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ORIGINAL RESEARCH PAPER

Macromycetes of Central European lichen Scots pine forests of the *Cladonio-Pinetum* Juraszek 1927 type in the "Bory Tucholskie" National Park (NW Poland)

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Abstract
Between 2014 and 2016, research was carried out in the "Bory Tucholskie" National Park, with the aim to investigate the diversity of species of macrofungi in *Cladonio-Pinetum*. The studies recorded 140 taxa of macromycetes, of which the majority was basidiomycete (136). The highest number of taxa of fungi (98) was found in 2016, while the lowest (76) was found in the first year of the study (2014). A total of 90 taxa were found in 2015. Among the identified species of macromycetes, *Inonotus obliquus* is on the list of protected fungi covered by partial legal protection and 23 reported species are on the "Red list of the macrofungi in Poland", which is concerned with the protection of the habitat of *Cladonio-Pinetum*.

Keywords
macromycetes; protected area; rare species; PNBT; Natura 2000; dry midland coniferous forest

Introduction

The "Bory Tucholskie" National Park (PNBT) was created on July 1, 1996 in the Pomeranian Province in the area of the Chojnice district, within the administrative borders of the communities of Chojnice and Brusy. Its total area is 4613.04 ha [1,2]. PNBT includes clean lakes and numerous bog ecosystems, and forest occupy a majority of the area. The most important objective of nature protection in this national park is preservation of the natural species in biocenotic lakes (especially oligotrophic lakes), bogs and pine forests [3].

Pine forests are the dominant component of forest ecosystems in the PNBT. Among these are predominantly sub-Atlantic mesophilous pine forests of *Leucobryo-Pinetum* (41.66% of terrestrial communities in the Park, with an area of 1911.82 ha) and midland dry pine forests of *Cladonio-Pinetum* (20.28% of terrestrial communities in the Park, with an area of 930.58 ha) [4,5].

The lichen-rich pine forests of *Cladonio-Pinetum* represent special habitats protected under the Natura 2000 scheme as Central European lichen Scots pine forests (91T0) [4–7]. This is a very unstable community. The method of creating *Cladonio-Pinetum* is not clearly defined. They may be a natural variation of pine forests, or their formation could be anthropogenic and associated with the historical and traditional agricultural economy of the population in heavily forested areas. Drawing a clear boundary between dry and fresh pine forests is difficult because all varieties of pine forests gradually transfer into one other. The main component of this community is lichen of the *Cladonia*

genus, section *Cladina* [7–10]. A large share of these lichens in the undergrowth of a pine forest community is an indicator determining the habitat of *Cladonio-Pinetum*. The habitat is very sensitive to changes in environmental factors. Decreasing patches of lichen in the undergrowth in favor of mosses may indicate a decrease in the surface area of this community [8,9]. The community of *Cladonio-Pinetum* is a priority in terms of conservation objectives in the PNBT [3].

To achieve this objective, it is important to monitor and document biodiversity of all the organisms that live in patches of the *Cladonio-Pinetum* community. Fungi are one of these organisms and play an important role in the structural and functional aspect of *Cladonio-Pinetum* and are an important component of undergrowth [11].

The fungi of *Cladonio-Pinetum* in Europe and Poland are known only to a minor extent. The macromycetes of *Cladonio-Pinetum* have been examined in the Lüchow-Dannenberg district of Germany [12]. In the publications of Polish mycologists, there are data on macroscopic fungi in the *Cladonio-Pinetum* community [13–21]. The fungi of these habitats have not been covered by separate observations. During comprehensive mycological research conducted in 2000–2001 in "Bory Tucholskie" National Park, observations were made in other dry pine forest habitats, and the results are included in a general statement of species [11].

In 2014 to 2016, a project was conducted in the PNBT ("Research on macroscopic fungi in the *Cladonio-Pinetum* in the 'Bory Tucholskie' National Park in 2014–2016") with the primary aim of creating a mycological inventory of the *Cladonio-Pinetum* community located mainly in the northwestern area of the Park, in the protective district Drzewicz. This paper presents the research results obtained during this project.

Material and methods

The material included macromycetes collected in the vegetative season in 2014 to 2016. Observations were carried out once a month (April–November), with a total of eight observations made each year. The study included all patches representing the most typical fragments of the community. Field investigations began with recognition of the habitat and locations where permanent plots were established. The range of occurrence of the habitat was established by Solon and Matuszkiewicz [4] and Matuszkiewicz et al. [5], who determined six permanent observation plots measuring 10 × 100 m (10 acres) and gave them the names CP 1 to CP 6 (Fig. 1). CP 1 is located in Forest Section 7, in a pine tree stand. The area has a slight incline, and the undergrowth is covered compact layer of *Cladonia* spp. Between these are mosses, namely *Pleurozium schreberi* and *Dicranum spurium*, and small quantities of deadwood (i.e., branches, logs). CP 2 is Forest Section 32, which is in a pine tree stand, with young pines in the undergrowth.

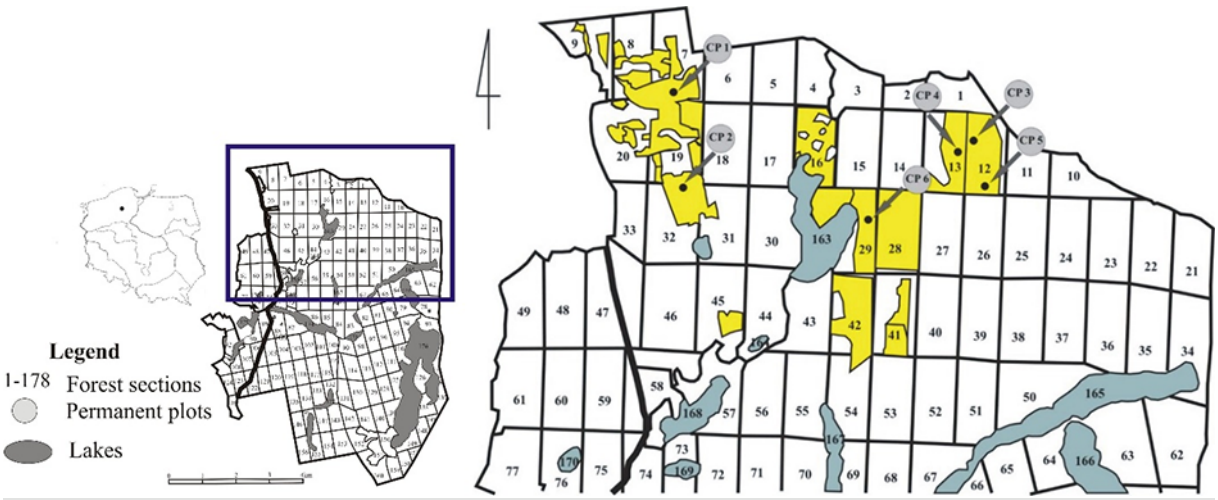

Fig. 1 Localization of permanent plots of *Cladonio-Pinetum* in the "Bory Tucholskie" National Park, protective district Drzewicz [from: Salamaga et al. (modified) [22] and BG].

The undergrowth is covered in a compact layer of *Cladonia* spp. Between these are mosses, namely *Pleurozium schreberi* and *Dicranum spurium*, with a small account of *Vaccinium myrtillus*, *Vaccinum vitis-idaea*, and *Calluna vularis*, and single pine logs, stumps, and trunks. CP 3 is located near the duct between Forest Sections 12 and 13. These are covered with a lichen layer of genus *Cladonia* spp., with a pine tree stand and birches. Between these are mosses, namely *Pleurozium schreberi* and *Dicranum spurium*, with small amounts of deadwood. CP 4 is in Forest Section 13, in lower terrain, with a few moss patches of *Pleurozium schreberi* and *Dicranum spurium*, a pine tree stand, and lots of dead wood (i.e., logs, stumps). CP 5 is in Forest Section 12, in a pine tree stand. The area has a slight incline, and the undergrowth is covered by a compact layer of *Cladonia* spp. Between these are mosses, namely *Pleurozium schreberi* and *Vaccium myrtillus* and small amounts of deadwood (i.e., branches). CP 6 is in Forest Section 29, near Krzywce Wlk Lake, in a pine stand with an admixture of birch. Patches of lichen are present in small numbers, and in the undergrowth there are a lot of mosses, namely *Pleurozium schreberi* and *Dicranum spurium*, with sparse *Vaccinum myrtillus* and deadwood (i.e., logs, branches, stumps, trunks). The pine tree stands are aged 40–128 years, with an average of 84 years [5]. The permanent plots were not indicated by signs in the area on a sustainable basis. Their geographical coordinates, determined by a Garmin Colorado 300 GPS receiver, were recorded and applied to the base GIS PNBT (to measure the center of each plot).

Geographical coordinates of the permanent plots and numbers of forest sections (f.s.) are as follows: CP 1 – f.s. 7, N 53.85243°, E 17.53777°; CP 2 – f.s. 32, N 53.84313°, E 17.54083°; CP 3 – f.s. 12, N 53.84719°, E 17.57927°; CP 4 – f.s. 13, N 53.84715°, E 17.57752°; CP 5 – f.s. 12, N 53.84407°, E 17.58092°; CP 6 – f.s. 29, N 53.8417°, E 17.56667°.

To perform a complete mycological inventory of *Cladonio-Pinetum*, an observation route was carried out for permanent plots, throughout the area occupied by *Cladonio-Pinetum*.

The material was identified as much as possible in the field in a fresh state and, in the case of questionable species, though collected specimens of fungi. Sporocarps of protected species of fungi were not collected. In the case of protected fungi and endangered and rare species, GPS coordinates were noted. Photographic documentation was done using a Nikon D5000.

Collected materials were studied with standard methods used in the taxonomy of macromycetes. Microscopic characteristics were viewed with a Nikon Eclipse 50i light microscope and a (binocular) stereoscopic microscope. Species were primarily marked using keys (e.g., [23–35]).

The nomenclature of basidiomycetous fungi after Knudsen and Vesterholt [32] was accepted. Names of species not included in this publication and names of ascomycetes were used according to Index Fungorum [36]. Protected species are listed by the regulation of the Minister of the Environment on the protection of species of fungi [37], with threat categories according to Wojewoda and Ławrynowicz [38].

Results

As a result of observations of *Cladonio-Pinetum* (in permanent plots and beyond) carried out during 2014–2016, a total of 140 taxa of macroscopic fungi was identified. Most (136 fungi taxa) were Basidiomycetes (Basidiomycota). Four taxa, namely *Chlorociboria* sp., *Elaphomyces granulatus*, *E. muricatus*, and *Gyromitra esculenta*, belong to Ascomycota.

During the 3 years of research, the highest number of fungi recorded was in 2016, with 98 taxa. The least taxa (76) were found in the first year of the study (2014). A total of 90 taxa were identified in 2015.

During the observation period, the influence of climatic factors on sporocarp formation was observed. After a period of intense precipitation and rising temperatures, a higher number of taxa was recorded, until October (Fig. 2).

Various taxa were also visible within the permanent plots. Permanent plot CP 3, which is located in Forest Section 12, was the richest in number of taxa, with 65 taxa

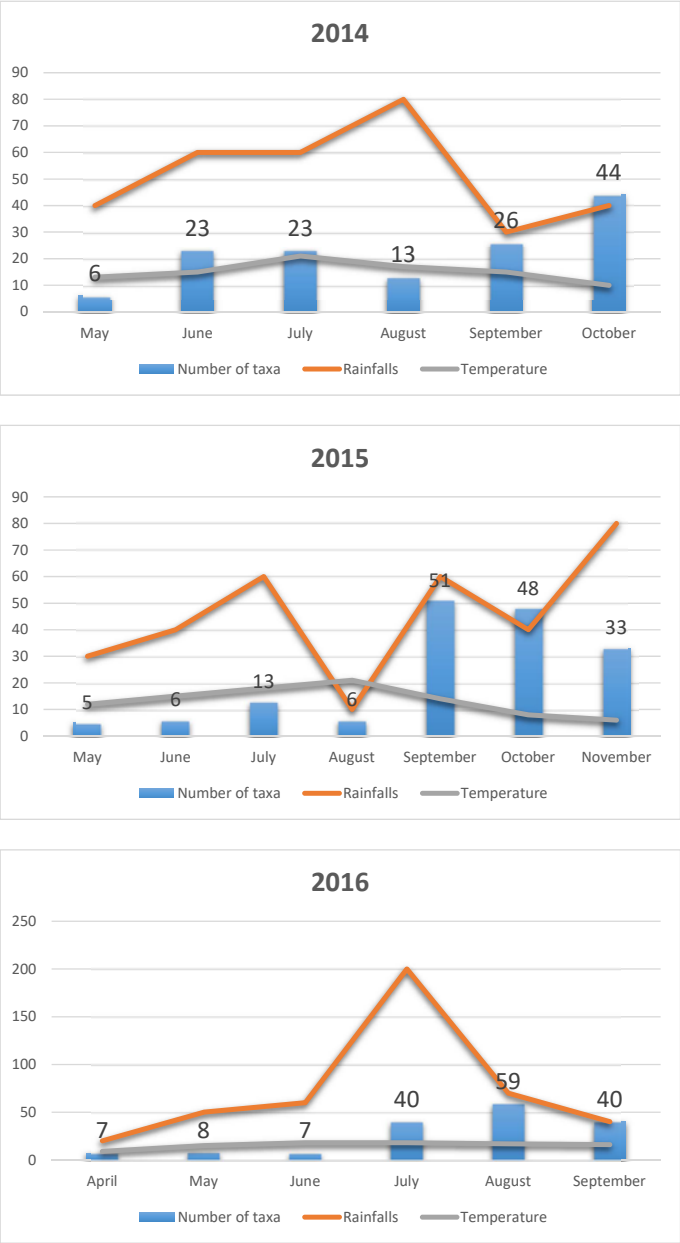

Fig. 2 The number of fungi taxa of *Cladonio-Pinetum* in the "Bory Tucholskie" National Park, 2014–2016 (meteorological data from [39]).

Tab. 1 The number of fungi taxa in the ecological groups in 2014–2016 in the "Bory Tucholskie" National Park.

Ecological group of fungi	2014	2015	2016	2014–2016
Terricolous	50	60	70	88
Litter-inhabiting	7	7	3	13
Xylobiontic	12	15	19	30
Bryophilous	2	2	1	2
Hypogeous	2	3	3	4
Cone-inhabiting	2	2	1	2
Fungicolous	1	1	1	2

found, while permanent plot CP 4, located in Forest Section 13, had the fewest, with only 33 taxa. Permanent plot CP 1 had 46 taxa, CP 2 had 58 taxa, CP 5 had 50 taxa, and CP 6 had 53 taxa of fungi.

Fungi recorded during field observations were on different substrates. The following ecological groups (structural division) were distinguished: (***i***) terricolous – fungi growing on soil, humus, peat, sand; (***ii***) litter-inhabiting – fungi colonizing the litter in the form of needles, small fallen twigs, leaves, grass blades, dead herbs; (***iii***) xylobiontic – fungi occurring on wood (logs, tree trunks, stumps, roots, branches); (***iv***) bryophilous – fungi colonizing mosses; (***v***) hypogeous – fungi growing under soil; (***vi***) cone-inhabiting – fungi growing on cones; (***vii***) fungicolous – fungi occurring on old sporocarps of other fungi.

Considering the data from 2014–2016 (Tab. 1), fungi growing on soil comprised the largest group (88 taxa). Among these were mycorrhizal fungi and decaying saprotrophic nutrition soil, humus, peat, or sand. The second largest group were xylobionts, with 30 taxa. This group included both fungi living on dead wood, as well as those living on trees as a parasitic species. A small group of fungi was growing on litter (13 taxa). The group of bryophilous and hypogeous fungi and fungi growing on pine cones included only a single species. Fungi inhabiting sporocarps were represented by two species – *Collybia tuberosa* and *C. cirrata*. Numerical proportions of fungi taxa observed each year were similar. Observations were always dominated by fungi growing on soil, followed by fungi colonizing wood, then fungi growing on litter. The numerical participation of taxa in the following groups of fungi: bryophilous fungi, hypogeous fungi, fungi growing on cones, and fruit bodies of other species of fungi, was insignificant for all years. This points to a limited number of taxa of litter-inhabiting fungi in 2016.

Due to these findings, identified taxa of fungi were divided into three trophic groups (functional separation): (***i***) mycorrhizal fungi, (***ii***) saprotrophic fungi, and (***iii***) parasitic fungi.

The analysis summarizing data from all years of observations shows that the largest group of fungi were ectomycorrhizal fungi, with 79 taxa (Tab. 2). These were only ectomycorrhizal fungi entering in symbiosis mainly with pine trees (e.g., *Amanita muscaria*, *Amanita gemmata*, *Boletus edulis*, *Laccaria laccata*) and, to a small degree, also with birch trees (*Cortinarius armillatus*, *Leccinum versipelle*) and spruce trees (e.g., *Gomphidius glutinosus*). Mycorrhizal partners of these trees were mostly basidiomycetes. Exceptions were hypogeous ascomycetes of the genus *Elaphomyces*. Saprotrophic fungi were also represented by a large number of taxa (58).

Numerous fungi occurred among saprotrophs colonizing dead pine and birch wood in tree stumps, trunks, logs, and branches (27 taxa). This group of fungi species also included decaying humus soil

Tab. 2 The number of fungi taxa in the trophic groups in 2014–2016 in the "Bory Tucholskie" National Park.

Trophic group	2014	2015	2016	2014–2016
Mycorrhizal fungi	50	55	68	79
Saprotrophic fungi	26	35	27	58
Parasiting fungi	0	0	3	3

(13 taxa), litter (13 taxa), dead mosses (two taxa), pine cones (two taxa), and other old sporocarps of fungi (one taxon). Parasites formed a small group of three species growing on the living trunks of pine trees – *Fomitopsis pinicola* and *Porodaedalea pini* – and on the roots of pine trees – *Sparassis crispa*. These fungi form sporocarps in numbers that do not cause a threat to forest stands. During each year of observations, mycorrhizal fungi were the largest group, with the highest number of taxa. Saprotrophic fungi also form a large group. Between 2014 and 2015, there were no species of parasitic fungi, while in 2016, there were three.

Among the recorded macromycetes, one species, *Inonotus obliquus*, is listed as protected fungi and is partially covered by legal protection [37], and 23 species are on the "Red list of acrofungi in Poland" [38] (Tab. 3).

In 2016, the occurrence of sporocarps *Phellodon tomentosus* was observed compared to previous years (dozens of sporocarps in one place), a species categorized as "E – endangered" [38]. It is a fungus with a spinose hymenophore found in coniferous and mixed forests, soil, or fallen needles, often among *Vaccinum myrtillus*. When drying sporocarps, they smell like spice – Maggie. They create "fairy rings", and their sporocarps fuse together [29] (Fig. 3). This fungus rapidly spreads in *Cladonio-Pinetum* from July to October. The fungus was observed in places that did not form sporocarps in previous years. He has performed in some places in mass.

Tab. 3 Species of macromycetes in *Cladonio-Pinetum* of the "Bory Tucholskie" National Park located on the "Red list of the macrofungi in Poland" [38].

Category E (endangered): three species
Cortinarius fulvescens
Phellodon tomentosus
Tricholoma focale
Category R (rare): 14 species
Calocera furcata
Cortinarius acutus
Cortinarius croceus
Crepidotus applanatus
Deconica montana
Gomphidius glutinosus
Gomphidius roseus
Gyroporus cyanescens
Inonotus obliquus
Lichenomphalia umbellifera
Porodaedalea pini
Sparassis crispa
Trametes coccinea
Tricholoma sejunctum
Category V (vulnerable): four species
Cortinarius armeniacus
Dacrymyces capitatus
Sarcodon squamosus
Thelephora caryophyllea
Category I (indeterminate): two species
Myxomphalia maura
Tricholoma equestre

List of macromycetes taxa recorded in *Cladonio-Pinetum* in the "Bory Tucholskie" National Park in 2014–2016

Abbreviations: CP 1 – CP 6 – names of permanent plots; f.s. – forest section; Roman numerals – months of note taxon; Arabic numerals – year of note taxon.

Amanita citrina (Schaeff.) Pers. f. ***citrina*** – on soil, among lichens and mosses, under pines; CP 3, X 2016; f.s. 20, X 2016; f.s. 28, X 2014, IX 2015; f.s. 32, VII, X 2016; f.s. 41, IX 2014, X 2016; f.s. 42, VIII 2016.

Amanita excelsa (Fr.: Fr.) Bertill. f. ***excelsa*** – on soil, among lichens and mosses, under pines; f.s. 8, X 2015.

Amanita fulva (Schaeff.: Fr.) Fr. – on soil, among lichens and mosses, under pines and birches; f.s. 32, VII 2016.

Amanita gemmata (Fr.) Bertill. – on soil, among lichens and mosses, under pines; CP 1, VI 2014; CP 2, IX 2016; CP 3, VI 2014, VIII–X 2016; CP 4, VI–VII 2014; CP 5, VII 2014; CP 6, VI 2014; f.s. 8, VI 2014, VII, IX 2016; f.s. 9, VII 2016; f.s. 20, X 2016; f.s. 32, X 2016; f.s. 41, VI 2014; f.s. 42, VIII 2016; f.s. 45, VI 2014.

Amanita muscaria (L.: Fr.) Pers. var. ***muscaria*** – on soil, among lichens and mosses, under pines and birches; CP 1, X 2015; CP

Fig. 3 Sporocarps of *Phellodon tomentosus* recorded in high abundance in *Cladonio-Pinetum* in the "Bory Tucholskie" National Park.

2, IX 2014, IX 2015; CP 3, IX 2014, IX–X 2015; f.s. 19, X 2016; f.s. 28, X 2014, IX 2015; f.s. 31, IX 2015; f.s. 32, X 2016; f.s. 33, IX 2015; f.s. 41, X–XI 2015, X 2016; f.s. 42, IX 2014, IX–X 2015.

Amanita pantherina (DC.: Fr.) Krombh. – on soil, among lichens and mosses, under pines; CP 2, VI 2014; CP 3, VII 2014, IX 2016; CP 4, VI 2014; f.s. 8, VI 2014; f.s. 32, VII 2016; f.s. 41, VI 2014; f.s. 42, IX 2015.

Amanita porphyria Alb. & Schwein.: Fr. – on soil, among lichens and mosses, under pines; CP 2, VII 2016; CP 4, IX 2016; CP 5, f.s. VII 2014; f.s. 32, VII 2016.

Amanita rubescens Pers.: Fr. f. ***rubescens*** – on soil, among lichens and mosses, under pines and birches; CP 1, VIII 2016; CP 2, X 2015, VII 2016; CP 3, VI 2014; CP 4, VI 2014, VII 2015, X 2016; CP 5, IX–X 2015; CP 6, X 2015; f.s. 19, VII 2015; f.s. 32, VII 2016.

Auriscalpium vulgare Gray – on pine cones; CP 1, X 2015.

Boletus edulis Bull.: Fr. – on soil, among lichens and mosses, under pines; CP 2, X 2015; CP 3, IX 2015; CP 6, IX 2015; f.s. 9, VII 2016; f.s. 19, IX 2014; f.s. 28, X 2014; f.s. 31, IX 2015; f.s. 32, IX 2015; f.s. 32, VII 2016; f.s. 33, IX 2015; f.s. 41, VIII 2016.

Boletus luridiformis Rostk. var. ***luridiformis*** – on soil, among mosses, under pines; CP 4, X 2016.

Boletus pinophilus Pilát & Dermek – on soil, among lichens, under pines; CP 3, IX 2015; CP 6, IX 2015; f.s. 19, IX 2015; f.s. 28, IX 2015.

Calocera furcata (Fr.) Fr. – on the fallen branches of pine; f.s. 7, XI 2015.

Calocera viscosa (Pers.) Fr. – on the logs of pine; CP 5, VIII 2016, IX 2016; f.s. 8, VII 2014; f.s. 32, VII 2016.

Cantharellus cibarius Fr. – on soil, among lichens and mosses, under pines; CP1, VI 2014, X 2014; CP2, VI 2014, VIII 2016; CP 3, VI, VIII 2014, VIII–IX 2016; CP 4, VI 2014, IX–X 2016; CP 5, VI 2014, X 2014, IX 2015; CP 6, VIII 2016; f.s. 7, VII 2016; f.s. 13, VII 2014; f.s. 19, VII 2015; f.s. 32, VII 2016, IX 2016; f.s. 41, VI, VIII 2014; f.s. 42, VII–VIII 2014, VIII 2016; f.s. 45, VI 2014.

Chalciporus piperatus (Bull.: Fr.) Bataille – on soil, among mosses, under pines and birches; f.s. 32, IX 2015.

Chlorociboria sp. – on log of birch; f.s. 29, VI 2016.

Chroogomphus rutilus (Schaeff.: Fr.) O. K. Miller var. ***rutilus*** – on soil, among mosses, under pines; CP 3, X 2015; f.s. 28, IX 2015.

Clitocybe metachroa (Fr.: Fr.) P. Kumm. var. ***metachroa*** – on litter among mosses; CP 1, XI 2015; f.s. 7, XI 2015; f.s. 19, XI 2015; f.s. 32, XI 2015; f.s. 42, XI 2015.

Clitocybe nebularis (Batsch: Fr.) P. Kumm. var. ***nebularis*** – on litter among mosses; f.s. 32, XI 2015.

Clitocybe phyllophila (Pers.: Fr.) P. Kumm. – on litter among mosses; f.s. 32, XI 2015.

Collybia cirrata (Schumach.) Quél. ("cirrhata") – on decaying sporocarps of other fungi; CP 2, IX, XI 2015; CP 5, X 2015; f.s. 42, IX 2016.

Collybia tuberosa (Bull.: Fr.) P. Kumm. – on decaying sporocarps of other fungi; CP 1, VI 2014; CP 3, X 2014; CP 4, X 2014; CP 5, VIII, X 2014; f.s. 28, X 2014; f.s. 45, VIII 2014.

Coltricia perennis (L.) Murrill – on soil, on paths, under pines; CP 1, VIII 2015; CP 2, IX 2015, VIII–IX 2016; CP 3, X 2016; CP 5, VII–VIII 2014; CP 6, VIII 2016; f.s. 7, IX 2016; f.s. 8, VII–VIII 2014, VIII 2015, VII–IX 2016; f.s. 9, VII 2016; f.s. 12, VIII 2014; f.s. 13, VIII 2015; f.s. 19, VII 2014, VIII–IX 2015; f.s. 20, X 2016; f.s. 28, VI 2014; f.s. 32, VII–VIII 2014, VIII 2015, VII, IX 2016; f.s. 33, V, VII 2014; f.s. 41, VIII 2016; f.s. 42, VIII–IX 2016.

Cortinarius acutus (Pers.) Fr. – on soil, among mosses, under pines; CP 2, X 2014, XI 2015; CP 3, X 2014; IX, XI 2015; CP 5, XI 2015; CP 6, XI 2015; f.s. 28, X 2014; f.s. 32, VII 2016; f.s. 41, X 2014, X–XI 2015; f.s. 42, X–XI 2015.

Cortinarius armeniacus (Schaeff.: Fr.) Fr. – on soil, among mosses, under pines; CP 3, IX 2014; CP 6, X 2015; f.s. 41, IX 2014.

Cortinarius armillatus (Fr.: Fr.) Fr. – on soil, among mosses, under birches; f.s. 28, IX 2015; f.s. 42, X 2015; f.s. 42, VIII–IX 2016.

Cortinarius brunneus (Pers.: Fr.) Fr. – on soil, among mosses and lichens, under pines; CP 3, VIII 2016; CP 6, VIII 2016; f.s. 41, VIII, X 2016; f.s. 42, X 2015, VIII 2016.

Cortinarius caperatus (Pers.) Fr.– on soil, among mosses, under pines; CP 1, X 2015, VII–VIII, X 2016; CP 2, IX–X 2015, VII–X 2016; CP 3, IX 2014, IX 2015, VIII–IX 2016; CP 4, IX 2014, IX–X 2015, IX–X 2016; CP 5, IX 2015, VIII–X 2016; CP 6, IX–X 2015, VIII–X 2016; f.s. 7, VIII–IX 2016; f.s. 8, VIII 2016; f.s. 9, VII, IX 2016; f.s. 12, VIII 2016; f.s. 13, VIII 2016; f.s. 19, VIII 2016; f.s. 20, VIII, X 2016; f.s. 28, IX 2015, VIII 2016; f.s. 29, VIII 2016; f.s. 31, IX 2015; f.s. 32, VII–VIII 2016; f.s. 33, IX 2015; f.s. 42, VIII–IX 2016; f.s. 45, IX 2015, VIII 2016.

Cortinarius cinnamomeoluteus P. D. Orton – on soil, among lichens, under pines; CP 6, X 2014; f.s. 28, X 2014.

Cortinarius cinnamomeus (L.: Fr.) Gray – on soil, among mosses and lichens, under pines; CP 1, X 2014; CP 2, X 2014; IX 2015; CP 3, X 2014, VIII–IX 2016; CP 4, X 2014; CP 5, X 2014, IX 2016; CP 6, X 2014; f.s. 19, X 2016; f.s. 28, X 2014; f.s. 28, IX 2015; f.s. 31, IX 2015; f.s. 32, IX 2015; f.s. 33, IX 2015; f.s. 41, VIII 2016; f.s. 42, VIII 2016.

Cortinarius croceoconus Fr. – on soil, among mosses and lichens, under pines; CP 5, X 2014.

Cortinarius croceus (Schaeff.: Fr.) Gray subsp. ***croceus*** – on soil, among mosses and lichens, under pines; CP 2, X 2014; CP 3, X 2014; CP 6, X 2014; f.s. 41, IX 2014.

Cortinarius flexipes (Pers.: Fr.) Fr. var. inolens – on soil, among mosses and lichens, under pines; CP 3, XI 2015; CP 6, X–XI 2015; f.s. 41, X 2014.

Cortinarius fulvescens Fr. – on soil, among mosses and lichens, under pines; CP 1, VIII 2016; CP 3, VIII 2016; CP 5, VIII 2016; CP 6, VII–VIII 2016; f.s. 19, VIII 2016; f.s. 32, VIII 2016; f.s. 41, X 2016.

Cortinarius mucosus (Bull.: Fr.) J. J. Kickx – on soil, among mosses and lichens, under pines; CP 1, IX–X 2014; CP 2, IX–X 2014, IX–X 2015, VIII, X 2016, CP 3, IX–X 2014, IX–X 2015, IX–X 2016; CP 4, IX–X 2014; CP 5, IX 2015, VIII, X 2016; CP 6, X 2014, IX 2015; f.s. 8, VIII 2016; f.s. 19, VIII, X 2016; f.s. 28, X 2014; f.s. 28, IX 2015; f.s. 31, IX 2015; f.s. 32, IX 2015; f.s. 33, IX 2015, IX 2016; f.s. 41, IX 2014, X 2015, VIII, X 2016; f.s. 42, IX 2014, IX–X 2015, VIII, X 2016; f.s. 45, IX 2015.

Cortinarius obtusus (Fr.: Fr.) Fr. s. l. – on soil, among lichens, under pines; CP 2, IX 2015; CP 6, X 2014.

Cortinarius sanguineus (Wulfen: Fr.) Fr. var. ***sanguineus*** – on soil, among lichens, under pines; f.s. 32, VII 2016; f.s. 42, VIII–IX 2016.

Cortinarius semisanguineus (Fr.: Fr.) Fr. – on soil, among mosses and lichens, under pines; CP 1, X 2014, VIII 2016; CP 2, X 2014, IX 2015, VIII–IX 2016; CP 3, XI 2015; CP 5, X 2014; CP 6, XI 2015; f.s. 7, VIII 2016; f.s. 8, VIII 2016; f.s. 19, VIII 2016; f.s. 28, X 2014; f.s. 31, IX 2015; f.s. 45, IX 2015.

Cortinarius traganus (Fr.) Fr. – on soil, among mosses, under pines; CP 1, IX 2015; CP 3, XI 2015; CP 5, VII, IX 2014.

Crepidotus applanatus (Pers.) P. Kumm. – on deciduous wood; CP 2, XI 2015; f.s. 19, XI 2015; f.s. 31, XI 2015; f.s. 32, XI 2015.

Cystoderma amianthinum (Scop.: Fr.) Fayod – on soil, among mosses; CP 3, X 2014; f.s. 32, XI 2015; f.s. 41, X 2014, X 2015; f.s. 42, XI 2015.

Dacrymyces capitatus Schwein. – on log of pine; CP 2, V 2016; CP 3, VI 2014; f.s. 32, VI 2014.

Dacrymyces stillatus Nees – on fallen twig of pine; CP 3, VI 2014, VII 2015; CP 5, VII 2015; CP 6, VII 2015.

Deconica montana (Pers.: Fr.) P. Kumm. – on mosses; CP 3, IX 2015; f.s. 8, VII 2014.

Elaphomyces granulatus Fr. – underground, on wild boar rooting, under pines; CP 2, IV, V 2016; CP 3, IV, V 2016; CP 4, IX 2015, VI 2016; CP 5, IX 2015; f.s. 8, V 2016; f.s. 32, V 2014.

Elaphomyces muricatus Fr. – underground, on wild boar rooting, under pines; f.s. 32, IV, V 2016.

Fomes fomentarius (L.) Fr. – on log and standing trunk of birch (deadwood); f.s. 13, VI 2015; f.s. 41, IX 2014, X 2016; f.s. 42, VIII, X 2015, VI, VIII–IX 2016; f.s. 45, VIII 2014.

Fomitopsis betulina (Bull.) B. K. Cui, M. L. Han & Y. C. Dai – on logs, deadwood and fallen twigs of birch; f.s. 42, VII 2014, VIII 2016.

Fomitopsis pinicola (Sw.) P. Karst.– on log and trunk of pine; CP 6, IV 2016; f.s. 29, VI 2016.

Galerina hypnorum (Schrank : Fr.) Kühner s. Horak 2005 and de Haan & Walleyn 2006 – on mosses (*Pleurozium schreberi*); CP 1, VI 2014, XI 2015, VII–VIII 2016; CP 2, VI 2014, IX, XI 2015, VII 2016; CP 3, X 2014, IX, XI 2015; CP 4, IX, XI 2015; CP 5, IX, XI 2015; CP 6, X 2014, IX, XI 2015; f.s. 28, X 2014, IX 2015; f.s. 32, IX, XI 2015, VII 2016; f.s. 33, IX 2015; f.s. 41, XI 2015; f.s. 45, IX 2015.

Gomphidius glutinosus (Schaeff.: Fr.) Fr. – on soil, among mosses, under spruce; f.s. 32, XI 2015.

Gomphidius roseus (Fr.) Fr. P. Karst. – on soil, among mosses and coniferous litter, under pines; CP 1, X 2016; CP 3, X 2014, X 2015; CP 5, X 2014; f.s. 28/41, X 2014; f.s. 32, IX 2015; f.s. 41, IX 2014; f.s. 41, X 2016; f.s. 42, IX 2015; f.s. 42, VIII 2016.

Gymnopilus penetrans (Fr.) Murrill – on trunk and fallen branches of pine; CP 1, VI, VIII 2014; CP 2, VI 2014, VII 2016; CP 5, VI 2014; f.s. 8, VII 2016; f.s. 12/13, VI 2014; f.s. 28, IX .2015; f.s. 32, IX 2015, VII 2016; f.s. 41, VI 2014, X 2015; f.s. 42, IX 2016.

Gymnopus androsaceus(L.: Fr.) J. L. Mata & R. H. Petersen. – on needles of pine; CP 1, VIII, X 2014, X 2015, X 2016; CP 2, VI–VII, X 2014, X 2015; CP 3, VIII, X 2014, X 2015; CP 4, X 2015; CP 5, VII 2014, X 2015; CP 6, X 2014, X 2015; f.s. 13, X 2015; f.s. 28, X 2014; f.s. 41, IX 2014; f.s. 41, VI 2014, X 2015; f.s. 42, IX 2014, X 2015.

Gymnopus confluens (Pers.: Fr.) Antonín, Halling & Noordel. – on coniferous litter; CP 2, VIII–IX 2016.

Gymnopus dryophilus (Bull.: Fr.) Murrill – on coniferous and deciduous litter; CP 1, XI 2015; CP 2, XI 2015; CP 3, XI 2015; f.s. 32, XI 2015.

Gymnopus peronatus (Bolton: Fr.) Gray – on coniferous litter; CP 2, IX, XI 2015; CP 6, VII 2015; f.s. 32, XI 2015; f.s. 41, XI 2015.

Gyromitra esculenta (Pers.) Fr. – on soil, among lichens; CP 2, IV 2016.

Gyroporus cyanescens (Bull.: Fr.) Quél. – on soil, among lichens, under pines and birches; CP 3, VIII–IX 2016; f.s. 42, VIII–IX 2016.

Hapalopilus nidulans (Fr.) P. Karst. – on branches of birch; CP 2, VII 2016; f.s. 19, VIII 2016.

Hygrophoropsis aurantiaca (Wulfen: Fr.) Maire – on soil, among mosses; CP 1, X 2014; XI 2015; CP 2, X 2014, IX, X 2015; CP 3, X 2014, XI 2015; CP 4, X 2014; CP 5, X 2014; CP 6, X 2014, XI 2015, VIII 2016; f.s. 32, XI 2015; f.s. 41, X 2015; f.s. 42, X 2014; f.s. 42, IX 2015.

Hypholoma capnoides (Fr.: Fr.) P. Kumm. – at the base of trunks of pine (deadwood); CP 3, VII 2016.

Hypholoma lateritiium (Schaeff.: Fr.) P. Kumm. – at the base of trunks of birch (deadwood); f.s. 31, IX 2015; f.s. 32, IX 2015.

Inocybe lacera (Fr.: Fr.) P. Kumm. var. ***lacera*** – on soil, among lichens, under pines; CP 6, f.s. 29, VIII 2016; f.s. 41, VI 2014.

Inocybe lanuginosa (Bull.: Fr.) P. Kumm. – on soil, near the paths, under pines; CP 3, VI 2014; f.s. 7, VII 2016; f.s. 41, VI 2014.

Inonotus obliquus (Fr.) Pilát – on deadwood of birches; CP 6, VII 2015; f.s. 13, VI 2015; f.s. 28, VIII 2014.

Laccaria bicolor (Maire) P. D. Orton – on soil, among mosses and lichens, under pines; CP 1, X 2015; f.s. 32/33, IX 2016; f.s. 41, X 2015.

Laccaria laccata (Scop.: Fr.) Cooke – on soil, among mosses and lichens, under pines; CP 1, X 2014, XI 2015; CP 2, X 2014; CP 3, X 2014; CP 4, X 2014, XI 2015; f.s. 32, XI 2015; f.s. 33, IX 2015; f.s. 41, X 2014, VIII 2016; f.s. 42, IX 2015, XI 2015.

Lactarius helvus (Fr.: Fr.) Fr. – on soil, among mosses, under pines; f.s. 42, VIII 2016.

Lactarius necator (Bull.: Fr.) Pers. – on soil, among mosses and lichens, under birches; f.s. 41, X 2016; f.s. 42, IX 2016.

Lactarius rufus (Scop.: Fr.) Fr. – on soil, among mosses and lichens, under pines; CP 1, VIII, X 2016; CP 2, VII 2014, VII–VIII 2016; CP 3, X 2014, XI 2015; CP 4, VI 2014; CP 5, IX 2015, VIII–IX 2016; CP 6, IX–X 2014, IX 2015, VIII 2016; f.s. 7, IX 2016; f.s. 8, VI 2014; f.s. 8, VIII 2016; f.s. 9, VII 2016; f.s. 12, VII 2014; f.s. 19, VIII 2016; f.s. 20, X 2016; f.s. 28, X 2014, IX 2015; f.s. 31, IX 2015; f.s. 32, VII, IX–X 2016; f.s. 41, IX 2014, X 2015; f.s. 41, X 2016; f.s. 42, IX 2014; IX–X 2015; f.s. 42, VIII 2016.

Leccinum melaneum (Smotl.) Pilát & Dermek – on soil, among mosses, under birches; CP 2, VIII 2016.

Leccinum scabrum (Bull.: Fr.) Gray – on soil, among mosses, under birches; CP 2, VIII 2016; f.s. 19, V 2015; f.s. 32, X 2016; f.s. 42, VIII 2016.

Leccinum versipelle (Fr. & Hök) Snell – on soil, among mosses, under birches; CP 1, VII 2015; CP 6, IX 2015; f.s. 28, IX 2015; f.s. 32, VI, IX 2016; f.s. 42, VIII 2016.

Lentinus substrictus (Bolton) Zmitr. & Kovalenko – on fallen twigs of birch; CP 5, VIII 2014; CP 6, VI 2014; f.s. 28, V 2014; f.s. 29, V 2015; f.s. 41, VI, VIII 2014, VI 2015; f.s. 42, X 2015.

Lichenomphalina umbellifera (L.: Fr.) Redhead, Lutzoni, Moncalvo & Vilgalys – on humus; f.s. 41, X 2015; f.s. 42, IX 2015.

Lyophyllum fumosum (Pers.: Fr.) P. D. Orton – on soil, on the paths; CP 1, X 2016; CP 3, X 2015, VIII 2016; f.s. 8, VIII 2016; f.s. 32, IX 2016.

Mycena epipterygia (Scop.: Fr.) Gray var. ***epipterygia*** – on soil, on coniferous litter; CP 3, XI 2015.

Mycena galericulata (Scop.: Fr.) Gray – on trunks of birch; CP 1, IV 2016; CP 2, IV 2016; CP 6, VIII 2016; f.s. 42, X 2015; f.s. 41, XI 2015.

Mycena galopus (Pers.: Fr.) P. Kumm. – on litter of pine; CP 2, X 2014, XI 2015; f.s. 28, X 2014; f.s. 32, XI 2015.

Mycena speirea (Fr.: Fr.) Gillet – on small fallen twigs of *Betula pendula*; f.s. 28, X 2014.

Myxomphalia maura (Fr.: Fr.) Hora – on soil, path; f.s. 7, VII 2016; f.s. 42, V 2016.

Paxillus involutus (Batsch : Fr.) Fr.– on soil, among mosses, under pines; CP 1, X 2014, X 2015, VIII, X 2016; CP 2, VII, IX–X 2014, X 2015, VIII–X 2016; CP 3, X 2014, X 2015, VIII–X 2016; CP 4, X 2014, X 2015, X 2016; CP 5, X 2014, VIII–IX 2016; CP 6, VIII, X 2016; f.s. 8, IX 2016; f.s. 19, VIII 2016; f.s. 20, X 2016; f.s. 28, X 2014; f.s. 32, IX 2015; f.s. 32, X 2016; f.s. 41, X 2016; f.s. 42, VIII, X 2016.

Phaeolus schweinitzii (Fr.) Pat. – at the base of trunk of pine; CP 5, VII 2015.

Phellodon tomentosus (L.) Banker – on soil, among litter, mosses, and lichens; CP 2, IX–X 2016; CP 3, IX–X 2014, IX–X 2015, VII–X 2016; CP 4, VIII, X 2014, IX 2015, IX–X 2016; CP 5, IX 2014, IX 2015, VIII–IX 2016; CP 6, VIII 2016; f.s. 7, VIII 2016; f.s. 8, VIII–IX 2016; f.s. 19, VIII 2016; f.s. 20, X 2016; f.s. 31, IX 2015; f.s. 32, IX 2015; f.s. 32, VIII–X 2016.

Pholiota cerifera (P. Karst.) P. Karst. – at the base of trunk of birch (deadwood); f.s. 20, X 2016.

Pholiota subochracea (A. H. Sm.) A. H. Sm. & Hesler – on standing trunk of pine (deadwood); CP 1, IX 2015.

Porodaedalea pini (Brot.) MurrillAmes – on trunk of living pine trees; CP 2, VII, X 2016.

Postia ptychogaster (F. Ludw.) Vesterh. – on log of pine; CP 6, VIII 2016.

Postia stiptica (Pers.) Jülich – on logs of pine; CP 4, X 2014, IX 2016.

Rhizopogon luteolus Fr. & Nordholm – underground, partially underground, on the paths, under pines; CP 1, VII 2015, X 2016; CP 3, IX–XI 2015; CP 5, VIII 2016; f.s. 7, V 2015; f.s. 7, IX 2015; f.s. 8, V–VII 2014, X 2015; f.s. 28, IX 2015; f.s. 13, VI 2016; f.s. 19, IX 2014; f.s. 31, IX 2015; f.s. 41, VIII, X 2014; f.s. 42, VIII 2016.

Rhizopogon roseolus (Corda) Th. M. Fries – underground, partially underground, on the paths, under pines; f.s. 9, XI 2015.

Rhodocollybia butyracea (Bull.: Fr.) Lennox f. ***asema*** (Fr.: Fr.) Antonín, Halling & Noordel. – on coniferous litter; CP 6, IX 2015; f.s. 28, X 2014.

Rhodocollybia maculata (Alb. & Schwein.: Fr.) Singer var. ***maculata*** – on coniferous litter; f.s. 8, VIII 2016.

Russula adusta (Pers.: Fr.) Fr. – on soil, among mosses and lichens, under pines; CP 2, VII 2016; f.s. 32, VIII 2016.

Russula aeruginea Lindblad – on soil, among mosses and litter, under birches; CP 3, 12, X 2014; f.s. 12/13, VI 2014; f.s. 28, X 2014; f.s. 32, VII 2016; f.s. 42, VIII 2016.

Russula brunneoviolacea Crawshay – on soil, among mosses and litter, under pines and birches; CP 2, XI 2015, VIII 2016; CP 5, VII 2014; CP 6, IX–X 2015.

Russula cavipes Britzelm. – on soil, among mosses and litter, under spruce; CP 5, VIII 2016; CP 6, IX 2015.

Russula claroflava Grove – on soil, among mosses, lichens, and litter, under birches; f.s. 32, VII 2016; f.s. 41, VIII 2016; f.s. 42, VIII 2016.

Russula cyanoxantha (Schaeff.) Fr. – on soil, among litter, under pines and birches; CP 2, VII 2016; CP 3, IX 2015; f.s. 32, VII 2016; f.s. 41, X 2014; f.s. 42, VIII 2016.

Russula decolorans (Fr.: Fr.) Fr. – on soil, among mosses and lichens, under pines; CP 1, VI, VIII–IX 2014, VII–VIII, X 2016; CP 2, VI, IX 2014, IX 2015, VII, IX–X 2016; CP 3, VI–IX 2014, VIII–X 2016; CP 4, VI–IX 2014, X 2015, IX–X 2016; CP 5, VI–IX 2014, IX 2015, VIII–IX 2016; CP 6, VI–VII, IX 2014, IX–X 2015, VIII–X 2016; f.s. 7, VII 2016; f.s. 8, VII 2016; f.s. 9, VII 2016; f.s. 12, VII–VIII 2014; f.s. 13, VII 2014; f.s. 19, VII 2014, VIII 2015; f.s. 20, X 2016; f.s. 32, VIII 2015, VII, IX 2016; f.s. 33, VII 2014, IX 2015; f.s. 42, VIII 2015; f.s. 45, VI 2014.

Russula emetica (Schaeff.: Fr.) Pers. s. l. – on soil, among mosses and lichens, under pines; CP 1, IX–X 2014, X, XI 2015, X 2016; CP 2, IX–X 2014, IX–X 2015, VIII–X 2016; CP 3, IX–X 2014; IX–XI 2015, VIII, X 2016; CP 4, IX–X 2014, X 2015; CP 5, IX–X 2014, X 2016; CP 6, IX–X 2014, IX–X 2015, VIII–X 2016; f.s. 7, IX 2016; f.s. 12, VII 2014; f.s. 13, VII 2014; f.s. 19, VIII, X 2016; f.s. 20, X 2016; f.s. 28, X 2014; f.s. 28, IX 2015; f.s. 32, IX 2014; f.s. 32, XI 2015, VII, X 2016; f.s. 41, IX 2014, X–XI 2015, VIII, X 2016; f.s. 42, IX 2014; f.s. 42, IX–X 2016.

Russula ochroleuca Pers.– on soil, among mosses and lichens, under pines; CP 1, VII 2016; f.s. 7, VII 2016; f.s. 41, X 2016.

Russula paludosa Britzelm. – on soil, among mosses and lichens, under pines; CP 1, VIII 2016; CP 2, VIII 2016; CP 3, IX 2014; CP 4, VII 2014, IX–X 2016; CP 5, VII, IX 2014; CP 6, IX 2014, X 2015, VIII 2016; f.s. 19, VIII 2016; f.s. 20, X 2016; f.s. 28, IX 2015; f.s. 32, VII, IX 2016.

Russula risigallina (Batsch) Sacc. var. ***risigallina*** – on soil, among mosses and lichens, under pines; CP 1, X 2015, VIII 2016; CP 2, X 2015, IX 2016; CP 3, VII 2014, VIII–IX 2016; CP 4, X 2015; CP 5, VIII 2016; CP 6, VIII–IX 2016; f.s. 7, VII, IX 2016; f.s. 8, IX 2016; f.s. 9, IX 2016; f.s. 20, X 2016; f.s. 32, IX 2016.

Russula turci Bres. – on soil, among mosses and lichens, under pines; CP 2, VII 2016; f.s. 9, VII 2016; f.s. 32, VII 2016.

Russula vesca Fr. – on soil, among mosses and lichens, under pines; CP 1, X 2015; CP 2, VI 2014, VII 2016; CP 3, VII 2014, X 2016; CP 4, VI–VII 2014; CP 5, IX 2014, X 2016; f.s. 7, VII 2016; f.s. 9, VII 2016; f.s. 20, X 2016; f.s. 32, VII 2016; f.s. 33, IX 2015.

Russula vinosa Lindblad – on soil, among mosses and lichens, under spruce; f.s. 32, VII 2016.

Sarcodon squamosus (Schaeff.) Quél. – on soil, among mosses and lichens, under pines; CP 1, X 2016; CP 2, X–XI 2015, X 2016; CP 3, X 2015, IX–X 2016; CP 4, X 2014, XI 2015, X 2016; f.s. 8, VIII 2016; f.s. 19/32, IX 2015; f.s. 20, X 2016; f.s. 32, IX 2015; f.s. 32, X 2016; f.s. 33, XI 2015.f.s. 41, X 2014; f.s. 42, IX 2016.

Schizopora paradoxa (Schrad.) Donk – on log of pine; f.s. 33, V 2016.

Scleroderma citrinum Pers.: Pers. – on soil, on the paths, under pines; CP 5, VII 2014; f.s. 28, X 2014; f.s. 41, VII 2014, VIII 2016; f.s. 42, VII, IX 2014, VIII–X 2016.

Sparassis crispa (Wulfen) Fr. – on living roots of pine trees; CP 5, VIII 2016.

Stereum hirsutum (Willd.) Pers. – on fallen twigs and logs of birch; CP 4, VII 2015.

Strobilurus stephanocystis (Hora) Singer – on cones of pine; CP 1, XI 2015; CP 2, XI 2015; CP 3, X 2014, XI 2015, IV 2016; CP 5, XI 2015, IV 2016; CP 6, XI 2015; f.s. 7, V 2016; f.s. 8, V 2015; f.s. 20/21, V 2016; f.s. 29, V 2014; f.s. 42, V 2016.

Strobilurus tenacellus (Wulfen : Fr.) Singer – on cones of pine; f.s. 41, VI 2014.

Suillus bovinus (L.: Fr.) Roussel – on soil, among mosses and lichens, under pines; CP 1, X 2014, X 2015, VIII, X 2016; CP 2, IX 2014, IX–X 2015, VIII 2016; CP 3, IX 2014, IX–X 2015, VIII–IX 2016; CP 4, X 2014, IX–X 2015, IX 2016; CP 5, IX–X 2014, IX–X 2015; CP 6, IX–X 2015, VIII 2016; f.s. 7, VIII 2016, f.s. 8, VIII 2016; f.s. 12, VIII 2016; f.s. 13, X 2015, VIII 2016; f.s. 19, VIII 2016; f.s. 20, VIII, X 2016; f.s. 28, X 2014; f.s. 28, IX 2015; f.s. 28, VIII 2016; f.s. 29, VIII 2016; f.s. 31, IX 2015; f.s. 32, IX 2015, VIII, X 2016; f.s. 33, IX 2015; f.s. 41, IX 2014, X–XI 2015, X 2016; f.s. 42, IX 2014, IX–X 2015; VIII–X 2016; f.s. 45, IX 2015, VIII 2016.

Suillus granulatus (L.: Fr.) Roussel – on soil, among mosses and lichens, under pines; f.s. 19, VII 2015; f.s. 32, VII 2016.

Suillus luteus (L.: Fr.) Roussel – on soil, among mosses and lichens, under pines; CP 1, VII 2015; CP 2, X 2015; CP 3, IX 2015; CP 5, IX 2015; f.s. 9, VII 2016; f.s. 28, IX 2015; f.s. 33, IX 2015; f.s. 42, X 2014, IX 2015.

Suillus variegatus (Sw.: Fr.) Kuntze – on soil, among mosses and lichens, under pines; CP 1, IX 2015; CP 2, IX 2015, VIII 2016; CP 3, X 2014, IX 2015; CP 4, IX 2015; CP 5, IX 2015; CP 5, VIII 2016; CP 6, X 2014, IX 2015, VIII 2016; f.s. 28, IX 2015; f.s. 31, IX 2015; f.s. 32, IX 2015; f.s. 41, X 2014; f.s. 45, IX 2015.

Tapinella atrotomentosa (Batsch: Fr.) Šutara – on trunks and dead roots of pine; CP 1, X 2015; CP 2, X 2015, VII 2016; CP 3, X 2015; CP 4, X 2015; CP 5, VII 2014; CP 6, VII 2014; f.s. 7, VII, IX 2016; f.s. 19, VIII 2015; f.s. 20, X 2016; f.s. 32, IX 2015.

Thelephora caryophyllea (Schaeff.) Pers. – on soil; CP 1, V 2016; f.s. 42, VIII 2016.

Thelephora terrestris Ehrh. – on soil, among coniferous litter; CP 1, X 2014, VII 2015, X 2016; CP 2, VI 2015; CP 3, VI 2015; CP 4, VIII 2014; CP 5, VIII 2014, VIII 2015, IX 2015; CP 6, X 2015, IX 2016; f.s. 8, VIII 2016; f.s. 13, V 2014; f.s. 19, VIII 2016; f.s. 19, VII 2015; f.s. 32, IX 2014; f.s. 32, X 2016; f.s. 41, IX 2014; f.s. 42, X 2015, IX 2016.

Trametes coccinea (Fr.) Hai J. Li & S. H. He – on fallen branches of birch; f.s. 41, VIII 2014.

Trametes hirsuta (Wulfen) Lloyd – on fallen branches of birch; f.s. 29, VI 2015.

Trichaptum abietinum (Dicks.) Ryvarden – on logs and fallen branches of pine; CP 1, V–VI 2015, IV 2016; CP 2, IV–V 2016; CP 3, V–VII 2015; CP 4, VII, IX 2014; VII–VIII, X 2015; V–VI 2016; CP 5, VI 2015, X 2016, V 2016; f.s. 19, VII 2014; f.s. 32, VI 2016; f.s. 33, V 2016; f.s. 41, VI 2014; f.s. 42, X 2015, VI, VIII 2016.

Tricholoma albobrunneum (Pers.: Fr.) P. Kumm. – on soil, under pines; CP 3, X 2016; CP 6, IX 2016; f.s. 33, XI 2015; f.s. 42, X 2015.

Tricholoma equestre (L.: Fr.) P. Kumm.– on soil, under pines; CP 2, X 2016; CP 3, X 2014, X–XI 2015, IX 2016; CP 4, X 2016; CP 5, X 2014, IX–X 2015; CP 6, X 2014, X 2016; f.s. 8, VIII 2016; f.s. 28, X 2014; f.s. 28, IX 2015; f.s. 32, XI 2015, IX–X 2016; f.s. 33, XI 2015; f.s. 41, IX 2014, X–XI 2015, X 2016; f.s. 42, X–XI 2015, VIII–IX 2016.

Tricholoma focale (Fr.) Ricken – on soil, under pines; CP 6, X 2015; f.s. 42, X 2015; f.s. 42, IX 2016.

Tricholoma fulvum (DC.: Fr.) Bigeard & H. Guill. – on soil, under birch; CP 1, X 2016; CP 3, X 2014, X 2016; f.s. 28, X 2014; f.s. 41/42, VIII 2016.

Tricholoma portentosum (Fr.: Fr.) Quél. – on soil, under pines; CP 1, XI 2015; CP 2, XI 2015; CP 3, XI 2015; CP 6, X 2016; f.s. 8, XI 2015; f.s. 12, X–XI 2015; f.s. 13, XI 2015; f.s. 16, XI 2015; f.s. 19, XI 2015; f.s. 20, X 2016; f.s. 28, XI 2015; f.s. 29, XI 2015; f.s. 31, XI 2015; f.s. 32, XI 2015; f.s. 41, X 2014, X–XI 2015; f.s. 42, XI 2015.

Tricholoma sejunctum (Sowerby: Fr.) Quél. – on soil, under pines; CP 3, X 2015, X 2016; f.s. 8, IX 2016; f.s. 13, X 2015; f.s. 20, X 2016; f.s. 32, X 2016; f.s. 41, X 2015.

Tricholoma terreum (Schaeff.) P. Kumm.– on soil, under pines; CP 3, X 2014, X 2015, IX 2016.

Tricholomopsis rutilans (Schaeff.: Fr.) Singer – on stump of pine; f.s. 32, IX 2016.

Tubaria conspersa (Pers.: Fr.) Fayod – on litter, small fallen twigs; CP 5, X 2014; CP 6, X 2014.

Tubaria furfuracea (Pers.: Fr.) Gillet s. l. – on litter, on small fallen branches; CP 3, X 2014.

Tylopilus felleus (Bull.: Fr.) P. Karst. – on soil, among mosses, under pines; f.s. 32, VII 2016.

Xerocomus badius (Fr.: Fr.) E.-J. Gilbert – on soil, among mosses and lichens, under pines; CP 1, VI 2014, VIII, X 2016; CP 2, IX–X 2015, VIII 2016; CP 3, IX 2014, VIII 2016; CP 4, X 2016; CP 5, XI 2015; CP 6, VIII 2016; f.s. 20, X 2016; f.s. 32, VII, X 2016; f.s. 41, VIII 2016; f.s. 42, XI 2015, VIII 2016; f.s. 45, IX 2015.

Xerocomus chrysenteron (Bull.) Quél. – on soil, among mosses, under pines; CP 3, IX 2015, VIII 2016; CP 5, IX 2014; f.s. 41, VIII 2016.

Xeromphalina cornui (Quél.) J. Favre – on needles of pine, among mosses; CP 2, VI 2014, X 2015; CP 4, VI 2014; f.s. 8, VII 2014.

Discussion

Three years of observations carried out between 2014 and 2016 on fungi of *Cladonio-Pinetum* in the PNBT revealed that the number of recorded taxa of macromycetes in the area is quite high, taking into account the character and specificity of this community. *Cladonio-Pinetum* covers the poorest sandy habitats, with forest stands built almost entirely of pine [5,40]. They are oligotrophic habitats poor in nutrients and water [9,40]. Due to the unfavorable conditions that prevail there for the formation of sporocarps by fungi, there are only 9–12 plant species in the *Cladonio-Pinetum* community [5].

In view of the latest research of all mycobiota of *Cladonio-Pinetum* in the PNBT, the total recorded 517 taxa of macroscopic fungi occurring in the area [41] represents 27% of the mycobiota in the PNBT.

The mycobiota of *Cladonio-Pinetum* in the Świętokrzyskie Mts was studied by Łuszczyński [20]. The author recorded 43 taxa during 40 field observations (4 years) of this community located on a small dune. In the present study, there were 17 taxa, namely *Agaricus sylvicola*, *Calocybe gambosa* f. *gambosa*, *Clitocybe gibba*, *Conocybe subpubescens*, *Echinoderma aspera*, *Lactarius uvidus*, *Lycoperdon perlatum*, *Macrolepiota procera*, *Marasmius bulliardii*, *Mycena pura*, *Phaeoclavulina abietina*, *Russula sardonia*, *R. xerampelina*, *Rhodocollybia butyracea* var. *butyracea*, *Scleroderma verrucosum*, *Trametes versicolor*, and *Xeromphalina campanella*. Some of these are associated with other plant communities surrounding the dune (*Sphagnetum magellanici* and *Vaccinio-uliginosi-Pinetum*), so their absence may result from this fact. The remaining 26 species are common of in these and Łuszczyński studies.

In the study of Sałata from the Annopol area [15], the following species of fungi are the most frequently found in *Cladonio-Pinetum*: *Coltricia perennis*, *Gyromitra esculenta*, *Thelephora terrestris*, *Sarcodon imbricatus*, *Suillus bovinus*, *Tricholoma equestre*, and *T. portentosum*. All of these except *S. imbricatus* were reported in *Cladonio-Pinetum* in PNBT. In the *Cladonio-Pinetum* communities of PNBT, *Sarcodon squamosus*, which is associated with pine, was recorded.

Rudnicka-Jezierska [16] listed 59 species of fungi with patches of this community in the Kampinos Forest. They are dominated by species typical of coniferous forests that are associated with dry, sandy habitats. A visible share of mycorrhizae species is associated with pine. With a recorded 35 taxa common to both foregoing studies [15,16], the similarity is quite large. Among those taxa not identified in Tuchola Forest were *Inocybe praetervisa*, *Laccaria amethystina*, *Lactarius glyciosmus*, *Lactarius pyrogalus*, *Lactarius torminosus*, *Lactarius vellereus*, and *Pseudohydnum gelatinosum*.

Diversity in terms of the number of taxa was seen in the permanent plots. Permanent plot CP 3, located in Forest Section 12, was the richest in number of taxa (65), while the lowest number of taxa was recorded in permanent plot CP 4, located in Forest Section 13 (33). This may be influenced by various factors such as coverage of undergrowth by lichens and mosses. Research plot CP 3, located near the path between Forest Sections 12 and 13, was covered with a lichen layer of genus *Cladonia* spp. Within the permanent plot, in the undergrowth, there are not only lichens but also mosses, namely *Pleurozium schreberi* and *Dicranum spurium*, which store water. As a result, enclaves are formed with good moisture conditions, which favors greater diversity of fungi species on the surface and creates a greater abundance of sporocarping [42]. Plot CP 4, although it seemed topographically favorable for high species diversity and abundance of fungi, proved to be the poorest in species. It is located in a low area where the undergrowth cover is a compact layer of lichens, with only a few patches of *Pleurozium schreberi*. Although the plots are on opposite sides of the path that separates Forest Sections 12 and 13, the differences in species composition are significant.

The dynamic nature of the dry pine forests contributes to a mosaic spatial complex of *Cladonio-Pinetum* with *Leucobryo-Pinetum* to appear in some places. This increases the diversity of fungal species in these habitats. The paths and areas near these have greater access to light, which has a positive influence on lichens, but there are fewer taxa of fungi with the growth of species adapted to the difficult conditions (e.g., *Coltricia perennis*, *Myxomphalia maura*) [32]. The mycobiota of *Cladonio-Pinetum* is a complex of species tolerant to poor, oligotrophic habitats and those that occupy more humid habitats. This is confirmed by data from the Świętokrzyskie Mts in the study by Łuszczyński [20]. Based on the analysis of the recorded fungi, the author stated that similarity in terms of species communities of *Cladonio-Pinetum* and *Leucobryo-Pinetum* is 51.1%.

The distinguished ecological groups have significant shares of terrestrial fungi (88 taxa), xylobionts (30 taxa), and litter-inhabiting fungi (13 taxa). Other groups (i.e., hypogeous fungi, bryophilous fungi, fungi growing on cones, and sporocarps of another fungi) were characterized by low numbers of taxa. In the observations conducted by Łuszczyński [20], terrestrial fungi, among these mycorrhizal fungi, were also dominant. In the PNBT, the ectomycorrhizal fungi (79 taxa) were associated mainly with pine and, to a small degree, with birch and spruce. A large number of species and sporocarps belonging to the group of mycorrhizal fungi shows good condition of mycorrhizae [11] and, consequently, forest stands. Saprotrophic fungi in decaying humus soil, also members of a group of terrestrial fungi, were represented in low numbers (nine taxa). Among the xylobionts, species were found that decompose dead wood of pine and of birch such as tree stumps, trunks, logs, and branches (27 taxa) and a small group of parasitic fungi (three species) growing on a pine tree in living tree trunks – *Fomitopsis pinicola*, *Porodaedalea pini* – and roots of trees – *Sparassis crispa*. These fungi form sporocarps in numbers that are non-threatening to the forest stands. There were no dangerous parasites of pines, *Heterobasidion annosum*. Particular attention was paid to numerous *Phellodon tomentosus* observations in 2016. This species should be covered with detailed observations because it has E category (endangered) assigned in the "Red list of macrofungi in Poland", and because it is possible that PNBT has very favorable conditions for its development. There is a need to ascertain whether this species will spread rapidly in the following years.

Litter-inhabiting fungi were reported in low numbers (13 taxa) due to the homogeneous character of the litter; *Cladonio-Pinetum* occurred mainly in coniferous litter. In all years of our study, mycorrhizal fungi were the predominant group, with fewer saprotrophic fungi. The smallest group comprised the parasites.

The presence of one protected species and 23 species listed on the "Red list of the macrofungi in Poland" [38] in community of *Cladonio-Pinetum* in the PNBT confirms that this is a valuable habitat with optimum conditions for the development of fungi.

Within the Park area, with the exception of the community of *Cladonio-Pinetum*, 47 species listed on the "Red list of macrofungi in Poland" were recorded [38,41].

Conclusions

In the "Bory Tucholskie" National Park, communities of *Cladonio-Pinetum* are well preserved [9]. In the undergrowth, terrestrial lichens form a dense turf of lichens, and coniferous species of bryophytes inhabit the spaces between the patches. Fungi are an important component of structural and functional undergrowth in *Cladonio-Pinetum*. As a result of observations in 2014–2016, 140 taxa of fungi were observed that form a complex of species growing in oligotrophic conditions of *Cladonio-Pinetum* (e.g., *Coltricia perennis*, *Myxomphalia maura*) and species that occur in wetter and more fertile habitats with patches of *Leucobryo-Pinetum* (e.g., *Russula paludosa*, *Leccinum versipelle*). The community of *Cladonio-Pinetum* is an interesting testing ground for mycological research on habitats for protected and endangered species (23 species on the "Red list of macrofungi in Poland" were reported) [38]. Certain behaviors can provide important active protection, such as entirely removing remaining wood after economic treatments as well as the removal of regenerated pine and oak [8,10]. Monitoring observations and documenting and searching for new locations of protected, rare, and endangered species are also ways to protect fungi [37] and thus these activities should be continued.

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