FUNGI AND FUNGI-LIKE ORGANISMS
ГРИБИ І ГРИБОПОДІБНІ ОРГАНІЗМИ

https://doi.org/10.15407/ukrbotj80.05.399
RESEARCH ARTICLE

Some wood-inhabiting *Basidiomycota* from the primeval forests with *Pinus cembra* in Ukraine

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Abstract. The *Pinus cembra* communities belong to the rarest and least studied woody habitats in Europe. This article reports 30 species of lignicolous *Basidiomycota* revealed in primeval spruce stands with the admixture of arolla pine in Gorgany Nature Reserve (the Ukrainian Carpathians). Five species, namely *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum* and *H. cremicolor*, are firstly reported in Ukraine. The records of *Cystostereum murrayi*, *Phellinus viticola* and *Pycnoporellus fulgens* deserve particular attention due to their value as bioindicators of natural forest ecosystems. The species composition of *Basidiomycota* per individual fallen log turned out to be rather poor. The fungi forming thin resupinate corticioid basidiocarps on the substrate underside prevail among the finds, indicating a lack of moisture in the surveyed treeline stands. Detailed descriptions of the substrate and collection site are given for each find. An overview of previous research on the diversity of lignicolous *Basidiomycota* in arolla pine forests is provided.

Keywords: *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum*, *Hypochnicium cremicolor*, *Phellinus viticola*, rare species, treeline, Ukrainian Carpathians

Introduction

Communities of *Pinus cembra* L. (*Pinaceae*) are restricted to high mountain altitudes in the Alps and the Carpathians and belong to the rarest and least studied forest types in Europe (Critchfield, Little, 1966; Blada, 2008; Kučera, 2019). In the Ukrainian Carpathians, stands with arolla pine have an insular pattern of distribution, occurring as small-area disjunctive localities scattered through the upper parts of river basins of the Brusturianka, Bystrytsia Nadvirnianska, Bystrytsia Solotvynska, Limnytsia, Prut and Svicha rivers (Sirenko, 2005; Popovych et al., 2019; Cherniavskyi, 2021). Overall, these stands cover an area of around 4195 ha; of them, nearly 4160 ha are located in the Gorgany region — the least populated part of the Ukrainian Carpathians, characterized by medium elevations (up to 1836 m a.s.l.), steep slopes and the presence of large stone fields covering the upper parts of the ridges (Sirenko, 2005; Klimuk et al., 2006).

ARTICLE HISTORY. Submitted 31 July 2023. Revised 20 October 2023. Published 16 November 2023
CITATION. Bohoslavets O.M., Prydiuk M.P. 2023. Some wood-inhabiting *Basidiomycota* from the primeval forests with *Pinus cembra* in Ukraine. *Ukrainian Botanical Journal*, 80(5): 399–408.

Arolla pine populations in Ukraine are under threat due to extensive logging and replacement by the Norway spruce (*Picea abies* (L.) H. Karst.) in forest stands. For this reason, the species is included in the *Red Data Book of Ukraine* (Chervona..., 2009; https://zakon.rada.gov.ua/laws/show/z0370-21#Text).

In the *National Habitat Catalogue of Ukraine* (Kuzemko et al., 2018), the forest communities with *Pinus cembra* are referred to as "Arolla pine forests". Hence, we apply the term "arolla pine forest" to describe forests with arolla pine in the Ukrainian Carpathians, irrespective of whether this species dominates or not in the stand.

Gorgany Nature Reserve was established in 1996 to protect the best-preserved forests of the upper part of the Bystrytsia Nadvirnianska river basin. Spruce-dominated forests cover approximately 86% of the reserve area, stone fields — nearly 11%, meadows — less than 2% (Klimuk et al., 2006). The primeval spruce stands with the admixture of arolla pine are scattered through the upper part of the forest belt (965–1580 m a.s.l.) and occupy 7.1% of the total area (Cherniavskyi, 2021). In 2017, some of the most valuable stands of Gorgany Nature Reserve became a part of the "Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe" UNESCO Natural World Heritage Site (UNESCO, 2017).

Information about the diversity of lignicolous fungi in the arolla pine communities is scattered over a range of scientific publications (Nicolotti et al., 1999; Bernicchia et al., 2007; Küffer et al., 2008; Holec et al., 2015; Merges, 2019). In most cases, they mention either the fungi occurring on wood of *P. cembra* (*Antrodia alpina* (Litsch.) Gilb. & Ryvarden, *Athelia epiphylla* Pers. s. l., *Chromosera cyanophylla* (Fr.) Redhead, Ammirati & Norvell, *Fomitopsis pinicola* (Sw.) P. Karst., *Gloeophyllum sepiarium* (Wulfen) P. Karst., *Heterobasidion annosum* (Fr.) Bref., *Piloderma byssinum* (P. Karst.) Jülich), or wood-inhabiting species forming an ectomycorrhizal symbiosis with arolla pine (*Amphinema byssoides* (Pers.) J. Erikss., *Tomentella stuposa* (Link) Stalpers, *Tylospora asterophora* (Bonord.) Donk, *T. fibrillosa* (Burt) Donk).

Dämon (2000), however, provided lists of noteworthy corticioid species recorded in two types of the arolla pine communities of the Austrian Alps. For a stand composed of *Abies alba* Mill., *Picea abies* and *Pinus cembra*, he reported *Amylocorticium subsulphureum* (P. Karst.) Pouzar, *Cerocorticium sulfureoisabellinum* (Litsch.) Jülich & Stalpers (as *Flavophlebia sulfureoisabellina* (Litsch.) K.H. Larss. & Hjortst.), *Gloeodontia subasperispora* (Litsch.) E. Larss. & K.H. Larss. (as *Gloeocystidiellum subasperisporum* (Litsch.) J. Erikss. & Ryv.), *Hermanssonia centrifuga* (P. Karst.) Zmitr. (as *Phlebia centrifuga* P. Karst.), *Odonticium romellii* (S. Lundell) Parmasto, *Phlebia segregata* (Bourdot & Galzin) Parmasto, *Sistotrema muscicola* (Pers.) S. Lundell, *Suillosporium cystidiatum* (D.P. Rogers) Pouzar and *Tubulicrinis* spp. From the larch-dominated stand with *Picea abies*, *Pinus cembra* and *Sorbus aucuparia* L. admixture, the following species were reported: *Amyloxenasma allantosporum* (Oberw.) Hjortstam & Ryvarden (as *Phlebiella allantospora* (Oberw.) K.H. Larss. & Hjortstam), *Athelopsis lacerata* (Litsch.) J. Erikss. & Ryvarden, *A. subinconspicua* (Litsch.) Jülich, *Basidiodendron caesiocinereum* (Höhn. & Litsch.) Luck-Allen, *Clavulicium delectabile* (H.S. Jacks.) Hjortstam (as *Membranomyces delectabile* (H.S. Jackson) Kotiranta & Saarenoksa), *Kneiffiella floccosa* (Bourdot & Galzin) Jülich & Stalpers (as *Hyphodontia floccosa* (Bourdot & Galzin) J. Erikss.) and *Tubulicrinis medius* (Bourdot & Galzin) Oberw.

Wood-inhabiting funga of the Ukrainian arolla pine communities is very poorly studied. Shevchenko (1972) mentioned *Fomitopsis pinicola* (Sw.) P. Karst., *Gloeophyllum sepiarium* (Wulfen) P. Karst. and *Porodaedalea pini* (Brot.) Murrill (as *Phellinus pini* (Thore) Pil.) as the species occurring on wood of arolla pine and dwarf mountain pine (*Pinus mugo* Turra). In addition, Shevchenko revealed the characteristic root rot caused, in his opinion, by *Phaeolus schweinitzii* (Fr.) Pat. on *P. cembra* in the Osmoloda Forestry (the Gorgany Mountain Range). The fruitbodies of the species, although, were not found (Shevchenko, 1972).

Since the data on tree pathogenic fungi published by Shevchenko in 1972, no more recent records of wood-inhabiting fungi from the Ukrainian arolla pine forests are known. In the recently published monograph on fungal diversity of the protected areas in the Ukrainian Carpathians (Dudka et al., 2019), species composition of such ecosystems is described as rather limited.

Materials and Methods

This article presents the results of five field surveys in the primeval arolla pine forests in the territory

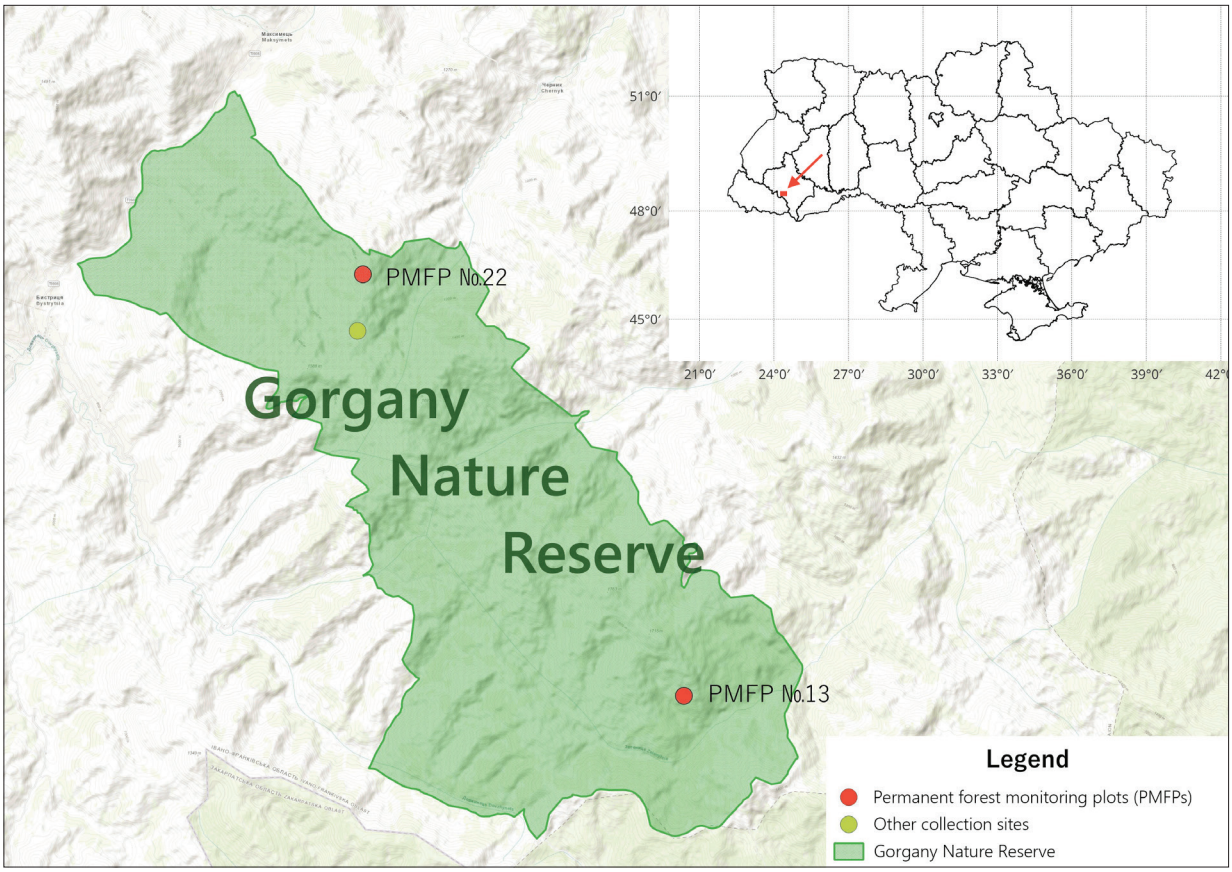

Fig. 1. Location of the studied sites

of Gorgany Nature Reserve (Fig. 1). We randomly examined fallen dead logs, branches and standing dead trunks within the permanent forest monitoring plots (PFMPs) No 22 and No 13, as well as their closest vicinities. We carried out surveys at PFMP No 22 on three separate occasions (21 October 2020, 13 October 2022 and 19 July 2023) and at PFMP No 13 on two occasions (10 August 2022 and 12 July 2023). In addition, we report one record from a spruce log fallen across the forest trail near PFMP No 6 (13 October 2022).

Original descriptions of the study sites were provided by Gorgany Nature Reserve. The studied localities represent the *Pineto (cembrae)-Piceetum (abietis) vaccinioso (myrtilli)-hylocomiosum* association, growing on shallow and rocky brown forest soils. PFMP No 13 (48°24'36"N, 24°23'28"E) occupies an area of 1 ha on the steep (29–32°) southwestern (209°) slopes of Dovbushanka Mt. at altitudes of 1250–1290 m a.s.l. The single-layered stand is dominated by *Picea abies* with the admixture of *Pinus cembra*, *Abies alba* and *Betula pendula*. The underbrush is represented by solitary trees of *Sorbus aucuparia*. PFMP No 22 (48°28'00"N, 24°19'11"E) occupies an area of 0.5 ha on the steep (18–40°) western (250°) slopes of Berezovachka Mt. at altitudes of 1450–1500 m a.s.l. The two-layered stand is composed of *Pinus cembra* representing the upper layer and *Picea abies* together with *Abies alba* and *Sorbus aucuparia* forming the canopy layer. The underbrush is absent. The area of PFMP No 22 belongs to the "Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe" UNESCO Natural World Heritage Site.

For each specimen, we recorded detailed information on its substrate (tree species, size, wood decay stage and type). Wood decay stages are given according to the classification of Renvall (1995). Specimens are deposited in the Fungarium of the National Herbarium of Ukraine (KW-M) at the M.G. Kholodny Institute of Botany, NAS of Ukraine. In those cases where confident specific

identification was possible in the field, we recorded the species occurrence without collecting a sample. Such species are referred to as "not." according to Kotlaba (1999).

Microscopic structures of the fungal fruitbodies were studied in water, 5% KOH solution and Melzer's reagent (Hjortstam et al., 1987).

The species were identified according to Hjortstam et al. (1987), Hansen & Knudsen (1997), Bernicchia & Gorjón (2010), Knudsen & Vesterholt (2012), Ryvarden & Melo (2014) and Læssøe & Petersen (2019). Scientific names of the taxa are provided according to the *Index Fungorum* database (https://www.indexfungorum.org/).

The map of the study sites (Fig. 1) was created using QGIS 3.28.0 software.

Results

We provide below a list of 30 wood-inhabiting *Basidiomycota* recorded in the primeval arolla pine forests of Gorgany Nature Reserve. Among these, we include a previously published (Bohoslavets, Prydiuk, 2023) record of *Hymenochaete fuliginosa* (Fr.) Lév. to gather all finds from the study area in one comprehensive list.

***AGARICOMYCETES* Doweld**

***AGARICALES* Underw.**

***Cystostereaceae* Jülich**

***Cystostereum murrayi* (Berk. & M.A. Curtis) Pouzar**

PFMP No 22, on standing dead trunk of *Picea abies* 19 cm in diameter, white rot, decay stage 2, with *Dacrymyces stillatus* and *Hypochnicium cremicolor*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71553).

***Hygrophoraceae* Lotsy**

***Lichenomphalia umbellifera* (L.) Redhead, Lutzoni, Moncalvo & Vilgalys**

PFMP No 22, on dead log of *Pinus cembra* 29 cm in diameter, brown rot, decay stage 4, with *Aphanobasidium subnitens* and *Ceraceomyces eludens*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71554).

***Mycenaceae* Overeem**

***Mycena maculata* P. Karst.**

PFMP No 22, on dead log of *Pinus cembra* 35 cm in diameter, white rot, decay stage 3, with *Athelia decipiens* and *A. fibulata*, 13 October 2022, leg. O. Bohoslavets, det. M. Prydiuk (KW-M71527).

***Radulomycetaceae* Leal-Dutra, Dentinger & G.W. Griff.**

***Aphanobasidium subnitens* (Bourdot & Galzin) Jülich**

PFMP No 22, on the side branch of dead log of *Pinus cembra* 29 cm in diameter, brown rot, decay stage 4, with *Ceraceomyces eludens* and *Lichenomphalia umbellifera*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71555).

***ATHELIALES* Jülich**

***Atheliaceae* Jülich**

***Athelia decipiens* (Höhn. & Litsch.) J. Erikss.**

Vicinity of PFMP No 22, on the fragment of dead log of *Picea abies* 20 cm in diameter, white rot, decay stage 2, with *Fomitopsis pinicola*, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71535); PFMP No 22, on dead log of *Pinus cembra* 35 cm in diameter, white rot, decay stage 3, with *Athelia fibulata* and *Mycena maculata*, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71536).

***A. fibulata* M.P. Christ.**

PFMP No 22, on dead log of *Pinus cembra* 35 cm in diameter, white rot, decay stage 3, with *Athelia decipiens* and *Mycena maculata*, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71537).

***Piloderma byssinum* (P. Karst.) Jülich**

PFMP No 22, on the bark of dead log of *Picea abies* 11 cm in diameter, white rot, decay stage 3, with *Amylostereum areolatum*, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71538).

***AMYLOCORTICIALES* Jülich**

***Amylocorticiaceae* Jülich**

***Ceraceomyces eludens* K.H. Larss.**

PFMP No 22, on dead log of *Pinus cembra* 29 cm in diameter, brown rot, decay stage 4, with *Aphanobasidium subnitens* and *Lichenomphalia umbellifera*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71556).

***AURICULARIALES* Bromhead**

***Auriculariaceae* Fr.**

***Alloexidiopsis calcea* (Pers.) L.W. Zhou & S.L. Liu**

PFMP No 13, on dead log of *Picea abies* 15 cm in diameter, white rot, decay stage 1, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71557).

***Exidia nigricans* (With.) P. Roberts**

PFMP No 22, on standing dead trunk of *Picea abies* 15 cm in diameter, white rot, decay stage 1, 19 July 2022, not. O. Bohoslavets.

***CANTHARELLALES* Gäum.**

***Botryobasidiaceae* Jülich**

***Botryobasidium isabellinum* (Fr.) D.P. Rogers**

PFMP No 13, on remnants of dead log of *Picea abies* and unrecognizable polypore (*Phellinus viticola*?) attached to it, brown rot, decay stage 5, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71558);

***B. vagum* (Berk. & M.A. Curtis) D.P. Rogers**

PFMP No 22, on dead log of *Pinus cembra* 26 cm in diameter, white rot, decay stage 2, with *Hyphoderma occidentale* and *Tubulicrinis glebulosus*, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71539); PFMP No 13, on the remnants of bark on dead log of *Picea abies* 24 cm in diameter, white rot, decay stage 2, with *Dacrymyces stillatus*, *Neoantrodia serialis* and *Trichaptum abietinum*, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71559); on dead log of *Picea abies* 11 cm in diameter, white rot, decay stage 2, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71560).

***GLOEOPHYLLALES* Thorn**

***Gloeophyllaceae* Jülich**

***Veluticeps abietina* (Pers.) Hjortstam & Tellería**

PFMP No 13, on dead log of *Picea abies* 9 cm in diameter, white rot, decay stage 1, with *Phellinus viticola*, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71561);

***HYMENOCHAETALES* Oberw.**

***Hymenochaetaceae* Donk**

***Hymenochaete fuliginosa* (Fr.) Lév.**

PFMP No 22, on dead log of *Pinus cembra* 30 cm in diameter, white rot, decay stage 2, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71523).

***Phellinus viticola* (Schwein.) Donk**

PFMP No 22, on standing dead trunk of *Picea abies* 8 cm in diameter, white rot, decay stage 2, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71542); on fallen branch of *Picea abies* 3 cm in diameter, white rot, decay stage 1, 19 July 2023, not. O. Bohoslavets; PFMP No 13, on dead log of *Picea abies* 26 cm in diameter, white rot, decay stage 2, 10 August 2022, leg. & det. O. Bohoslavets (KW-M71540); on dead log of *Picea abies* 5 cm in diameter, white rot, decay stage 3, with *Xylodon asper*, 10 August 2022, leg. & det. O. Bohoslavets (KW-M71541); on dead log of *Picea abies* 14 cm in diameter, white rot, decay stage 3, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71562); on standing dead trunk of *Picea abies* 14 cm in diameter, white rot, decay stage 2, 12 July 2023, not. O. Bohoslavets; on dead log of *Picea abies* 9 cm in diameter, white rot, decay stage 1, with *Veluticeps abietina*, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71563);

***Tubulicrinis glebulosus* (Fr.) Donk**

PFMP No 22, on dead log of *Pinus cembra* 26 cm in diameter, white rot, decay stage 2, with *Botryobasidium vagum* and *Hyphoderma occidentale*, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71543).

***Schizoporaceae* Jülich**

***Xylodon asper* (Fr.) Hjortstam & Ryvarden**

PFMP No 13, on dead log of *Picea abies* 5 cm in diameter, white rot, decay stage 3, with *Phellinus viticola*, 10 August 2022, leg. & det. O. Bohoslavets (KW-M71544); PFMP No 22, on dead log of *Picea abies* 7 cm in diameter, white rot, decay stage 3, with *Xenasmatella vaga*, 19 July 2023, leg. & det. O. Bohoslavets (KW-M71564).

Incertae sedis

***Trichaptum abietinum* (Pers. ex J.F. Gmel.) Ryvarden**

PFMP No 13, on the remnants of bark on dead log of *Picea abies* 24 cm in diameter, white rot, decay stage 2, with *Botryobasidium vagum, Dacrymyces stillatus* and *Neoantrodia serialis*, 12 July 2023, not. O. Bohoslavets; PFMP No 22, on dead log of *Picea abies* 13 cm in diameter, brown rot, decay stage 2 with *Fomitopsis pinicola*, 19 July 2023, not. O. Bohoslavets.

***POLYPORALES* Gäum.**

***Fomitopsidaceae* Jülich**

***Fomitopsis pinicola* (Sw.) P. Karst.**

Vicinity of PFMP No 22, on the fragment of dead log of *Picea abies* 20 cm in diameter, white rot, decay stage 2, with *Athelia decipiens*, 21 October 2020, not. O. Bohoslavets; PMFP No 22, on standing dead trunk of *Picea abies* 11 cm in diameter, brown rot, decay stage 2, 19 July 2022, not. O. Bohoslavets; on dead log of *Picea abies* 13 cm in diameter, brown rot, decay stage 2 with *Trichaptum abietinum*, 19 July 2023, not. O. Bohoslavets; PFMP No 13, on dead log of *Picea abies* 26 cm in diameter, brown rot, decay stage 3, 12 July 2023, not. O. Bohoslavets.

***Neoantrodia serialis* (Fr.) Audet**

PFMP No 13, on dead log of *Picea abies* 24 cm in diameter, brown rot, decay stage 2, with *Botryobasidium vagum, Dacrymyces stillatus* and *Trichaptum abietinum*, 12 July 2023, leg. & det. O. Bohoslavets (KW-M71565).

***Hyphodermataceae* Jülich**

***Hyphoderma occidentale* (D.P. Rogers) Boidin & Gilles**

PFMP No 22, on dead log of *Pinus cembra* 26 cm in diameter, white rot, decay stage 2, with *Botryobasidium vagum* and *Tubulicrinis glebulosus*, 13

October 2022, leg. & det. O. Bohoslavets (KW-M71545).

***Pycnoporellaceae* Audet**

***Pycnoporellus fulgens* (Fr.) Donk**

PFMP No 22, on lying dead trunk of *Picea abies* 5 cm in diameter, brown rot, decay stage 2, 13 October 2022; leg. & det. O. Bohoslavets (KW-M71546).

Incertae sedis

***Climacocystis borealis* (Fr.) Kotl. & Pouzar**

PFMP No 13, on dead log of *Picea abies* 21 cm in diameter, white rot, decay stage 4, 12 July 2023, not. O. Bohoslavets.

***Hypochnicium albostramineum* (Bres.) Hallenb.**

PFMP No 22, on the bark on dead log of *Pinus cembra* 35 cm in diameter, white rot, decay stage 1, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71547).

***H. cremicolor* (Bres.) H. Nilsson & Hallenb.**

PFMP No 22, on standing dead trunk of *Picea abies* 19 cm in diameter, white rot, decay stage 2, with *Cystostereum murrayi* and *Dacrymyces stillatus*, 19 July 2022, leg. & det. O. Bohoslavets (KW-M71566).

***RUSSULALES* Kreisel ex P.M. Kirk, P.F. Cannon & J.C. David**

***Echinodontiaceae* Donk**

***Amylostereum areolatum* (Chaillet ex Fr.) Boidin**

PFMP No 22, on dead log of *Picea abies* 11 cm in diameter, white rot, decay stage 3, with *Piloderma byssinum*, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71548).

***Stereaceae* Pilát**

***Stereum sanguinolentum* (Alb. & Schwein.) Fr.**

PFMP No 22, on the underside of the fallen branch of *Pinus mugo* 12 cm in diameter, white rot, decay stage 1, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71549).

***Xenasmataceae* Oberw.**

***Xenasmatella vaga* (Fr.) Stalpers**

PFMP No 22, on dead log of *Picea abies* 7 cm in diameter, white rot, decay stage 3, with *Xylodon asper*, 19 July 2023, not. O. Bohoslavets.

***TRECHISPORALES* K.H. Larss.**

***Hydnodontaceae* Jülich**

***Brevicellicium olivascens* (Bres.) K.H. Larss. & Hjortstam**

Vicinity of PFMP No 6, UNESCO Natural World Heritage Site, primeval arolla pine forest, 48°27'49"N, 24°19'10"E, 1415 m a.s.l., on dead log of *Picea abies* 20 cm in diameter, white rot, decay stage 3, 13 October 2022, leg. & det. O. Bohoslavets (KW-M71550).

***DACRYMYCETES* Doweld**

***DACRYMYCETALES* Henn.**

***Dacrymycetaceae* J. Schröt.**

***Dacrymyces stillatus* Nees**

PFMP No 22, on fallen branch of *Picea abies* 7 cm in diameter, white rot, decay stage 2, 21 October 2020, leg. & det. O. Bohoslavets (KW-M71551); on standing dead trunk of *Picea abies* 19 cm in diameter, white rot, decay stage 2, with *Cystostereum murrayi* and *Hypochnicium cremicolor*, 19 July 2022, not. O. Bohoslavets; PFMP No 13, on dead log of *Picea abies* 30 cm in diameter, white rot, decay stage 3, 10 August 2022, leg. & det. O. Bohoslavets (KW-M71552); on dead log of *Picea abies* 24 cm in diameter, white rot, decay stage 2, with *Botryobasidium vagum, Neoantrodia serialis* and *Trichaptum abietinum*, 12 July 2023, not. O. Bohoslavets.

Discussion

The recorded fungi belong to 27 genera, 18 families, 11 orders and 2 classes. Almost all species (except for *Dacrymyces stillatus* classified in *Dacrymycetes*) belong to *Agaricomycetes*, in which *Polyporales* and *Hymenochaetales* are the largest orders represented in our records by seven and five species, respectively. The *Atheliaceae* and *Hymenochaetaceae* are the best represented families, with three species in each.

According to the trophic strategy, most of the species turned out to be saprobic, except for mycorrhizal *Piloderma byssinum* and a basidiolichen *Lichenomphalia umbellifera*. White rotters are the predominant group among wood-decaying fungi — only four of the revealed species (*Fomitopsis pinicola*, *Neoantrodia serialis*, *Pycnoporellus fulgens* and *Veluticeps abietina*) are causing brown rot. Host trees on which the species were recorded are presented in Table 1. *Athelia decipiens* and *Botryobasidium vagum* were the only species recorded on both spruce and arolla pine wood.

Out of 30 species, 17 (*Alloexidiopsis calcea*, *Amylostereum areolatum*, *Aphanobasidium subnitens*, *Athelia decipiens*, *A. fibulata*, *Botryobasidium isabellinum*, *B. vagum*, *Brevicellicium olivascens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum*, *H. cremicolor*, *Phellinus viticola*, *Piloderma byssinum*, *Tubulicrinis glebulosus* and *Xylodon asper*) are reported here for the first time in Gorgany Nature Reserve. For *Tubulicrinis glebulosus* this is the second report from the country, since Shevchenko (2018) recorded the species

Table 1. **Fungi recorded in the primeval forests with arolla pine in Ukraine and associated host tree species**

Species of fungi	*Picea abies*	*Pinus cembra*	*Pinus mugo*
Alloexidiopsis calcea	+		
Amylostereum areolatum	+		
Aphanobasidium subnitens		+	
Athelia decipiens	+	+	
Athelia fibulata		+	
Botryobasidium isabellinum	+		
Botryobasidium vagum	+	+	
Brevicellicium olivascens	+		
Ceraceomyces eludens		+	
Climacocystis boreali	+		
Cystostereum murrayi	+		
Dacrymyces stillatus	+		
Exidia nigricans	+		
Fomitopsis pinicola	+		
Hymenochaete fuliginosa		+	
Hyphoderma occidentale		+	
Hypochnicium albostramineum		+	
Hypochnicium cremicolor	+		
Lichenomphalia umbellifera		+	
Mycena maculata		+	
Neoantrodia serialis	+		
Phellinus viticola	+		
Piloderma byssinum	+		
Pycnoporellus fulgens	+		
Stereum sanguinolentum			+
Trichaptum abietinum	+		
Tubulicrinis glebulosus		+	
Veluticeps abietina	+		
Xenasmatella vaga	+		
Xylodon asper	+		

in Ichnia National Nature Park on wood of *Pinus sylvestris*.

Five species, namely *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum* and *H. cremicolor*, are new to Ukraine. The latter species was previously reported from Sviati Hory National Nature Park but, upon closer examination, Akulov & Ordynets (2011) re-identified the specimen as *Hypochnicium wakefieldiae* (Bres.) J. Erikss.

Among the records, *Cystostereum murrayi*, *Phellinus viticola* and *Pycnoporellus fulgens* are commonly considered indicators of the naturalness of forest ecosystems (Kotiranta, Niemelä, 1993; Parmasto, Parmasto, 1997; Tortić, 1998; Holec, 2004, 2008).

Holec (2008) and Kotiranta & Niemelä (1993) listed *Cystostereum murrayi* among the most demanding species in their indicator fungi lists, occurring exclusively in natural forests. Recorded at an elevation of nearly 1470 m a.s.l., this is so far the uppermost known locality of the species in Ukraine.

Phellinus viticola (Fig. 2) is another collected species warranting particular attention. In Ukraine, the species had previously been known only from the territories of the Carpathian National Nature Park and Marmarosy Massif of the Carpathian Biosphere Reserve (Dudka et al., 2019). Pilát was the first to discover the species (as *Phellinus isabellinus* (Fr.) B. & G.) in 1937 in the Berlebash stream valley (Kavina, Pilát, 1942; Holec, 2002). Almost 80 years later, Akulov (2016) published two more locations, in the primeval spruce forest near the Lysycha subalpine meadow and in old-growth spruce forest covering the slopes of Petros Marmaroskyi mountain.

Albeit *P. viticola* is a poorly known species in Ukraine, the striking abundance of its basidiomata observed within the study sites on moderately rotten woody debris with relatively small diameters (down to 3 cm) aligns remarkably well with the ecological characteristics mentioned in the literature. According to Pouska et al. (2013), in an old-growth mountain spruce forest in the Bohemian Forest (Czech Republic) it is, similarly, one of the most abundantly occurring species on naturally fallen spruce logs. The fruitbodies of *P. viticola* are restricted to moderately decomposed wood and may be produced with a relatively small mycelial mass (Renvall, 1995; Rajala et al., 2015). The distribution of this species is also shown to be significantly affected by the connectivity between logs suitable for colonization (Jönsson et al., 2008).

Although *P. viticola* is generally not considered rare (Ryvarden, Melo, 2014; Læssøe, Petersen, 2019), the species distribution is clearly limited by the availability and spatial connectivity of suitable substrata. We believe that this feature, together with the basidiomata abundance and their both noticeable and well-recognizable appearance, makes it an especially convenient indicator species of the conservational value of European boreo-montane spruce forests. However, the presence of *P. viticola* fruitbodies should not be perceived as direct evidence of an absence of human influence on the

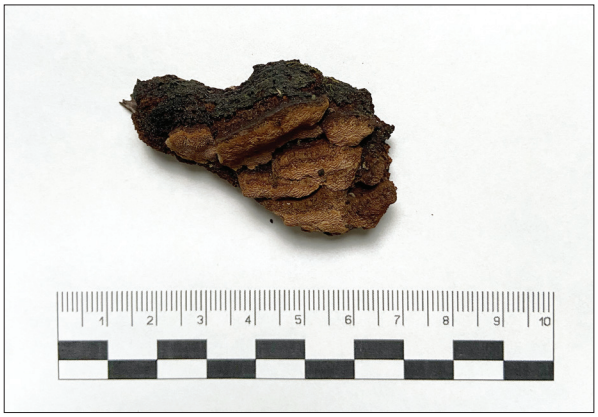

Fig. 2. General view of basidiomata of *Phellinus viticola* (KW-M71542)

area, but rather could be seen as a sign of existence of some fundamental traits of a natural ecosystem, making it worthy of protection.

Since the vast majority of the recorded species are represented by a single find, we conclude that the diversity of wood-inhabiting *Basidiomycota* in the Ukrainian primeval arolla pine forests requires further research. However, some general features of the fungal communities of these habitats can already be noted.

The species composition of *Basidiomycota* per individual fallen log is found to be quite poor: we could not find more than four fungal species on any of the examined pieces of wood. The fungi forming thin resupinate corticioid basidiocarps on the underside of the substrate clearly prevail in the species composition. This trend seems to be a consequence of a lack of moisture in the surveyed treeline stands growing on shallow rocky soils, also resulting in the well-documented phenomenon of slow wood decay in subalpine habitats (Shevchenko, 1972; Lambert et al., 1980; Kueppers et al., 2004; Bisht et al., 2014). Further studies of wood-inhabiting fungal communities in the Ukrainian arolla pine forests will provide valuable insights into the wood decay dynamics in these ecosystems, which are constantly exposed to harsh climatic conditions and threatened with substantial area decline due to ongoing climate changes (Kuzemko et al., 2018).

Acknowledgements

Authors would like to express their sincere gratitude to all who contributed to this research. Special thanks go to those who accompanied us on expeditions, provided valuable assistance in editing the text and contributed to the creation of illustrations: Maksym M. Bohoslavets, Mykhaylo M. Filiuk, Valeriia D. Gorodchanina, Yuliia V. Harhat, Roman I. Kuznietsov, Uliana D. Miskevych, Oksana V. Ostashuk, Orest M. Ostashuk, Yaroslav V. Petrashchuk, Tetiana I. Polatayko, Vasyl S. Popovych, Arkadii S. Savchuk, Mykhailo M. Savchuk, Vasyl V. Yaremchuk, Stepan V. Yusyp and Dr. Mariia V. Shevchenko. We are deeply grateful to the anonymous reviewers and the Editorial Board of the *Ukrainian Botanical Journal* for their helpful advice.

We sincerely acknowledge the Frankfurt Zoological Society and the "Support to Nature Protected Areas" Project of the German Government for their vital financial support throughout our research.

Ethics Declaration

The authors declare no conflict of interest.

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Деякі базидієві гриби, асоційовані з деревним субстратом, із пралісів з участю *Pinus cembra* в Україні

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Реферат. Угруповання з участю *Pinus cembra* належать до найрідкісніших та найменш вивчених оселищ Європи. У статті наведено 30 видів базидієвих грибів, асоційованих з деревним субстратом, виявлених у кедрових пралісах природного заповідника "Горгани" (Українські Карпати). П'ять видів, а саме *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum* та *H. cremicolor*, є новими для території України. З-поміж усіх знахідок, *Cystostereum murrayi*, *Phellinus viticola* та *Pycnoporellus fulgens* заслуговують на особливу увагу, оскільки вони є біоіндикаторами природних лісових екосистем. Видовий склад базидієвих грибів на індивідуальних деревних рештках виявився досить бідним. Серед знахідок переважають гриби, що формують тонкі кортиціоїдні плодові тіла на нижній стороні субстрату, що вказує на нестачу вологи в обстежених деревостанах на верхній межі лісу. Для кожної знахідки наведено детальний опис субстрату та місця збору. Подано огляд попередніх досліджень різноманіття базидієвих грибів, асоційованих з деревним субстратом, у лісах з участю сосни кедрової європейської.

Ключові слова: верхня межа лісу, рідкісні види, Українські Карпати, *Aphanobasidium subnitens*, *Ceraceomyces eludens*, *Hyphoderma occidentale*, *Hypochnicium albostramineum*, *Hypochnicium cremicolor*, *Phellinus viticola*