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Present state of research on soil microfungi of the Bohemian Forest (Šumava Mts.)

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Abstract
The state of knowledge of soil microfungal diversity in the Bohemian Forest (Šumava Mts.) is summarized. At present, 152 species, varieties and forms of micromycetes (44 Zygomycetes, 7 Ascomycetes and 101 Deuteromycetes) are known to have been isolated from soils in this region. It is about 25% of all soil microfungi yet known from the Czech and Slovak regions.

Key words: Deuteromycetes, Ascomycetes, Zygomycetes, peat, Norway spruce forest, Czech Republic

Introduction

For a long time, soil micromycetes in the Bohemian Forest (Šumava Mts.) had not got much interest of mycologists. The first research on soil micromycetes from this area was probably done by Dyr (1941). He concerned on zygomycetes only. In 1980, Holubová-Jechová & Jančařík (1980) published a paper on mycoflora of peat and peat substrates. In 1985 and 1990 occasional examinations of soil samples were done by Kubátová (unpubl.). After 1993, an overall interest has increased in mycological investigations of Czech mountains, including the Bohemian Forest, but not from the point of view of soil microfungi. Two major studies were carried out at the Department of Botany, Charles University, Prague: "Biodiversity of the natural ecosystems of the Bohemian Forest (reference areas for the UNESCO Biosphere Reserve management)" in 1993–1994 and "Centres of biological diversity in the Šumava Biosphere Reserve" in 1994–1996. Studies on biodiversity of soil microfungi at several localities in the Bohemian Forest were conducted (Kubátová & al. 1998) within these projects. Some interesting records of rare micromycetes were prepared for publication (Kubátová & al., in press). The results of our previous studies were a base for another project started in 1999: "Biodiversity of several groups of non-vascular plants." One of the aims of this study is to study soil microfungal communities of different habitats (forests, peat bogs, glacial cirques) in the Bohemian Forest and the Giant Mts. At the end of the second millennium, investigation into soil microfungi were conducted in other laboratories, too. Nováková & Blažková (2000) focused on the comparison of soil micromycete communities in the forests of Czech mountains, including the Bohemian Forest. Nováková has continued in a detailed study of soil micromycetes in different stages of the damaged Norway spruce forests in the Bohemian Forest.

The main aim of this paper is to summarize our knowledge of soil micromycetes diversity in the Bohemian Forest, including the not yet published previous data and the preliminary results of our current research.

Localities and methods

This part gives for comparison brief data on methods and localities. Table 1 shows data from published papers. For more details see the corresponding papers. Table 2 gives data on our own not yet published investigations.

Results and Discussion

Table 3 gives the summarized list of all yet known species of soil micromycetes from the Bohemian Forest. The list is based on the data published by Dyr (1939, 1941), Holubová-Jechová & Jančařík (1980), Kubátová & al. (1998), Nováková & Blažková (2000), Kubátová & al. (in press), and yet unpublished data of Kubátová (from 1985, 1990) and preliminary results of Kubátová and Váňová (from 1999 and 2000, unpubl.). The list does not include the fungi determined only at the genus level. This list presents 152 species, varieties and forms isolated from the Bohemian Forest. From the systematic point of view, 44 species belong to Zygomycetes, 7 to Ascomycetes, and 101 to Deuteromycetes (mitosporic fungi), mainly anamorphic Ascomycetes. Compared with the list of soil micromycetes from the former Czechoslovakia (Řepová 1989a,b, 1990a,b) and with the list of soil species of the genus *Penicillium* from the Czech and Slovak Republics (Nováková & Kubátová 1995) in which over 600 species of soil micromycetes are presented, it is about 25% of all yet known soil microfungi from the Czech and Slovak Republics.

At the end of the Table 3, numbers of species isolated by several authors are also mentioned. These figures are very different depending on the methods used, the number of samples and the variability of the studied localities (compare with Tables 1 and 2).

Dyr (1941) has focused on Zygomycetes only. He reported 19 species from three localities of the Bohemian Forest (Jezerní stěna, Pancíř Mt., Černé Lake). Since that time however,

Table 1. – Published papers on soil microfungi in the Bohemian Forest, used materials and methods.

Author	Localities	Incubation media and temperature	Samples
Dyr (1938, 1939, 1941)	Jezerní stěna (in original "See-wand"), Pancíř Mt., Černé Lake (beech and Norway spruce forests)	malt agar	not known
Holubová-Jechová & Jančařík (1980)	Soumarský Most (peat-bog)	2% wort-beer agar with rose Bengal, pepton-PCNB medium for *Fusarium*	2 samples of extracted pure peat
Kubátová, Váňova & Prašil (1998)	Svaroh Mt., Černé Lake, Jezerní hora Mt., Čertovo Lake, Laka Lake, Ždanidla Mt., Roklanská smrčina (spruce forest), Mlynářská slať (mire), Jezerní slať (mire), spring of the Teplá Vltava River, Medvědice, Mrtvý luh (mire) (Norway spruce forests, beech forests, mixed forests in glacial cirques, peat bogs)	soil agar with rose Bengal and glucose, wort-beer agar, Sabouraud's agar, corn-meal agar, bait (caterpillar) 25°C, heat treatment	121samples, mainly from H horizon, on mires from the surface layer of peat substrate
Nováková & Blažková (2000)	Trojmezí (Norway spruce forest)	soil agar with rose Bengal, wort-beer agar with rose Bengal, Sabouraud's agar with rose Bengal, 25°C	3 collections with samples from several soil horizons

Table 2. – Not yet published investigations on soil microfungi in the Bohemian Forest, used materials and methods.

Author	Localities	Incubation media and temperature	Samples
KUBÁTOVÁ – unpubl. (1985)	**11** – mixed forest near Čertovo Lake, altitude about 930 m, under *Polytrichum* sp. near a road, isol. July 1985; **13** – meadow near Gerlova Huť, about 6 km NE of Železná Ruda, altitude about 1000 m, under *Hieracium aurantiacum, Cirsium canum, Avenella flexuosa, Agrostis tenuis* etc., isol. July 1985	soil agar with rose Bengal and glucose 25°C	2 soil samples from H horizon
KUBÁTOVÁ – unpubl. (1990)	**183** – Norway spruce forest near Plešné Lake, altitude about 1095 m, under *Oxalis acetosella, Calamagrostis villosa, Dryopteris* sp., isol. July 1990; **184** – peak of the Strážný Mt., 4.5 km NW of Strážný, altitude about 1115 m, beech forest with *Vaccinium myrtillus, Polytrichum* sp., isol. July 1990; **196** – Norway spruce forest on the Studená hora Mt., 4 km SW of Modrava, altitude about 1200 m, under *Vaccinium myrtillus, Calamagrostis villosa*, isol. August 1990; **197** – Heath 0.5 km S of Horská Kvilda, altitude about 1040 m, *Calluna vulgaris, Rhodococcus vitis-idaea, Avenella flexuosa, Cladonia* sp., isol. August 1990; **198** – Norway spruce forest ca 3.5 km NE of Horská Kvilda, altitude about 1150 m, *Avenella flexuosa, Vaccinium myrtillus, Polytrichum* sp., *Sphagnum* sp., isol. August 1990	soil agar with rose Bengal and glucose, Sabouraud's agar 25°C	5 soil samples from H horizon
KUBÁTOVÁ & VÁŇOVÁ – present study (1999–2000)*	Vydra River valley, Trojmezná Mt., Trojmezí, Plechý Mt., Plešné Lake, Houska mire (Norway spruce forests, mixed forests, peat bog)	soil agar with rose Bengal and glucose, wort-beer agar, baits (nails, filter paper) 25°C, ca 6°C	30 soil samples, mainly from H horizon, on mire from surface layer of peat substrate

*) More detailed data will be given in the final report.

some taxonomic changes have been made because most of the species had been invalidly described and some species had been declared as doubtful taxa.

Thus, *Absidia orchidis* is listed here as *A. coerulea* var. *coerulea*. The name *Absidia coerulea* has a longer history. Bainier in 1889 described *Absidia coerulea* as a species with blue-violet colour of colony, with globose sporangiospores. He gave no size of these characteristics. In 1896, Deckenbach described a new species *Absidia tieghemii* with good illustration and description, where sporangiospores were smaller than 3 μm in diam. Oudemans described *Mucor saccardoi* in 1902; the size of sporangiospores being 4–7 μm in diam. Vuillemin in 1903 used this name and established the new genus *Proabsidia* with only one species *P. saccardoi*. In the same year, Vuillemin described *Tieghemella orchidis* with sporangiospores 2.5–3.5 μm in diam. Hagem in 1908 transferred *T. orchidis* to the genus *Absidia* as *A. orchidis*. Lendner distinguished in 1908 two species: *A. coerulea* and *A. orchidis*. Ellis and Hesseltine

Table 3. – List of soil microfungi yet known from the Bohemian Forest. References: 1 – Dyr (1939, 1941), zygomycetous species; 2 – Holubová-Jechová & Jančařík (1980); 3 – Kubátová & al. (1998); 4 – Nováková & Blažková (2000); 5 – Kubátova & al. (in press), new records of several fungi; 6 – Kubátová 1985, 1990 (not yet published), case study; 7 – Kubátová & Váňová (not yet published), preliminary results of current study (1999, 2000). Notes: * in original papers under another name, see comments in the text; †doubtful taxon, § strain is deposited in the Culture Collection of Fungi, Prague (see Kubátová & al. 1997).

Micromycete species	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Zygomycetes							
Absidia coerulea Bainier var. *coerulea*	+*		+§				+
Absidia coerulea Bainier var. *saccardoi* (Oudem.) Váňová			+				
Absidia cylindrospora Hagem			+				
Absidia glauca Hagem	+			+			
Micromucor isabellinus (Oudem.) Arx		+*	+				+
Micromucor ramannianus (Moller) Arx var. *angulisporus* Naumov ex Váňová			+	+		+	+
Micromucor ramannianus (Moller) Arx var. *ramannianus*	+*	+*	+				+
Mortierella alpina Peyronel			+				
Mortierella bainieri Cost.			+				
Mortierella elongata Linnem.			+				
Mortierella exigua Linnem.			+§				
Mortierella gamsii Milko	+*		+				
Mortierella humilis Linnem. ex W. Gams			+				
Mortierella hyalina (Harz) W. Gams			+				
Mortierella jenkini (A. L. Sm.) Naumov			+				
Mortierella minutissima Tiegh.			+				
Mortierella parvispora Linnem.			+§				
Mortierella polycephala Coem.	+						
†*Mortierella pusilla* Oudem.	+						
Mortierella verticillata Linnem.			+				
†*Mucor bathogenus* Dyr	+						
Mucor circinelloides Tiegh. f. *circinelloides* Schipper			+				
Mucor circinelloides Tiegh. f. *griseocyanus* (Hagem) Schipper	+*						
Mucor cylindrosporus Y. Ling	+*						
Mucor dimorphosporus Lendn.	+*	+*	+				
Mucor genevensis Lendn.	+						
Mucor hiemalis Wehmer f. *corticolus* (Hagem) Schipper			+				
Mucor hiemalis Wehmer f. *hiemalis*	+	+	+				+
Mucor hiemalis Wehmer f. *luteus* (Linnem.) Schipper			+				+
Mucor hiemalis Wehmer f. *silvaticus* (Hagem) Schipper							+
Mucor mucedo Fresen.	+						
Mucor plumbeus Bonord.	+	+	+				+
Mucor sciurinus Naumov	+*						
Mucor strictus Hagem	+						
†*Mucor subabundans* Dyr	+						
Mucor wosnessenskii Schostak.			+				

Table 3. – continued

Micromycete species	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Pilaira anomala (Ces.) J. Schroet.			+				
Pilobolus crystallinus (F. H. Wigg.: Fr.) Tode			+				
Rhizopus arrhizus A. Fisch.			+				
Rhizopus stolonifer (Ehrenb.: Fr.) Vuill. var. *stolonifer*			+	+			
Syncephalastrum racemosum Cohn ex J. Schroet.							+
Thamnidium elegans Link	+						
Umbelopsis vinacea (Dixon-Stew.) Arx							+
Zygorhynchus moelleri Vuill.	+	+	+			+	
Ascomycetes and anamorphs							
Acremonium apii (Sm. et Ramsey) W. Gams			+*				
Acremonium berkeleyanum (Karsten) W. Gams			+				
Alternaria alternata (Fr.: Fr.) Keissl.			+				+
Amblyosporium botrytis Fresen.			+§				
Arthrinium arundinis (Corda) Dyko et B. Sutton			+				
Arthriniium phaeospermum (Corda) M. B. Ellis			+				
Aspergillus versicolor (Vuill.) Tirab.			+				
Aureobasidium pullulans (de Bary) Arnaud			+				
Beauveria bassiana (Bals.-Criv.) Vuill.			+				+
Beauveria brongniartii (Sacc.) Petch			+				+
Botrytis cinerea Pers.: Fr.			+				
Calcarisporium arbuscula Preuss			+				+
Chaetomium crispatum Fuckel							+
Chaetomium globosum Kunze				+			
Chaunopycnis alba W. Gams					+		
Chloridium virescens (Pers.: Fr.) W. Gams et Hol.-Jech.				+			
Chloridium virescens (Pers.: Fr.) W. Gams et Hol.-Jech. var. *chlamydosporum*			+				
Cladosporium cladosporioides (Fresen.) de Vries			+				+
Cladosporium herbarum (Pers.: Fr.) Link			+				+
Cladosporium sphaerospermum Penz.			+				
Cylindrocarpon destructans (Zinssmeister) Scholten			+	+		+	
Cylindrocarpon magnusianum (Sacc.) Wollenw.			+			+	+
Dactylaria lanosa Malla & W. Gams			+§		+		
Dinemasporium strigosum (Pers.: Fr.) Sacc.			+				
Doratomyces asperulus Wright et Marchand			+				
Doratomyces microsporus (Sacc.) F.J.Morton et G. Sm.			+				
Doratomyces nanus (Ehrenb.: Fr.) F.J.Morton et G. Sm.			+§				+
Epicoccum nigrum Link			+				
Fusarium cf. *croockwellense* Burgess, Nelson et Toussoun			+				
Fusarium solani (Martius) Sacc.			+				
Fusarium cf. *solani* (Mart.) Appel et Wollenw.		+					
Fusarium tabacinum (Beyma) W. Gams			+				

Table 3. – continued

Micromycete species	1	2	3	4	5	6	7
Gelasinospora tetrasperma Dowding			+				
Geomyces pannorum (Link) Sigler et J.W. Carmich.							+
Graphium penicillioides Corda			+				
Humicola fuscoatra Traaen			+				
Humicola grisea Traaen			+				
Mariannaea elegans (Corda) G. Arnaud ex Samson			+				
Oidiodendron echinulatum G. L. Barron			+				
Oidiodendron griseum Robak							+
Oidiodendron maius G.L. Barron							+
Oidiodendron tenuissimum (Peck) S. Hughes				+			
Paecilomyces carneus (Duché et R. Heim) A.H.S. Br. et G. Sm.			+				+
Paecilomyces farinosus (Holmsk.: Fr.) A.H.S. Br. et G. Sm.			+				+
Paecilomyces lilacinus (Thom) Samson							+
Penicillium aurantiogriseum Dierckx				+			
Penicillium cf. *aurantiogriseum* Dierckx			+				
Penicillium brevicompactum Dierckx			+				
Penicillium canescens Sopp						+§	+
Penicillium chrysogenum Thom			+				
Penicillium citrinum Thom			+	+			+
Penicillium coalescens Quintan.			+				
Penicillium commune Thom				+			
Penicillium coprophilum (Berk. et M.A. Curtis) Seifert et Samson			+				
Penicillium corylophilum Dierckx				+			
Penicillium crustosum Thom			+				
Penicillium daleae K.M. Zalessky							+
Penicillium expansum Link: Fr.			+				
Penicillium fellutanum Biourge				+			
Penicillium funiculosum Thom			+				
Penicillium glabrum (Wehmer) Westling		+*	+				+
Penicillium inflatum Stolk et Malla			+	+			+
Penicillium janczewskii K.M. Zalessky			+				
Penicillium janthinellum Biourge						+§	
Penicillium lanosum Westling			+				+
Penicillium lividum Westling			+	+		+	+
Penicillium melinii Thom						+	
Penicillium miczynskii K.M. Zalessky			+	+			+
Penicillium minioluteum Dierckx							+
Penicillium montanense M. Chr. et Backus			+				+
Penicillium olsonii Bainier et Sartory							+
Penicillium piceum Raper et Fennell			+				
Penicillium primulinum Pitt		+*					
Penicillium pulvillorum Turfitt			+				+

Table 3. – continued

Micromycete species	1	2	3	4	5	6	7
Penicillium purpurogenum Stoll			+				
Penicillium restrictum J.C. Gilman et E.V. Abbott			+				
Penicillium rubefaciens Quintan.			+				
Penicillium roseopurpureum Dierckx		+					
Penicillium simplicissimum (Oudem.) Thom		+	+			+	
Penicillium smithii Quintan.			+§			+	+
Penicillium soppii K.M. Zalessky			+				
Penicillium spinulosum Thom			+	+		+	+
Penicillium thomii Maire			+§				
Penicillium verruculosum Peyronel			+				
Pithoascus intermedius (C.W. Emmons et B.O. Dodge) Arx			+				
Pseudeurotium zonatum Beyma							+
Scopulariopsis brevicaulis (Sacc.) Bainier			+				
Scytalidium lignicola Pesante			+				
Sordaria fimicola Ces. & De Not.				+			
Sphaerodes fimicola (E.C.Hansen) P.F. Cannon et D. Hawksw.			+				
Thysanophora penicillioides (Roum.) W.B. Kendr.			+	+			+
Tolypocladium cylindrosporum W. Gams			+				+
Tolypocladium geodes W. Gams			+				+
Tolypocladium inflatum W. Gams			+				+
Trichocladium asperum Harz			+§				
Trichocladium opacum (Corda) S. Hughes			+				
Trichoderma hamatum (Bonord.) Bainier			+				
Trichoderma harzianum Rifai						+	
Trichoderma polysporum (Link: Fr.) Rifai			+§				+
Trichoderma saturnisporum Hammill			+§		+		
Trichoderma viride Pers.: Fr.		+	+	+			+
Ulocladium botrytis Preuss			+				
Verticillium bulbilosum W. Gams et Malla			+§			+	+
Verticillium lecanii (Zimm.) Viégas			+	+			
Verticillium luteoalbum (Link: Fr.) Subram.			+				
Verticillium psalliotae Treschew			+				
Volutella ciliata (Alb. et Schw.: Fr.) Fr.			+				
Wardomyces humicola Hennebert et G.L. Barron			+				
Total number of species: 152	**19**	**12**	**112**	**20**	**3**	**14**	**47**

in 1965 united the above mentioned species together under the older name *Absidia coerulea* because strains of both taxa made together normal mature zygospores. VÁŇOVÁ (1985) distinguished two varieties in the species *A. coerulea*: nominate variety with sporangiospores mostly 3–3.9 μm in diam. and another variety var. *saccardoi* with sporangiospores mostly 4.2–6.5 μm in diam. The latter variety is rarer. Therefore, *A. orchidis* Hagem is considered here as a synonym of *A. coerulea* var. *coerulea.*

Some changes have appeared in several other names listed by DYR (1941): *Mortierella candelabrum* Tiegh. et Le Mon. is given here as *Mortierella gamsii, Mucor griseo-cyanus* Hagem as *Mucor circinelloides* f. *griseocyanus, Mucor microsporus* Namysl. as *Mucor cylindrosporus, Mucor racemosus* Fres. as *Mucor dimorphosporus, Mucor flavus* Bainier as *Mucor sciurinus* and *Mucor ramannianus* Möller as *Micromucor ramannianus* (see MILKO 1974, SCHIPPER 1976, VÁŇOVÁ 1991).

Mortierella pusilla, Mucor bathogenus and *Mucor subabundans* were declared as doubtful taxa. The latter two species were described by Dyr. The illustration of *Mucor bathogenus* (DYR 1938) resembles to some species of the genus *Zygorhynchus*, the type material is not available. Dyr affirmed that this species has some affinities with *Z. vuilleminii* (= *Z. moelleri*), but forms no zygospores. Authors, who were interested in the genus *Mucor*, gave no references about this species. Maybe it was a sterile strain of the homothallic genus *Zygorhynchus*. *Mucor subabundans* (DYR 1940) was not fully described, no illustration was given and the type material was not available either. According to the description, this species has some affinity to *Mucor hiemalis* (see SCHIPPER 1973). MILKO (1974) attached *M. subabundans* as a synonym to the also doubtful species *Mucor abundans* Povah.

HOLUBOVÁ-JECHOVÁ & JANČAŘÍK (1980) studied peat used for production of seedlings. Therefore, they concerned especially on isolation of soil phytopathogenic fungi. At the Soumarský Most locality they found 12 species of soil micromycetes. Some of them are given in the present list under their current valid names. Thus, *Mortierella isabellina* is now listed as *Micromucor isabellinus*, *Mortierella ramanniana* as *Micromucor ramannianus*, *Mucor racemosus* as *M. dimorphosporus*, *Penicillium diversum* var. *aureum* as *P. primulinum*, and *Penicillium frequentans* as *P. glabrum*.

KUBÁTOVÁ & al. (1998) found 112 fungal species (incl. varieties and forms). This high number is due to several different types of habitats (Norway spruce forests, beech forests and peat bogs) on 12 localities and to a higher number of processed soil samples. One of the *Fusarium tabacinum* strains isolated at the Medvědice locality was recently redetermined as *Acremonium apii* (in the Table 3 signed by asterisk). This species has somewhat narrower conidia than *F. tabacinum* and like *F. tabacinum* it forms cream and slimy colonies. One record of *Acremonium apii* from the Czech Republic, isolated from beet seedling soil in Semčice, is cited by FASSATIOVÁ (1982).

NOVÁKOVÁ & BLAŽKOVÁ (2000) studied soils in Norway spruce forest at the Trojmezí locality only. They determined 20 fungal species.

The paper by KUBÁTOVÁ & al. (in press) presents three new records of micromycetes from the Bohemian Forest (new records for the Czech Republic). The records of *Dactylaria lanosa* and *Trichoderma saturnisporum* were published earlier (KUBÁTOVÁ & al. 1998), *Chaunopycnis alba* was determined later. The latter fungus was found in the vicinity of the Čertovo Lake. It is noteworthy by its affinity to peat bogs of cold northern European regions (e.g. Sweden), it was also often found on mosses and lichens in Antarctica and Spitsbergen. It is known to produce immunosuppressive compound cyclosporin similarly to *Tolypocladium inflatum*, another species typical for some soils in the Bohemian Forest.

Table 3 (for more details see Table 4) presents also some yet unpublished data by Kubátová from the years 1985 and 1990. This pilot study was very limited and aimed to compare soil micromycetes of some typical habitats (meadow, heath, Norway spruce forest and beech forest). The limited number of soil samples and methods used gave limited results, i.e. only 14 species isolated. It is noteworthy that *Penicillium melinii,* typical species of grasslands and heaths (after CHRISTENSEN 1981) rarely found in other habitats, was isolated from a soil sample of heath (locality Horská Kvilda).

The last column of the Table 3 gives the preliminary list of species isolated by Kubátová

Table 4. – Case study of soil micromycetes in 1985 and in 1990 (A. KUBÁTOVÁ – unpubl.). Key of localities: 11 – Čertovo Lake (mixed forest); 13 – Gerlova Huť (meadow); 183 – Plešné Lake (Norway spruce forest); 184 – Strážný Mt. (beech forest); 196 – Studená hora Mt. (heath); 197, 198 – Horská Kvilda (Norway spruce forest).

Micromycete species	Localities						
	11	13	183	184	196	197	198
Cylindrocarpon destructans				+			
Cylindrocarpon magnusianum			+				
Micromucor ramannianus var. *angulisporus*	+						
Penicillium canescens		+					
P. glabrum	+						
P. janthinellum		+					
P. lividum					+		
P. melinii						+	
P. simplicissimum						+	
P. smithii						+	
P. spinulosum			+		+		
Trichoderma harzianum					+		
Verticillium bulbilosum							+
Zygorhynchus moelleri						+	
Number of species: 14	**2**	**2**	**2**	**1**	**3**	**4**	**1**

and Váňová in 1999 and 2000. They studied several localities (Vydra River valley, Plešné Lake and Trojmezná Mt. to Plechý Mt. ridge and Houska mire) and determined 47 soil micromycete species (10 Zygomycetes, 2 Ascomycetes and 15 Deuteromycetes). Within these species, *Chaetomium crispatum* is a rarely isolated fungus. This study is still going on and its final results will be published later.

From the above survey and from our own experience, it is obvious that *Micromucor ramannianus* var. *angulisporus, Penicillium spinulosum* and *Trichoderma viride* are the most frequent and abundant soil fungi of the Bohemian Forest. Other characteristic species for the soil habitats of this area seem to be *Mortierella* spp., *Tolypocladium* spp., *Penicillium inflatum, P. lividum, Verticillium bulbilosum* etc. The majority of the listed species belong to the typical soilborne fungi.

Fourteen strains of microfungi isolated from soils in the Bohemian Forest were deposited at the Culture Collection of Fungi, Department of Botany, Charles University, Prague (see KUBÁTOVÁ & al. 1997). They are marked by § in Table 3.

CONCLUSION

In the last decade there was a rapid development of studies on soil microfungi in the Šumava National Park. Publication of the results of other studies on soil micromycetes from this area is expected. Moreover, investigations into other groups of micromycetes, which may sometimes also occur in soil, are just being carried out. For example, VÁŇOVÁ & KUBÁTOVÁ (2001) prepared a paper on coprophilous microfungi, Z. Landa & al. (Faculty of Agriculture, University of South Bohemia, České Budějovice) are interested in entomogenous fungi associated with the spruce bark beetle *Ips typographus*. D. Novotný & al. (Czech Collection of Microorganisms, Masaryk University, Brno) are specialized on ophiostomatalean fungi asso-

ciated with *Ips typographus*, B. Voženílková & al. (Faculty of Agriculture, University of South Bohemia, České Budějovice) focus on plant pathogens (including *Fusarium*) and K. Prášil (Department of Botany, Charles University, Prague) and M. Réblová (Institute of Botany, Academy of Sciences, Prague) are continuing their research on lignicolous micromycetes, some of them are also sometimes isolated from soil.

To complete our knowledge on soil microscopic fungi of the Šumava National Park, it is necessary to focus on several different fields: (1) It is obvious from the above cited survey that little attention was paid to microscopic fungi living in the soils of mountain meadows and heaths. A detailed comparison of several types of habitats should be also done. (2) All studies still done were concerned with the so-called cultivable soil fungi, i.e. microfungi capable to grow on agar nutrient media. However, many other fungi which do not grow under common laboratory conditions, e.g. zoosporic fungi (Chytridiomycota), some fungi-like organisms as Oomycota and Hyphochytriomycota and of course some phytopathogenic fungi are known to occur in soil. Therefore studies on overall soil micromycete diversity ought to include special methods for these groups of fungi. (3) It is important to know which species of fungi are occurring in soil due to their role in decomposition and nutrient cycling. However, it is very difficult to study their activity and their individual ecological role. Frankland (1990) summarized the progress in ecological methods of investigation of soil fungi. She pointed out that the statement of S.D. Garrett from 1950's on soil fungi is still true: "We see what we cannot identify and identify what we cannot see." To complete the ecological study of soil fungi she recommended, beside the measurement of fungal activity, the combination of three types of methods: direct observation, isolation techniques and quantification. To these methods, new molecular approaches could be now added to study the diversity of soil fungi. Interesting results were obtained e.g. by Viaud & al. (2000). They compared ITS sequences isolated from soil fungi obtained by dilution-plating method and from total environmental (soil) DNA. The results obtained by these two methods were very different. In the ITS sequences from total environmental DNA several microorganisms were distinguished, which are not commonly isolated by plating methods (e.g. some members of Plasmodiophoromycota, Oomycota etc.). The molecular methods appear thus to be a useful complement to the other methods.

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References

Christensen M., 1981: Species diversity and dominance in fungal communities. *In: The fungal community, its organisation and role in the ecosystem, Wicklow D.T. & Carroll G.C. (eds), Marcel Dekker, Inc. New York & Basel., pp. 201–232.*

Dyr J., 1938: *Mucor bathogenus* n. sp. *Studia Botanica Čechoslovaca, 1(2): 52–60.*

Dyr J., 1939: O rozmnožování některých pozemních plísní [About reproduction of some soil moulds]. *Věda přírodní, 19: 258–264 (in Czech).*

Dyr J., 1940: Generis *Mucor* Mich. species duae novae. *Studia Botanica Čechica, 3: 80.*

Dyr J., 1941: Zygomyceten in Waldboden der Böhmischen Lander. *Studia Botanica Čechica, 4: 73–157.*

Fassatiová O., 1982: Species of the genus *Acremonium* Link ex Fr. in Czechoslovakia (Hyphomycetes). *Novitates Botanicae Universitatis Carolinae, 1: 7–13.*

Frankland J.C., 1990: Ecological methods of observing and quantifying soil fungi. *Transactions of the Mycological Society of Japan, 31: 89–101.*

Holubová-Jechová V. & Jančařík V., 1980: Mykoflóra rašeliny a rašelinných substrátů [Mycoflora of peat and peat substrates]. *Lesnictví, 26(12): 1085–1104 (in Czech).*

Kubátova A., Černy M. & Nováková A., in press: New records of micromycetes from the Czech Republic. IV. *Acrodontium salmoneum, Chaunopycnis alba* and *Cylindrocarpostylus gregarius*, and notes on *Dactylaria lanosa* and *Trichoderma saturnisporum. Czech Mycology, 53 (in press).*

KUBÁTOVÁ A., VAŇOVÁ M. & PRAŠIL K., 1997: CCF Catalogue of filamentous fungi. *Novitates Botanicae Universitatis Carolinae, 10/1996: 5–120.*

KUBÁTOVÁ A., VAŇOVÁ M. & PRAŠIL K., 1998: Contribution to the biodiversity of soil microfungi of the Šumava Mts., Czech Republic. *Silva Gabreta, 2: 23–34.*

MILKO A.A., 1974: Opredelitel' mukoral'nych gribov. *Dumka naukova, Kiev, 303 pp.*

NOVÁKOVÁ A. & BLAŽKOVÁ P., 2000: Mikroskopické houby v půdách vybraných horských smrčin České republiky [Microscopic fungi in soils of selected mountain spruce forests in the Czech Republic]. *Silva Gabreta, 5: 63–68 (in Czech).*

NOVÁKOVÁ A. & KUBÁTOVÁ A., 1995: Studium rodu *Penicillium* v České a Slovenské republice a přehled druhů uváděných z tohoto území [Study of the genus *Penicillium* in Czech and Slovak Republics and survey of reported species]. *In: Současný stav, využití moderních metod a perspektivy studia rodu Penicillium [Present state, modern methods and perspectives in Penicillium study]. KUBÁTOVÁ A. & PRAŠIL K. (eds), Czech Scientific Society for Mycology,Praha, pp. 31–88 (in Czech).*

ŘEPOVÁ A., 1989a: Soil micromycetes from Czechoslovakia – a list of isolated species with bibliography. *Česká Mykologie, 43: 169–175.*

ŘEPOVÁ A., 1989b: Soil micromycetes from Czechoslovakia – a list of isolated species with bibliography. II. *Česká Mykologie, 43: 235–243.*

ŘEPOVÁ A., 1990a: Soil micromycetes from Czechoslovakia – a list of isolated species with bibliography. III. *Česká Mykologie, 44: 35–50.*

ŘEPOVÁ A., 1990b: Soil micromycetes from Czechoslovakia – a list of isolated species with bibliography. IV. *Česká Mykologie, 44: 170–178.*

SCHIPPER M.A.A., 1973: A study on variability in *Mucor hiemalis* and related species. *Studies in Mycology, 4: 1–40.*

SCHIPPER M.A.A., 1976: On *Mucor circinelloides*, *Mucor racemosus* and related species. *Studies in Mycology, 12: 1–40.*

VAŇOVÁ M., 1985: Rod *Absidia* van Tiegh. v Československu III [The genus *Absidia* van Tiegh. in Czechoslovakia III]. *Česká Mykologie, 39: 85–96 (in Czech).*

VAŇOVÁ M., 1991: Nomen novum, nomenclatural changes and taxonomic rearrangements in Mucorales. *Česká Mykologie, 45: 25–26.*

VAŇOVÁ M. & KUBÁTOVÁ A., 2001: Příspěvek k poznání koprofilních hub na Šumavě [Contribution to the knowledge of coprophilous fungi in the Bohemian Forest (the Šumava Mts.)]. *Silva Gabreta, 7: 191–198 (in Czech).*

VIAUD M., PASQUIER A. & BRYGOO Y., 2000: Diversity of soil fungi studied by PCR–RFLP of ITS. *Mycological Research, 104(9): 1027–1032.*