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# Contribution to the biodiversity of soil microfungi of the Šumava Mts., Czech Republic

## Příspěvek k biodiverzitě půdních mikromycetů české Šumavy

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**Abstract**

An attempt has been made to determine the soil micromycetes from 12 localities of the Šumava Mts. (Bohemian Forest), Czech Republic, including peat-bogs, Norway spruce forests, beech forests and mixed forests in glacial cirques. The study was conducted in the period 1993–1996 and represents the first investigation of soil deuteromycetous fungi of this area. Altogether 139 fungal species, varieties or undetermined fungi were recovered from 121 soil samples. Majority of the taxa belong to the *Zygomycetes* (30) and *Deuteromycetes (Fungi Imperfecti)* (100). The most frequent species were *Trichoderma viride* (in 57 % of all samples), *Penicillium spinulosum* (55.4 %), *Micromucor ramannianus* var. *ramannianus* (33.1 %), and *Mucor hiemalis* f. *hiemalis* (24.8 %). Other frequent fungi appeared to be *Penicillium inflatum* (19 %), *Penicillium glabrum* (16.5 %), *Mortierella elongata* (14.9 %), *M. alpina* (13.2 %), *Micromucor isabellinus* (13.2 %), and *Micromucor ramannianus* var. *angulisporus* (13.2). Majority of the conidial fungi isolated are new records for this region. Some species were found for the first time in the Czech Republic: *Amblyosporium botrytis, Dactylaria lanosa, Dinemasporium strigosum, Gelasinospora tetrasperma, Mortierella minutissima, Penicillium coalescens, P. montanense,* and *Trichoderma saturnisporum.*

*Key words:* soil micromycetes, Šumava Mts. (Bohemian Forest), peat-bogs, forests, new records, *Zygomycetes, Ascomycetes, Deuteromycetes*

## Introduction

The study of microscopic soil fungi in the Czech and Slovak Republics has a long tradition. General survey is given in comprehensive work of Řepová (1989a, b, 1990a, b). Nevertheless soil micromycetes of Šumava Mts. (Bohemian Forest) were for a long time omitted. Only the contribution on *Zygomycetes* is available (Dyr 1941). In the course of 1993–96 an investigation of soil micromycetes in the Šumava Mts. was carried out. This study was made in the frame of two major grant projects: „Biodiversity of the natural ecosystems of Šumava mountains (reference areas for the management of the UNESCO Biosphere Reserve)" and „Centres of biological diversity in the Šumava Biosphere Reserve." Preliminary results of these studies were mentioned in annual grant reports (Kubátová & Prášil 1993, Váňová 1993, Kubátová, Váňová & Prášil 1994, Kubátová & Váňová 1997).

The aim of this study was to carry out introductory inventory of soil microfungi as the base for detailed study focused on overall biodiversity of this region.

## Material and methods

Since July 1993 to August 1996 one hundred and twenty-one soil samples were studied by cultivation and microscopic methods. The samples were collected in twelve different localities of the Šumava Mts. (see bellow). The studied sites covered peat-bogs, Norway spruce and beech forests, and mixed forests in glacial cirques. From each locality 6–16 samples were collected. Majority of the samples were obtained from three sites in a depth of five centimetres.

In the laboratory both soil dilution method and direct inoculation of soil were used. For isolation several nutrient agar media were tried: soil agar with rose bengal and glucose, wort-beer agar, Sabouraud's agar, and corn-meal agar. All media contained streptomycin to suppress bacteria. In some cases additional methods were used including heat treatment and the use of sterile caterpillars as a bait for isolation of micromycetes.

Incubation of the Petri dishes was made at 25 °C. After several days the visible colonies were transferred to other agars for identification. These media were malt-extract agar, Czapek yeast extract agar, soil extract agar, wort-beer agar, potato-carrot agar, and corn-meal agar.

Identification of soil micromycetes was made according to their microscopic and macromorphological features.

**Localities** (see Figure 1)

1. **Svaroh Mt.** – on border ridge of Šumava Mts. above Černé jezero Lake; Norway spruce forest with herbaceous layer; soil samples collected at elevation 1200–1333 m.
2. **Černé jezero Lake** – glacial cirque above the lake; Norway spruce forest with and without herbaceous layer, and in mixed forest dominated by *Picea abies* and *Fagus sylvatica*; soil samples collected at elevation 1030–1200 m.
3. **Jezerní hora Mt.** – above Čertovo jezero Lake; Norway spruce forest with and without herbaceous layer; soil samples collected at elevation 1200–1340 m.
4. **Čertovo jezero Lake** – glacial cirque above the lake; Norway spruce forest with and without herbaceous layer, and mixed forest dominated by *Picea abies* and *Fagus sylvatica*; soil samples collected at elevation 1080–1190 m.
5. **Laka Lake** – slope above the lake; Norway spruce forest with herbaceous layer; soil samples collected at elevation 1090–1200 m.
6. **Ždanidla Mt.** – natural beech forest on a slope of the mount, on some sites with intrusions of *Picea abies*; soil samples collected at elevation ca 1300 m.
7. **Roklanská smrčina spruce forest** – Norway spruce forest with and without herbaceous layer; soil samples collected at elevation 1080–1150 m.
8. **Mlynářská slať mire** – sampling sites on peat-bog without trees and in forest with *Pinus mugo* or *Picea abies*, and vacciniaceous plants and mosses; soil samples collected at elevation 1040–1060 m.
9. **Jezerní slať mire** – peat-bog dominated by *Pinus mugo*, vacciniaceous plants and mosses; elevation ca 1070 m.
10. **Spring of Teplá Vltava river** – on the slope of Černá hora Mt.; Norway spruce forest; soil samples collected at elevation 1180–1200 m.
11. **Medvědice** – part of Stožec Mt., natural type of beech forest on the slope of hill with intrusions of *Picea abies* and *Abies alba*, and with herbaceous layer; soil samples collected at elevation ca 900 m.
12. **Mrtvý luh mire** – peat-bog on the confluence of the Teplá and Studená Vltava rivers; sampling sites dominated by *Pinus mugo*, vacciniaceous plants and mosses; elevation 740 m.

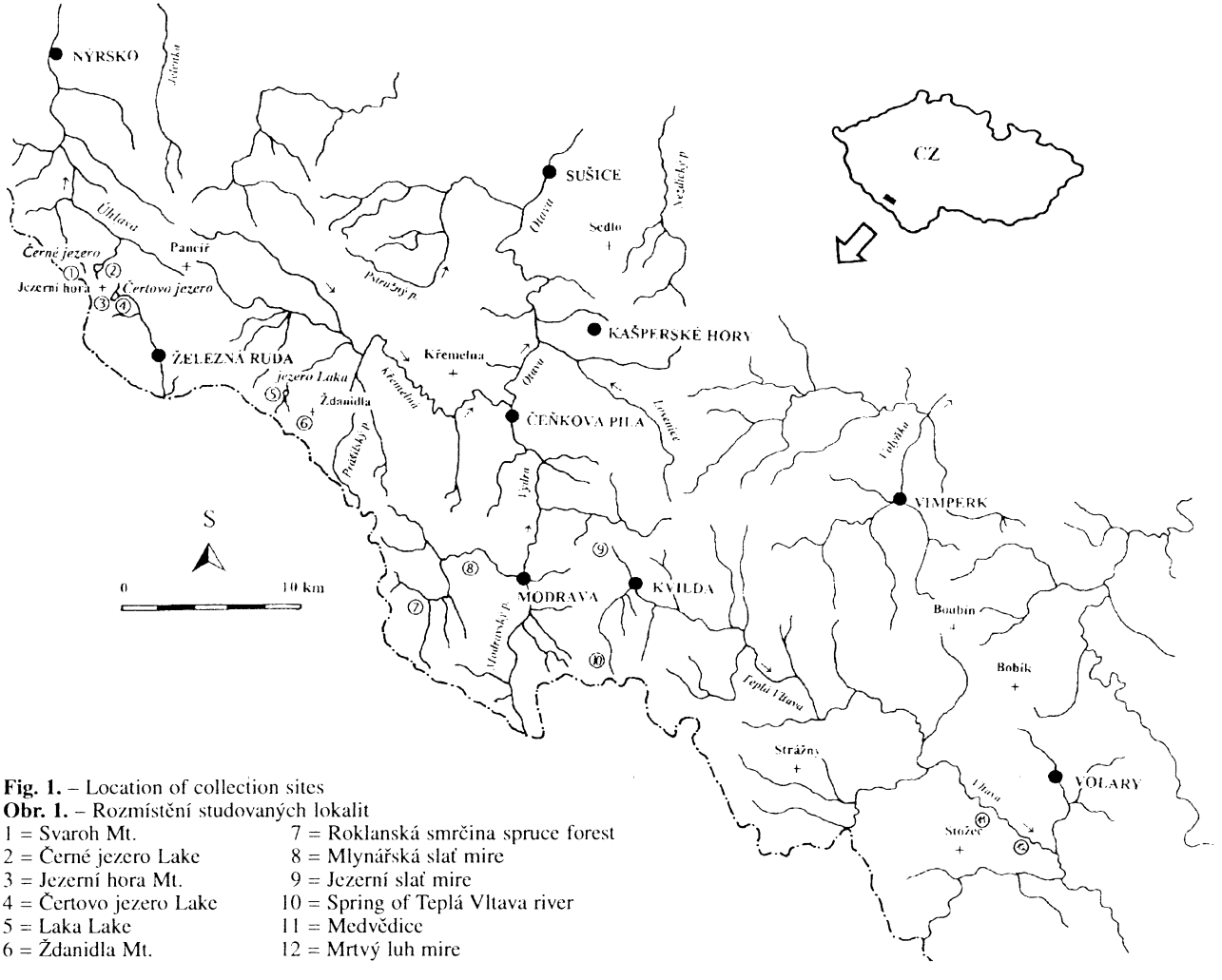


**Fig. 1.** – Location of collection sites
**Obr. 1.** – Rozmístění studovaných lokalit

1 = Svaroh Mt.
2 = Černé jezero Lake
3 = Jezerní hora Mt.
4 = Čertovo jezero Lake
5 = Laka Lake
6 = Ždanidla Mt.
7 = Roklanská smrčina spruce forest
8 = Mlynářská slať mire
9 = Jezerní slať mire
10 = Spring of Teplá Vltava river
11 = Medvědice
12 = Mrtvý luh mire

## Results

During four years of study 121 soil samples were processed. In these samples altogether 139 micromycetes representing 53 genera were discovered, including undetermined fungi andsterile mycelia. The majority of the fungi belong to *Deuteromycetes* (100 taxa), 30 taxa belong to *Zygomycetes*, 4 taxa belong to *Ascomycetes* and one fungus to *Basidiomycetes*. In

**Table 1** – Structure of soil microfungal communities on twelve localities of the Šumava Mts.
**Tabulka 1.** – Struktura společenstev půdních mikromycetů na dvanácti lokalitách na Šumavě.

| Locality | The most frequent taxa | | No. of other frequent fungi | No. of rare taxa | Total No. of taxa |
|---|---|---|---|---|---|
| | 100 – 50 % | | 49 – 30 % | 29 – 5 % | |
| 1 | *Penicillium spinulosum* | 90 % | 3 | 27 | 32 |
| | *Trichoderma viride* | 60 % | | | |
| 2 | *Penicillium spinulosum* | 90 % | 1 | 21 | 24 |
| | *Trichoderma viride* | 60 % | | | |
| 3 | *Penicillium spinulosum* | 70 % | 2 | 16 | 23 |
| | *Trichoderma viride* | 60 % | | | |
| | *Beauveria brongniartii* | 50 % | | | |
| | *Mortierella alpina* | 50 % | | | |
| | *Mortierella elongata* | 50 % | | | |
| 4 | *Trichoderma viride* | 90 % | 3 | 25 | 31 |
| | *Penicillium spinulosum* | 60 % | | | |
| | *Micromucor ramannianus var. ramannianus* | 50 % | | | |
| 5 | *Penicillium spinulosum* | 90 % | 2 | 21 | 26 |
| | *Micromucor ramannianus var. ramannianus* | 50 % | | | |
| | *Trichoderma viride* | 60 % | | | |
| 6 | *Penicillium spinulosum* | 60 % | 2 | 22 | 27 |
| | *Penicillium inflatum* | 60 % | | | |
| | *Trichoderma viride* | 50 % | | | |
| 7 | *Penicillium spinulosum* | 70 % | 3 | 23 | 28 |
| | *Cladosporium herbarum* | 50 % | | | |
| 8 | *Penicillium spinulosum* | 90 % | 4 | 27 | 34 |
| | *Micromucor ramannianus var. ramannianus* | 60 % | | | |
| | *Trichoderma viride* | 60 % | | | |
| 9 | *Micromucor ramannianus var. ramannianus* | 67 % | 7 | 17 | 27 |
| | *Trichoderma viride* | 67 % | | | |
| | *Penicillium glabrum* | 50 % | | | |
| 10 | *Penicillium glabrum* | 100 % | 4 | 33 | 40 |
| | *Micromucor ramannianus var. ramannianus* | 50 % | | | |
| | *Verticillium psalliotae* | 50 % | | | |
| 11 | *Trichoderma sp.* | 75 % | 2 | 50 | 54 |
| | *Trichoderma viride* | 69 % | | | |
| 12 | *Trichoderma sp.* | 73 % | 4 | 28 | 35 |
| | *Micromucor isabellinus* | 64 % | | | |
| | *Penicillium glabrum* | 55 % | | | |

Notes to localities:
1 = Svaroh Mt.
2 = Černé jezero Lake
3 = Jezerní hora Mt.
4 = Čertovo jezero Lake
5 = Laka Lake
6 = Ždanidla Mt.
7 = Roklanská smrčina spruce forest
8 = Mlynářská slať mire
9 = Jezerní slať mire
10 = Spring of Teplá Vltava river
11 = Medvědice
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addition, four types of sterile mycelium were isolated. The most frequent genera were found to be *Penicillium* (31 species) and *Mortierella* (12 species). Summary of all fungi isolated is listed below in the Table 2.

Comparison of species richness among localities and total frequency of microfungi in 121 soil samples are given in the Table 1 and 2. The most frequent fungi were *Trichoderma viride* (in 57 % of all samples), *Penicillium spinulosum* (55.4 %), *Micromucor ramannianus* var. *ramannianus* (33.1 %), *Trichoderma sp.* (28.1 %), and *Mucor hiemalis* f. *hiemalis* (24.8 %). The *Trichoderma viride* and *Micromucor ramannianus* var. *ramannianus* were found in every of the twelve localities. They are considered to be typical for colder and acid forest soils. Other frequent species are presented by *Penicillium inflatum* (19 %), *Penicillium glabrum* (16.5 %), *Mortierella elongata* (14.9 %), *M. alpina* (13.2 %), *Micromucor isabellinus* (13.2 %), and *Micromucor ramannianus* var. *angulisporus* (13.2). The majority of microfungi occurred in low frequency, even many species were found only once.

Comparing the twelve localities, the numbers of species isolated are in the range of 23 (Jezerní hora Mt.) to 54 (Medvědice). Data on the structure of fungal communities in these localities are given in the Table 1 and 2. On all of the localities were found one or a few of very frequent species, a few of other frequent fungi and many of rarely isolated species.

All the fungi isolated are saprotrophic soilborne species. Noteworthy, some of these saprobes are also entomogenous (*Beauveria bassiana, B. brongniartii, Paecilomyces farinosus, Tolypocladium geodes, T. inflatum, Verticillium lecanii,* and *V. psalliotae*), phytopathogenic (*Acremonium sp., Botrytis cinerea, Cylindrocarpon destructans, C. magnusianum, Fusarium solani, Penicillium brevicompactum, Phoma sp.,* and *Verticillium sp.*), fungicolous (*Acremonium berkeleyanum, Amblyosporium botrytis, Calcarisporium arbuscula, Papulaspora sp., Penicillium brevicompactum, P. glabrum, P. spinulosum, Sepedonium sp., Sphaerodes fimicola, Trichoderma viride,* and *Verticillium psalliotae,*) and coprophilous (*Doratomyces microsporus, D. nanus, Pilaira anomala, Pilobolus crystallinus, Sphaerodes fimicola* and *Volutella ciliata*). Noteworthy, perithecial fungus *Gelasinospora tetrasperma* was isolated only in heat treated soil sample.

Some species are noteworthy from the reason they were not yet published from the area of the Czech Republic: *Amblyosporium botrytis, Dactylaria lanosa, Dinemasporium strigosum, Gelasinospora tetrasperma, Mortierella minutissima, Penicillium coalescens, P. montanense,* and *Trichoderma saturnisporum.*

Majority of the fungi isolated, especially members of *Deuteromycetes*, are new fungal records for the Šumava Mts. Some micromycetes isolated from soil but having close affinity to wood and herbaceous stems were found by Prášil & Réblová (1998, this volume), too (*Alternaria alternata, Aureobasidium pullulans, Botrytis cinerea, Calcarisporium arbuscula, Cladosporium herbarum, Epicoccum nigrum, Phoma sp.* and *Trichocladium opacum*).

Only one author studied soil microfungi in Šumava Mts. region (Dyr 1941). Dyr reported from the locality Jezerní hora Mt. the following species: *Micromucor ramannianus* (as *Mortierella ramanniana*), *Mucor genevensis*, *M. hiemalis*, *M. circinelloides* f. *griseocyanus* (as *M. griseo-cyanus*), *M. dimorphosporus* (as *M. racemosus*) *M. sciurinus* (as *M. flavus*), *M cylindrosporus* (as *M. microsporus*), *Mortierella polycephala*, *M. gamsii* (as *M. candelabrum*) and two doubtful species *Mortierella pusilla* and *Mucor bathogenus*. In the locality Černé jezero Lake the same author reported *Mucor dimorphosporus* (as *M. racemosus*), *M. hiemalis, M. strictus, Micromucor ramannianus* (as *Mortierella ramanniana*), *Mortierella polycephala*, and doubtful species *Mortierella pusilla*. Some of these species were found again after fifty years on Jezerní hora Mt. and Černé jezero Lake or on other localities. However, ten of Dyr's fungi were not found.

On this place it is important to emphasize three points generally valid in all inventorial studies. Numbers of fungi recorded from soil substrata depend on:

**Table 2.** – List of soil micromycetes isolated from twelve localities of the Šumava Mts. and their frequency
**Tabulka 2.** – Přehled půdních mikromycetů získaných ze dvanácti lokalit Šumavy a frekvence jejich výskytu

| Fungi | Frequency of fungi on several localities (%) | | | | | | | | | | | | Total frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | (%) |
| **ZYGOMYCETES:** | | | | | | | | | | | | | |
| ***Absidia coerulea*** Bainier var. ***coerulea*** | – | – | – | 10 | – | – | – | – | – | 12.5 | – | – | 1.65 |
| ***Absidia coerulea*** Bainier var. ***saccardoi*** (Oudem.) Váňová | – | – | – | – | – | 10 | – | – | – | 25 | – | – | 2.5 |
| ***Absidia cylindrospora*** Hagem | – | 10 | – | – | – | – | – | – | – | – | – | – | 0.8 |
| ***Micromucor isabellinus*** (Oudem.) Arx | – | 10 | – | 10 | – | – | – | 40 | – | – | 18.8 | 63.6 | 13.2 |
| ***Micromucor ramannianus*** (Möller) Arx var. ***angulisporus*** (Naumov) Váňová | 40 | 20 | 30 | 10 | – | 30 | 10 | 10 | – | – | 6.3 | – | 13.2 |
| ***Micromucor ramannianus*** (Möller) Arx var. ***ramannianus*** | 20 | 20 | 10 | 50 | 50 | 30 | 20 | 60 | 66.7 | 50 | 25 | 18.2 | 33.1 |
| ***Mortierella alpina*** Peyronel | 20 | – | 50 | 30 | 20 | 20 | 20 | – | – | – | – | – | 13.2 |
| ***Mortierella bainieri*** Cost. | 10 | – | 10 | – | – | – | 10 | – | – | – | – | – | 2.5 |
| ***Mortierella elongata*** Linnem. | 20 | – | 50 | 20 | 30 | 20 | 40 | – | – | – | – | – | 14.9 |
| ***Mortierella exigua*** Linnem. | – | – | – | – | 10 | 10 | – | – | – | – | 18.8 | – | 4.1 |
| ***Mortierella gamsii*** Milko | – | – | – | – | – | – | – | – | – | 12.5 | – | – | 0.8 |
| ***Mortierella humilis*** Linnem. ex W. Gams | 10 | 10 | 20 | – | 10 | – | – | – | 16.7 | – | – | – | 5.0 |
| ***Mortierella hyalina*** (Harz) W. Gams | 20 | 10 | 10 | – | 20 | – | – | – | – | – | – | – | 5.0 |
| ***Mortierella jenkini*** (A. L. Sm.) Naumov | – | – | – | – | – | 10 | – | – | – | – | – | – | 0.8 |
| ***Mortierella minutissima*** Tiegh. | 10 | – | – | – | – | – | – | 10 | – | – | – | – | 1.7 |
| ***Mortierella parvispora*** Linnem. | 20 | – | 10 | 20 | – | – | – | 20 | – | 25 | 6.3 | 9 | 9.1 |
| ***Mortierella verticillata*** Linnem. | 10 | – | – | – | – | – | 10 | 10 | – | – | – | – | 2.5 |
| ***Mortierella sp.*** | – | – | – | – | – | – | – | – | 16.7 | – | 12.5 | 18.2 | 3.3 |
| ***Mucor circinelloides*** Tiegh. f. ***circinelloides*** Schipper | – | – | – | – | – | – | – | – | – | 12.5 | – | 18.2 | 1.7 |
| ***Mucor dimorphosporus*** Lendn. | – | – | – | 10 | – | – | – | – | – | – | – | – | 0.8 |
| ***Mucor hiemalis*** Wehmer f. ***corticolus*** (Hagem) Schipper | – | – | 10 | 20 | – | 10 | 10 | – | 16.7 | 25 | 25 | 18.2 | 11.6 |
| ***Mucor hiemalis*** Wehmer f. ***hiemalis*** | 30 | 30 | 30 | 40 | – | 20 | 20 | 10 | 33.3 | 25 | 37.5 | 18.2 | 24.8 |
| ***Mucor hiemalis*** Wehmer f. ***luteus*** (Linnem.) Schipper | 10 | 10 | – | – | – | – | – | 10 | – | 12.5 | 6.3 | – | 4.1 |

| Fungi | Frequency of fungi on several localities (%) | | | | | | | | | | | | Total frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | (%) |
| ***Mucor plumbeus*** Bonord. | 10 | – | – | – | – | – | – | – | – | – | 6.3 | – | 1.7 |
| ***Mucor wosnessenskii*** Schostak. | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Pilaira anomala*** (Ces.) Schröt. | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Pilobolus crystallinus*** (F. H. Wigg.: Fr.) Tode | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Rhizopus arrhizus*** A. Fisch. | 10 | – | – | 10 | 10 | 10 | – | 20 | 33.3 | – | – | – | 6.6 |
| ***Rhizopus stolonifer*** (Ehrenb.: Fr.) Vuill. var. ***stolonifer*** | – | – | – | 20 | 10 | – | – | – | 16.7 | – | – | 18.2 | 5 |
| ***Zygorhynchus moelleri*** Vuill. | – | – | – | – | – | 10 | – | – | – | – | – | – | 0.8 |
| **ASCOMYCETES:** | | | | | | | | | | | | | |
| ***Gelasinospora tetrasperma*** Dowding | – | – | – | – | – | – | – | – | – | 12.5 | – | – | 0.8 |
| ***Pithoascus intermedius*** (C. W. Emmons et B. O. Dodge) Arx | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Sphaerodes fimicola*** (E.C.Hansen) P.F. Cannon et D. Hawksw. | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| **undetermined ascomycete** | – | – | – | – | – | – | – | – | 16.7 | – | – | – | 0.8 |
| **DEUTEROMYCETES:** | | | | | | | | | | | | | |
| ***Acremonium berkeleyanum*** (Karsten) W. Gams | – | 10 | – | – | – | 10 | – | – | – | – | – | – | 1.65 |
| ***Acremonium sp.*** | – | – | – | – | – | – | – | 20 | 16.7 | 25 | – | 9 | 5.0 |
| ***Alternaria alternata*** (Fr.: Fr.) Keissl. | – | – | – | 10 | 10 | – | – | 10 | – | – | – | 18.2 | 4.1 |
| ***Amblyosporium botrytis*** Fresen. | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Arthrinium arundinis*** (Corda) Dyko et B. Sutton | – | 10 | – | – | – | 10 | 10 | – | – | – | – | – | 2.5 |
| ***Arthrinium phaeospermum*** (Corda) M. B. Ellis | – | – | – | – | – | – | – | – | – | 12.5 | – | – | 0.8 |
| ***Aspergillus versicolor*** (Vuill.) Tirab. | – | – | – | – | – | – | – | – | – | – | – | 18.2 | 1.65 |
| ***Aureobasidium pullulans*** (de Bary) Arnaud | – | – | – | – | – | – | – | – | 16.7 | 12.5 | – | – | 1.65 |
| ***Beauveria bassiana*** (Bals.–Criv.) Vuill. | – | – | – | – | – | – | 10 | – | – | – | – | – | 0.8 |
| ***Beauveria brongniartii*** (Sacc.) Petch | 20 | – | 50 | – | 30 | 10 | – | – | – | – | – | – | 9.1 |
| ***Beauveria sp.*** | – | – | – | – | – | – | – | – | – | – | – | 18.2 | 1.65 |
| ***Botrytis cinerea*** Pers.: Fr. | – | – | – | – | – | 10 | 20 | 20 | – | 12.5 | – | 9 | 5.8 |
| ***Calcarisporium arbuscula*** Preuss | – | – | – | – | – | – | 10 | – | – | 38 | 6.3 | – | 4.1 |

| Fungi | Frequency of fungi on several localities (%) | | | | | | | | | | | | Total frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | (%) |
| ***Chloridium virescens*** (Pers.: Fr.) W. Gams et Hol.–Jech. var. ***chlamydosporum*** | – | – | – | 10 | – | – | – | – | – | – | – | – | 0.8 |
| ***Chloridium sp.*** | – | – | – | 10 | – | – | – | – | – | – | – | – | 0.8 |
| ***Cladosporium cladosporioides*** (Fresen.) de Vries | – | – | – | – | 10 | – | – | – | – | – | – | 27.3 | 3.3 |
| ***Cladosporium herbarum*** (Pers.: Fr.) Link | – | – | – | – | 10 | – | 50 | 10 | 16.7 | 12.5 | – | 18.2 | 9.1 |
| ***Cladosporium sphaerospermum*** Penz. | – | – | – | – | – | – | – | – | – | 12.5 | – | – | 0.8 |
| ***Coniella sp.*** | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Coniothyrium sp.*** | – | – | – | – | – | – | – | – | – | 12.5 | – | – | 0.8 |
| ***Cylindrocarpon destructans*** (Zinssmeister) Scholten | – | – | – | – | – | – | 10 | – | – | 25 | 18.8 | – | 5.0 |
| ***Cylindrocarpon magnusianum*** (Sacc.) Wollenw. | – | – | – | – | – | 20 | 10 | – | – | – | 12.5 | – | 4.1 |
| ***Dactylaria lanosa*** Malla et W. Gams | 20 | – | 10 | – | – | – | – | – | – | – | – | – | 2.5 |
| ***Dactylaria sp.*** | – | – | – | – | – | – | – | – | 16.7 | 25 | – | – | 2.5 |
| ***Dichobotrys sp.*** | – | – | – | 10 | – | – | – | – | – | – | – | – | 0.8 |
| ***Dinemasporium strigosum*** (Pers.: Fr.) Sacc. | – | – | – | 10 | – | – | – | – | – | – | – | – | 0.8 |
| ***Doratomyces asperulus*** Wright et Marchand | – | – | – | – | – | – | – | – | – | – | – | 9 | 0.8 |
| ***Doratomyces microsporus*** (Sacc.) F.J.Morton et G. Sm. | – | – | – | – | – | – | – | – | – | 12.5 | – | – | 0.8 |
| ***Doratomyces nanus*** (Ehrenb.: Fr.) F.J.Morton et G. Sm. | – | – | – | – | – | – | – | – | – | – | 25 | – | 3.3 |
| ***Epicoccum nigrum*** Link | – | – | 10 | – | – | – | – | – | – | 12.5 | – | – | 1.7 |
| ***Fusarium cf. croockwellense*** Burgess, Nelson et Toussoun | – | – | – | – | – | – | – | 10 | – | – | – | – | 0.8 |
| ***Fusarium solani*** (Martius) Sacc. | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Fusarium tabacinum*** (Beyma) W. Gams | – | – | – | – | – | – | – | – | – | – | 12.6 | 9 | 2.5 |
| ***Fusarium sp.*** | – | 10 | – | – | – | – | – | – | – | – | 6.3 | – | 1.7 |
| ***Graphium penicillioides*** Corda | – | – | – | – | – | – | – | – | – | – | – | 9 | 0.8 |
| ***Graphium sp.*** | – | – | – | – | – | – | – | – | – | – | 6.3 | 9 | 1.7 |
| ***Humicola fuscoatra*** Traaen | – | – | – | – | – | – | – | – | 16.7 | – | 6.3 | – | 1.7 |
| ***Humicola grisea*** Traaen | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Mariannaea elegans*** (Corda) G. Arnaud ex Samson | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Oidiodendron echinulatum*** G. L. Barron | – | – | – | – | – | – | – | – | – | – | – | 9 | 0.8 |

| Fungi | Frequency of fungi on several localities (%) | | | | | | | | | | | | Total frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | (%) |
| ***Oidiodendron sp.*** | – | – | – | – | – | – | – | – | 16.7 | – | – | – | 1.7 |
| ***Paecilomyces carneus*** (Duché et R. Heim) A.H.S.Br. et G.Sm. | – | – | – | – | – | – | – | – | – | – | 18.8 | – | 2.5 |
| ***Paecilomyces farinosus*** (Holmsk.: Fr.) A. H. S. Br. et G. Sm. | 10 | – | – | – | 10 | – | 10 | 10 | – | 37.5 | – | – | 5.8 |
| ***Papulaspora sp.*** | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Penicillium cf. aurantiogriseum*** Dierckx | – | – | – | – | – | – | – | – | – | – | – | 9 | 0.8 |
| ***Penicillium brevicompactum*** Dierckx | 10 | – | – | – | – | – | – | – | – | – | 6.3 | 9 | 2.5 |
| ***Penicillium chrysogenum*** Thom | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Penicillium citrinum*** Thom | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Penicillium coalescens*** Quintan. | – | – | – | – | – | – | – | 10 | 33.3 | – | – | 9 | 3.3 |
| ***Penicillium coprophilum*** (Berk. et M. A. Curtis) Seifert et Samson | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Penicillium crustosum*** Thom | – | – | – | – | – | – | – | – | – | – | – | 9 | 0.8 |
| ***Penicillium expansum*** Link: Fr. | – | 10 | – | – | – | – | – | 10 | – | – | 6.3 | – | 0.8 |
| ***Penicillium funiculosum*** Thom | – | 10 | – | – | – | – | – | 10 | 33.3 | – | – | – | 3.3 |
| ***Penicillium glabrum*** (Wehmer) Westling | 10 | – | – | 10 | 10 | – | – | – | 50 | 100 | – | 54.5 | 16.5 |
| ***Penicillium inflatum*** Stolk et Malla | 20 | 20 | 10 | 30 | 20 | 50 | 40 | 10 | – | 25 | 6.3 | – | 19.0 |
| ***Penicillium janczewskii*** K. M. Zalessky | – | 20 | – | – | – | – | – | – | – | – | – | – | 1.7 |
| ***Penicillium lanosum*** Westling | – | – | 10 | 20 | – | 10 | 10 | 10 | – | 12.5 | 18.8 | – | 8.3 |
| ***Penicillium lividum*** Westling | 30 | – | – | – | 10 | 20 | – | – | 16.7 | – | – | 18.2 | 7.4 |
| ***Penicillium miczynskii*** K. M. Zalessky | 20 | – | – | 10 | 20 | 10 | – | 10 | – | 25 | 6.3 | – | 8.3 |
| ***Penicillium montanense*** M. Chr. et Backus | – | – | – | – | – | – | – | 30 | 16.7 | – | – | – | 3.3 |
| ***Penicillium piceum*** Raper et Fennell | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Penicillium pulvillorum*** Turfitt | – | – | – | – | 10 | – | – | – | – | – | – | – | 0.8 |
| ***Penicillium purpurogenum*** Stoll | – | – | – | 10 | – | – | – | – | – | – | – | – | 0.8 |
| ***Penicillium restrictum*** J. C. Gilman et E. V. Abbott | – | – | – | 10 | – | – | – | 10 | – | – | – | – | 1.7 |
| ***Penicillium rubefaciens*** Quintan. | 10 | – | – | – | – | – | – | – | – | 12.5 | – | – | 1.7 |

| Fungi | Frequency of fungi on several localities (%) | | | | | | | | | | | | Total frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | (%) |
| ***Penicillium simplicissimum*** (Oudem.) Thom | 10 | – | – | – | – | – | – | 20 | – | – | – | – | 2.5 |
| ***Penicillium smithii*** Quintan. | 10 | – | – | – | – | – | – | 20 | 33.3 | – | – | 36.4 | 7.4 |
| ***Penicillium soppii*** K. M. Zalessky | – | – | – | – | – | – | – | 10 | – | – | – | – | 0.8 |
| ***Penicillium spinulosum*** Thom | 90 | 90 | 70 | 60 | 90 | 60 | 70 | 90 | – | – | 6.3 | 36.4 | 55.4 |
| ***Penicillium thomii*** Maire | 10 | – | – | – | – | – | – | 10 | 33.3 | 12.5 | – | 45.5 | 8.3 |
| ***Penicillium verruculosum*** Peyronel | – | – | – | – | – | – | – | – | 16.7 | – | – | – | 0.8 |
| ***Penicillium sp.*** (subgen. ***Furcatum)*** | – | – | – | – | – | – | – | – | – | – | 12.5 | – | 1.7 |
| ***Penicillium sp.*** (subgen. ***Penicillium)*** | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Penicillium sp.*** (subgen. ***Biverticillium)*** | – | – | – | – | – | – | – | 10 | – | – | – | 9 | 1.7 |
| ***Penicillium sp.*** | – | 10 | – | – | – | – | – | 40 | – | – | – | – | 4.1 |
| ***Phoma sp.*** | – | – | – | – | 10 | – | 10 | – | 16.7 | 12.5 | 18.8 | – | 5.8 |
| ***Scopulariopsis brevicaulis*** (Sacc.) Bainier | – | – | – | – | – | – | – | – | – | 12.5 | – | – | 0.8 |
| ***Scytalidium lignicola*** Pesante | – | – | – | 10 | – | – | – | – | – | – | – | – | 0.8 |
| ***Sepedonium sp.*** | – | – | – | – | – | – | – | – | – | – | 12.5 | – | 1.7 |
| ***Stachybotrys sp.*** | – | – | – | – | – | – | – | – | – | – | – | 9 | 0.8 |
| ***Thysanophora penicillioides*** (Roum.) W. B. Kendr. | – | – | – | – | – | – | 10 | – | – | 12.5 | – | – | 1.7 |
| ***Tolypocladium cylindrosporum*** W. Gams | 10 | 20 | – | – | 10 | – | 10 | – | – | – | – | – | 4.1 |
| ***Tolypocladium geodes*** W. Gams | – | – | 10 | – | 10 | 10 | 10 | – | – | 38 | – | – | 5.8 |
| ***Tolypocladium inflatum*** W. Gams | – | 20 | 10 | 10 | 10 | – | 20 | – | – | 12.5 | – | – | 6.6 |
| ***Trichocladium asperum*** Harz | – | 10 | 10 | – | – | – | – | – | – | 12.5 | – | – | 2.5 |
| ***Trichocladium opacum*** (Corda) S. Hughes | – | – | – | 10 | – | – | – | – | – | – | 6.3 | – | 1.7 |
| ***Trichoderma hamatum*** (Bonord.) Bainier | – | – | – | 20 | 10 | 10 | – | – | – | – | 6.3 | – | 4.1 |
| ***Trichoderma polysporum*** (Link: Fr.) Rifai | – | – | 10 | 10 | – | 20 | – | – | – | 25 | 18.8 | – | 7.4 |
| ***Trichoderma saturnisporum*** Hammill | – | – | – | – | – | 10 | – | – | – | – | – | – | 0.8 |
| ***Trichoderma viride*** Pers.: Fr. | 60 | 60 | 60 | 90 | 50 | 50 | 40 | 60 | 66.7 | 38 | 68.8 | 36.4 | 57 |
| ***Trichoderma sp.*** | 20 | 10 | – | 20 | 20 | – | – | 30 | 33.3 | 25 | 75 | 72.7 | 28.1 |
| ***Ulocladium botrytis*** Preuss | – | 10 | – | – | – | – | – | – | – | – | – | 9 | 1.7 |
| ***Verticillium bulbilosum*** W. Gams et Malla | – | – | – | – | – | – | – | 20 | – | – | – | – | 1.7 |

| Fungi | Frequency of fungi on several localities (%) | | | | | | | | | | | | Total frequency |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | (%) |
| ***Verticillium lecanii*** (Zimm.) Viégas | – | – | – | – | – | 10 | – | – | – | – | – | – | 0.8 |
| ***Verticillium luteoalbum*** (Link: Fr.) Subram. | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Verticillium psalliotae*** Treschew | 10 | – | 20 | – | – | – | 10 | – | – | 50 | – | – | 6.6 |
| ***Verticillium sp.*** | – | 10 | – | – | – | – | – | 10 | – | – | – | – | 1.7 |
| ***Volutella ciliata*** (Alb. et Schw.: Fr.) Fr. | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| ***Wardomyces humicola*** Hennebert et G. L. Barron | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| **undetermined black fungus** | – | – | – | – | – | – | – | – | 16.7 | – | – | – | 0.8 |
| **BASIDIOMYCETES:** | | | | | | | | | | | | | |
| **undetermined arthrosporic fungus** | – | – | – | – | – | – | – | – | – | – | 6.3 | – | 0.8 |
| **STERILE FUNGI:** | | | | | | | | | | | | | |
| **sterile brown mycelium** | – | – | – | – | – | – | 10 | – | – | – | – | – | 0.8 |
| **sterile dark grey mycelium** | – | – | – | – | – | – | 10 | – | – | – | – | – | 0.8 |
| **sterile dark mycelium** | 10 | – | 10 | – | – | – | – | – | 16.7 | – | 6.3 | 9 | 4.1 |
| **sterile pale mycelium** | – | – | – | – | – | – | – | – | – | 12.5 | – | – | 0.8 |
| **No. of samples** **121** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 6 | 8 | 16 | 11 | |
| **No. of taxa** **139** | 32 | 24 | 23 | 31 | 26 | 27 | 28 | 34 | 27 | 40 | 54 | 35 | |

Notes to localities:
1 = Svaroh Mt.
2 = Černé jezero Lake
3 = Jezerní hora Mt.
4 = Čertovo jezero Lake
5 = Laka Lake
6 = Ždanidla Mt.
7 = Roklanská smrčina spruce forest.
8 = Mlynářská slať mire
9 = Jezerní slať mire
10 = Spring of Teplá Vltava river
11 = Medvědice
12 = Mrtvý luh mire

(1) Methods of examination. Cultivation methods enable to isolate only a part of saprotrophic fungi occurring in soil. A choice of isolation media is also important.

(2) Extent of study, on numbers of soil samples examined.

(3) Undoubtedly, on opinion and knowledge of investigators. At present, species of the genera *Penicillium, Trichoderma, Fusarium,* etc. are still very difficult to determine by conventional methods because morphological features are not often clear cut and may overlap.

For these reasons, the present study is considered as partial contribution to the biodiversity of studied area. More detailed study will be needed to evaluate total fungal biodiversity.

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## References

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

KUBÁTOVÁ A. & PRÁŠIL K., 1993: Půdní mikromycety (askomycety a jejich anamorfy) [Soil micromycetes (Ascomycetes and anamorphs]. *In: J. Váňa (ed.): Biodiverzita přírodních ekosystémů Šumavy. Zpráva o výsledcích projektu (grant 124/FDR) za rok 1993, p. 41–49. Ms., project report, Charles university, Prague. (in Czech).*

KUBÁTOVÁ A. & VÁŇOVÁ M., 1997: Půdní mikromycety [Soil micromycetes]. *In: J. Váňa (ed.): Program GEF – Ochrana biodiverzity v České republice. Závěrečná zpráva. Název projektu: Centra biologické diverzity v biosférické rezervaci Šumava, p. 54–61. Ms., project report, Charles university, Prague. (in Czech).*

KUBÁTOVÁ A., VÁŇOVÁ M. & PRÁŠIL K., 1994: Biodiverzita saprofytických mikromycetů vybraných šumavských lokalit [Biodiversity of saprophytic micromycetes of several localities of Šumava Mts.]. *In: J. Váňa (ed.): Biodiverzita přírodních ekosystémů Šumavy (referenční plochy pro management biosférické rezervace UNESCO). Zpráva o výsledcích projektu (grant 40757/FDR) za rok 1994, p. 14–30. Ms., project report, Charles university, Prague. (in Czech).*

PRÁŠIL K. & RÉBLOVÁ M., 1998: Biodiversity of selected ascomycetes groups in the Šumava Mountains. *Silva Gabreta, 2. (this volume).*

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.*

VÁŇOVÁ M., 1993: Půdní mikromycety (Zygomycetes) [Soil micromycetes (Zygomycetes)]. *In: J. Váňa (ed.): Biodivezita přírodních ekosystémů Šumavy. Zpráva o výsledcích projektu (grant 124/FDR) za rok 1993, p. 50–51. Ms., project report, Charles university, Prague. (in Czech).*