Project “Protection, Economic Development and Promotion of Eco Tourism in Mavrovo National Park”

# Fungi of National Park Mavrovo

## Final Report

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# Contents

# 1. Introduction

In view of the mycological data available to date, in the Republic of Macedonia much systematic fungi research remains to be conducted. Nonetheless, in recent years a clear picture of mycobiota in certain regions of the country (Pelister Mt., Jakupica Mt., Galichica Mt., Kozhuv Mt., Shar Planina Mt., Ograzhden, Jablanica Mt. etc) has been produced.

The first data on the fungal diversity of Mavrovo NP area have been published by Lindtner (1932), Pilát (1936-1942), Pilát & Lindtner (1938, 1939) Litschauer (1939), Pilát (1953), Grujoska (1970), Grujoska & Papazov (1974) and Tortic (1982, 1983 & 1988). The research was continued by Karadelev (2000, 2009) and Karadelev & Rusevska (2004) where the emphasis was laid on lignicolous macromycetes, although terricolous fungi were also collected.

Hence, for the purposes of this project, the valorisation of Mavrovo NP was performed on the basis of the best-studied macromycetes fungi. These include the majority of the species of the class Basidiomycetes and a substantial number of representatives of the classes Ascomycetes (orders Pezizales, Helotiales, and a part of Sphaeriales) and Myxomycetes of the division Myxomycota. Reference is made to other fungal groups in the case of analysis of rare species and substrates.

The investigation of macrofungi on Mavrovo NP within the project was done in the period between March 2010 and November 2010. The purpose of the research was to establish the qualitative - quantitative structure of terricolous and lignicolous (wood-inhabiting) fungi in different forest biocenoses in Mavrovo NP

The research was conducted in two stages as follows: first, field research activities in the studied area aiming at collection of mycological material; second, laboratory analyses of the material collected.

*Phase 1 – Field Research Activities*

This phase consisted of collection of mycological material in order to prepare a collection of species growing in the forest associations, and also in meadows and alpine pastures. These research activities covered localities of different climate and vegetation features so as to achieve greater variety of the structure of species of the fungi collected. The following localities were visited:

**Lake Mavrovo area**: vill. Mavrovo, Mavrovi Anovi, r. Mavrovska Reka, vill. Nikiforovo, vill. Leunovo, Bunec, vill. Kichinica, Kozha Mt., Jasterbec, vill. Vrben.

**River Radika (upper course)**: vill. Brodec, vill. Krakornica, vill. Bogdevo, Sostav, Pilana, Strezimir, Adzina Reka, vill. Nichpur, Torbeshki Most, Shtirovica.

**Bistra Mt.**: vill. Sence, Barich, vill. Volkovija, vill. Belichica, Toni Voda, Churkov Dol, vill. Galichnik, Carevec, vill. Rosoki, vill. Selce, vill. Sushica, r. Garska Reka, St. Jovan Bigorski Monastery, r. Tresonechka Reka, Elenski Skok, vill. Tresonche, Koritnik, Bachilishte, Dzigelica, Krtulj.

**Korab Mt.**: vill. Nistrovo, vill. Bibaj, r. Ribnichka Reka, vill. Ribnica, vill. Tanushe, vill. Grekaj, vill. Nivishte, Karaula, Kishevica.

**Deshat Mt.:** vill. Trebište, Korija, Lokuf, vill. Žirovnica, Brezna, vill. Rostushe, vill. Bitushe, vill. Velebrdo, vill. Skudrinje.

For the purpose of achieving greater diversity of species, research was conducted on different substrates both on deciduous and coniferous trees. Thus, the largest number of species were collected on *Fagus, Quercus, Salix, Alnus* and *Populus*, whereas as far as coniferous species are concerned the material was collected on *Abies* and *Picea*. The determination of the species was performed during the field research and in the Mycological Laboratory within the Institute of Biology, Faculty of Natural Science, Skopje, microscopically, by using reagents. Certain species were identified while still in a fresh condition (*Agaricales*), and the others were to undergo further laboratory analyses.

*Phase 2 – Laboratory Activities*

Laboratory activities comprised the following:

- Identification of terricolous and lignicolous species of fungi collected during field research;
- Identification of lignicolous species of fungi from the collection Fungi Macedonici.

For identification of species standard methods were used, implying microscoping, application of reagents (Melzer reagents, Sulphovanilin, Cotton blau, KOH, etc.) and use of special books for identification. The following keys and monographs were used as resources for determination of the collected fungi: Alessio (1985); Moser (1983); Breitenbach & Kränzlin (1981, 1986, 1991, 1995, 2000);

Jülich (1984); Ryvarden & Gilbertson (1993-1994); Eriksson & Ryvarden (1975); Eriksson, Hjortstam & Ryvarden (1973-1984); Pegler, Spooner & Young (1993); Corfixen et al. (1997); Däncke (2001); Heilmann-Clausen, Verbeken & Vesterhold (1998); Krieglsteiner (2000); Ahti et al. (2000); Neubert, Nowotny & Baumann (1993) and Pegler, Roberts & Spooner (1997). The identification of species was executed in the Mycological Laboratory at the Institute of Biology within the Faculty of Natural Science and Mathematics in Skopje, the Republic of Macedonia. The representative species were preserved and deposited in the existing national myco-collection (MCF – Macedonian Collection of Fungi) at the Mycological Laboratory of the Institute of Biology within the Faculty of Natural Science and Mathematics in Skopje. A data input were made in specially prepared database software called MACFUNGI.

## 2. Review of Fungi Research in the Area

Based on research to date, 1,200 macromycetes species have been recorded in the Republic of Macedonia. In comparison with data from other European countries, this figure is minor. In view of ecological circumstances, approximately 4,000 macro-mycetes species should be found in the Republic of Macedonia. In total there are approximately 660 fungi species known from the area of Mavrovo NP but that is a result both of collected material that has not been unidentified yet as well as the insufficient research in the past.

This list for the Mavrovo NP was compiled on the basis of published data by Suleymani & Karadelev (2009); Karadelev (2000); Karadelev & Rusevska (2004); Pilát (1953); Litschauer (1939); Pilát & Lindtner (1938, 1939); Pilát (1936-1942); Pilát (1937); Lindtner (1932); Grujoska (1970); Grujoska & Papazov (1974); Tortic (1982, 1983 & 1988); project report result from Orlandini (2009) and recently identified species (2010) by the present author. The data from the Macedonian collection of fungi (MCF) database were also included in the list. The number of species published by different authors for the territory of the Mavrovo NP is as follows:[1]

1. Lindtner (1932) - 1 species
2. Pilát (1936-42) – 4 species

[1] See Annex I for more information.

3. Pilát (1937) - 9 species
4. Pilát & Lindtner (1938) - 52 species
5. Pilát & Lindtner (1939) - 8 species
6. Litschauer (1939) - 2 species
7. Pilát (1953) - 1 species
8. Grujoska (1970) - 16 species
9. Grujoska & Papazov (1974) - 3 species
10. Tortic (1982) - 2 species
11. Tortic (1983) - 1 species
12. Tortic (1988) - 144 species
13. Karadelev (2000) - 124 species
14. Karadelev & Rusevska (2004) – 223 species
15. Suleymani & Karadelev (2009) - 156 species
16. Orlandini (2009 - project report) - 145 species
17. Karadelev (MCF database & recently identified) - 383 species

The survey conducted from the second half of April 2010 to early November 2010 on more than fifty localities on the territory of the national park, also includes citation of the unpublished records on species collected in Lake Mavrovo area and Korab mountain up till now, exsiccates deposited in different collections, research notes of the present authors, other individual collectors, and data from field research trips organised by Macedonian Mycological Society (MMS), Biology Students' Research Society (BSRS), students' field research trips, etc. Many specimens collected in Macedonia have been deposited in the following collections: Botanical Department, Faculty of Science in Zagreb (ZA), National History Museum in Belgrade (BEO), and National Museum Prague (PRM). The data from the personal fungarium of M. Karadelev have been included in the National Collection of Fungi – (MCF), housed at the Institute of Biology, Faculty of Natural Science, Ss Cyril and Methodius University in Skopje.

The listed species were predominantly found by the present author during long years of research. A small number of specimens were brought from various places by several other collectors. Rarely noted species are generally considered as rare. The main difficulty in investigating the occurrence and distribution of fungal species is that they cannot be recognised while in a vegetative state; the mycelium may grow for years in soil or in wood but the species can be identified only when it produces

carpophores. The carpophores may be perennial or coriaceous and long-lasting, which can therefore be found often, or short-lived and developing at a particular time in the year and can be recorded only if the right person comes to the right place at the right time. Some fungi fructify every season; others in intervals of several years. Many species are rather small or even inconspicuous and easily overlooked in the field. Since most of them cannot be recognised without a microscope, the result may be that one has collected a dozen or more specimens of one and the same species, and very probably missed several others.

Currently, Mavrovo NP is one of the richest areas in fungi species in Macedonia.

## 3. Inventory of Fungi Species in Mavrovo NP

There are a total of 660 fungi species known from Mavrovo NP, 256 of which are lignicolous, and 404 are terricolous. As the aspect of macrofungi changes with seasons, many species now missing in one or more localities will certainly be found there during more intensive research. The largest number of species, 585, belong to the phylum Basidiomycota, 69 species belong to Ascomycota, and 12 species to Myxomycota. Of this number, 101 species have been recorded for the first time in the area of Mavrovo National Park, while 53 species are new data for the mycota of the Republic of Macedonia.

| | |
|---|---|
| Total number of fungi species recorded in Mavrovo NP | 660 |
| Number of species from literature | 374 |
| New species for MNP (project results) | 101 |
| New species for Macedonia | 53 |

The aforementioned data underline that Mavrovo National Park is the only known locality in the country for 53 macromycetes. Part of the registered species are incorporated in the European Red List of threatened macromycetes (Ing 1993), then in the Preliminary Red List of Fungi of the Republic of Macedonia (Karadelev 2000); they are candidates for protection within the Bern Convention; they are part of the red lists of the neighbouring regions or included in other lists of important or threatened species.

| List of special interest | № of species from MNP |
|---|---|
| European Red List | 39 |
| Preliminary Red List of Fungi of Macedonia | 20 |
| Appendix I Bern Convention | 1 |
| ECCF Atlas of 50 threatened European species | 4 |
| Globally significant species | 19 |
| Key species | 63 |
| "Top species" | 10 |

A full list of macromycetes recorded in Mavrovo NP is provided in Annex II. The list of new fungal species for the Republic of Macedonia, comprising all detailed data on the individual finds is provided in Annex V, while the list of new species for MNP is provided in Annex III. The poisonous and comestible species of fungi known from MNP are provided in Annex IV.

## 3. 1. Fungi Species from Mavrovo NP on European Fungi Red List [2]

| № | Species | Category |
|---|---|---|
| 1. | Amanita caesarea | D |
| 2. | Astraeus hygrometricus | C |
| 3. | Battarraea phalloides | D |
| 4. | Boletus aereus | C |
| 5. | Boletus appendiculatus | C |
| 6. | Boletus fechtneri | B |
| 7. | Boletus queletii | B |
| 8. | Boletus rhodoxanthus | A |
| 9. | Boletus satanas | A |
| 10. | Caloscypha fulgens | C |
| 11. | Clavariadelphus truncatus | D |

[2] Bruno Ing (1993). Toward a Red List of Endangered European Macrofungi. Royal Botanic Gardens, Kew, 231-237.

| | |
|---|---|
| 12. Cortinarius bulliardii | B |
| 13. Cudonia circinans | C |
| 14. Dentipellis fragilis | C |
| 15. Dichomitus campestris | C |
| 16. Ganoderma resinaceum | C |
| 17. Geastrum nanum | B |
| 18. Geastrum triplex | D |
| 19. Hygrocybe punicea | C |
| 20. Hygrophorus poetarum | D |
| 21. Hygrophorus pudorinus | B |
| 22. Inonotus hispidus | C |
| 23. Ishnoderma resinosum | C |
| 24. Lactarius violascens | C |
| 25. Leucopaxillus gentianeus | C |
| 26. Lycoperdon mammaeforme | C |
| 27. Mutinus caninus | C |
| 28. Omphalotus olearius | C |
| 29. Onnia tomentosa | B |
| 30. Phelodon melaleucus | C |
| 31. Phelodon niger | B |
| 32. Phylloporus pelletieri | B |
| 33. Pisolithus arhizus | C |
| 34. Ramaria botrytis | C |
| 35. Ramaria formosa | C |
| 36. Sarcodon leucopus | C |
| 37. Terrana caerulea | C |
| 38. Tricholoma aurantium | B |
| 39. Volvariella caesiotincta | C |

**Categories:**

A - Widespread losses, rapidly declining populations, many national extinctions, high level concern;

B - Widespread losses, evidence of steady decline, some national extinctions, medium level concern;

C - Widespread, but scattered populations, fewer extinctions, lower-level concern;

D - Local losses, some extinctions but mainly at edge of geographical range.

**Amanita caesarea**

**Bistra Mt**., vill. Selce, Golubarnik, X-0519152, Y-4637158, (1177), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 02.10.2010, (leg. et det. M. Karadelev).

**Astraeus hygrometricus**

**Korab Mt**., vill. Bibaj, X-0469061, Y-4620008, (1200), fir forest, 030.06.2010, (leg. et det. M. Karadelev).

**Battarraea phalloides**

**River Radika (course),** near St. Jovan Bigorski Monastery (Lindtner 1932, Tortic 1988) – probably extinct.

**Boletus aereus**

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 02.10.2010, (leg. et det. M. Karadelev).

**Boletus appendiculatus**

**Bistra Mt**., vill. Selce, Golubarnik, X-0519152, Y-4637158, (1177), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Boletus fechtneri**

**Bistra Mt**., vill. Galichnik (Karadelev & Rusevska 2004).

**Boletus queletii**

**Deshat Mt**., above vill. Bitushe (Karadelev & Rusevska 2004).

**Lake Mavrovo area**, Bunec (Karadelev 2000).

**Bistra Mt.**, vill. Tresonche (Karadelev & Rusevska 2004).

**Bistra Mt**., vill. Lazaropole (MCF data).

**Bistra Mt**., Krtulj, X-0471559, Y-4600125, (1420), beech forest, 10.10.2010, (leg. et det. M. Karadelev).

**Boletus rhodoxanthus**

**Bistra Mt**., Krtulj, X-0471559, Y-4600125, (1420), beech forest, 10.10.2010, (leg. et det. M. Karadelev).

**Boletus satanas**

**Lake Mavrovo area**, Bunec (Karadelev 2000; Karadelev & al. 2004).

**Caloscypha fulgens**

**River Radika (upper course),** Adzina Reka X-0472350, Y-4630005, (1595), mixed spruce and fir forest, 19.06.2010, (leg. et det. M. Karadelev).

**Lake Mavrovo area**: vill. Vrben, X-0477090, Y-4617999, (1350), fir forest, 13.05.2010, (leg. et det. M. Karadelev).

**Bistra Mt**., vill. Volkovija, X-0472008, Y-4617692, (1246), fir forest, 13.05.2010, (leg. et det. M. Karadelev).

**Clavariadelphus truncatus**

**Bistra Mt**., vill. Volkovija, X-0472008, Y-4617692, (1246), fir forest, 11.10.2010, (leg. et det. M. Karadelev).

**Cortinarius bulliardii**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Cudonia circinans**

**River Radika (upper course),** Adzina Reka X-0472795, Y-4630183, (1527), mixed spruce and fir forest, 11.10.2010, (leg. et det. M. Karadelev).

**Dentipellis fragilis**

**Bistra Mt**., between Korotnik and Bachilishte (MCF database).

**Korab Mt**., Kishevica, X-0470084, Y-4617783, (1092), mixed deciduous forest, 18.09.2010, (leg. et det. M. Karadelev).

**Dichomitus campestris**

**Bistra Mt**., vill. Selce, Golubarnik, X-0519152, Y-4637158, (1177), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Deshat Mt.:** vill Rostushe, pine plantings, X-0464429, Y-4607542, (1196), 19.09.2010, (leg. et det. M. Karadelev).

**Bistra Mt**., Dzigelica, X-0475538, Y-4601963, (1224), oak forest, 02.10.2010, (leg. et det. M. Karadelev).

**Ganoderma resinaceum**

**Bistra Mt**., along Tresonecka Reka (MCF database).

**Geastrum nanum**

**Bistra Mt**., vill. Lazaropole (Karadelev & Stojanovska 2002-2003, Karadelev & Rusevska 2004).

**Geastrum triplex**

**Lake Mavrovo area**, Bunec (Karadelev 2000, Karadelev & Stojanovska 2002-2003).

**Hygrocybe punicea**

**Bistra Mt**., vill. Galichnik (MCF database).

**Hygrophorus poetarum**

**Lake Mavrovo area**, Bunec (MCF database).

**Hygrophorus pudorinus**

**River Radika (upper course),** Adzina Reka X-0472795, Y-4630183, (1527), mixed spruce and fir forest, 11.10.2010, (leg. et det. M. Karadelev).

**Inonotus hispidus**

**River Radika (course),** near St. Jovan Bigorski Monastery (MCF database).

**Ishnoderma resinosum**

**Bistra Mt**., vill. Volkovija, X-0472008, Y-4617692, (1246), fir forest, 13.05.2010, (leg. et det. M. Karadelev).

**Lactarius violascens**

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 10.10.2010, (leg. et det. M. Karadelev)

**Leucopaxillus gentaineus**

**River Radika (upper course),** Adzina Reka X-0472795, Y-4630183, (1527), mixed spruce and fir forest, 11.10.2010, (leg. et det. M. Karadelev).

**Lycoperdon mammaeforme**

**Bistra Mt**., vill. Selce, Golubarnik, X-0519152, Y-4637158, (1177), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Mutinus caninus**

**Bistra Mt**., vill. Lazaropole (MCF database).

**Omphalotus olearius**

**Bistra Mt**., vill. Selce, Golubarnik, X-0519152, Y-4637158, (1177), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Onnia tomentosa**

**Bistra Mt**., vill. Sence (MCF database).

**Phelodon melaleucus**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Phelodon niger**

**Lake Mavrovo area**, vill Mavrovo. (MCF database).

**Phylloporus pelletieri**

**Bistra Mt.**, vill. Lazaropole (Karadelev, Rusevska & Spasikova 2007).

**Pisolithus arhizus**

**Bistra Mt.**, vill. Tresonche (above), (Karadelev, Rusevska, Miteva, Stojkoska 2003; Karadelev & Rusevska 2004).

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Ramaria botrytis**

**Bistra Mt.**, vill. Selce, Golubarnik, X-0519152, Y-4637158, (1177), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Ramaria formosa**

**River Radika (upper course),** vill. Nichpur, X-0472543, Y-4621201, (1166), oak forest, 29.06.2010, (leg. et det. M. Karadelev).

**Sarcodon leucopus**

**Deshat Mt.:** vill. Rostushe, pine plantings, X-0464429, Y-4607542, (1196), 10.10.2010, (leg. et det. M. Karadelev).

**Terrana caerulea**

**River Radika (course),** St. Jovan Bigorski Monastery, near the bridge, (716), azonal forest, 19.10.2010.

**Tricholoma aurantium**

**Lake Mavrovo area**, vill. Mavrovo, (MCF database).

**Volvariella caesiotincta**

**Deshat Mt.:** vill. Bitushe, (MCF database).

## 3. 2. Fungi Species from Mavrovo NP Included in Preliminary Red List of Macedonia[3]

| N° | Species | Category |
|---|---|---|
| 1. | Agaricus macrosporus | EXP |
| 2. | Amanita caesarea | EXP |
| 3. | Amylostereum areolatum | RH |
| 4. | Battarea phalloides | RH |
| 5. | Boletus fechtneri | EXP |
| 6. | Boletus pulverulentus | RS |
| 7. | Boletus rhodoxanthus | RS |
| 8. | Boletus satanas | EXP |
| 9. | Calvatia gigantea | RS |
| 10. | Craterellus cornucopioides | EXP |
| 11. | Exidia pithya | RH |
| 12. | Hirneola auricula judae | RV |
| 13. | Macrolepiota procera | EXP |
| 14. | Metulodontia nivea | RS |
| 15. | Mutinus caninus | RS |
| 16. | Peniophora junipericola | RH |
| 17. | Phellinus robustus | RH |
| 18. | Porostereum spadiceum | RS |
| 19. | Rigidoporus undatus | RS |
| 20. | Tremella folliacea | RS |

Categories:

RS - especially rare or rare species in Macedonia

RH - species growing in endangered or rare habitats

EXP - especially rare or rare species in Macedonia, threatened due to excessive exploitation

[3] Karadelev, M., 2000. Preliminary Red List of Macrofungi in the Republic of Macedonia. European Council of Conservation of Fungi, Newsletter 10, 7-11.

**Agaricus macrosporus**

**Bistra Mt**., vill. Galichnik (Karadelev 1999; Karadelev 2000; Karadelev 2001; Peric, Karadelev & Tkalcec 2001; Karadelev & Rusevska 2004).

**Deshat Mt.:** vill. Zhirovnica, Brezna, X-0465114, Y-4612848, (1125), beech forest, 3.10.2010, (leg. et det. M. Karadelev).

**Amanita caesarea**

**Bistra Mt**., vill. Selce, Golubarnik, X-0519152, Y-4637158, (1177), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 02.10.2010, (leg. et det. M. Karadelev).

**Amylostereum areolatum**

**River Radika (upper course),** Adzina Reka (Tortic 1988).

**Battarraea phalloides**

**River Radika (course),** near St. Jovan Bigorski Monastery (Lindtner 1932, Tortic 1988) – probably extinct.

**Boletus aereus**

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 02.10.2010, (leg. et det. M. Karadelev).

**Boletus fechtneri**

**Bistra Mt**., vill. Galichnik (Karadelev & Rusevska 2004).

**Boletus pulverulentus**

**Lake Mavrovo area**, Bunec (Tortic 1988).

**Boletus rhodoxanthus**

**Bistra Mt**., Krtulj, X-0471559, Y-4600125, (1420), beech forest, 10.10.2010, (leg. et det. M. Karadelev).

**Boletus satanas**

**Lake Mavrovo area**, Bunec (Karadelev 2000; Karadelev & al. 2004).

**Calvatia gigantea**

**Bistra Mt**., vill. Galichnik (Karadelev, Miteva & Stojkoska 2004).

**Craterellus cornucopioides**

**Bistra Mt**., vill. Lazaropole (MCF database)

**Lake Mavrovo area**, Bunec (MCF database)

**Deshat Mt**., above vill. Bitushe (MCF database);

**Lake Mavrovo area**, Bunec (Karadelev 2000; Karadelev & Rusevska 2004)

**Bistra Mt**., vill. Tresonche (MCF database).

**Exidia pithya**

**River Radika (upper course),** Adzina Reka (Tortic 1988).

**River Radika (upper course),** Adzina Reka X-0472795, Y-4630183, (1527), mixed spruce and fir forest,01.07.2010, (leg. et det. M. Karadelev).

**Hirneola auricula judae**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 02.10.2010 & 10.10.2010, (leg. et det. M. Karadelev).

**Macrolepiota procera**

**Lake Mavrovo area**, vill. Vrben (MCF data).

**Bistra Mt.**, vill. Galichnik (Karadelev & Rusevska 2004).

**Lake Mavrovo area**, Bunec (Karadelev 2000, Karadelev & Rusevska 2004).

**Bistra Mt**., vill. Lazaropole (Karadelev & Rusevska 2004).

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 02.10.2010, (leg. et det. M. Karadelev).

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Lake Mavrovo area**: vill. Vrben, X-0477090, Y-4617999, (1350), fir forest, 13.05.2010, (leg. et det. M. Karadelev).

**Deshat Mt.:** vill. Bitushe, beech forest, X-0464429, Y-4607542, (1196), beech forest, 19.09.2010, (leg. et det. M. Karadelev).

**Metulodontia nivea**

**River Radika (upper course),** above vill. Nichpur, 1450 m a.s.l., 24.07.1935, on branch of Abies, leg. V. Lindtner, det. V. Litschauer, rev. E. Parmasto, coll. BEO/PRM (Pilat & Lindtner 1938, Tortic 1988).

**Mutinus caninus**

**Bistra Mt.**, vill. Lazaropole (MCF data);

**River Radika (upper course),** vill. Nichpur, 1400 m a.s.l., July 1937, mixed forest, leg. et det. M. Tortic, (Tortic 1988).

**Peniophora junipericola**

**Bistra Mt**., vill. Lazaropole (Karadelev & Rusevska 2004).

**Lake Mavrovo area**: vill. Vrben, X-0477090, Y-4617999, (1350), fir forest, 13.05.2010, (leg. et det. M. Karadelev).

**Phellinus robustus**

**River Radika (upper course),** vill. Nichpur, X-0472543, Y-4621201, (1166), oak forest, 29.06.2010, (leg. et det. M. Karadelev).

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Porostereum spadiceum**

**Lake Mavrovo area**, Bunec (Tortic 1988).

**Rigidoporus undatus**

**Bistra Mt.**, vill. Tresonche (MCF data).

**Tremella folliacea**

**Lake Mavrovo area**: Kozha Mt., X-0480466, Y-4620244, (1616), beech forest, 01.07.2010, (leg. et det. M. Karadelev).

## 3.3. Threatened Fungi Species from Mavrovo NP - Candidates for Listing in Appendix I of the Bern Convention[4]

| N° | Species |
|---|---|
| 1. | Phylloporus pelletieri |

**Phylloporus pelletieri**

**Bistra Mt.**, vill. Lazaropole (Karadelev, Rusevska & Spasikova 2007).

**Fig. 1** *Phylloporus pelletieri*, a very rare fungal species known only from MNP.

## 3.4. Threatened Fungi Species from Mavrovo NP included in ECCF Atlas of 50 Threatened European Species[5]

| N° | Species |
|---|---|

[4] 33 Threatened Fungi in Europe: http://www.artdata.slu.se/Bern_Fungi/ECCF%2033_T-PVS%20%282001%29%2034%20rev_low%20resolution_p%201-14.pdf

[5] Otto, P. (2002). Mapping and Monitoring of Threatened fungi in Europe, ECCF – European Council for Conservation of Fungi in Europe.

| | |
|---|---|
| 1. | Amanita caesarea |
| 2. | Battarraea phalloides |
| 3. | Phylloporus pelletieri |
| 4. | Pisolithus arhizus |

**Amanita caesarea**

**Bistra Mt**., vill. Selce, Golubarnik, X-0519152, Y-4637158, (1177), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 02.10.2010, (leg. et det. M. Karadelev).

Photo: Matthias Theiss

**Fig. 2** *Amanita caesarea* (Jajcharka), an economically important species in MNP.

**Battarraea phalloides**

**River Radika (course),** near St. Jovan Bigorski Monastery (Lindtner 1932, Tortic 1988) – probably extinct.

**Fig. 3** *Battarraea phalloide*s, a probably extinct species from MNP area.

**Phylloporus pelletieri**

**Bistra Mt.**, vill. Lazaropole (Karadelev, Rusevska & Spasikova 2007).

**Pisolithus arhizus**

**Bistra Mt.**, vill. Tresonche (above), (Karadelev, Rusevska, Miteva & Stojkoska 2003; Karadelev & Rusevska 2004).

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

Photo: Matthias Theiss

**Fig. 4** *Pisolithus arhizus*, a rare and threatened species in Europe.

## 3.5. Macrofungi Known Only from the Area of Mavrovo NP in Macedonia (MCF database)

| Species | | Data sources |
|---|---|---|
| 1. Amylostereum | areolatum | Tortic (1988) |
| 2. Athelopsis | glaucina | Pilát & Lindtner (1938), Tortic (1988) |
| 3. Bovista | pusilla | Karadelev (2000), Karadelev & Rusevska (2004), Suleymani & Karadelev (2009) |
| 4. Cortinarius | elegantissimus | Suleymani & Karadelev (2009) |
| 5. Exidia | umbrinella | Pilát & Lindtner (1938), Tortic (1988) |
| 6. Intextomyces | contiguus | Pilát & Lindtner (1938), Tortic (1988) |
| 7. Lycoperdon | spadiceum | Pilát & Lindtner (1939), Tortic (1988) |
| 8. Lycoperdon | ericetorum | Pilát & Lindtner (1939), Tortic (1988) |
| 9. Metulodontia | nivea | Pilát & Lindtner (1938), Tortic (1988) |
| 10. Microglossum | viride | Suleymani & Karadelev (2009) |
| 11. Peziza | varia | Karadelev & Rusevska (2004) |

| | | |
|---|---|---|
| 12. Pholiota | adiposa | Karadelev & Rusevska (2004) |
| 13. Tomentella | spongiosa | Litschauer (1939), Tortic (1988) |
| 14. Tomentella | hoehnelii | Litschauer (1939), Tortic (1988) |
| 15. Tyromyces | chioneus | Karadelev & Rusevska (2004) |

**Amylostereum areolatum**

**River Radika (upper course),** Adzina Reka (Tortic 1988).

**Athelopsis glaucina**

**River Radika (upper course),** vill. Nichpur, (Pilát & Lindtner 1938, Tortic 1988).

**Bovista pusilla**

**Bistra Mt.**, vill. Lazaropole (Karadelev 2000, Karadelev & Rusevska 2004, Suleymani & Karadelev 2009).

**Cortinarius elegantissimus**

**Lake Mavrovo area**: Bunec (Suleymani & Karadelev 2009).

**Exidia umbrinella**

**River Radika (upper course),** vill. Nichpur, (Pilát & Lindtner 1938, Tortic 1988).

**Intextomyces contiguous**

**River Radika (upper course),** vill. Nichpur, (Pilát & Lindtner 1938, Tortic 1988).

**Lycoperdon spadiceum**

**River Radika (upper course),** vill. Nichpur, (Pilát & Lindtner 1938, Tortic 1988).

**Lycoperdon ericetorum**

**River Radika (upper course),** vill. Nichpur, (Pilát & Lindtner 1938, Tortic 1988).

**Metulodontia nivea**

**River Radika (upper course),** vill. Nichpur, (Pilát & Lindtner 1938, Tortic 1988).

**Microglossum viride**

**Lake Mavrovo area**: Bunec (Suleymani & Karadelev 2009).

**Peziza varia**

**Bistra Mt.**, vill. Lazaropole (Karadelev & Rusevska 2004).

**Pholiota adiposa**

**Bistra Mt.**, vill. Lazaropole (Karadelev & Rusevska 2004).

**Tomentella spongiosa**

**River Radika (upper course),** vill. Nichpur, (Litschauer 1939, Tortic 1988).

**Tomentella hoehnelii**

**River Radika (upper course),** vill. Nichpur, (Litschauer 1939, Tortic 1988).

**Tyromyces chioneus**

**Bistra Mt.**, vill. Lazaropole (Karadelev & Rusevska 2004).

## 3.6. New Fungi Species for Macedonia Recorded for the First Time from Mavrovo NP in 2009-2010 (project result)

| N° | Species | |
|---|---|---|
| 1. | Agaricus | langei |
| 2. | Aureoboletus | gentilis |
| 3. | Bertia | moriformis |
| 4. | Boidinia | furfuracea |
| 5. | Calocera | furcata |
| 6. | Calocybe | carnea |
| 7. | Ciboria | batschiana |
| 8. | Clavaria | tenuipes |
| 9. | Clitocybe | phaeophthalma |
| 10. | Conocybe | palydospora |
| 11. | Conocybe | pilosella |
| 12. | Cortinarius | brunneofulvus |
| 13. | Cortinarius | cephalixus |
| 14. | Cortinarius | diabolicus |
| 15. | Cortinarius | magicus |
| 16. | Cortinarius | mussivus |
| 17. | Cortinarius | nanceinensis |
| 18. | Cortinarius | nemorensis |
| 19. | Cortinarius | pseudocyanites |

| | | |
|---|---|---|
| 20. | Cortinarius | rapaceus |
| 21. | Cortinarius | subannulatus |
| 22. | Cortinarius | torvus |
| 23. | Cortinarius | azureus |
| 24. | Cortinarius | hercynicus |
| 25. | Cortinarius | melanotus |
| 26. | Cortinarius | olidus |
| 27. | Crepidotus | epibryus |
| 28. | Cudonia | circinans |
| 29. | Dasiscyphus | acuum |
| 30. | Dasyscyphus | tenuissimus |
| 31. | Dictydiaethalium | plumbeum |
| 32. | Didymium | bahiense |
| 33. | Femsjonia | pezizaeformis |
| 34. | Hygrocybe | russocoriacea |
| 35. | Hygrophorus | ligatus |
| 36. | Hymenoscyphus | fructigenus |
| 37. | Hypomyces | aurantius |
| 38. | Lactarius | picinus |
| 39. | Lasiospaeria | spermoides |
| 40. | Pachyella | violaceonigra |
| 41. | Phellodon | connatus |
| 42. | Polyporus | tuberaster |
| 43. | Ramaria | fennica |
| 44. | Russula | risigallina |
| 45. | Russula | azurea |
| 46. | Russula | parazurea |
| 47. | Rutstroemia | firma |
| 48. | Sarcodon | leucopus |
| 49. | Stemonitis | splendens |
| 50. | Trichia | decipiens |
| 51. | Trichia | scabra |

| | | |
|---|---|---|
| 52. | Xerocomus | leonis |
| 53. | Xerula | melanotricha |

**Agaricus langei**

**River Radika (upper course),** Mihailova Livada, X-0474219, Y-4620776, (1504), meadow, 28.08.2009, (leg. et det. C.Orlandini).

**Aureoboletus gentilis**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Bertia moriformis**

**Bistra Mt.**, vill. Lazaropole X-0473727, Y-4598227, (1370), beech forest, 18.07.2010, (leg. et det. M. Karadelev).

**Boidinia furfuracea**

**River Radika (upper course),** Adzina Reka X-0472350, Y-4630005, (1595), mixed spruce and fir forest, 19.06.2010, (leg. et det. M. Karadelev).

**Calocera furcata**

**River Radika (upper course),** Shtirovica, X-0468203, Y-4628405, (1440), meadow, 25.08.2009, (leg. et det. C.Orlandini).

**Calocybe carnea**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Ciboria batschiana**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Clavaria tenuipes**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Clitocybe phaeophthalma**

**Deshat Mt.:** vill. Zhirovnica, Brezna, X-0465114, Y-4612848, (1125), beech forest, 3.10.2010, (leg. et det. M. Karadelev).

**Conocybe palydospora**

**Bistra Mt.**, Dzigelica, X-0475538, Y-4601963, (1224), oak forest, 02.10.2010, (leg. et det. M. Karadelev).

**Conocybe pilosella**

**Bistra Mt**., vill. Sushica, Crveni Krasti, X-0471559, Y-4600125, (1420), beech forest, 02.10.2010, (leg. et det. M. Karadelev).

**Cortinarius brunneofulvus**

**Deshat Mt.:** vill. Zhirovnica, Brezna, X-0465114, Y-4612848, (1125), beech forest, 3.10.2010, (leg. et det. M. Karadelev).

**Cortinarius cephalixus**

**Bistra Mt**., vill. Volkovija, X-0472008, Y-4617692, (1260), fir forest, 11.10.2010, (leg. et det. M. Karadelev).

**Cortinarius diabolicus**

**Deshat Mt.:** vill. Zhirovnica, Brezna, X-0465114, Y-4612848, (1125), beech forest, 3.10.2010, (leg. et det. M. Karadelev).

**Cortinarius magicus**

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 10.10.2010, (leg. et det. M. Karadelev).

**Cortinarius mussivus**

**Bistra Mt**., vill. Volkovija, X-0472008, Y-4617692, (1260), fir forest, 11.10.2010, (leg. et det. M. Karadelev).

**Cortinarius nanceinensis**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Cortinarius nemorensis**

**Lake Mavrovo area**: Kozha Mt., X-0480775, Y-4620226, (1694), beech-fir forest, 26.08.2009, (leg. et det. C.Orlandini).

**Cortinarius pseudocyanites**

**Deshat Mt.:** vill. Zhirovnica, Brezna, X-0465114, Y-4612848, (1125), beech forest, 3.10.2010, (leg. et det. M. Karadelev).

**Cortinarius rapaceus**

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 10.10.2010, (leg. et det. M. Karadelev).

**Cortinarius subannulatus**

**River Radika (upper course),** Adzina Reka X-0473679, Y-4625794, (1513), mixed spruce and fir forest, 11.10.2010, (leg. et det. M. Karadelev).

**Cortinarius torvus**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Cortinarius azureus**

**Deshat Mt.:** vill. Zhirovnica, Brezna, X-0465114, Y-4612848, (1125), beech forest, 3.10.2010, (leg. et det. M. Karadelev).

**Cortinarius hercynicus**

**Lake Mavrovo Area**, vill. Vrben, X-0477372, Y-4618619, (1329), meadow, 14.10.2009, (leg. et det. C.Orlandini).

**Cortinarius melanotus**

**Bistra Mt.**, vill. Volkovija, X-0473487, Y-4617639, (1201), meadow, 9.10.2009, (leg. et det. C.Orlandini).

**Cortinarius olidus**

**Deshat Mt.:** vill. Zhirovnica, Brezna, X-0465114, Y-4612848, (1125), beech forest, 3.10.2010, (leg. et det. M. Karadelev).

**Crepidotus epibryus**

**Korab Mt**., Kishevica, X-0470084, Y-4617783, (1092), mixed deciduous forest, 18.09.2010, (leg. et det. M. Karadelev).

**Cudonia circinans**

**River Radika (upper course),** Adzina Reka X-0473679, Y-4625794, (1513), mixed spruce and fir forest, 11.10.2010, (leg. et det. M. Karadelev).

**Dasiscyphus acuum**

**River Radika (upper course),** Adzina Reka X-0472778, Y-4630155, (1570), mixed spruce and fir forest, 1.07.2010, (leg. et det. M. Karadelev).

**Dasyscyphus tenuissimus**

**Bistra Mt**., vill. Sushica, X-0471559, Y-4600125, (1420), beech forest, 02.10.2010, (leg. et det. M. Karadelev).

**Dictydiaethalium plumbeum**

**Deshat Mt.:** vill Rostushe, pine plantings, X-0464429, Y-4607542, (1196), 19.09.2010, (leg. et det. M. Karadelev).

**Didymium bahiense**

**Korab Mt**., Kishevica, X-0470084, Y-4617783, (1092), mixed deciduous forest, 18.09.2010, (leg. et det. M. Karadelev)

**Femsjonia pezizaeformis**

**Korab Mt**., vill. Bibaj, X-0469061, Y-4620008, (1200), fir forest, 30.06.2010, (leg. et det. M. Karadelev).

**Hygrocybe russocoriacea**

**Lake Mavrovo Area**, vill. Vrben, X-0477372, Y-4618619, (1329), meadow, 14.10.2009, (leg. et det. C.Orlandini).

**Hygrophorus ligatus**

**Deshat Mt.:** vill. Rostushe, pine plantings, X-0464429, Y-4607542, (1196), 19.09.2010, (leg. et det. M. Karadelev).

**Hymenoscyphus fructigenus**

**Korab Mt**., vill. Tanushe, Melnik, X-0465317, Y-4616986, (1553), beech forest, 30.06.2010, (leg. et det. M. Karadelev).

**Hypomyces aurantius**

**River Radika (upper course),** Adzina Reka X-0472778, Y-4630155, (1570), mixed spruce and fir forest, 1.07.2010, (leg. et det. M. Karadelev).

**Lactarius picinus**

**Korab Mt**., Kishevica, X-0470084, Y-4617783, (1092), mixed deciduous forest, 18.09.2010, (leg. et det. M. Karadelev).

**Lasiospaeria spermoides**

**Lake Mavrovo Area,** Petti kilometar, X-0474189, Y-4619668, (1554), beech forest, 19.06.2010, (leg. et det. M. Karadelev).

**Pachyella violaceonigra**

**Korab Mt**., Kishevica, X-0469918, Y-4618193, (974), mixed deciduous forest, 18.09.2010, (leg. et det. M. Karadelev).

**Fig. 5** *Pachyella violaceonigra*, a new species for Macedonia

**Phellodon connatus**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Polyporus tuberaster**

**Korab Mt**., Kishevica, X-0470084, Y-4617783, (1092), fir forest, 18.09.2010, (leg. et det. M. Karadelev).

**Ramaria fennica**

**Lake Mavrovo Area**, vill. Vrben, X-0477372, Y-4618619, (1329), meadow, 14.10.2009, (leg. et det. C.Orlandini).

**Russula risigallina**

**Korab Mt**., vill. Tanushe, Melnik, X-0464602, Y-4617784, (1351), beech forest, 22.08.2009, (leg. et det. C.Orlandini).

**Russula azurea**

**Lake Mavrovo Area**, vill. Vrben, X-0474800, Y-4619813, (1642), beech forest, 8.10.2009, (leg. et det. C.Orlandini).

**Russula parazurea**

**River Radika (upper course),** vill. Bogdevo, X-0475801, Y-4621500, (1495), beech forest, 23.08.2009, (leg. et det. M. Karadelev).

**Rutstroemia firma**

**Bistra Mt.**, vill. Rosoki (above), X-0475155, Y-4601599, (1010), oak forest, 10.10.2010, (leg. et det. M. Karadelev).

**Fig. 6** Sarcodon leucopus, a new species for Macedonia.

**Sarcodon leucopus**

**Deshat Mt.:** vill Rostushe, pine plantings, X-0464429, Y-4607542, (1196), 10.10.2010, (leg. et det. M. Karadelev).

**Stemonitis splendens**

**Korab Mt**., Kishevica, X-0469918, Y-4618193, (974), mixed deciduous forest, 18.09.2010, (leg. et det. M. Karadelev).

**Trichia decipiens**

**Lake Mavrovo area**: Kozha Mt., X-0480466, Y-4620244, (1616), beech-fir forest, 1.07.2010, (leg. et det. M. Karadelev).

**Trichia scabra**

**Korab Mt**., Kishevica, X-0470084, Y-4617783, (1092), fir forest, 18.09.2010, (leg. et det. M. Karadelev).

**Xerocomus leonis**

**Deshat Mt.:** vill Rostushe, Duf waterfall, X-0466313, Y-4607542, (880), Carpinetum, 19.09.2010, (leg. et det. M. Karadelev).

**Xerula melanotricha**

**Bistra Mt**., vill. Volkovija, X-0472008, Y-4617692, (1260), fir forest, 11.10.2010, (leg. et det. M. Karadelev).

## 3.7. Species from Mavrovo NP with Globally Significant Status

| N° | Species |
|---|---|
| 1. | Aleurodiscus disciformis |
| 2. | Amanita caesarea |
| 3. | Astraeus hygrometricus |
| 4. | Battarraea phalloides |
| 5. | Boletus aereus |
| 6. | Boletus appendiculatus |
| 7. | Boletus impolitus |
| 8. | Boletus rhodoxanthus |
| 9. | Boletus satanas |
| 10. | Clavariadelphus truncatus |
| 11. | Cortinarius bulliardii |
| 12. | Dentipellis fragilis |
| 13. | Lactarius violascens |
| 14. | Lycoperdon mammaeforme |
| 15. | Phelodon melaleucus |
| 16. | Phelodon niger |
| 17. | Phylloporus pelletieri |
| 18. | Pisolithus arhizus |
| 19. | Sarcodon leucopus |

**Species with globally significant status** – These are internationally signify-cant species**,** which have found satisfactory conditions for growth in MNP and their

optimal areal or most of its population is located here. These are species included in conservation programmes worldwide (European Red List of threatened macromycetes, the Bern Convention, and European Council for Conservation of Fungi).

### 3.8. Key Species from Mavrovo NP

1. Agaricus langei
2. Amanita caesarea
3. Aureoboletus gentilis
4. Battarraea phalloides
5. Boidinia furfuracea
6. Boletus aereus
7. Boletus appendiculatus
8. Boletus impolitus
9. Boletus rhodoxanthus
10. Boletus satanas
11. Calocera furcata
12. Calocybe carnea
13. Caloscypha fulgens
14. Ciboria batschiana
15. Clavaria tenuipes
16. Clavariadelphus truncatus
17. Conocybe palydospora
18. Conocybe pilosella
19. Cortinarius bulliardii
20. Cortinarius brunneofulvus
21. Cortinarius cephalixus
22. Cortinarius delibutus
23. Cortinarius magicus
24. Cortinarius mussivus
25. Cortinarius nanceinensis
26. Cortinarius pseudocyanites
27. Cortinarius rapaceus
28. Cortinarius subannulatus
29. Cortinarius torvus
30. Cortinarius azureus
31. Cortinarius hercynicus
32. Cortinarius melanotus
33. Cortinarius olidus
34. Crepidotus epibryus
35. Hericium coralloides
36. Dasiscyphus acuum
37. Dictydiaethalium plumbeum
38. Didymium bahiense
39. Globulicium hiemale
40. Hygrophorus ligatus
41. Hypomyces aurantius
42. Intextomyces contiguus
43. Lactarius violascens
44. Lactarius picinus
45. Lycoperdon mammaeforme
46. Omphalotus olearius
47. Pachyella violaceonigra
48. Phellodon connatus
49. Phelodon melaleucus
50. Phelodon niger
51. Phylloporus pelletieri
52. Pisolithus arhizus
53. Pluteus thomsonii
54. Polyporus ciliatus
55. Ramaria fennica
56. Russula azurea

57. Russula parazurea
58. Rutstroemia firma
59. Sarcodon leucopus
60. Terrana caerulea
61. Tricholoma pessundatum
62. Xerocomus leonis
63. Xerula melanotricha

**Key species** - There are a number of criteria to be met for selection of these macromycetes species in MNP and assessment of their significance. It is a must that these species meet the criterion of falling into one of the following groups:

- Globally significant species
- Threatened species (threatened in Macedonia or on a global level)
- Types of indicators (species indicating a preserved habitat, sensitive species, or specific species growing in old forest ecosystems unaffected by anthropogenic influence)
- Prime Mushrooms Areas selected species (see below)
- Economically significant species.

**Fig.7** *Phelodon melaleucus,* a key species from MNP, Rosoki, oak wood.

**Fig. 8** *Pluteus thomsonii* (left) and *Aureoboletus gentilis* (right), key species from MNP.

**Top Species**

Ten of the key species have been selected as top species, primarily on the basis of the identifiability criterion, which implies that NP officials involved in monitoring, assessment, and undertaking of measures can easily identify the species. These are species of larger dimensions, distinctive colour or form, and difficult to replace with similar species. The top ten species in MNP are as follows:

*Amanita caesarea*
*Battarraea phalloides*
*Boletus aereus*
*Boletus appendiculatus*
*Boletus rhodoxanthus*
*Boletus satanas*
*Clavariadelphus truncatus*
*Cortinarius bulliardii*
*Hericium coralloides*
*Pisolithus arhizus*

**Fig. 9** *Hericium coralloides,* a top species from MNP, Adzina Reka, on fir.

## 4. Species and Habitats Analysis

There are a total of about 660 fungi species known from Mavrovo NP, 256 of which are lignicolous, and 404 are terricolous. As the aspect of macrofungi changes with seasons, many species now missing in one or more localities will certainly be found there during more intensive research.

The largest number of species, 585, belongs to Basidiomycota (24 are from Gasteromycetes), 63 species belong to Ascomycota, and 12 species to Myxomycota. Of the lignicolous species, the main part was collected on *Fagus* (124), *Abies* (41), *Picea* (19) and *Quercus* (79). A few species were collected on *Alnus, Salix, Populus*, on mushrooms fruiting body, etc. As far as the terricolous species are concerned, the greatest number of them were collected in two beech associations (*Calamintho grandiflorae-Fagetum* and *Festuco heterophyllae-Fagetum*), oak associations (*Quercetum frainetto-cerris* and *Orno-Quercetum petraeae*), beech and fir associations (*Abieti-Fagetum* and *Fago-Abieteteum meridionale),* and spruce association (*Abieti-Piceetum scardicum*), which are the best studied forests in the mountain.

The most common species were as follows: *Agaricus campestris, A.macrosporus, Amanita rubescens, Armillaria mellea, Boletus aestivalis, B.edulis, Bovista plumbea, Cantharellus cibarius, Diatrype disciformis, Diatrype stigma, Hebeloma sinapizans, Laccaria laccata, Lactarius piperatus, Lepista nuda, Lycoperdon perlatum, Marasmius oreades, Mycena pura, Panellus stypticus, Peniophora quercina, Polyporus arcularius, Russula cyanoxantha, Schizopora paradoxa, Stereum hirsutum, Trametes hirsuta, Trametes versicolor, Vuilleminia comedens* and *Xerula radicata.*

The largest number of species, 267, is known from the beech forests, 103 species were collected in fir forest, 128 in oak forest, 63 in spruce forest, 47 in different forest associations developing along the rivers and streams (azonal types), and 51 species in planted pine forests. Outside the forest communities, 38 species are known from mountain and alpine pastures, and 45 species were collected in the meadows, at forest edge, etc.

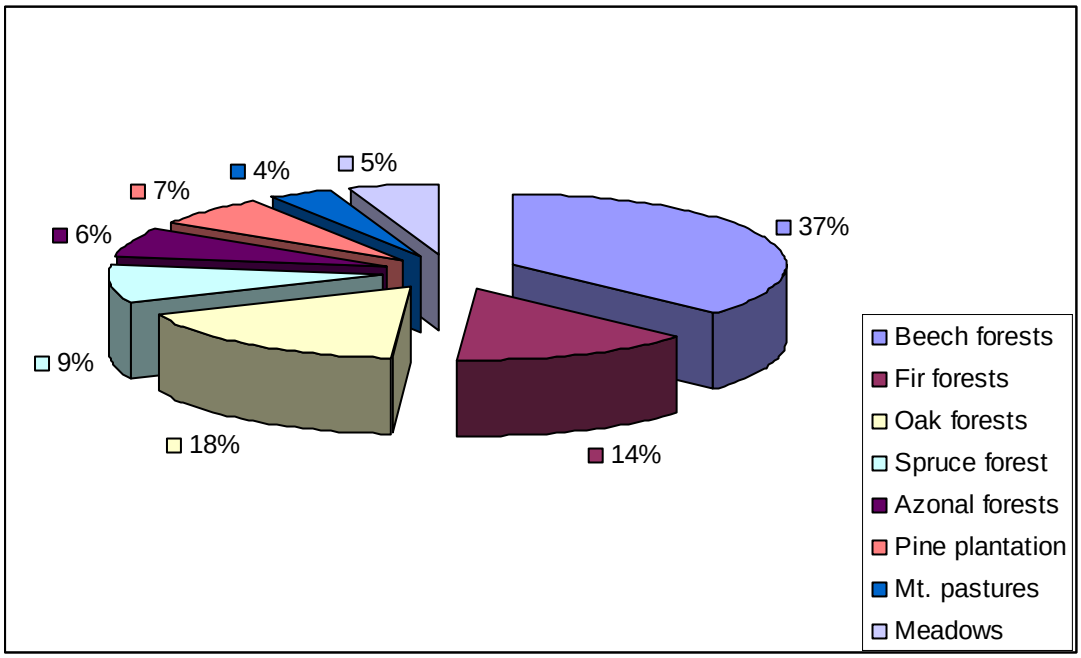


**Fig. 10** Participation of fungal species in different forest communities and habitat types in Mavrovo NP.

***Beech (and fir) forests***

The fungi data primarily refer to the clean beech associations (*Festuco heterophyllae-Fagetum* and *Calamintho grandiflorae-Fagetum*) in the area of the villages: Brodec, Galichnik, Lazaropole, Nistrovo, Ribnica, Zhirovnica, Tanushe, then the localities Kishevica, Kozha Mt. etc., at the altitude 1000 – 1,800 m; 267 species are known from these forests, 128 of which were lignicolous, and 139 terricolous. Of the lignicolous species, the main part were collected on *Fagus silvatica*.

Part of the recorded species, such as *Bertia moriformis, Fomes fomentarius, Inonotus nodulosus, Laxitextum bicolour, Marasmius alliaceus, Mycena renatii, Sterem insignitum, S.rugosum* and *Xerula radicata* are rather characteristic species of beech. The most common species were as follows: *Amanita rubescens, Armillaria mellea, Diatrype disciformis, Diatrype stigma, Laccaria laccata, Lactarius piperatus, Lycoperdon perlatum, Mycena pura, Mycena rosea, Panellus stypticus, Russula cyanoxantha, Schizopora paradoxa, Stereum hirsutum, Trametes hirsuta, Trametes versicolor* and *Xerula radicata*. Certain species such as *Amanita citrina, Cortinarius brunneofulvus, Hygrophorus chrysodon, Lactarius blenius, Lactarius palidus, Lactarius piperatus, Lactarius volemus, Russula alutacea, Russula aurea, Russula cyanoxantha, Russula solaris, R. ochroleuca* and *Tricholoma sulphureum* are mycorrhizal fungi known to associate with beech. The rest of the species are saprobes.

It is particularly important to highlight the parasitic species on the most frequent tree representatives in beech associations on Mavrovo NP. These are the following species: *Armillariella mellea, Ganoderma applanatum, Fomes fomentarius, Polyporus squamosus, Laetiporus sulphureus* and *Trametes gibbosa.* The species *Ganoderma applanatum, Polyporus squamosus, Trametes gibbosa* and *Fomes fomentarius* are established only as parasites on beech trunks.

The mixed beech and fir associations (*Abieti-Fagetum macedonicum* and *Fago-Abieteteum meridionale*) are also very rich in fungi (103 species) due to the presence of mycorrhizal fungi with *Abies.* There are data only from the associations developing on the areas of Volkovija village, Vrben village, around Lake Mavrovo and Kozha Mt. The greatest part of the registered species were saprobes growing on soil, dry branches, stumps, and logs of fir. The following species can be pinpointed as the most common and specific: *Amylostereum chailletii, Caloscypha fulgens, Cortinarius cephalixus, Cortinarius delibutus, Cortinarius mussivus, Cortinarius melanotus, Otidea abietina, Trichaptum abietinum, Phlebia quelletii,* and *Xerula melanotricha*. Particularly important parasitic species on fir in the studied area were as follows: *Armillaria mellea, Heterobasidion annosum, Phellinus hartigii* and *Fomitopsis pinicola.*

**Fig. 11** *Phellinus hartigii*, a dangerous parasite on fir.

***Spruce forests***

In the area of the upper course of Radika River (Adzina Reka) there is a well-developed fir-spruce mixed forest (*Abieti-Piceetum scardicum).* This small area is rich in fungi and total of 63 species have been identified. Part of the recorded species, such as *Amylostereum areolatum, Exidia pythia, Gloeophyllum sepiarium, Hymenochaete fuliginosa, Lactarius aurantiacus, L. deterrimus, Tremiscus helvelloides* are characteristic species of spruce, while *Amylostereum chailletii, Gloeophyllum abietinum, Mycromphale perforans, Phlebia quelleti, Phellinus hartigii* and *Trichaptum abietinum* are characteristic of fir. Other species such as *Heterobasidion annosum* and *Fomitopsis pinicola* are typical of conifers and known as dangerous parasites on conifers.

**Fig. 12** *Fomitopsis pinicola*, a parasitic and saprotrophic species on conifers in MNP.

The most common species in this association were as follows: *Agaricus silvaticus, Amanita rubescens, Armillaria mellea, B.erythropus, Cantharellus cibarius, Clitocybe gibba, Hydnum repandum, Lactarius deterrimus, Lepista nuda, Mycromphale perforans, Phlebia quelleti, Stereum sanguinolentum* and *Trichaptum abietinum.* The following species can be pinpointed as particularly important and rare: *Amylostereum areolatum, Boidinia furfuracea, Caloscypha fulgens, Cortinarius sub-annulatus, C. torvus, Cudonia circinans, Dasiscyphus acuum, Dentipellis fragilis, Exidia pithya, Globulicium hiemale, Hericium coralloides* and *Hygrophorus pudori-nus.*

***Thermofilous and Supra-Mediterranean Oak Woods***

The oak associations (*Orno-Quercetum petraeae* Em 1968 and *Quercetum frainetto-cerris* Ht. 1959) are developed in the lowest part of Mavrovo NP, at an altitude between 700 and 1,100 m. The tree belt is dominated by *Quercus petraea, Q. cerris, Q. frainetto, Fraxinus ornus, Carpinus betulus* and *Acer campestre*. The main data are from the area of the localities of Rosoki village, Selce village, Sushica village, around the Tresonecka Reka river etc. A total number of 128 species are known from these forests.

In the oak forests many macromycete species, both lignicolous and terricolous, were noted. The most common species were: *Amanita caesarea, Armillaria mellea, Boletus edulis, B. aestivalis, Cantharellus cibarius, Clitocybe gibba, Craterellus cornucopioides, Hydnum repandum, Lactarius volemus, Lactarius zonarius, Lepista nebularis, L. nuda, Leccinum carpini, Russula cyanoxantha, R. vesca, R. virescens, Stereum hirsutum, Trametes hirsuta* and *T. versicolor.* Some of the species such as *Amanita crocea, Boletus aereus B. luridus, B. quelletii, B. rhodoxanthus, Lactarius volemus, L. zonarius, Russula aurea* and *R. ochroleuca* are known mycorrhizal fungi associated with oak. Some of the lignicolous species usually grow as saprobes on fallen branches, stems and stumps of oak and other deciduous trees such as: *Daedalea quercina, Dichomitus campestris, Exidia truncata, Hapalopilus rutilans, Hymenochaete rubiginosa, Radulomyces molaris, Peniophora quercina* and *Vuilleminia comedens.* Some rare species such as: *Aureoboletus gentilis, Clavaria tenuipes, Cortinarius bulliardii, Cortinarius nanceinensis, Cortinarius torvus,*

*Phellinus robustus, Phellodon connatus, Phelodon melaleucus, Pluteus thomsonii,* and *Rutstroemia firma* were collected in oak forests.

**Fig. 13** *Boletus rhodoxanthus,* a top species from MNP, Sushica, oak forest.

***Salix alba* and *Populus alba* Galleries**

The associations *Salicetum albae-fragilis* and *Salicetum eleagni* are spread along the gorge of the Radika river and its tributaries (Mavrovska Reka, Zhirovnicka Reka, Tresonechka Reka, Ribnichka Reka, etc). The tree belt is dominated by *Salix alba*, accompanied by *Salix fragilis, Salix eleagnus, Alnus glutinosa* etc. A considerable number of species (47) were collected in these associations. All of the known species were lignicolous, and they were collected as parasites and saprobes on *Salix alba* and *Alnus glutinosa.* Part of the registered species, such as *Phellinus igniarius* and *Laetiporus sulphureus* are characteristic species of *Salix.* It is particularly important to underscore the parasitic species in these associations such as the following: *Fomes fomentarius, Ganoderma applanatum, Polyporus squamosus,* and *Laetiporus sulphureus*. The species *Phellinus igniarius* is established as a dangerous parasite on *Salix alba.*

**Fig. 14** *Laetiporus sulphureus*, a parasite or saprobe on willows.

***Pine plantations***

In some places within the mountain regions of Mavrovo NP (around Rostushe village) there are plantations mainly consisting of *Pinus silvestris.* This small area is rich in fungi and a total of 51 species were identified.

Part of the recorded species, such as *Chroogomphus rutilus, Lactarius deliciosus, Russula rhodopus, Russula torulosa, Suillus luteus, S. granulatus* and *Tricholoma pessundatum* are characteristic species of pine. Other species such as *Heterobasidion annosum* and *Fomitopsis pinicola,* are typical of conifers and the former is known as a very dangerous parasite on root of conifers. The following species can be pinpointed as particularly important and rare: *Dictydiaethalium*

*plumbeum, Hygrophorus ligatus, Sarcodon leucopus, Tricholoma pessundatum* and *Xerocomus leonis.*

***High Mountain/Alpine Pastures***

Due to the extreme climate conditions, the high mountain/alpine pastures are not characterised by great diversity of fungal species. These species have to be adapted to environmental conditions such as the great differences in temperature between night and days and the intensive UV-radiation.

The fungi data primarily refer to the area above 1,600 m on the localities of Strezimir, Brodečki Most, above Adžina Reka river, Vraca, Toni Voda, Carevec, above Galichnik village etc, and 47 species, mainly terricolous, are known from these areas. The most common species are: *Agaricus campestris, A.macrosporus, Bovista plumbea, Calvatia utriformis, Cystoderma carcharias, Entoloma nitidum, Hygrocybe conica, Marasmius oreades* and *Stropharia semiglobata*, and rare species are the following: *Amylostereum laevigatum (*on *Juniperus nana), Discina parma, Hygrocybe obrussea, Xeromphalina campanella* and *Panaeolus semiovatus.*

***Meadows in the Forest Belt***

The meadows in the forest belt are characterised by great fungi species diversity (38 species), both mycorrhizal and non-mycorrhizal. The most abundant species were as follows: *Agaricus arvensis, A.campestris, A.macrosporus, Bovista plumbea, Calvatia utriformis, Hygrocybe conica, Macrolepiota procera, Stropharia semiglobata, Collybia butyracea, Laccaria laccata, Lycoperdon perlatum* and *Marasmius oreades.* Certain species such as *Lactarius blenius, Lactarius piperatus, Russula aurea, Russula cyanoxantha, Russula solaris* and *R. ochroleuca* are mycorrhizal fungi known to associate with beech. The rest of the species such as *Hygrocybe conica, Marasmius oreades, Stropharia semiglobata, Psilocybe bullacea* etc are saprobes.

**Fig. 15** *Calvatia utriformis*, a common species typical of alpine pastures.

## 4.1. Edible and Toxic Species in MNP

About twenty species of high quality edible fungi grow in Mavrovo NP area, comprising an important part of the country's biological resources. In recent years the

interest in certain fungi species as a source of economic benefit has greatly increased. Considerable amounts of fungi are collected in the forests and sold for export to Western Europe without any control. The species with the greatest demand and highest prices on the Macedonian "fungi market" are: *Amanita caesarea*, all edible boletes, especially *Boletus edulis, B.aestivalis* and *B.aereus, Cantharellus cibarius* and *Morchella* spp. of the class Ascomycetes. Some of these species are rare in the national park. All of these facts are indicative of the current uncontrolled conditions under which fungal reserves are exploited within the country.

Regarding edibility, that is to say, toxicity of fungi, the following can be ascertained: 130 species can be used for human nutrition, whereas 43 species are poisonous. Part of the edible ones, such as: *Armillaria mellea, Boletus* (*edulis, aestivalis* and *aereus*), *Cantharellus cibarius, Craterellus cornucopioides, Hydnum repandum, Macrolepiota procera, Marasmius oreades, Morchella esculenta, Lactarius deliciosus,* etc. possess excellent culinary qualities. A great concern is the fact that the species *Boletus aestivalis, B. aereus* and *B. edulis, Cantharellus cibarius, Craterellus cornucopioides, Morchella spp.* and *Lactarius deliciosus* are gathered in large quantities by the local population and are sold at mushroom-purchase points. Owing to excessive exploitation and improper collection of fruit bodies, the vitality of these species has been reduced. The rest of the edible species are collected only for personal needs, which does not have an influence on their mycodiversity. The following species of edible fungi are recommended for special attention. They are the most intensively collected, and their populations should be more carefully managed on an annual basis, with the ultimate aim of initiating stricter management regimes where and when necessary. The list of commercial and potentially commercial mushrooms in Mavrovo NP area is provided in the table below.

| **Fungi species** | **Exported species** | **Potentially commercial species** |
|---|---|---|
| *Agaricus campestris* | | * |
| *Agaricus arvensis* | | * |
| *Agaricus macrosporus* | | * |
| *Amanita caesarea* | * | * |
| *Armillaria mellea* | | * |
| *Boletus aereus* | * | |
| *Boletus aestivalis* | * | |
| *Boletus edulis* | * | |
| *Boletus regius* | | * |
| *Boletus fechtneri* | | * |
| *Cantharellus cibarius* | * | |

| | | |
|---|---|---|
| *Craterellus cornucopioides* | | * |
| *Hydnum repandum* | | * |
| *Lactarius deliciosus* | * | |
| *Lepista nuda* | | * |
| *Marasmius oreades* | * | |
| *Macrolepiota procera* | | * |
| *Morchella esculenta* | * | |
| *Pleurotus ostreatus* | | * |
| *Russula cyanoxatha* | | * |

The most common and characteristic edible fungi in the main ecosystems of Mavrovo National Park are as follows:

*I. Coniferous forest ecosystems*

1. Spruce communities: *Agaricus silvicola, Amanita rubescens, Armillaria mellea, Boletus edulis, B. erythropus, Cantharellus cibarius, Hydnum repandum, Lactarius deliciosus, Sarcodon imbricatum* and *Tricholomopsis rutilans.*
2. Fir communities: *Amanita rubescens, Boletus edulis, Cantharellus cibarius, Clitocybe gibba, Lactarius deliciosus, Lepista nuda, Sarcodon imbricatum* and *Xerocomus badius.*
3. Planted pine forest: *Cantharellus cibarius, Gyroporus castaneus, Lactarius deliciosus, Suillus granulatus* and *Tricholoma terreum.*

*II. Deciduous forest ecosystems*

1. Beech communities: *Amanita rubescens, Armillaria mellea, Boletus edulis, Clitopilus prunulus, Gyroporus castaneus, Lactarius piperatus, L. volemus, Lepista nuda, Macrolepiota rhacodes, Pleurotus ostreatus, Polyporus squamosus, Ramaria aurea, Russula cyanoxantha* and *Oudemansiella radicata.*
2. Oak communities: *Amanita caesarea, Armillaria mellea, Boletus edulis, B. aestivalis, B. aereus B. erythropus, Cantharellus cibarius, Craterellus cornucopioides, Flammulina velutipes, Hydnum repandum, Lactarius volemus, Lepista nebularis, L. nuda, Leccinum carpini, Russula cyanoxantha, R. vesca* and *R. virescens.*
3. Azonal forests: *Laetiporus sulphureus, Pleurotus ostreatus, Pleurotus pulmonarius, Agricybe cylindracea* and *Hirneola auricula judae.*

*III. Herbaceous ecosystems*

*1.* Meadow and alpine pastures: *Agaricus arvensis, A. campestris, A.macrosporus, Bovista plumbea, Calvatia utriformis, Macrolepiota procera* and *Marasmius oreades.*

Of the poisonous species (43), particularly frequent is *Amanita pantherina*, whose consumption may lead to death. There were 10 deadly poisonous species causing different syndromes, such as: *Amanita phalloides, A. verna, A. pantherina Clitocybe cerussata, C. dealbata, Cortinarius sanguineus, Galerina autumnalis, Inocybe geophylla, Lepiota castanea* and *Omphalotus olearius.* The rest of the poisonous fungi (30) are not deadly poisonous, and more common of them are: *Amanita muscaria, Boletus luridus, Hebeloma sinapizans, Lepiota cristata, Lepiota clypeolaria, Mycena pura, Mycena rosea, Paxillus involutus, Russula emetica* and *Tricholoma sulphureum.* The list of poisonous species collected in Mavrovo NP area is provided below:

| | |
|---|---|
| Albatrellus cristatus | poisonous |
| Amanita muscaria | poisonous |
| Amanita pantherina | deadly poisonous |
| Amanita phalloides | deadly poisonous |
| Amanita verna | deadly poisonous |
| Boletus satanas | poisonous |
| Boletus calopus | poisonous |
| Clitocybe phaeophthalma | poisonous |
| Clitocybe cerussata | deadly poisonous |
| Clitocybe dealbata | deadly poisonous |
| Cortinarius humicola | poisonous |
| Cortinarius sanguineus | deadly poisonous |
| Galerina autumnalis | deadly poisonous |
| Gyromitra esculenta | poisonous |
| Hebeloma sinapizans | poisonous |
| Helvella crispa | poisonous |
| Hygrophoropsis aurantiaca | poisonous |
| Hypholoma fasciculare | poisonous |
| Inocybe rimosa | poisonous |
| Inocybe amethystina | poisonous |
| Inocybe geophylla | deadly poisonous |
| Lactarius scrobiculatis | poisonous |
| Lactarius torminosus | poisonous |
| Lactarius chrysorrheus | poisonous |
| Laetiporus sulphureus | poisonous |
| Lepiota clypeolaria | poisonous |
| Lepiota cristata | poisonous |
| Lepiota castanea | deadly poisonous |

| | |
|---|---|
| Meripilus giganteus | poisonous |
| Mycena pelianthina | poisonous |
| Mycena rosea | poisonous |
| Mycena pura | poisonous |
| Omphalotus olearius | deadly poisonous |
| Paxillus involutus | poisonous |
| Pholiota squarosa | poisonous |
| Pisolithus arrhizus | poisonous |
| Psilocybe rhombispora | poisonous |
| Ramaria formosa | poisonous |
| Rhizopogon roseolus | poisonous |
| Russula emetica | poisonous |
| Tricholoma sulphureum | poisonous |
| Tricholoma bufonium | poisonous |
| Tricholoma saponaceum | poisonous |

(photo: Matthias Theiss)

**Fig. 16** *Boletus satanas* – a poisonous top species in Mavrovo NP.

## 5. Conservation Problems

The threats to the fungi in Mavrovo NP can be summarized in the following points – gaps in the knowledge of macromycetes and fragility.

### 5.1. Gaps in the Knowledge of Macromycetes

A thorough review and analysis of the mycological literature about fungal research in the area of Mavrovo NP leads to the conclusion that the available scientific information about macromycetes is rather scanty. As mycological science developed in Macedonia, the few mycologists who worked here failed to lay solid foundations for purposeful taxonomic and ecological investigations on macromycetes. These basic areas of mycology are still poorly developed with respect to macromycetes.

- ✓ Macromycetes species composition has not been studied adequately in the area. Systematic study of these fungi has been carried out for many years only in a few regions.
- ✓ Mycological studies using the stationary method have been carried out only in recent years. The latter studies have begun to provide more information on the species composition, phenology, ecotrophic structure, and productivity (the number and biomass of fruiting bodies) of macromycetes.
- ✓ A very significant gap in the exploration of macromycetes is the lack of systematic longterm studies of species composition, and the mapping of these fungi, in the nation's reserves.
- ✓ Too little is known about the species composition and productivity of the edible fungi. There is practically no scientific information on the reserves of edible fungi in the area.
- ✓ Low awareness of the public authorities on the values and importance of fungal diversity on Mavrovo NP should be stressed out.

These major gaps in knowledge present great obstacles to the creation of a science-based program for protection of fungal diversity. In order to overcome these obstacles, mycological research in the area must be intensified, and the facts about species composition and distribution of the macromycetes ascertained.

### 5.2. Fragility

Macromycetes are susceptible to different anthropogenic influences such as:

- ✓ Clearing and burning of forests rapidly alters macromycetes species composition. Some fungi groups are replaced by others in the process of secondary succession.
- ✓ Additional anthropogenic activities that threaten the survival of macromycetes and the structure of fungi in the ecosystems in Mavrovo NP include intensive collection of edible fungi.
- ✓ Pollution – based on industrial pollutants (especially acid precipitation).
- ✓ Climate change - although there are no data for climate change impact on the ecosystems in Mavrovo NP, negative influence upon certain species can be expected.
- ✓ Destruction of forest communities. Most vulnerable to these pressures are edible fungi, mycorrhizal fungi, litter saprotrophs, and species that are strictly acidophilic or calciphilic.
- ✓ Uncontrollable collection of mushrooms. There is uncontrolled collection of mushrooms, particularly *Amanita caesarea, Boletus edulis, Boletus aestivalis, Boletus aereus, Cantharellus cibarius, Lactarius deliciosus* and *Morchella* spp. Some of these species are now rare in Mavrovo NP area.

## 6. Protection Measures

The main factors of threat to fungi in Mavrovo NP are fragmentation and destruction of fungi habitats and uncontrolled collection of commercial species. The major and primary threat to fungi in Mavrovo NP is fragmentation and destruction of their habitats. The second very significant factor is the direct impact of people involved in fungi collection, which besides affecting the commercial species also has a negative effect on the populations of other species. The other factors that overall endanger fungi (climate effects, pollution and acid rain) within the park have minor impact, and their effect cannot be observed during the brief period of time during the project activities. The conservation of fungi habitats will ensure direct *in situ* protection of species. By regulating the rules of sustainable use of commercial fungal species, the mycofund of the National Park will be protected, and indirectly the entire ecosystem.

1. In order to prevent fragmentation and destruction of fungi habitats, it is essential to ensure proper fire protection, in particular in the PMA. For these areas, it is vital to impose a ban on forest exploitation along with a ban on removal of old and fallen trunks and branches where many specific and rare fungal species grow.
2. The long-term removal of fruit bodies from a small number of commercial species leads to decreased production of fruit bodies from these species, a lower degree of colonisation in new areas, genetic impoverishment and modification of the mycota composition in the forests, which eventually results in replacement of edible with inedible species. The methods of improper fungi collection, which include collection of very young fruit bodies, uprooting and damaging the mycelium, destruction of old and mature fruit bodies, treading, turning over of the soil etc lead to continuous reduction of the species composition and the quantity of fungi. Therefore, it is necessary to undertake the following protection measures:
   - Establishment of a system of recording the quantities from each commercial species aimed at obtaining relevant data for determination of the quantity from that species in different parts of the park.
   - Issuance of permits to commercial companies with strict requirements so as to prevent employment of destructive methods of fungi collection.
   - Organisation of educational courses for fungi-collectors, aimed at identification of species and sustainable fungi collection.
   - Issuance of individual permits for collection to the educated fungi-collectors.
   - Prohibition of commercial species exploitation in PMA, whereby genetic reservoirs for research will be formed, and unhindered growth and possible cultivation of these species will be enabled.
   - Limitation of commercial species exploitation in specific periods of the year with the purpose of conservation of fruit bodies in order to allow spreading of spores.
   - A percentage of the funds obtained by issuance of permits for commercial species collection ought to be earmarked for scientific research and education of collectors.

## 7. Prime Mushroom Areas

Upon completion of species inventorisation and selection and evaluation of the key species, zoning has been made within the National Park. It is of particular relevance to fungi from the aspect of mycopopulation conservation on Mavrovo NP territory. To that goal, objective and quantitative criteria have been applied in correlation with the expert arbitrary assessment. The primary criterion for identification of the Prime Mushrooms Areas (PMA) in Mavrovo NP is the high extent of diversity and number of key species in a specific area. This is the method employed to define the areas where *in situ* species protection can be enforced in their natural habitats. The selected localities are significant and representative forest ecosystems in Mavrovo NP, within the boundaries of which fungi are connected via saprotrophic, symbiotic and parasitic relations. The areas of grassy vegetation have not been taken into consideration due to the low mycodiversity and number of fungi.

The methodology of defining the PMA boundaries consists of collection of field data on species distribution and the precise locality of the finds by means of GPS satellite navigator. For the sake of exact determination and outlining of the borderlines, in addition to the distribution of a specific vegetation type, the other abiotic factors that have brought about occurrence of key species in a certain area have also been considered (exposition, altitude etc). Based on all of the above data, the following PMA have been selected:

- vill. Volkovija
- vill. Rosoki
- Adzina Reka river
- vill. Rostushe (above)

**PMA Volkovija**

Fir association (*Fago-Abietetum meridionale*) very rich in mushrooms due to the presence of mycorrhizal fungi with *Abies.*

European Red List species (ERL): *Caloscypha fulgens, Clavariadelphus truncatus and Ishnoderma resinosum.*

Macedonian Red List species (MRL): None

European Council for Conservation of Fungi Atlas (ECCF): None

New fungi species for Mavrovo NP (NSMNP): None

New fungi species for Macedonia (NSM): *Cortinarius cephalixus, Cortinarius mussivus, Cortinarius melanotus* and *Xerula melanotricha*

Globally significant species (GSS): *Clavariadelphus truncates*

Key species: *Caloscypha fulgens, Clavariadelphus truncatus, Cortinarius cephalixus, Cortinarius delibutus, Cortinarius mussivus, Cortinarius melanotus* and *Xerula melanotricha.*

## PMA Adzina Reka

Mixed fir-spruce forest (*Abieti-Piceetum scardicum),* very rich in fungi due to the presence of mycorrhizal fungi with *Abies* and *Picea*.

ERL: Caloscypha fulgens, Cudonia circinans, Hygrophorus pudorinus, Leucopaxillus gentianeus

MRL: Amylostereum areolatum, Exidia pithya

ECCF: None

NSMNP: Amylostereum areolatum

NSM: Boidinia furfuracea, Cortinarius subannulatus, Cudonia circinans, Dasiscyphus acuum and Hypomyces aurantius.

Globally significant species (GSS): None

Key species: Boidinia furfuracea, Cortinarius subannulatus, Cortinarius torvus, Globulicium hiemale, Hericium coralloides, Hypomyces aurantius, Dasiscyphus acuum, Dentipellis fragilis,

## PMA Rosoki

Oak forest (*Quercetum frainetto-cerris*) with many macromycete species, both lignicolous and terricolous.

ERL: Cortinarius bulliardii, Dichomitus campestris, Phelodon melaleucus, Pisolithus arhizus, Ramaria botrytis
MRL: Hirneola auricula judae, Macrolepiota procera, Phellinus robustus
ECCF: Pisolithus arhizus
NSMNP: None
NSM: Aureoboletus gentilis, Calocybe carnea, Ciboria batschiana, Clavaria tenuipes, Cortinarius nanceinensis, Cortinarius torvus, Phellodon connatus and Rutstroemia firma
Globally significant species (GSS): Cortinarius bulliardii, Pisolithus arhizus, Phelodon melaleucus
Key species: Aureoboletus gentilis, Boletus aereus, Calocybe carnea, Ciboria batschiana, Clavaria tenuipes, Cortinarius bulliardii, Cortinarius nanceinensis, Cortinarius torvus, Phellodon connatus, Phelodon melaleucus, Pisolithus arhizus, Pluteus thomsonii and Rutstroemia firma

**PMA Rostushe (above)**

Old pine (*Pinus nigra*) plantation very rich in mushrooms due to the presence of mycorrhizal fungi with pine.

ERL: Dichomitus campestris, Sarcodon leucopus
MRL: None
ECCF: None
NSMNP: None
NSM: Dictydiaethalium plumbeum, Hygrophorus ligatus, Sarcodon leucopus and Xerocomus leonis.
Globally significant species (GSS): Sarcodon leucopus
Key species: Dictydiaethalium plumbeum, Hygrophorus ligatus, Sarcodon leucopus Tricholoma pessundatum and Xerocomus leonis.

# 8. Recommendations

### 1. Monitoring System

Overall, the monitoring should abide by the following parameters: **i)** population density, to be defined by means of total counting i.e. census of all units regardless of the age structure and growth level; **ii)** physical distribution of units, to be determined by counting of units and groups of units articulated via the number of recorded fruit bodies; **iii)** Age structure, to be determined by means of phenological monitoring in the fructification stage, and **iv)** climate factors impact on population growth.

The data analysis will yield information concerning the abundance, variability, dynamics and threats to the population of the monitored species. The identification of the total number of fruit bodies will yield data on the population number and density. The monitoring of the said parameters will provide significant information on the fluctuation of the number, the reproductive capacity, and the physical distribution of the species. The phenological measurements will follow the fructification stage, the growth dynamics of the fruit bodies, the number of fruit bodies that reach a mature stage, and other parameters, which is important for defining the population vitality.

In the inception phase, it is necessary to commence monitoring and recording of finds from the selected 10 "top species", on which a monitoring methodology should be generated in the forthcoming period. Part of the rare and threatened species, and the commercial fungal species would be a subject of monitoring. Concerning the commercial fungal species, analysis will be conducted on their qualitative and quantitative composition as well as evaluation of the presence and quantities of purchased samples originating from the territory of the National Park. Thus, major data will be obtained as regards the economic potential of the park in relation to this activity. That is the reason why the following species (top species) should be a subject of an initial monitoring in the forthcoming period. The monitoring would cover as follows:

- Identification of the presence, distribution and condition of the *Battarraea phalloides* population, which is treated as an extinct species.
- Preparation of action plans for conservation of the population of the following rare species: *Boletus rhodoxanthus, Boletus satanas, Clavariadelphus truncatus, Cortinarius bulliardii, Hericium coralloides* and *Pisolithus arhizus;*

- Preparation of an action plan for sustainable use of the following commercial species: *Amanita caesarea, Boletus appendiculatus* and *Boletus aereus.*

2. **Qualitative research.** It is essential to ensure permanent further research into the fungi of the National Park, which will complement the inventorisation and physical distribution of the species. The plenitude of new and attractive data obtained in the course of the project implementation points to the fact that this is an area of immense mycodiversity. The findings will directly reflect upon the evaluation of certain parts of the park, and will enable paving the path for future park management.

3. **Engagement** of an ecologist or biologist aimed at qualitative biodiversity research, and analysis of the data obtained during the monitoring of the selected species within the National Park.

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