MACROFUNGI OF THE CENTRAL BÖRZSÖNY MTS.:

FUNGISTICAL AND ECOLOGICAL CHARACTERISATION AND CONSERVATION

PhD thesis

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The applicant met the requirement of the PhD regulations of the Corvinus University of Budapest, he took into consideration all the comments and suggestions on his preliminary dissertation, thus the dissertation is accepted for the defence process.

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1. Scientific background and aims

The intensity of scientific research on the Macrofunga of Hungary is far from that of other European countries, although mycological research began in our country as long as four hundred years ago (CLUSIUS 1601). Several blank spots of our knowledge disappeared during the past long centuries; however, numerous questions are still to be answered. The number of mushroom species living in Hungary can only be estimated, and the approximated number varies within a rather wide range. Nevertheless, it is a sure fact that the Funga of Hungary is quite rich in species, even when compared to those of other European countries. This is caused principally by the special climatic features and the geographic situation of the Carpathian Basin.

Vegetative structures (i.e. mycelia) of the macrofungi are hard to investigate on field, and are only occasionally applicable for accurate species identification, thus for ecological studies we should basically rely on the occurring fruitbodies. Nevertheless, they represent only a certain stage in the life cycle of the respective species; consequently, they are not unambiguous indicators of the mycelia abundance. Although some results of previous studies based on mycelium investigations (from soil samples) have been published, few researchers apply these methods owing to the long time and sophisticated laboratory background they require.

A further difficulty of mycological studies is that the sporocarps of macrofungi disappear in a short time, so at a certain sampling occasion only a certain proportion of existing species can be detected. Beside, the remarkable variability of annual and seasonal mushroom aspects also leads to the fact that the entire macrofungal community of a given site can only be explored by repeated field works, carried out in several years. A single sampling occasion is not only insufficient, but it also conceals the possibilities of artefacts if general conclusions are tried to be drawn from it (BARKMAN 1965). According to the literature, so that to compile the (almost) complete list of fruiting mushroom species of a certain habitat, at least 7 years are required, with 8 sampling occasions in each year (PÁL-FÁM 2001). Moreover, we should note that the number of mushroom species living in a plant community usually exceeds that of the vascular plants (SILLER and MAGLÓCZKY 2002). The fungal species number is even higher if we include the microscopically observable fungal structures, since the respective techniques reveal the mycelia of much more species than those based on the macroscopic observation of the sporocarps (JONSSON et al. 1999).

The admirably diverse ecological functions of mushrooms cause further difficulties when characterizing a fungal community. We should also mention the problems of species identification in case of some taxa, as well as the continuous changes of mushroom taxonomy and of the classification of the fungal species. A further drawback is that the results of different authors are often hard to compare owing to the differing methods they applied.

Fortunately, the research on mushrooms intensified in Hungary during the past years, thus we have more and more occurrence data of an increasing number of species. Consequently, we have the possibility to analyse these data – together with new ones – with detailed statistical methods, and to characterize and compare different macrofungal communities. In addition to the intensified macro-mycological studies, the community approach becomes more and more prevalent among the Hungarian mycologists.

Rather few are Hungarian studies have been published on the habitat preference and fruiting dynamics of mushroom species. Virtually all aspects of plant indication are known in details, yet studies sparsely deal with the similar behaviour of the macrofungal species. Based on these few results, 99 Hungarian indicator species have been appointed (PÁL-FÁM et al. 2005). Similarly, rather low is the number of studies on naturalness and state of degradation that are based on both the vegetation and the funga of a certain area, and the majority of such results have been published just recently.

Today, every increasing stress is laid on nature conservation, and thus on the protection of fungal species. Protecting mushrooms raises several practical problems that never or less frequently turn up in case of plants or animals. For example, the difficulty of determining the habitats and the distribution of a certain species, or the sporadic and fluctuating fruiting. A further important difference is that *ex situ* protection cannot (or just hardly can) be applied for mushrooms. According to KOST and HAAS (1989), protection of macrofungi can only be achieved *in situ*. Due to these reasons, the most appropriate method for preserving both the species and the species diversity of mushrooms seems to be protecting them within their natural habitats.

From the macro-mycological point of view, Börzsöny Mts. can be considered as a moderately explored territory in Hungary, however, the results of several studies have not been published, yet. According to the literature, up to now 636 mushroom species were detected within this region. Although several sampling sites were delineated within these mountains for mycological studies, much more published data derive from other similar highlands of our country. Since no study focused exclusively and systematically onto the

Mycota of the Börzsöny, I have considered it an important task to investigate and evaluate the macrofungi of this region in as much details as possible.

My aims for my ten-year-long complex investigations on the macrofungal communities of the Central Börzsöny were as follows:

1. I aimed at compiling a species list, as complete as possible, of the mushrooms inhabiting the Central Börzsöny, based on own original observation records. Besides, I was to compare this with similar data deriving from both the Börzsöny and published from other regions of Hungary. (By this task I was to contribute to the mycological knowledge not only on the study area, but also the whole Hungarian Funga.) I also aimed at characterizing the area from taxonomical point of view.

2. I was to characterize all the characteristic woodland habitats of the Central Börzsöny from mycological point of view, based on functional spectra, species number, sporocarp production, community structure and species composition.

3. I aimed at evaluating the status of nature conservation of the habitats and comparing them from this point of view, on the grounds of the inhabiting macrofungi. (Consequently, I was to support nature conservation agencies for evaluating certain regions from mycological aspect.)

4. I was to compare the mushroom communities of the studied habitats based on the abundance relations and diversities.

5. I aimed at studying the correlations between macrofungal and plant communities.

6. I aimed at characterizing the fruiting dynamics of several species.

7. I was to study the degree of naturalness and degradation of the habitats based on both plant and mushroom species composition.

8. I was to characterize the habitats on the grounds of indicator mushroom species.

9. I aimed at investigating the habitat preference of macrofungal species according to the followings:

- In case of the frequent species (i.e. those having more than 14 occurrence data) I was to characterize the habitat preference in the Central Börzsöny.
- In case of some rare and endangered species I was to study their habitat preference on the grounds of their records from the Börzsöny together with those deriving from other Hungarian regions. I was also to compare my results to the habitat characteristics observed elsewhere in Europe.

2. Materials and methods

Central Börzsöny is an app. 150 km^2 wide area, bordered by the Kemence valley from North, the Kemence-Nagybörzsöny line from West, the Nagybörzsöny–Kóspallag–Szokolya line from South and the line of Szokolya–Nógrád–Diósjenő from East. It is the highest, most compact central region of the Börzsöny Mts. Its dominant base rocks are andesite and andesite tuff, rarely dacite. Exclusively some smaller areas of the rim mounts, near Nagybörzsöny and on the Szőlőhegy of Szokolya are on Leitha limestone or loam deposited during the glacial. The most widespread soil type is the slightly clayey brown forest soil, but ranker and slightly podsolic brown forest soils and lithosoils are also frequent. At higher elevations, the climate is of montane type, with 6-7 °C mean annual temperature, 700-900, or sometimes 1000 mm of mean annual rainfall (LÁNG 1955).

Central Börzsöny belongs to the vegetation zone of the closed deciduous woodlands: most parts are covered by forests. Treeless habitats established only on the steepest, south-facing slopes and on the clearings. Its flora and vegetation is characteristic of the middle mountains, yet it also has some montane character. The extended, wide beech zone is composed of calcifuge sub-montane and montane beech woodlands. In the narrow, deep valleys andesite ravine woodlands, while in the lower, widening parts hornbeam-alder riverine woodlands establish. In lower basins and on the foothills extended hornbeam-sessile oak woodlands and Turkey oak woodlands occur. Coniferous species are represented by *Picea abies* and *Larix decidua* plantations in the beech zone, and by *Pinus sylvestris* and *Pinus nigra* plantations within the zone of the oak forests. Alien deciduous trees are *Quercus rubra* and *Robinia pseudoacacia,* introduced on the marginal regions.

The studied habitats lie within and around the triangle-shaped Királyrét basin of tectonic origin, at 270-300 altitudes. The following plant associations were sampled systematically: zonal plant associations of vast extension (*Carici pilosae-Carpinetum* and *Quercetum petraeae-cerris*), edaphic plant associations (*Aegopodio-Alnetum, Luzulo nemorosae-Fagetum sylvaticae* and *Deschampsio flexuosae-Quercetum sessiliflorae*) as well as forest plantations (*Pinetum sylvestris* cultum and *Piceetum* cultum). When choosing the habitats, an important aim was to sample all the forest types that are important from macrofungal point of view, and those being characteristic of the Central Börzsöny. Besides, I also included those data in my dissertation, which I recorded during sporadic samplings within the area of the Central Börzsöny.

The extension of the minimal area for botanical investigations is known. It contains app. 85% of the vegetation. Nevertheless, no such area is delineated for sampling mushrooms, since no matter to what extension do we increase the size of the sampled area, the cumulative species number does not reach a saturation point, unless we sample the whole area of interest. Thus, I had to sample the whole habitats during my field work, so that to get as detailed information on the mushroom communities as it was possible (which was my primary aim). Since the habitats differ from each other, only abundance relations can be studied on standardised extensions. Should I studied sampling sites of the similar extension, I would have lost even 50% of the data, in case of certain habitats.

In the sampled habitats constant relevées of 500 m^2 area were designated for phyto- and mycocoenological studies. When delineating the relevées, homogenous vegetation and soil conditions of the area were important aspects.

For each species, the date and exact location of the collection and the substrate was recorded, and the localities with herbarium samples was also documented (altogether 656 pieces). These are deposited in and can be acquired from my own collection. In several cases, photos and detailed descriptions were also made of the species.

Statistical analyses were carried out with the NuCoSa software (TÓTHMÉRÉSZ 1996). Functionality groups of the species were delineated according to ARNOLDS et al. (1995). If more than one possible group were found, I decided on the bases of my own field experiences.

The existence of the fungal communities was demonstrated by dominance-diversity investigations, separately for the wood and the soil inhabiting species. Similarities and dissimilarities of the phytosociologically studied 8 habitats were examined by treating them as independent data sets. I used hierarchical clustering methods (complete linkage), applying binary comparative function (Jaccard index), which is based on the presence and absence of the species. I carried out these calculations for the soil inhabiting and wood inhabiting species separately. All the analyses were also made for the sporocarp numbers, by principal component analysis applying the quantitative distance function of Matushita.

For the evaluation and the comparison of the nature conservational values the proposed Red List of the Hungarian mushrooms (RIMÓCZI et al. 1999) was applied.

Diversity ordering was used for comparing diversities of the mushroom communities, applying the functions of Rényi, as it is recommended by TÓTHMÉRÉSZ (1997) for communities of medium or high species number. These functions were constructed based on the logarithm of the sum of the right-side dominance values. In case of the xylophagous communities, habitats with primordial community structure were also included in the diversity ordering, because mushroom communities may establish on these habitats subsequent to the cessation of forest management. In case of the soil inhabiting species, those habitats were excluded from diversity ordering that had no mushroom communities according to the dominance-diversity analysis.

Macrofungal communities (wood and soil inhabiting communities, respectively) were compared to plant communities by classification methods (Jaccard index, complete linkage), separately to the species composition of the canopy and the herb layer.

Between the May and December of 2005 and 2006, I carried out more intense sampling than in other years so that to monitor the fruiting behaviour of the species. Consequently, I had the possibility to study the fruiting dynamics and to correlate them with the rainfall data of the Királyrét.

Degree of degradation was determined in case of plant communities according to MORSCHHAUSER (1995). In contrast, for mushroom communities degree of degradation was estimated on the grounds of the proportion of endangered species.

Subsequent to the compilation of literature data on the indicator mushroom species, the evaluation of the studied habitats was made on the base of these species.

Habitat preference was investigated in case of macrofungal species with more than 14 occurrence data. The number of occurrences of a certain species within the different habitat types was considered as a single dataset. Distances were calculated applying the quantitative distance function of Matushita (for the soil and wood inhabiting species, respectively), since beside presence-absence data the number of records were also of great importance in case of each habitat. Subsequently, data were analysed by principal component and correspondence analyses.

For the habitat preference studies rare and endangered mushroom species were selected based on my own experiences gained within the Börzsöny, elsewhere in Hungary and in other European countries. For these analyses, I preferred those species of the proposed Hungarian Red List that have IUCN values 1 and 2. However, some species not included on the List, or those of IUCN value 3, were also chosen.

3. Results and discussion

1. As a result of the ten-year-long investigations (2001-2010) 613 macrofungal species have been documented from the Central Börzsöny, with 4101 occurrence data. 281 species of these are considered new for the mountains. In this way (taking previously published data into consideration) Börzsöny Mts. becomes the most explored territory in Hungary from mycological point of view, with a total number of 917 mushroom species documented.

13 species were proven to be new for the Hungarian Funga: *Cortinarius depressus, Clavulinopsis laeticolor, Exidia cartilaginea, Lepiota apatelia, Otidea abietina, Otidea felina, Pachyella celtica, Russula emeticicolor, Russula pseudoromellii, Russula sublevispora, Sistrotrema confluens, Steccherinum aridum, Tremella encephala.*

The collected species belong to 56 families of 14 orders. The largest ones are *Agaricales* (14 families, 427 species) and *Aphyllophorales* (22 families, 108 species). The most frequently found families are *Tricholomataceae*, *Russulaceae*, *Cortinariaceae* and *Boletaceae*.

2. The species-based functional spectra of the sample habitats showed unambiguous mycorrhizal dominance (characteristic to many deciduous forests in the medium high mountains) in case of the turkey oak forest, hornbeam-oak forest and the three calcifuge forest stands. High xylophage dominance was observed only in the alder forest stand. Here the percentage of mycorrhizal species was the lowest, but the values of the necrotrophic parasites were the highest amongst all the studied habitats.

The two coniferous plantations showed different functional characteristics: the Scotch pine stand was dominated by wood inhabiting saprotrophic species, while in the spruce stand the frequency of soil inhabiting saprotrophic species was the highest. In these two habitats, the soil-inhabiting saprotrophs had the highest, while the necrotrophic parasites had the lowest percentage proportion compared to the other (native) forest stands.

Summarising the experiences of several years, the functional spectra of the different habitats seems to be constant characteristics of macrofungal communities. In years with climatic conditions close to the average, the functional spectrum detected within a single year is a real and stable characteristic of a certain fungal community. The macrofungal communities of the different habitats have their own characteristic and unique functional spectra, which is relatively constant within a single year.

The functional spectra calculated on the basis of the fruitbody number of the study habitats showed higher percentage values for wood inhabiting saprotrophic species than those calculated on the grounds of species composition. However, the differences between the two spectra are highly variable.

In the majority of the habitats, the wood inhabiting species did not show community structure based on their sporocarp numbers. Unambiguous establishment of wood inhabiting communities were only observed in the hornbeam-oak and alder forests. The soil inhabiting species possessed clear community structure in all habitats, except for the alder stand and the two coniferous plantations. (In the two plantations the absence of structure may be explained by the lack of time or the presence of alien species.).

The species composition based classification of the soil inhabiting communities revealed considerable difference between the alder stand and the other study stands. Rest of the habitats was clustered into two groups. The first group contained the two coniferous stands. The other, larger one was further divided into two sub-groups: one of the two zonal communities (hornbeam-oak stand and Turkey oak stand) and the other containing the three edaphic calcifuge stands.

The wood inhabiting fungal communities were classified into two clusters based on their species sets. The first one contained the two coniferous stands, while the other was divided into two further groups: one composing of the Turkey oak and the alder stands, the other comprising of the hornbeam-oak forest and the calcifuge stands.

3. When evaluating the conservation status of the stands, I found the highest percentage proportion (app. 60%) of endangered species in the calcifuge stands. The second highest proportion (app. 50%) was observed in the stands of hornbeam-oak, Turkey oak and spruce stands, while the lowest values of endangered species were found in the alder stand (34,7%) and the Scotch pine stand (27,4%). From the 35 macrofungal species protected by law in Hungary, 8 species were documented in the Börzsöny, with 33 occurrence data.

4. The Principal Component Analysis of fruitbody numbers and species composition of the soil inhabiting species separated the two coniferous stands from the others, these two being very similar to each other. Another similar and well separated group was that of the calcifuge habitats. The alder stand was also clearly separated from the others, with no similarity with any other stands. It was difficult to evaluate the relationship between the hornbeam-oak and the Turkey oak stands: they were similar on the basis of their species composition, but different on the grounds of their fruitbody numbers. All the analyses of the wood inhabiting communities separated the two coniferous stands from the others, too. In case of the other habitats, the clusters partially changed if not the species sets but the sporocarp numbers were analysed. Turkey oak, calcifuge oak and alder stands comprised another group. The hornbeam-oak and one of the two calcifuge beech stands (Lukács-szállás) formed another separate group, the other calcifuge beech stand is somewhat separated from them.

Diversity ordering of wood inhabiting communities unambiguously demonstrated that the hornbeam-oak stand was more diverse than the alder stand, as well as the oak stand was more diverse than the three calcifuge stands, considering both the rare and the frequent species. Regarding rare species, the most diverse habitat was the hornbeam-oak stand, followed by the alder, Turkey oak, calcifuge oak, calcifuge beech (Lukács-szállás) stands, respectively, while the least diverse was the other calcifuge beech stand (Boros-hegy). Considering the frequent species, the order was: Turkey oak, calcifuge beech (Boros-hegy), hornbeam-oak, calcifuge oak, calcifuge beech (Lukács-szállás) stands, while the least diverse was the alder stand.

According to the diversity ordering of the soil inhabiting communities the hornbeam-oak stand was more diverse than the calcifuge beech (Boros-hegy) and the Turkey oak stand, and these all were more diverse than the other calcifuge beech (Lukács-szállás) stand, regarding both the rare and the frequent species. In case of rare species diversity order was as follows: calcifuge oak, hornbeam-oak, calcifuge beech (Boros-hegy), Turkey oak stands, while the least diverse was the calcifuge beech stand of Lukács-szállás. The frequent species showed the following order: hornbeam-oak, Turkey oak, calcifuge beech stand of Boros-hegy, calcifuge beech stand of Lukács-szállás, while the least diverse was the calcifuge oak stand.

5. Neither soil inhabiting nor wood inhabiting species composition showed any correlation with clustering by the species of the canopy layer. Similarly, no correlation was observed between the wood inhabiting communities and the herb layer. However, similarity was found between the classification of the soil inhabiting communities and the herb layer.

6. When examining the dynamics of fruitbody development, I found correlation between precipitation and fruitbody development, although fruiting is also affected by other environmental factors. With a time lag of one month, the fluctuation of precipitation was followed by the similar change in the number of fruiting mushroom species. However, no correlation was found between the dynamics of fruitbody numbers and precipitation.

7. Plant and fungal species composition revealed the same order of the habitats, according to their state of degradation. The two calcifuge stands (the beech stand of the Boros-hegy and the calcifuges oak stand) can be considered as undegraded, followed by the more degraded hornbeam-oak, Turkey oak and alder stands, respectively. These last three stands can be considered moderately degraded, yet in a continuously increasing degree.

8. The lowest species number and abundance of macrofungal species indicating disturbance were observed in the calcifuge oak and calcifuge beech (Boros-hegy) stands. The next group contains the two zonally developed (Turkey oak, hornbeam-oak) stands together with the alder stand, while the two most intensely disturbed habitats were the coniferous stands.

The highest proportion of species indicating naturalness was found in the calcifuge beech stand of Boros-hegy, the hornbeam-oak and alder stands. Species indicative of the natural, undisturbed stands fruited in the highest number in the hornbeam-oak stand and the calcifuge beech stand of the Boros-hegy. In the calcifuge oak stand only three such species was found, but similarly low was the number of those species indicating degradation. In the spruce stand several widespread, common species of wide ecological tolerance range fruited, which may also indicate disturbance here. These species are native to the montane spruce forests of Europe. In the Scotch pine stand only one indicator species of naturalness was found, namely *Stereum subtomentosum*. (The reason for its occurrence may have been the presence of deciduous colouring trees.) Other general species are almost identical with those of the spruce stand. From the two zonally developed stands, the hornbeam-oak stand seems to be closer to the natural state than the Turkey oak stand, based on the indicator species of naturalness.

9. Two tendencies were observed when examining the habitat preference of the frequent species (i.e. those documented by more than 15 occurrence data). The first axis can be related to the vegetation types. To the left of the axis species preferring calcifuge forests clustered, while on its right side species preferring both the calcifuges and the zonal stands also turn up. Further can be found the species of the deciduous stands, finally species preferring coniferous forests stands on the right end of the axis. The second axis can be related to the soil pH of the habitats. Species preferring the slightly acidic pH of the zonal deciduous stands are to be found at the bottom, while the species preferring the acidic soil of the spruce and the calcifuges stands are placed above.

The habitat preference of the majority of the 34 rare taxa correlated with the European habitat characteristics. Nevertheless, there were some exceptions. *Boletus pinophilus* proved to be characteristic of the acidic deciduous forests in Hungary, with no occurrence in coniferous stands. *Pluteus umbrosus* prefers undisturbed forests with appropriate amount of dead wood, and it was missing from the parks. *Tricholoma psammopus* prefers deciduous and mixed deciduous-coniferous forests in the medium high mountains of Hungary (always close to *Larix*), and it did not occur in high mountains, as mentioned in the literature. Several species proved to fruit less frequently in Hungary than in other European countries, chiefly due to the lack of optimal habitats: *Albatrellus confluens*, *Boletus pinophilus, Tremella encephala, Tricholoma aurantium*.

4. New scientific results

1. With a ten-year-long field work (2001-2010) I proved the presence of 613 macrofungal species in the Central Börzsöny, with 4101 occurrence data. Based on my own work and literature data, I compiled the macrofungal species list of the Börzsöny, with the aim of completeness.
2. I have demonstrated the presence of 281 species, which were not observed in the Börzsöny previously. Thus, the presence of altogether 917 mushroom species is proven in the mountains, so Börzsöny Mts. is actually the most explored territory in Hungary, from the macrofungal point of view.
3. In case of 13 species, my records are the first observations of their presence in Hungary (according to the respective publications). These are: *Cortinarius depressus, Clavulinopsis laeticolor*, *Exidia cartilaginea, Lepiota apatelia*, *Otidea abietina*, *Otidea felina*, *Pachyella celtica, Russula emeticicolor*, *Russula pseudoromellii*, *Russula sublevispora, Sistrotrema confluens, Steccherinum aridum, Tremella encephala*.
4. I have characterized the habitats of the Börzsöny from the aspects of macrofungal mycology, on the grounds of the functional spectra, species number, sporocarp abundance, community structure, diversity and species composition. I have confirmed the fact that functional spectra of species numbers is a relatively constant feature of the habitats. When comparing the years, I found that species number and sporocarp abundance considerably varies according to the weather, thus these cannot be considered as constant characteristics.
5. I concluded that the two coniferous (Scotch pine and spruce) stands do not have any structured mushroom communities, according to the fruitbody numbers of the wood and soil inhabiting species.
6. I evaluated the nature conservational status of the stands based on the mushroom species, and I also compared them to each other. The highest proportion (60%) of endangered species was observed in the calcifuge stands. Lowest was this percentage value in the alder (34,7%) and the Scotch pine (27,4%) stands.
7. From the 35 macrofungal species protected by law in Hungary, I documented the presence of 8 in the Börzsöny, with 33 occurrence data.

8. Based on my investigations on the fruiting dynamics, I confirmed that the number of the fruiting species follows the fluctuations of the precipitation, with a time lag of app. one month.
9. I have proved that the order of the habitats constructed on the bases of the degree of degradation is just the reverse of the order set up by the number of endangered mushroom species.
10. I investigated the habitat preference of 60 frequent species by statistical methods. In case of 34 rare species I studied the preference on the bases of occurrence data.

5. Proposals and the possibilities of practical applications

My results clearly demonstrated that the degradation of the habitats can be evaluated by mycological parameters, and these estimations are admirably similar to that made on the bases of botanical data.

The role of macrofungal species in the conservational evaluation of the habitats has increased recently. My results from the Central Börzsöny demonstrated that the protection of the calcifuge forests is reasonable, also because of their fungal values. However, these stands are not under legal protection today.

My studies confirmed that natural forest management of certain forest communities considerably increases the fungal diversity, especially that of the wood inhabiting species.

One of the most important results for the practical application is the studies on the macrofungal communities of the Pogány-Rózsás forest reserve. These works were carried out within the framework of the National Biodiversity Monitoring Programme. Annual report was submitted on these results to the Office of Nature Conservation of the Ministry of Environment and Water.

When determining the Hungarian distribution of the 35 macrofungal species put under legal protection, the authors applied also my own records from the Börzsöny Mts.

The 613 mushroom species and the 4101 occurrence data documented in my dissertation are essential contributions to the knowledge on the distribution and habitat characteristics of the Hungarian macrofungi. Moreover, the presented data – together with several other publications – represent a base for the revision of the Red List of the Hungarian mushrooms, published already more than ten years ago.

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