СЕКЦІЯ І
ЛІСОВЕ ТА САДОВО-ПАРКОВЕ ГОСПОДАРСТВО, ЕКОЛОГІЯ

UDK 581.2

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XYLOTROPHIC FUNGI OF HARDWOOD FOREST IN THE ENTERPRISE «ZHOVTNEVE LISOVE HOSPODARSTVO»

Wood-decay fungi are ecologically important organisms and the principal agents of wood decomposition. The diversity and community of wood-decay fungi are triggered by the available amount of dead wood. Abundance and diversity of wood-inhabiting fungi were studied in managed (selective sanitation cutting and clear-cuts) and unmanaged stands in 76-107-year-old oak forest in the eastern Ukraine. Fungi were detected on stem living, standing dead and fallen trees and stumps, coarse woody debris (logs, fallen branches etc) in 2021-2022. Fungi were identified after culturing on synthetic media or as fruit bodies. Living and dead wood of oak were colonized by fungi represented by Ascomycota (15 species) and Basidiomycota (26 species). Our study detected at all experimental plots together 41 species of (934 findings of xylotrophic fungi), 11 orders (4 from Basidiomycota division (class Agaricomycetes) and 7 from Ascomycota (class Sordariomycetes and Dothideomycetes).

Twenty fungal species (48%) occurred in both type of stands, while 16 (37%) species occurred exclusively in unmanaged stands and 2 (5%) in managed stands. Abundance of fungi was non-significantly greater in managed (489) than in unmanaged stands (475). Diversity of fungi was significantly less in managed (29) than in unmanaged stands (45). Abundance of fungi per samples, trees, logs and branches were significantly less in managed than in unmanaged stands. The study shows that the forest management applied (sanitation cutting which are associated with less coarse woody debris) resulted in a small decrease in diversity of fungi in the deadwood and did not lead to elimination of aggressive wood-decay fungi (Laetiporus sulphureus and Fistulina hepatica).

***Key words**: wood-decay fungi, oak stands, wood decomposition, forest ecosystem.*

Introduction. Forest ecosystem is consisting of different biodiversity elements with their tight ecological links and wood-inhabiting (xylotrophic) fungi are essential elements to study. Wood-inhabiting fungi have been well studied in temperate and boreal ecosystems [8, 14] and in warm mixed and tropical forests [17]. Ukrainian forest ecosystems are being located in temperate zone and Mid-Latitude Xeric belt and most studies included findings and description of different wood-decay species which play

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a significant role in wood decomposition [4-6, 11, 25-27], yet no studies have provided an estimate of the diversity of wood-decay fungi in managed and unmanaged oak forests at national or regional levels in Ukraine [26]. According to previous studies [2, 14], standing and lying deadwood accounts for 10-20% of the biomass in mature forests, therefore, we expect that variable forest management can provide different amounts of deadwood, establishing different microclimates with various habitat conditions, this, in its turn, affect the abundance and diversity of fungi [8, 14, 24] in Ukrainian forest. Moreover, it is possible that the intensity of management and the silvicultural practices adopted may affect the amount and quality of deadwood in forest ecosystems, as in managed forests, the amount of deadwood is reduced by extraction of timber and wood biomass.

Therefore, our tasks focus on analysis the effects of forest management on biodiversity, comparing each region unmanaged forests with different types of the managed forest using experimental plots [22]. Within our task in this study our first steps concentrated mainly on wood-decay fungi in unmanaged forests and managed forests.

So, we hypothesized that wood-inhabiting fungi respond to forest management practices differently in variable habitats and probably oak-associated species are more flexible and adaptable to new conditions using other hardwood trees in mix forests [23], therefore, the hypothesis is tested that forest management in oak forest leads to decreased abundance and diversity of wood-decay fungi, because of less available deadwood.

So, the objective is to study the fungal diversity associated with different types of forest management that is crucial for maintaining forest diversity in Ukraine. The subject is the mix oak forest stand in Left-bank Ukraine.

Both objective and subject aims to generate knowledge on the species composition of wood-inhabiting fungi in different types of forest management to determine the effects of management practices in mature oak forest on the occurrence (abundance and diversity) of wood-inhabiting fungi and to detect the common and rare fungal species present in/on deadwood in eastern Ukraine.

Materials and methods. Our study was carried out in the north-eastern part of Ukraine (Kharkiv region, forest enterprise “Zhovtneve lisove hospodarstvo”. The monitoring plots (MP) were established in 76-107-year-old oak stands of vegetative origin with a relative density of stocking of 0.6-0.7 and 50-80% of pedunculate oak (*Quercus robur* L.) in the composition (Table 1).

The climate of the study region is temperate continental, the growing season is on average 190 ± 5 days and annual precipitation averages 492 mm, of which 280 mm falls in the growing season.

Both managed and unmanaged study areas share similarities in terms of bedrock.

Table 1

Characteristics of the studied oak stands and their coordinates

Monitoring plot	Stand characteristics					Location of plot	
	Composition*, %	Age, year	Forest management under last decade**	Relative density of stocking	Stock, $m^3 \cdot ha^{-1}$	Compartment	Subcompartment
MP1	Oak 80%–20% Linden, Aspen	76	Managed (CC)	0.60	180	9	3
MP2	Oak 80%–20% Linden, Ash–Maple	106	Managed (SC)	0.70	270	16	2
MP3	Oak 80%–20% Linden, Maple	101	Managed (CC)	0.60	210	36	1
MP4	Oak 50%–40% Linden 10% Maple	96	Managed (SC)	0.60	210	40	2
MP5	Oak 90%–10% Ash–Maple	107	Unmanaged	0.50	170	2	9
MP6	Oak 60%–20% Ash 20% Maple	107	Unmanaged	0.70	400	7	15
MP7	Oak 60%–20% Linden 20% Ash	107	Unmanaged	0.60	369	16	3
MP7	Oak 90% 10 % Ash	102	Unmanaged	0.60	254	17	23

* - Oak = Pendulate oak (*Quercus robur* L.); Ash = common ash (*Fraxinus excelsior* L.); Maple = Norway maple (*Acer platanoides* L.); Linden = small-leaved linden (*Tília cordata* Mill.); Aspen = common aspen (*Populus tremula* L.).

** - SC – selective cutting, CC – clearcutting.

The soils in these areas are near-neutral, and the forest type (grey forest soil), composition, and density are also comparable. It is worth noting that no logging or harvesting activities have occurred in either of the MP4-8 while on stands MP1-4 sanitary cutting have applied for the past two decade.

The stands are composed of a dominating *Quercus robur* L. in the canopy layer, followed by *Franixus excelsior* L. and *Tília cordata* Mill., covering from 10 to 50%. Secondly, shrubs such as *Acer campestre* L., *Acer platanoides* L, *Corylus avellana* L., *Ulmus laevis, U. minor* and so on, covered from 3 to 74% of the study area, while herbaceous plants such as *Achillea millefolium* L., *Anemone ranunculoides* (L.) Holub, *Anthriscus cerefolium* (L.) Hoffm., *Convolvulus arvensis* (L), *Galium aparine* L., *Galium* spp., *Polygonatum multiflorum* L., *Psephellus sumensis* (Kalen.) Greuter, covered from 1 to the 60%. The soils are mostly blanketed by dead biomass from the adjacent trees, i.e., litter, branches and logs, covering from 70 to 95% of the forest surface.

Forest health condition was evaluated visually at the end of August 2021-2022 on a range of visual characteristics (crown density and colour, the presence and proportion of dead branches in the crown, fruit bodies of wood-decay fungi etc.) according to "Sanitary rules in the forests of Ukraine" (Sanitary rules in the forests of Ukraine 2016). Six trees for each monitoring plots were selected for careful

examination. Each tree was ranked according to one out of six categories (1st – healthy; 2nd – weakened; 3rd – severely weakened; 4th – drying; 5th – recently died; 6th – died over year ago).

Health condition index (HCI) was calculated as weighted mean value from trees number of each category of forest health condition. Healthy stand has HCI 1.00-1.50. HCI was 1.51-2.50 for weakened stand, 2.51-3.50 for severely weakened stand, 3.51-4.50 for drying stand, and 4.51-6.00 for dead stand.

Sampling Design: six oak trees were randomly selected and marked at each monitoring plots for careful observation. Three 200 m^2 permanent plots (20×10 m2) were randomly placed in each monitoring plots near monitoring trees (18 in total). Each plot was surveyed every May, October, November and December during 2021-2022 to collect all wood-decay fungi from all monitoring and all woody debris. To analyse fungal community, all fruiting bodies were collected on all substrates (living, dying and dead trees, fallen trees, stumps, branches etc), with the aim of finding as many species as possible for all habitats. Fungal fruiting bodies were carried to the laboratory, where they were stored at 4-8°C, and processed within 24 h after collection for identification. The fungi were classified into the following functional groups: saprotrophic, biotrophic, mycorrhizal and pathogenic fungi for further statistical analysis. The samples that could only be identified to the genus level were grouped into a genus taxon.

Most of the species were identified in the Laboratory of Department of Forest Mycology and Plant Pathology, Swedish University of Agricultural Sciences (Uppsala, Sweden) and were studied by the usual macro- and micromorphological techniques using analytical keys [3, 12, 20]. During the fieldwork, detailed information regarding the diameter and decay stage of the associated woody debris pieces was recorded for each fungal specimen.

Both frequency of occurrence and abundance of the different fungal species on each site were used to test for differences in the fungal community in the managed and unmanaged areas. Frequency was estimated from the presence/absence data matrix of each fungal species. Relative abundance was calculated for each area as the number of samples colonized by a taxon divided by the total number of samples collected in that site.

Fungal identification. The fruit bodies were identified at species level whenever possible according to the mycological keys.

For molecular identification DNA was extracted from the unidentified fruit bodies/fungal cultures of the isolates representing morphological groups. Internal transcribed spacer (ITS) regions 1 and 2, including the ribosomal 5.8S gene, were amplified using the primers pairs ITS1-F and ITS4. The reaction mixture contained, in a total volume of 15 µl, 200 µM deoxyribonucleotide triphosphates, 0.2 µM of each primer, 0.03 U/µl Thermo Green Taq polymerase with reaction buffer Green, and 2.75 mM final concentration of MgCl2. The thermal cycling was carried out using an

Applied Biosystems GeneAmp PCR System 2700 thermal cycler (Foster City, CA, USA). An initial denaturation step at 95°C for 5 min was followed by 35 amplification cycles of denaturation at 95°C for 30 s, annealing at 55°C for 30 s, and extension at 72°C for 30 s. The thermal cycling was ended by a final extension step at 72°C for 7 min. PCR products were size separated on 1% agarose gels and visualized under UV light. The PCR products were purified with Qiagen DNA extraction PCR M kit (Qiagen, Hilden, Germany). Sequencing was carried out by Macrogen Inc., Korea. Raw sequence data were analysed using the SeqMan Pro version 10.0 software from DNASTAR package (DNASTAR, Madison, WI, USA). Databases at GenBank and at the Department of Forest Mycology and Plant Pathology, Swedish University of Agricultural Sciences, were used to determine the identity of ITS rRNA sequences. The criteria used for identification were sequence coverage > 80%; similarity to taxon level 98-100%, similarity to genus level 92-97%.

Statistical analyses. All data were tested for adherence to the normal distribution using the Kolmogorov–Smirnov test and for homogeneity of variances using Bartlett's Test. Data on oak tree affected by wood decay fungi were subjected to analysis of variance (ANOVA) using a general linear model (GLM) where significant treatment effects occurred ($p<0.05$), means were separated using HSD Tukey post hoc test after ANOVA. For all plots, Chi-square tests were used to determine differences in tree mortality or tree health. Means were compared by the HSD Tukey post hoc test with a significance level of 0.05. Intervals of confidence were determined to distinguish treatments representing different monitoring plots.

Detrended correspondence analysis (DCA), a multivariate statistical technique to find the main gradients in large, species-rich but usually sparse data and Bray–Curtis dissimilarity were employed to compare fungal species compositions in different study sites. Shannon’s H0 diversity index was used for the analysis.

Statistical data analysis was performed using the statistical software package PAST: Paleontological Statistics Software Package for Education and Data Analysis.

Analysis of Literary Sources. Wood-decay fungi are ecologically, and functionally important organisms are the principal agents of wood decomposition, degrading differently the dead wood resource and regulating the carbon cycle. The diversity and community composition of these fungi are primarily influenced by the size of the woody debris [Ponce 2023, Kuffer 2008].

Despite the high importance of wood-decay fungi in forest ecosystems, their communities within Ukrainian hardwood forest have received limited attention in previous studies [4, 26]. Moreover, Left-Bank Ukraine are recognized as crucial biodiversity spots which contains a wide range of flora and fauna, including fungal species related to the vegetation and tree species on which they grow [27]. Undoubtedly, the decay stage also influences the abundance and composition of wood-decay fungi [19], however, the number of fungi involved in wood decomposition process is still unknown. Nevertheless, the proportion of wood decay fungi or fungal

species depending on wood is approximately 20-40% of the estimated 1.5 million fungal species worldwide [8, 10, 14].

Intensive forest management in Europe, exhaustive harvesting and utilization of dying or uprooted trees has lowered the large amount of dead wood and wood debris resulted in a reduction in the abundance and diversity of wood-decay fungi, including endangered species [10, 14]. In Ukraine there is a considerable utilization of dying and dead trees, resulting in a reduction dead wood in forest compare with most other EU countries. Moreover, studies on the abundance, diversity and productivity of wood-decay fungi in managed and unmanaged forests remain limited, as most of the previous research has primarily focused on richness and species composition [6-8]. That's why the aim of our research is to study the effects of forest management on the wood-inhabiting fungal communities.

Results. *Wood-decay fungi community composition*. Living and dead wood of oak were colonized by fungi represented by Ascomycota (15 species) and Basidiomycota (26 species) (Table 2). Our study detected at all experimental plots together 41 species of (934 findings of xylotrophic fungi), 32 genera, 18 families, 11 orders (4 from Basidiomycota division (class Agaricomycetes) and 7 from Ascomycota (class Sordariomycetes and Dothideomycetes). A comprehensive list of all the identified species and taxa can be found in Table 2.

To understand species richness, which the count of the number of species present in an area, we used different indices of alpha diversity. Most of the time, the abundance of distribution is noticeable when have been utilizing more than one index of diversity (Table 3).

So, we can understand of how diverse a single sample (managed forest and unmanaged forest) is, usually taking into account the number of different species presented in each site.

The metrics in Table 3 consider the number of different species observed, and some consider the abundances at which those species are found in the sample. We can see that the evenness of the abundances of the of xylotrophic fungi in unmanaged forest has led to an increased diversity compared to managed forest, even though they have the same number of species.

Table 2

List of the species found in forest enterprise "Zhovtneve lisove hospodarstvo" with information belonging to the size (MP1-MP8) of the wood and the forest management practices (managed and unmanaged forests)

Species	Managed forest				Unmanaged forest			
	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8
Ascomycota								
Alternaria alternata (Fr.) Keissl.	3.06	0.00		0.72	1.40	2.50	0.85	
Biscogniauxia nummularia (Bull.) Kuntze		0.99			0.70			0.96

Continuation of table 2

Botrytis cinerea Pers.	7.14	0.00			1.40	3.33	1.69	1.92
Ceratocystis piceae (Münch) B.K. Bakshi		0.00		2.16	1.40	0.00		2.88
Clonostachys rosea (Link) Schroers. Samuels. Seifert & W. Gams		1.98	3.55		1.40	1.67		2.88
Cytospora sp.	5.10	0.00	2.13		0.70	2.50	1.69	3.85
Epicoccum nigrum Link	7.14	4.95		1.44	0.70		2.54	
Metapochonia bulbilosa (W. Gams & Malla) Kepler. Rehner & Humber	6.12	11.88	10.64	9.35	3.50	10.00	6.78	
Nectria cinnabarina (Tode) Fr.1 (KX586144)	3.06	0.00		0.72		4.17		5.77
Ophiostoma canum (Münch) Syd. & P. Syd.1 (KX586141)		0.99	1.42	3.60	3.50		5.08	5.77
Phoma glomerata (Corda) Wollenw. & Hochapfel	2.04	0.99			0.70	0.83	2.54	3.85
Sporothrix inflata de Hoog1 (KX586142)		1.98			0.70	1.67	0.85	
Sporothrix schenckii Hektoen & C.F. Perkins	8.16	0.99	10.64	13.67	2.80	1.67		1.92
Sydowia polyspora (Bref. & Tavel) E. Müll.	6.12	1.98	1.42	0.00	6.29	9.17	2.54	1.92
Trichoderma viride Pers.	12.24	17.82	39.72	29.50	2.80	17.50	10.17	0.96
Truncatella angustata (Pers.) S. Hughes	2.04	1.98			2.80	4.17	4.24	
Basidiomycota								
Antrodia albida (Fr.) Donk		0.99	0.71		1.40	1.67	0.85	
Auricularia auricula-judae (Bull.) Quél.					1.40			1.92
Bjerkandera adusta (Willd.) P. Karst.	1.02			0.72	0.70			0.96
Exidia glandulosa (Bull.) Fr.	0.00				2.80		0.85	1.92
Ganoderma lucidum (Curtis) P. Karst	1.02	8.91	10.64	3.60	4.20	5.00	6.78	0.96
Hapalopilus rutilans (Pers.) Murrill	2.04	0.99	2.13		7.69	6.67	10.17	2.88
Fuscoporia ferruginosa (Schrad.) Murrill					1.40			1.92
Hymenochaete rubiginosa (Dicks.) Lév.				0.72	3.50	0.83	2.54	3.85
Hyphoderma occidentale (D.P. Rogers) Boidin & Gilles				1.44	2.80	0.83	3.39	3.85
Hyphoderma setigerum (Fr.) Donk	2.04	4.95	0.71		0.70	1.67	0.85	1.92
Hyphoderma sp.					0.70		0.85	0.96

Continuation of table 2

Hyphodontia quercina (Pers.) J. Erikss.			1.42		0.70	2.50	1.69	
Irpex lacteus (Fr.) Fr.	4.08	0.99		0.72	4.20	1.67	1.69	2.88
Fistulina hepatica (Schaeff.)	5.10	11.88	2.84	13.67	11.19	7.50	3.39	7.69
Fomitiporia robusta (P. Karst.) Fiasson & Niemelä					0.70	0.83	0.85	0.96
Fomes fomentarius (L. ex Fr.) Gill	2.04	5.94		0.72	1.40		3.39	
Laetiporus sulphureus (Bull.) Murrill	11.22	11.88	8.51	10.07	5.59	1.67	5.08	2.88
Polyporus picipes Fr					4.20		5.93	
Pseudoinonotus dryadeus (Pers.) T. Wagner & M. Fisch	2.04	5.94	1.42	4.32	5.59	3.33	0.85	8.65
Schizophyllum commune Fr.					2.10	4.17	1.69	2.88
Stereum gausapatum (Fr.) Fr	3.06			1.44	4.20		2.54	3.85
Stereum hirsutum (Willd.) Pers.		0.99	2.13		1.40		2.54	4.81
Trametes ochracea (Pers.) Gilb. & Ryvarden	4.08				0.70		2.54	1.92
Trametes versicolor (L.) Lloyd, Mycol. Writ. (Cincinnati),				1.44		1.67		4.81
Trichaptum biforme (Fr.) Ryvarden						0.83	2.54	4.81
Number of findings	***98***	***101***	***141***	***139***	***143***	***120***	***118***	***104***
Number of species	***22***	***21***	***16***	***19***	***38***	***29***	***32***	***32***
Number of species per sample	***1.78***	***2.24***	***3.44***	***3.48***	***2.60***	***2.03***	***1.90***	***1.89***
Number of species in trees	***2.68***	***3.49***	***1.83***	***1.32***	***2.52***	***3.22***	***5.56***	***1.93***
Number of species in logs	***3.23***	***1.65***	***2.12***	***1.15***	***3.23***	***2.15***	***4.42***	***2.23***
Number of species in branches	***0.52***	***0.45***	***0.23***	***0.36***	***2.23***	***2.36***	***1.96***	***1.18***
Number of species in stumps	***0.13***	***0.23***	***0.59***	***0.47***	***3.55***	***2.47***	***2.15***	***1.85***

Moreover, Dominance and Shannon index indicated that forest community of unmanaged forest is dominated by one species, making it less diverse.

Table 3

Alpha diversity indices for average data for sites with different forest management practices (managed and unmanaged forests)

Alpha diversity indices	Managed forest (MP1-4)	Unmanaged forest (MP5-8)
Dominance, D.	0.2076	0.257
Simpson index	0.7934	0.743
Shannon index	2.38	2.33
Menhinick index	1.919	2.619
Fisher alpha	8.807	17.79
Chao-1	29	45

We tried to examine alpha diversity to determine if there are major differences between two populations or groups in their data set, or if there have been major changes within a group over time. We plotted the species richness ("Chao1"), Shannon, and Simpson diversities for these managed and unmanaged forest stands (Fig.1).

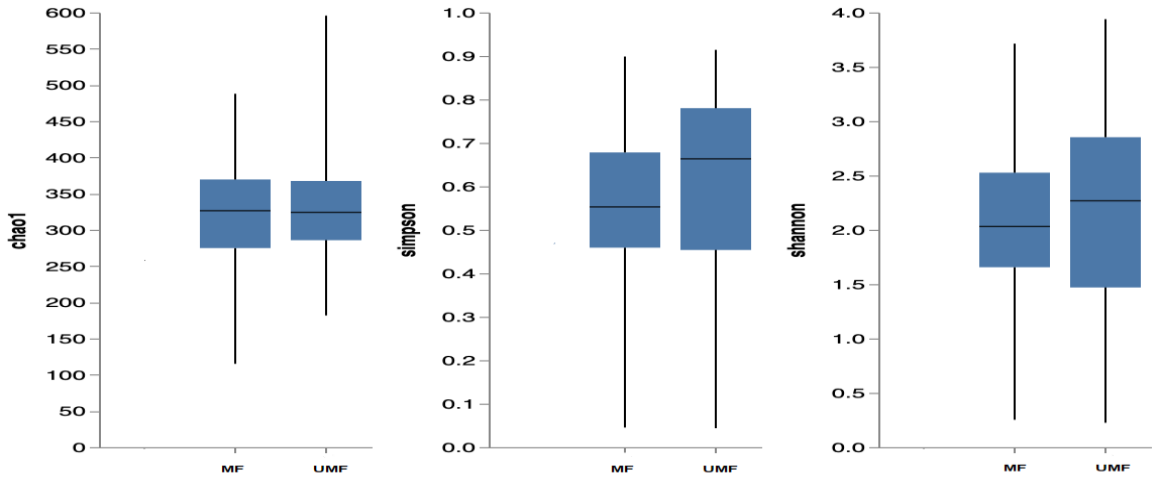

Figure 1. The Chao, Simpson and Shannon Indexes for average data for sites with different forest management practices (managed and unmanaged forests)

The Chao1 Index indicates that these groups have very similar numbers of observed species. However, both Simpson and Shannon indices hint that the xylotrophic fungi from managed forest may have a less even spread of abundances than the unmanaged forest. Menhinick index, Shannon's diversity index and Simpson's diversity index indicate a trend for decreased diversity with more forest management practices (Table 3). Dominance index shows slightly least dominance of individual species in the unmanaged forest. When analysing the woody substrate preferences for the groups studied, we did not detect any specific preference for the different decay stages and stage of the wood (standing trees, fallen trees, branches, logs, stumps) excluding few species which have a limited habitat (data not shown). Although, Ascomycota and Heterobasidiomycota were found mostly in soft decayed wood of standing or fallen trees while corticoids appeared to be more flexible, being associated with a wider range of woody decay stages and sizes. Polyporoids, on the other hand, exhibited a more generalist behaviour, being capable of growing across various decay stages of the trees and branches.

Effects of forest management on biodiversity of xylotrophic fungi. Sixteen fungal species (37%) occurred in both type of stands, while 20 (48%) species occurred exclusively in unmanaged stands and 2 (5%) in managed stands. Abundance of fungi was non-significantly greater in managed (489) than in unmanaged stands (475). Diversity of fungi was significantly less in managed (29) than in unmanaged stands (45). Abundance of fungi per samples, trees, logs and branches were significantly less in managed than in unmanaged stands (Table 2).

The unmanaged stand, in comparison with the managed stand, had in 1,67 times more oak trees and 1,09 times % greater tree density, 11 times greater dead wood volume, 1,47 times more wood volume in standing dead trees and 1,69 times less decayed stumps (data not shown). Of course, fungal diversity depends on amount of dead wood, that in its turn depends on forest characteristics and dynamics but is also highly influenced by management practices [14, 27].

The most common species affecting the forest health of the oak plantations were *Fomitiporia robusta*, *Laetiporus sulphureus* and *Fistulina hepatica*. which were the most common in managed than in unmanaged stands (Table 2). *Auricularia auricula-judae, Hymenochaete rubiginosa, Fuscoporia ferruginosa, Hyphoderma sp., Polyporus picipes, Trichaptum biforme* and *Schizophyllum commune* were occurred only in the unmanaged stand (Table 2).

Diversity of fungi (measured as average number of species per sample) from trees, logs, fallen branches and stumps was significantly higher in unmanaged stands. Abundance of decayed fungi was significantly greater in the unmanaged stand. Diversity was the greatest in the logs and fallen trees, hosted the largest number of cultured species in the managed stand and in the unmanaged stand (Table 2). Communities detected within a stand tended to be more similar to each other ($F_{9,49} = 3.29$, $R2 = 0.38$, $P = 0.001$) than communities from different, managed and unmanaged, stands ($F_{1,51} = 1.54$, $R2 = 0.03$, $P < 0.001$). There was little evidence of spatial correlation between fungal diversity and sampling method (Mantel $r = 0.13$, $P = 0.003–0.005$) and positive correlation between fungal diversity and type of stand (Mantel $r = 0.96$, $P = 0.007$). Sorensen's qualitative similarity index (CN) showed large difference in diversity of fungi in managed or unmanaged stands (range 0.69-0.71).

Discussion. Wood-decay fungi contribute to nutrient cycling, providing the availability of resources for several groups of organisms, facilitating regeneration of a forest (regeneration has often started after decay of fallen logs, branches and stumps in situ). Therefore, measures aimed at conserving wood-decay fungi can thus be justified on the basis of their contribution to productivity of the forest and to biodiversity [14, 19].

Considering that habitat quality, deadwood availability and variety, we demonstrated that they did not differ greatly in our study sites as a result of the natural development occurring during the last decades, and only forest management affected alpha biodiversity of wood decay fungi, that is confirming by published data [1, 8, 14, 19]. According to our preliminary data, most of the variation in fungal community structure remains unexplained and that is common in ecological studies because of many interacting factors can be overlooked or unmeasured [1, 19], including soil humidity and temperatures, populations of saproxylic insects, the long-term monitoring of microbial communities [14].

We used a combined approach to study forest biodiversity by investigating wood-inhabiting fungal communities in relation to different forest management

practice. To take into account the structural heterogeneity of the study areas, we avoided to use stratification in our sampling design. The only controlled factor was related to the volume and type of deadwood, but we did not find strong correlation between type of deadwood and abundance of wood decay fungi. Our hypothesis that forest management practices played a major role in shaping the fungal community composition were supported by results. Our results showed a similarity of the fungal community structure within the study areas in managed forest as well as in unmanaged forest with different amount of deadwood, because no clear clusters emerged, only unmanaged and manged sites (Fig. 2).

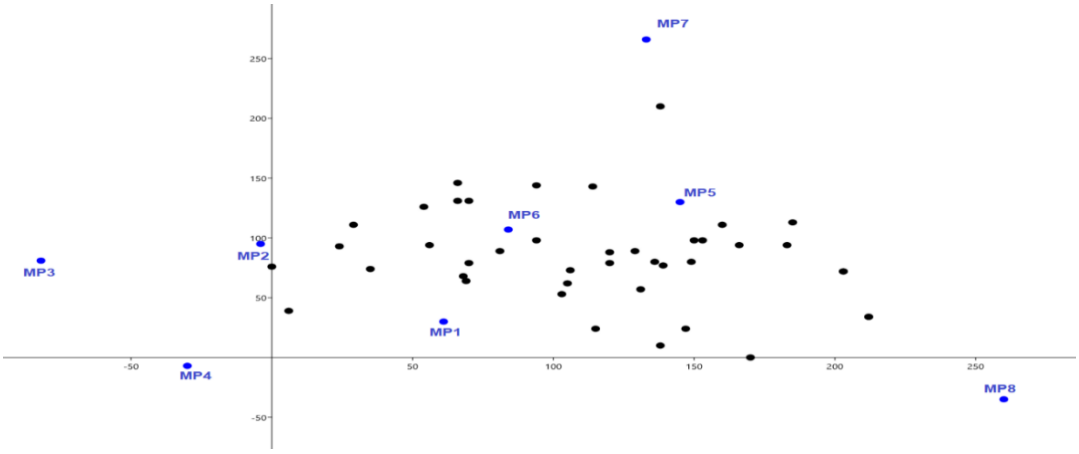

Figure 2. The relationship between fungal community structure and monitoring sited investigated via detrended correspondence analysis (DCA) (MP1-4 – managed forest, MP5-8 unmanaged forest; fungal species from Table 1 were not pointed out and indicated as black dots)

Forest management practices affect the mycobiota and could cause decreases in abundance and diversity of wood-inhabiting fungi [23] or may have no effect [8, 14, 21]. Our observations on diversity of fungi agree with results of numerous studies [8, 14, 19, 22-24] recorded reduction of species in managed forests than in unmanaged ones, and less fungal diversity in thinned broadleaved forests than in non-thinned ones. Decrease in diversity of wood-decay fungi in the managed stand seems to have resulted from reduction in available deadwood volume and woody debris that is common and has been reported previously [8, 14, 18, 24].

Our study presents mycological effects of forest management on abundance and diversity of fungi in oak mixed forest. Samples were taken from two stands lying in close proximity (managed and unmanaged) each of them consists of four monitoring sites.

Conclusion. The diversity and community of wood-decay fungi are triggered by the available amount of dead wood. According to our data, most of the variation in fungal community structure depends on many interacting factors as soil humidity and temperatures, populations of saproxylic insects, the long-term monitoring of microbial communities. Our study resulted in community of wood-decay fungi associated with dead wood. The study detected at all experimental plots together 41 species of (934

findings of xylotrophic fungi), 11 orders (4 from Basidiomycota division (class Agaricomycetes) and 7 from Ascomycota (class Sordariomycetes and Dothideomycetes).

Twenty fungal species (48%) occurred in both type of stands, while 16 (37%) species occurred exclusively in unmanaged stands and 2 (5%) in managed stands. Abundance of fungi per samples and per sites were non-significantly in both managed and unmanaged stand. However, diversity of fungi was significantly less in managed than in unmanaged stands. The study shows that the forest management applied (sanitation cutting which are associated with less coarse woody debris) resulted in a small decrease in diversity of fungi in the deadwood and did not lead to elimination of aggressive wood-decay fungi (*Laetiporus sulphureus* and *Fistulina hepatica*).

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КСИЛОТРОФНА МІКОБІОТА ЛИСТЯНИХ НАСАДЖЕННЯХ ФІЛІЇ «ЖОВТНЕВЕ ЛІСОВЕ ГОСПОДАРСТВО»

Дереворуйнівні гриби є екологічно важливими організмами та одними з найголовніших компонентів лісових екосистем, завдяки їм здійснюється деструкція деревини та її залучення до кругообігу речовин. Різноманітність і структура угруповань дереворуйнівних грибів часто обумовлені доступною кількістю мертвої деревини. Нами досліджено чисельність і різноманітність деревних грибів на ділянках мішаних дубових лісів віком 76-107 років, де проводились лісогосподарські заходи (вибіркові та суцільні санітарні рубки). Дослідження проводились у 2021-2022 роках і різні види грибів були виявлені та ідентифіковані на живих, сухостійних і повалених деревах і пнях, колодах, опалих гілках тощо. Жива та мертва деревина дуба колонізована грибами Ascomycota (15 видів) та Basidiomycota (26 видів).

Наші дослідження виявили на всіх дослідних ділянках разом 41 вид (934 знахідки ксилотрофних грибів), 11 порядків (4 з відділу Basidiomycota (клас Agaricomycetes) і 7 з Ascomycota (клас Sordariomycetes і Dothideomycetes).

Двадцять видів грибів (48%) зустрічаються в обох типах насаджень, тоді як 16 (37%) видів зустрічаються виключно в насадженнях без проведення заходів і 2 (5%) в насадженнях, де проводились санітарні рубки. Чисельність грибів була незначно більшою в насадженнях, де проводились санітарні рубки (489), ніж там де заходи були відсутні (475). Різноманітність грибів була значно меншою в насадженнях, де проводились санітарні рубки (29), ніж у насадженнях без заходів (45). Чисельність грибів на один зразок, дерево, колоду та гілку була меншою в насадженнях де проводились рубки. Дослідження показує, що проведення санітарних рубок призвело до незначного зменшення різноманітності грибів у валежній деревині та не призвело до ліквідації агресивних дереворуйнівних грибів (Laetiporus sulphureus та Fistulina hepatica).

***Ключові слова**: дереворуйнівні гриби, дуб звичайний, деструкція деревини, лісові екосистеми.*