3.6 Species composition and diversity of fungi on anthropogenic substrata

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INTRODUCTION

Fungi are dominating organisms of soil ecosystems and it is known for a long time, that they form also an integral part of biological soil crusts (Fletcher & Martin 1948). Unfortunately, the fungi in crusts were, as yet, studied only marginally. The most substantial is the survey of fungi associated with biological soil crusts in desert grasslands by States & Christensen (2001) and Grishkan et al. (2006). In semiarid or even arid regions, the biological soil crusts are known for a long time. In some respects, abandoned ore sedimentation basins in our country represent somewhat similar habitats. However, the limiting factor for growth of plants and other organisms on these anthropogenic habitats is not precipitation but the high amount of metal compounds and other associated factors (e.g., low pH and high salinity).

In this chapter, results of two-year study of microfungal communities in surface biological soil crusts or surface layer on four sedimentation basins (Měděnec, Radvanice, Ostrov, Dvůr Králové) compared with an agricultural locality (all in the Czech Republic) are given.

MATERIALS AND METHODS

Localities (see Colour plates, Figs. 3.1.1, 3.1.2) and sampling of surface biological soil crusts or surface layer: Měděnec, abandoned ore sedimentation area (sampling in May 2005 and May 2006), Radvanice, abondoned ore sedimentation basin (July 2005 and June 2006), Ostrov II, active ash-sedimentation basin (June 2005 and June 2006), Dvůr Králové I, active ash-sedimentation basin (July 2005 and June 2006) and pasture near Netluky (November 2005 and August 2006). Characteristics of the studied localities are given in the Chapter 2.1 and 3.1. On the two mentioned abandoned ore sedimentation basins (Měděnec and Radvanice), biological soil crusts were well developed in contrast to active ash-sedimentation basins (Ostrov II and Dvůr Králové I). From each locality, two composed samples of biological soil crust or surface layer (of ca 0.5 cm thickness) were taken into sterile plastic bags. For the mycological analysis the same material of biological soil crusts was used as for study of algae and cyanobacteria. Altogether, 10 samples of biological soil crusts were processed during this study.

Cultivation and identification: Microscopic fungi on biological soil crusts were studied by the same cultivation methods as described in the Chapter 2.4.

Identification of soil micromycetes was made according to the literature cited in Chapter 2.4 and according to Samson & Frisvad (2004). Several fungal strains were deposited at Culture Collection of Fungi (CCF), Department of Botany, Charles University, Prague, Czech Republic (see in Table 3.6.1).

Statistical methods: Detrended Correspondence Analysis (DCA) was performed using Canoco 4.5 (Ter Braak & Šmilauer 1998) to ordinate localities based on their microfungal composition.

RESULTS AND DISCUSSION

In Table 3.6.1, a list of fungi isolated from biological soil crusts or surface layer during 2005–06 on four sedimentation basins comparing with an agricultural locality is given. Altogether 124 taxa (species, forms, and undetermined isolates) of microscopic fungi belonging to at least 50 genera were recorded (for examples see Colour plates, Figs. 3.6.1 a–d).

The majority of the fungi isolated are anamorphs of *Ascomycota* (110 taxa, 89%); fourteen taxa (11%) belong to *Zygomycota*. The most frequent genera were *Penicillium* (15 species), *Phoma* (10 species including undetermined isolates), *Mucor* (8 species including undetermined isolates), and sterile dark mycelia.

The most frequent fungus was *Cladosporium herbarum* dominating on three localities. Other fungi were frequent only on two or one of five localities: *Alternaria alternata*, *Aureobasidium* sp., *Botrytis cinerea*, *Cladosporium cladosporioides*, *Clonostachys rosea* f. *rosea*, *Emericellopsis minima*, *Fusarium* sp., *Geomyces pannorum*, *Mucor* spp., *Phoma* sp., *Trichoderma harzianum*, and *T. virens*. The majority of recorded fungi were isolated only rarely. The major part of the fungi found during this study is known as soil saprotrophs (Domsch et al. 1993). Among them, several are also plant pathogens (*Acremonium*, *Clonostachys*, *Fusarium*, *Phoma*), food-borne fungi (*Eurotium amstelodami*, *Aspergillus terreus*, *Penicillium brevicompactum*, *P. carneum*, *P. crustosum*, *P. echinulatum*, and *P. griseofulvum*), coprophiles (*Mucor*, *Sporormiella*), entomopathogens (*Beauveria bassiana*), opportunistic human pathogens (*Aspergillus fumigatus*), or freshwater hyphomycetes (*Heliscus lugdunensis*).

Table 3.6.1 Microscopic fungi isolated from biological soil crusts or surface layer of four sedimentation basins and one agricultural site in 2005 and 2006.

	Locality, year of sampling									
Microscopic fungi	**ME 2005**	**ME 2006**	**RA 2005**	**RA 2006**	**OS 2005**	**OS 2006**	**DK 2005**	**DK 2006**	**NE 2005**	**NE 2006**
Absidia spinosa									1	
Acremonium strictum				1						
Acremonium spp. (3 spp.)			1		1		1			
Alternaria alternata		1	1		2		1	1		2
Alternaria sp.	1									
Arthrinium arundinis	1		1		1					
Aspergillus fumigatus	1				1					
Aspergillus sydowii					1					
Aspergillus terreus							1	1		
Aureobasidium sp.					2	1				
Beauveria bassiana					1					
Botrytis cinerea					2	1				1
Chaetomium sp.						1				
Cladosporium cladosporioides				1	1				2	
Cladosporium herbarum	2	1	2		1	1	2	1		2
Clonostachys rosea f. *catenulata*				1					1	
Clonostachys rosea f. *rosea*				1					2	
Clonostachys sp.						1				
Emericellopsis minima ***CCF 3729***							2			
Epicoccum nigrum		1						1		1
Eurotium amstelodami					1					
Fusarium avenaceum	1	1								
Fusarium culmorum	1								1	
Fusarium lateritium					1					
Fusarium tricinctum									1	
Fusarium spp. (3)							1		1	2
Geomyces pannorum					1			2		
Heliscus lugdunensis						1				
Mortierella sp.									1	
Mortierella spp. (2)		1								
Mucor hiemalis f. *hiemalis*	1									
Mucor spp. (7)	2	1	1		1		1	1	2	
Paecilomyces sp.					1					
Penicillium brasilianum										1
Penicillium brevicompactum	1				1					
Penicillium carneum ***CCF 3719***						1				
Penicillium chrysogenum										1
Penicillium crustosum					1					
Penicillium echinulatum ***CCF 3718***					1					
Penicillium griseofulvum					1					
Penicillium purpurogenum			1							
Penicillium scabrosum										1
Penicillium smithii					1					
Penicillium spp. (2)					1					
Penicillium spp. (3)		1			1			1		
Phialophora sp. (2)		1			1					
Phoma cf. *eupyrena*		1							1	
Phoma sp. (2)	1									
Phoma sp. (3)		1								
Phoma sp. (2)			1							

	Locality, year of sampling									
Microscopic fungi	**ME 2005**	**ME 2006**	**RA 2005**	**RA 2006**	**OS 2005**	**OS 2006**	**DK 2005**	**DK 2006**	**NE 2005**	**NE 2006**
Phoma sp. (2)					1			1		
Rhinocladiella sp.			1							
Rhizopus arrhizus									1	
Rhizopus microsporus var. *rhizopodiformis*							1			
Sordaria fimicola										1
Sporormiella sp.		1								
Stemphylium sp.					1					
sterile dark mycelia (2)	1									
sterile dark mycelia (3)		1								
sterile dark mycelia (3)			1							
sterile dark mycelia (3)				1			1	1		
sterile dark mycelia (2)					1					
sterile dark mycelia (2)						1				
sterile grey mycelium	1									
sterile light mycelia (2)					1					
Trichoderma harzianum			2	1						
Trichoderma virens			1	2						
Trichoderma viride								1		
Trichoderma spp. (3)	1					1			1	
Truncatella angustata		1								
Ulocladium botrytis										1
Ulocladium sp.	1									
Umbelopsis angularis										1
undetermined arthrosporic fungus						1				
undetermined ascomycetes (2)					1			1		
undetermined basidiomycete				1						
undetermined coelomycete				1						
undetermined dark fungus					1					
undetermined filamentous yeast							1			
undetermined fungi (2)			1		1					
undetermined fungi (3)							1			
undetermined light fungi (3)					1			1		1
undetermined pycnidial fungi (2)		1	1							
undetermined sporodochial fungi (2)	1			1						
No. of taxa:	**17**	**19**	**16**	**10**	**34**	**11**	**13**	**13**	**12**	**12**
Total No. of taxa: 124	**33**		**24**		**42**		**23**		**24**	

Notes: CCF = Culture Collection of Fungi, Prague, CZ; Localities: **OS** = Ostrov, **ME** = Měděnec, **RA** = Radvanice, **DK** = Dvůr Králové, **NE** = Netluky; Occurrence: **1** = rarely isolated species, **2** = frequent species.

The localities differed in species richness (Table 3.6.1). The richest spectrum of fungi was found at the active sedimentation pond at Ostrov, 42 species (including undetermined isolates). On locality Měděnec we discovered 33 species, on Radvanice 24 species, and on Dvůr Králové 23 species. On Netluky (agricultural site) 24 species of fungi were isolated also.

The biological soil crusts on sedimentation basins differed also by fungal spectrum (Table 3.6.1). On the active sedimentation basin, Ostrov, *Alternaria alternata*, *Aureobasidium* sp. and *Botrytis cinerea* dominated. They are typical decomposers of litter. In 2005, many food-borne contaminants were found on this locality (*Eurotium amstelodami*, *Penicillium brevicompactum*, *Penicillium crustosum*, *P. echinulatum*, and *P. griseofulvum*). These r-strategs probably occurred with accidental waste pollution. Freshwater hyphomycete *Heliscus lugdunensis* represents an interesting record on this locality (Fig. 3.6.1a). It was found only once, however this fungus is known to grow also in waters contaminated by heavy metals (Braha et al. 2007). On the other active sedimentation basin, Dvůr Králové, different fungi were frequently isolated: *Cladosporium herbarum*, *Emericellopsis minima* and *Geomyces pannorum*. Whilst *C. herbarum* and *G. pannorum* are typical litter and soil fungi, respec-

tively, *Emericellopsis minima* is a somewhat rare fungus. On the locality Měděnec *Cladosporium herbarum*, *Mucor* sp., *Phoma* sp. and sterile dark mycelia, i.e., typical soil and litter fungi dominated. On the Radvanice locality, we frequently recorded *Cladosporium herbarum*, *Trichoderma harzianum*, *T. virens* and sterile dark mycelium. Among them, *T. virens* and sterile dark mycelia were formerly found as abundant on another abandoned ore-sedimentation basin at Chvaletice (Kubátová et al. 2002). On agricultural locality (pasture Netluky) *Alternaria alternata*, *Cladosporium cladosporioides*, *C. herbarum*, *Clonostachys rosea* f. *rosea*, *Fusarium* sp., and *Mucor* sp. dominated.

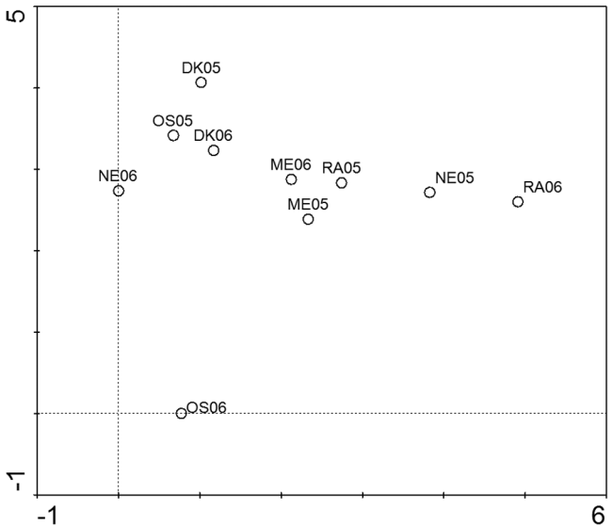

Fig. 3.6.2 Testing the differences in fungal species richness and composition of biological soil crusts on four ore-sedimentation basins and one agricultural site. DCA ordination diagram showing the position of samples in the range of the first two ordination axes (**ME** = Měděnec, **RA** = Radvanice, **OS** = Ostrov, **DK** = Dvůr Králové, **NE** = Netluky, 05 = 2005, 06 = 2006).

The sampling on studied sites was made twice, in 2005 and 2006. Using DCA, we tested changes of species composition during this period (see Fig. 3.6.2). From this ordination diagram great differences are obvious not only among localities but also between the years on the same locality. The localities Měděnec and Dvůr Králové show the smallest differences between the years, while in Netluky the difference is the greatest. It corresponds with less or more different species composition recorded in relevant samples.

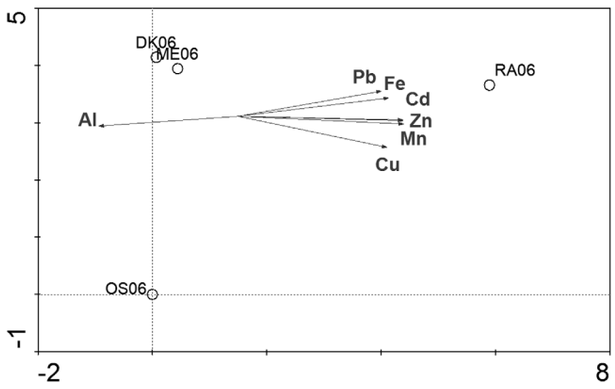

Fig. 3.6.3 Testing the differences in fungal species richness and composition of samples from 2006. DCA ordination diagram showing the position of samples in the range of the first two ordination axes (**ME** = Měděnec, **RA** = Radvanice, **OS** = Ostrov, **DK** = Dvůr Králové).

In 2006, the contents of heavy metals in biological soil crusts were measured on studied ore-sedimentation basins (see Chapter 3.2). The effect of heavy metals content on species composition is demonstrated on DCA ordination diagram (Fig. 3.6.3). The great distance of Radvanice site from other localities could correspond with the high content of different metals on this locality.

CONCLUSIONS

Microfungi isolated from crusts or surface layer of sedimentation basins during the two-year study belong mostly to the known soil and litter fungi similarly to microfungi found on crusts on natural substrata. Only low number of fungal dominants were recorded on the studied localities. The majority of the fungi were isolated only once. Fungal species composition of the biological soil crusts on the localities studied was different probably due the different characteristics of localities. Moreover, the species composition differed on the same locality between the two years studied.