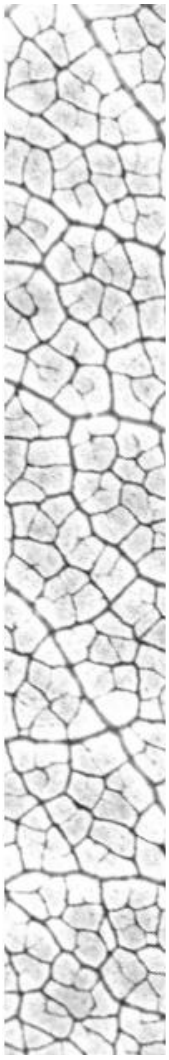

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Communities structure displayed by pathogenic polypore fungi types in oak groves of various viability levels

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Abstract
The paper focuses on the study of composition and species correlation in typical specific communities of nemoral biocenoses with *Quercus robur L.* Species of various viability levels growing in the south-west of Central Russian Upland have been examined. Three polypore fungi types living on oaks have been found to make up the characteristic combination of species in dendro-trophic pathogenic polypore fungi communities growing on oaks in upland and ravine groves, namely, *Fistulina hepatica*, *Laetiporus sulphureus*, *Fomitiporia robusta*. These ones are constant species in the communities' composition, displaying the highest dominance in terms of population, with 44.9%, 28.8%, 20.4%, respectively, in upland groves, and 45.0%, 26.3%, 20.5%, respectively, in ravine groves. *F. hepatica* is an indicator species which characterizes the vitality of oak stand: the higher dominance is displayed by the species, the poorer is oak stand condition.

Keywords: specific structure, pathogenic polypore fungi (PPF) community, *Quercus robur*, oak stand viability category (VC_{1-6}), dominance index (D)

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INTRODUCTION

The composition of forests and species correlation depend on the condition of the forest-forming species, which is the function of silvicultural operations and recreational impact. In the forest-steppe oak groves, the forest-forming species are represented by English oak, or *Quercus robur* L., which underwent intensive agricultural influence in the past and is now exposed to recreational impact. Today the groves consist mainly of 3^{d} to 5^{th} oak generations. This paper focuses on the forest composition and species distribution in the structure of some typical specific communities in oak stands which are in various health condition.

The goal of the research is to study the composition and correlation of species in typical specific communities of nemoral biocenoses with *Quercus robur L.* which display various viability levels. The objectives, therefore, include the following: 1) revealing the composition of PPF communities living on *Quercus robur L.* in oak stands of various viability levels, and 2) studying the correlation of species and identifying indicator PPF species living on oaks.

MATERIALS AND METHODS

The research took place during the vegetation seasons of 2011-2018 in the south-west of Central Russian Upland (Central Russian Physiographic province). The survey area was located between 50°20' and 50°86' north latitude and between 36°01' and 38°16' east longitude. Field study was conducted in oak stands of upland and ravine oak groves (with forest growth conditions indicated herein as D_2 and E_2, respectively), using a combination of methods (Guidelines for planning, organizing and conducting forest pathology surveys 2007. Mueller, Bills, 2004. Lonsdale, Pautasso, Holdenrieder, 2008. Dighton, White, Oudemans, 2005 Karadzic, 2010. Glaeser, Smith, 2010. Markovic, Lucic, Rakonjac, 2013. Lynch, Eskalen, 2014. Dunaev, et al. 2017. Dunaev, 2017).

In assessing oak stands viability, we have applied formal guidelines for planning, organizing and conducting forest pathology surveys (Guidelines for planning, organizing and conducting forest pathology surveys, 2007). Specific structure of PPF communities

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was studied with the help of estimated figures expressed with a simple percentage ratio of the particular and the general, with ***C*** denoting constancy, ***D*** denoting dominance level (Stepanovskikh, 2001). and f_s, f_{sd}, f_d denoting occurrence frequency of the species under study in one or another dominance status, in respect to a total of similar biocenoses in the surveyed area (De Vries, 1937, Dunaev, 2017).We have used estimation scales for ***C*** and ***D*** indices. Depending on the ***C*** value, there may be three species categories (Stepanovskikh, 2001) including: *constant ones*, occurring in more than 50% of samples; *additional ones* occurring in 25−50% of samples, and *accidental ones* occurring in less than 25% of samples. Depending on the ***D*** value (in terms of population), we can speak about the following categories of species (dominance classes) (Lyubarskii, 1975; Esmaeili, et al, 2014). *minor ones*, with population share within $0<N\leq4$ and *N (*%) denoting the total population; *secondary ones* with population share within $4<N\leq16$; *subdominant ones* falling within $16<N\leq36$; *dominant ones* with population within $36<N\leq64$; and *absolute dominants* falling within $64<N\leq100$.

In order to reveal the interrelations, we have used correlation and regression analysis methods (Lakin, 1990).

RESULTS AND DISCUSSION

The data obtained from detailed and reconnaissance field surveys reveal that oak substrate of oak stands in groves contain the following species of PPF communities living on oaks (Dunaev, 2017, Dunaev, 2017). *Fistulina hepatica* (Schaeff.) With., *Laetiporus sulphureus* (Bull.) Murrill, *Fomitiporia robusta* (P. Karst.) Fiasson & Niemelä, *Inocutis dryophila* (Berk.) Fiasson & Niemelä, *Pseudoinonotus dryadeus* (Pers.) T. Wagner & M. Fisch., *Daedalea quercina* (L.) Pers., *Hapalopilus croceus* (Pers.) Donk., *Grifola frondosa* (Dicks.) Gray, *Fomes fomentarius* (L.) Fr., *Polyporus squamosus* (Huds.) Fr. Each PPF community living on oaks is formed by a dendro-trophic (parasite) PPF community and a xylotrophic (saprotrophic) PPF community. In other words, they are formed by two PPF oak communities of a higher differentiation level which differ depending on the substrate they live on (on fresh and recently dried substrate or on an abiogenic one). As a result, their composition differs in quality and quantity. This is why specific structures of these communities deserve individual attention.

Specific structure of dendro-trophic PPF communities on oaks. We have found out that the characteristic combination of dendro-trophic PPF communities living on oaks in upland and ravine groves of the area under study includes three species of oak-dependent polypore fingi: *F. hepatica*, *L. sulphureus* and *F. robusta*. They are constant species in the composition of the communities, displaying the highest dominance in terms of population, namely: 44.9%, 28.8% and 20.4%, respectively, in upland groves, and 45.0%, 26.3% and 20.5%, respectively, in ravine groves. Two of the species under study are close to the status of constant and secondary ones. They include *I. dryophila* in dendro-trophic PPF communities living on oaks in upland oak groves and *D. quercina* in those growing in ravine groves. Other species should be considered accidental or additional and minor ones in dendro-trophic PPF communities of the region's oak groves.

We have revealed two different specific coenotic structures of PPF communities which are connected with *Quercus*-dendro-components of oak stands in sprouting ravine and upland groves. The first one reflects the specific structure of elementary *dendro-tropic* PPF communities limited to dendro-components of oak stands in a *better* sanitary condition (weight-average viability condition category $VC_{1\text{-}6}$ equal to 2.3 points and less, that is, $VC_{1\text{-}6} \leq 2.3$). The second one reflects the specific structure of elementary *dendro-tropic* PPF communities limited to dendro-components of oak stands which are in a *worse* sanitary condition ($VC_{1\text{-}6}$ equal to about 2.4 points and higher that is, $VC_{1\text{-}6} \geq 2.4$).

The first structure characterizes the sub-regional type of dendro-trophic PPF communities on oaks, with unpronounced dominance of *F. hepatica* (upland groves: 39.4±5.89%; ravine groves: 33.6±6.53%), given a prevailing sub-dominance of *L. sulphureus* (upland groves: 32.4±5.57%; ravine groves: 32.8±5.28%) and sub-dominance of *F. robusta* (upland groves: 20.3±2.45%; ravine groves: 23.4±4.54%). The second structure is typical of dendro-trophic PPF communities living on oaks, with a pronounced dominance of *F. hepatica* (upland groves: 50.3±5.41%; ravine groves: 51.6±4.40%), given sub-dominance of *L. sulphureus* (upland groves: 25.1±5.81%; ravine groves: 22.6±3.83%) and *F. robusta* (upland groves: 20.4±4.48%; ravine groves: 18.8±2.31%). The above two specific structures characterizing two different sub-regional types of dendro-trophic communities living on oaks may lay the foundation for a hierarchy of PPF community living on *Quercus robur L.*

We have revealed a proven positive correlational inter-dependence between weight-average value of oak stand viability condition ($VC_{1\text{-}6}$) and the index of *F. hepatica* dominance in PPF communities on oaks ($\mathbf{D}_{Fh}$) (see the **Table 1**)$\overline{D}Fh$: r=0.525 (t_{ϕ}=3.698, t_{st}=2.021, k=36, P=0.05) (upland and ravine groves) (See the **Table 1**).

The regression patterns developed on the basis of the proven positive correlational inter-relation which was revealed during the research, reflect the inter-dependence between weight-average value of oak stand viability category ($VC_{1\text{-}6}$) and the index of *F. hepatica dominance* in PPF communities living on oaks

Table 1. VC1-6 and DFh values compared series

No.	Oak stand in oak grove -year	VC_{1-6}, points	D_{Fh}, %	No.	Oak stand in oak grove -year	VC_{1-6}, points	D_{Fh} $\overline{D}Fh$, %
1	KD[1]-13*	2.10	38.5	20	AG-10	2.02	20.0
2	GF-13	2.16	62.5	21	AG-11	2.05	7.7
3	KD-11	2.17	8.3	22	AG-13	2.12	41.7
4	KchD-15	2.20	47.0	23	AG-12	2.23	27.3
5	ShD-11	2.25	26.3	24	AR-12	2.26	61.5
6	GF-12	2.27	50.0	25	PZ-15	2.28	40.0
7	ShD-12	2.28	58.6	26	MSh-12	2.34	37.0
8	KD-10	2.30	14.3	27	R-11	2.43	33.3
9	O-15	2.32	55.0	28	R-10	2.45	56.2
10	ShD-10	2.32	33.3	29	AR-10	2.48	38.5
11	SW-1	2.36	50.0	30	R-14	2.54	45.4
12	D-11	2.38	47.6	31	R-12	2.58	33.3
13	D-13	2.39	71.4	32	AG-14	2.60	60.0
14	SW-10	2.41	50.0	33	K-13	2.63	69.4
15	KD-14	2.54	50.0	34	R-13	2.70	66.7
16	D-12	2.65	60.0	35	AR-14	2.70	66.7
17	D-14	2.67	50.0	36	CF-14	2.84	38.5
18	ShD-13	2.71	50.0	37	DB-13	2.89	38.5
19	UW-15	2.98	66.7	38	K-14	3.24	73.1

Note:[1]oak stand in the following groves: KD – Korovinskaya Dacha; GF – Grafovsky Forest; KchD – Korochanskaya Dacha; ShD – Shebekinskaya Dacha; O – Ogurtsovo; SW – solid wood; D – Dubovoye; UW – Underwood; *year of survey: 13 – 2013; 11 – 2011; 15 – 2015; 12 – 2012;10 – 2010; 14 – 2014; AG – Arkhiyereyskaya Grove; AR – Armyachiy Ravine; PZ – Popova Zashchita, MSh – Mukhanovo-Shelenkovo; R – Rog; K – Kondaurovka; CF – City Forest; DB – Dolzhik-Bessonovsky; 10 – 2010; 11 – 2011; 13 – 2013; 12 – 2012; 14 – 2014, 15 – 2015.

($\mathbf{D_{Fh}}$)$\overline{D}Fh$: VC_{1-6} ($\mathbf{D_{Fh}}$) $\overline{D}Fh$):Y=0.0084X+2.0592; $\mathbf{D_{Fh}}$ (VC_{1-6}): $\overline{D}Fh$(KC_{1-6}):$\overline{D}Fh$(KC_{1-6}):Y=32.9183X−34.5219. Thus, these patterns enable us to assess each of the above values based on the changes in the other one.

Specific structure of xylotrophic PPF living on oaks. Species which participate in xylotrophic PPF communities include viable ones (those which generate new conks or new hymenial layers) on old abiogenic substrate, that is, species displaying evident saprotrophic properties. We have determined that elementary xylotrophic PPF communities living on oaks in upland and ravine groves of the region under study are basically represented by three pathogenic polypore fungi which display pronounced saprotrophic properties: *F. hepatica*, *L. sulphureus* and *D. quercina*. Besides, *F. fomentarius* has been found on abiogenic substrate in *ravine* groves.

Three types of elementary xylotrophic PPF have been revealed on oaks in oak grove biocenoses. The first one is the typical xylotrophic PPF community living on ravine oak stands which are in a better sanitary condition, with a pronounced sub-dominance of *F.hepatica* and given a higher dominance status of *L. sulphureus* and sub-dominance of *D. quercina.* The second type is the typical xylotrophic PPF community living on ravine oak stands which are in a worse sanitary condition, with a pronounced dominance of *F.hepatica* and given a pronounced sub-dominance or secondary role of *L. sulphureus* and sub-dominance of *D. quercina.* The third one is typical xylotrophic PPF community living on oaks in upland oak stands irrespective of their sanitary condition, with *F. hepatica* prevailing and *L. sulphureus и D. quercina* being co-dominant and subdominant ones.

CONCLUSION

Thus, we have found that characteristic combination of dendro-trophic PPF species living on oaks in upland and ravine oak groves of the region under study is represented by three types of oak-dependent polypore fungi, namely, *F. hepatica*, *L. sulphureus* and *F. robusta*. These species are constant ones in the community composition, displaying the highest dominance in terms of population, with 44.9%, 28.8% and 20.4%, respectively, for upland groves and 45.0%, 26.3%, 20.5%, respectively, for ravine groves.

F. hepatica is an indicator species which characterizes oak stand viability condition: the higher the dominance of a species, the poorer is oak stand condition. In order to assess each of the above parameters based on the changes in the correlating one, we have developed the following regression patterns: ($\mathbf{D_{Fh}}$)$\overline{D}Fh$: VC_{1-6} ($\mathbf{D_{Fh}}$): $\overline{D}Fh$):$\overline{D}Fh$):Y=0.0084X+2.0592; $\mathbf{D_{Fh}}\overline{D}Fh$($KC_{1-6}$):$\overline{D}Fh$($KC_{1-6}$): ($VC_{1-6}$): Y=32.9183X−34.5219. They are based on the proven positive correlational inter-dependency revealed during the study. We suggest using them to reflect the inter-dependence between the value of weight-average viability category for oak stand (VC_{1-6}) and *F. hepatica* dominance index for PPF communities living on oaks.

Dominant species in the xylotrophic PPF communities living in groves, on oaks which are in various health condition, are represented by *F. hepatica* *L. sulphureus* and *D. quercina.*

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