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Fungi associated with the beetles of *Ips typographus* on Norway spruce in Southern Poland

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The mycobiota of the beetles of the phloem-feeding spruce bark beetle, *Ips typographus* was studied. The most important group of fungi were the ophiostomatoid fungi. Among them *O. penicillatum* was very frequent ophiostomatoid species. Other common fungi were *O. ainoae, O. bicolor, O. piceaperdum* and *O. piceae*. The ophiostomatoid fungi were often more frequent in beetles collected in galleries than in the beetles caught with a trap. Generally the ophiostomatoid fungi were more often isolated from the beetles bathed in sterile water for 30 seconds. However *C. polonica*, *O. ainoae*, and *O. minutum* occurred most abundantly in the beetles disinfected in 96% ethyl alcohol for 15 and 30 seconds.

Key words: *Ips typographus*, *Picea abies*, ophiostomatoid fungi

INTRODUCTION

Many phloeophagous bark beetles transport various fungi. The most numerous group are blue-stain fungi belonging to the ascomycete genera *Ceratocystis* and *Ophiostoma* and their anamorphs (Wingfield et al. 1993). Most of these fungi causing discolouration of conifers sapwood are saprotrophes or weakly virulent pathogens, but some species are virulent pathogens, which cause serious tree diseases (Brasier 1991; Harrington 1993).

The Eurasian spruce bark beetle, *Ips typographus* (*Coleoptera*: *Scolytidae*) is one of the important forest pests on various species of spruce. It usually breeds in weakened trees and timber, but when its population increases to high levels, it may also attack healthy trees. *I. typographus* generally overwinters as adult beetles in the forest litter and flies in the spring. After the flight period the beetles search a suitable host and enter through the bark. The female of *I. typographus* deposes the eggs in brood galleries excavated in the phloem. The larvae feed on the bark and the phloem, making characteristic tunnels (Michalski and Mazur 1999; Skuhravý 2002). While constructing galleries in the bark and the phloem, beetles disseminate fungal

spores. Propagules of blue-stain fungi may be disseminated by wind or rain but often they are carried by specific insect vectors (Upadhyay 1981). *I. typographus* has no specialized organs for the transmission of fungal associates. Propagules of these fungi are carried externally in pits on the prononta and elytra and within the digestive system (Furniss et al. 1990; Solheim 1993). In addition, several mite species associated with *I. typographus* in Europe (Moser et al. 1989) and with *I. typographus* f. *japonicus* in Japan (Moser et al. 1997) play a significant role in transmitting ascospores and conidia of these fungi.

The spruce bark beetle *Ips typographus* (L.) is an efficient vector of several ophiostomatoid fungi, including *Ceratocystis polonica*, various *Ophiostoma* species as well as *Leptographium* spp. and *Pesotum* spp. (Siemaszko 1939; Kotýnková-Suchrová 1966; Solheim 1986; Harding 1989; Viiri 1997; Kirisits 2001; Kirschner 2001; Viiri and Lieutier 2004; Jankowiak 2004).

The first record of ophiostomatoid fungi associated with *I. typographus* in Poland was made by Siemaszko (1939). He reported that *Ceratocystis polonica, Ophiostoma penicillatum, O. piceae, O. minutum* and *Graphium pycnocephalum* were associated with *I. typographus* in the Białowieża Forest.

The aim of this work was to determine fungi associated with the beetles of *I. typographus* collected in different parts of Southern Poland. Moreover, this study was designed to examine how methods of beetles disinfectation affect on isolation of fungi associated with *I. typographus*.

MATERIALS AND METHODS

Study areas, beetle collection and fungal isolation

The investigations were conducted in the years 1998–2001 on three study plots located in 80 years old montane stands of *Picea abies* (L.) H. Karst. in the Ustroń Forest District (Hołcyna Forest Range, compartment 90b; 49°43′ N, 18°56′ E; 700-770 m above sea level), the Gorce National Park (Łopuszna Forest Range, compartment 75b; 49°29′ N, 20°08′ E; 790-970 m a. s. l.), and the Krynica Experimental Forest (Kopciowa Forest Range compartment 3d; 49°26′ N, 20°58′ E; 720-750 m a. s. l.). Norway spruce is the dominant tree species in the study areas.

The beetles were collected using two methods. They were caught with a trap or collected from galleries on infested spruce trees. In the first case, the beetles were caught with a trap with commercially prepared IPSLURE® and IPSODOR® during their flight period (1st–30th of May of each year). In the second case, the adult beetles of *I. typographus* were collected from their galleries in the phloem of *Picea abies* trees in July. The galleries were taken from weakened, wind-fallen and wind-broken trees as well as from the trap trees. The weakened trees infested by *Ips typographus* were felled. From parts of the trunk infested by *I. typographus* 6–8 discs (approximately 20 cm thick) and chips (30 cm long) with intact bark were cut. In the laboratory the bark was separated from the wood under sterile conditions and the beetles were taken out of the galleries. In total, the beetles were collected from 77 Norway spruce trees.

Before isolation of the fungi, the beetles were bathed in sterile water for 30 seconds, or disinfected in 96% ethyl alcohol for 15 and 30 seconds. After drying on a

sterile blotting paper the disinfected beetles were crushed on a microscopic slide and using a sterile scalpel were evenly spread over on the surface of medium. In total, the isolations were performed from 1691 adults of *I. typographus*.

All isolations were made on 2% malt extract agar (2% MEA; 20 g malt extract, 20 g agar, 1000 ml distilled water) supplemented with the antibiotic tetracycline (200 mg per 1 liter of culture medium) to inhibit bacterial growth. Pure cultures of the fungi were also grown on 2% MEA. The primary isolation plates were incubated at room temperature in the dark. Colonies of fungi growing from the beetles were compared on the basis of macro- and microscopic characteristics, and pure cultures were derived from representative colonies in order to identify the fungi. Typical cultures of each isolated ophiostomatoid taxon have been deposited in the culture collection of the Laboratory of Department of Forest Pathology, Agricultural University of Cracow, Poland.

Data analysis

The frequency of occurrence of each fungal species was expressed as the percentage of beetles, from which a given species was isolated in relation to the total number of beetles from which isolations were made. Frequencies were computed using the following formula: $F = (NF/NT) \times 100$, were F represents the frequency of occurrence (%) of each fungal species, NF represents the number of beetles from which a particular fungus was isolated and NT is the total number of beetles from which fungal isolation was attempted.

Only the most frequently isolated fungi were subjected to statistical analysis (*C. polonica*, *Ophiostoma ainoae*, *O. bicolor*, *O. piceaperdum*, *O. minutum*, *O. penicillatum* and *O. piceae*). For the major fungal associates, contingency tables with Yates'a correction were used to detect differences between fungal frequencies and applied disinfection methods (Tadeusiewicz et al. 1993; Stanisz 1998). The data were analysed by Statistica® 6,0 software.

RESULTS

Fungal composition

A total of 42 taxa were identified, and 28 species of fungi were distinguished which did not produce spores or, in spite of fructification, could not be identified. The spectrum of fungi consisted mainly of ascomycetes and anamorphic fungi, but a few zygomycetes and basidiomycetes were also isolated. The most important group of fungi were the ophiostomatoid fungi (14 species). Great part of them ophiostomatoid fungi found belonged to genera *Ophiostoma* H. et P. Syd. (8 species), *Graphium* Corda (2 species), *Pesotum* Crame et Schoknecht (2 species), *Ceratocystis* Ellis et Halsted (1 species) and *Leptographium* Lagerberg et Melin (1 species). The most frequent ophiostomatoid species was *O. penicillatum*. Other common fungi were *O. ainoae, O. bicolor, O. piceaperdum* and *O. piceae*. *C. polonica*, *G. fimbriisporum*, *O. flexuosum* and *O. minutum* were generally rare. Species not belonging to the ophiostomatoid fungi were relatively rare. In this group, one ascomycete *Petriella sordia* as well as anamorphic fungi and zygomycetes (*Trichoderma* sp., *Candida* sp., *Phoma*

sp., *Cytospora* sp. and *Mucor* sp.) were most abundant. Among basidiomycetes *Gloeocystidium ipidophilum* was most commonly isolated (Tab. 1).

The ophiostomatoid fungi were often more frequently found on the beetles collected from galleries than on the beetles caught in the traps. Among these, *O. piceaperdum* occurred only more frequently in the beetles caught with a trap. In contrast to the ophiostomatoid fungi, other species were frequently isolated from the beetles caught in the traps (Tab. 1).

Table 1

Fungi isolated from the beetles of *Ips typographus* collected from galleries (BG) and from traps (BT)

Fungi	Frequencies of occurrence (%)	
	BG	BT
Ophiostomatoid fungi		
Ceratocystis polonica (Siem.) C. Moreau	13.2	2,0
Ophiostoma ainoae Solheim	35.2	23.3
Ophiostoma bicolor Davids. et Wells	32.8	16.2
Ophiostoma cucullatum Solheim	3.5	0.3
Ophiostoma flexuosum Solheim	7.3	2.2
Ophiostoma minutum Siem.	4.7	2.3
Ophiostoma penicillatum (Grosm.) Siem.	58.5	34.3
Ophiostoma piceae sensu lato	23.3	12
Ophiostoma piceaperdum (Rumb.) von Arx	12.5	17
Graphium fimbriisporum (Morelet) Jacobs, Kirisits et Wingf.	6.7	4.7
Graphium pycnocephalum Grosm.	0.1	
Leptographium euphyes Jacobs et Wingf.	0.1	0.9
Pesotum sp. 1	3.9	1.8
Pesotum sp. 2	0.2	0.4
Other		
Acremonium sp.	0.8	2.2
Alternaria alternata (Fr.) Keissl.	0.1	
Candida sp.	7	16.7
Cerocorticium cf. *notabile* (Jacks.) Jülich et Stalp.	1.4	0.5
Cladosporium cladosporioides (Fresen.) de Vries		0.2
Cylindrocarpon sp.		3.4
Cytospora sp.		1.3
Discomycetes sp.1		0.4
Drechslera poae (Baudys) Schoemaker		0.5
Epicoccum nigrum Link		0.6
Fusarium sp.		0.2
Gliocladium sp.		0.8
Gloeocystidium ipidophilum Siem.	2.3	
Hormonema sp.		2.2
Monodictys castaneae (Wallr.) Hughes	0.1	
Mortierella isabellina Oudem.	0.1	1
Mucor mucedo Mich. et St.-Am.		0.4

Tab. 1 cont.

Mucor sp.	7.9	17.4
Petriella sordida (Zukal) Barron et Gilman	2.2	0.9
Pezizella sp.		0.1
Phoma sp.		3.7
Raffaelea sp.		0.1
Rhinocladiella atrovirens Nannf.		0.3
Sclerotium sp.	0.1	0.3
Sordaria fimicola (Rob.) Ces. et de Not.		0.1
Stachybotrys atra Corda		1.5
Trichoderma sp.	5.2	10
Ulocladium sp.		0.9
Unidentified:		
Basidiomycota (6 species)		0.8
Others (22 species)	0.8	1.8
Number of investigated beetles	789	902
Number of "sterile" beetles	9	66

The composition of the mycobiota was quantitatively different at various study plots. The pathogenic species *Ceratocystis polonica* occurred most frequently on the *I. typographus* beetles from Łopuszna, where it was isolated in 2.7% to 24.5% of the cases. In contrast, it was sporadically isolated from the beetles collected in Hołcyna.

Table 2

Frequency (%) of ophiostomatoid fungi isolated from the beetles of *I. typographus* on three study plots (Ł – Łopuszna, H – Hołcyna, K – Kopciowa)

Fungi	Isolated from					
	BG*			BT*		
	Ł	H	K	Ł	H	K
Ceratocystis polonica	24.5	3	8.2	2.7	2.3	1
Ophiostoma ainoae	26.6	30.3	56.4	15.6	20.9	33
Ophiostoma bicolor	20.2	54.3	24.6	14.9	21.9	11.8
Ophiostoma cucullatum	1.2	7.1	2.6	0	0.3	0.6
Ophiostoma flexuosum	2.7	0.7	24.1	1	1	4.6
Ophiostoma minutum	2.1	3.7	10.3	1.7	1.3	3.9
Ophiostoma penicillatum	60.9	53.9	61	34.9	32.6	35.3
Ophiostoma piceae sensu lato	12.5	30	32.3	13.2	8.3	14.4
Ophiostoma piceaperdum	8.9	10.9	21	10.8	13	26.8
Graphium fimbriisporum	0.6	6	17.9	3	2.6	8.2
Graphium pycnocephalum	0	0	0.4	0	0	0
Leptographium euphyes	0	0	0.4	0	2	0.6
Pesotum sp. *1*	4.6	3.7	3.1	1.4	0	3.9
Pesotum sp. *2*	0.3	0	0.4	1.4	0	0
Number of investigated the beetles	327	267	195	295	301	306

Explanations: *BG beetles from galleries; BT* beetles from traps

O. penicillatum was most common in all plots except one (in Hołcyna), where *O. bicolor* was the most abundant species on the beetles collected from the galleries. Among the study plots, *O. ainoae*, *O. flexuosum*, *O. minutum*, *O. piceae O. piceaperdum* and *G. fimbriisporum* occurred most frequently in the beetles of *I. typographus* in Kopciowa (Tab. 2).

Comparison of frequencies of ophiostomatoid fungi with different disinfectation methods of the beetles of *I. typographus*

The methods of beetles disinfectation had relatively strong influence on the result of fungi isolation. More significant differences were found when fungi were isolated from the beetles collected from the galleries of *I. typographus* than the beetles caught with a trap. Generally the ophiostomatoid fungi were more often isolated from the beetles bathed in sterile water for 30 seconds. However *C. polonica*, *O. ainoae*, and *O. minutum* occurred most abundantly in the beetles disinfected in 96% ethyl alcohol for 15 and 30 seconds (Tab. 3).

In the case of the beetles collected from galleries of *I. typographus*, *O. penicillatum* (67.7%), *O. piceae* (40.3%), *O. bicolor* (40,3%) and *O. ainoae* (33.8%) were most frequently isolated from the beetles, which were bathed in sterile water for 30 seconds. The beetles disinfected in 96% ethyl alcohol for 15 seconds were most frequently colonized by *O. penicillatum* (57.5%), *O. ainoae* (39.3%), *O. bicolor* (31.9%) and *O. piceae* (17.5%). *O. penicillatum* (54.0%), *O. ainoae* (32.3%), *O. bicolor* (26.2%) and *C. polonica* (20.4%) occurred most frequently in the beetles disinfected in 96% ethyl alcohol for 30 seconds (Tab. 3). Among the ophiostomatoid fungi tested, the frequencies of *O. ainoae* i *O. piceaperdum* were least affected by the different methods of beetles disinfectation (the differences were not significant). For other ophiostomatoid fungi the most significant differences were between the beetles bathed in

Table 3

The most abundant species in the assemblages of ophiostomatoid fungi isolated from the beetles depending on methods of beetles disinfection, and statistical evaluation of differences in their frequency (based on chi-square test)

	Percentage in quantitative structure of a assemblage					
Fungi	beetles from galleries			beetles from traps		
	I	II	III	I	II	III
Ceratocystis polonica	3.42^{ac}	15.59^{a}	20.45^{c}	0.63^{a}	4.33^{ab}	1.29^{b}
Ophiostoma ainoae	33.84	39.34	32.32	20.57	22.74	26.54
Ophiostoma bicolor	40.30^{ac}	31.94^{a}	26.24^{c}	10.44^{ac}	16.61^{a}	21.68^{c}
Ophiostoma minutum	4.94	6.46^{b}	2.66^{b}	1.58	1.81	3.56
Ophiostoma penicillatum	67.68^{ac}	57.49^{a}	53.99^{c}	35.44	30.69	36.25
Ophiostoma piceae	40.30^{ac}	17.49^{a}	12.17^{c}	12.66	10.47	12.62
Ophiostoma piceaperdum	15.58	11.03	10.98	23.42^{ac}	10.83^{a}	15.86^{c}

Explanations: ^{a} differences between disinfectation I and II significant at 0.05 level; ^{b} differences between disinfectation II and III significant at 0.05 level; ^{c} differences between disinfectation I and III significant at 0.05 level; I - beetles bathed in sterile water for 30 sec; II - beetles disinfected in 96% ethyl alcohol for 15 sec; III - beetles disinfected in 96% ethyl alcohol for 30 sec.

sterile water for 30 seconds, and the beetles disinfected in 96% ethyl alcohol for 15 and 30 seconds (Tab. 3).

In the case of the beetles of *I. typographus* caught with a trap, *O. penicillatum* (35.4%), *O. piceaperdum* (23.4%), *O. ainoae* (20.6%) and *O. piceae* (12.7%) were most frequently isolated from the beetles bathed in sterile water for 30 seconds. The beetles disinfected in 96% ethyl alcohol for 15 seconds were most frequently colonized by *O. penicillatum* (30.7%), *O. ainoae* (22.7%), *O. bicolor* (16.6%) and *O. piceaperdum* (10.8%). From the beetles disinfected in 96% ethyl alcohol for 30 seconds *O. penicillatum* (36.2%), *O. ainoae* (26.5%), *O. bicolor* (21.7%) and *O. piceaperdum* (15.9%) were most frequently isolated. The frequencies of majority of the ophiostomatoid fungi (*O. ainoae*, *O. minutum*, *O. penicillatum* and *O. piceae*) were least affected by the different methods of disinfectation of the beetles (the differences were not significant).

DISCUSSION

The assemblage of ophiostomatoid fungi as the one recorded in the present study is associated with *I. typographus* also at other parts of its distribution range in Europe (Siemaszko 1939; Mathiesen-Käärik 1953; Kotýnková-Suchrová 1966; Solheim 1986; Harding 1989; Jankowiak 2001; Viiri 1997; Grubelnik 1998; Kirschner 1998; Kirisits 2001, 2004) and in Japan (Yamaoka et al. 1997). Recently Viiri and Lieutier (2004) have studied the mycobiota of *I. typographus* in three areas in France and have recorded the same fungi as those occurring in other parts of Europe. In a comprehensive study Yamaoka et al. (1997) reported 9 ophiostomatoid fungi associated with *I. typographus* f. *japonicus* in Japan and only *O. japonicum* was not found during the present study. All of the fungi reported by Grubelnik (1998) and Kirisits (2001) in Austria were also isolated from *I. typographus* beetles in this study. In the Norwegian study, Solheim (1986) isolated 10 species of ophiostomatoid fungi from discoloured wood of *Picea abies*, and only *O. tetropii* Mathiesen was not found during the present study. This *Ophiostoma* species is mainly associated with cerambycid beetles from genus *Tetropium* Kirby (Mathiesen 1951; Upadhyay 1981; Jacobs et al. 2003a), which commonly infest spruce trees already colonised by *I. typographus* and often initiate their galleries in the vicinity of breeding systems of the spruce bark beetle. In Denmark and Sweden, Harding (1989) reported 16 species of ophiostomatoid fungi, of which *O. cainii* (Olchow. et Reid) Harrington and *L. lundbergii* Lagerb. et Melin were not found during the present study. In Germany, Kirschner (2001) found 12 species of ophiostomatoid fungi. In this group *Ceratocystiopsis alba* (de Vay, Davidson et Moller) Upadhyay, *O. arraucariae* (Butin) de Hoog et Scheffer, *O. japonicum* Yamaoka et Wingf. and *O. obscura* (Davidson) von Arx were not found during the present study. Such a high diversity of ophiostomatoid fungi associated with *I. typographus* between the studies conducted in Germany and in Poland is probably due to the completely different investigatory methods used in both studies. Also in Germany Kirschner and Oberwinkler (1999) found *O. neglectum* Kirschner et Oberwinkler to be associated with *I. typographus*. This species probably remained undetected in the present study because it is mainly transmitted by *Dryocoetes*

autographus (Ratz.) and *Hylurgops palliatius* (Gyll.), which colonise weakened trees or logs and often infest trees in the same time or after *I. typographus*.

Siemaszko (1939) recorded only 5 ophiostomatoid fungi in the previous investigations in North-Eastern Poland. All of the fungi displayed by Siemaszko were also found in this study. In the study on the entomopatogenic fungi Bałazy (1969) reported 2 ophiostomatoid fungi, including *Graphium penicillioides* Corda.

Among the ophiostomatoid fungi, *Leptographium euphyes*, *Graphium fimbriisporum* and *G. pycnocephalum* have rarely been mentioned as associates of *I. typographus*. *Leptographium euphyes* was only reported in association with *I. typographus* by Jankowiak (in press). *Graphium fimbriisporum* was mainly mentioned by Kirisits (1996, 2004), Grubelnik (1998), Jacobs et al. (2003b) in Austria where it was an important associate of *I. typographus* and by Jankowiak in Poland. *G. pycnocephalum* was reported as frequent associate of *I. typographus* in Poland (Siemaszko 1939) and rarely in Germany, Sweden (Kirisits 2004) and former Czechoslovakia (Kotýnková-Suchrová 1966). Among *Ophiostoma* species, *O. flexuosum* has seldom been mentioned as associates of *I. typographus*. It was only found to be associated with *I. typographus* in Germany, Denmark and Sweden (Harding 1989), Norway (Solheim 1986) and Poland (Jankowiak 2001).

Besides *O. piceapardum* all of the ophiostomatoid fungi occurred most abundantly on the beetles collected from the galleries than on the beetles caught with a trap. Since the beetles of *I. typographus* hibernate in the soil, they are easily contaminated with spores of litter and soil fungi like *Mucor* sp. and *Penicillium* sp. These fungi could have had antagonistic influence on the growth of the ophiostomatoid fungi, since they produce volatile and non-volatile organic compounds limiting the growth of the pathogens (Wells and Bell 1979; Kwaśna 1987). Probably the beetles in the trap are stronger contaminated with spores of antagonistic fungi.

Frequency of the fungal associates of the beetles *I. typographus* was considerably different from the results of the previous studies (Siemaszko 1939; Solheim 1986; Harding 1989; Viiri 1997; Kirschner 2001; Kirisits 2004). A similar spectrum of ophiostomatoid fungi as that recorded on the beetles in this study was found also on larvae and in galleries of *I. typographus* by Jankowiak (2001, 2004, in press). In the present study *O. penicillatum* was the most commonly found species, whereas the pathogenic species *C. polonica* was found only infrequently, especially on the beetles caught with a trap. A similar results as that recorded from this study were obtained by Yamoaka et al. (1997) who isolated *O. ainoae*, *O. piceae*, *O. bicolor* and *O. penicillatum* from the beetles of *Ips typographus* f. *japonicus* with a frequency of occurrence greater than 30%. In contrast to this study, Siemaszko (1939) found *C. polonica*, *O. penicillatum* and *Graphium pycnocephalum* to be the most common, and *O. piceae* and *O. minuta* less common associates of *I. typographus*. There were big quantitative differences in the composition of the mycobiota of the beetles *I. typographus* at various localities in this study. The quantitative differences have mainly been documented for the most virulent *C. polonica*, but also for other fungal associates of the spruce bark beetle. *C. polonica* occurred at high frequencies in North-Eastern Poland (Siemaszko 1939), in Norway (Solheim 1993) and at some localities in Austria (Kirisits

2001). In contrast, it was not recorded at all in former Czechoslovakia (Kotýnková-Suchrová 1966) and only rarely in Sweden and Denmark (Harding 1989), Finland (Viiri 1997), Germany (Harding 1989, Kirschner 1998, 2001) and France (Salle et al. 2003). It was also relatively frequently recorded in a recent study conducted in France (Viiri and Lieutier 2004). These results show a big variation in the abundance of blue-stain fungi associated with *I. typographus* at different parts of the distribution range of this insect in Europe. The variation of the mycobiota of *I. typographus* between different localities in Europe was explained by different researchers (Harding 1989; Solheim 1993; Kirisits 2004). Kirisits (2004) accepts that the methodology employed in different studies may often be very important (especially the differences in timing and methods of fungal isolation). Qualitative and quantitative differences in the composition of the mycobiota of *I. typographus* may also be dependent on the population dynamics of *I. typographus* (Solheim 1992a, 1993). Kirisits (2004) suggested that the climate has a strong influence on the frequency of ophiostomatoid fungi. Following this hypothesis, *C. polonica*, which has a relatively low temperature tolerance (maximum around 31-32°C) may be replaced by other fungi such as *O. bicolor* with a higher temperature tolerance (Solheim 1991).

Basidiomycetes have only occasionally been reported as associates of bark beetles (Siemaszko 1939; Whitney et al. 1986; Kirschner 2001; Kirisits 2004). Among the basidiomycetes, *G. ipidophilum* and *Cerocorticium* cf. *notabile* have been identified. These species were relatively rare associates of the beetles *I. typographus* in Southern Poland, but from the present study it is concluded that *I. typographus* acts as a vector of *G. ipidophilum* and *C. notabile*. *G. ipidiophilum* has been reported in Poland (Siemaszko 1939), Germany (Kirschner 1998) and Austria (Grubelnik 1998). The common basidiomycete reported by Solheim (1992b) in Norway represents also *G. ipidiophilum*. The non-ophiostomatoid fungi were frequently carried by the beetles *I. typographus* in this study. These fungi represent wood-colonising fungi (*Rhinocladiella atrovirens*), mycoparasitic and mycophilic fungi (*Gliocladium* sp., *Trichoderma* sp.), phytopathogenic fungi (*Alternaria alternata*, *Pestalotia hartigii*, *Cylindrocarpon* sp., *Fusarium* sp.) and other ecological groups.

The results of this study confirmed that the beetles of *I. typographus* transport spores of fungi laterally on the pronota and elytra as well as in the digestive tract. Generally *C. polonica*, *O. ainoae*, and *O. minutum* occurred most abundantly on the beetles disinfected in 96% ethyl alcohol for 15 and 30 seconds than on the beetles bathed in sterile water for 30 seconds. This difference may be caused by the variation between beetles, presence of the antagonistic fungi on the surface of the pronota and elytra or some other factors.

This study showed, that ophiostomatoid fungi are the most frequent species transmitted by *I. typographus*. These species were found more frequently when fungi were isolated from the beetles collected from the galleries of *I. typographus* than the beetles caught with a trap. The varying frequencies of ophiostomatoid fungi should be linked with strong contamination of the beetles from the traps by conidia of saprotrophic fungi.

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Grzyby towarzyszące chrząszczom *Ips typographus* na świerku pospolitym w południowej Polsce

Streszczenie

Badano grzyby towarzyszące chrząszczom *Ips typographus* w trzech rejonach południowej Polski oraz określono wpływ różnych metod dezynfekcji chrząszczy na wynik izolacji grzybów. Wśród izolatów grzybów wyróżniono ponad 70 gatunków, głównie grzybów workowych i mitosporowych. Do najczęściej związanych z kornikiem drukarzem należały grzyby ofiostomatoidalne: *Ophiostoma penicillatum*, *O. ainoae*, *O. bicolor*, *O. piceaperdum* i *O. piceae*. Gatunki nie należące do grzybów ofiostomatoidalnych były stosunkowo rzadkie. W tej grupie najliczniej reprezentowane były: *Candida* sp., *Cytospora* sp., *Mucor* sp., *Petriella sordia*, *Phoma* sp. i *Trichoderma* sp.

Prawie wszystkie gatunki grzybów ofiostomatoidalnych były częściej izolowane z chrząszczy zebranych z żerowisk kornika drukarza, a inne gatunki grzybów zwiększały częstość występowania w przypadku chrząszczy odławianych do pułapek feromonowych.

Na wynik izolacji grzybów stosunkowy duży wpływ miały metody dezynfekcji chrząszczy, zwłaszcza dla chrząszczy zebranych z żerowisk kornika drukarza. W większości przypadków grzyby ofiostomatoidalne były częściej izolowane z chrząszczy moczonych przez 30 sekund w wodzie sterylnej. Jednak takie gatunki jak *Ceratocystis polonica*, *O. ainoae*, i *O. minutum* stwierdzano częściej na chrząszczach dezynfekowanych przez 15 lub 30 sekund w 96 % alkoholu etylowym.