

ADDITIONS TO THE SPECIES LIST OF APHYLLOPHOROID FUNGI IN TAYMYRSKY DOLGANO-NENETSKY DISTRICT (ARCTIC SIBERIA, KRASNOYARSK KRAI, RUSSIA)

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A total of 49 species of aphylloroid fungi (*Agaricomycetes*) were recorded for the first time in Taymyrsky Dolgano-Nenetsky District. The ranges expansion of phytopathogenic fungi associated with alien and native woody plants to the north, as well as the increase in the number of the wooden infrastructure destroyers, are discussed.

Keywords: *Agaricomycetes*, Arctic greening, global warming, plant pathogens, permafrost, tundra, urban mycobiota

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INTRODUCTION

The Arctic mycobiota is poorly studied compared to other regions of the planet (Dahlberg, Bültmann, 2013). At the same time, a number of regions are the least studied, located in Asia, including Taymyrsky Dolgano-Nenetsky District (TDND), on the territory of which are the Taimyr Peninsula, the Putorana Plateau and the Anabar Plateau, as well as vast flat territories (Mukhin, 2010).

The region is home to unique, northernmost forest areas on the planet – Lukunskaya (72° 34' N) and Ary-Mas (72° 28' N), which is formed by *Larix gmelinii* (Rupr.) Kuzen. (Kryuchkov, 1972; Ary-Mas, 1978). The northernmost continental part of Eurasia – Cape Chelyuskin – is located here. Arctic deserts, arctic and subarctic tundra, forest-tundra and northern taiga are widespread in the region, and mountain landscapes are vast, which is why the mycobiota of the region can be rich (Shiryayev et al., 2018; Red data book, 2022).

However, the increasing intensity of anthropogenic pressure on fragile Arctic ecosystems is especially evident within the boundaries of the Norilsk industrial region, where thousands of hectares are covered with destroyed trees and pronounced soil erosion, which is widely known as the “Norilsk dead forest” (Kirdyanov et al., 2020).

In Norilsk City, the average annual air temperature has increased by 2.6°C over 60 years (Report., 2023), which has made it possible for boreal plants to be introduced into populated areas (Druckenmiller et al., 2024). This may lead to the dispersal of alien fungal species to the northern

regions, as it observed in Yamal-Nenets Autonomous District and Murmansk Region (Khimich et al., 2020; Shiryayev et al., 2020). The import of alien building materials for economic purposes is another important factor that can affect the formation of local mycobiota. It is worth noting that the trends of decreasing fungal biodiversity due to economic activity on the one hand, and the emergence of new species due to global warming and plant introduction on the other, have not yet been studied in the region.

For TDND, information has been published on the occurrence of 133 species of aphylloroid fungi (Karatygin et al., 1999; Mukhin, Kotiranta, 2001; Shiryayev, 2011, 2017, 2018), which were collected in natural and man-made habitats. However, this list is poor compared to neighboring Arctic regions (Kotiranta, Mukhin, 2000; Khimich et al., 2020; Shiryayev et al., 2020; Shiryayev, Mikhalyova, 2013).

The purpose of this study is to identify species of aphylloroid fungi previously unknown in TDND.

MATERIALS AND METHODS

TDND is located entirely north of the Arctic Circle. TDND area is 879.9 thousand km². The north of the region has an arctic climate, while the south has a subarctic (continental) climate. The capital of TDND is Dudinka town (69°24' N, 86°10' E).

The largest city of TDND, Norilsk City (69°21' N, 88°11' E), has a population of 235.000. It is the second most populous city in Krasnoyarsk Krai. The average annual air temperature in Norilsk is –9.6°C, with the average

temperature of the coldest month (January) is -26.7°C , and the warmest month (July) is 7.9°C . On average, 341 mm annual precipitation.

The material was collected by the author in September 2004 in natural forest-tundra plain areas located to the east of the Yenisei River, where the forest stand is formed by low-growing *Larix gmelinii*, *Betula tortuosa* Kedeb. and *Alnus fruticosa* Rupr. [= *Alnus alnobetula* subsp. *fruticosa* Raus], as well as in the western and southern parts of the Putorana Plateau, where northern boreal forests grow with *Larix gmelinii*, *Picea obovata* Ledeb., *Betula tortuosa*, *Alnus fruticosa* and *Juniperus sibirica* Burgsd. The material was also collected in anthropogenic habitats of Norilsk City (including the Kayerkan, Valek, Oganer, Talnakh, Snezhnogorsk districts) and Dudinka town on alien trees, e.g. *Pinus sylvestris* L., *P. sibirica* Du Tour and *Populus tremula* L., and in the floodplains of the Yenisei and Pyasina rivers. Some samples from anthropogenic habitats were collected by colleagues in 2006–2020.

The names of plant species are given according to the Plants of the world online database (www.powo.science.kew.org). Fungal names are given according to the Index Fungorum (2024) online database (www.indexfungorum.org). The materials are deposited in the Biological Museum of the Institute of Plant and Animal Ecology of the Ural Branch of the Russian Academy of Sciences, Ekaterinburg (SVER).

The following abbreviations used in the species list: Dudinka – DUD, Norilsk (center) – NOR, Kayerkan – KAY, Oganer – OGA, Snezhnogorsk – SNE, Talnakh – TAL, Valek – VAL; *Larix gmelinii* – Lg, *Picea obovata* – Po, *Alnus fruticosa* – Af, *Betula tortuosa* – Bt, *Pinus sylvestris* – Ps, *Pinus sibirica* – Psib, *Populus tremula* – Pt, *Salix* spp. – Sa.

RESULTS

Species list of aphyllophoroid fungi, collected for the first time in TDND

Amylocorticium cebennense (Bourdot) Pouzar – SNE, Lg, mixed forest with Lg, Po, Af, Bt, 20.08.2004 SVER(F)86510.

A. subincarnatum (Peck) Pouzar – TAL, Po, larch-spruce-birch mixed forest, 19.08.2004 SVER(F)86527.

Amylostereum chailletii (Pers.) Boidin – TAL, Lg, mixed forest with Lg, Po, Af, Bt, 19.08.2004 SVER(F)86540.

Antrodia sinuosa (Fr.) P. Karst. – NOR, Ps, sawdust warehouse, 05.09.2013 SVER(F)86526.

Athelia bombacina (Pers.) Jülich – SNE, Po, edge of mixed forest, 23.08.2004 SVER(F)86511.

Baltazaria galactina (Fr.) Leal-Dutra, Dentinger et G.W. Griff. – VAL, Bt, birch-alder bushes, 21.08.2004 SVER(F)86548.

Botryobasidium candicans J. Erikss. – TAL, Po, mixed forest with Lg, Po, Af, Bt, 19.08.2004 SVER(F)86541.

B. obtusisporum J. Erikss. – VAL, Lg, larch-spruce-birch forest, 18.08.2004 SVER(F)86500.

B. pruinaum (Bres.) J. Erikss. – DUD, Bt, Af and Bt bushes, 25.08.2004 SVER(F)86509.

Cerioporus scutellatus (Schwein.) Zmitr. – SNE, Af, mixed forest with Lg, Po, Af, Bt, 04.09.2011 SVER(F)86539.

Coniophora puteana (Schumach.) P. Karst. – NOR, Psib, logs at the base of a building on the territory of the Norilsk state farm, 12.06.2012 SVER(F)86528.

Crustoderma longicystidium (Litsch.) Nakasone – DUD, Larix sp., trunk in the port, 25.09.2012 SVER(F)86525.

Cyanosporus caesius (Schr.) McGinty – TAL, Lg, mixed forest with Lg, Po, Af, Bt, 19.08.2004 SVER(F)86517.

C. simulans (P. Karst.) B.K. Cui et Shun Liu – VAL, Po, mixed forest with Lg, Po, Bt, Af, 21.08.2004 SVER(F)86505.

Cyrtidiella albida (H. Post) C.C. Chen et Sheng H. Wu [= *Phlebia albida* H. Post] – DUD, Bt, slope to the Yenisei River, 25.08.2004 SVER(F)86543.

Daedaleopsis confragosa (Bolton) J. Schröt. – TAL, alive Sa, river bank, 19.08.2004 SVER(F)86512.

Dacryobolus sudans (Alb. et Schwein.) Fr. – VAL, Lg, mixed forest Lg, Po, Bt, Af 22.08.2004 SVER(F)86508.

Dendrocorticium polygonioides (P. Karst.) M.J. Larsen et Gilb. – OGA, Bt, mixed forest, 23.08.2004 SVER(F)86524.

Hydnomerulius pinastri (Fr.) Jarosch et Besl – KAY, Psib, burnt wooden rafters at the entrance to the Cuprum-mine, 06.03.2016 SVER(F)86501.

Hyphoderma occidentale (D.P. Rogers) Boidin et Gilles – TAL, Sal, mixed forest, 19.08.2004 SVER(F)86513.

H. setigerum (Fr.) Donk – OGA, Bt, birch-alder bushes intermixed with dead larch trees, 22.08.2004 SVER(F)86529.

H. sibiricum (Parmasto) J. Erikss. et Å. Strid – SNE, Lg, larch-spruce forest intermixed with alder, 01.09.2013 SVER(F)86507.

Hyphodontia spathulata (Schr.) Parmasto – SNE, Af, mixed forest with larch, spruce, alder, birch, 21.08.2009 SVER(F)86542.

Hypochnicium lundellii (Bourdot) J. Erikss. – TAL, Lg, larch-dominated forest, 19.08.2004 SVER(F)86547.

Jaapia argillacea Bres. – OGA, Lg, fallen trunk at the hospital territory, 23.08.2004 SVER(F)86537.

Leptoporus mollis (Pers.) Quél. – SNE, Po, mixed forest, 26.08.2016 SVER(F)86549.

Leptosporomyces galzinii (Bourdot) Jülich – VAL, Lg, mixed forest with Lg, Po, Af, Bt, 22.08.2004 SVER(F)86514.

L. fusoides (Jülich) Krieglst. – SNE, Lg, mixed forest with Lg, Af, Bt, 04.09.2011 SVER(F)86502.

Megalocystidium leucoanthum (Bres.) Jülich s.l. – SNE, Af, mixed forest with Lg, Po, Af, Bt, 23.08.2004 SVER(F)86530.

Mutatoderma mutatum (Peck) C.E. Gómez – OGA, Bt, hospital park, 23.08.2004 SVER(F)86536.

Mycoacia livida (Pers.) Zmitr. – TAL, Po, river shore, mixed forest with Lg, Po, Af, Bt, 19.08.2004 SVER(F)86506.

Peniophora erikssonii Boidin – SNE, Af, inside Af and Bt bushes, 23.08.2004 SVER(F)86515.

P. pithya (Pers.) J. Erikss. – NOR, Lg, Norilsk state farm, 05.09.2013 SVER(F)86522.

Penttilamyces romellii (Ginns) Zmitr., Kalinovskaya et Myasnikov – SNE, Lg, mixed forest with Lg, Po, Af, Bt, 11.09.2016 SVER(F)86523.

Ph. tremula (Bondartsev) Bondartsev et P.N. Borisov – SNE, alive Pt, house yard, 14.06.2020 SVER(F)86535.

Ph. lilascens (Bourdot) J. Erikss. et Hjortstam – TAL, Po, larch-spruce forest, 19.08.2004 SVER(F)86503.

Porodaedalea abietis (P. Karst.) Bernicchia et Gorjón [= *Phellinus abietis* (P. Karst.) H. Jahn] — SNE, Po, larch-spruce forest, 04.09.2011 SVER(F)86531.

Rhodofomes cajanderi (P. Karst.) B.K. Cui, M.L. Han et Y.C. Dai [= *Fomitopsis cajanderi* (P. Karst.) Kotl. et Pouzar] — DUD, driftwood Larix, rivershore, 04.09.2011 SVER(F)86538.

Repetobasidium erikssonii Oberw. — DUD, Larix sp., fire wood in the yard, 25.08.2004 SVER(F)86544.

Sistotrema diademiferum (Bourdot et Galzin) Donk — DUD, Sa, slope to the Yenisei River, 25.08.2004 SVER(F)86532.

Sistotremella perpusilla Hjortstam — TAL, Po, mixed forest with Lg, Po, Af, Bt, 19.08.2004 SVER(F)86534.

Spongiporus perdelicatus (Murrill) Zmitr. — SNE, Lg, mixed forest with Lg, Po, Af, Bt, 28.08.2020 SVER(F)86521.

Steccherinum tenuispinum Spirin, Zmitr. et Malysheva — VAL, Af, bushes of Af and Bt, 21.08.2004 SVER(F)86545.

Trametes hirsuta (Wulfen) Pilát — TAL, Bt, mixed forest with Lg, Po, Af, Bt, 19.08.2004 SVER(F)86518.

Trichaptum bifforme (Fr.) Ryvarden — SNE, Bt, lake shore, mixed forest with Lg, Po, Af, Bt, 06.09.2020 SVER(F)86520.

Tubulicrinis borealis J. Erikss. — NOR, Larix sp., fire wood in the yard, 22.08.2020 SVER(F)86504.

Tulasnella thelephorea (Juel) Juel — TAL, Lg, mixed forest with Lg, Po, Af, Bt, 19.08.2004 SVER(F)86546.

Typhula ishikariensis S. Imai — DUD, on cereals, slope to the Yenisei River and town loans, 28.06.2020 SVER(F)86533.

Vararia investiens (Schwein.) P. Karst. — TAL, Lg, mixed forest with Lg, Po, Af, Bt, 19.08.2004 SVER(F)86519.

DISCUSSION

Forty-nine species of aphylloroid fungi have been identified for the first time in TDND. In total, taking into account previously published data (Karatygin et al., 1999; Mukhin, Kotiranta, 2001; Shiryaev, 2011, 2017, 2018), the list of aphylloroid fungi in the region is 182 species. However, this number is lower than the lists known for neighboring high-latitude regions. Thus, 326 species were identified in the Yamal-Nenets Autonomous District (Shiryaev et al., 2020) and 223 species in the arctic part of Yakutia (Kotiranta, Mukhin, 2000; Shiryaev, 2012, 2017, 2018; Shiryaev, Mikhalyova, 2013). In the richest Russian Arctic territory, Murmansk Region, 473 species of aphylloroid fungi are known (Khimich et al., 2020), although the area of the region is smaller compared to the above-mentioned Asian territories.

It is expected that the species list of aphylloroid fungi in TDND will increase thanks to research in the foothill and mountainous regions of the Putorana Plateau, where highly productive, for Arctic latitudes, old-growth northern boreal forests are locally distributed (Grigoriev et al., 2019).

Due to the ongoing warming of the Arctic climate, the species of fungi that have appeared in the region recently can be divided into three groups:

1. Due to the increase in above-ground phytomass, and, consequently, mortmass of woody plants such as

Larix gmelinii, *Picea obovata* as well as *Alnus fruticosa*, *Betula tortuosa*, it became possible to expand the ranges of some fungal species (*Baltazaria galactina*, *Botryobasidium candicans*, *B. pruinaum*, *Cyanosporus simulans*, *Daedaleopsis confragosa*, *Dacryobolus sudans*, *Dendrocorticium polygonioides*, *Hyphoderma occidentale*, *H. sibiricum*, *Leptoporus mollis*, *Leptosporomyces fusoides*, *Mycoacia livida*, *Peniophora erikssonii*, *Spongiporus perdelicatus*, *Steccherinum tenuispinum*) to the north with a maximum of finds in the boreal regions of Central Siberia (Kotiranta, Shiryaev, 2015). However, it is worth noting that the soil-inhabiting species of aphylloroid fungi are still rare in TDND, and widespread species from the genera *Thelephora*, *Clavaria*, and *Clavulina* are encountered only occasionally. Probably, permafrost restrains the northward advance of the “southern” species of humus saprobes and mycorrhiza-forming fungi.

2. In natural and anthropogenic habitats, the number of pathogenic fungi species on woody and herbaceous plants increases. In nature, *Daedaleopsis confragosa* have been collected on living willow branches, and *Porodaedalea abietis* has been found on living spruce trees. *Typhula ishikariensis*, which causes snow mold disease, develops on cereals in the Yenisei River floodplain and on nearby lawns in Dudinka town. This fungus has not yet been collected in the region’s upland habitats. In urban parks, *Phellinus tremula* has been collected on alien aspen, and *Trametes hirsuta* has been found on a frost crack in a living birch.

3. In anthropogenic habitats, saprobic fungi appear, associated with the destruction of wooden residential and commercial infrastructure. Thus, in 2009, basidiomata of *Coniophora puteana* were collected on the logs of *Pinus sibirica* (alien for the natural flora of the region) located at the base of a building on the territory of the Norilsk state farm. In 2016, *Hydnomerulius pinastri* was collected in Kayerkan on burnt wooden (siberian pine, probably) rafters at the entrance to the mine. In 2015, saprobic *Antrodia sinuosa* developed en masse on pine warehouse sawdust (*Pinus sylvestris* is alien for the natural flora of the region).

Fungal species included in the Red data book of Krasnoyarsk Krai (2022) were not found in TDND. However, *Clavulinopsis subarctica* (Pilát) Jülich, which develops on mosses in the tundra zone, was collected in the region (Shiryaev, 2017, 2018). It is included in the new edition of the Red data book of the Russian Federation (Order., 2023). Undoubtedly, climate warming, which causes “Arctic greening”, leads to the “borealization” of its mycobiota (Shiryaev et al., 2020). It is likely that after a new series of mycological studies, other rare species of aphylloroid fungi will be identified in TDND.

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Впервые приводятся данные о находках 49 видов афиллофороидных грибов (*Agaricomycetes*) в Таймырском Долгано-Ненецком р-не Красноярского края. Обсуждается проблема расширения на север ареалов фитопатогенных грибов, развивающихся на интродуцированных и местных древесных растениях, а также разрушающих деревянные конструкции хозяйственных и жилых строений в городах региона.

Ключевые слова: вечная мерзлота, городская микобиота, патогены растений, позеленение Арктики, потепление климата, *Agaricomycetes*