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FUNGI OCCURRING ON STUMPS IN SELECTED SUBCOMPARTMENTS OF THE ZIELONKA EXPERIMENTAL FOREST DISTRICT

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Abstract. Fungi play an important role, as by decomposing dead organic matter they contribute to the carbon cycle in nature. Apart from this beneficial effect, fungi in forest ecosystems cause diseases of deciduous trees. Stumps, being remnants of stems left after felled trees, provide nutrient resources for various organisms, including fungi causing the most dangerous diseases of forest trees such as *Armillaria* root rot or *Heterobasidion* root rot. Colonisation of stumps is determined by three major factors, i.e. microhabitat, availability of nutrients and occurrence of other competing organisms. The primary aim of this study was to prepare an inventory of fruiting bodies of fungal species found on stumps in selected subcompartments of the Zielonka Experimental Forest Division, to present fungal species diversity in the analysed area and to identify factors determining the occurrence of fungi in the investigated area as well as those determining the intensity of stump colonisation by fungi. Results indicate that fruiting bodies were found less frequently on pine stumps than on stumps of deciduous species. The most abundant fungal species in terms of population size observed on stems in the analysed areas were *Trametes versicolor* (191 localities), *Schizophyllum commune* (136 localities) and *Stereum hirsutum* (130 localities). A vast majority of species reported in the analysed areas have a positive effect on the forest ecosystem.

Key words: fungi, wood decomposition, stumps

INTRODUCTION

Fungi serve an important function by decomposing dead organic matter, thus contributing to the cycle of elements in nature (mainly nitrogen and carbon). The role of saprotrophic fungi in the course of many ecological processes is underestimated and their effect on the carbon cycle in nature is inestimable [Sierota 2011]. Fungi in the

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forest ecosystem, apart from their positive role, also cause diseases of deciduous plants. Stumps and roots remaining after felled trees provide nutrients for different organisms, including fungi causing the most dangerous diseases of forest trees, such as *Armillaria* root rot or *Heterobasidion* root rot. In order to eliminate losses caused by pathogenic fungi saprotrophic organisms are used, mainly fungi promoting decomposition of stump wood, e.g. *Hypholoma fasciculare* (Huds:Fr) Kummer [Pearce and Malajczuk 1990], *Trametes versicolor* (L.exFr.) Pil [Szewczyk and Molińska-Glura 2010], *Phlebiopsis gigantea* (Fr.:Fr) Jülich or *Pleurotus ostreatus* (Jacq.:Fr) Kummer [Rykowski 1990, Sierota and Sternak 1993]. Stump colonisation is determined by three main factors, i.e. microhabitat, availability of nutrients and the occurrence of other competing organisms. These three elements accounted for differences in experiments conducted in different locations [Dowson et al. 1988]. In the course of time under the influence of many biotic and abiotic factors stump wood is gradually decomposed. Mycobiotas change with the progressing degree of wood decomposition. The number of epixylic fungi on oak may reach 61 species, while on birch it may be as many as 68 species [Chlebicki 1996, after Gutowski 2004]. The main aim of the study was to prepare an inventory of fruiting bodies of fungal species found on stumps in selected subcompartments of the Zielonka Experimental Forest District, to present diversity of fungal species observed in the analysed area, and to identify factors determining the intensity of stump colonisation by fungi. On the basis of the recorded results we may specify the role of individual fungal species in wood decomposition and the matter cycle in the analysed areas, as well as determine their role in the forest ecosystem and human economy.

METHODS

Analyses were conducted on seven experimental plots located in the Zielonka Experimental Forest Division (N: 52°33’1.73”, E: 17°6’35.18”). On randomly selected plots the number of stumps was determined for individual tree species and on the basis of the occurrence of fruiting bodies it was analysed what fungal species colonised them. Fruiting bodies observed on dead wood were not included in the study results. The study was based on available literature containing descriptions of species of arboreal fungi [Breitenbach and Kränzlin 1986, Grzywacz 1989, 1990, Gumińska and Wojewoda 1988, Łakomy and Kwaśna 2008]. Results were analysed statistically using the ANOVA Kruskal-Wallis test to compare plots in terms of differences in the occurrence of fungal species and analogously in relation to individual fungal species jointly.

Characteristics of the experimental plots were as follows: Experimental plot I is located in subcompartment 43f, of 3.85 ha, a 10-year old stand on a fresh mixed coniferous forest site, with pine, larch and spruce as presently dominant species. In that plot mainly oak stumps were found, with pine stumps constituting a minor part. In plot II located in subcompartment 24l of 5.52 ha was covered by a pine-oak stand growing on the fresh mixed broadleaved forest site managed with the complex felling system with pine and oak regenerations of different ages, with groups of young oak and remnants of the old stand aged 115 years. Plot III is a belt of an oak stand in subcompartment 32h, managed in the group felling areas of 5.07 ha in a fresh mixed broadleaved forest site, with pine (aged 105 years) and oak (aged 45 years) as dominant species. Oak aged 8 years could be found in groups. Oak and pine at various stages of decomposition could be found in the plot. In plot IV in subcompartment 34c of 6.56 ha there was a pine-oak stand managed with complex felling systems with oak regeneration in groups and pine regeneration in inter-group spaces. Pines were aged 105 years and oaks were aged 45 years. Trees in groups and intergroup spaces were 8 years old. Plot V of 3.63 ha was located in subcompartment 70i. It is a pine culture in several groups with 7-year old oaks in a fresh mixed broadleaved forest site. Plot VI of 2.09 ha in subcompartment 11d was covered by a pine-oak stand in a fresh mixed broadleaved forest site managed with complex felling systems, with oak regeneration in groups and pine regeneration in intergroup spaces. In this plot a large number of pine and oak stumps is found, with scattered birch and maple stumps. Plot VII of 5.64 ha is located in subcompartment 2f in a fresh mixed broadleaved forest site and comprises pine and oak culture with fragments of an older pine stand and single remnant oaks aged 121 years. In that plot there were very few stumps, all of them pine.

RESULTS

The highest number of oak stumps with fruiting bodies of fungi was found in plot I. Pine stumps, both those covered with fruiting bodies of fungi and those free of them, were much less numerous. Oak stumps were most frequently colonised by 2 species of fungi, i.e. *Trametes versicolor* and *Schizophyllum commune* (Fr.), which were dominant species in the mycobiota of that plot. Dead pine seedlings with characteristic symptoms of *Armillaria* root rot were also observed in that plot, but fruiting bodies of *Armillaria* spp. were not found in the course of a survey of the analysed plot. In plot II there were 169 pine stumps; however, stumps with fruiting bodies growing on them constituted a slight proportion of the total number (6%). The number of oak stumps free of fruiting bodies on their surface (78 specimens) was also higher than the number of stumps of this species with fruiting bodies of fungi (41 specimens). We need to mention here the localities of *Sparassis crispa* (Wulf.) Fr., a fungal species covered by species protection in Poland. Two fruiting bodies of that fungus were observed on a pine stump among pine regeneration. In that plot 33 localities of *Stereum hirsutum* (Willd.) Pers. were reported. In plot III the number of oak stumps with fruiting bodies of fungi and that of stumps free of them were similar. Old pine stumps were colonised by fungi to a limited degree. On stumps located at the edge of the belt and in its central, well-insolated part a much greater number of fruiting bodies of different fungal species was recorded than in the other, shaded area of the analysed stand belt. On dead oak wood left in that belt fruiting bodies of *Trametes versicolor*, *Trametes hirsuta* (Wulfen) Pilát and *Stereum hirsutum* were reported, while on dead birch wood there were fruiting bodies of *Fomes fomentarius* (L.) J.J. Kickx. In plot IV the number of pine stumps (52 specimens) and oak stumps (23) were colonised by fungi to a similar degree. Occasionally hornbeam stumps were found in that plot. We need to mention here *Trichaptum fuscoviolaceum* (Ehrenb.) Ryvarden and *Inonotus triqueter* (Fr.) P. Karst., which fruiting bodies were found in considerable numbers on pine stumps, as well as fruiting bodies of *Heterobasidion annosum* Niemelä et. Korhonen, a species causing a dangerous disease of forest trees. On shaded and wet fragments of the plot *Hypholoma fasciculare* (Huds.) P. Kumm. fruiting bodies with hemispherical caps were observed, occasionally growing in abundant clusters. In plot V the highest number of pine stumps was recorded (Table 2),

Table 1. Species of fungi found in individual plots
Tabela 1. Gatunki grzybów występujące na poszczególnych powierzchniach

Fungal species Gatunek grzyba	Frequency of occurrence of fungal species in individual plots Częstość występowania gatunków grzybów na poszczególnych powierzchniach						
	I	II	III	IV	V	VI	VII
Armillaria spp. (Fr.:Fr) Staude							7
Cerrena unicolor (Bull.) Murrill	6		2	1			
Chondrostereum purpureum (Pers.) Pouzar						10	
Daedalea quercina (L.) Pers.	4	2	6		1		
Ganoderma applanatum (Pers.) Pat.					1		
Heterobasidion annosum (Fr.) Bref.				8	5	2	2
Hypholoma fasciculare (Huds.) P. Kumm.				11	34	1	2
Inonotus triqueter (Fr.) P. Karst.	6	9	6	12	4	14	
Laxitextum bicolor (Pers.) Lentz	21	1		1	2	22	
Lenzites betulina (L.) Fr.	28	1	1				
Merulius tremellosus Schrad.	23					18	
Phellinus igniarius (L.) Quél					1		
Phellinus robustus (P. Karst.) Bourdot & Galzin	2					2	
Pseudohydnum gelatinosum (Scop.) P. Karst.					3		
Schizophyllum commune Fr.	113	1		11		11	
Sparassis crispa (Wulfen) Fr.		1					
Stereum hirsutum (Willd.) Pers.	21	33	27	9	1	39	
Trametes ochracea (Pers.) Gilb. & Ryvarden				16		4	
Trametes versicolor (L.) Lloyd	109	7	22	1	11	41	
Trichaptum fuscoviolaceum (Ehrenb.) Ryvarden	5		6	31	9		
Trametes hirsuta (Wulfen) Lloyd				1			

free of fruiting bodies and frequently in the state of advanced decomposition. In turn, the number of oak stumps, both those with fruiting bodies of fungi and those with no fruiting bodies covering their surface, was lowest among all the surveyed plots. A large area of the analysed plot was covered by an abundant layer of vegetation cover composed of herbaceous plants and subshrubs, mainly blackberries. In those places moisture content at the ground surface was much higher than in the other areas. We need to stress here the occurrence of a large number of *Hypholoma fasciculare* fruiting bodies growing in clusters at stump bases, with the number of localities being exceptional in relation to the other fungal species. In plot VI a large number of pine and oak stumps was recorded, while the number of oak stumps covered with fruiting bodies of fungi and those free of them were similar, with the number of oak stumps free of fungal fruiting bodies

Table 2. Numbers of stumps in experimental plots
Tabela 2. Liczebność pniaków na powierzchniach badawczych

Area Powierzch-nia	Number of			
	colonised pine stumps	uncolonised pine stumps	colonised oak stumps	uncolonised oak stumps
I	41	58	243	78
II	10	159	41	78
III	12	71	53	32
IV	52	66	23	36
V	51	174	19	7
VI	35	144	90	108
VII	9	51	0	0

being the highest among all the analysed plots (Table 2). In that plot birch and maple stumps appeared occasionally. *Chondrostereum purpureum* (Pres.) Pouzar was observed on birch stumps. The fungal species most frequently observed on stumps were *Trametes versicolor* and *Stereum hirsutum*, mainly on oak stumps. Fragments of that plot with greater insolation showed a greater diversity of fruiting bodies in the mycobiota. Plot VII in terms of the occurring fungal species and their localities showed very limited diversity, with only 3 species reported and fruiting bodies of fungi from the genus *Armillaria* spp. being observed in greatest abundance. Additionally, in that plot fruiting bodies of *Stereum hirsutum* were observed in an extensive wound on a living oak, thus it may be considered a wound parasite [Łakomy and Kwaśna 2008] and these fruiting bodies were not included among the species recorded in that plot. Observed fungal species are listed in Table 1. It results from the statistical analysis with the application of the Kruskal-Wallis test, comparing the plots in terms of differences in the occurrence of fungi, that no significant differences could be found between the plots. What is more, no significant differences could be detected when analysing the occurrence of individual fungal species in all the plots jointly. Recorded results are presented analogously in Figs 1 and 2.

DISCUSSION AND RESULTS

Recorded results indicate that fruiting bodies were found less frequently on pine stumps than on stumps of deciduous species. This may be connected with the fact that pine stumps are sites for the growth and development of a smaller number of saprotrophic fungal species in comparison to stumps of deciduous species. The experimental plots located in wet areas, with a rich vegetation cover, shrub layer or covered with a thick weed layer were poorest in fungal species occurring on stumps in comparison to the plots with scarce vegetation cover and shrub layer, diversified in terms of availability of sunlight, moisture and substrate. Moreover, in the weeded plots we may observe a predominance of pileate species over fungi forming conk fruiting bodies. The most

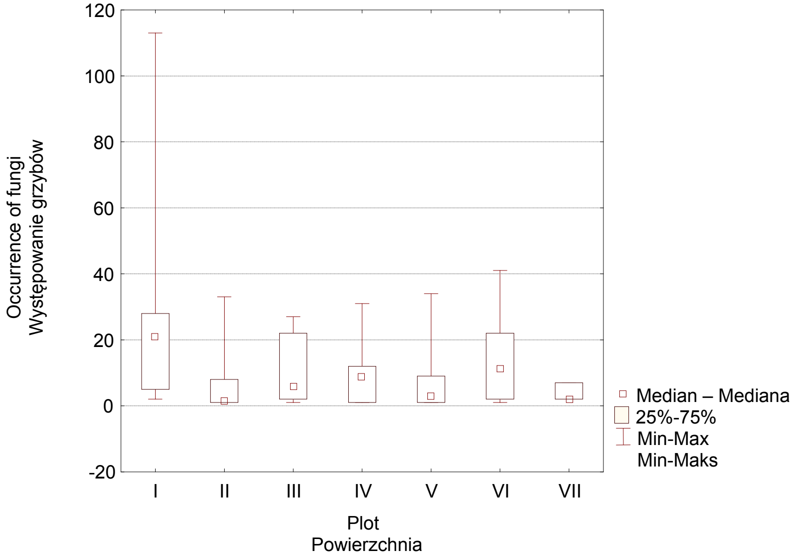

Fig. 1. Comparison of plots in terms of differences in occurrence of fungal species
Rys. 1. Porównanie powierzchni pod względem różnic w występowaniu gatunków grzybów

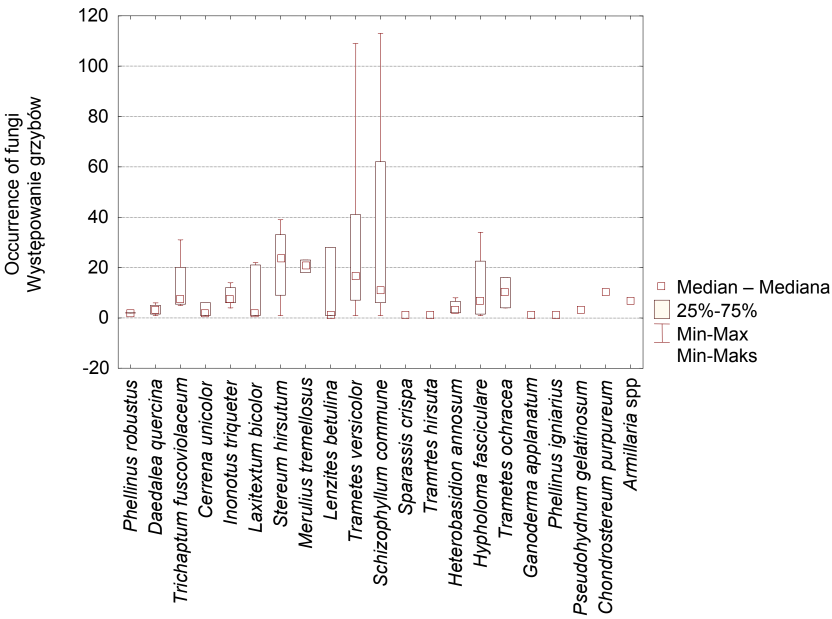

Fig. 2. Comparison of occurrence of individual fungal species in all plots jointly
Rys. 2. Porównanie występowania poszczególnych gatunków grzybów na wszystkich powierzchniach łącznie

abundant fungi included *Hypholoma fasciculare* as well as fungi from the genus *Armillaria* spp., while among fungi forming conk fruiting bodies *Heterobasidion annosum* was frequently recorded, which fruiting bodies grew most frequently in the area of the butt swelling. These fungal species may easily colonise stumps in locations with a considerable weed cover, since infestation with these pathogens occurs additionally through contact of diseased and healthy roots [Mańka 2005]. In turn, species diversity of fungi found on those stumps appeared in more open areas, well-insolated and with poorer vegetation cover. Mycobiotas of such plots are sometimes represented by around a dozen species. Fruiting bodies themselves are better developed, more showy and well-coloured, facilitating a certain identification of species. Light is required for normal development of fruiting bodies in most species [Orłoś 1966]. Thus we may conclude that field conditions, the degree of surface vegetation cover and microhabitat conditions influence the distribution, the degree of infestation and the development of fungi found on stumps. The degree of stump decomposition influenced mycobiotas observed there. Individual phases of wood decomposition were preferred by different fungal species. It was observed that stumps being in a late stage of decomposition are most frequently colonised by sulphur tuft *Hypholoma fasciculare*. An identical observation was made by Rayner [1977]. In terms of their population size the most abundant species of fungi growing on stems in the analysed plots turned out to be turkey tail *Trametes versicolor* (191 localities), *Schizophyllum commune* (136 localities) and *Stereum hirsutum* (130 localities). Such a situation may result from the large number of stumps of deciduous species, mainly oak, as substrates, on which the above presented fungal species live and develop. Saprotrophic fungi developing on wood of deciduous species contribute to its decomposition, formation of white rot and general depreciation of wood. The above mentioned fungal species develop not only on stumps of forest trees, but also on dead wood and timber, particularly left for a longer time in places of temporary lumber storage. Turkey tail is the most harmful species of the three mentioned above, as it may completely colonise poorly protected timber. Lumber with visible signs of infestation with these pathogenic fungi not only deteriorates in terms of its technical and utility parameters, but also loses its economic value by being classified to lower and thus cheaper quality grades of individual dimensional classes. Moreover, *Stereum hirsutum* may be a wound parasite and colonise healthy living trees, thus having a negative effect on the prospective condition and physiology of the tree. These considerations may be concluded with the recommendation to present foresters with a warning concerning the threat posed by these pathogenic fungal species in areas with a higher potential risk of their colonisation. In four plots the presence of *Heterobasidion annosum* was reported, while in one plot fungi from the genus *Armillaria* were observed. These species infest completely healthy trees and shrubs of different species. They cause some of the most economically important diseases in forest management. The presence of these species should be an impulse for the undertaking of adequate protection measures in order to protect the young generation trees in the stand and conduct more detailed analyses before planned regeneration of a given area. At the same time it was observed that no fruiting bodies of *Armillaria* spp. were found on stumps colonised by sulphur rot and other stumps in their vicinity, despite the fact they were recorded in the same experimental plot. *Hypholoma fasciculare* limits the occurrence of *Armillaria* spp. [Łakomy 1998]. Data reported by Łakomy [2004] showed that not only *Hypholoma fasciculare*, but also *Trametes versicolor* have a limiting effect on growth and development of fungi from the genus *Armillaria* spp. (pathogen growth was inhibited by 50-96%). The use of certain saprotrophic fungi may prove to be an effective weapon against root pathogens. However, the most essential aspect is the fact that a vast majority of species found in the analysed plots have a positive effect on the forest ecosystem. They are saprotrophs decomposing dead wood found in the form of stumps, dead trees and tree stems. *Trametes versicolor* is capable of decomposing an oak stump in 80% within 6 months from its colonisation [Łakomy 2004]. Without the "effort" of the saprotrophic fungi to decompose dead organic matter, wood would remain on the ground for a much longer time [Piotrowski 2010]. Fungi found on stumps and the other dead wood are important elements of the forest ecosystem. They influence the richness and stabilisation of this ecosystem through continuous processes connected with the cycle of matter and subsequently the cycle of minerals in nature.

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GRZYBY WYSTĘPUJĄCE NA PNIAKACH W WYBRANYCH WYDZIELENIACH NADLEŚNICTWA DOŚWIADCZALNEGO ZIELONKA

Streszczenie. Grzyby pełnią ważną funkcję. Rozkładając martwą materię organiczną, przyczyniają się w ten sposób do obiegu węgla w przyrodzie. W ekosystemie leśnym, oprócz wspomnianej pozytywnej roli, powodują choroby roślin drzewiastych. Pniaki będące pozostałością po ściętym drzewie są bazą pokarmową dla rozmaitych organizmów, w tym grzybów powodujących najgroźniejsze choroby drzew leśnych, np. opieńkową zgniliznę korzeni drzew czy hubę korzeni. Zasiedlenie pniaków jest determinowane przez trzy główne czynniki: mikrosiedlisko, dostępność bazy pokarmowej oraz występowanie innych organizmów konkurencyjnych. Głównym celem pracy była inwentaryzacja owocników gatunków grzybów na pniakach w wybranych wydzieleniach Nadleśnictwa Doświadczalnego Zielonka, zobrazowanie różnorodności gatunkowej grzybów na badanym obszarze, określenie czynników decydujących o intensywności zasiedlenia pniaków przez grzyby. Uzyskane wyniki badań wskazują, że na pniakach sosnowych owocniki znajdowały się rzadziej niż na pniakach gatunków liściastych. Najbardziej licznymi pod względem liczebności gatunkami grzybów występującymi na pniach na badanych powierzchniach okazały się: wroślak różnobarwny (191 stanowisk), rozszczepka różnobarwna (136 stanowisk) oraz skórnik szorstki (130 stanowisk). Zdecydowana większość gatunków występujących na badanych powierzchniach ma pozytywny wpływ na ekosystem leśny.

Słowa kluczowe: grzyby, rozkład drewna, pniaki

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