Fungi

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Abstract: Fungi represent an important component of the majority of all habitats. For the purposes of this publication because of practical reasons only the so-called makromycetes are discussed. There live about 4-5 thousands macromycetes species in the Czech Republic (CR). By the concrete endangered species of fungi it is not possible to go out from the detailed red list, because it hasn't been published yet (it will be brought out during the year 2006). For the 4th part of reds books of SR and CR only 119 endangered species were processed in detail, in the amendment to the act about the specially protected species of organisms 95 species has now been drafted.
The exalted majority of all these fungi are bound on jeopardy habitats, respectively these habitats may be characterized also by the help of the occurrence of rare or indicating fungi species. The occurrence of concrete fungi on a site is given by a broad complex of many different sorts of factor, that differ significantly from those, that determine the occurrence of e.g. vascular herbage. Some groups of fungi may be used as well detectors of the level of the naturalness of the vegetation, soil conditions, biological quality of humus, changes of the macro-, mezo- and microclimate and the stress of the environment caused by the civilization. It is necessary to look on the specificity of the biology and ecology of the fungi. The occurrence of some very scarce species of fungi in CR and the representation of macromycetes in the formation groups of habitats of CR is summarized here. In the end the most important factors, which endanger fungi currently are taken through and also the most important literature to the topic is mentioned.

Introduction

Fungi are considered as an independent kingdom. For the purposes of this catalogue only the so called macromycetes are mentioned – this means fungi with well developed sporocarps or with stromata with the size of at least 0,5 cm. Systematically this are bigger representatives of Ascomycetes and nearly all species of Basidiomycetes. The reason is that for these artificially created groups there are more detailed data available about the ecology and jeopardy of its species. There live 4-5 thousands species of macromycetes in Czech Republic. The accurate number isn't known, because a full list of flora nor a collective check-list has been processed yet. There have been only partial studies about some groups, e.g. about Gasteromycetidae and Hydnaceae or polyporuses. Concerning concrete endangered fungi species, in Czech republic it is not possible to start from a detailed red list currently, because hasn't been published yet (it is prepared, in advance there have been enlisted about 1035 macromycetes species, editors are Jan Holec and Miroslav Beran and it will be printed during the year 2006).). For the 4th part of reds books of SR and CR (Kotlaba et al., 1995) were processed only 119 endangered species of species in detail, part of them was chosen and added to the list of organisms especially protected by law (46 species, see Antonín & Bieberová 1995).

In the amendment to the act about the specially protected species of organisms has been in the first phase drafted apart from the currently listed another 54 endangered species (Holec & Beran 2004a, b), during the second phase in spring of the year 2005 was the number reduced and on the whole now there are drafted 95 species. The exalted majority of all these fungi is bound on jeopardy habitats, respectively these habitats may be characterized also by the help of the occurrence of the endangered species of fungi. To etch the situation, in the preliminary version of the red list of macromycetes CR is the total amount of 1035 species (approximately a fifth to a fourth of the whole our mycoflora macromycetes) it is divided to the categories of its jeopardy in the following way:

Table 1: Number of species of macromycetes CR in single category of endanger.
The percentual ratio means the amount of the species included in the red list, not from all species of macromycetes in CR.

Species number	Category of endangering	Legend to the category of endangering
75 (7%)	?Ex	missing taxa
217 (21%)	CR	critically endangered taxa
247 (24%)	EN	high endangered taxa
90 (9%)	VU	endangered taxa
111 (11%)	NT+LC	potentially endangered taxa + taxa exigent of paying attention in future
295 (28%)	DD	taxa, whose endanger isn't enough generally known

Indication importance of the group

Macromycetes are specific because of their presence on a locality is possible to determine only according to the occurrence of the sporocarps (by a common fieldwork it is impossible to use more exactly methods, like e.g. identification of the mycelium in the soil by the help of DNA analyses). However sporocarps grow up from the mycelium only in a certain fraction of a year and only at that time, if it is a good weather. It can also happen, that the species is on the site present in the form of a mycelium, but creates sporocarps once every two or five years (rarely are known also species, that create them once every ten or fifty years). To find the species on the site it is necessary to visit it more times within a year and a weather favorable for a fructification. At the same time it is impossible to tell, that if a species was seen on the locality lets say in the 80ies in the20th century, that it is there still today (mycelium can of itself have ended its life or the succesional changes have got on so much, that they didn't allow the species to survive). therefore it is necessary to watch the interesting localities in a long term and regularly. As far as want to use fungi as detectors of some factors of the environment, it is impossible to visit the locality only once, but it is much more suitable to record the whole vegetative season. However it is even better to monitor 3-5 seasons, this will detect also fungi creating their sporocarps only once every two or five years (rarely they are known species, that fructify once every ten or fifty years, or compensate „poor" records in years, when mushrooms „don't grow". Fungi fulfill in ecosystems a destructive function, which they accomplish in concrete cases as saprophytes, parasites or mycorrhitic symbionts (this is a very coarse division, in the single case is the situation more complicated). For their occurrence on concrete locations the most important condition presents a fitting substrate, host or mycorrhitic partner; only on the next level of the importance comes the character of the habitat. Natural factors, that affect the

occurrence of the single fungi species in the concrete habitats, are the type of vegetation, level of its naturalness, the succession stage, in which the vegetation is situated, macro-clime of the locality, mezoclime of the definite habitat, micro-clime of the concrete site and the chemical, physical and biological characteristics of the substrate (in case of soil e.g. pH, content of calcium, granularity, quantity and type of humus and so on., in case of wood e.g. content of lignin, cellulose and so on.). It is not possible to leave out the influence of interspecific competition (e.g. among the species living on wood in a concrete fallen trunk or among the mycelium of mycorrhitic species on rootlets of trees), however this influence is practically very complicated to evaluate, for it is methodologically exacting. Concerning the substrates, it is important to distinguish its type (e.g. wood, overburden humus, turf, excrements), species (e.g. *Fagus sylvatica*, a deer excrement etc.), part (e.g. trunk, branch, leaf, stem etc.), age (e.g. young trunk, dry stem of a herb), degree of decomposition (e.g. hardwood, disintegrating wood), chemical and physical properties, level of the succession of organisms in the substrate (e.g. some fungi species may enter only after other ones etc.). By a host or mycorrhitic partner very important is its species, age, ontogenetic stage, seasonal state, health, presence of other parasites, endophytes or symbiontes in the host, biochemical characteristics. It is clear, that the occurrence of a fungi on a post is given by a broad complex of many sorts of factors, that distinguish considerably from those, that determine the occurrence of e.g. vascular plants. Only few species of fungi are bound on narrowly determined vegetation units (type of associations or units on third level in the Catalogue of habitats CR, e.g. T1.2). Fungi do naturally „distinguish " rather units on level of communities or classes (in catalogue units on second level, e.g. L2) and in then they settle appropriate substrates or „look out " fitting hosts or partners. In many cases most divergent (by fungi) are not „pure" typical habitats, but ecotones between them (watercourse shores, peat-bog borders to forests, trenches along forest roads, hedgerows), patches in landscape matrix (little forest peat-bogs, springs, light spots etc.) or places affected by smaller disturbances (exposed soil in the forests with removed humus layer, hollow way shores, scenes of a fire etc.). Lapidary told, a mycologist “likes” in the landscape other places than a phytocenologist. This everything is necessary to look by the classification of the importance of concrete species of fungi for a habitat. The biggest indication importance have naturally the species with narrow or clean-cut bindings on an endangered habitat or directly endangered substrate. There is quite a number of such species, genera or even a whole phylum or narrower ecological groups between fungi. Excellent detectors of natural forests are some fungi living on wood bound on dead trunks in many different stages of decay. Natural to primeval forests, where the dead trunks are not removed, are then the only spots in the landscape, where these in principle relict species can live. However, they often demand except of the presence of a substrate often demand a well-balanced and damp mezoclimate, which can be guaranteed only in larger forests with an indiscrete forest area, without forest paths or larger forest roads. Some more sensitive species demand also an absolute continuum of vegetation, this means forests, where wood had never been artificially removed. There is a rule, that wherewith larger the forest is, thereby bigger is the chance for life of these rare species, because there are many available dead trunks or stumps in all phases of decay. On wood living fungi are in natural to primeval forests one of the most important components of native nature at all. In the mountains have survived on such locations e.g. some boreal-mountainous species, that have their refuges there. Generally it is possible to say, that presence of

rare on wood living fungi should always be a valid reason to monitor the location and to its protection. This is also valid e.g. for old trees, stumps and dead trunks in parks, avenues and on dikes of ponds, they shouldn't be removed. Mycorrhitic fungi and some other groups (e.g. genera *Bankeraceae* and *Thelephoraceae* or *Ramariaceae*) sensitively respond to negative processes, that happen in the soil (acidification, deposition of nitrogen, accumulation of raw humus). It shows especially the absence of sensitive species as *Cortinarius*, *Inocybe, Russula* or *Lactarius*. Alike respond also some saprophytic fungi relative to *Phaeocollybia* or *Gomphus clavatus*. The absence of sporocarps of mycorrhitic fungi on locations can pre-indicate the disturbance of ectomycorhitic conditions and can serve as a warning against the deterioration of the health of the host tree species. Some species of mycorrhitic fungi and partly also saprophytes are also well detectors of soil reaction, because they are bound on basic soil (basiphilous species) or directly on lime soil (calcareous species). Some groups of fungi are excellent detectors of unmanured meadows and grasslands, e.g. species from the genus *Hygrophoraceae,* Ascomycetes of the genus *Geoglossaceae, Clavariaceae* or some *Entoloma*. For rock-outcrop stands and dry grasslands of thermophyticum is the characteristic species *Geastrum, Tulostoma* and many others. Thermophyticum in Czech Republic is also for some warm-requiring (mostly Mediterranean) species the most northern region of their occurrence in Europe. At the same time there are some species of warm-requiring fungi significantly spreading to Czech republic, which validates the hypothesis of global warming. The majority of fungi have relatively extensive areas of occurrence involving one or more continents. Is it given mostly by the possibility of remote transport of spores. Endemism is therefore rare by fungi, especially in the scale of Europe. Time shows mostly, that the distribution of the species was rather imperfect generally known, and not that it was bound to any smaller region. This a also the case of *Geastrum pouzarii,* long regarded as Czech endemic species, which was not long time ago found in Switzerland. Lastly it is possible to conclude, that some species or groups of fungi can be used as well detectors of the level of naturalness of the vegetation, soil conditions, biological quality of humus, changes of macro-, mezo- and microclimate and civilization stress of the environment. It is necessary to consider the specificity of biology and ecology of the fungi (as whole or as single species).

Occurrence of most rare species of CR

Following is connected only to species listed in reds books of SR and CR (Kotlaba et al. 1995), protected species (Antonín & Bieberová 1995) and proposed for protection (Holec & Beran 2004a, b), from which stem all the data below. Many other species are also rare, but data about their ecology and distribution enlargement weren't published yet in a more available literature or weren't published at all. An important refuge for fungi bound on mountain beech-spruce-fir forest and mountain pine forests is Boubínský forest, the only locality with an occurrence of the rare species *Laurilia sulcala* and *Amylocystis lapponica* in CR. Only from Boubínský and Žofínský forest is in our country known *Pseudorhizina sphaerospora* and *Phellinus ferrugineo-fuscus*., in CR. They both are extremely rare boreal-Montane species. On old dead firs in forest Boubínský, Žofínský and Mionši (locality of the type) is bound *Phellinus pouzarii*. A rare species on bark of dead firs in firry beech forests and herb-rich beech forests is *Cyphella digitalis*.

Some locations of the most upper positions of Krkonoše-mountains are refuges for pronouncedly mountain fungi species. To them belongs e.g. *Myxomphalia marthae*, known from the vegetation of *Pinus mugo* csrubs and from supramountainous localities of climax spruce forests on locations Navorská louka, Kotel, Dvoračky and Obří důl. In the vegetation of low grasslands and lichens in the highest part of Studniční hora and Vysoké kolo grow *Entoloma alpicolum*, a prominent species of snow beds and arctoalpinous associations of *Juncion trifidi* and *Salicion herbaceae*. Evidently is a glacial relict *Entoloma fuscotomentosum*, a species known from Krkonoše, Pančavského vodopád and Labské boudy growing in erosion scratches, on exposed soil and in the seat snow smack. On the nature reserve Ranšpurk and Cahnov on the confluence of the rivers Morava and Dyje are our only localities of a species of primeval alluvial forests of *Alno-Ulmion - Omphalina discorosea*. On the same localities and in addition even on the locality Boří les near Břeclav grows the next distinguished and rare species of alluvial forests *Crepidotus crocophyllus*. A rare species of sedge-mossy and sedge-Sphagnum communities of medium positions is *Armillaria ectypa* known only of the three locations outside of protected areas. A typical warm-requiring species of xerotermic grasslands, dry grasslands and pastures on the locations Raná, Srdov, Radotínské údolí and Malá Chuchle is *Leucopaxillus lepistoides* a resembling ecology has *Floccularia straminea*, known from National nature reserve Karlštejn, Malá Chuchle and surroundings of Benátky nad Jizerou. A warm-requiring species, which has in CR its northern margin of its distribution in Europe and currently is only known from the surroundings of Roblín in Czech carst area, is *Amanita ovoidea*. Exclusively on *Quercus cerris* on the location Rendezvous near Valtice (thermophilous oak forests) grows the scarce species *Inonotus andersonii*. A very rare species is also *Endoptychum agaricoides*, an important species of sandy sites (mostly in *Corynephorion canescentis*), whose occurrence in southern Moravia (near Hodonín and Dolní Věstonice) has a relict character, because this sites are disappearing from our landscape. Interesting is the only locality of *Leucoagaricus pilatianus* in CR – Kinského gardens in Prague. This species is common in natural deciduous forests in lower positions, and also from parks and locust forests. A model example of high endangered group of underground Gasteromycetidae (whose currently distribution in CR is in addition nearly unknown) is *Melanogaster tuberiformis*. It grows in humic layers in natural deciduous and secondary coniferous forests on sandy and basic soils and is known only from Zadní Kopanina in Czech carst and from Studce near Loučeně.

List of formation groups of habitats with brief characteristics and importance for fungi

V – Streams and water bodies

There are no macromycetes growing in this habitat. From wood lying in water of torrents are known many species of Ascomycetes, that are endangered by a largely water pollution; regarding their substrate, which stems from the surrounding vegetation, it is perhaps better to assign them to the habitats lining these small watercourses.

M – Wetlands and riverine vegetation

The diversity of macromycetes isn't too large, but there live some very rare wetland species with narrow ecological bindings, especially on alive, laid or withered parts of reed, sedge, or other wetland plants, *Petasites,* etc . Next group are saprophytes on

debris or humus from decaying bodies of the mentioned plants. In both cases it is especially category M1. According to the narrow ecological bindings of many species of fungi are these habitats mycologically very important, though they are scarcely studied. A minimal importance have categories M2, M3, M4 and M6, that are for fungi not stable enough. For wetlands without occurrence of trees or shrubs is typical the absence of mycorrhitic fungi.

R – Springs and mires

as far as we look really only on springs alone without their surroundings of shrubs and trees, then their mycoflora is not very rich, but in the same way as in category M (see above) they are its part are many species with narrow ecological bindings. These are especially muscicolous and in part also sphagnicolous species (e.g. from genus *Galerina, Omphalina*) and some species of damp to sedge meadows. Peat-bogs are mycologically highly interesting habitats with the occurrence of many narrowly bound and else not growing fungi, whose occurrence has sometimes even a relict character. These are species bound on living or withering *Sphagnum* (sphagnicolous), on turf itself (turficolous), on other present mosses (muscicolous), on plants growing on the peat-bog, then hygrophilous species of terrestrial saprophytes and hygrophilous mycorrhitic fungi bound on local tree species (willow, alder, birch, *Pinus mugo, Pinus xpseudopumilio*, spruce). These ecological groups are necessary to distinguish, because each of them has in the environment of a peat-bog a different niche. Another important criterion is the altitude, when some species grow only in higher positions (raised bogs) or on the contrary in lower positions (fens and transitional mires).

S – Cliffs and boulder screes

As far as we don't mean lichenized fungi or lichens, then no macromycetes species grow on bare cliffs or stones. On their surface they can live only at that time, if it is damp and at least partly coated by a layer of humus, lichens or plants (most often a moss). Then they grow species bound on this substrate – these are therefore no specifically „rocky " fungi . Due to the number of species, these sites are poor; relatively richest are rocks and screes in damp and shady places (passes, valley bottoms, northern slopes etc.), that are covered by a rich moss vegetation, where live muscicolous fungi species. In caves we often find fungi only then, if there is some wood in it, whereon grow up often atypically -built sporocarps of common lignicolous fungi.

A - Alpine treeless habitats

A specific environment with occurrence of common psychrophile and mountain species of humus and terrestrial saprophytes and mycorrhitic symbionts of local tree species (especially *Pinus mugo*, birch, spruce and willow), but also some rare arctic-alpine species, whose occurrence has a relict character. Although the arctic-alpine mycoflora isn't in CR very rich, each of these species has a big importance for nature protection, because alpine positions in Krkonoše, Jeseníky and Kralický Sněžník are in central Europe the only isles outside of Alps and Carpathian Mountains, where such species live.

T - Secondary grasslands and heathlands
Mycologically a very important habitat, where mycorrhitic and lignicolous fungi don't grow (they have no host, or substrate), but in the group of terrestrial saprophytes there lives quite a number of important and endangered species or whole groups. These are e.g. Ascomycetes from the phylum *Geoglossaceae*, Clavariaceae, species from the phylum *Hygrophoraceae* and *Entolomataceae*, some Gasteromycetidae, especially from the phylum *Geastraceae* and many others. This category of habitats is in so heterogeneous, that it is not possible to characterize every important partial category separately. A very specific mycoflora is especially in category T1 (mainly unmanured and *Violion caninae* grasslands), T5 (typical occurrence of many psamophlous species, especially some important and rare Gasteromycetidae) and above all T3 – dry grasslands. This no forest vegetation of termophyticum hosts many rare warm-requiring and at the same time calcareous or basiphilous species, whose occurrence often has a relict character or is on its northern limit of their distribution in central Europe. Rare fungi of these habitats are ones of the most endangered in our country, because this environment is not stabile and dependent on human activities.

K – scrubs
From a mycological point of view is this again a very heterogeneous habitat, which for many
Fungi presents an appropriate environment, because it is often a ecoton among several various habitats. However, it is impossible to tell generally, that some endangered species would be directly bound on the scrubs, it is much rather a binding on local tree species (mycorrhitic and lignicolous fungi) or on varied rich humus, which stems from the scrub (terrestrial saprophytic fungi).

L – Forests
Forests are ideal habitats for the majority of macromycetes, that have here their highest diversity of all habitat types. It is the ideal environment for almost all ecological and taxonomical groups of fungi. This is given not only by a diversity of substrates and hosts, but also by a well-balanced and damp mezo- and microclimate. Mycorrhitic fungi are usually most abundant in forests with a low layer of upper humus or directly on bare or exposed soil. It is also very important, that the soil wasn't influenced by acid rain or eutrophization – this is not good for mycorrhitic fungi. Terrestrial saprophytes are most abundant on sites with a high layer of upper humus. Lignicolous fungi are one of the most important components of live nature, where are many fallen or dead trunks present. A huge importance have they in this view primeval-like forest reserves, that make up a refuge for many rare lignicolous fungi demanding not only a fit substrate, but also a specific micro-climate and a continuity of vegetation.

X - Habitats strongly influenced or created by man
Also in these habitats live some rare and endangered species of fungi. Cultural spruce or pine forests (especially on poorly or sandy soil and at the same time in the area less affected by pollutants and eutrophization) have a high diversity of mycorrhitic fungi and endangered Hydnaceae (genera *Phellodon, Hydnellum, Bankera, Sarcodon*). On ruderal places close to big cities can we find e.g. some rare Gasteromycetidae (e.g. from generus *Geastrum)*, whose occurrence has somewhat ephemeral character. With the

decline of extensively farmed fields fell back also some other Gasteromycetidae formerly present there. Mycologically very rich locality with the occurrence of many endangered species (mycorrhitic, and also lignicolous) used to be old parks, avenues or pond dikes (the dike of pond Luční near Tábor was even enunciate as a reserve, protecting rare species of fungi). Man created or changed habitats should not be underestimated; they often have a high diversity of fungi, that is given through a variety of the environment (hedgerows, undergrowth, presence of many foreign tree species) and all sorts of small disturbances (trenches, dikes, exposed soil round forest roads etc.). For instance: artificial spruce forests on calcite in Czech carst was mycologically very rich and some new species were described there (especially from the genus *Agaricus*).

Factors endangering fungi

Except natural factors is the occurrence of fungi affected also by the human activities. Many species were thanks to this activities spread into nature (e.g. some parasites, symbionts, synantropic species, species living in forest-free areas etc.), others are by this activities threatened. Most important factors, that threatens fungi, are following:

1. Global civilization stress of the environment
    - changes of soil quality (acidification, eutrofization, accumulation of raw humus, deposition of heavy metals, toxic microelements, radioactive elements) – they have a negative influence especially on mycorrhitic fungi and some soil or humus saprophytes.
    - climate changes (big fluctuations of temperature and rainfall, global warming, frequent droughts)
    - weakening of plant partners (especially tree species) by mycorrhitic fungi
    - extinction of host tree species by lignicolous fungi (e.g. local extinction of fir, elm trees etc.)

2. Direct clearance, damages or changes of sites of fungi
    - building-up of all kinds and mining of raw materials (direct destruction of sites)
    - excessive fertilization and use of many different sorts of chemicals in agriculture and forestry inclusively liming of forests (threatens especially more sensitive mycorrhitic fungi, humus and soil saprophytes)
    - compaction of soil by a heavy gadgetry
    - large-scale woodcuts, breaking down of larger forests parts (forest paths, ski slopes, forest roads), that is joined by the penetration of winds, warming, desiccation and fluctuations in microclimate
    - removing of fallen trunks from forests (it is a substrate for lignicolous species)
    - cutting old avenues, old trees in parks etc.
    - replacement of deciduous and mixed forests with a monoculture of coniferous trees
    - ingrowths of meadows (species of *Violion caninae* grasslands vanish) and dry grasslands locations of termophyticum
    - desiccation and destruction of wetlands of all kinds
3. Direct collection of sporocarps by edible macromycetes species

- it didn't cause a complete fade away of any definite fungi, because the mycelium stays in soil, but can markedly weaken or press the mycelium, which can cause a decrease of fructification (production of sporocarps)

Literature

Red book of SR a ČR and publications about protected fungi

Summarizing collective publications bearing on published or in herbarium documented data about ecology and the distribution of the endangered and scarce species of fungi in Czech Republic: Kotlaba et al. (1995), Antonín & Bieberová (1995), Holec & Beran (2004a, b). Particular data are involved e.g. in following studies: Beran & Tondl (1997), Holec (2000).

Floristic and ecologic studies

Of a huge amount of this studies we chose e.g. following: Kotlaba (1984), Papoušek (2004), Pilát (1969). Svrček (1965) summarized the situation of mycofloristic research in the former Czechoslovakia.

Mycocenologic studies

Studies focused on an analyzes of macromycetes communities were published e.g. by Fellner (1987, 1988), Holec (1997), Lepšová (1988), Winterhoff (1992).

Monographic studies about some fungi groups

This are mostly taxonomical monographs, which mostly summarize also data about the distribution and ecology of the species. Examples of those wrtitings adíla: Hrouda (1992, 1999), Pilát (1958).

Theoretical and methodical aspect of the protection of Fungi

Studies focused on this topic were published by e.g. Borovička (2002), Fellner(1985), Kotlaba (1989), Kuthan & Kotlaba (1990), Pegler et al. (1993), Šebek (1980, 1982, 1983).

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