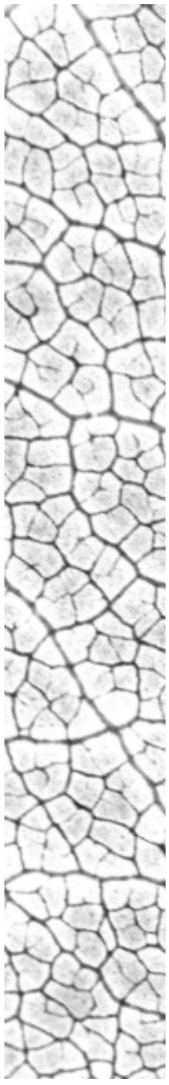

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New trophic classification of wood-destroying fungi the case of community of pathogenic polypore fungi types on Pedunculate oak

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Abstract
Studies were conducted in the seasons 2011-2018. The object of research was the types of common pathogenic Polyporaceae s. l. on the English oak Quercus robur L. in the oak forests of the south-west of the Central Russian Upland (in the administrative boundaries of the Belgorod Region of the Russian Federation). The main subject of research was the trophic specialization of certain types of pathogenic polypore fungi (PPF) on Pedunculate oak. In the process of research, practical methods of direct mycocenologic observation, numerical methods of variation statistics and the method of analogies were used. Based on the generalization of experimental data obtained during the practical study of the trophic specialization of wood-destroying fungi from the commonness of PTH on oak in the oak forests of the south-west of the Central Russian Upland, a new ecotrophic classification has been developed, including the following groups of wood-destroying fungi: biotrophic pathogens, saprotrophic pathogens, pathogenic saprotrophs, non-pathogenic saprotrophs.

Keywords: trophic classification, community of pathogenic polypore fungi (PPF) on Pedunculate oak, biotrophic pathogen, saprotrophic pathogen, pathogenic saprotroph, index biotrophicity

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INTRODUCTION

The ideas and concepts of “parasite”, “pathogen”, “biotroph” begin different ecotoropic series, but their antipodes largely converge in one focus i.e. in the concept and representation of “saprotroph” that is, not a parasite, not a pathogen, not a biotroph. When approaching this focus, it is difficult to determine the essence of the trophic specialization of wood-destroying fungi, without involving at least two of the three definitions indicated.

Traditionally, relating to trophic, wood-destroying fungi (Bondartseva 1983) have been subdivided into parasites (obligate and facultative) and saprotrophs (obligate and facultative). But the concept of “parasite” in the ecology of fungi has recently been abandoned (Yezhov et al. 2011, Zmitrovich et al. 2012), since the concept of “parasite” reflects the way of life as a whole rather than the trophic characteristic of a species. Taking into account, moreover, the fact that among wood-destroying fungi there are no pure biotrophs (Bondartseva 1983), instead of the outdated traditional classification, the following is proposed: xylotrophs (i.e., the same saprotrophs); obligate pathogenic saprotrophs (species confined to living trees); optional pathogenic saprotrophs (species that begin their development on living trees and continue to grow on fresh deadwood and stumps).

However, such a classification seems to be rather “broad” with respect to polyporous wood-destroying fungi in forest-steppe oak forests. For example, *Laetiporus sulphureus* and *Ganoderma applanatum*, attributed to optional pathogenic saprotrophs, can in no way belong to the same trophic group, since the first species is much more common on the living substrate, and the second is the actual saprotroph. Likewise, *Laetiporus sulphureus* and *Daedalea quercina* on oak must be attributed to the same optional pathogenic saprotrophs, whereas the first species is common on the living substrate, for the second it is an exception to the rule. In connection with the above arguments, the goal was formulated - to develop an ecotrophic classification for wood-destroying fungi using the example of types of a community of pathogenic polypore fungi (PPF) on a pedunculate oak.

The tasks were set as follows. 1. To propose for consideration a two-dimensional construction of the

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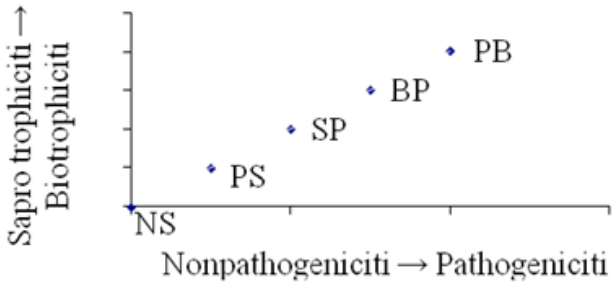

Fig. 1. Diagram of the distribution of ecotrophic groups of fungal organisms in the field of the corresponding coordinates: PB - pathogenic biotrophs; BP - biotrophic pathogens, SP - saprotrophic pathogens, PS - pathogenic saprotrophs, NS - non-pathogenic saprotrophs

trophic specialization scale involving the pathogenicity factor. 2. To study the trophic specialization of common types of PPF on oak. 3. To substantiate the belonging of PPF species on an oak to one or another trophic group using numerical methods and the method of analogies.

MATERIALS AND METHODS

Studies were conducted in the seasons 2011-2018. The object of research was the types of community of PPF on pedunculate oak in the oak forests of the south-west of the Central Russian Upland (in the administrative boundaries of the Belgorod Region of the Russian Federation). The main subject of research was the trophic specialization of certain types of PPF on oak. In the process of research, practical methods of direct mycocenological observation (Dighton et al. 2005, Hawksworth and Mueller 2005, Mueller et al. 2004, Ottosson 2013), numerical methods of variation statistics (Lakin 1990), and the analogy method (Ushakov 2005) were used.

RESULTS AND DISCUSSION

The PPF communities on oak in the oak forests of the south-west of the Central Russian Upland consists of the following types of wood-destroying fungi: *Fistulina hepatica*, *Laetiporus sulphureus*, *Fomitiporia robusta*, *Inocutis dryophila*, *Pseudoinonotus dryadeus*, *Daedalea quercina*, *Hapalopilus croceus*, *Grifola frondosa*, *Fomes fomentarius*, *Polyporus squamosus*.

Taking into account the occurrence of fungi species, including PPF on oak, on living and / or on inert substrates and in view of the partial overlap of such concepts as parasite, biotroph, pathogen, it was proposed to consider a two-dimensional construction of the trophic specialization scale - biotrophic “and” non-pathogenic - pathogenicity “(**Fig. 1**) (Dunaev 2017). The distribution of species of fungi in a given coordinate system makes it possible to distinguish the following ecotrophic groups.

Pathogenic biotrophs (PB) (see **Fig. 1**), that is, true parasites that live at the expense of the owner and die with it (for example, pathogens of powdery mildew or leaf rust). Biotrophic pathogens (BP) are species exhibiting pronounced pathogenic and biotrophic properties. Saprotrophic pathogens (SP) are species that exhibit pronounced pathogenic properties that live on a living and inert substrate. Pathogenic saprotrophs (PS) are species that exhibit pronounced saprotrophic properties, but which in some cases can act as pathogens. Non-pathogenic saprotrophs (NS) are species that exhibit exclusively saprotrophic properties and are not marked as pathogens.

The group of pathogenic biotrophs, as well as the group of non-pathogenic saprothrophes, are not part of the species participating in PPF communities on oak.

Thus, the species considered in the composition of PPF communities on oak in the oak forests of the region can be represented by three trophic groups, including pathogenic species: a group of biotrophic pathogens, a group of saprotrophic pathogens, a group of pathogenic saprotrophs. Belonging to one or another of these groups can be quite clearly defined for the most common types of participants of PTG communities on an oak, in respect of which the manifestation of the manifestation of certain properties can be statistically substantiated. These characteristic species serve as certain standards in their trophic groups, focusing on the proximity or remoteness to which the trophic affiliation of other, less common species, whose judgment on trophic specialization is difficult due to the lack of accounting material for statistical justification, can be determined. The characteristic species naturally appear: *F. robusta, F. hepatica, L. sulphureus, D. quercina*. The first type is common on a living substrate, the other two - on the living and inert, the fourth - on the inert substrate.

For the statistical substantiation of the characteristic species belonging to a particular trophic group, the data on the prevalence of species on living and inert substrates (by the presence of lively fruiting bodies) and biotrophism index (biotrophism) (B), constructed as a ratio of prevalence on vegetative trees (numerator) to the sum of the prevalence values on the living and inert substrate (Dunaev 2017):

$$\boldsymbol{B} = \frac{p_b}{(p_b + p_s)} \times 100\%, p_b = n_b/N_b\,, p_s = n_s/N_s$$

where p_b – s the occurrence of a species as a biotroph (prevalence on vegetative and freshly dried oak trees): n_b – is the number of finds of representatives of the species on a living and freshly dried substrate; N_b – is the number of recorded vegetative and freshly dried oak trees; p_s – occurrence of the species as saprotrophy (prevalence on the old inert substrate — dry deadbelt, oak stumps): n_s – number of finds of representatives of the species in the inert substrate; N_s – is the number of counted inert substrate units.

Table 1. Some statistical characteristics of the series of values * of biotrophicity (B) of typical species in the composition of PPF communities on oak

The most common types of PPF communities on oak	*F. hepatica*	*L. sulphureus*	*F. robusta*	*D. quercina*
Average values of biotrophic index $\bar{B} \pm S\bar{B}$, %	36.7±2.93	37.7±3.40	100.0±0.00	4.4±2.98
Limits of variation /B_{min} – B_{max}/	11.1-60.7	10.0-74.1	-	0.0-35.3
The frequency of occurrence of variants with values B≥50.0, %	20.0	22.7	100.0	0.0

Note: * Into the series of values of the biotrophy of species of *F. hepatica, L. sulphureus, D. quercina*, the variants with values of B = 100.0% were not included, since these are, as a rule, stands with a single occurrence of these species

The judgment of the characteristic species belonging to a different trophic group is based on the analysis of statistics (**Table 1**) of the biotrophic B value series of the most common and characteristic PPF species on oak, calculated for the surveyed tree stands in the region oak forests. Based on the cited results of statistical analysis (see **Table 1**), it is possible, first of all, to oppose in trophic terms the types of *F. robusta* and *D. quercina*. *F. robusta* exhibits an extreme degree of biotrophism in the group of polte fungi (= 100.0%; the frequency of occurrence of the variant with B≥50.0 is equal to 100.0%). It is not in the full sense of biotrophs, as it is able to develop for a while on a fresh deadwood and windbreak, but in any case it acts as a pathogen.

D. quercina exhibits an extreme degree of saprotrophism ($\bar{B}$=4.4%; the frequency with which the variant with B≥50.0 is 0.0%), is not a real saprotroph. *F. robusta,* therefore, acts as a characteristic (reference) species - a representative of the trophic group of biotrophic pathogens (BP). *D. quercina,* therefore, acts as a characteristic (reference) species - a representative of the trophic group of pathogenic saprotrophs (PS). Similarly, on the basis of the statistics cited (see Table 1), two types of *F. hepatica* and *L. sulphureus* can be compared and countered with *F. robusta* on the one hand, and *D. quercina* on the other. *F. hepatica* and *L. sulphureus* are similar to each other (see **Table 1**): they are neither explicit saprotrophs nor explicit biotrophs, but are always present in the consortium of oak as pathogens on living trees. These are characteristic representatives of the trophic group of saprotrophic pathogens (SP)

The remaining types of PPF communities on an oak relating to trophic specialization can be assessed by the degree of their proximity to characteristic species representing all three trophic types (trophocene elements) of pathogenic wood-destroying fungi. Along with *F. robusta*, 4 more species should be attributed to biotrophic pathogens: *I. dryophila, P. dryadeus, H. croceus, G. frondoza*. The group of saprotrophic pathogens, which settle and develop on living oak trees and continue their long-term development on already inert wood (dead wood, stumps, front trees, felled logs, windbreak and windfall), should be attributed, besides *F. hepatica* and L. *sulphureus*, also 2 species: *P. squamosus, F. fomentarius*. The group of pathogenic saprotrophs, that is, species that usually develop on an inert substrate, but in some cases populate living oak trees, should be attributed to *D. quercina*.

CONCLUSION

Based on the generalization of experimental data obtained during the practical study of the trophic specialization of wood-destroying fungi from PPF communities on pedunculate oak in the oak forests of the south-west of the Central Russian Upland, a new ecotrophic classification has been developed, including the following groups of destructive fungi. Biotrophic pathogens are species exhibiting pronounced pathogenic and biotrophic properties. Saprotrophic pathogens are species that exhibit pronounced pathogenic properties that live on a living and inert substrate. Pathogenic saprotrophs are species that exhibit pronounced saprotrophic properties, but which in some cases can act as pathogens. Non-pathogenic saprotrophs are species that exhibit exclusively saprotrophic properties and are not marked as pathogens.

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