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Species diversity, abundance and dominance of macromycetes in beech forest stands with different intensity of shelterwood cutting interventions

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Abstract

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The aim of this work is to enrich the knowledge of the dynamics of species diversity, abundance and distribution of fruiting bodies and dominance of macromycetes species in a mycocoenosis of beech forest stands. We studied the issue in beech stands in the Kremnické vrchy Mts (Central Slovakia), in the years 2007 and 2008. The experimental area consists of a series of four partial research plots (PRP) obtained by applying a series of regeneration cuts differing in intensity and a control intact plot in the original stand. Altogether we identified 154 species of macromycetes and one species of Fungi imperfecti. We obtained various values of abundance and distribution of fruiting bodies and species dominance on the particular partial plots. The species spectrum concerning the most dominant species was almost the same on each PRP. As for the ecotrophic demands of macromycetes, we can see that the abundance values in lignicolous species increased beginning with the plot with the heaviest intervention up to the intact control plot. On the other hand, the plot subjected to light cut and the control plot exhibited increased abundance of terrestrial saprophytes and ectomycorrhizal symbionts.

Key words

abundance, cutting interventions, dominance, *Fagus sylvatica* L., macromycetes, species diversity

Introduction

Beech covering 31.2% of the total forest land in Slovakia was the leading woody plant in the country in the year 2008 (Collective, 2008). The species is of key importance both to landscape forming and to commercial forest management. Until recently, the damage and threat to beech trees by biotic agents – insects and fungi was not considered significant (Korpeľ et al., 1991). In the last years, however, a steep increase in biotic damage to beech is evident. This is true for increasing populations of insects feeding on leaves and of wood destroying insects as well as for fungal diseases – mycoses. Macromycetes (macrofungi) growing in beech forest stands build an intricate ecotrophic-ecotopic system linked with beech and with the beech-associated environment. Each mycocoenosis in beech stands is characterised by its species diversity and dominance, abundance, distribution and fruit bodies fructification of the individual fungal species.

Mycofloristic research, especially analysis of mycocoenoses in beech forest stands has been area of interest of several authors. Dynamics of species diversity, dominance, succession and production of macromycetes in beech forest stands in Slovakia and in the Czech Republic was studied, among others, by Adamčík et al. (2007), Čížková (2007), Holec (1992, 1994, 2008), Jančařík (2004), Lazebníček (1988), Mihál (1992, 1994, 1995a, b), Mihál and Bučinová (2005) Mihál et al. (2009), Pavlík (1997), Vaník (1970), in abroad by Adamczyk (1995), Andersson (1995), Grzywacz (1990), Matsuda (1994), Salerni and Perini (2004), Tratnik and Pohleven (1995), Tyler (1991), Willig and Schlechte (1995) and others.

The aim of this work is to contribute to the knowledge about dynamics of the species diversity, abundance and distribution of fruiting bodies and dominance of macromycetes in beech forest stands long term treated with applying regeneration cuts of various intensity.

Material and methods

The issue was studied on a permanent research plot series situated in beech stands of the Ecological Experimental Site (EES) Kováčová in the Kremnické vrchy Mts. The series consists of five partial research plots (PRP) with different densities obtained applying a series of regeneration shelterwood cuts with different intensities. The first cut series in March 1989 resulted in forming five PRPs with stocking densities scaled from clear cut to the original intact forest stand (control). The second cut series applied in March 2004 modified the stocking density values on individual plots in the way summarised in Table 1. Mycological research was pursued on four PRPs (except for clear cut), that means PRP H (heavy intervention), PRP M (medium intervention), PRP L (light intervention) and PRP C (control without intervention). Our research on these four PRPs was realised after the second series of regeneration cuts in 2004 leading to even more stocking density reduction (Table 1).

Table 1. Basic characteristics of the locality EES Kremnické vrchy Mts and the individual partial research plots (PRP)

Orographic unit	Kremnické vrchy Mts
Partial research plot	Ecological – Experimental Stationary Kováčová
Localisation	N – 48º38'10", E – 19º04'08"
Altitude [m a.s.l.]	470–490
Exposition	SW
Slope [º]	20
Geological substrate	Andesite, tuffaceous agglomerates
Soil type	Cambisol (andosol) saturated
Humus form	Mull
Throughfall [mm] *	653
Temperature [ºC] *	8.3
Forest type groups	Fagetum pauper inferiora
Vegetal association	Dentario bulbiferae – Fagetum Zlatník, 1936
	Carici pilosae – Fagetum Oberd., 1958
Tree composition of total EES [%]	Beech 95, fir 2, hornbeam 2, oak 1
Age of mature stand [years]	105–110
Stocking of stand [before 2004] **	0.3–0.5–0.7–0.9
Stocking of stand [since 2004] **	0.0–0.3–0.5–0.9
Crown canopy of total EES [%]	0.0–97.0
Area of total EES [ha^{-1}]	1.2

* Throughfall and Temperature: average values from 2003–2005.
** Stocking and Area of individual Partial Research Plots (PRP):

Before 2004

PRP: H (heavy cutting intervention), stocking: 0.3 area: 0.35 ha^{-1}
PRP: M (light cutting intervention), 0.5 ….. 0.35 ha^{-1}
PRP: L (mild cutting intervention), 0.7 ….. 0.35 ha^{-1}
PRP: C (control plot - without cutting intervention), 0.9 ….. 0.15 ha^{-1}

Since 2004

PRP: H (heavy – now clear cutting intervention), stocking: 0.0 area: 0.35 ha^{-1}
PRP: M (medium cutting intervention), 0.3 ….. 0.35 ha^{-1}
PRP: L (light cutting intervention), 0.5 ….. 0.35 ha^{-1}
PRP: C (control plot – without cutting intervention), 0.9 ….. 0.15 ha^{-1}.

The surveys were done monthly, in the growing seasons 2007 (May 4, June 7, July 13, August 14, September 21, October 17) and 2008 (May 6, June 11, July 8, August 8, September 23, October 16).

In the surveys we recorded the species diversity and abundance of fructification in macromycetes on the research plots. Moreover, there was recorded the fruiting bodies distribution, that means the number of occurrence spots of fruiting bodies across the given plot. In such a way, each species was assigned with a number of abundance A (number of fruiting bodies) and a number of distribution D (number of occurrence spots of the species). Summarizing the two characteristics A + D we obtained a number of dominance (Do), ranking the given species into the appropriate class at the scale of dominant species in the mycocoenosis on the given research plot. More details about the discussed methodical approach can be found in Mihál (1994, 1995b). It is necessary to add that in most fruticose and resupinate fruiting bodies of lignicolous species, the values of their abundance and distribution were identical, as the precise determining of the number of fruiting bodies in such species was not possible (such as *Bisporella citrina, Calocera viscosa, Durela commutata, Hypoxylon multiforme, Trametes versicolor* and others).

The species diversity was assessed according to the assessment keys assembled by Breitenbach and Kränzlin (1986), Červenka et al. (1971), Hagara et al. (1999), Jülich (1984), Moser (1983), Papoušek (2004), Veselý et al. (1972) and others. There were also used matching standards from the collection of the author of this paper. Selected species of the identified macromycetes have been deposed as exciccata by the author at the Institute of Forest Ecology SAS in Zvolen.

All the identified macromycetes have been ranked by their ecotrophic demands (growing substrate) in the individual ecotrophic groups – lignicolous found on wood substrate (parasitic and saprophytic), and terrestrial species growing from humus litter and soil horizons (saprophytic and ectomycorrhizal fungi), as well as the species parasitizing on herbs, fungi and epiphytic species.

Results

In the following we present the list of the identified macromycetes species together with abbreviated labels of the plots which the occurrence of the species was recorded on individual plots (for abbreviations of PRP see Table 1). The species were classified in Ascomycotina, Basidiomycotina and Deuteromycotina – Fungi imperfecti. Taxonomic nomenclature of macromycetes species is proposed by Lizoň and Bacigálová (1998) and Škubla (2003).

Ascomycotina:

Aleuria *aurantia* (Pers.) Fuckel – L, ***Ascocoryne*** *sarcoides* (Jacq.) J. W. Groves et D. E. Wilson – ML, ***Ascodichaena*** *rugosa* (L.) Butin – MLC, ***Bisporella*** *citrina* (Batsch) Korf et S. E. Carp. – ML, ***Dasyscyphus*** *ciliaris* (Schrad.) Sacc. – C, ***Diatrype*** *disciformis* (Hoffm.) Fr. – HMLC, *D. stigma* (Hoffm.) Fr. – HMLC, ***Durella*** *commutata* Fuckel – LC, ***Eutypella*** *quaternata* (Pers.) Rappaz – HMLC, ***Hypoxylon*** *fragiforme* (Pers.) J. Kickx f. – HMLC, *H. multiforme* (Fr.) Fr. – HMLC, ***Kretzschmaria*** *deusta* (Hoffm.) P. M. D. Martin – LC, ***Melanopsamma*** *pomiformis* (Pers.) Sacc. – HLC, ***Microsphaera*** *alphitoides* Griffiths et Maubl. – H, ***Nectria*** *cinnabarina* (Tode) Fr. – L, *N. cosmariospora* Ces. et De Not. – C, *N. episphaeria* (Tode) Fr. – L, *N. peziza* (Tode) Fr. – L, ***Peziza*** *arvernensis* Boud. – C, ***Rhytisma*** *acerinum* (Pers.) Fr. – HMLC, ***Valsa*** *ambiens* (Pers.) Fr. – HMLC, ***Xylaria*** *hypoxylon* (L.) Grev. – ML, *X. polymorpha* (Pers. ex Mérat) Grev. – HL.

Basidiomycotina:

Agaricus *essettei* Bon – L, *A. silvaticus* Schaeff. – M, ***Amanita*** *phalloides* (Fr.) Link – L, *A. vaginata* (Bull.) Lam. – HL, ***Armillaria*** *ostoyae* (Romagn.) Herink – HML, ***Auricularia*** *mesenterica* (Dicks.) Pers. – HML, ***Bjerkandera*** *adusta* (Willd.) P. Karst. – HMLC, ***Calocera*** *cornea* (Batsch) Fr. – ML, *C. viscosa* (Pers.) Fr. – ML, ***Cantharellus*** *cibarius* Fr. – MC, ***Chondrostereum*** *purpureum* (Pers.) Pouzar – ML, ***Chrysomphalina*** *chrysophyllum* (Fr.) Clémençon – L, ***Clavariadelphus*** *pistillaris* (L.) Donk – C, ***Clavicorona*** *pyxidata* (Pers.) Donk – L, ***Clitocybe*** *fragrans* (Sowerby) P. Kumm. – H, *C. nebularis* (Batsch.) P. Kumm. – LC, ***Coprinus*** *disseminatus* (Pers.) Gray – L, *C. domesticus* (Bolton) Gray – L, *C. micaceus* (Bull.) Fr. – L, ***Cortinarius*** *duracinus* Fr. – ML, *C. multiformis* (Fr.) Fr. – C, ***Craterellus*** *cornucopioides* (L.) Pers. – HMLC, ***Cyathus*** *striatus* (Huds.) Willd. – HM, ***Dacrymyces*** *stillatus* Nees. – HMLC, ***Daedalea*** *quercina* (L.) Fr. – HM, ***Daedaleopsis*** *confragosa* (Bolton) J. Schröt. – C, ***Exidia*** *glandulosa* (Bull.) Fr. – HMLC, *E. pithya* (Alb. et Schwein.) Fr. – MLC, ***Fomes*** *fomentarius* (L.) J. Kickx f. – HMLC, ***Galerina*** *badipes* (Fr.) Kühner – L, *G. pumila* (Pers.) Singer – L, ***Gymnopilus*** *junonius* (Fr.) P. D. Orton – L, *G. penetrans* (Fr.) Murrill – L, *G. sapineus* (Fr.) Maire – LC, ***Gymnopus*** *peronatus* (Bolton) Antonín et al. – L, *G. fusipes* (Bull.) Gray – M, ***Hericium*** *clathroides* (Pall.) Pers. – C, ***Heterobasidion*** *annosum* (Fr.) Bref. – L, ***Hygrophorus*** *eburneus* (Bull.) Fr. – HL, *H. poetarum* R. Heim – M, ***Hymenochaete*** *rubiginosa* (J. Dicks.) Lév. – HMLC, ***Hypholoma*** *fasciculare* (Huds.) P. Kumm. – ML, *H. sublateritium* (Schaeff.) Quél. – HL, ***Inocybe*** *asterospora* Quél. – L, ***Inonotus*** *nodulosus* (Fr.) P. Karst. – C, ***Kuehneromyces*** *mutabilis* (Schaeff.) Singer et A. H. Sm. – L, ***Laccaria*** *amethystina* (Huds.) Cooke – L, *L. laccata* agg. – L,

Lactarius *blennius* (Fr.) Fr. – LC, *L. fuliginosus* (Fr.) Fr. – L, *L. piperatus* (L.) Gray – HMLC, *L. pterosporus* Romagn. – LC, *L. salmonicolor* R. Heim et Leclair – HL, *L. volemus* (Fr.) Fr. – ML, ***Lentinus*** *strigosus* (Schwein.) Fr. – HML, *L. torulosus* (Pers.) Lloyd – ML, ***Lenzites*** *betulina* (L.) Fr. – ML, ***Lepiota*** *clypeolaria* (Bull.) P. Kumm. – L, *L. cristata* (Alb. et Schwein.) P. Kumm. – L, ***Lycopedon*** *perlatum* Pers. – MLC, *L. pyriforme* Schaeff. – LC, *L. umbrinum* Pers. – L, ***Lyophyllum*** *loricatum* (Fr.) Kühner – L, ***Marasmiellus*** *foetidus* (Sowerby) Antonín et al. – LC, ***Marasmius*** *alliaceus* (Jacq.) Fr. – HLC, *M. bulliardii* Quél. – LC, *M. rotula* (Scop.) Fr. – LC, ***Megacollybia*** *platyphylla* (Pers.) Kotl. et Pouzar – MLC, ***Mycena*** *alcalina* (Fr.) P. Kumm. – LC, *M. crocata* (Schrad.) P. Kumm. – L, *M. epipterygia* var. *viscosa* (Maire) Ricken – HL, *M. filopes* (Bull.) P. Kumm. – LC, *M. haematopus* (Pers.) P. Kumm. – ML, *M. polygramma* (Bull.) Gray – LC, *M. pura* (Pers.) P. Kumm. – L, *M. stipata* Maas Geest. et Schwöbel – L, *M. stylobates* (Pers.) P. Kumm. – LC, ***Omphalina*** *epichysium* (Pers.) Quél. – L, ***Oligoporus*** *stipticus* (Pers.) Gilb. et Ryvarden – LC, *O. subcaesius* (A. David) Ryvarden et Gilb. – L, *O. tephroleucus* (Fr.) Gilb. et Ryvarden – C, ***Panellus*** *stipticus* (Bull.) P. Karst. – HMLC, ***Phanerochaete*** *laevis* (Pers.) J. Erikss. et Ryvarden – L, ***Phellinus*** *hartigii* (Allesch. et Schnabl) Pat. – C, ***Phlebia*** *radiata* Fr. – L, ***Pholiota*** *squarrosa* (Weigel) P. Kumm. – L, ***Pleurotus*** *pulmonarius* (Fr.) Quél. – HMLC, ***Pluteus*** *atromarginatus* (Konrad) Kühner – L, *P. cervinus* (Schaeff.) P. Kumm. – ML, *P. romellii* (Britzelm.) Sacc. – L, *P. salicinus* (Pers.) P. Kumm. – L, ***Polyporus*** *arcularius* (Batsch) Fr. – M, *P. brumalis* (Pers.) Fr. – L, *P. melanopus* (Sw.) Fr. – MLC, *P. varius* (Pers.) Fr. – HMLC, ***Psathyrella*** *piluliformis* (Bull.) P. D. Orton – L, *P. spadiceogrisea* (Schaeff.) Maire – M, ***Pseudocraterellus*** *undulatus* (Pers.) Rauschert – ML, ***Pycnoporus*** *cinnabarinus* (Jacq.) P. Karst. – M, ***Rickenella*** *fibula* (Bull.) Raithelh. – ML, ***Russula*** *aeruginea* Lindblad – LC, *R. aurea* Pers. – HMC, *R. chloroides* (Krombh.) Bres. – LC, *R. cyanoxantha* (Schaeff.) Fr. – HML, *R. fellea* (Fr.) Fr. – MLC, *R. foetens* (Pers.) Fr. – HMLC, *R. heterophylla* (Fr.) Fr. – M, *R. nigricans* (Bull.) Fr. – L, *R. nobilis* Velen. – LC, *R. olivacea* (Schaeff.) Pers. – MLC, *R. vesca* Fr. – MC, ***Schizophyllum*** *commune* Fr. – HMLC, ***Schizopora*** *flavipora* (Berk. et M. A. Curtis ex Cooke) Ryvarden – HML, *S. radula* (Pers.) Hallenb. – L, ***Scleroderma*** *citrinum* Pers. – HL, ***Stereum*** *gausapatum* (Fr.) Fr. – M, *S. hirsutum* (Willd.) Gray – HMLC, *S. rugosum* (Pers.) Fr. – MC, ***Trametes*** *gibbosa* (Pers.) Fr. – HMLC, *T. velutina* (Planer) G. Cunn. – HML, *T. versicolor* (L.) Pilát – HMLC, ***Trechispora*** *cohaerens* (Schwein.) Jülich et Stalpers – L, ***Tremella*** *mesenterica* Retz. – ML, ***Trichaptum*** *abietinum* (J. Dicks.) Ryvarden – MLC, ***Tricholoma*** *album* (Schaeff.) P. Kumm. – L, *T. imbricatum* (Fr.) P. Kumm. – L, *T. terreum* (Schaeff.) P. Kumm. – L, ***Tricholomopsis*** *rutilans* (Schaeff.) Singer – L, ***Xerocomus*** *chrysenteron* (Bull.) Quél. – L, ***Xerula*** *melanotricha* Dőrfelt – L, *X. radicata* (Relhan) Dörfelt – HML.

Deuteromycotina – Fungi imperfecti:

Bispora *antennata* (Pers.: Fr.) E. W. Mason – HMLC.

The total amount of fungal species identified in the stand at the EES over the whole study period was 154 macrofungal species and one imperfect fungus (Fungi imperfecti), from which 23 belonged to Ascomycotina and 131 to Basidiomycotina. The abundance values of the species identified on the individual PRPs in Table 2 show trends increasing from the least stocked plots to the plots with the highest stocking density. The only exception is the lower species abundance on the intact control plot C. The lower number of the species on plot C may follow from the fact that the area of this plot is smaller compared to the other as well as from rather stable and uniform climatic and ecological conditions on the plot C – unlike on the other plots where these conditions were close dependent on the cutting intensity. The highest number of macrofungal species was recorded on the PRP L offering the most favourable conditions: optimal stocking density, sufficient wood substrate and probably also the highest proportion of fir (17%) compared to the other partial plots.

Table 2. Number of fungi species on individual partial plots (PRP) during 2007–2008

Years / PRP	H	M	L	C	Total in years
2007	28	49	97	44	120
2008	30	51	90	46	113
Total in PRP	44	67	128	65	155

Similar trend as in the species abundance was observed in dynamics of abundance and distribution of fruiting bodies and dominance of macromycetes (Table 3). The table illustrates the interannual decrease in values on the least stocked plots H (heavy cut) and M (medium cut) and increased on the plots L (light cut) and C (no cut – control) with the highest stocking density. In general, in the year 2008 were higher also the values of abundance of fruiting bodies. The highest values of abundance and distribution of fruiting bodies were observed always on plot L. On the other hand, the lowest values on plot C reflect the conditions on this plot, being also in accordance with the low number of the species recorded on the control plot.

The information about the 10 most dominant macrofungal species on the individual PRPs in year 2007 is in Table 4, in year 2008 in Table 5. Due to the limited space, there are presented only the first 10 most dominant species representing from 10% to 37% of the all species spectrum determined on individual partial plots. The two tables exhibit practically the same species spectrum of the leading macromycetes – reflecting

the well-balanced mycocoenosis in the whole beech stand at the EES and only slight differences in the species diversity between the plots. Both tables show that the most dominant were lignicolous macrofungi occurring, unlike terrestrial saprophytes and ectomycorrhizal symbionts, in large amounts on wood substrate over the whole study period and affected the species composition of the group of the most dominant macromycetes.

The abundance of species in individual ecotrophic groups on individual PRPs is illustrated in Table 6 – showing that the ratio between the lignicolous species (51.3% from the total species number) and terrestrial species (46.1%) is almost 1 : 1 – pointing at rather favourable climatic, ecological and soil–humification conditions for fructification of terrestrial macromycetes. In presence of sufficient supply of wood substrate

Table 3. Values of abundance of fruitbodies (A), distribution of ones (D) and species dominance (Do) on individual partial plots (PRP) in the EES Kremnické vrchy Mts during 2007–2008

Years	2007			2008			2007 + 2008		
PRP	A	D	Do	A	D	Do	A	D	Do
H	1,708	1,575	3,283	1,194	1,109	2,303	2,902	2,684	5,586
M	1,781	1,090	2,871	1,680	1,081	2,761	3,461	2,171	5,632
L	4,075	1,540	5,615	7,271	1,651	8,922	11,346	3,191	14,537
C	1,028	637	1,665	2,364	784	3,148	3,392	1,421	4,813
Total	8,592	4,842	13,434	12,509	4,625	17,134	21,101	9,467	30,568

Table 4. The most dominant species of macromycetes on partial plots (PRP) in 2007

PRP	Species of macromycetes	Do total
H	*Schizophyllum commune* (602), *Hypoxylon fragiforme* (568), *Trametes versicolor* (440), *Bjerkandera adusta* (250), *Trametes velutina* (244), *Stereum hirsutum* (232), *Hypoxylon multiforme* (196), *Exidia glandulosa* (172), *Diatrype disciformis* (120), *Diatrype stigme* (112)	2,936
M	*Panellus stipticus* (433), *Trametes versicolor* (320), *Bjerkandera adusta* (280), *Trametes velutina* (248), *Hypoxylon fragiforme* (172), *Cyathus striatus* (162), *Schizophyllum commune* (140), *Stereum hirsutum* (120), *Trametes gibbosa* (120), *Trichaptum abietinum* (116)	2,111
L	*Panellus stipticus* (963), *Armillaria ostoyae* (891), *Hypoxylon fragiforme* (372), *Trametes versicolor* (352), *Bjerkandera adusta* (260), *Exidia glandulosa* (222), *Stereum hirsutum* (204), *Gymnopilus sapineus* (203), *Diatrype disciformis* (144), *Trametes velutina* (144)	3,755
C	*Hypoxylon fragiforme* (192), *Panellus stipticus* (153), *Marasmiellus foetidus* (135), *Diatrype disciformis* (120), *Trametes versicolor* (108), *Stereum hirsutum* (84), *Lactarius piperatus* (70), *Bjerkandera adusta* (60), *Exidia glandulosa* (56), *Lycoperdon pyriforme* (54)	1,032

Do, number of dominance (in the parenthesis).

Table 5. The most dominant species of macromycetes on partial plots (PRP) in 2008

PRP	Species of macromycetes	Do total
H	*Trametes versicolor* (480), *Hypoxylon fragiforme* (444), *Hypoxylon multiforme* (240), *Trametes velutina* (216), *Stereum hirsutum* (180), *Diatrype disciformis* (120), *Trametes gibbos*a (108), *Valsa ambiens* (84), *Diatrype stigme* (72), *Eutypella quaternata* (72)	2,016
M	*Craterellus cornucopioides* (406), *Panellus stipticus* (268), *Trametes versicolor* (228), *Hypoxylon fragiforme* (216), *Trametes velutina* (192), *Bjerkandera adusta* (186), *Trametes gibbosa* (144), *Stereum hirsutum* (108), *Trichaptum abietinum* (92), *Diatrype disciformis* (84)	1,924
L	*Panellus stipticus* (3818), *Hypoxylon fragiforme* (456), *Trametes versicolor* (360), *Craterellus cornucopioides* (268), *Armillaria ostoyae* (261), *Marasmius rotula* (248), *Trametes gibbosa* (248), *Stereum hirsutum* (216), *Trametes velutina* (216), *Bjerkandera adusta* (192)	6,035
C	*Craterellus cornucopioides* (1289), *Hypoxylon fragiforme* (312), *Panellus stipticus* (244), *Lactarius blennius* (175), *Stereum hirsutum* (160), *Trametes versicolor* (144), *Valsa ambiens* (112), *Diatrype disciformis* (96), *Trametes gibbosa* (84), *Eutypella quaternata* (72)	2,688

Do, number of dominance (in the parenthesis).

produced by regeneration shelterwood cutting, the highest portion of lignicolous macromycetes is corresponding to presumptions. Relatively low presence of ectomycorrhizal symbionts (22.7%) can be assigned to the negative influence of cutting interventions (especially in year 2004) removing trees as mycorrhizal partners of symbiotic fungi and resulting in considerable stand opening, soil dessication, weed succession and formation of connected shrub and herb layer hindering, to a large extent, fructification in symbiotic macromycetes. Step-by-step increase in symbiotic species from PRP H (new-created clearing) to PRP L (stocking 0.5 and presence of fir) corresponds to the micro-environment. This trend is to large extent followed also by terrestrial saprophytic macromycetes.

During the whole study period we recorded rather few lignicolous species occurring in the stands at EES as parasites (Table 7). The major part of lignicolous macromycetes on the individual PRPs were saprophytes on abundant dead wood substrate left after the cutting, especially on plots H, M and L. From the parasitic species listed in Table 7, the species *Microsphaera alphitoides* was recorded only on plot H – parasitizing on oak leaves in the undergrowth. Another plant-parasite *Rhytisma acerinum* was found growing on sycamore leaves on all PRPs. There was also recorded the species *Heterobasidion annosum* parasitizing on fir root buttresses on plot L, the species *Nectria cosmariospora* was observed on the fruiting bodies of *Inonotus nodulosus* and *Nectria episphaeria* on the fruiting bodies of *Eutypella quaternata* and *Diatrype disciformis*.

The overall dynamics of the mycoceonosis at the EES over the whole study period is summarised in Table 8 – showing in all the studied factors the trends increasing from the lowest stocked partial plots to the densest ones. The brackets in case of plots C and L underline the special features of these two plots: the plot C (control) having smaller area than the other plots and the plot L almost optimally stocked, having the highest presence of fir. The just mentioned general increase of selected factors can be considered as the natural process of development of the mycocoenosis at the EES where the values of the studied factors reflect the suitability of climatic, ecological and soil-humification conditions on individual PRPs in dependence on intensity of the applied regeneration cut. The species spectra of the most dominant macromycetes on the individual PRPs were almost identical, independent from the degree of canopy opening in the parent stand. Presumption of substantial changes in the species diversity in the dominant macromycetes could be well-reasoned in case of strongly reduced compactness of the forest stand or in case of harvesting all trees and replacing them with other woody plants (e.g. spruce, pine, self seeding pioneer species).

Table 6. Number of macromycetes species within the ecotrophic groups on the partial plots (PRP) during investigated period

	Lignicolous species		Terrestrial species		Herbo-parasite	Myco-parasite	Epiphyte
PRP	PA	SA	SA	EC			
H	0	30	3	9	2	0	0
M	1	45	5	14	1	0	1
L	4	62	31	28	1	1	1
C	3	34	10	15	1	1	1
Total	5	74	36	35	2	2	1
Total	79		71		2	2	1

PA, parasitic species; SA, saprophytic ones; EC, ectomycorrhizal ones. Epiphyte: *Ascodichaena rugosa.*

Table 7. Parasitic macromycetes determined on partial plots (PRP)

PRP	Species of macromycetes
H	*Microsphaera alphitoides* (HP), *Rhytisma acerinum* (HP)
M	*Fomes fomentarius* (LP), *Rhytisma acerinum* (HP)
L	*Armillaria ostoyae* (LP), *Heterobasidion annosum* (LP), *Kretzschmaria deusta* (LP), *Nectria episphaeria* (MP), *Rhytisma acerinum* (HP)
C	*Fomes fomentarius* (LP), *Inonotus nodulosus* (LP), *Kretzschmaria deusta* (LP), *Nectria cosmariospora* (MP), *Rhytisma acerinum* (HP)

HP, herboparasite; LP, lignicolous parasite; MP, mycoparasite.

Table 8. Dynamics of investigated factors by the individual partial plots

Factors	H → M → (L) → (C)
Number of species	rising data
Abundance of fruit bodies	rising data
Distribution of fruit bodies	rising data
Values of dominance	rising data
Most dominant species	well-balanced species spectrum of macromycetes
Parasites	rising data
Saprophytes	rising data
Ectomycorrhizal symbionts	rising data

(L) and (C) – see text in Results.

Discussion

Several of the most dominant macrofungal species listed in Tables 4 and 5 were identified in similar beech stands also by other authors. Tratnik and Pohleven (1995) report the species *Hypoxylon fragiforme* as frequently occurring on dead wood in beech forest stands. Andersson (1995) describes the species *Xylaria hypoxylon* as the most frequent in beech stands; the characteristic species according to this author are also *Hypoxylon fragiforme, Kretzschmaria deusta, Polyporus varius, Pseudovalsa spinifera* and *Stereum hirsutum*. Similarly, Lazebníček (1988) and Vaník (1970) classify the species *Diatrype disciformis, Fomes fomentarius, Hypoxylon fragiforme, Kretzschmaria deusta*, *Stereum hirsutum, Trametes versicolor* as typical macromycetes species of beech stands. The species *Schizophyllum commune, Trametes velutina* a *Trametes versicolor* are reported by Willig and Schlechte (1995) as the species with the highest abundance of fruiting bodies and frequency occurrence on dead beech wood. Adamczyk (1995), apart from the just mentioned species, ranked to the most dominant species of beech stands also *Marasmius alliaceus*, *Marasmius rotula, Mycena galericulata* and *Rhodocollybia butyracea* f. *asema*. These species, together with *Marasmius rotula*, *Cyathus striatus*, *Valsa ambiens*, *Mycena renati* and others are considered as dominant macromycetes in beech ecosystems exposed to airborne pollution in various degrees and managed in various ways (e.g. Mihál, 1992, 1995a, 1995b; Mihál and Bučinová, 2005). Comparing the species diversity of dominant macromycetes at the EES in the earliest 1990s (Mihál, 1992) with the today state we can see that the species *Armillaria ostoyae*, *Hypoxylon fragiforme*, *Schizophyllum commune* and *Trametes velutina* have been among the most dominant macrofungal species at EES already since 1990. Some typical dominant macromycetes occur in beech stands as parasites: *Armillaria ostoyae*, *Fomes fomentarius*, *Kretzschmaria deusta*, species of the genus *Nectria* and other reported by Jančařík (2004), Čížková (2007), Grzywacz (1990), Mihál et al. (2009) as frequent parasites in beech forest stands.

As for the number of the species in the individual ecotrophic groups (Table 6), it is necessary to point out that the species number at the EES was in each group limited by the environmental conditions on the separate plots modelled by a series of cuts with different intensities. Holec (1992) suggests that terrestrial fungal species are associated with a certain layer of cover humus and substrate in this layer, mycorrhizal species are most affected by the presence of their partner and by the site climate, and the occurrence of lignicolous fungi requires wood in various phases of decay – in close correlation with the degree of naturaleness of the forest and supply of wood substrate. These conditions were overlapping on all partial plots, dependent on its stocking density. General retreat in mycorrhizal symbionts from the most disturbed PRPs (low stocking → removal of trees as symbiotic partners) was also observed in different managed spruce forests by Mihál and Gáper (1995), who speaking about decrease of symbiotic macromycetes and increase of lignicolous saprophytic fungi in a spruce monoculture affected by snow and wind disturbance. In case of lignicolous saprophytes, the dead wood substrate in appropriate amounts is considered as the factor limiting occurrence of these fungi. Vaník (1970) declares lignicolous fungi in beech stands to be useful saprophytes releasing dry branches from beech stems, decomposing stumps, facilitating, in such a way, the "self–cleaning" process in the forest. The same species, however, may turn to harmful parasites when the forest is weakened by long lasting drought or by other harmful factors (insects, mechanical injury).

In case of terrestrial saprophytes, apart from the microclimate, additional limiting factors are humification of organic matter in soil and thickness of humus and leaf and wood debris layer. Holec (1994) means that the thickness of forest litter and the humus form control the abundance of both saprophytic and ectomycorrhizal fungi as well as their mutual proportion. For example, in beech stands with mull humus form,

saprophytic macrofungi are more abundant than ectomycorrhizal. Murphy and Miller (1993) found out the saprophytic species *Collybia subnuda* among the dominant fungi in deciduous forests. Likewise, Tyler (1991), studying the effect of removing forest litter on fruiting bodies production, observed that on the plot with forest litter maintained was the fructification more abundant in the saprophytic species *Mycena cinerella, Mycena galopoda* and *Rhodocollybia butyracea* f. *asema*; on the plots with forest litter removed was the fructification more abundant in the species belonging to the genera *Lactarius* and *Russula*. Contrarily, Salerni and Perini (2004) studying the production dynamics in the ectomycorrhizal species *Boletus edulis* observed the most abundant fruiting bodies were produced exactly on the plots with the thickest forest litter layer.

Conclusions

In this work we present the results of a study focussed on the dynamics of species diversity, abundance and distribution of fruiting bodies and dominance of macromycetes in a mycocoenosis of beech forest stands long–term managed by applying series of shelterwood regeneration cuts of various intensities. The problem was investigated at the Ecological Experimental Site (EES) Kováčová in the Kremnické vrchy Mts, in the years 2007 and 2008. The site consists of five partial research plots (PRP) obtained by applying regeneration shelterwood cuts of various intensities. The first important regeneration harvesting in March 1989 resulted in modelling five PRPs with densities from the clear cut up to the control without intervention. The second cut series in March 2004 modified the stocking density values on the individual PRPs – for the applied approach see Table 1. The total number of fungal species identified at the EES over the study period was 154 macromycetes (Ascomycotina, Basidiomycotina) and one species of Fungi imperfecti. The trend in species diversity was increasing from the least stocked PRPs up to the densest stocked plots. Similar trend as in the species diversity was observed in the dynamics of abundance and distribution of fruiting bodies and in the values of dominance of macrofungi. In the both study years, the species composition of the most dominant macromycetes seemed practically the same on all plots – exhibiting a species–balanced mycocoenosis across the whole stand at the EES and only slight differences in the species diversity among the plots. The major part of the group of the most dominant species consisted of lignicolous macromycetes. The mutual proportion of lignicolous (51.3% of the total species number) and terrestrial species (46.1%) was practically 1 : 1 – pointing to relatively favourable climatic, ecological and soil-humification conditions for fructification of terrestrial macromycetes. The highest portion of lignicolous macromycetes, thanks to abundant wood substrate remained after the cutting intervention, was consistent with presumptions. Relatively low presence of ectomycorrhizal symbionts (22.7%) may follow from negative impact of cutting interventions (especially in 2004) removing trees as mycorrhizal partners of symbiotic fungi and considerable opening of forest stand canopy resulting in soil desiccation on the individual PRPs.

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Druhová diverzita, abundancia a dominancia makromycétov v bukových lesných porastoch s rôznou intenzitou ťažbovo-obnovných zásahov

Súhrn

V práci uvádzame výsledky štúdia dynamiky druhovej diverzity, abundancie, distribúcie plodníc a dominancie makromycétov v mykocenóze bukových lesných porastov, na ktorých sa dlhodobo aplikuje rôzna intenzita ťažbovo-obnovných zásahov. Problematiku sme skúmali na výskumnej ploche v bukových porastoch na Experimentálnom a ekologickom stacionári (EES) Kováčová v Kremnických vrchoch počas rokov 2007 a 2008. Stacionár pozostával z piatich čiastkových výskumných plôch (ČP), na ktorých sa aplikovala rôzna sila ťažbovo-obnovných zásahov. Prvým významným ťažbovo-obnovným zásahom z marca roku 1989 bolo vytvorenie piatich ČP s odstupňovaným zakmenením, od holiny až po kontrolu bez zásahu. Druhým ťažbovo-obnovným zásahom z marca roku 2004 bolo ďalšie odstupňovanie zakmenenia jednotlivých ČP v zmysle postupov, ktoré konkretizujeme v tabuľke 1. Celkovo sme počas doby výskumu v poraste EES zistili 154 druhov makromycétov a 1 druh nedokonalej huby (Fungi imperfecti). Zistili sme stúpajúci trend početnosti druhov od najmenej zakmenených ČP až po najviac zakmenené ČP, pričom najviac druhov bolo zistených na ČP L, so zakmenením 0,5. Podobný trend ako v prípade početnosti druhov sme zaznamenali aj v prípade dynamiky hodnôt abundancie a distribúcie plodníc a hodnôt dominancie makromycétov. V obidvoch rokoch výskumu sa na jednotlivých ČP vyskytovalo prakticky to isté druhové zloženie najdominantnejších makromycétov, čo svedčí o druhovo vyváženej mykocenóze celého porastu EES a minimálnych rozdieloch v druhovej diverzite vyskytujúcej sa na jednotlivých ČP. Skupina najdominantnejších druhov bola tvorená najmä lignikolnými makromycétami. Vzájomný pomer lignikolných druhov (51,3 % z celkového počtu druhov) a terestrických druhov (46,1 %) bol približne vyrovnaný, čo poukazuje na pomerne vhodné klimaticko-ekologické a pôdno-humifikačné pomery pre fruktifikáciu terestických makromycétov. Najvyšší pomer u lignikolných makromycétov je vzhľadom na dostatok drevného substrátu z ťažbovo-obnovných zásahov očakávaný. Pomerne nízke zastúpenie ektomykoríznych symbiontov (22,7 %) môžeme pripísať negatívnemu vplyvu ťažbových zásahov (najmä zásahu z roku 2004), kedy došlo k odstráneniu stromov ako mykoríznych partnerov symbiotických húb, značnému presvetleniu porastov a následnej desikácii pôdy na jednotlivých ČP.

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