в связи с возможностью колонизации свободных от конкуренции ниш в определенных участках растительного покрова в условиях северотаежной подзоны.

Ключевые слова: бореальные леса, Север европейской России, пионерные сообщества, лигнотрофные базидиомицеты, спорадически распространенные виды.

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