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Trans-species relation in communities of pathogenic *Polyporaceae* on pedunculate oak *Quercus robur L.*

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Abstract

Studies were conducted in the seasons 2011-2018. The object of the research was the communities of pathogenic polypore fungi (PPF) on Pedunculate oak in the oak forests of the south-west of the Central Russian Upland (in the administrative boundaries of Belgorod Region of the Russian Federation). The subject of research was trans-species relation in PPF communities on Pedunculate oak. The aim of the work was to identify and describe trans-species relation in PPF communities on oak. Tasks were set as follows. 1. Identify the species composition of the PPF communities on oak associated with the upland and small oak forest in steppe ravines of the study region. 2. Assess the prevalence of individual species in PPF communities. 3. Investigate trans-species relation in PPF communities. In the process of research phytopathological and mycocenological methods were used As a result of the research, real trans-species relation were revealed in the most common and frequently occurring types of PPF on oak within various communities: Mutually positive type relationships based on the proto-operation were found between Laetiporus sulphureus and Fistulina hepatica. Neutral type relationships were found in between Fistulina hepatica and Fomitiporia robusta, Laetiporus sulphureus and Fomitiporia robusta.

Keywords: pathogenic polypore fungi (PPF), Pedunculate oak, community, trans-species relation, coefficient of ecological similarity (CES)

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INTRODUCTION

The commonality of pathogenic polypore fungi Polyporaceae are trophotopically associated with pedunculate oak Quercus robur L. i.e. the main forest formers in the forest-steppe. In the coenotic respect, these communities were not distinguished and not studied, and in fact it is their representatives that together are a permanent endogenous factor in the development and formation of forest-steppe oak ecosystems, which are essential for maintaining a stable natural environment in forest-steppe regions. If a community is understood as "a group of species found together in a limited space and time" (Fukami 2010, Morin 2011, Ottosson 2013), then the community of pathogenic polypore fungi (PPF) on pedunculate oak in oak forest steppes should be considered as specific fungal community (Dunaev 2017). This paper is devoted to the study of trans-species relation in PPF communities on oak. The aim of the work was to identify and describe trans-species relation in PPF communities on oak. Tasks were set as follows. 1. To identify the species composition of the PPF communities on oak associated with the upland and small oak forest in steppe ravines of the study region. 2. Assess the prevalence of individual species in PPF communities. 3. Investigate trans-species relation in PPF communities.

MATERIALS AND METHODS

Studies were conducted in the seasons 2011-2018. The object of research was the PPF communities on oak in the oak forests of the south-west of the Central Russian Upland (within the administrative boundaries of the Belgorod Region of the Russian Federation). The subject of research was trans-species relation in PTH communities on oak. In the process of research, phytopathological and mycocenological methods were used (Dunaev 2017, Dunayev et al. 2014).

RESULTS AND DISCUSSION

As a result of field surveys, both detailed and reconnaissance, it was found that the following species participating in PPF communities on oak are found in oak stands of oak forests in the region on the oak

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Table 1. Comparison and assessment of the similarity of PPF species preferences on oak on five dimensions of niche space

	Fh	***Ls***	***Fr***	***Id***	***Pd***	***Dq***	***Hc***	***Ps***	***Ff***	***Gf***
Fh	+++++	+++0+	+0+0-	+0+--	+0+0-	+0+0+	+0+0-	0++0-	0+00-	+000-
Ls		+++++	+++0-	+0+--	+0+--	+0+0+	+0+0-	0++0-	0+00-	+00--
Fr			+++++	+++0+	+++-+	+-+0-	+++0+	00+0+	0000+	++0-+
Id				+++++	+++-+	+-+--	+++-+	00+-+	000-+	++0-+
Pd					+++++	+-+0-	+++-+	00+0+	000-+	++0++
Dq						+++++	+-+0-	00+0-	0000-	+-0--
Hc							+++++	00+0+	0000+	++0-+
Ps								+++++	0000+	000-+
Ff									+++++	00--+
Gf										+++++

Note: Fh – F. hepatica; *Ls – L. sulphureus*; *Fr – F. robusta*; *Id – I. dryophila*; *Pd – P. dryadeus*; *Dq – D. quercina*; *Hc – H. croceus*; *Ps – P. squmosus*; *Ff – F. fomentarius*; *Gf – G. frondosa:* «+» – preferences match, "0" - partially match, "-" - do not match

substrate: *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.

The names of the species of Polyporaceae are given in accordance with the modern nomenclature of basidiomycetes (Index fungorum 2018). As a rule, not all the representatives of this list are part of a particular PPF community at the elementary level, more often they are found no more than 3-5. Under the PPF community of the elementary level, we mean the commonality of pathogenic rubus fungi within the boundaries of an individual oak forest phytocenosis (Dunaev 2017). Further, trans-species relations are considered in the elementary PPF communities on oak.

It is known that any biotic community is distinguished by the presence of internal relations (interactions, connections), which are represented as mutual influences of populations (and individual representatives) of species on each other (Pianka 1981). These relationships can carry elements of antagonism either - symbiosis (Pianka 1981). Each PPF community on an oak tree is a horizontal community that can be described as a system of interacting, differentiated by ecological niches, competing with each other species, evolving in the direction of differentiation of ecological niches (Whittaker 1969, 1980). The horizontal community is also considered as an ecological open system [9], defined by the relations of competition, independence, community, amensalism between organisms of different types, ensuring their sustainable coexistence on a certain space-time interval. Some of the above, typical of horizontal communities of iconic typical relationships, primarily antagonistic, have been identified in the communities of wood-destroying fungi (Medvedev 2005, Penzina 2003). However, for the PPF communities on the oak, such relationships are not studied at all.

A procedure for measuring niches (Pianka 1981) allows one to assess the existence of certain trans-species relations in species communities, i.e., isolating and grading important directions for changing the overall habitat of communities and comparing the areas of existence of individual species in this environment. The regularities (dimensions) of niches of PPF species on oak are: the type of substrate, the dimension of substrate, the feature of substrate, the place of localization in the body of the phorophyte-substrate, the type of rot caused. Based on these measurements and, based on the knowledge of the preferences of each type of PPF on oak, it is possible to compare each species with each for each dimension. Preferences according to the type of substrate take into account the number and systematic affiliation of Phorophytes-substrates. Substrate-type preferences take into account the state of the substrate (live or dead). The preferences for the dimension of the substrate take into account the size (diameter) of the substrate. Local preferences in the body of the phorophyte-substrate take into account the location inside (mycelium) and outside (fruit bodies) of the phorophyte. The preferences of the type of called rot take into account which component of the phorophyte lignocellulosic complex is primarily used for nutrition.

Comparison and assessment of similarity of PPF species preferences on oak among themselves for each measurement was carried out according to the following quality scale: "+" - preferences are the same, "0" - partially match, "-" - do not match. The values of preference similarity estimates between species of PPF on oak obtained from the primary data on the environmental characteristics of each species in the assessment process on the specified quality scale are shown in **Table 1** (estimated values of similarity are given for each pair of species in the above-considered sequence of preferences).

Using these derived assessment values, we calculated the values of the indicator adopted in this work — the coefficient of ecological similarity (CES)— for each matching pair of PPF species on oak. For each such CES pair, there is a ratio of the sum of estimates of the similarity of individual preferences to the total number of preferences considered.

For example, for the *Fh-Ls* pair (see **Table 1**), the set of preference similarity estimates is as follows: +1 +1 +1

Table 2. The coefficients of environmental similarity of PPF types on oak

	Fh	Ls	Fr	Id	Pd	Dq	Hc	Ps	Ff	Gf
Fh	1.0	0.8	0.2	0.0	0.2	0.6	0.2	0.2	0.0	0.0
Ls		1.0	0.4	0.0	0.0	0.6	0.2	0.2	0.0	0.2
Fr			1.0	0.8	0.6	0.0	0.8	0.4	0.2	0.4
Id				1.0	0.6	-0.2	0.6	0.2	0.0	0.4
Pd					1.0	0.0	0.6	0.4	0.0	0.8
Dq						1.0	0.0	0.0	-0.2	-0.4
Hc							1.0	0.4	0.2	0.2
Ps								1.0	0.2	0.0
Ff									1.0	-0.2
Gf										1.0

Note: [yellow box] – common species (prevalence 2-10% or more), [cyan box] – rare species (about 1%), [empty box] – rare species (about 0%)

0 +1. Adding the resulting positive points, we get the number 4; attributing it to the total number of preferences in different dimensions, we obtain CES = 4/5 = 0.8, which indicates a rather significant coincidence of environmental requirements in the adopted 5-dimensional space for the existence of PPF species on oak.

All calculated CES values for PPF species on oak are presented in **Table 2**.

Before interpreting the data in **Table 2**, it is necessary to recall the general ideas about the evolution of trans-species relations in horizontal communities of species in order to reduce competition by differentiating ecological niches (Pianka 1981, Whittaker 1980). Differentiation can go in areas such as the development of a new resource and more efficient development of a common resource. In the light of these ideas and, based on the knowledge of the bioecology of PPF species on oak, it is necessary to formulate some initial assumptions that allow interpreting the relationships between species in communities.

- The most common types of PPF on oak were the most evolved towards smoothing of competitive relations, the connections between which, rather close, were maintained for quite a long time.

- The presence of a relatively large total amount of resources between the PPF species on the oak indicates more likely the removal of competitive tension between the species due to the complimentary development of the total amount of resources.

- The presence of a relatively small total amount of resources between species of PPF on oak indicates: a) for common species - the intensity of competitive relations in a small common area of resources; b) for rare species - preferential indifference.

- Between the most common and less common types of PPF on oak in the presence of a large total amount of resources, competitive relations are possible, in the presence of a small total amount of resources - the relationship of mutual restriction.

- In all cases of the presence of a zero and a negative indicator of the total amount of resources, it should be assumed that indifferent (neutral, independent) relations exist between species of PPF on oak.

Guided by the points outlined, the data in **Table 2** were analyzed. As a result of the analysis, it was found that negative, neutral and positive heterotypic reactions could occur between representatives of PPF species on an oak tree. At the species level, such relationships can be characterized as competition, neutralism, and the like of proto-cooperation. The real inter-species relations were revealed in the most common and frequently encountered types of PPF on oak in the composition of societies: Between *L. sulphureus* and *F. hepatica* are mutually positive relations of the type of proto-operation. Between *F. hepatica* and *F. robusta*, *L. sulphureus* and *F. robusta* there is neutralism. The possibility of the real existence of mutually negative (competitive) and neutral relations between the less common and widespread types of PPF on oak has been established. Between *I. dryophila* and *F. robusta*, *D. quercina* and *F. hepatica*, *D. quercina* and *L. sulphureus* there is competition. Neutralism can be seen between *P. dryadeus* and *F. hepatica*. The types of possible relationships between common and rare species, rare and rare species, as well as between rare species are defined. Between the species of pairs *H. croceus* and *F. robusta*, *G. frondoza* and *P. dryadeus* there is competition. Between other species there is neutralism.

CONCLUSION

Based on the research results, the following generalizations can be made. Negative, neutral, and positive heterotypic reactions may occur between representatives of PPF species on an oak tree as part of communities. At the species level, such relationships can be characterized as competition, neutralism, and a kind of proto-cooperation. Given research revealed real trans-species relationships in the most common and frequently occurring types of PPF on oak. Between *L. sulphureus* and *F. hepatica* there are mutually positive relations of the type of proto-operation. Between *F. hepatica* and *F. robusta*, *L. sulphureus* and *F. robusta* there is neutralism. The possibility of the real existence of mutually negative (competitive) and neutral relations between the less common and widespread types of PPF on oak has been established. Between *I. dryophila* and *F. robusta*, *D. quercina* and *F. hepatica*, *D. quercina* and *L. sulphureus* there is competition. Neutralism is between *P. dryadeus* and *F. hepatica*. The types of possible relationships between common and rare species, rare and rare species, as well as between species are defined. Between the species of pairs *H. croceus* and *F. robusta*, *G. frondoza* and *P. dryadeus* there is competition. Between other species there is neutralism.

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