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„A qualitative survey of the macromycete diversity of mapping areas in the Lobau in 2017 - changes in the population compared to 1981-1990"

verfasst von / submitted by

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Ich danke meiner Familie für ihre Unterstützung während meines Studiums.

Mit dieser Arbeit hoffe ich, meinen Beitrag zum Verständnis der Natur leisten zu können.

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Abstract

From March to November in 2017 the mycoflora of hardwood alluvial forests and dry grasslands within the Lobau, a nature reserve close to Vienna, was surveyed. This study aims to contribute to the knowledge of fungal biodiversity in Austria and of its temporal variability. Various aspects of fungal ecology were compared with results of a long-time study between 1981 and 1990 as well as a recent study which took place in autumn 2015. Number of species as well as proportion of ecotypes varied among plots and months during this study. Findings indicate a change of the relative proportion of ecotypes as well as shift of fruiting time. 51 species not recorded yet in the Lobau, one of them new in Austria, were found.

Keywords

Mycology, Biodiversity, Alluvial Forest, Grassland, Lobau

Introduction

Motivation and aim of this study

By searching the internet for information for "biodiversity of animals", "biodiversity of plants", "biodiversity of bacteria" and "biodiversity of fungi" via Google it becomes obvious by comparing the sheer numbers of queries that there is quite a discrepancy between available data of these groups of organisms. Also by simply looking at the google trends, which is probably positively correlated with the public interest in a certain topic, for "animals", "bacteria", "fungi" and "plants" the lowest values were in both cases related with the term fungi (Fig. 1).

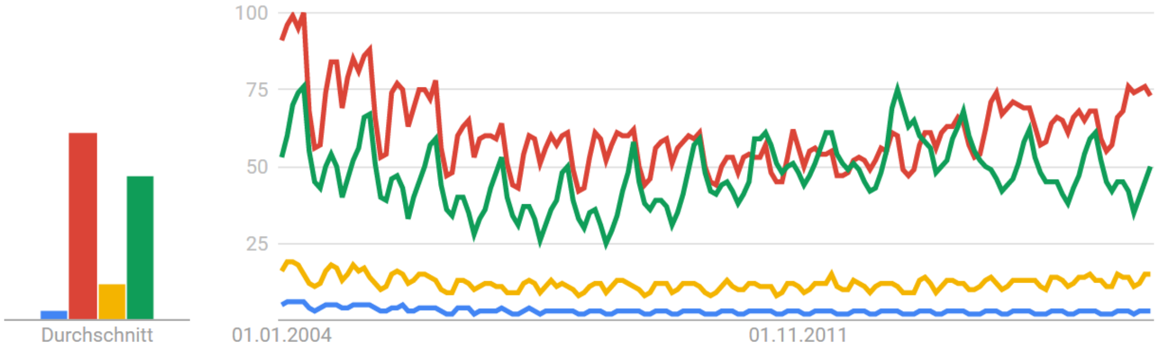

Fig. 1: Number of queries for the terms animals (red), plants (green), bacteria (yellow), fungi (blue). www.google.com/trends, 29.03.2017, 19h30.

Also by taking a closer look at the query "fungi" we can perceive a fluctuating public interest in this topic (Fig. 2) which is probably caused by the culinary aspect of these organisms, because the highest peaks appear each year during the main fruiting season of mushrooms from September to November.

Fig. 2: Seasonal flutctuation of the number of queries for the term "fungi". www.google.com/trends, 21.11.2017, 19h30.

This shall demonstrate that both information as well as interest in fungi seems to be relatively low compared to other organism groups. It´a pity, because these fascinating multifarious organisms are fundamental for the functioning of the global ecosystem and influence the human civilisation through many different ways. This large discrepancy between a comparatively moderate public interest in fungi and their importance for life on earth as we know it motivated the author to contribute to the knowledge of their biodiversity.

Fungal fruit bodies were sampled in a more or less weekly interval between March and November 2017 in order to draw conclusions on their biodiversity and how this was influenced by climate change. The plots in which the monitoring took place were all located within the UNESCO biosphere reserve Lobau, a riparian zone of the Danube, closely located to Vienna. The type of vegetation of the observed study ranged from alluvial forests to dry grasslands, which makes the comparison between localities interesting.

Even though fungi reach their highest abundance and productivity in forests their importance for other habitat types should not be neglected (cf. Arnolds, 1992). Dry grasslands poor in nutrients are considered valuable localities for fungi to grow and feature a relatively high amount of microfungi; many fungi species at this vegetation type can be considered "grasslands specialists" (cf. Blakesley and Buckley, 2016). Today many grassland fungi are red-listed because of the decrease in number of dry grasslands in Europe (cf. Heilmann-Clausen and Vesterholt, 2008).

Picking fungal fruit bodies is an effective and simple way to evaluate fungal biodiversity and can be regarded a first step to gain insights into their biology which can be used for future studies. It has been shown in a long time study that picking of fruit bodies does not harm the subterranean mycelium, but trampling seems to be much more detrimental for the fruit body richness (Egli et al. 2006).

The macro-fungal fruit body biodiversity of this year was compared with results of previous studies carried out in the very same study plots (Krisai-Greilhuber 1992, Stulik 2015). The data from Krisai-Greilhuber (1992) come from monitoring of the very plots (together with additional areas) between 1981 and 1990 and resulted in her dissertation, altogether 523 species were identified. The statistical evaluation of her study was published later (Straatsma & Krisai-Greilhuber 2003). Stulik (2015) observed three of these eight locations between August and November in 2015 for his master thesis and encountered 79 fungal species.

Fungi – a short overview

Fungi are an ecological, morphological and physiological highly diverse group of eukaryotic, heterotrophic organisms, which are closer related with animals than with plants. The fungal kingdom comprises microscopically small species like *Saccharomyces cerevisiae* as well as an *Armillaria bulbosa* individual that colonizes several hectares by clonal growth and has an approximate weight of many tons and an age of over thousand years (Smith et al. 1992). The total number of fungal species was estimated around 1.5 million (Blackwell, 2011) species but is probably much higher (Hawksworth and Lücking, 2017); the list of macromycetes found in Austria features 8,248 taxa at the moment (Austrian Mycological Society, 2018) while the estimated number of fungi taxa in Austria is approximately 16,320 (Krisai-Greilhuber, 2015). Due to this huge number and the resulting multifariousness only a brief overview of these fascinating organisms shall be provided here.

Concerning fungal impact on human society and economy, fungi are considered integral not only for the fermentation of food and beverages but also for the biotechnological production of organic substances (Adrio and Demain, 2003). Further fungal enzymes are considered a valuable tool for bioremediation due to their capability to degrade pollutants (Tortella et al. 2005).

Around 60 % of all described fungi are Ascomycota, while Basidiomycota approximately represent 30 % of all fungal species known so far (cf. Bresinsky et al., 2008). Asco- and Basidiomycota forming together the subkingdom Dikarya (Hibbett et al., 2007), the age of the divergence of these two groups is estimated to have happened between 452 and 1,489 million years ago, depending on the interpretation of the fossil records (Taylor and Berbee, 2006). The earliest fungal fossils were dated to be around 540 million years old, but due to their soft thalli many fungal residues probably did not outlast (cf. Nabors and Scheibe, 2007).

Within the majority of terrestrial ecosystems fungi play an essential part as saprotrophs making dead organic material accessible to primary producers again; also plastic can be degraded by some fungal species (Khan et al. 2017). A high diversity of saprotrophic fungi is hypothesized to slow down CO_2 emission in forests (Yang et al. 2016). One species is even able to use ionizing radiation through the pigment melanin for growth (Dadachova et al. 2007).

Another important aspect of fungal ecology is symbiosis with plants and animals ranging from mutualism to parasitism (cf. Nabors and Scheibe, 2007). Some fungi are inevitable plant symbionts supporting their host, for instance microscopically endophytic fungi seem to be present in nearly all plants (Rodriguez et al. 2009) and are also considered promising for the production of valuable biological compounds (Aly et al. 2010).

Mycorrhizae are another prominent example of symbiotic interactions between plants and fungi. The vast majority of land plant species requires a mycorrhizal fungus which supports the plant by enhancing nutrient and water uptake and protecting it from detrimental microorganisms – in

return the fungus receives carbohydrates and assimilates from its host. We can basically distinguish between endo- and ectomycorrhizae. Endomycorrhizal fungi belong to the Glomeromycota which are present in 80 % of all land plants and form arbuscular structures inside the roots cells. Due to this peculiar trait they are also called arbuscular mycorrhizal (AM) fungi. (cf. Weiler and Nover, 2008)
Furthermore AM fungi are also regarded beneficial for soil health and fertility making them important rhizosphere microorganisms (Jeffries et al., 2003).
Ectomycorrhizae, which contain Asco- and Basidiomycota species, are associated with conifers and deciduous trees and form the so called Hartig-net between cortex cells of the plant root (cf. Weiler and Nover, 2008). The mycorrhizae of individual trees tend to connect with each other forming a network which enables signal, substance and water exchange between the connected individuals. This network is often refered to as “wood wide web”, because the mycelia enable communication between single trees. (cf. Wohlleben, 2016)

However there are also certain species which are symbiotically associated with animals and humans, respectively. Even the human body contains a high number of fungal species, the so called mycobiome (Huffnagle and Noverr, 2013), species composition varies strongly depending on the position on and inside of the body (Underhill and Iliev, 2014).

One should not assume that fungi coexist with plants in a mutualistic way only. Instead they can display a parasitic lifestyle as well. Pathogenic fungi can cause severe damage and can be regarded a severe menace to animals and plants (Fisher et al. 2012).

Among entomopathogenic fungi very peculiar phenomena have established during evolution like a fungus influencing the behaviour of its infected host (Harmon, 2009). Another curious example is the caterpillar fungus *Cordyceps sinensis* which is regarded medicinally valuable is in some rural parts of Tibet responsible for 80 % of the local cash income (Winkler, 2008).

Fungi and climate change

Cordyceps sinensis appears to be threatened by climate change (Yan et al. 2017) but it seems not to be the only fungal species affected by it, for instance many fungi considered pests shift their range polewards (Bebber et al. 2013).

For the temperate continental zone of Europe the annual mean temperature has increased between 3-4 °C; further annual precipitation is supposed to increase during winter by 10 % whereas in summer rainfall decreases by 10 % (Lindner et al. 2010).

Concerning climate change in Austria an increase of temperatures of approximately 1.4 °C is assumed during the first half of this century, further an increase of precipitation during winter and a decrease during summer is expected. Frequency of extreme weather events as heat waves and higher precipitation during spring and autumn are expected to increase during the 21st century (Austrian Panel on Climate Change, 2014).

Biomass productivity of eastern Austrian forests is believed to decline due to climate change (Austrian Panel on Climate Change, 2014) to which extent this has an impact on fungi is not fully elucidated, because production of fruit bodies does not seem to correlate significantly with the general productivity of a year (Straatsma & Krisai-Greilhuber, 2003).

Due to climate change e.g. drought and extreme precipitations soil fertility and its capacity of storing water and nutrients seem to get reduced (Austrian Panel on Climate Change, 2014), fungal-based soil food webs as on extensively managed grasslands are considered relatively resistant even though not resilient against such drought events (de Vries et al. 2012).

Climate change is believed to influence the fruit body phenology – for some species the fruiting period is extending, for others it is contracting – and also the choice of the host tree (Boddy et al. 2014). In southern England the duration of the fruiting season became twice as long during the last half of the 20th century (Smalley, 2007). Phenological changes of fungal fruiting appear to be quite complex and also depend on geographic position, in Austria most species start to fruit later nowadays than in former times (Kauserud et al. 2012).

Material and Methods

Study sites

The monitoring was conducted in eight plots (Tab. 1) within the Lobau which represent different vegetation types. In order to see if there was a correlation between species number and area, the plots differed in size. The Lobau is a riparian zone of the river Danube and part of the UNESCO biosphere reserve, representing with a total area of 23.000 hectares 24 % of the whole extent of it (https://www.wien.gv.at/umwelt/wald/erholung/nationalpark/lobau/, 26.01.18, 15h00).
Principally the plots are characterized by their proximity to the river Danube. L2, L5, L7 and L8 are hardwood alluvial or floodplain forests, respectively.

L1, L3 and L4 represent dry grasslands, so called "Heißländen", featuring a peculiar fauna and flora. This landscape type emerges at desiccated riverbeds over gravel in alluvial forests. After the regulation of the Danube, starting in the late 19th century, this vegetation type prospered in the Lobau, as a consequence of the lowered water level and the resulting availability of new nutrient rich habitats. Before this time, the distribution of these dry grasslands was much smaller, rather scattered and unsettled. However the existence of this ecologically interesting vegetation-type is threatened seriously since 1938 by more competitive woody species, and would probably perish completely without human preservation efforts. (Schratt-Ehrendorfer, 2011)
On February 2nd all plots surveyed by Krisai-Greilhuber between 1981 and 1990 were visited in order to clarify the exact area of the study sites.

Plot	Name of the location	Plot size (ha)
L1	Am Kühwörther Wasser	0,7
L2	Gänsehaufen	1,3
L3	Kreuzgrund	3,7
L4	Lehnerin	1,45
L5	Herrnau I	2,3
L7	Herrnau II	0,8
L8	Kaufau	1,25

Tab. 1: Name of study sites and respective size.

Description of the plots

L1 – Am Kühwörther Wasser

Fig. 3: Image of L1.

This grassland plot has a size of 0.7 hectare and is located as well as L2 next to a small bayou of the Danube, the so called "Kühwörther Wasser" (Fig. 3). In contrast to the decade between 1980 and 1990 in which wild boars were absent at this location (Krisai-Greilhuber, 1992) those animals could be witnessed during spring. Many spiked plants e.g. *Rosa canina, Crataegus monogyna* and *Berberis vulgaris* grow in this area. *Rhamnus frangula* individuals is quite common in the close proximity of this plot as well as *Populus nigra* and *Salix purpurea.* There is no shading by trees as in the forest plots, which probably caused high evaporation during summer months. Scrub vegetation encroachment was obvious and there does not seem to be any effort by the forestry administration for counteracting this process. Flooding events occurred two times during this study close to this location. Beneath the grass was a quite well developed moss layer. Mosses are supposed to have a positive effect on fungi on grasslands (cf. Arnold, 1992).

L2 – Gänsehaufen

Fig. 4: Image of L2.

Even though the distance to the grassland plot L1 is quite small the discrepancy concerning the vegetation is huge. *Populus alba* is the dominant tree species at this location (Fig. 4), other common tree species are *Ailanthus altissima, Cornus sanguinea*, *Crataegus monogyna, Prunus padus* and *Sambucus nigra*. *Solidago canadensis* is apparently the most dominant herbaceous species between late spring and fall, but during March and April *Allium ursinum* is highly abundant. Other common plants in this location are *Glechoma hederacea*, *Humulus lupus*, *Rubus caesius, Salvia glutinosa* and *Stachys recta*. Sporadically the soil was grazed by wild boars (*Sus scrofa*) (Fig. 5).


Fig. 5: Soil at L2 which was sporadically grazed by wild boars.

L3 – Kreuzgrund

Fig. 6: Image of L3, circled areas within the whole polygon represent spots featuring trees which were excluded from the surveys.

L3 is the largest plot and grassland respectively, but spots with many densely growing trees (*Populus alba* and *P. nigra*) were excluded from investigations (Fig. 6). Next to this location lies a small *Pinus nigra* (Fig. 9) woodlot, which was probably responsible for the presence of mycorrhizal fungi at L3. Also here signs of scrub vegetation encroachment are obvious but less strong than at L1. Concerning the scrubs present here, *Berberis vulgaris, Crataegus monogyna* and *Hippophae rhamnoides* are the most common ones.

Mowing at this location was carried out in the middle of March (Fig. 7), at the end of June (Fig. 8) and at the beginning of September by the forest administration. Grasses as well as other herbaceous species were densely growing (Fig. 10), which made it sometimes difficult to spot tiny mushrooms.


Fig. 7: L3 in March, after mowing.


Fig. 8: L3 in June after mowing.

Fig. 9: L3 at the end of September, woodlot of *Pinus nigra* trees in the background.

Fig. 2: L3 at the beginning of October.

L4 – Lehnerin

Fig. 3: Google Earth image of L4.

This grassland plot (Fig. 11) is much smaller than L3 (Tab. 2) and scrub encroachment is quite progressed (Fig. 12). Also here mowing was performed at the same dates as in L3. At this location the ground vegetation is less dense than at L3, mosses are quite frequent here similar to Kreuzgrund (L3). Apparently the ground featured more pebbles than the other grassland (Fig. 13).

Fig. 4: Shrubs were quite common at L4. Picture was recorded in March.


Fig. 5: Picture of the soil at L4.

L5 – Herrnau I

Fig. 6: Image of L5 situated right next to Mühlleiten.

L5 is located next to Mühlleiten a small rural village (Fig. 14), agricultural fields are in close proximity. It is considered a hard alluvial forest but due to lack of flooding events tree species not typical for alluvial vegetation prosper (Krisai-Greilhuber, 1992). Anthropogenic influence was visible by the presence of trash but the degree of pollution by waste was relatively small. People going for a walk with dogs were witnessed regularly. Deadwood is abundantly distributed ranging from small branches to overthrown trees.

Right next to this plot two old gas pipes (length of approximately 3.5 km) were modernized which supply the metropolitan area of Vienna, Viennese airport and the refinery of Schwechat. In order to avoid damage on the local precious environment construction works were conducted in the previous winter. Recovering of the present vegetation afterwards was of public interest and a possible negative effect of the whole project was not considered detrimental for the ecology (Mauritsch and Nußbaum, 2017). Heavy machines were seen in March (Fig. 15), but vegetation seemed to recover during spring (Fig. 16).

Fig. 15: Pictures of heavy machines used for the modernization work of the gas system.

Fig. 16: During spring vegetation recovered again at places soil was dug up.

L7 – Herrnau II

Fig. 17: Picture of L7 which was in close proximity to L5.

Vegetation is similar to L5 i.e. hard alluvial forest (called in German “mäßig frische Harte Eichen-Lindenau“) with high abundance of *Fraxinus excelsior* (Krisai-Greilhuber, 1992). The characteristic feature of this plot is a dried out riverbed. Abundance of dead wood is quite high ranging from smaller branches to larger broken trees (Fig. 18). Except for little trash lying around sporadically no signs of anthropogenic influence was visible. Strollers were witnessed only sporadically at his place.

Fig. 18: L7 at the beginning of March.

L8 – Kaufau

Fig. 19: Picture of L8 which was closely located to Mühlleiten.

This plot is located in close proximity to L5, L7 and Mühlleiten (Fig. 19) respectively and has similar vegetation as in the two plots mentioned above. It is considered a (called in German "mäßig frische Harte Eichen-Lindenau") which features also *Corylus avellana* commonly (Krisai-Greilhuber, 1992). Also here construction works at the local gas pipe lines were conducted (Fig. 7). Right next to the plot a maize field is situated, which had approximately the same size as the plot. Also a warning shield concerning the presence of *Hymenoscyphus fraxineus* was seen close to L8. As in the other two hard wood alluvial forests deadwood is highly abundant, but no waste was seen here. Apart from the construction works and the agriculture, no signs of human activity were visible here. Regularly people riding bicycles and going for a walk with dogs were seen.

Hedera helix is obviously the most abundant herbaceous plant at this locality during the whole season. Another important aspect of this plot is the fact that trees are growing much more densely than at L5 and L7.

Fig. 20: Construction works closely to L8.

Vegetation

Concerning the vegetation at the observed plots an overview is given in Krisai-Greilhuber (1992). The data provided in her work are summarized here (Tab. 2 – Tab. 8).

Grassland vegetation

	Plots		
Trees	L1	L3	L4
Acer pseudoplatanus			x
Alnus incana			x
Populus alba		x	x
Populus nigra	x	x	x
Quercus robur		x	
Ulmus minor			x

Tab. 2: Tree species at the grasslands.

	Plots		
Shrubs	L1	L3	L4
Berberis vulgaris			x
Cornus mas			x
Cornus sanguineus	x		x
Crataegus monogyna	x	x	x
Frangula alnus	x		x
Hippophae rhamnoides			x
Ligustrum vulgare	x	x	x
Populus nigra	x	x	
Rhamnus catharticus	x		x
Rosa canina	x	x	x
Rosa rubiginosa	x		x
Salix elaegnos	x		
Salix purpurea	x		x

Tab. 3: Shrubs at the grasslands.

Herbaceous plants	Plots L1	L3	L4
Acer pseudoplatanus	x		
Achillea collina	x		
Achillea millefolium agg.	x	x	x
Acinos arvensis	x	x	
Agropyron trichophorum		x	
Agrostis stolonifera agg.			x
Allium oleraceum			x
Allium scordoprasum		x	x
Alyssum alyssoides	x		x
Anagallis arvensis		x	
Anemone sylvestris			x
Anthyllis vulneraria			x
Arabis sagittata			x
Aristolochia clematitis	x		x
Asparagus officinalis	x		
Asperula cynanchica		x	
Astragalus cicer		x	
Astragalus glyciphyllos		x	
Bellis perennis			x
Briza media			x
Bromus erectus		x	
Bromus mollis			x
Buphthalum salicifolium		x	x
Calamagrostis cf. *canescens*			x
Calamagrostis epigeios	x		
Campanula persicifolia		x	
Carduus nutans		x	
Carex caryophyllea			x
Carex flacca			x
Carex tomentosa	x		
Carpinus betulus juv.			x
Centaurea jacea	x		
Centaurea stoebe		x	
Centaurium erythraea		x	x
Cerastium glutinosum		x	x
Cerastium pumilum		x	
Cirsium arvense			x
Colchicum autumnale		x	x
Consolida regalis			x
Coronilla varia		x	x
Cynanchum vincetoxicum	x		x
Dactylis glomerata agg.		x	
Dorycnium germanicum		x	x
Echium vulgare	x	x	x
Equisetum arvensis			x
Erigeron acris subsp. *acris*	x		x
Erigeron cf. *annuus*	x		

Erucastrum gallicum		x	x
Eryngium campestre	x	x	x
Erysium hieraciifolium		x	
Euphorbia cyparissias	x	x	x
Euphorbia seguierana		x	
Euphrasia stricta		x	
Festuca rupicola	x	x	x
Fragaria viridis			x
Galium album	x		
Galium mollugo agg.	x	x	x
Galium verum agg.	x	x	x
Gypsophila repens		x	
Helianthemum ovatum		x	x
Herniaria glabra	x		x
Hieracium pilosella		x	
Hieracium piloselloides		x	x
Inula britannica	x		
Koeleria macrantha		x	x
Leontodon hispidus	x		x
Lepidium campestre	x		x
Linum catharticum		x	
Lithospermum purpureocaeruleum		x	
Lolium perenne			x
Lotus corniculatus	x	x	x
Medicago lupulina	x	x	x
Melica ciliata			x
Muscari racemosum		x	x
Myosotis arvensis		x	
Myosotis ramosissima		x	
Neotinea (=Orchis) ustulata		x	
Oenothera biennis agg.			x
Oenothera cf. *biennis*	x		
Ophrys sphegodes			x
Orchis militaris	x	x	x
Orchis morio		x	
Papaver rhoeas		x	x
Petrorhagia saxifraga	x	x	
Pimpinella saxifraga		x	
Plantago lanceolata	x	x	x
Poa angustifolia	x		
Poa pratensis		x	x
Poa trivialis			x
Polygala comosa			x
Populus alba juv.	x		
Potentilla argentea agg.	x	x	
Potentilla pusilla		x	
Potentilla verna agg.	x	x	
Prunella vulgaris	x		
Pyrus pyraster juv.			x

Quercus robur juv.			x
Rhinanthus minor		x	x
Rubus caesius	x		x
Salvia nemorosa		x	
Salvia pratensis		x	
Sanguisorba minor	x	x	x
Scabiosa columbaria agg.		x	
Scabiosa ochroleuca		x	x
Sedum sexangulare	x	x	x
Senecio cf. *jacobaea*		x	
Senecio vernalis		x	
Solidago virgaurea	x		x
Stachys recta		x	
Stipa joannis		x	x
Taraxum officinale agg.	x		x
Tetragonolobus maritimus			x
Teucrium chamedrys		x	x
Thesium arvense		x	x
Thymus glabrescens		x	x
Tragopogon dubius		x	
Tussilago farfara			x
Ulmus minor juv.	x	x	
Valeriana officinalis			x
Verbascum lychnitis		x	
Veronica arvensis		x	
Veronica prostrata		x	
Vicia angustifolia		x	
Viola hirta		x	x
Vitis vinifera ssp. *sylvestris*		x	

Tab. 4: Herbaceous plants at the grasslands.

Mosses	Plots L1	L3	L4
Abietinella abietina	x		
Cladonia pyxidata s.l.		x	x
Dicranella sp.	x		
Homalothecium phillipeanum	x		
Pleurozium schreberi	x		
Polytrichum piliferum	x		
Rhacomitrium canescens	x		x
Selaginella helvetica		x	
Tortella tortuosa	x		x

Tab. 5: Mosses at the grasslands.

Forest plots

Trees	Plots 5	7	8	2
Acer campestre	x	x	x	
Acer pseudoplatanus	x		x	
Carpinus betulus	x	x	x	
Fraxinus excelsior	x	x	x	x
Juglans nigra			x	
Populus alba			x	x
Populus canescens				x
Populus nigra				x
Prunus avium			x	
Quercus robur	x	x	x	
Tilia cordata	x	x		
Ulmus minor	x	x	x	x

Tab. 6: Tree species at the forest plots.

Shrubs	Plots 5	7	8	2
Berberis vulgaris	x		x	
Clematis vitalba	x	x	x	x
Cornus mas	x	x	x	
Cornus sanguinea	x	x	x	x
Corylus avellana	x	x	x	x
Crataegus laevigata	x	x	x	x
Euonymus europaea			x	x
Ligustrum vulgare			x	
Lonicera xylosteum	x		x	
Sambucus nigra	x	x	x	x
Viburnum opulus			x	

Tab. 7: Shrub species at forest plots.

Herbaceous plants	Plots 5	7	8	2
Adoxa moschatellina			x	
Aegopodium podagraria	x	x	x	x
Allium scorodoprasum	x	x		
Allium ursinum	x	x	x	x
Anemone ranunculoides			x	
Anthariscus sylvestris	x	x		
Artemisia vulgaris				x
Astragalus glyciphyllos			x	
Brachypodium sylvaticum	x	x		
Cardamine impatiens	x	x		x
Carex acutiformis				x
Circaea lutetiana				x
Cirsium arvense	x			x
Colchicum autumnale	x	x	x	
Convallaria majalis	x	x	x	
Convolvulus arvensis				x
Cruciata laevipes	x			
Dactylis glomerata			x	
Equisetum arvense				x
Eupatorium cannabium				x
Euphorbia cyparissias	x		x	
Festuca gigantea				x
Ficaria verna ssp. *verna*			x	x
Fragaria vesca	x	x		
Gagea lutea			x	x
Galanthus nivalis			x	x
Galium aparine	x	x	x	x
Galium mollugo agg.	x	x	x	
Geranium robertianum			x	
Geum urbanum	x	x	x	
Glechoma hederacea				x
Hedera helix			x	
Heracleum sphondylium	x	x	x	x
Humulus lupulus		x		x
Hypericum maculatum			x	
Impatiens noli-tangere				x
Impatiens parviflora			x	x
Lapsana communis				x
Lathraea squamaria			x	
Lithospermum purpurocaeruleum	x	x	x	
Loranthus europaeus			x	
Maianthemum bifolium			x	
Melica nutans	x	x	x	
Mentha longifolia	x			
Milium effusum	x		x	x
Neottia nidus-avis			x	x
Parietaria officinalis	x	x	x	x

Paris quadrifolia			x	
Physalis alkekengi	x	x		x
Polygonatum multiflorum	x	x	x	
Pulmonaria officinalis				x
Rubus caesius	x	x	x	x
Salvia glutinosa	x	x	x	x
Sanicula europaea	x	x	x	
Scilla vindobonensis				x
Senecio fuchsii				x
Silena alba	x			
Solidago gigantea	x	x		x
Stachys sylvatica	x	x	x	x
Stellaria media	x	x		
Stellaria nemorium				x
Symphytum officinalis				x
Symphytum tuberosum				x
Urtica dioica				x
Vicia cracca				x
Viola hirta	x			
Viola mirabilis		x		
Viola odorata			x	x
Viola reichenbachiana	x	x	x	

Tab. 8: Herbaceous plants at the forest plots.

Climate data

In this study meteorological data i.e. temperature and precipitation recordings of the weather station "Forsthaus Lobau", which is the closest one next to the surveyed plots, were considered.

Soil data

By considering the soil data (Krisai-Greilhuber, 1992) the following dendrogram was constructed with R, by using Euclidean distance as distance methode, in order to compare it with another one created by considering the species similarities of the plots (Fig. 21). As for the plots L5, L7 and L8 no individual data were available, these three plots were grouped together.

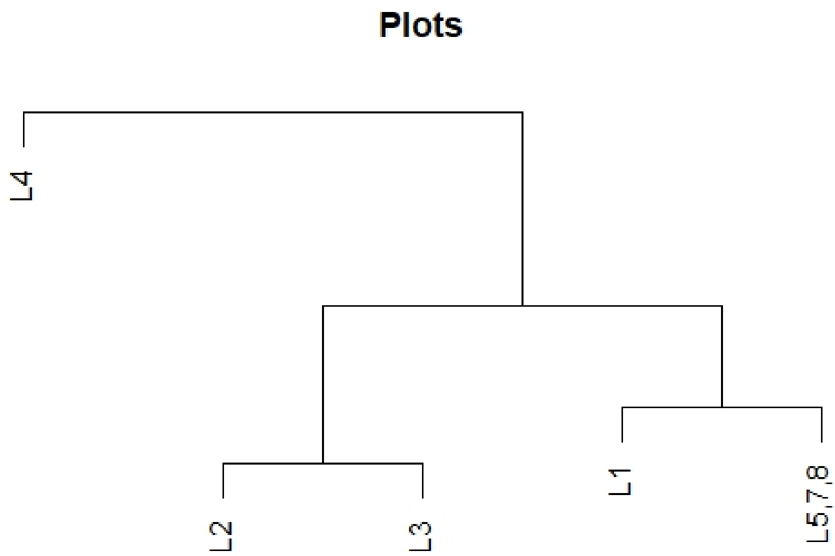

Fig. 8: Dendrogram of plot similarity based on soil characteristics.

Sampling

The fungal biodiversity was evaluated by picking macromycetal fruit bodies in a more or less weekly interval in all eight plots from March to November in 2017. In order to disturb the environment of the Lobau as less as possible only as much fruit bodies per species were picked as needed for the species determination. The frequency of fruit bodies was estimated ranging from 1 to 5 (Tab. 9), this system was used by Krisai-Greilhuber (1992). Each collected fruit body was packed separately to avoid mixing of spores, which are often necessary for unambiguous identification of a species.

Frequency classes		Number of fruit bodies
1	rare	1-2
2	dispersed	3-10
3	common	11-100
4	frequent	101-500
5	highly frequent	>500

Tab. 9: Abundance classes used for quantifying the number of fruit bodies.

Difficulties concerning sampling were the presence of litter in March and in autumn (Fig. 22) as well as abundant, densely growing herbaceous plants like *Allium ursinum* (Fig. 23), which made detection of mushrooms difficult and time consuming.

Fig. 22: Litter in the forest plots.

Fig. 23: *Allium ursinum* was highly abundant in this month.

Species identification

The identification of the species was basically carried out morphologically by using current determination literature (e.g. Knudsen and Vesterholt, 2008). Macroscopic as well as microscopic (e.g. spores size) characters of the macromycetes were considered for determination. Some individuals, which were difficult to determine, were dried and later identified by Sanger Sequencing of the ITS barcoding region at the Department of Botany and Biodiversity Research. It has to be emphasized that without the support of my supervisor, Dr. Irmgard Krisai-Greilhuber, the determination process of certain species would have been much less successful. This is also because identification of mushrooms is far away from being trivial and simply requires a lot of experience and knowledge.

Systematics

For gaining information on systematic aspects of the species collected the *Index Fungorum* (http://www.indexfungorum.org/) was considered.

Statistics

Statistical analysis was done with R (version 3.4.2), for creating diagrams Excel (©Microsoft), R (version 3.4.2) and SPSS Statistics 20 (© IBM) were used. For the comparison of the data with previous fungi recordings the dissertation of Irmgard Krisai-Greilhuber (Krisai-Greilhuber, 1992; Straatsma and Krisai-Greilhuber, 2003), the masterthesis of Martin Stulik (Stulik, 2016) and a database comprising all fungi found in the Lobau, provided by I. Krisai-Greilhuber for personal use, was used. However here it should be considered that the whole investigation on the macromycetes of the Lobau by Krisai-Greilhuber in collaboration with the Austrian Mycological Society spanned over a decade and not just one year. Also more study sites were investigated during their work, but due to the limited time frame it was decided to reduce the number of plots.

Results and Discussion

Total number of species

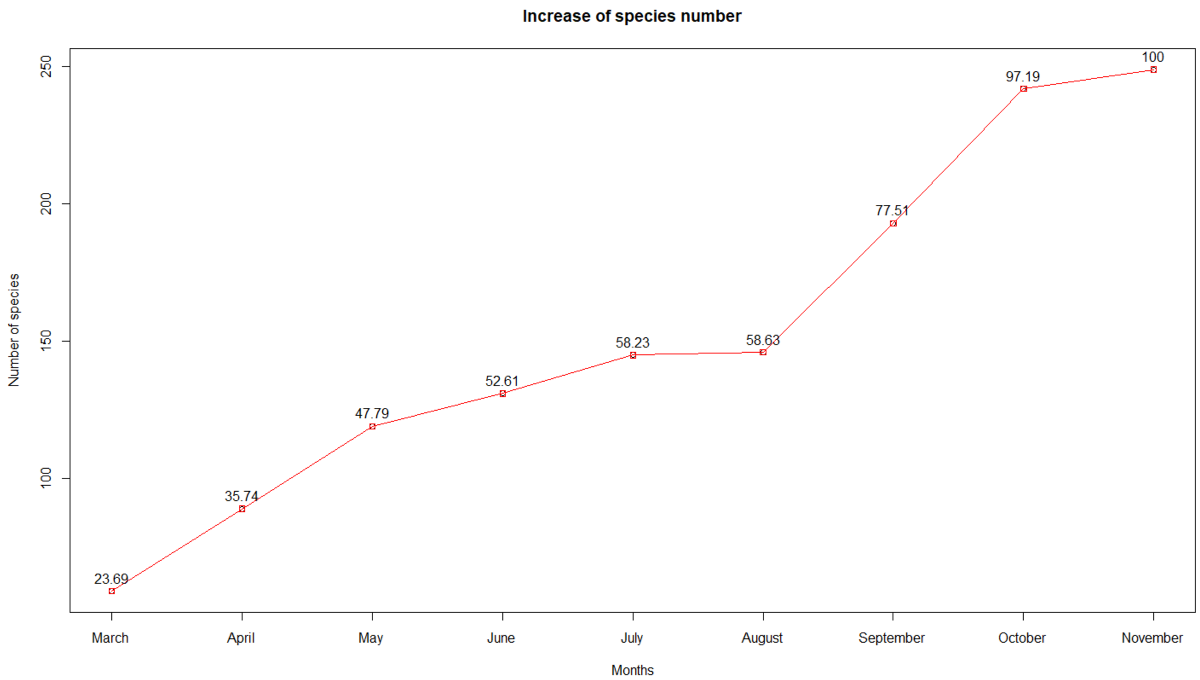

Fig. 24: Increase of total number of found fungal species and subspecies respectively found during this study.

After all a total number of 246 fungal taxa, i.e. species and infraspecific taxa, could be found during this study. Each month new taxa were found and determined which were not found before in this study (Fig. 24). Nearly a fourth (23.69 %) of all species found in this study was already found in the first month. The other two spring months April and May contributed over ten percent of the total number of species each, while between June and August the number of new discoveries decreased each month more and more. The smallest increase was contributed by August which was almost certainly caused by the very dry weather conditions of this month.

The highest increase of the total number of species took place during September and October. This was principally expected because it is the main season for mushrooms to grow. If more suveys were performed probably more species could have been found.

	Months									
Plots	March	April	May	June	July	August	September	October	November	Sum
L1	5	3	2	0	1	0	9	12	3	35
L2	15	15	19	13	10	7	29	19	9	136
L3	6	7	9	0	1	0	6	19	6	54
L4	6	7	7	0	0	0	6	14	3	43
L5	22	17	12	9	13	5	20	22	9	129
L7	32	19	17	18	17	6	30	34	6	179
L8	22	18	16	16	6	4	42	30	3	157
Sum	108	86	82	56	48	22	142	150	39	733

Tab. 10: Number of records found at each plot during the study.

Some species were found several times at the same plots during the season and at different plots within the same month. In total a number of 733 records was achieved (Tab. 10).

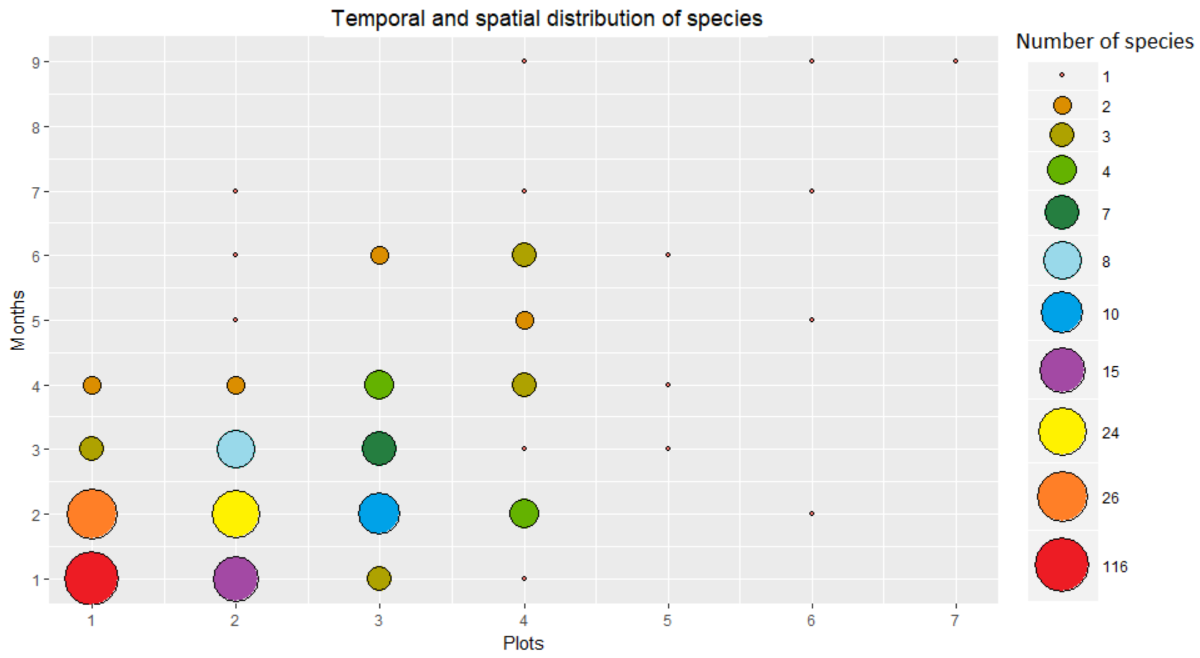

Fig. 25: Scatterplot of the number species which appeared at nplots (x-axis) in nmonths (y-axis).

Most species (116) were found one time on one plot (Fig. 25). 26 species appeared on one plot in two months and 24 were present on two plots for two months. Only one species i.e. *Schizophyllum commune* could be seen each month and on every observed plot. The constant presence of this species is not very suprising because it is the tenth most macromycets in Austria (Dämon and Krisai-Greilhuber, 2017).

In the long time study half of the species found were rare which means that they displayed a low abundance, yearly frequency and range. Only two species were found in all plots i.e. *Mycena galericulata* and *Lentinus (Polyporus) arcularius* (Krisai-Greilhuber 1992; Straatsma & Krisai-Greilhuber, 2003). This year *M. galericulata* was found in the forest plots but not in the grasslands and *L. arcularius* was found both in grasslands (L3, L4) and in a forest (L7).

Frequency of species

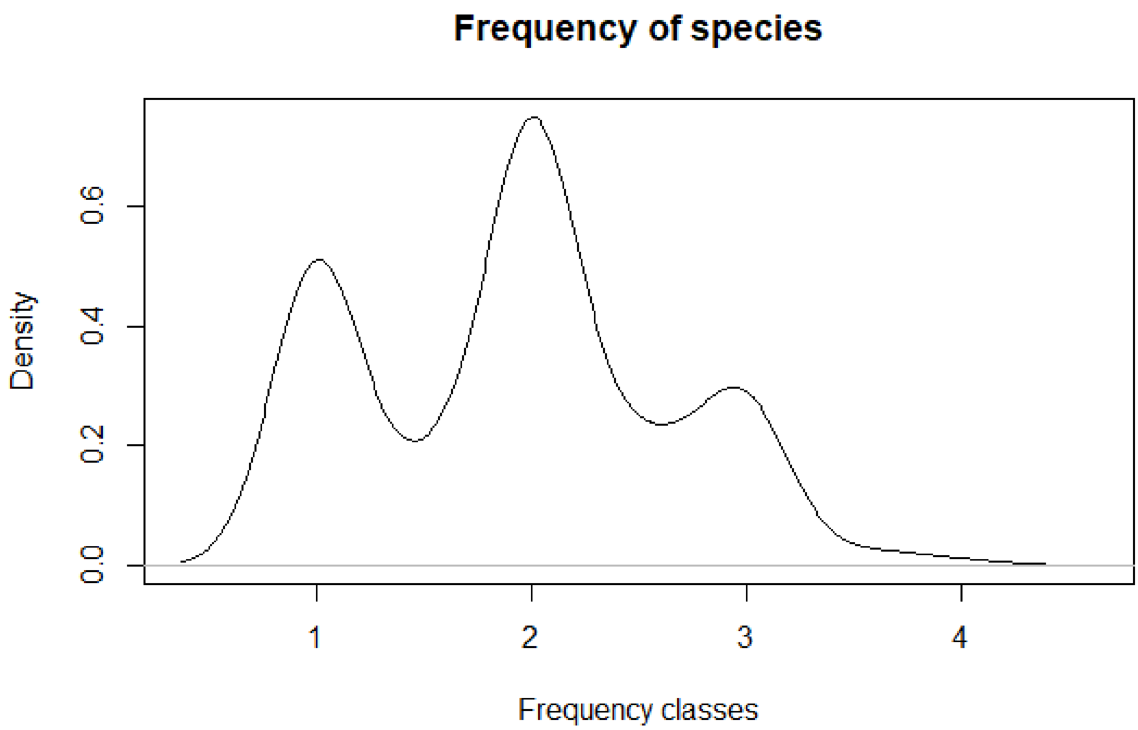

Fig. 26: Density plot of averaged frequencies of all species from March to November.

Most species were considered dispersed, so they were assigned to frequency class 2. No highly frequent species were encountered during this study (Fig. 26, Tab. 11). The abundance of fruit bodies of one and the same species varied between the plots and among the months (Tab. 19, Tab. 22).
However in this year at the observed plots many species reached their maximum productivity (= number of sporomata) in different plots e.g. *Armillaria gallica, Coprinellus micaceus, Coriolopsis gallica, Coriolopsis trogii, Dumontinia tuberosa* etc.
This incidence, that within one year a certain species produced their maximum number of fruit bodies in different plots and not just in one, has also been shown in the long-time study at the plots of *Lainzer Tiergarten* (Krisai-Greilhuber 1992, Straatsma & Krisai-Greilhuber, 2003).

	Frequency classes	Number of species	Percentage
1	rare	68	27,3
2	dispersed	121	48,6
3	common	56	22,5
4	frequent	4	1,6
5	highly frequent	0	0,0

Tab. 3: Table of absolute number and percentage of species which appeared at a given frequency.

Species Systematics

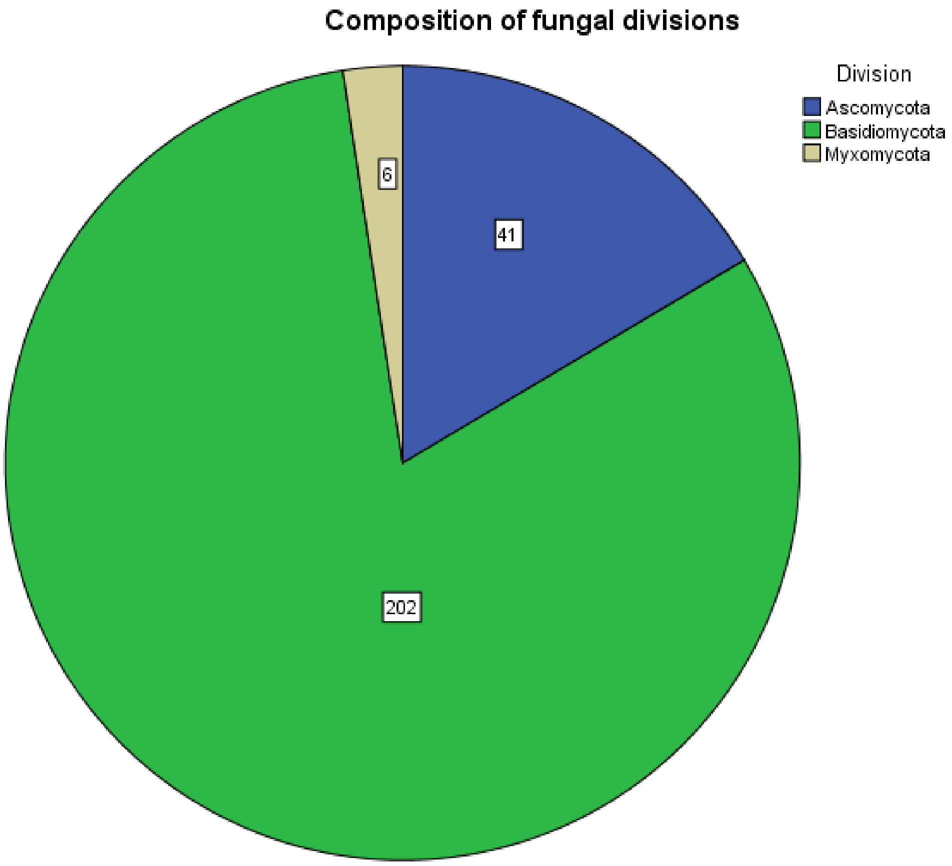

Fig. 9: Pie chart of fungal divisions.

Over eighty percent of the species found were Basidiomycota, 16.47 % were Ascomycota and only 2.41 percent were Myxomycota (Fig. 27, Tab. 12).

Division	Number	Percentage
Ascomycota	41	16,47
Basidiomycota	202	81,12
Myxomycota	6	2,41

Tab. 12: Total number and percentage of fungal divisions.

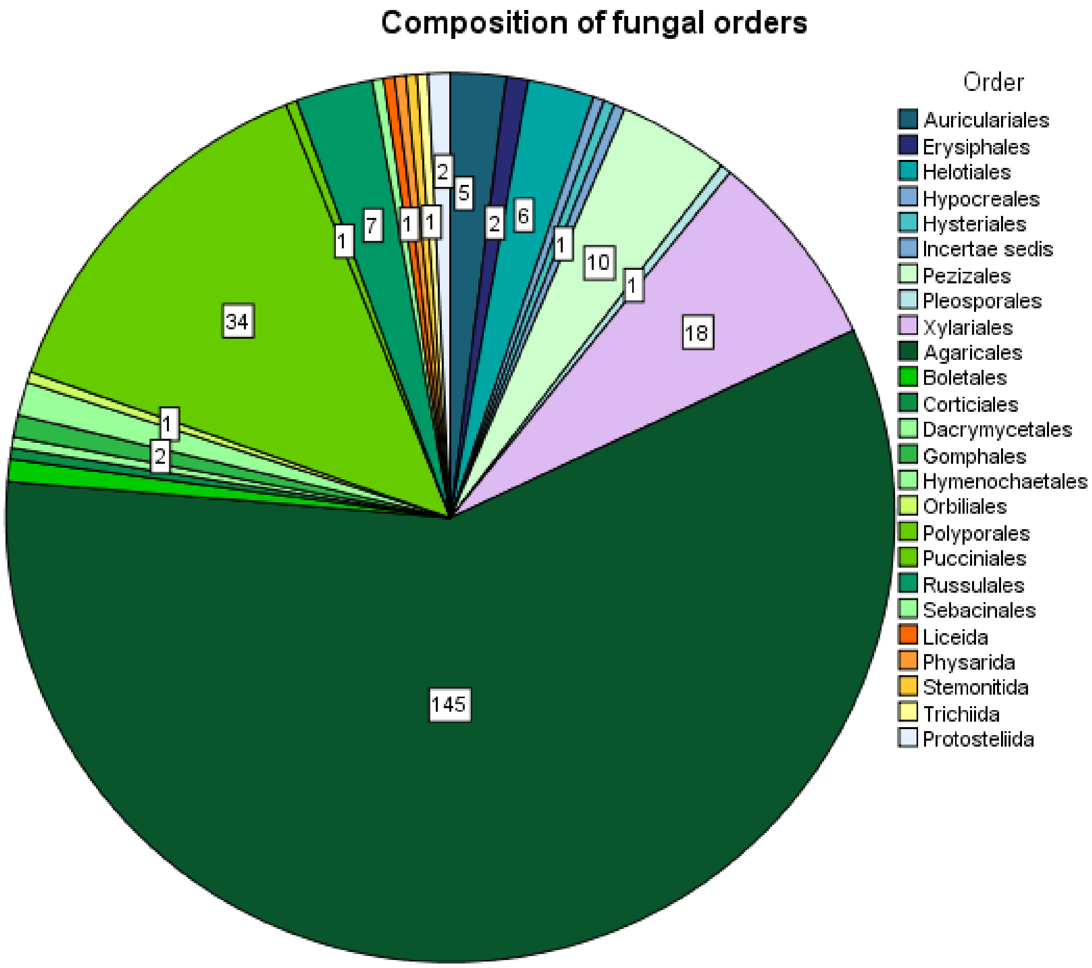

Fig. 28: Pie chart of fungal orders.

The most abundant order was Agaricales, featuring over 58 % of the total species found. Nearly all other orders featured between one and ten species (Fig. 28, Tab. 13).

Division	Order	Number	Percentage
Ascomycota	Auriculariales	5	2,01
	Erysiphales	2	0,80
	Helotiales	6	2,41
	Hypocreales	1	0,40
	Hysteriales	1	0,40
	Incertae sedis	1	0,40
	Pezizales	10	4,02
	Pleosporales	1	0,40
	Xylariales	18	7,23
Basidiomycota	Agaricales	145	58,23
	Boletales	2	0,80
	Corticiales	1	0,40
	Dacrymycetales	1	0,40
	Gomphales	2	0,80
	Hymenochaetales	3	1,20
	Orbiliales	1	0,40
	Polyporales	34	13,65
	Pucciniales	1	0,40
	Russulales	7	2,81
	Sebacinales	1	0,40
Myxomycota	Liceida	1	0,40
	Physarida	1	0,40
	Protosteliida	2	0,80
	Stemonitida	1	0,40
	Trichiida	1	0,40

Tab. 13: Absolute number and percentage of fungal orders.

List of all species found in this study

Class	Order	Family	Genus	*Species*
Ascomycetes	Incertae sedis	Incertae sedis	Phaeobotryosphaeria	*P. visci*
Dothideomycetes	Hysteriales	Hysteriaceae	Hysterium	*H. angustatum*
Dothideomycetes	Pleosporales	Pleosporaceae	Helminthosporium	*H. juglandinum*
Leotiomycetes	Erysiphales	Erysiphaceae	Microsphaera	*M. alphitoides*
Leotiomycetes	Erysiphales	Erysiphaceae	Uncinula	*U. bicornis*
Orbiliomycetes	Orbiliales	Orbiliaceae	Orbilia	*O. auricolor*
Pezizomycetes	Helotiales	Dermateaceae	Mollisia	*M. cinerea*
Pezizomycetes	Helotiales	Helotiaceae	Hymenoscyphus	*H. fraxineus*
Pezizomycetes	Helotiales	Helotiaceae	Bisporella	*B. citrina*
Pezizomycetes	Helotiales	Hyaloscyphaceae	Dasyscyphella	*D. nivea*
Pezizomycetes	Helotiales	Sclerotiniaceae	Dumontinia	*D. tuberosa*
Pezizomycetes	Pezizales	Morchellaceae	Disciotis	*D. venosa*
Pezizomycetes	Pezizales	Morchellaceae	Morchella	*M esculenta*
Pezizomycetes	Pezizales	Morchellaceae	Verpa	*V. conica*
Pezizomycetes	Pezizales	Pezizaceae	Peziza	*P. phyllogena*
Pezizomycetes	Pezizales	Pyronemataceae	Cheilymenia	*C. vitellina*
Pezizomycetes	Pezizales	Pyronemataceae	Scutellinia	*S. crinita*
Pezizomycetes	Pezizales	Pyronemataceae	Tarzetta	*T. cupularis*
Pezizomycetes	Pezizales	Pyronemataceae	Tarzetta	*T. cupularis var. velata*
Pezizomycetes	Pezizales	Sarcoscyphaceae	Sarcoscypha	*S. austriaca*
Pezizomycetes	Pezizales	Sarcoscyphaceae	Sarcoscypha	*S. coccinea*
Sordariomycetes	Hypocreales	Nectriaceae	Pseudocosmospora	*P.* sp. agg.
Sordariomycetes	Xylariales	Diatrypaceae	Diatrypella	*D. verruciformis*
Sordariomycetes	Xylariales	Xylariaceae	Biscogniauxia	*B. granmoi*
Sordariomycetes	Xylariales	Xylariaceae	Daldinia	*D. childiae*
Sordariomycetes	Xylariales	Xylariaceae	Hypoxylon	*H. fragiforme*
Sordariomycetes	Xylariales	Xylariaceae	Hypoxylon	*H. fuscum*
Sordariomycetes	Xylariales	Xylariaceae	Hypoxylon	*H. howeanum*
Sordariomycetes	Xylariales	Xylariaceae	Hypoxylon	*H. macrocarpum*
Sordariomycetes	Xylariales	Xylariaceae	Hypoxylon	*H. perforatum*
Sordariomycetes	Xylariales	Xylariaceae	Hypoxylon	*H. ticinense*
Sordariomycetes	Xylariales	Xylariaceae	Lopadostoma	*L. gastrinum*
Sordariomycetes	Xylariales	Xylariaceae	Nemania	*N. serpens*
Sordariomycetes	Xylariales	Xylariaceae	Rosellinia	*R. corticium*
Sordariomycetes	Xylariales	Xylariaceae	Virgariella	*V.* sp.
Sordariomycetes	Xylariales	Xylariaceae	Xylaria	*X. digitata*
Sordariomycetes	Xylariales	Xylariaceae	Xylaria	*X. hypoxylon*
Sordariomycetes	Xylariales	Xylariaceae	Xylaria	*X. longipes*
Sordariomycetes	Xylariales	Xylariaceae	Xylaria	*X. polymorpha*

Tab. 14: List of all found Ascomycota species and their taxonomic position.

Agaricomycetes	Agaricales	Agaricaceae	Agaricus	*A. bitorquis*
				A. xanthodermus
			Lepiota	*L. cristata*
			Leucoagaricus	*L. badhamii*
				L. leucothites
				L. barssii
				L. serenus
			Lycoperdon	*L. excipuliformis*
			Melanophyllum	*M. haematospermum*
			Tulostoma	*T. brumale*
		Amanitaceae	Amanita	*A. strobiliformis*
		Bolbitiaceae	Bolbitius	*B. titubans*
			Conocybe	*C. velutipes*
				C. juniana
				C. moseri var. moseri
				C. subovalis
				C. subxerophytica
			Panaeolus	*P. acuminatus*
				P. guttulatus
		Cortinariaceae	Cortinarius	*C. atrocoeruleus*
		Crepidotaceae	Crepidotus	*C. applanatus*
				C. autochthonus
				C. caspari
				C. caspari var. caspari
				C. caspari var. subglobisporus
				C. cesatii
				C. crocophyllus
				C. malachioides
				C. malachius
				C. mollis
		Entolomataceae	Clitopilus	*C. scyphoides var. omphaliformis*
			Entoloma	*E. aranaeosum*
				E. incanum
				E. plebejum
				E. rusticoides
				E. sericellum
				E. versatile
		Fistulinaceae	Fistulina	*F. hepatica*
		Hygrophoraceae	Cuphophyllus	*C. fuscescens*
		Hymenogastraceae	Galerina	*G. marginata*
			Hebeloma	*H. crustuliniforme*
				H. vaccinum
				H. velutipes
		Inocybaceae	Inocybe	*I. dulcamara*

			I. fastigiata
			I. furfurea
			I. fuscidula
			I. hirtella var. bispora
			I. inodora
			I. mixtilis
			I. rimosa
			I. splendens var. splendens
		Simocybe	*S. centunculus*
			S. centunculus var. centunculus
			S. sumptuosa
	Marasmiaceae	Baeospora	*B. myosura*
		Crinipellis	*C. scabella*
		Gymnopus	*G. aquosus*
			G. dryophilus
			G. erythropus
			G. impudicus
		Hydropus	*H. trichoderma*
		Gymnopus	*G. foetidus*
			G. brassicolens
			M. epiphyllus
			M. rotula
			M. wynnea
		Megacollybia	*M. platyphylla*
	Mycenaceae	Hemimycena	*H. cucullata*
		Antheniella	*A. flavoalba*
		Mycena	*M. abramsii*
			M. acicula
			M. galericulata
			M. galopus
			M. haematopus
			M. inclinata
			M. metata
			M. olida
			M. polygramma
			M. pseudopicta
			M. renati
			M. tintinnabulum
		Phloeomana	*P. hiemalis*
			P. speirea
			P. speirea f. candida
		Mycenella	*M. bryophila*
			M. cf. *salicina*
	Nidulariaceae	Cyathus	*C. striatus*

	Physalacriaceae	Armillaria	*A. cepistipes*
			A. gallica
			A. mellea
		Cylindrobasidium	*C. evolvens*
		Flammulina	*F. elastica*
			F. fennae
			F. populicola
			F. velutipes
			F. velutipes var. velutipes
		Strobilurus	*S. stephanocystis*
			S. tenacellus
		Xerula	*X. radicata*
	Pleurotaceae	Hohenbuehelia	*H. wilhelmii* (former European *H. angustata*)
			H. petaloides
		Pleurotus	*P. calyptratus*
			P. dryinus
			P. ostreatus
	Pluteaceae	Pluteus	*P. cinereofuscus*
			P. hispidulus
			P. leonius
			P. nanus
			P. pellitus
			P. podospileus
			P. romellii
			P. salicinus
			P. semibulbosus
	Psathyrellaceae	Coprinellus	*C. disseminatus*
			C. domesticus
			C. micaceus
		Coprinopsis	*C. atramentaria*
			C. picacea
		Psathyrella	*P. candolleana*
			P. conopilus
			P. fusca (=tephrophylla)
			P. gracilis
			P. leucotephra
			P. lutensis
			P. melanthina
			P. orbitarum
			P. panaeoloides
			P. pseudocorrugis
	Schizophyllaceae	Schizophyllum	*S. amplum*
			S. commune
	Strophariaceae	Agrocybe	*A. vervacti*

		Leratiomyces	*L. laetissimus*
		Meottomyces	*M. dissimulans*
		Stropharia	*S. coronilla*
	Tricholomataceae	Clitocybe	*C. agrestis*
			C. candicans
		Lepista	*L. sordida*
		Melanoleuca	*M. microcephala*
		Omphalina	*O. pyxidata*
		Tricholoma	*T. populinum*
	Tubariaceae	Flammulaster	*F. muricatus*
		Tubaria	*T. conspersa*
			T. dispersa
			T. furfuracea
Auriculariales	Auriculariaceae	Auricularia	*A. auricula-judae*
			A. mesenterica
		Exidia	*E. nigricans*
	Hyaloriaceae	Myxarium	*M. nucleatum*
Boletales	Paxillaceae	Paxillus	*P. ammoniavirescens*
	Suillaceae	Suillus	*S. luteus*
Corticiales	Corticiaceae	Dendrothele	*D. acerina*
Gomphales	Gomphaceae	Ramaria	*R. pseudogracilis*
			R. stricta
Hymenochaetales	Hymenochaetaceae	Hymenochaete	*H. rubiginosa*
		Fuscoporia	*F. ferruginosus*
		Fomitiporia	*F. hippophaecola*
Polyporales	Fomitopsidaceae	Antrodia	*A. albida*
		Fomitopsis	*F. pinicola*
	Ganodermataceae	Ganoderma	*G. applanatum*
	Meruliaceae	Abortiporus	*A. fractipes*
		Bjerkandera	*B. adusta*
		Gloeoporus	*G. dichrous*
	Phanerochaetaceae	Byssomerulius	*B. corium*
		Porostereum	*P. spadiceum*
	Polyporaceae	Coriolopsis	*C. gallica*
			C. trogii
		Daedaleopsis	*D. confragosa*
		Dichomitus	*D. campestris*
		Fomes	*F. fomentarius*
		Laetiporus	*L. sulphureus*
		Neolentinus	*N. cyathiformis*
		Lentinus	*L. tigrinus*
		Cellulariella	*C. warnieri*
		Porostereum	*P. spadiceum*

			Oligoporus	*O. fragilis*
				O. lacteus (=tephroleucus)
				O. subcaesius
			Neofavolus	*N. alveolaris*
			Lentinus	*Lentinus arcularius*
			Picipes	*Picipes badius*
			Cerioporus	*Cerioporus varius*
			Skeletocutis	*S. nivea*
			Trametes	*T. hirsuta*
				T. ochracea
				T. pubescens
				T. versicolor
		Steccherinaceae	Irpex	*I. lacteus*
			Steccherinum	*S. bourdotii*
				S. ochraceum
		Tubulicrinaceae	Lyomyces	*L. sambuci*
	Russulales	Auriscalpiaceae	Artomyces	*A. pyxidatus*
		Peniophoraceae	Peniophora	*P. limitata*
				P. quercina
		Russulaceae	Lactarius	*L. controversus*
				L. sanguifluus
		Stereaceae	Stereum	*S. hirsutum*
				S. subtomentosum
	Sebacinales	Sebacinaceae	Craterocolla	*C. cerasi*
Dacrymycetes	Dacrymycetales	Dacrymycetaceae	Dacrymyces	*D. stillatus*
Pucciniomycetes	Pucciniales	Melampsoraceae	Melampsora	*M.* sp.

Tab. 15: List of all found basidiomycota species.

Myxogastria	Liceida	Enteridiidae	Lycogala	*L. epidendrum*
	Physarida	Physaridae	Fuligo	*F. septica*
	Protosteliida	Ceratiomyxidae	Ceratiomyxa	*C. fruticulosa*
				C. poriodes
	Stemonitida	Stemonitidaceae	Stemonitopsis	*S. typhina*
	Trichiida	Trichiidae	Metatrichia	*M. vesparium*

Tab. 16: List of all found myxomycota species.

Redlist species

34 species i.e. 13.76 % of the total number of taxa found in this study were redlisted (Dämon & Greilhuber, 2017). Except *Verpa conica* all redlist species found are Basidiomycota.

Abortiporus fractipes, Antrodia albida, Conocybe subxerophytica, Coprinopsis picacea, Cortinarius atrocoeruleus, Craterocolla cerasi, Crepidotus autochthonus, Crepidotus crocophyllus, Entoloma plebejum, Entoloma versatile, Flammulaster muricatus, Flammulina fennae, Hebeloma vaccinum, Hohenbuehelia wilhelmii, Hydropus trichoderma, Inocybe inodora, Lactarius controversus, Lentinus tigrinus, Leucoagaricus serenus, Melanoleuca microcephala, Mycena olida, Mycena pseudopicta, Mycenella bryophila, Omphalina pyxidata, Panaeolus guttulatus, Pleurotus calyptratus, Pluteus hispidulus, Pluteus pellitus, Pluteus podospileus, Psathyrella leucotephra, Psathyrella lutensis, Simocybe sumptuosa, Tulostoma brumale, Verpa conica.

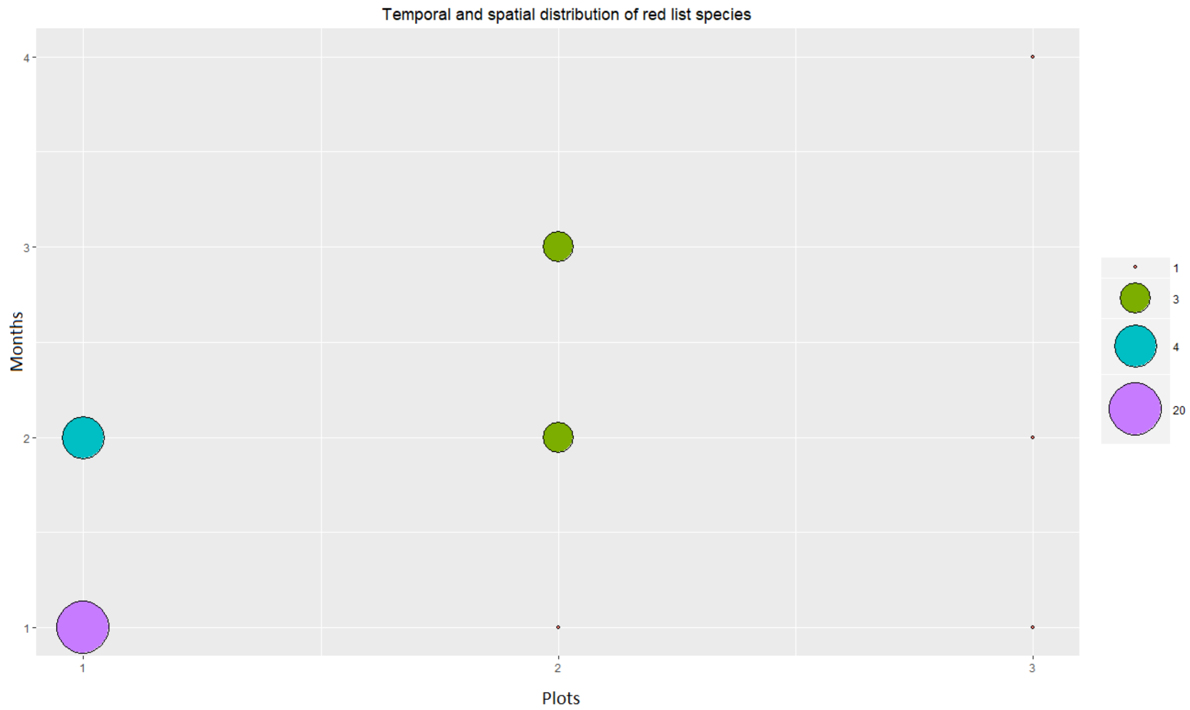

Fig. 29: Number of months and plots a redlist species was encountered.

Most redlist species (20) produced fruit bodies at only one plot in just one month (Fig. 29). One species (*Crepidotus autochthonus*) fruited at three plots four months. This was apparently the maximum time value for a redlist species to produce fruit bodies in this study. Redlist species produced fruit bodies in each month and at each plot (Tab. 17).

Species	Months	Plots
Abortiporus fractipes	June	L2
Antrodia albida	March, April	L2
Conocybe subxerophytica	April	L4
Coprinopsis picacea	October, November	L7, L8
Cortinarius atrocoeruleus	October, November	L1, L4, L7
Craterocolla cerasi	March	L5
Crepidotus autochthonus	June, August, September, October	L2, L5, L8
Crepidotus crocophyllus	July, September, October	L2, L5
Entoloma plebejum	May	L2
Entoloma versatile	October	L8
Flammulaster muricatus	July	L7
Flammulina fennae	July, September, October	L2, L8
Hebeloma vaccinum	October, November	L1
Hohenbuehelia wilhelmii	July	L2
Hydropus trichoderma	October	L1, L3, L7
Inocybe inodora	April, October	L3, L4
Lactarius controversus	September, October	L1
Lentinus tigrinus	September	L1
Leucoagaricus serenus	October	L5
Melanoleuca microcephala	October	L4
Mycena olida	October	L8
Mycena pseudopicta	October	L3, L4
Mycenella bryophila	September	L8
Omphalina pyxidata	September, October	L1, L4, L7
Panaeolus guttulatus	May	L3
Pleurotus calyptratus	April	L2
Pluteus hispidulus	July	L8
Pluteus pellitus	September	L8
Pluteus podospileus	September	L2
Psathyrella leucotephra	October, November	L7
Psathyrella lutensis	October	L3
Simocybe sumptuosa	September	L2
Tulostoma brumale	April, May, November	L1, L4
Verpa conica	April	L7

Tab. 4: Months and plots redlist species where found.

Plot	Number of redlist species	Amount of redlist species from total number of red-list species
L1	7	25.93
L2	10	12.82
L3	5	13.16
L4	7	19.44
L5	4	5.19
L7	6	6.19
L8	8	7.92

Tab. 18: Number and percentage of redlist species which were found at a certain plot.

Most red-list species were encountered at L1, least at L5 (Tab.18).

Month	Number of redlist species	Amount of redlist species from total number of red-list species
March	2	3.33
April	6	11.32
May	3	5.56
June	1	2.94
July	5	13.89
August	1	5.88
September	10	10.53
October	17	16.35
November	5	16.67

Tab. 19: Number and percentage of redlist species which were found in a certain month.

Most red-list species appeared during November, least in June (Tab. 19).

Months

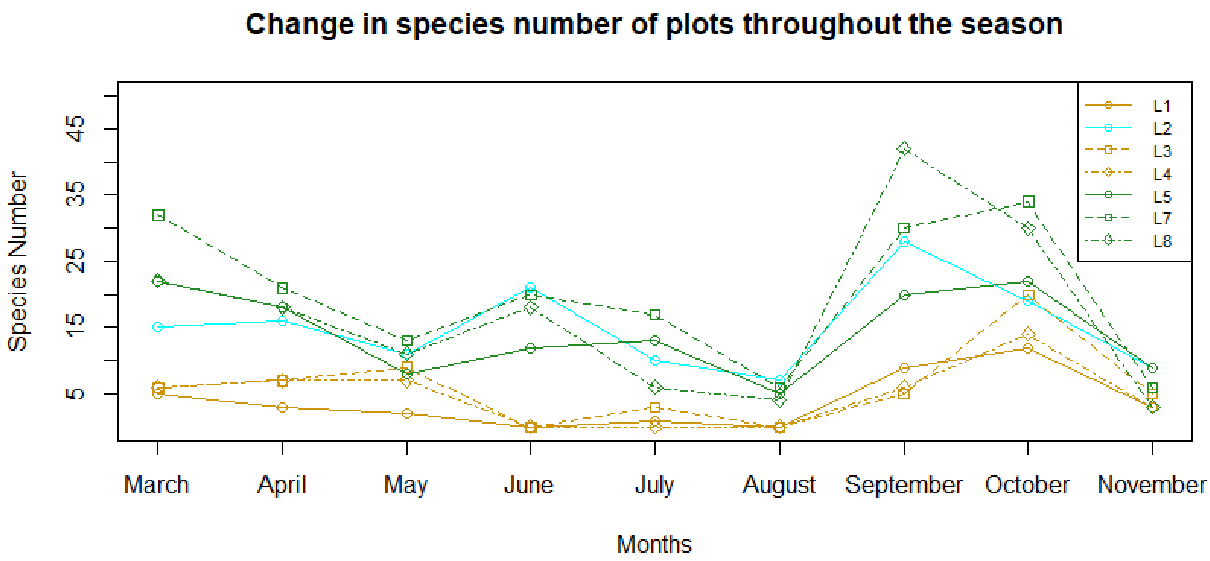

Fig. 30: Line chart of the number of species found at each plot during the season.

Month	#Species	Percentage of total number of species
March	60	24,29
April	53	21,46
May	54	21,86
June	34	13,77
July	36	14,57
August	17	6,88
September	95	38,46
October	104	42,11
November	30	12,15

Tab. 18: Number and percentage of species found in the respective months.

An ANOVA indicated a difference in species number between months, post-hoc Tukey test showed that between October and August ($p = 0.0022651$) and September and August ($p = 0.0052731$) a significant difference exists. The difference between all other months was not found to be significant.

The least number of species was found in August probably due to low soil moisture caused by drought of this month that is detrimental for fungi in the ground (Toberman et al. 2008). Summer drought was probably more severe for fungi at the grasslands because lacking of trees and therefore absence of shading by canopy led to higher evaporation and reduction of soil moisture. During the summer months the soil at the grasslands appeared to be absolutely dry. Some species found in March were probably remains from the last season but were recorded in order to get a complete overview of fungal species present in this area.

At grasslands nearly each month less species fruited than in forests (Fig. 30, Tab. 18). The highest numbers of species were found in September and October. At each plot the number of species increased during these months. The last survey took place at the beginning of November. If the sampling would have lasted longer probably more species were found in the last month.

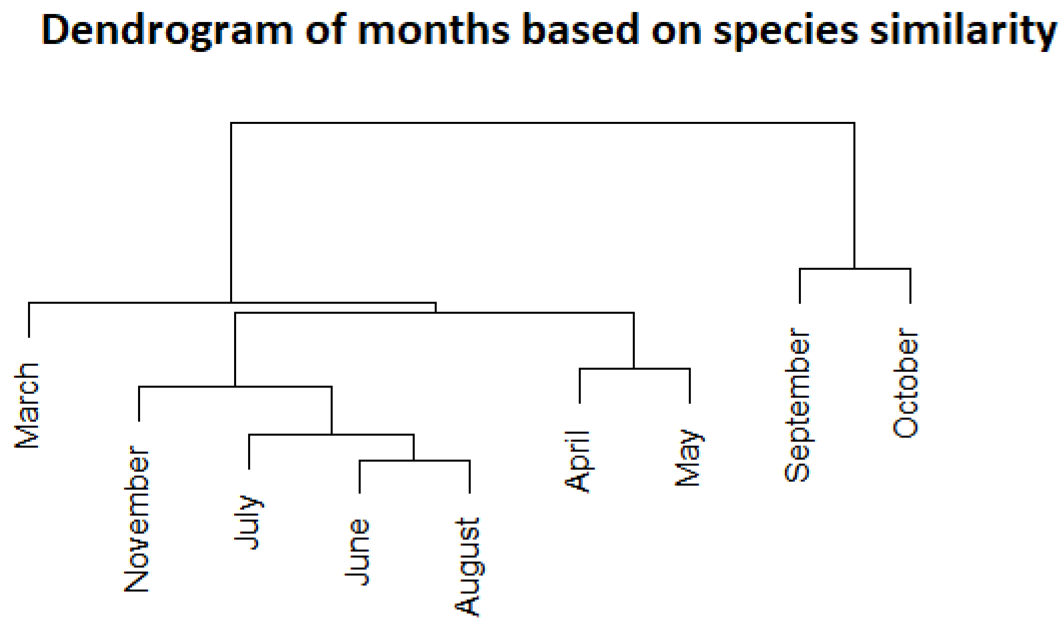

Fig. 31: Dendrogram of the months based on the species similarity.

Principally we can see that the clustering of the months based on their species similarity reflects more or less the time interval between the single months (Fig. 31). Because autumn is considered the main season for fungi to produce sporomata it is not surprising that September and October are within a clade separated from the other months. In these two autumn months species were found which have not been present before in this season. On the other hand June, July, August and November are clustered closely together because in these months almost only lignicolous species were found which were nearly always present during this study.

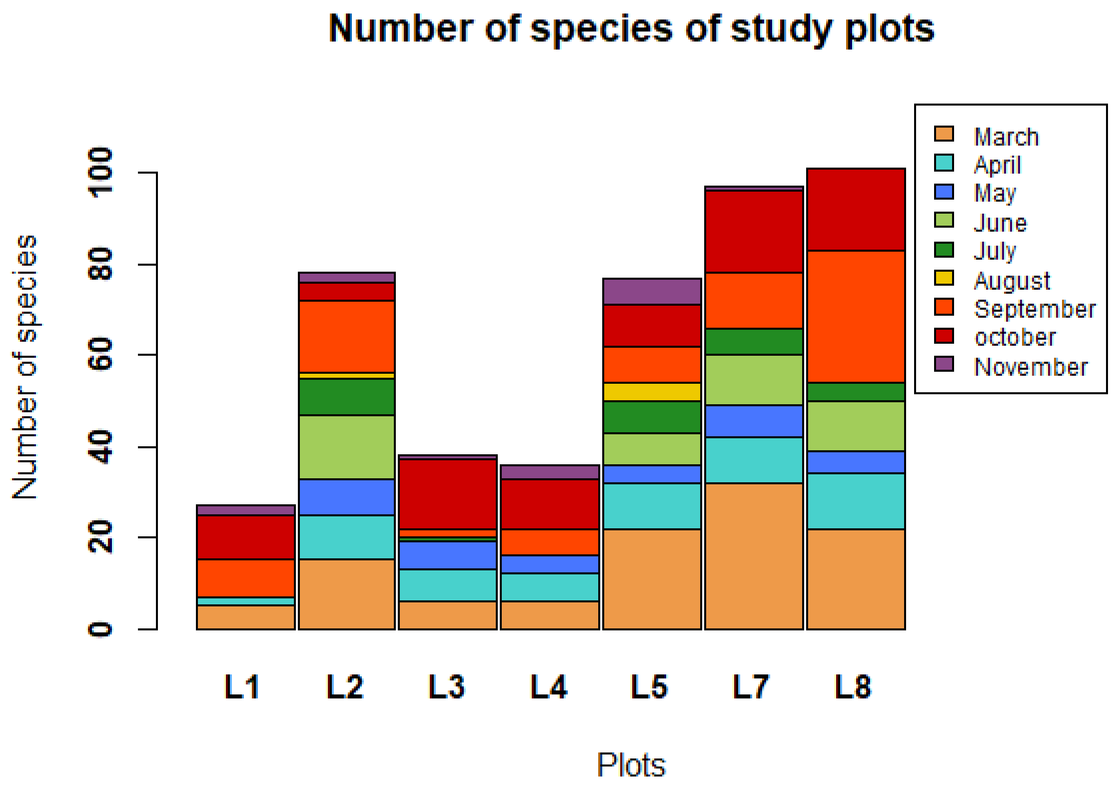

Fig. 32: Number of species found at each plot with respect to the month they were found for the first time.

At L2 and L5 each month contributed to the total amount of species found at these two plots (Fig. 32). The fungi found at L1 were composed only of species found in five months i. e. March, April, September, October and November. Also at L3 and L4 no (or just one at L3) new species were present between June and August at these plots. Concerning L7 and L8, in August and November no species new to these two study sites were encountered.

Species	Months								
	March	April	May	June	July	August	September	October	November
Abortiporus fractipes				1					
Agaricus bitorquis								2	
Agaricus xanthodermus									1
Agrocybe vervacti			1					3	
Amanita strobiliformis				1			1		
Antrodia albida	2	2							
Armillaria cepistipes								3	
Armillaria gallica								4	
Armillaria mellea								3	
Artomyces pyxidatus			2,5				1	2	
Auricularia auricula-judae	2,7	2,33	2,17	2			2	2	
Auricularia mesenterica	2,58	2,83	2,83	1,5	2	2	2	3	3
Baeospora myosura								2	
Biscogniauxia granmoi	2	2							
Bisporella citrina							2,5	2	2
Bjerkandera adusta	2						3		
Bolbitius titubans								1	
Byssomerulius corium							2	2	
Ceratiomyxa fruticulosa			1,5		1,5				
Ceratiomyxa poriodes					1				
Cheilymenia vitellina		3							
Clitocybe agrestis							2	2	
Clitocybe candicans								2	
Clitopilus scyphoides var. omphaliformis				1					
Conocybe velutipes								1	
Conocybe juniana							2		
Conocybe moseri var. moseri			1,5						
Conocybe subovalis							3		
Conocybe subxerophytica		1							
Coprinellus disseminatus			2				3		
Coprinellus domesticus						2			
Coprinellus micaceus		2	2		1,5		2,67	2	3
Coprinopsis atramentaria			1						
Coprinopsis picacea								1	1
Coriolopsis gallica	2,83	2,67				2	2	2	2
Coriolopsis trogii	2,67	2,5				2			
Cortinarius atrocoeruleus								2	1

Tab. 19: List of species found in the months of this study with averaged abundance levels in cells.

Species	Months								
	March	April	May	June	July	August	September	October	November
Craterocolla cerasi	3								
Crepidotus applanatus					1	2	2,25	3	
Crepidotus autochthonus				1		2	2,75	2	
Crepidotus caspari			1	1,5					
Crepidotus caspari var. caspari							2		
Crepidotus caspari var. subglobisporus								2	
Crepidotus cesatii				2					
Crepidotus crocophyllus					1		2	1	
Crepidotus malachioides					1				
Crepidotus malachius			2				2		
Crepidotus mollis			2				3	4	2
Crinipellis scabella								2	2
Cuphophyllus fuscescens									2
Cyathus striatus							2		
Cylindrobasidium evolvens									1
Dacrymyces stillatus				1					
Daedaleopsis confragosa	2,67				1				
Daldinia childiae	3	3			2		2		
Dasyscyphella nivea	3	3							
Dendrothele acerina	2,83	2,5					2		2
Diatrypella verruciformis	3								
Dichomitus campestris	2								
Disciotis venosa			2						
Dumontinia tuberosa	3,67	2							
Entoloma aranaeosum							2	1	
Entoloma incanum								1	
Entoloma plebejum			1						
Entoloma rusticoides								2	
Entoloma sericellum								1	
Entoloma versatile								1	
Exidia nigricans	2,67	2	2						
Fistulina hepatica							1		
Flammulaster muricatus					1				
Flammulina elastica								1	
Flammulina fennae					1		1,75	2	
Flammulina populicola								2	
Flammulina velutipes	1								1

Tab. 19 (continued): List of species found in the months of this study with averaged abundance levels in cells.

Species	Months								
	March	April	May	June	July	August	September	October	November
Flammulina velutipes var. velutipes							2		
Fomes fomentarius	2	2					1	1	
Fomitopsis pinicola			1				1	1	
Fuligo septica				1					
Galerina marginata								2	
Ganoderma applanatum	2						1		
Gloeoporus dichrous	2								
Gymnopus aquosus			2,5				2		
Gymnopus dryophilus			2				3		
Gymnopus erythropus							2	3	
Gymnopus impudicus				1				2	
Hebeloma crustuliniforme								2	
Hebeloma vaccinum								2	2
Hebeloma velutipes							2		
Helminthosporium juglandinum							2		
Hemimycena cucullata							2,5		
Hohenbuehelia wilhelmii					1				
Hohenbuehelia petaloides								1	
Hydropus trichoderma								1	
Hymenochaete rubiginosa	2,25								
Hymenoscyphus fraxineus				2,17	2		2,5		
Hypoxylon fragiforme							2		
Hypoxylon fuscum	3								
Hypoxylon howeanum	2						2		
Hypoxylon macrocarpum	3	3							
Hypoxylon perforatum	2								
Hypoxylon ticinense	2,5		2	1,5	1	1,5	2		2
Hysterium angustatum							2		
Inocybe dulcamare			1,5					3	1
Inocybe fastigiata								1	
Inocybe furfurea								2	
Inocybe fuscidula			1						
Inocybe hirtella var. bispora								3	
Inocybe inodora		1						2	
Inocybe mixtilis							2	1	
Inocybe rimosa					1		3	3	
Inocybe splendens var. splendens								3	

Tab. 19 (continued): List of species found in the months of this study with averaged abundance levels in cells.

Species	Months								
	March	April	May	June	July	August	September	October	November
Irpex lacteus	2,5					1	2	2	
Lactarius controversus							1	1	
Lactarius sanguifluus								2	
Laetiporus sulphureus	1			1			1		
Neolentinus cyathiformis		1	1						
Lentinus tigrinus							2		
Cellulariella warnieri	2	1		1	1,5	2	2	2	
Lepiota cristata							3	3	
Lepista sordida								1	
Leratiomyces latissimus							3		2
Leucoagaricus badhamii								2	
Leucoagaricus leucothites							1	2	
Leucoagaricus barssii							1	3	
Leucoagaricus serenus								2	
Lopadostoma gastrinum	3								
Porostereum spadiceum	2,5								
Lycogala epidendrum			2,5	1,5	2			3	2
Lycoperdon excipuliformis							2	1	
Lyomyces sambuci	2								
Gymnopus foetidus		2		1					
Gymnopus brassicolens								2	
Marasmius epiphyllus		2						3	
Marasmius rotula			1	2	2		1,25	3	
Marasmius wynneae								2	
Megacollybia platyphylla								1	
Melampsora sp.	3								
Melanoleuca microcephala								1	
Melanophyllum haematospermum								1	
Meottomyces dissimulans			1						
Metatrichia vesparium	1	2							
Microsphaera alphitoides							1		
Mollisia cinerea		2							
Mollisia melaleuca	3								
Morchella esculenta		2	1,5						
Mycena abramsii		2	2						
Mycena acicula		2	2				1		
Atheniella flavoalba							2	1	

Tab. 19 (continued): List of species found in the months of this study with averaged abundance levels in cells.

Species	Months								
	March	April	May	June	July	August	September	October	November
Mycena galericulata			1				2	2	1
Mycena galopus								1	
Mycena haematopus							3	2	
Phloeomana hiemalis		2	2						
Mycena inclinata							2	2	2
Mycena metata								1	
Mycena olida								1	
Mycena polygramma							2	1	
Mycena pseudopicta								2	
Mycena renati		3	2,25	1			1,67		
Phloeomana speirea			2				1,5		
Phloeomana speirea f. *candida*				1					
Mycena tintinabulum								2	
Mycenella bryophila							1		
Mycenella cf. *salicina*							2		
Myxarium nucleatum	3								
Nemania serpens	3								
Oligoporus fragilis							1		
Oligoporus lacteus (=tephroleucus)	2						2		
Oligoporus subcaesius					1		2	1	
Omphalina pyxidata							3	3	
Orbilia auricolor				1					
Panaeolus acuminatus		1						1	
Panaeolus guttulatus			1						
Paxillus ammoniavirescens							2		
Peniophora limitata	3								
Peniophora quercina	2								
Peziza phyllogena									1
Fuscoporia ferruginosa	2	3							
Fomitiporia hippophaecola	1,5								
Pleurotus calyptratus		1							
Pleurotus dryinus							1		
Pleurotus ostreatus							2	1	
Pluteus cinereofuscus					1				
Pluteus hispidulus					1				
Pluteus leonius							2		
Pluteus nanus			1,25	1			2	1	

Tab. 19 (continued): List of species found in the months of this study with averaged abundance levels in cells.

Species	Months								
	March	April	May	June	July	August	September	October	November
Pluteus pellitus							1		
Pluteus podospileus							2		
Pluteus romellii			1		1		2		
Pluteus salicinus								1	
Pluteus semibulbosus				1	1				
Neofavolus alveolaris	1	2	2,33	1,88	1		1		
Lentinus arcularius		1,5	2						
Picipes badius	2			1					
Cerioporus varius					1	1			
Porostereum spadiceum	2								
Psathyrella candolleana		2	1,5		1	1,5	1	2	
Psathyrella conopilus									2
Psathyrella fusca (=tephrophylla)		2	1						2
Psathyrella gracilis							2		
Psathyrella leucotephra								1	2
Psathyrella lutensis								2	
Psathyrella melanthina		1	1				3	2	
Psathyrella orbitarum								2	
Psathyrella panaeoloides		2	2				3	3	
Psathyrella pseudocorrugis			1						
Pseudocosmospora agg.							1		
Ramaria pseudogracilis								1	
Ramaria stricta								1	
Rosellinia corticium	3								
Sarcoscypha austriaca	2,75								
Sarcoscypha coccinea	1	1							
Schizophyllum amplum	2							3	
Schizophyllum commune	2,1	2,75	2,7	2	1	2	2	2	3
Scutellinia crinita		1							
Simocybe centunculus			1				2		
Simocybe centunculus var. *centunculus*					1				
Simocybe sumptuosa							2		
Skeletocutis nivea	3	3	2	2	1	2	1,83	2	2
Botryosphaeria visci		1,5	1						
Steccherinum bourdotii		2		1					
Steccherinum ochraceum	2,5	3		1,5	1	2	2		
Stemonitopsis typhina					1				

Tab. 19 (continued): List of species found in the months of this study with averaged abundance levels in cells.

	Months								
Species	March	April	May	June	July	August	September	October	November
Stereum hirsutum			2	1		2	2	2	
Stereum subtomentosum	2				1				
Strobilurus stephanocystis		1	2						
Strobilurus tenacellus			2						
Stropharia coronilla							3	3	
Suillus luteus								1	
Tarzetta cupularis		4	4	1,5					
Tarzetta catinus			3						
Trametes hirsuta	2								
Trametes ochracea	2,5								
Trametes pubescens									2
Trametes versicolor	2,25	2		2	1	2	2	2	
Tricholoma populinum									1
Tubaria conspersa		2			2		2,17	3	3
Tubaria dispersa							2		
Tubaria furfuracea		2	2						
Tulostoma brumale		2	2						2
Unicinula bicornis							2,25		
Verpa conica		2							
Virgariella mitosporic state of *Hypoxylon fuscum)*	2								
Xerula radicata							1	1	
Xylaria digitata	3								
Xylaria hypoxylon			2	2	1				
Xylaria longipes	3	3						2	
Xylaria polymorpha	2	1		2	2	2	2	1	

Tab. 19 (continued): List of species found in the months of this study with averaged abundance levels in cells.

The abundance of the species differed throughout the season (Tab. 19).

Plots

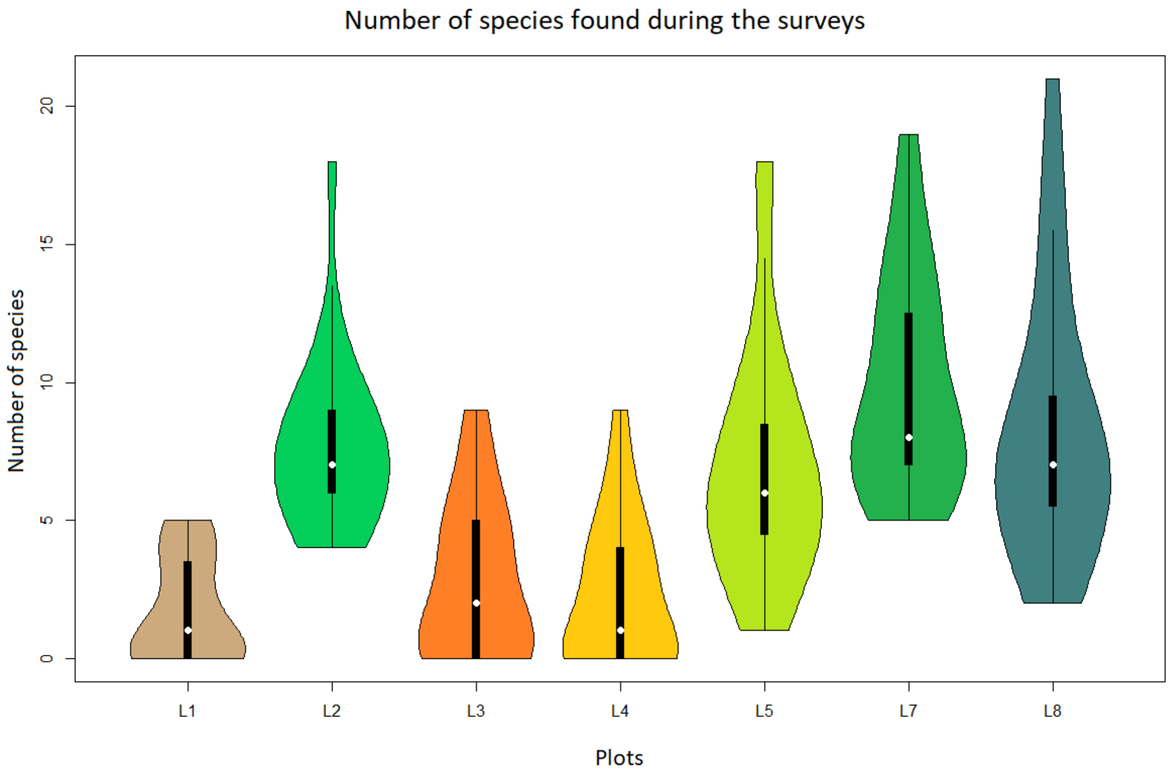

Fig. 33: Violine chart of the number of species found during the surveys at the plots.

Plot	#species
L1	26
L2	75
L3	36
L4	34
L5	73
L7	95
L8	98

Tab. 20: Number of species found at the respective plots.

The number of species which were found during the study varied significantly between the observed plots (p = 3.509e-05). A post-hoc Tukey test revealed that this variation was caused by the difference in species number between grassland plots (L1, L3 and L4) and forests (L2, L5, L7 and L8), the difference between L1 and L2 was not significant. Between the grasslands themselves no significant variation in species number was detected, neither was a significant variation visible between the forest plots.

The grasslands featured a lower number than the mixed forests and the alluvial forest (Fig. 33, Tab. 20). By comparing the dendrogram of the soil parameters with that based on species composition it seems that soil factors don't seem to be responsible for the species present on the single plots.

Considering the results of the long-time study it has been proposed that unknown factors influence the fungal biodiversity of a certain plot and the abundance of fruit bodies (Straatsma & Krisai-Greilhuber, 2003).
Both dryness and flooding are detrimental for the macrofungal richness of a certain area (cf. Arnolds, 1992). At L1 both conditions were given and that is probably why this plot featured the lowest number of species.

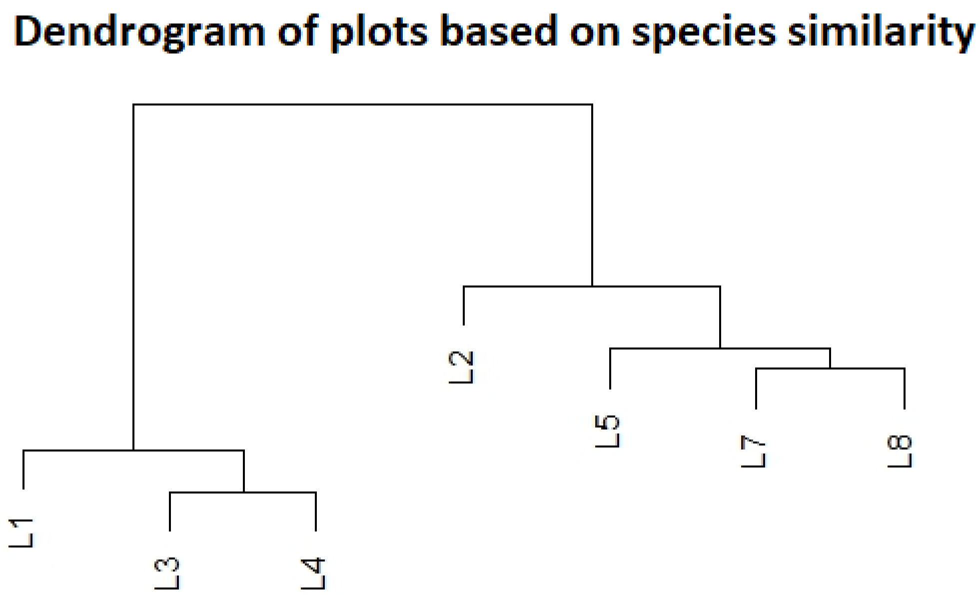

Fig. 34: Dendrogram of the study plots based on the species similarity.

The dendrogram of plots based on their species similarity reflects the vegetation type of the study sites i.e. grasslands L1, L3 and L4 are within one clade as well as the forests L5, L7 and L8 (Fig. 34). L2 is positioned right next to the hardwood alluvial forests. So eventhough L1 and L2 are relatively close to each other their fungal species composition is almost totally different, except for lignicolous species like *Schizophyllum commune* which were present nearly wherever deadwood and enough moisture was given.

By comparing the clustering based on soil properties (Fig. 21) it seems that these factors did not have an impact on the species composition of a certain plot, because the clustering of the two dendrograms does not match at all.

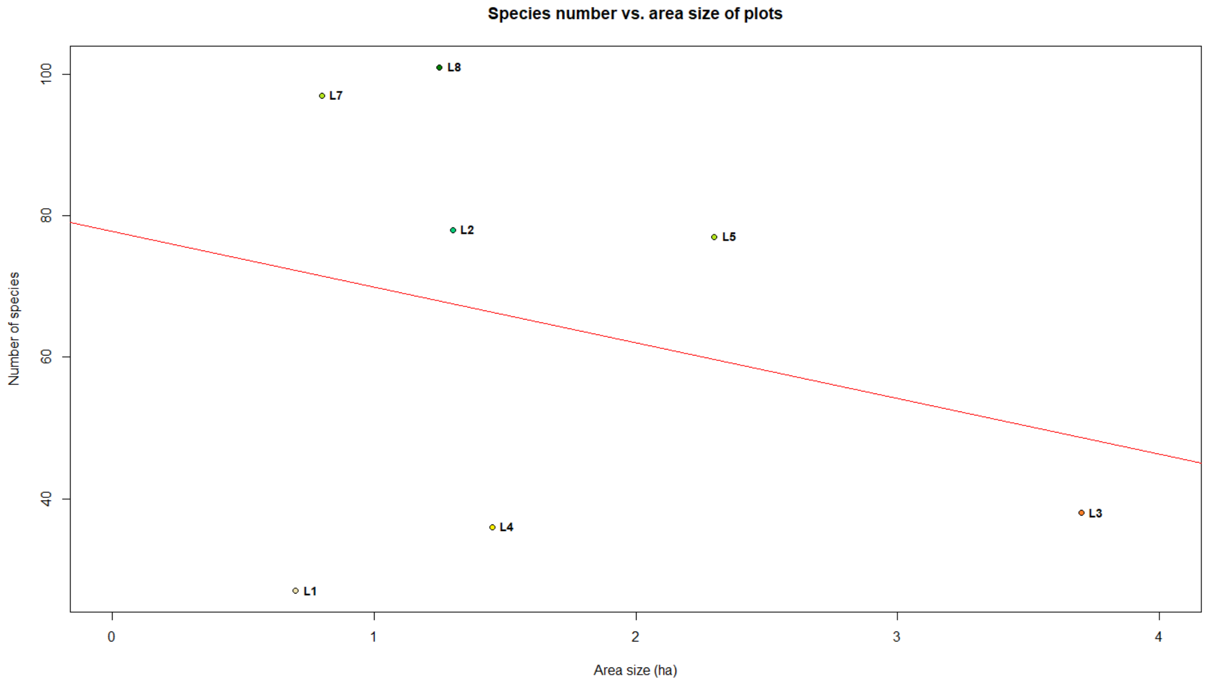

Fig. 35: Correlation between area size and species number.

Plot	#species	Area (ha)
L1	26	0,7
L2	75	1,3
L3	36	3,7
L4	34	1,45
L5	73	2,3
L7	95	0,8
L8	98	1,25

Tab. 21: Number of species found at the certain plots and their size.

Species number did not depend on the size of a certain plot (Fig. 35, Tab. 21). Also in the long time study no correlation between area size and number of species was visible (Krisai-Greilhuber 1992, Straatsma & Krisai-Greilhuber, 2003). This incidence seems to be true for both mycorrhiza as well as saprotroph species (Fig. 36, Fig. 37).

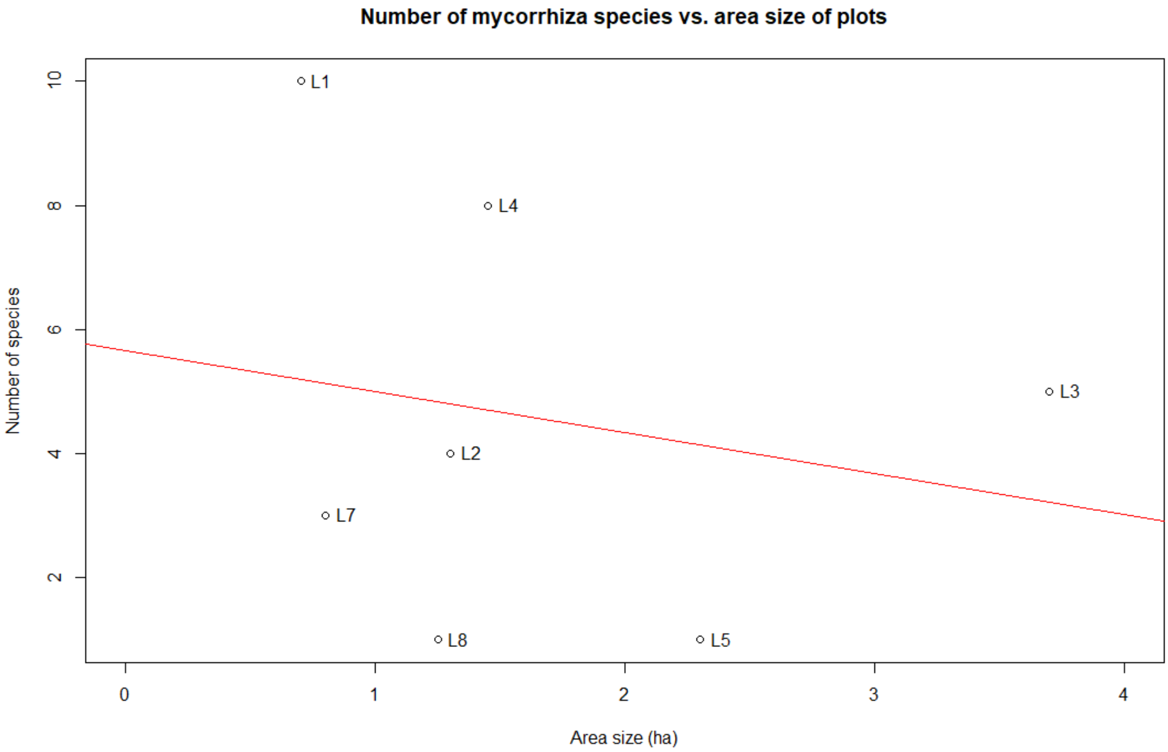

Fig. 36: Correlation between area size and number of mycorrhizal fungal species.

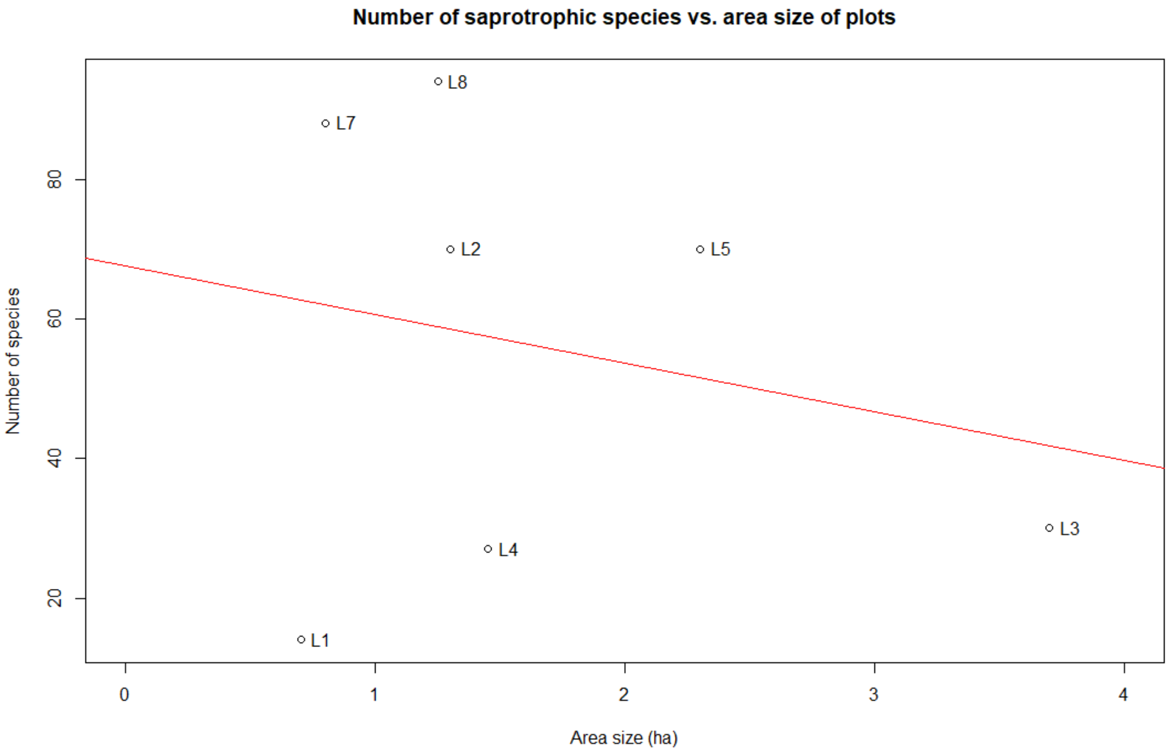

Fig. 37: Correlation between area size and number of saprotrophic species.

Species	Plots						
	L1	L2	L3	L4	L5	L7	L8
Abortiporus fractipes		1					
Agaricus bitorquis					1,33	2	
Agaricus xanthoderma					1		
Agrocybe vervacti			3	1			
Amanita strobiliformis		1					
Antrodia albida		2					
Armillaria cepistipes						3	
Armillaria gallica		3,5			4	3,5	3,5
Armillaria mellea						3	
Artomyces pyxidatus		2				3	
Auricularia auricula-judae		2	3		2	2,5	2
Auricularia mesenterica		2	3	2	2,5	3	3
Baeospora myosura			2				
Biscogniauxia granmoi					2		2
Bisporella citrina		3			2,33	2	
Bjerkandera adusta		2				2	
Bolbitius titubans			1				
Byssomerulius corium						2	
Ceratiomyxa fruticulosa		1			2		
Ceratiomyxa poriodes		1					
Cheilymenia vitellina						3	
Clitocybe agrestis	2						
Clitocybe candicans					2		
Clitopilus scyphoides var. *omphaliformis*						1	1
Conocybe velutipes			1				
Conocybe juniana							2
Conocybe moseri var. *moseri*		2	1				
Conocybe subovalis							3
Conocybe subxerophytica				1			
Coprinellus disseminatus		3					
Coprinellus domesticus					2		
Coprinellus micaceus			1		4	3	3
Coprinopsis atramentaria							1
Coprinopsis picacea						1	1
Coriolopsis gallica					3	3	3
Coriolopsis trogii	2	3			2	3	3
Cortinarius atrocoeruleus	2			1		1	

Tab. 22: List of species found at the study plots and their averaged abundance level.

Species	Plots						
	L1	L2	L3	L4	L5	L7	L8
Craterocolla cerasi					3		
Crepidotus applanatus		3				2	3
Crepidotus autochthonus		2			2		3
Crepidotus caspari							2
Crepidotus caspari var. *caspari*					2	2	2
Crepidotus caspari var. *subglobisporus*		2					
Crepidotus cesatii		2					
Crepidotus crocophyllus		1			1		
Crepidotus malachioides		1					
Crepidotus malachius		2				2	
Crepidotus mollis		3,5					
Crinipellis scabella			2	2			
Cuphophyllus fuscescens				2			
Cyathus striatus		2					
Cylindrobasidium evolvens					1		
Dacrymyces stillatus							1
Daedaleopsis confragosa	2			3	1	3	
Daldinia childiae		2		2	3	3	
Dasyscyphella nivea		3					
Dendrothele acerina					3	3	2,5
Diatrypella verruciformis						3	
Dichomitus campestris						2	
Disciotis venosa					2		
Dumontinia tuberosa					3,5	3,5	4
Entoloma aranaeosum							2
Entoloma incanum				1			
Entoloma plebejum		1					
Entoloma rusticoides			2				
Entoloma sericellum						1	
Entoloma versatile							1
Exidia nigricans		2			3	2,5	2,5
Fistulina hepatica						1	1
Flammulaster muricatus						1	
Flammulina elastica							1
Flammulina fennae		2					2
Flammulina populicola		2					
Flammulina velutipes		1			1	1	1

Tab. 5: List of species (continued) found at the study plots and their averaged abundance level.

Species	Plots						
	L1	L2	L3	L4	L5	L7	L8
Flammulina velutipes var. *velutipes*		2					
Fomes fomentarius		2			1		
Fomitopsis pinicola		1					
Fuligo septica		1					
Galerina marginata		2					
Ganoderma applanatum					2		
Gloeoporus dichrous				2			
Gymnopus aquosus							2
Gymnopus dryophilus				3	2		
Gymnopus erythropus					3		
Gymnopus impudicus				2	1	1	
Hebeloma crustuliniforme	2						
Hebeloma vaccinum	2						
Hebeloma velutipes	2						
Helminthosporium juglandinum							2
Hemimycena cucullata				3			2
Hohenbuehelia angustata		1					
Hohenbuehelia petaloides							1
Hydropus trichoderma	1		1			1	
Hymenochaete rubiginosa						2,5	2
Hymenoscyphus fraxineus					2	2,5	3
Hypoxylon fragiforme							2
Hypoxylon fuscum					3	3	3
Hypoxylon howeanum						2	2
Hypoxylon macrocarpum		3			3	3	3
Hypoxylon perforatum							2
Hypoxylon ticinense		2			3	3	2
Hysterium angustatum						2	
Inocybe dulcamare			3	2,5			
Inocybe fastigiata	1						
Inocybe furfurea	2						
Inocybe fuscidula				1			
Inocybe hirtella var. *bispora*	3						
Inocybe inodora			2	1			
Inocybe myxtilis		2					
Inocybe rimosa	3	3				1	
Inocybe splendens var. *splendens*	3						

Tab. 22 List of species (continued) found at the study plots and their averaged abundance level.

Species	Plots						
	L1	L2	L3	L4	L5	L7	L8
Irpex lacteus	2	2			2	3	2
Lactarius controversus	2						
Lactarius sanguifluus			2				
Laetiporus sulphureus			1				1
Neolentinus cyathiformis		1					
Lentinus tigrinus	2						
Cellulariella warnieri			2				2
Lepiota cristata	3		3				3
Lepista sordida							1
Leratiomyces latissimus	2		3	3			
Leucoagaricus badhamii						2	
Leucoagaricus leucothites	1					2	2
Leucoagaricus barssii					2	3	
Leucoagaricus serenus					2		
Lopadostoma gastrinum							3
Porostereum spadiceum		2				3	
Lycogala epidendrum		3			3	3	3
Lycoperdon excipuliformis				2			
Lyomyces sambuci						2	
Gymnopus foetidus						1	2
Gymnopus brassicolens						2	
Marasmius epiphyllus					3		2
Marasmius rotula		2			2	2	3
Marasmius wynneae				2			
Megacollybia platyphylla						1	
Melampsora sp.	3						
Melanoleuca microcephala				1			
Melanophyllum haematospermum							1
Meottomyces dissimulans					1		
Metatrichia vesparium		2			1		
Microsphaera alphitoides							1
Mollisia cinerea						2	2
Mollisia melaleuca		3					
Morchella esculenta		3	2	1	2	2	2
Mycena abramsii		2				2	2
Mycena acicula						2	2
Atheniella flavoalba			1			2	2

Tab. 22: List of species (continued) found at the study plots and their averaged abundance level.

Species	Plots						
	L1	L2	L3	L4	L5	L7	L8
Mycena galericulata		2			2	1	2
Mycena galopus							1
Mycena haematopus						3	3
Phloeomana hiemalis							2
Mycena inclinata					2	2	2
Mycena metata							1
Mycena olida							1
Mycena polygramma		3					1
Mycena pseudopicta			2	2			
Mycena renati						4	2
Phloeomana speirea							2
Phloeomana speirea f. *candida*						1	
Mycena tintinabulum							2
Mycenella bryophila							1
Mycenella cf. *salicina*		2					
Myxarium nucleatum					3		
Nemania serpens						3	3
Oligoporus fragilis							1
Oligoporus lacteus (=tephroleucus)						2	2
Oligoporus subcaesius					1	2	2
Omphalina pyxidata	3			3			
Orbilia auricolor							1
Panaeolus acuminatus				1			
Panaeolus guttulatus			1				
Paxillus ammoniavirescens				2			
Peniophora limitata					3		
Peniophora quercina					2		
Peziza phyllogena			1				
Fuscoporia ferruginosa					3		
Fomitoporia hippophaecola			2	1			
Pleurotus calyptratus		1					
Pleurotus dryinus					1		
Pleurotus ostreatus					2		
Pluteus cinereofuscus					1		
Pluteus hispidulus							1
Pluteus leonius					2		
Pluteus nanus		2			1	2	2

Tab. 22: List of species (continued) found at the study plots and their averaged abundance level.

Species	Plots L1	L2	L3	L4	L5	L7	L8
Pluteus pellitus							1
Pluteus podospileus		2					
Pluteus romellii		1				2	2
Pluteus salicinus						1	
Pluteus semibulbosus		1			1	1	1
Neofavolus alveolaris		2			2,5	2,5	2
Lentinus arcularius			2	2		2	
Picipes badius					2		1
Cerioporus varius					1		1
Porostereum spadiceum							2
Psathyrella candolleana		1		1	2		2
Psathyrella conopilus					2		
Psathyrella fusca (=tephrophylla)		2				1	2
Psathyrella gracilis		2					
Psathyrella leucotephra						2	
Psathyrella lutensis			2				
Psathyrella melanthina		1				3	3
Psathyrella orbitarum					2		
Psathyrella panaeoloides			3				
Psathyrella pseudocorrugis							1
Pseudocosmospora agg.					1		
Ramaria pseudogracilis						1	
Ramaria stricta							1
Rosellinia corticium							3
Sarcoscypha austriaca					2,5		3
Sarcoscypha coccinea						1	
Schizophyllum amplum						2	
Schizophyllum commune	3	3	2	2	3	3	3
Scutellinia crinita						1	
Simocybe centunculus		2				1	
Simocybe centunculus var. centunculus						1	
Simocybe sumptuosa		2					
Skeletocutis nivea		3			2	3	3
Sphaeropsis visci	2		1				
Steccherinum bourdotii						2	1
Steccherinum ochraceum					3	2	3
Stemonitopsis typhina						1	

Tab. 22: List of species (continued) found at the study plots and their averaged abundance level.

Species	Plots						
	L1	L2	L3	L4	L5	L7	L8
Stereum hirsutum						2	2
Stereum subtomentosum						2	
Strobilurus stephanocystis			2				
Strobilurus tenacellus			2				
Stropharia coronilla		3	3	3			
Suillus luteus			1				
Tarzetta cupularis		4					
Tarzetta catinus		3					
Trametes hirsuta		2		2			
Trametes ochracea		2				3	
Trametes pubescens					2		
Trametes versicolor	2	2	1		3	2	2
Tricholoma populinum				1			
Tubaria conspersa	3	2	3	2	3	2	
Tubaria dispersa							2
Tubaria furfuracea			2				
Tulostoma brumale	2			2			
Unicinula bicornis					2,5		2
Verpa conica						2	
Virgariella mitosporic stage of *H. fuscum*					2		
Xerula radicata						1	1
Xylaria digitata		3					
Xylaria hypoxylon						2	
Xylaria longipes		3				3	
Xylaria polymorpha					2	2	

Tab. 22: List of species (continued) found at the study plots and their averaged abundance level.

Ecology

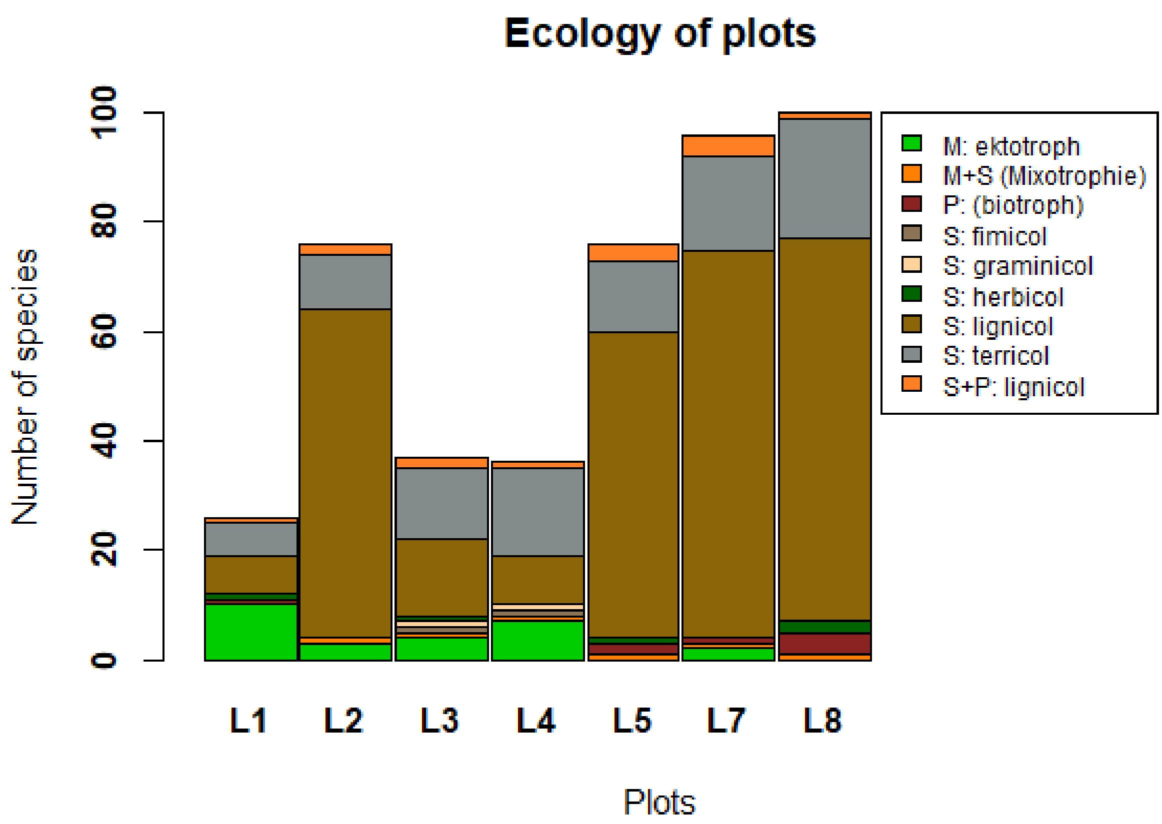

Fig. 38: Numbers of species found at each plot with respect to the ecotype the species belongs to.

In most terrestrial ecosystems and escpecially in forests saprotrophic basidiomycetes represent the majority of fungal species (cf. Heilmann-Clausen and Vesterholt, 2008). It seems that the higher number of species of L2, L5, L7 and L8 was mainly caused by the greater amount of lignicolous species (Fig. 38, Tab. 23). An explanation for this is simply the higher amount of lumber/wood at those plots. The proportion of ecotypes varied between the plots. In each plot except L4 lignicolous species were the most common ecotype. In all plots except L1 terricol species were the second largest ecological group.

In general fungal ecotypes which can be found at dry grasslands are saprotrophs, parasites of vascular plants and mosses, but also arbuscular mycorrhiza e.g. of the genus *Cortinarius* (cf. Blakesley and Buckley, 2016). *Cortinarius atrocoeruleus* was found at L1 and L4 this year (October and November) but also at the forest plot L7, where it is most probably shows its normal ectomycorrhizal behaviour.

The abundance of ectomycorrhizal fungi outside forests is generally low, but some macrofungi in grasslands seem to be able to form symbioses with *Helianthemum* (cf. Arnolds, 1992). A member of this plant genus *Helianthemum ovatum* grows at L3 and L4 (Krisai-Greilhuber, 1992), but the presence of ectomycorrhizal species *Inocybe dulcamara*, *Lactarius sanguifluus* and *Suillus* *luteus*) at L3 was probably caused by the presence of *Pinus nigra* trees growing in direct proximity of L3 (pers. comm. Krisai-Greilhuber).

In the forest plots lignicolous species were the vastly dominant ecological group, whereas in the grasslands terricolous were in the majority or the number of terricolous and lignicolous species was almost equal. Although the total number of species found was higher at L5, L7 and L8 the amount of ectomycorrhizal fungi seems smaller compared to the other study sites. This incidence could be owed to the fact that these three plots are under the highest antropogenic influence due to their location close to Mühlleiten. As mentioned before construction works of the underground gas pipelines (see Material and Methods) might have harmed the mycelia of mycorrhizal fungi, but also in the long-time study mycorrhizal species were absent in some years (Krisai-Greilhuber 1992; Straatsma & Krisai-Greilhuber, 2003).

Also in a recent study conducted in an alluvial forest in central Slovakia the most dominant ecotypes were lignicolous and terricolous saprotrophs respectively, the number of mycorrhizal species was also here relatively low compared to the other ecological groups (Mihál and Blanár, 2014). Wood degrading fungi should not be considered generalists, on the contrary, they seem to have a rather distinct specifity for their host trees even stronger than symbiotic fungal species have (Purahong et al. 2018).

Ecology		**L1**	**L2**	**L3**	**L4**	**L5**	**L7**	**L8**
Mycorrhiza: ektotroph		10	3	4	7	0	2	0
Mixotrophie: Mycorrhiza + Saprotrophic		0	1	1	1	1	1	1
Saprotrophic	fimicol	0	0	1	1	0	0	0
	graminicol	0	0	1	1	0	0	0
	herbicol	1	0	1	0	1	0	2
	lignicol	7	60	14	9	56	71	70
	terricol	6	10	13	16	13	17	22
Saprotrophic (lignicol) + parasitic		1	2	2	1	3	4	1
Parasitic: biotroph		1	0	0	0	2	1	4

Tab. 23: Abundance of fungal ecotypes.

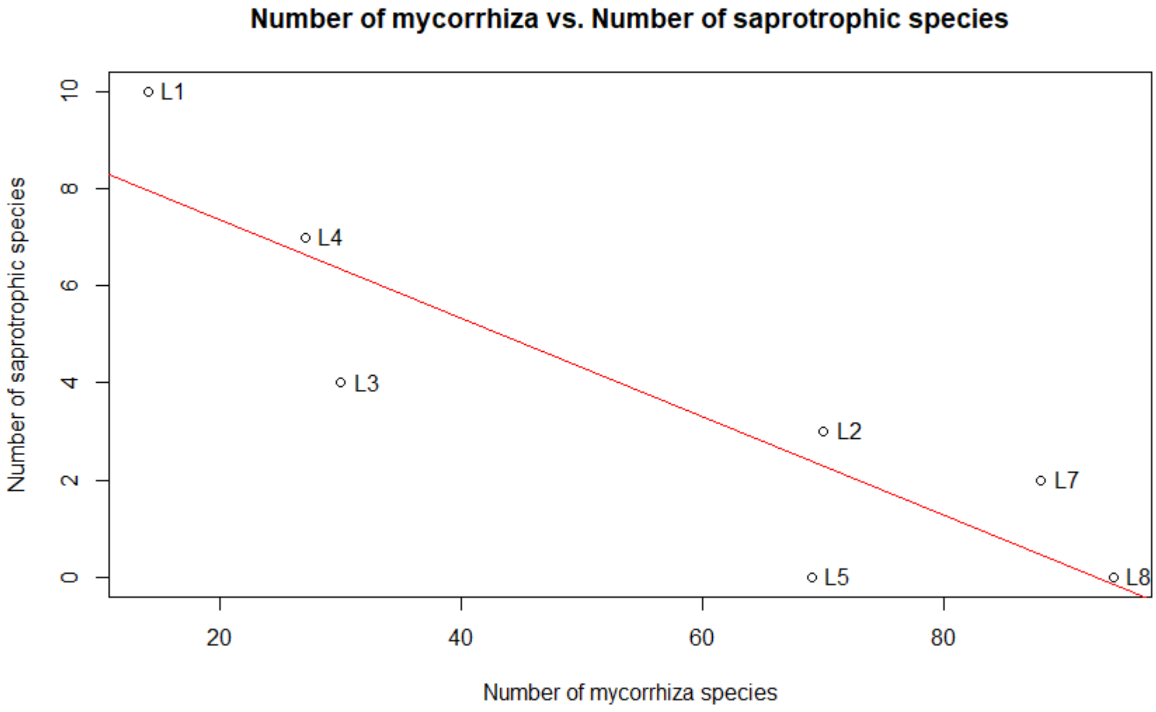

Fig. 39: Correlation between number of mycorrhizal fungal species and saprotrophic species.

A positive correlation between mycorrhiza and saprotrophic species was proposed (Krisai-Greilhuber 1992; Straatsma & Krisai-Greilhuber, 2003) but this was not the case in this year (Fig. 39). It should be mentioned at this point that during her study in some years mycorrhizal fungi were absent (Krisai-Greilhuber 1992; Straatsma & Krisai-Greilhuber, 2003).

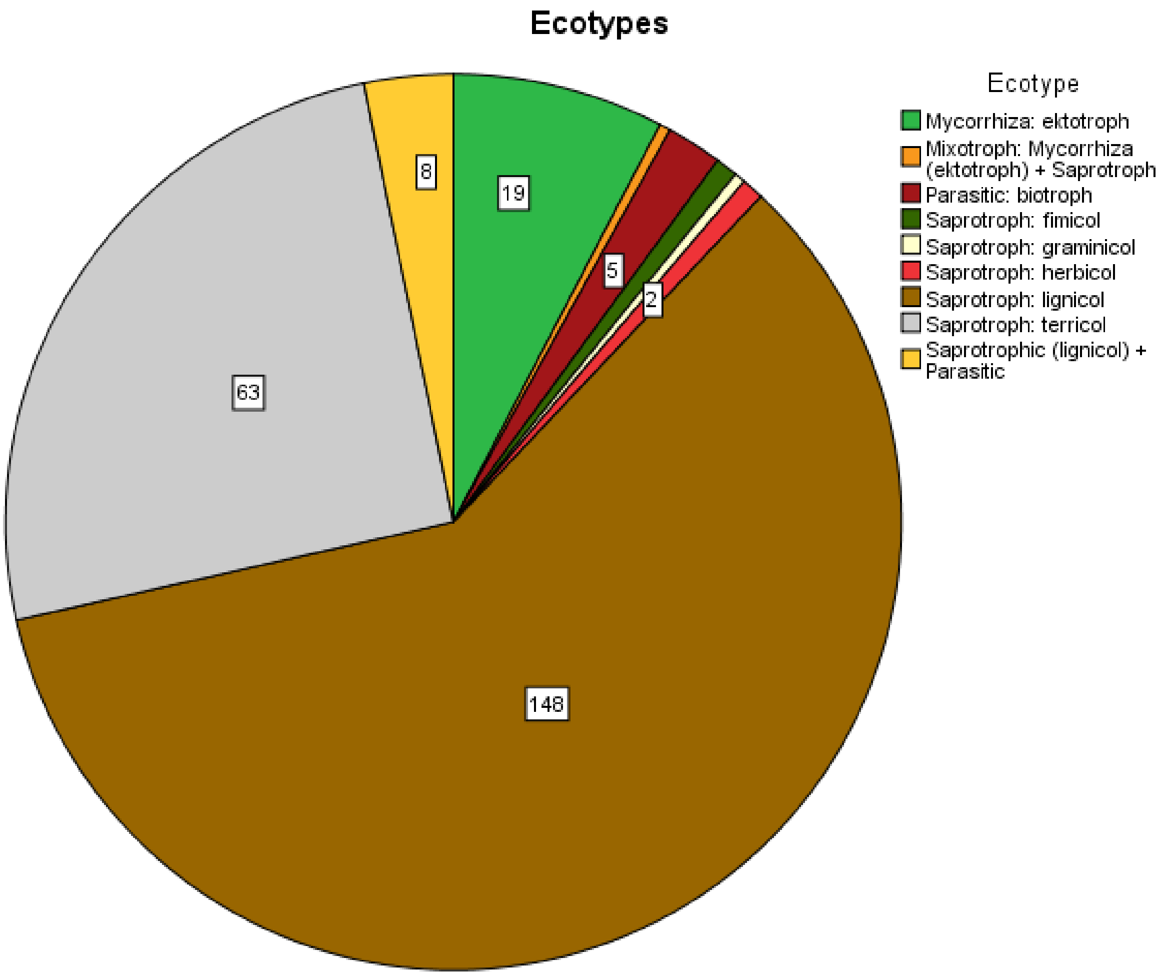

Fig. 40: Pie chart of fungal ecotypes.

Ecotype		#species	Percentage
Mycorrhiza: ektotroph		19	7.63
Mixotroph: Mycorrhiza (ektotroph) + Saprotroph		1	0.40
Saprotrophic	fimicol	2	0.80
	graminicol	1	0.40
	herbicol	2	0.80
	lignicol	148	59.44
	terricol	63	25.30
Saprotrophic (lignicol) + Parasitic		8	3.21
Parasitic: biotroph		5	2.01

Tab. 24: Table of absolute number and percentage of ecotypes.

Over 75 % of the species found during this study were saprotrophs (Fig. 40, Tab. 24). The biggest group were lignicolous, over one fourth were terricolous. Two species were fimicolous so those fungi used dung as nutrient source. Herbicolous were also respresented by two species and one fungus was graminicolous.

19 species were ectomycorrhizal, one species (*Morchella esculenta*) was mixotroph which means that it is able to live as a symbiont but can also use dead organic material as energy source. Eight species were

both saprotrophic and parasitic and five species were biotroph parasites.

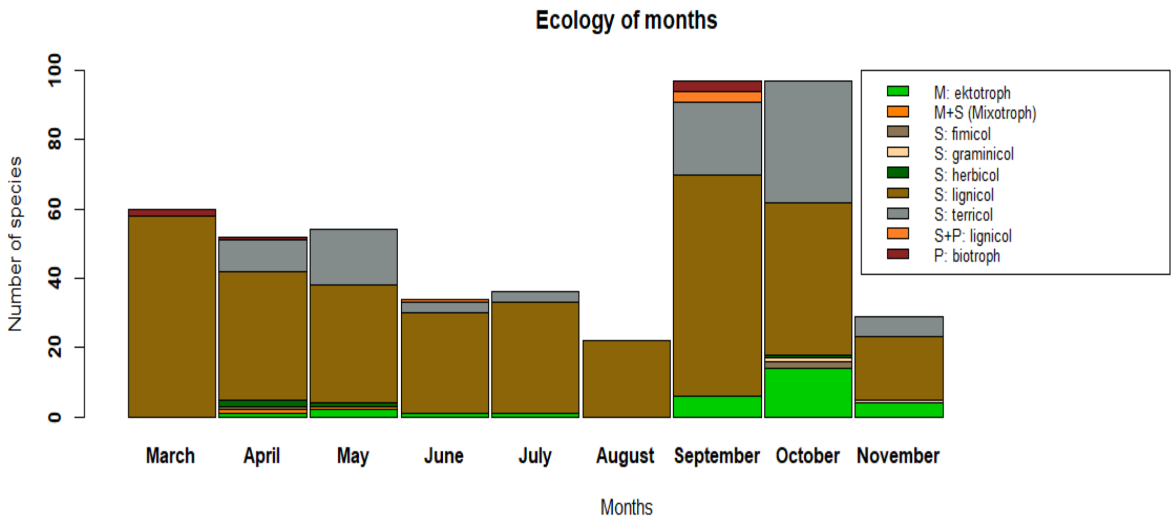

Fig. 41: Numer of species found during the season and their ecotype.

The lignicolous species were each month in the vast majority concerning the fungal ecotypes (Fig. 41, Tab. 25). Number of mycorrhizal and saprotroph-terricolous species increased during the main fruiting season. In August only lignicolous species were found, but also only one survey was performed due to the dry weather of this month.

Ecology		March	April	May	June	July	August	September	October	November
Mycorrhiza: ektotroph		0	1	2	1	1	0	6	14	4
Mixotrophie: Mycorrhiza + Saprotrophic		0	1	1	0	0	0	0	0	0
Saprotrophic	fimicol	0	1	0	0	0	0	0	2	0
	graminicol	0	0	0	0	0	0	0	1	1
	herbicol	0	2	1	0	0	0	0	1	0
	lignicol	58	37	34	29	32	22	64	44	18
	terricol	0	9	16	3	3	0	21	35	6
Saprotrophic (lignicol) + parasitic		0	0	0	1	0	0	3	0	0
Parasitic: biotroph		2	1	0	0	0	0	3	0	0

Tab. 25: Table of number of ecotypes found during the season.

Climatic data

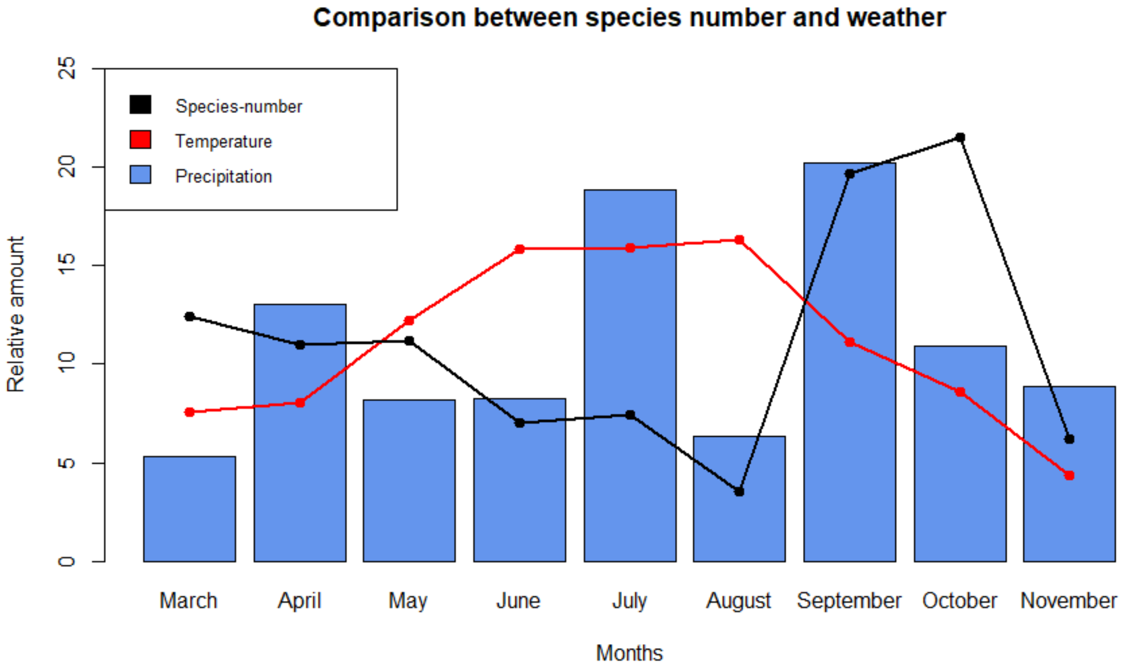

Fig. 42: Relation between species number, precipitation and temperature.

Between March and October an increase in temperature caused a more or less decrease in the species number each month (Fig. 42, Tab. 26). In November both species number and temperature dropped. By comparing temperature with species number it seems that beyond 16.5 °C (Fig. 43) the amount of fruit bodies became lower in this year, whereas precipitation had a positive effect on the number of species (Fig. 44). Eventhough weather seems to be important for mushroom growth and production it cannot explain annual productivity completely (summarised by Egli, 2011).

By considering the ecology of the species found in each month during this study, it seems that terricolous and mycorrhizal fungi profited from the relatively high precipitation in September and the temperature drop in autumn.

Month	Precipitation [mm]	Temperatur [°C]	#species
March	0.816	11,15	60
April	1.997	11,88	53
May	1.252	18,06	54
June	1.257	23,33	34
July	2.884	23,49	36
August	0.965	24,08	17
September	3.093	16,44	95
October	1.665	12,63	104
November	1.350	6,39	30

Tab. 26: Precipitation, temperature and species number during the season.

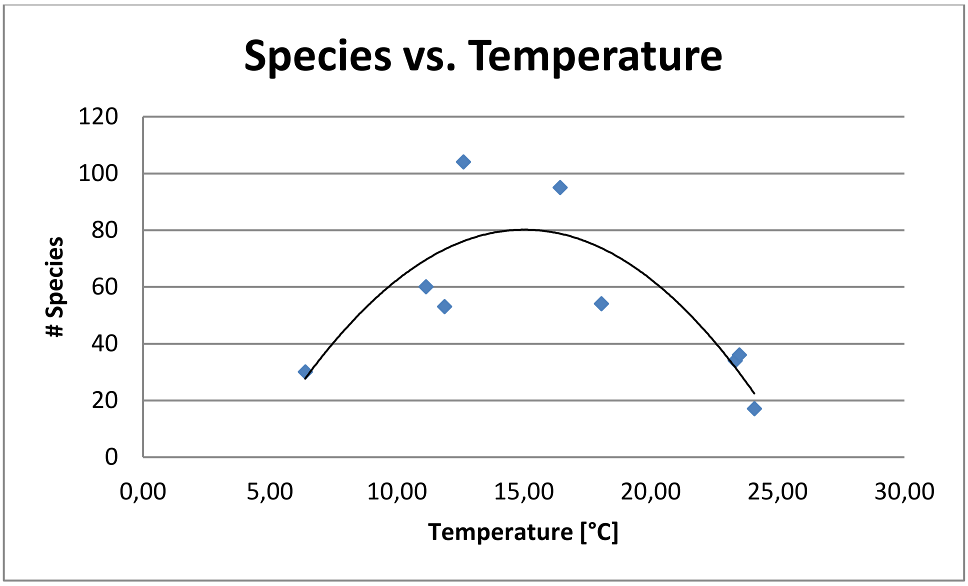

Fig. 43: Relation between number of species and temperature.

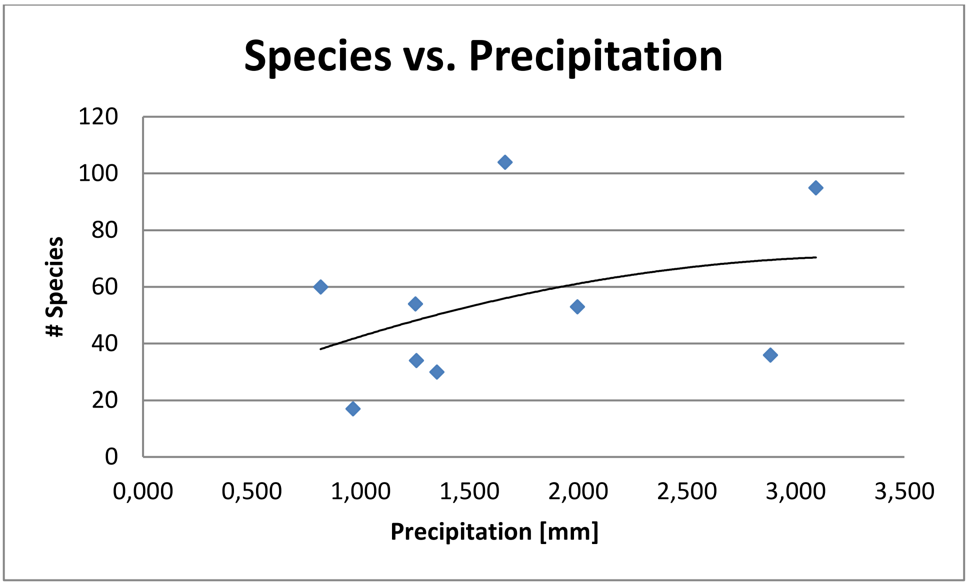

Fig. 44: Relation between number of species and temperature.

The number of fungi found in a certain environment seems to be narrowed by unfavourable weather conditions whereas humidity appears to be more important than temperature (Talley et al. 2002). Further it seems that rain, in spring and in autumn, is the main factor for the production of fruit bodies in autumn (Salerni et al. 2002).

However a very clear relation between abundance of fungal species and weather was not determined for the data of the long-time study (Straatsma & Krisai-Greilhuber, 2003). For a solid comparison between results of the long-time study and recent data more surveys need to be conducted.

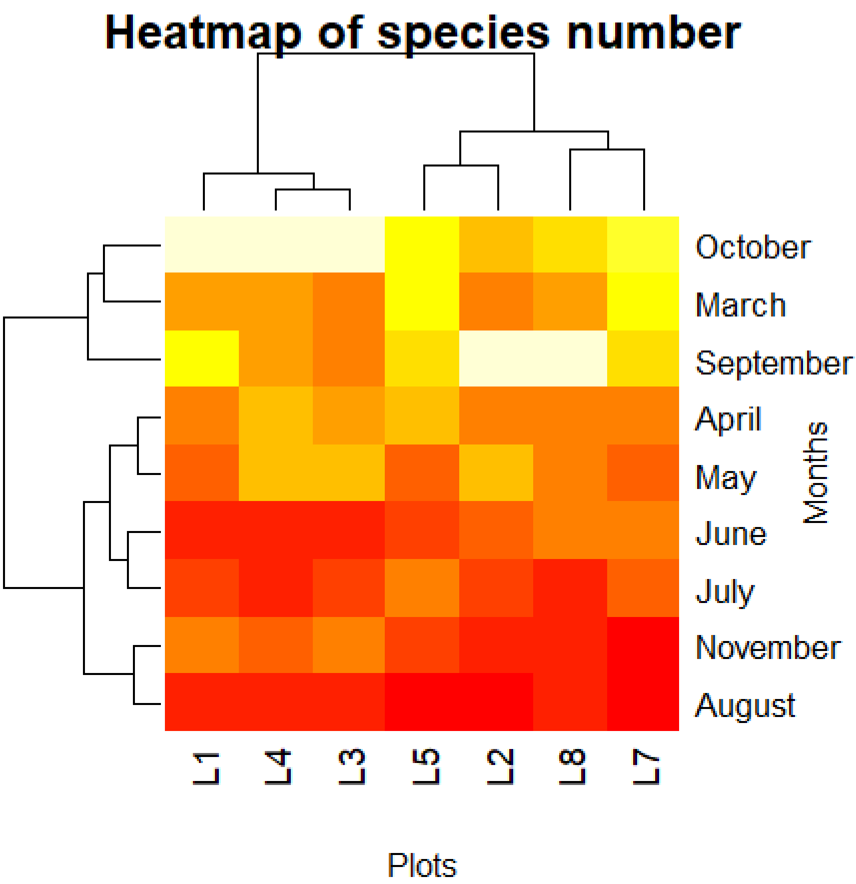

Fig. 45: Heatmap of the comparison of the species number at the plots during the the season. The brighter the colour the higher is the relative increase of the species number in the respective month.

The Heatmap (Fig. 45) gives information on the influence of months and their weather conditions respectively on the species number of the certain plots. By comparing colour of squares which corresponds to the number of species, conspicuous changes in species number can be detected.

It seems that October, September and March had a positive effect on the species number whereas during August the opposite was the case, species number was low in each plot. It has to be considered that in November just one survey was conducted therefore the number of species is comparatively small.

Bright colours in “September” and “October” tell that in these months an increase in the number of species happened. Especially grasslands (L1, L3 and L4) showed a conspecious increase in the species number in October, another remarkable increase was in September at L2 and L8.

Comparison with previous studies

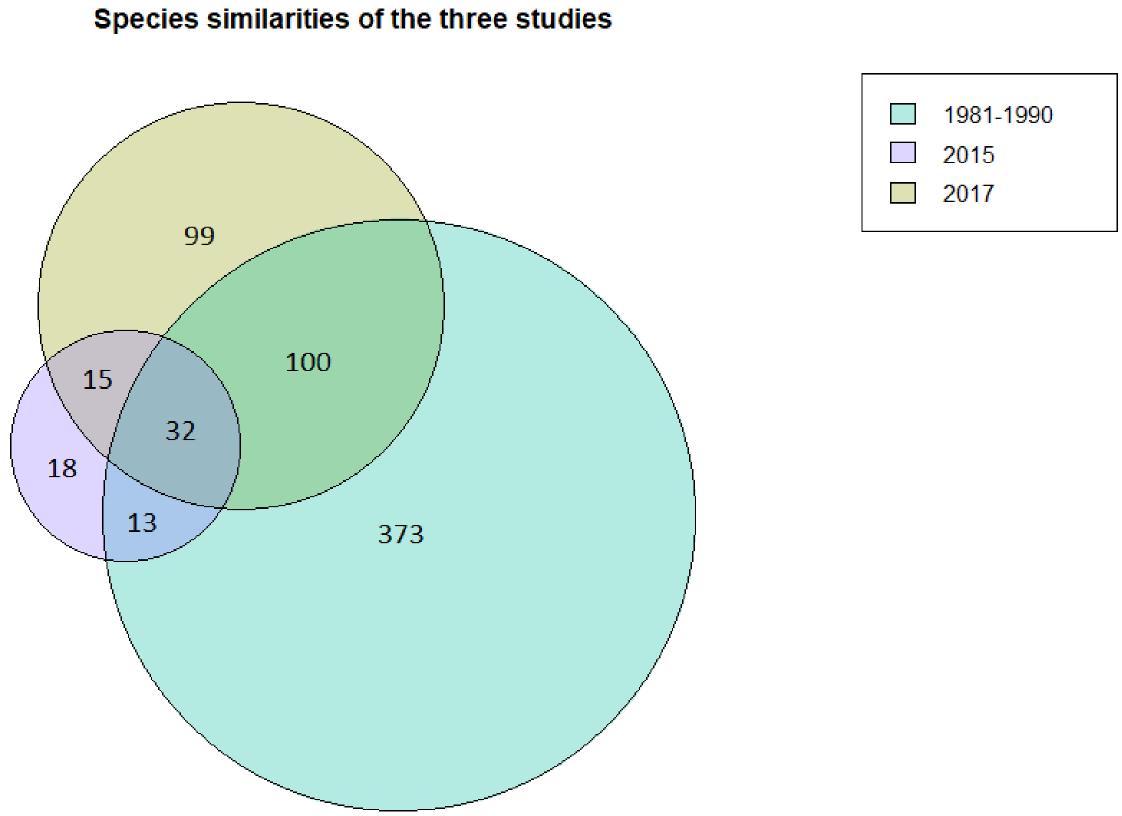

Fig. 46: Venn diagram of species similaritis of the three studies i.e. 1981-1990, 2015 and 2017.

In this study 246 fungal species were found, in the long-time study 518 species were encountered on the respective plots; in 2015 78 species were determined on plots L5, L7 and L8 during a study between August and November. 32 species were present in all three studies, 100 were found in the long time study and in 2017 again (Fig. 46).

99 species and subspecies respectively were found for the first time on the investigated plots. It should be emphasized that most of these species were found at other localities within the Lobau, only 51 of them have not been recorded in the Lobau before.

17 species were encountered in 2015 and 2017 but not in the long time study. 18 species were found in 2015 but neither in the long time study nor during this investigation. 13 species were found in 2015 and the long time study but not again in 2017. 373 species were found in the long time study only but neither in 2015 nor 2017.

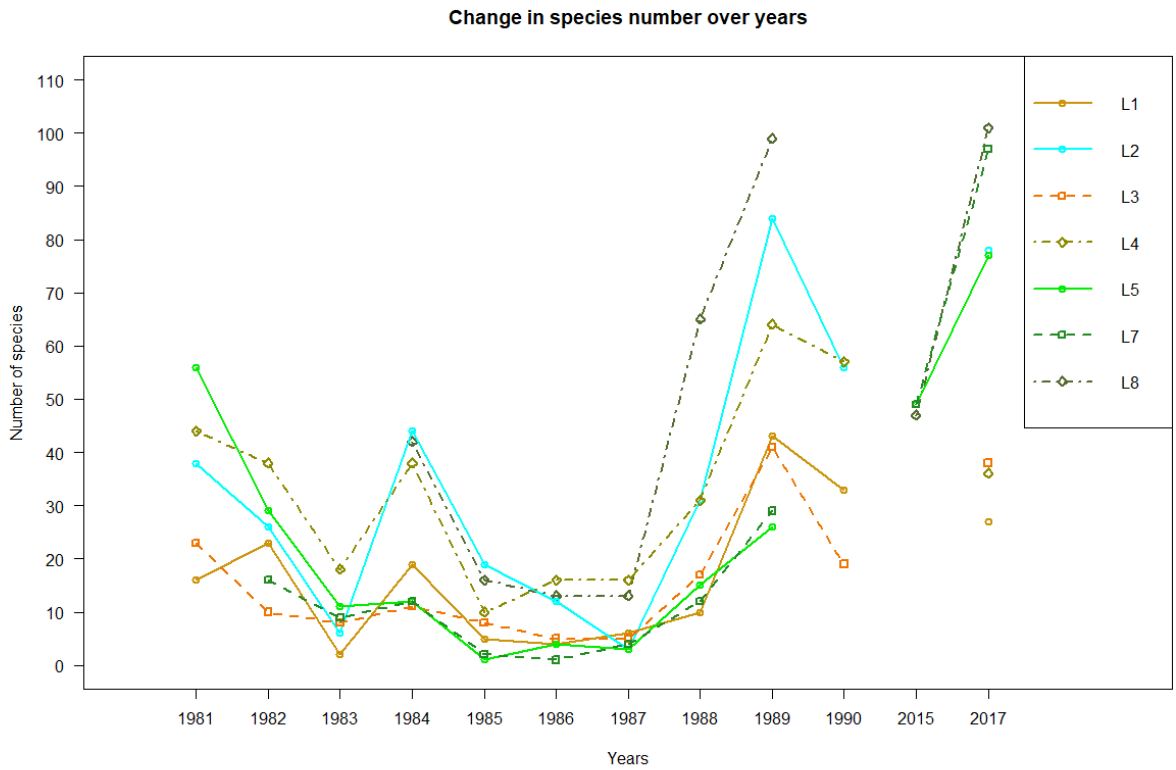

Fig. 47: Line chart of the change in species number of the study plots during the years of investigations.

The number of encountered species changed during the years of investigations (Fig. 47, Tab. 27). Surveys were not conducted each year at every plot that's why gaps are present in the diagram. The highest number of species (99) was found at L8 in 1989. In this study at each plot relatively high numbers of species were found compared to the previous years, which is of course also owed to the expertise and support of my supervisor.

	Plots						
Years	**L1**	**L2**	**L3**	**L4**	**L5**	**L7**	**L8**
1981	16	38	23	44	56	NA	NA
1982	23	26	10	38	29	16	NA
1983	2	6	8	18	11	9	NA
1984	19	44	11	38	12	12	42
1985	5	19	8	10	1	2	16
1986	4	12	5	16	4	1	13
1987	6	3	5	16	3	4	13
1988	10	31	17	31	15	12	65
1989	43	84	41	64	26	29	99
1990	33	56	19	57	NA	NA	NA
2015	NA	NA	NA	NA	49		47
2017	27	78	38	36	77	97	101

Tab. 27: Because of the ecological discrepancies between the plots forests and grasslands are discussed separately.

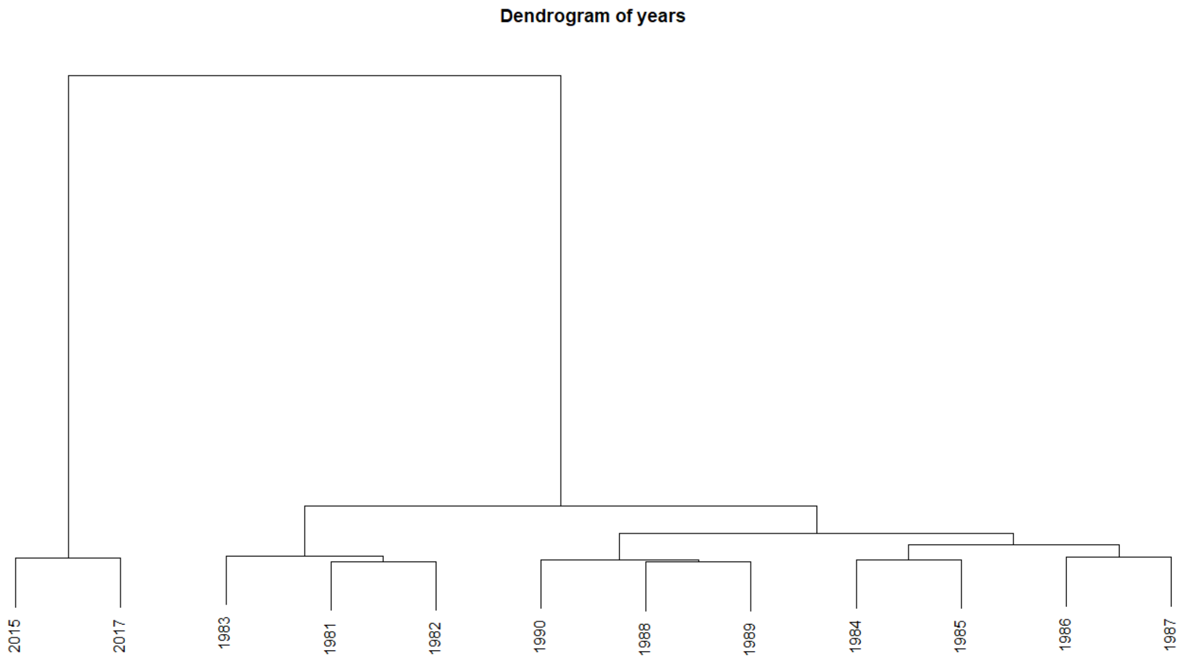

Fig. 48: Dendrogram based on species similarity of the years of investigation.

During the long time study high variation in species composition and fruit body abundance was found (Krisai-Greilhuber 1992, Straatsma & Krisai-Greilhuber, 2003). 2015 and 2017 differed from the years of the long time study conducted at the study plots (Fig. 48). It seems that species similarity depends more or less on the time-distance between the respective years because the smaller it is the closer together are the respective clades.

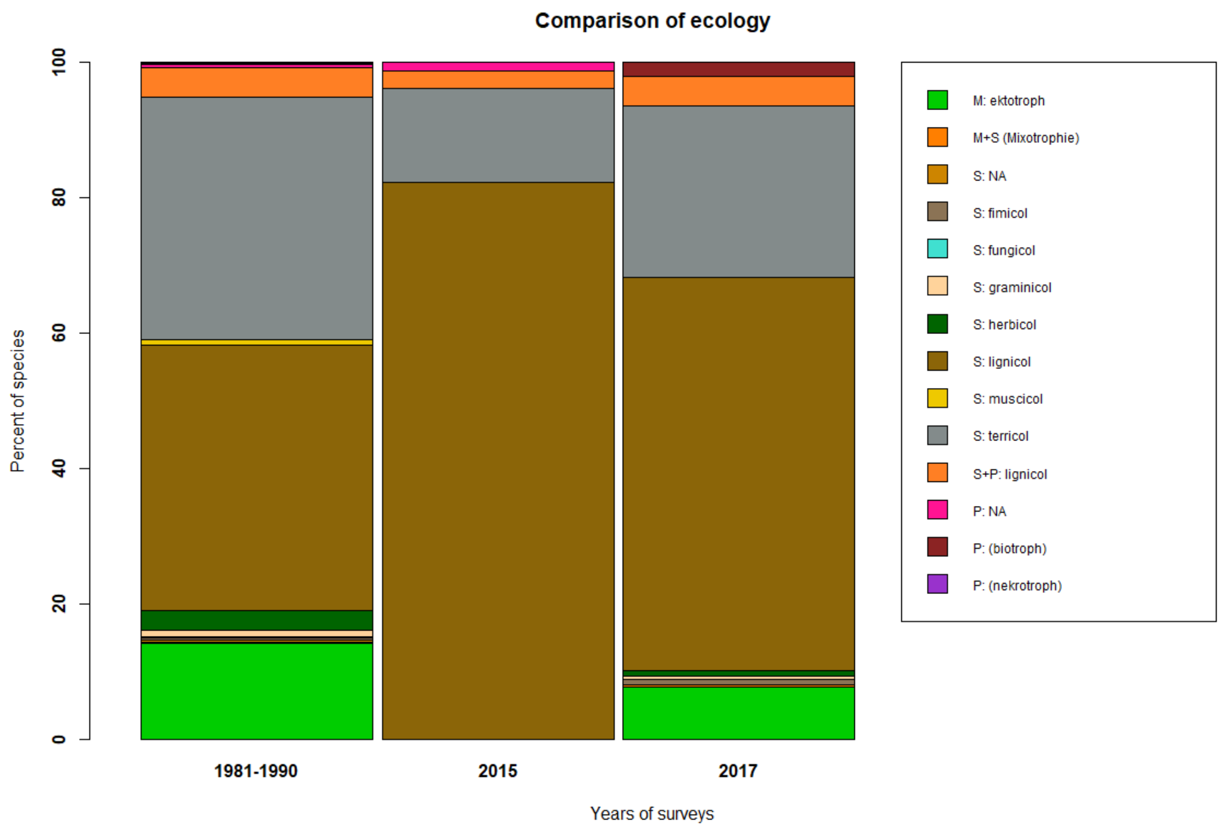

Fig. 49: Percental composition of the ecotypes of each study.

Compared to the long time study the amount of lignicolous species as well as the number of parasitic biotrophs has increased in 2017, while the amount of terricolous, mycorrhizal and herbicolous species has become lower (Fig. 49, Tab. 28). Not all ecotypes that were found during the long time study could be found in 2017 again. In 2015 only four ecotypes were found i.e. lignicolous, terricolous, mixotrophs (mycorrhizal and saprotroph) and parasites (Stulik, 2016).

During the 1980's a decrease of ectomycorrizhal fungi was witnessed in European forests and interpreted as a result of forest aging, whereas the number of other ecotypes did not became lower (Egli, 2011).

	1981-1990		2015		2017	
Ecology	%	#	%	#	%	#
M: ektotroph	14,16	74	0,00	0	7,63	19
M+S (Mixotrophie)	0,18	1	0,00	0	0,40	1
S: NA	0,36	2	0,00	0	0,00	0
S: fimicol	0,18	1	0,00	0	0,80	2
S: fungicol	0,18	1	0,00	0	0,00	0
S: graminicol	1,08	6	0,00	0	0,40	1
S: herbicol	2,87	15	0,00	0	0,80	2
S: lignicol	39,25	205	82,28	65	58,23	144
S: muscicol	0,72	4	0,00	0	0,00	0
S: terricol	35,84	187	13,92	11	25,30	63
S+P: lignicol	4,48	23	2,53	2	4,42	11
P: NA	0,36	2	1,27	1	0,00	0
P: (biotroph)	0,18	1	0,00	0	2,01	5
P: (nekrotroph)	0,18	1	0,00	0	0,00	0

Tab. 28: Absolute number and percentage of ecotypes found in the respective studies.

Found 2015 and 2017 on the observed plots but not in the long time

Armillaria gallica, Byssomerulius corium, Crepidotus applanatus, C. malachioides Dasyscyphella nivea, Dichomitus campestris, Hypoxylon fragiforme, Irpex lacteus, Leucoagaricus barssii, Lyomyces sambuci, Mycenella bryophila, Picipes badius, Simocybe sumptuosa, Skeletocutis nivea, Stereum hirsutum.

Found in 2017 and not in the other two studys at the observed plots

At this point it has to be said that not of all of the species listened here were new in the whole Lobau, but just only for the plots investigated in this study. By considering data of previous mushroom samplings at this area (provided by Krisai-Greilhuber) it turned out that only 51 species were not found (or simply not recorded) in the Lobau before.

Agaricus xanthoderma, Baeospora myosura, Biscognauxia granmoi, Cheilymenia vitellina, Clitocybe candicans, Conocybe juniana, C. moseri var. moseri, C. subovalis, C. subxerophytica, Craterocolla cerasi, Crepidotus autochthonus, C. caspari var. caspari, C. caspari var. subglobisporus, C. crocophyllus, C. malachius, Cuphophyllus fuscescens, Cylindrobasidium evolvens, Daedaleopsis confragosa, Daldinia childiae, Dendrothele acerina, Diatrypella verruciformis, Disciotis venosa, Entoloma aranaeosum, E. plebejum, E. rusticoides, E. sericellum, E. versatile, Exidia nigricans, Flammulaster muricatus, Flammulina elastic, F. fennae, F. populicola, F. velutipes, F. velutipes var. velutipes, Fomitopsis pinicola, Galerina marginata, Gloeoporus dichrous, Gymnopus erythropus, Hebeloma crustuliniforme, Helminthosporium juglandinum, Hymenoscyphus fraxineus, Hypoxylon macrocarpum, H. perforatum, Hysterium angustatum, Inocybe fastigiata, I. furfurea, I. fuscidula, I. hirtella var. bispora, I. mixtilis, I. splendens var. splendens, Lactarius sanguiflus, Leucoagaricus leucothites, Lopadostoma gastrinum, Porostereum spadicea, Gymnopus brassicolens, Megacollybia platyphylla, Melampsora sp.*, Melanoleuca microcephala, Microsphaera alphitoides, Mycena metata, M. tintinnabulum, Mycenella* cf. *salicina, Myxarium nucleatum, Nemania serpens, Oligoporus fragilis, Orbilia auricolor, Paxillus ammoniavirescens, Peniophora quercina, Peziza phyllogena, Phloeomana speirea* f. *candida, Pleurotus calyptratus, Pluteus leonius, P. pellitus, Polyporus varius, Psathyrella conopilus, P. gracilis, P. lutensis, P. melanthina, Pseudocosmospora* agg.*, Ramaria pseudogracilis, Rosellinia corticium, Sarcoscypha austriaca, S. coccinea, Simocybe centunculus, S. centunculus var. centunculus, Botryosphaeria visci, Steccherinum bourdotii, Stemonitopsis typhina, Strobilurus stephanocystis, S. tenacellus, Suillus luteus, Tarzetta cupularis var. velata, Unicinula bicornis, Verpa conica, Virgariella* (mitosporic stage of *H. fuscum), Xylaria digitata, X. hypoxylon, X. polymorpha.*

Fig. 50: Perithecium of *Sarcoscypha austriaca* or S*arcoscypha coccinea.*

A quite common species in forests during March was *Sarcoscypha austriaca*, which can be recognized by the characteristic red medulla of the perithecium. In order to determine it correctly and to prevent confusion with *S. coccinea*, a species that looks almost exactly the same, the hyphae at the outside of the excipulum i.e. amphitecium have to be checked to see if they are coiled or straight (Fig. 51). *Sarcoscypha austriaca* features the first hyphae type while *S. coccinea* the latter one. *Sarcoscypha* species produce fruit bodies on smaller branches at least one year in or on the ground. (Pidlich-Aigner, 1999)

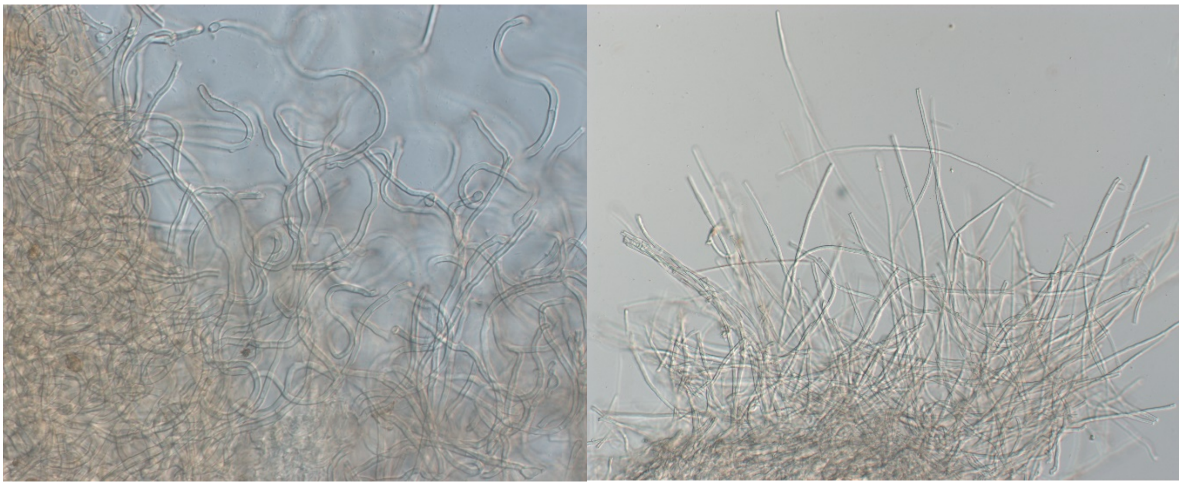

Fig. 51: Hyphae at the amphithecium of *Sarcoscypha austriaca* (left) and *Sarcoscypha coccinea* (right). Images provided by Irmgard Krisai-Greilhuber.

Fig. 52: *Fomitopsis pinicola*.

Another very common lignicolous polypore, *Fomitopsis pinicola,* (Fig. 52) was encountered at L3, L7 and L8. The characteristically coloured hard basidiomata are plurienne and display geotropism. *Fomitopsis pinicola* grows in deciduous as well as in mixed and coniferous forests. This species has a wide distribution from Mediterranean regions to Northern Europe, large parts of North and South Asia, northern Africa and in both American subcontinents (cf. Krieglsteiner, 2000).

Species and infraspecific taxa newly recorded in the Lobau

Name	Plot	Month
Agaricus xanthodermus	L5	November
Ceratiomyxa porioides	L2	July
Cheilymenia vitellina	L7	April
Conocybe moseri var. *moseri*	L2, L3	May
Craterocolla cerasi	L5	March
Crepidotus autochthonus	L2, L5, L8	June, August, Sept, Oct.
Crepidotus caspari var. *caspari*	L5, L7, L8	September
Crepidotus caspari var. *subglobisporus*	L2	October
Crepidotus crocophyllus	L2, L5	July, September, October
Cuphophyllus fuscescens	L4	November
Daldinia childiae	L2, L4,L5,L7	March, April, July, September
Diatrypella verruciformis	L7	March
Entoloma araneosum	L8	September, October
Entoloma sericellum	L7	October
Entoloma versatile	L8	October
Flammulina elastica	L8	October
Flammulina populicola	L2	October
Flammulina velutipes var. *velutipes*	L2	September
Gloeoporus dichrous	L4	March
Helminthosporium juglandinum	L8	September
Hymenoscyphus fraxineus	L5, L7, L8	June, July, September
Hypoxylon fragiforme	L8	September
Hypoxylon macrocarpum	L2, L5, L7, L8	March, April
Hypoxylon perforatum	L8	March
Hysterium angustatum	L7	September
Inocybe fastigiata	L1	October
Inocybe furfurea	L1	October
Inocybe hirtella var. *bispora*	L1	October
Inocybe mixtilis	L2	September, October
Inocybe splendens var. *splendens*	L1	October
Lactarius sanguifluus	L3	October
Porostereum spadicea	L2, L7	March
Gymnopus brassicolens	L7	October
Melanoleuca microcephala	L4	October
Microsphaera alphitoides	L8	September
Mycena metata	L8	October
Phloeomana speirea var. *candida*	L7	June
Myxarium nucleatum	L5	March
Oligoporus fragilis	L8	September
Orbilia auricolor	L8	June
Paxillus ammoniavirescens	L4	September
Peniophora quercina	L5	March
Pluteus leonius	L5	September
Pseudocosmospora agg.	L5	September
Ramaria pseudogracilis	L7	October
Simocybe centunculus var. *centunculus*	L7	July

Steccherinum bourdotii	L7, L8	April, June
Stemonitopsis typhina	L7	July
Suillus luteus	L3	October
Unicinula bicornis	L5, L8	September
Virgariella (mitosporic stage of H. fuscum)	L5	March

Tab. 29: List of taxa not recorded in the Lobau yet.

Altogether 51 taxa i.e. 42 species, 8 infraspecific taxa and one mitosoporic stage i.e. *Virgariella* (Fig. 60), were found which were not recorded before in the Lobau (Tab. 29). It should be emphasized that many infraspecific taxa were not yet described in the determination literature in the time when the long time study was conducted. Also new techniques like DNA sequencing and availability of data in the internet enabled a better and easier determination than in former times.

At each of the study plots new species were encountered, at least one of the newly recorded species was present in each month. So it is not advisable to exclude certain months from investigations concerning the fungal biodiversity or neglect some plots, eventhough during September and October most new species could be found. Out of these new species 41 were found on only one plot, five were present on two plots, three on three plots and two on four plots. Concerning the systematics 36 (70.58 %) of the newly recorded species were basidiomycetes, 13 (25.5 %) were ascomycetes and two belong to myxomycetes.

At the plots located near Mühlleiten (L5, L7 and L8) most new species were found (Tab. 30) maybe caused by anthropogenic dispersal, but to answer this question further studies are needed. The new species at those three plots were mainly lignicolous. So maybe also the amount of deadwood present raised and could be responsibel for the higher amount of newly recorded lignicolous species. Further, flooding events are rare near the village and so the forest composition changes slowly from riverine forest to normal deciduous forest which naturally is followed by occurrence of species of deciduous forests, respectively. At the grasslands less new species were found than in the forest plots, but the proportion of ectomycorrhizal species was higher compared to the other ecotypes (Fig. 53). At L1 all new species were EM fungi, none of them were also present at L2 eventhough the distance between these two plot is short. The absence or low amount of new EM species respectively compared to lignicolous species in the forests, matches with the assumption that EM fungi become fewer in forests (Arnolds, 1991). Most new species were found between September and November (Tab. 31).

Ramaria pseudogracilis was not found (or simply not recorded) in Austria before but could be expected to occurr. Within a textbook for determination of species of the genus Ramaria, this species is keyed out right to the quite similar *R. stricta* var*. stricta*, but it has larger spores (cf. Christan, 2008).

Many species from the lignicolous, resupinate genus *Crepidotus* were new in the Lobau. Members of this genus resemble each other very strongly and have to be distinguished microscopically by considering their spore morphology and cystidia (cf. Consiglio et al. 2008).

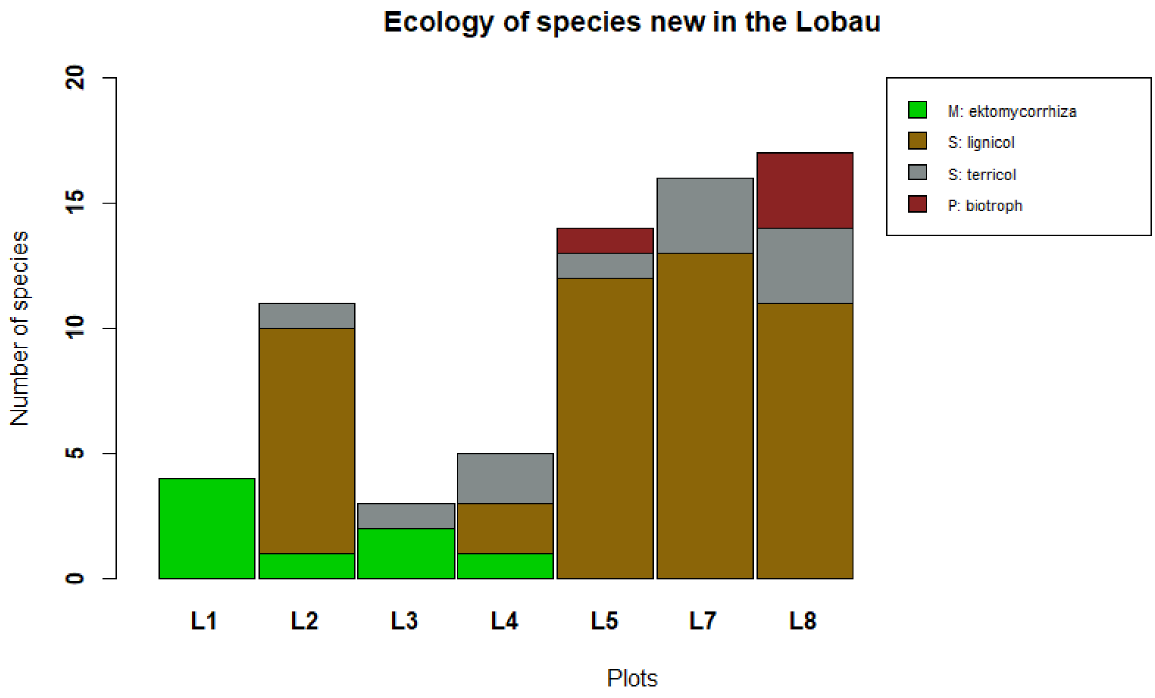

Fig. 53: Ecology of newly recorded species with respect to the plot they were found.

Plot	Number of newly found species
L1	4
L2	10
L3	3
L4	5
L5	14
L7	15
L8	16

Tab. 30: Number of newly recorded species at the study plots.

Month	Number of newly found species
March	10
April	4
May	1
June	5
July	6
August	1
September	17
October	19
November	2

Tab. 31: Number of newly recorded species present in a certain month.

Fig. 54: Habitus of *Paxillus ammoniavirescens*.

Fig. 55: Habitus of *Paxillus ammoniavirescens.*

Fig. 56: Cap of *Paxillus ammoniavirescens.*

Paxillus ammoniavirescens (Fig. 54 - 56) was one of the species not recorded previously in the Lobau yet and was found at L4 in September. This species was described as new to science only in 1999 by Dessì and Contu (Dessì and Contu, 1999). The identification was i.a. performed with the help of NH_3 vapour that led to a colour reaction of the cap i. e. turned greenish (Hahn, 2012).

Fig. 57: Habitus of *Flammulina velutipes*.

Fig. 58: Habitus of *Flammulina velutipes*.

Eventhough *Flammulina velutipes* (Fig. 57 and 58) was known to grow in the Lobau the infraspecific taxa were not distinguished earlier, e.g. *var. velutipes*. The three *Flammulina* species resemble each other very strongly and have to be distinguished microscopically (Fig. 59). Due to their conspicuous orange colour species of this genus were relatively easy to detect.

Flammulina velstipes is a saprobiont that growingon trunks or branches of deciduous trees especially willows. It is occurs in in nearly all types of deciduous forests, often found along floating water. Fruit bodies are produced generally in each month except July. (cf. Gminder and Krieglsteiner, 2001)

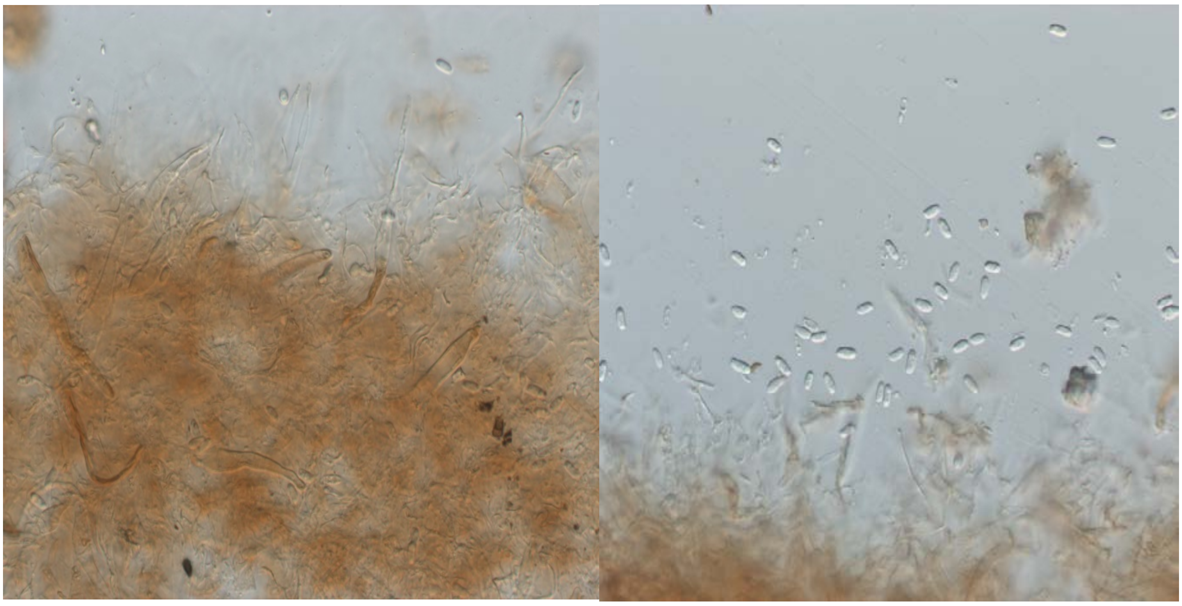

Fig. 59: Pileipellis and spores of *Flammulina velutipes.* Images provided by Irmgard Krisai-Greilhuber.

Fig. 60: Mycelium of *Virgariella*. Image provided by Irmgard Krisai-Greilhuber.

Virgariella is the mitosporic stage of *Hypoxylon fuscum* (Fig. 60).

Species found in all three studys

Antrodia albida, Armillaria mellea, Artomyces pyxidatus, Auricularia auricula-judae, A. mesenterica, Bjerkandera adusta, Coprinellus disseminates, C. micaceus, Coriolopsis gallica, Crepidotus caspari, C. cesatii, Fistulina hepatica, Fomes fomentarius, Fuscoporia ferruginosa, Hypoxylon ticinense, Laetiporus sulphureus, Lycogala epidendrum, Marasmius rotula, Mycena galericulata, M. haematopus, M. inclinata, M. polygramma, Phloeomana hiemalis, P. speirea, Pluteus cinereofuscus, P. salicinus, Neofavolus alveolaris, Schizophyllum commune, Steccherinum ochraceum, Stereum subtomentosum, Trametes versicolor, Xylaria longipes.

27 species could be found in all three studies, at L5, L7 and L8. *Pluteus cinereofuscus* was the only terricolous species all other were ligincolous sapotrophs. However, eventhough the species were present in the period 1981-1990 they were not present each year (Tab. 32).
Nevertheless those species are suitable for investigating a possible change of their fruiting season.

Fig. 61: Cap of *Armillaria gallica*.

Fig. 62: Habitus of *Armillaria gallica*.

Fig. 63: Habitus of *Armillaria gallica*.

Armillaria species (*A. gallica* (Fig. 61-63)and *A. mellea*) were highly abundant in autumn within the forest plots this year; also in 2015 these fungi were recorded at the forest plots (Stulik, 2016). This genus represents aggressive forest pathogens (Baumgartner et al., 2011) and further one of the world's biggest organism belongs to this genus (Smith et al., 1992). The occurrence of this species reflects the aging process of the forest and is quite common in Austria (pers. comm. Krisai-Greilhuber). *Armillaria gallica* was found more often than *A. mellea, A. gallica* was also the dominant *Armillaria* species in an alluvial forest in Serbia (Keca et al., 2009).

Fig. 64: Fresh fruit bodies of *Coprinellus micaceus.*

Fig. 65: Decaying fruit bodies of *Coprinellus* sp.

Coprinellus fruit bodies (Fig. 64) were present at high quantities during autumn but appeared also quite commonly between April and November. For the distinction between the two very similar *Coprinellus* species i.e. *C. domesticus* and *C. micaceus,* spores have to be analysed microscopically. The latter species was encountered more often in this study than *C. domesticus* and *C. disseminatus*. Fruit bodies of this genus tend to rott extremely quickly (Fig. 65). *Coprinellus micaceus* is a cosmopolitan species (absent in Antarctica) and is able to produce mushrooms throughout the whole year. This saprotrophic fungus lives in deciduous and mixed forests as well as in gardens and parks. (cf. Gminder, 2010)

Fig. 66: *Fistulina hepatica*

The soft and red fruit bodies of *Fistulina hepatica* resemble raw meat and are edible (Fig. 66); it is also refered to as beefsteak fungus. This species prefers hardwood alluvial forests, but grows also in other forest types e.g. mesophilic beechforests or oak forests as well as gardens and parks. Concerning its ecology it can live parasitically but also uses dead wood e.g. stumps as nutrient source. Basidiomata are normally encountered in summer and beginning of fall. *Fistulina hepatica* has a broad global distribution (e.g. Australia, parts of Asia, large parts of Europe and North America) but its total population seems to decrease. (cf. Krieglsteiner, 2000)

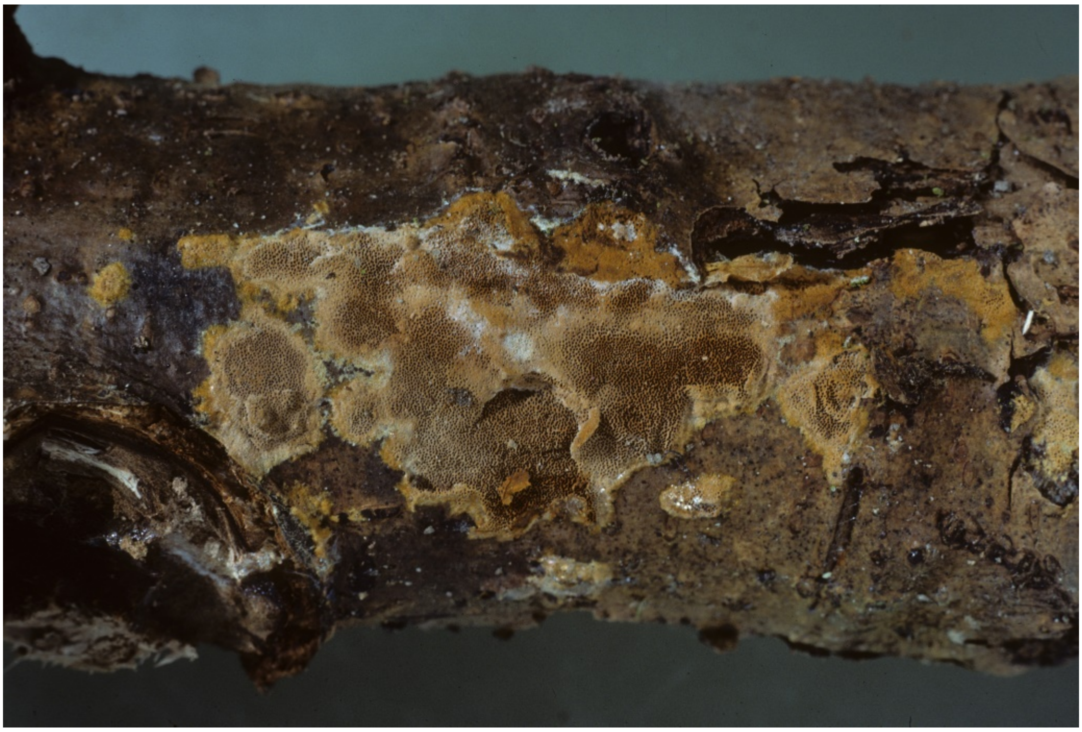

Fig. 67: Habitus of *Fuscoporia ferruginosus*. Image provided by Anton Hausknecht.

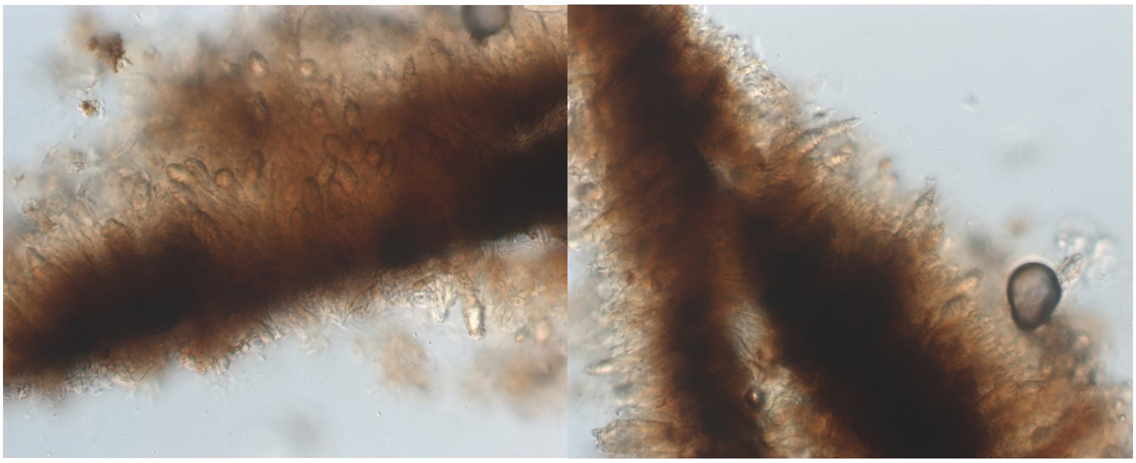

Fig. 68: Hymenium of *Fuscoporia ferruginosus*. Images provided by Irmgard Krisai-Greilhuber.

Lignicolous *Fuscoporia ferruginosus* (Fig. 67 and 68) prefers mesophilic beech forests but is also quite common in alluvial forests. The resupinate brownish fruit body can reach a length of some metres and a width of 4-5 cm. This polypore avoids dry areas with cold winters and produces fruit bodies throughout the year. The species is distributed in Asia, Europe, North- and Central America and also colonises Northern parts of Afrika. (cf. Krieglsteiner, 2000).

Fig. 69: Young fruit body of *Trametes versicolor.*

Trametes versicolor (Fig. 69) is the most common species in Austria (Dämon and Krisai-Greilhuber, 2017) and features a quite variable morphology. The annual fruit bodies are soon infected by insects, however this species can be seen throughout the year. Its favorite substrate are stumps of *Fagus sylvatica*, but also many other deciduous trees are used as nutrient source by this lignicolous fungus. (cf. Krieglsteiner, 2000)

Species	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Antrodia albida				x				x	x	
Artomyces pyxidatus	x			x				x	x	x
Auricularia auricula-judae			x							
Auricularia mesenterica	x									
Bjerkandera adusta	x				x			x	x	
Coprinellus disseminatus								x	x	
Coprinellus micaceus	x							x	x	
Coriolopsis gallica	x	x		x				x	x	
Crepidotus caspari								x	x	
Crepidotus cesatii	x	x						x	x	x
Fistulina hepatica							x			
Fomes fomentarius								x	x	
Hypoxylon ticinense				x		x		x	x	
Laetiporus sulphureus					x			x	x	x
Lycogala epidendrum				x						
Marasmius rotula	x							x	x	x
Mycena galericulata			x					x	x	x
Mycena haematopus									x	x
Mycena inclinata			x							
Mycena polygramma									x	
Pluteus cinereofuscus				x		x	x		x	
Pluteus salicinus		x						x	x	
Schizophyllum commune		x						x	x	x
Steccherinum ochraceum				x				x	x	
Stereum subtomentosum						x			x	x
Trametes versicolor				x				x	x	x
Xylaria longipes	x									

Tab. 32: Presence of species found in all three studies between 1981 and 1990.

Found in the long time study and again 2017 but not in 2015

Abortiporus fractipes, Agaricus bitorquis, Agrocybe vervacti, Amanita strobiliformis, Armillaria cepistipes, Atheniella flavoalba, Bisporella citrina, Bolbitius titubans, Cellulariella warnieri, Ceratiomyxa fruticulosa, Clitocybe agrestis, Clitopilus scyphoides var. omphaliformis, Conocybe velutipes, Coprinellus domesticus, Coprinopsis atramentaria, C. picacea, Coriolopsis trogii, Cortinarius atrocoeruleus, Crepidotus mollis, Crinipellis scabella, Cuphophyllus virgineus var. fuscescens, Cyathus striatus, Dacrymyces stillatus, Dumontinia tuberosa, Entoloma incanum, Fuligo septica, Ganoderma applanatum, Gymnopus aquosus, G. dryophilus, G. foetidus, G. impudicus, Hebeloma vaccinum, H. velutipes, Hemimycena cucullata, Hohenbuehelia wilhelmii, H. petaloides, Hydropus trichoderma, Hymenochaete rubiginosa, Hypoxylon fuscum, H. howeanum, Inocybe dulcamara, I. inodora, I. rimosa, Lactarius controversus, Neolentinus cyathiformis, Lentinus tigrinus, Lepiota cristata, Lepista sordida, Leratiomyces laetissimus, Leucoagaricus badhamii, L. serenus, Marasmius epiphyllus, M. wynneae, Melanophyllum haematospermum, Meottomyces dissimulans, Metatrichia vesparium, *Mollisia cinerea, M. melaleuca, Morchella esculenta, Mycena abramsii, M. acicula, M. olida, M. pseudopicta, M. renati, Oligoporus lacteus, O. subcaesius, Omphalina pyxidata, Panaeolus acuminatus, P. guttulatus, Peniophora limitata, Fomitoporia hippophaecola, Pleurotus dryinus, P. ostreatus, Pluteus hispidulus, P. nanus, P. podospileus, P. romellii, P. semibulbosus, Lentinus arcularius, Porostereum spadiceum, Psathyrella candolleana, P. fusca, P. leucotephra, P. orbitarum, P. panaeoloides, P. pseudocorrugis, Ramaria stricta, Schizophyllum amplum, Scutellinia crinita, Stropharia coronilla, Tarzetta catinus, T. cupularis, Trametes hirsuta, T. ochracea, T. pubescens, Tricholoma populinum, Tubaria conspersa, T. dispersa, T. furfuracea, Tulostoma brumale, Xerula radicata.*

Fig. 70: Cap of *Amanita strobiliformis*.

Fig. 71: Habitus of *Amanita strobiliformis*.

Fig. 72: Stipe of *Amanita strobiliformis*.

Amanita strobiliformis (Figs. 70-72) occurred two times during this study namely in June and September at L2 represented by only one basidioma each time. This whitish basidiomycete is an ectomycorrhizal fungus of deciduous trees mainly *Fagus sylvativa* but e.g. also *Betula pendula, Quercus robur* and *Tilia cordata* and fruits between Mai and November (cf. Gminder at al. 2003)

Fig. 73: Habitus of *Coprinopsis picacea.*

The spectacular coloured, long ovoid cap of *Coprinopsis picacea* (Fig. 73) makes this fungy easily recognizable. It tends to produce fruit bodies relatively late in the season, normally this saprotrophic species is found on alkaline, calcareous soils. This species occurs in Europe but also in Australia; it is considered rare. In Austria its RedList status is near threatened (Dämon and Krisai-Greilhuber, 2017). The typical habitat of that species is mesophilic beech forest, but it also grows at waysides of forests. (Gminder, 2010)

Fig. 74: Cap of *Inocybe dulcamara*.

Fig. 75: Habitus of *Inocybe dulcamara*.

Inocybe dulcamara (Figs. 74 and 75) was found at grasslands L3 and L4 and fruited in May and than again in September and October. This species is quite variable concerning its colour and morphology; fruit bodies are produced between May and October. *Inocybe dulcamara* occurs in nearly all European countries and also in North America and Asia. This ectomycorrhizal fungus of deciduous trees and conifers produces fruit bodies in forests as well as in grasslands, but avoids places with a high nitrogen content (cf. Gminder, 2010).

Fig. 76: *Cellulariella warnieri.*

The lignicolous, resupinate *Cellulariella warnieri* (Fig. 76) is a very rare Mediterranean species and is considered as critically endangered in Austria, because it is only known from the Lobau (Dämon and Krisai-Greilhuber, 2017). It was found in two plots (L3 and L8) in this study. In the forest plot (L8) it occurred from March until October. It produces quite large semicircular, annual fruit bodies which can reach a diametre of 50 cm and a thickness of up to 4 cm and are zonated concentrically (cf. Bernicchia, 2005).

Fig. 77: Habitus of *Neolentinus cyathiformis*.

Fig. 78: Stipe of *Neolentinus cyathiformis*.

Fig. 79: Cap of *Neolentinus cyathiformis*.

The thermophile species *Neolentinus cyathiformis* (Figs. 77-79) grows normally in alluvial forests where it uses fresh dead trees as nutrient source especially *Populus*. This was also the case in this study because it was found in April and May at L2, a plot dominated by *Populus alba* (cf. Gminder et al., 2001).


Fig. 80: *Three ascomata of Morchella esculenta.*

The favoured edible mushroom *Morchella esculenta* (Fig. 80) was quite common in April within forests plots.


Fig. 81: Cap of *Psathyrella candolleana*.

Fig. 82: Gills of *Psathyrella candolleana*.

Fig. 83: Habitus of *Psathyrella candolleana*.

Psathyrella candolleana (Figs. 81-83) was often found in this survey and produces generally fruit bodies from January until December. The gills are at first bright but turn violet-grey after a while. It is a quite common species in alluvial forests, where it uses dead wood especially of beech as nutrient source. This species grows in Europe as well as in Australia and parts of Asia (cf. Gminder, 2010).

Fig. 84: *Psathyrella panaeoloides* on L3.

The earliest agaricoid fungus of the grasslands was found at L3, namely *Psathyrella paneoloides* (Fig. 84). It has relatively small fruit bodies, which makes it sometimes difficult to find them. Rhomboid spores are an important character to identify it microscopically. *Psathyrella panaeoloides* is a typical grassland fungus and starts to produce basidiomata in spring; it is supposed to be heliophil and grows on alkaline loamy soils (cf. Gminder, 2010).

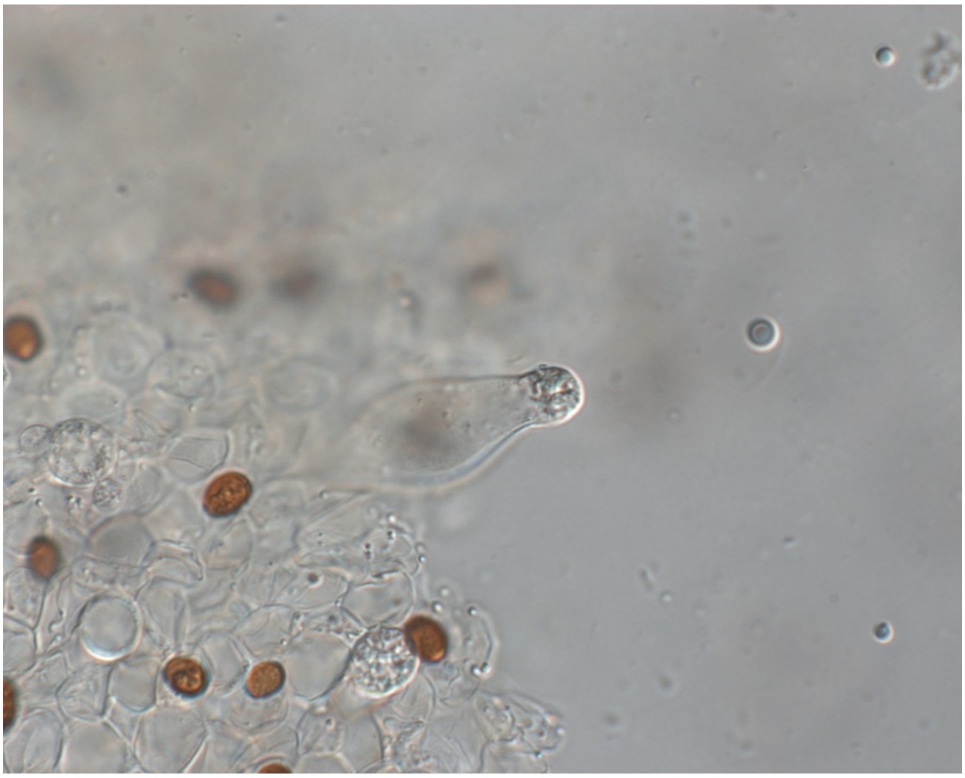

Fig. 85: Cystidia and spores of *Psathyrella panaeoloides*. Image provided by Irmgard Krisai-Greilhuber.

Only found 2015 at the plots

Ascocoryne sarcoides Conocybe rickeniana, Cosmospora episphaeria, Daldinia petriniae, Datronia mollis, Eutypella scoparia, Helicobasidium purpureum, Hypoxylon sp., H. fuscum, Inonotus hispidus, Melogramma campylosporum (= M. bulliardii), Meripilus giganteus, Mycena viscosa, Peroneutypa scoparia, Pholiotina velata, Schizopora paradoxa, Trichia decipiens, Vesiculomyces citrinus.

Found 2015 and in the long time study but not in 2017

Arcyria denudata, Calocera cornea, Ceriporia purpurea, Clitopilus hobsoni, Coprinopsis lagopus, Entoloma araneosum f. *fulvostrigosum, Gymnopus brassicolens, Mycena corynephora, M. stylobates, Pholiotina arrhenii, Psathyrella fatua, P. marcescibilis, P. prona.*

Only found in the long time study and not again

Agaricus bresadolanus, A. pequinii, Agrocybe dura, A. pediades, A. pusiola, Amanita rubescens, A. solitaria, Anthracobia maurilabra, A. melaloma, Antrodia malicola, Antrodiella hoehnelii, Arachnopeziza aurata, Arcyria cinerea, A. obvelata, Arrhenia baeospora, A. obatra, A. rickenii, A. spathulata, Ascobolus carbonarius, Ascocoryne cylichnium, Atheniella leptophylla, Basidiomycetes sp.*, Bispora antennata, Bolbitius lacteus, B. reticulatus, B. reticulatus* f. *aleuriatus, Botryobasidium aureum, B. conspersum, Bovista polymorpha, B. pusilla, B. pusilliformis, B.* sp.*, B. tomentosa, Brunnipila clandestina, Calyptella capula, Cellypha goldbachii, Cerrena unicolor, Chamaemyces fracidus, Chondrostereum purpureum, Clavulina cinerea, C. coralloides, Clitocella popinalis, Clitocybe barbularum, C. diosma, C. marginella, C. rivulosa, C. truncicola, Collaria arcyrionema, Collybia cookei, Comatricha nigra, Coniophora puteana, Conocybe brachypodii, C. dumetorum* var. *phaeoleiospora, C. echinata, C. graminis, C. juniana* var. *subsejuncta, C. lobauensis, C. microrrhiza, C. moseri, C. rostellata, C. semiglobata, C. sienophylla, C.* sp.*, C. subpubescens, C. tenera, Coprinellus angulatus, C. ellisii, C. flocculosus, C. impatiens, C. saccharinus, C. truncorum, C. xanthothrix, Coprinopsis coniophora, C. gonophylla, C. insignis, C. jonesii, C. melanthina, C. phaeospora, C. spelaiophila, C. stangliana, C. strossmayeri, Cortinarius alborufescens, C. alnetorum, C. cedriolens, C. decipiens, C. paracephalixus* agg.*, C. pulchripes, C. scandens, C. sciophyllus, C.* sp.*, Crepidotus subverrucisporus, Cribraria cancellata, C. intricata, Cristinia helvetica, Crocicreas coronatum, Cuphophyllus virgineus, Cyathus olla, Cylindrobasidium laeve, Cystolepiota seminuda, Dacrymyces capitatus, Daedalea quercina, Daedaleopsis confragosa* var. *tricolor, Daldinia fissa, Delicatula integrella, Diatrype stigma, Dictydiaethalium plumbeum, Encoelia fascicularis, E. furfuracea, Enteridium lycoperdon, Entoloma excentricum, E. flocculosum, E. formosum, E. fridolfingense, E. hebes, E. indutoides* var. *griseorubidum, E. longistriatum* var. *sarcitulum, E. nausiosme, E. pleopodium, E. pseudoexcentricum, E. sordidulum, E. turci, E. undatum, E. undulatosporum, Flagelloscypha kavinae, Fungi* sp.*, Galerina autumnalis, G. graminea, G. sp., Gastrosporium simplex, Geastrum minimum, G. striatum, Geopora arenicola, G. arenosa, Gloiodon strigosus, Gymnopus confluens, G. hariolorum, G. hybridus, Gyrodon lividus, Gyromitra parma, Hebeloma fragilipes, H. laterinum, H. mesophaeum, H. populinum, H.*

pseudoamarescens, H. pusillum, H. sp., *Helvella ephippium, H. macropus, H. spadicea, Hemimycena candida, H. mairei, Hemipholiota populnea, Hemistropharia albocrenulata, Hemitrichia clavata, H. serpula, Hohenbuehelia atrocoerulea, H. grisea, H. mastrucata, Homophron spadiceum, Humaria hemisphaerica, Hyalopeziza millepunctata, Hygrocybe acutoconica, H. calciphila, H. conica, H. miniata, Hymenoscyphus fructigenus, H. repandus, H. scutula, H.* sp., *Hyphodontia alutaria, H. arguta, Hypholoma lateritium, Inocybe adaequata, I. albomarginata, I. bongardii, I. bresadolae, I. cincinnata, I. cookei, I. flavella, I. flocculosa, I. fraudans, I. godeyi, I. hirtella, I. javorkae, I. leiocephala, I. maculata, I. margaritispora, I. oblectabilis, I. obscurobadia, I. ochracea, I. phaeodisca, I. phaeodisca* var. *geophylloides, I. phaeoleuca, I. pseudodestricta, I.* sp., *I. splendens, I. squamata, I. vulpinella, Laccaria tetraspora, Lachnella villosa, Lachnum fasciculare, L. pudicellum, L.* sp., *L. virgineum, Lactarius pubescens, L. zonarius, Lamprospora carbonicola, Lasiosphaeria ovina, L. spermoides, Lepiota angustispora, L. aspera, L. boudieri, L. brunneoincarnata, L. coloratipes, L. lilacea, L. parvannulata, L. psalion, L.* sp., *L. subincarnata, Leptosphaeria doliolum, Leucoagaricus sericifer, Limacella glioderma, Lycogala exiguum, Lycoperdon lividum, L. molle, L. pratense, L.* sp., *Marasmiellus ramealis, M. vaillantii, Marasmius curreyi, M. torquescens, Melanoleuca atripes, M. exscissa, M. polioleuca, M. polioleuca* f. *fragillima, M. rasilis, Mollisia benesuada, M. fusca, M. hydrophila, M. lividofusca, Mucilago crustacea, Mucronella calva* var. *aggregata, Mycena adscendens, M. citrinomarginata, M. filopes, M. leptocephala, M. mucor, M. niveipes, M. polyadelpha, M.* sp., *M. stipata, M. vitilis, Mycenella trachyspora, Nectria cinnabarina, Neolentinus lepideus, Omphalina hepatica, Ossicaulis lignatilis, Panaeolus cinctulus, P. pseudoguttulatus, Panellus stipticus, Parasola auricoma, P. conopilus, P. kuehneri, P. plicatilis, Paxillus involutus, P. rubicundulus, Peniophora cinerea, P. versicolor, Perenniporia fraxinea, Peziza ampliata, P. celtica, P. domiciliana, P. granularis, P. limnaea, P. micropus, P. petersii, P.* sp., *P. subviolacea, P. succosa, P. vacinii, Phellinus conchatus, P. laevigatus, Phlebia fuscoatra, P. tremellosa, Phloeomana alba, Pholiota conissans, P. highlandensis, P. squarrosa, P. dasypus, P. mairei, Phylloporia ribis, Phyllotopsis rhodophyllus, Physarum pezizoideum, P.* sp., *P. viride* f. *aurantium, Pleurotus cornucopiae, Pluteus aurantiorugosus, P. cervinus, P. chrysophaeus, P. ephebeus, P. hispidulus* var. *cephalocystis, P. luctuosus, P. phlebophorus, P. thomsonii, Poculum firmum, Polyporus brumalis, P. ciliatus, P. squamosus, P. tuberaster, Propolis farinosa, Psathyrella ammophila, P. corrugis, P. corrugis* f. *gracilis, P. gordonii, P. orbicularis, P. pygmaea, P. senex, P. spadiceogrisea, P.* sp., *P. supernula, P. sylvestris, Pseudoclitocybe expallens, Puccinia graminis, Pyronema omphalodes, Radulomyces confluens, Ramaria decurrens, Resupinatus applicatus, Rickenella fibula, Rigidoporus sanguinolentus, Romagnesiella clavus, Rosellinia aquila, Rugosomyces carneus, R. ionides, R. obscurissimus, Russula amoenolens, R. delica, R. exalbicans, Sarcodontia crocea, Schizopora radula, Scleroderma verrucosum, Scutellinia scutellata, Sebacina epigaea, Sphaerobolus stellatus, Steccherinum fimbriatum, Stemonitis axifera, Stereum rugosum, Stropharia caerulea, Symphytocarpus flaccidus, Tephrocybe ambusta, T. anthracophila, T.*

mephitica, Tephrocybe sp.*, Tomentella ferruginea, Trametes betulina, T. suaveolens, Trichia varia, Tricholoma scalpturatum, Trichopeziza mollissima, Tubaria* sp.*, Tubulifera arachnoidea, Tulostoma squamosum, Typhula erythropus, Tyromyces chioneus, Uromyces pisi-sativi, Valsella salicis, Volvariella bombycina, V. caesiotincta, Volvariella pusilla, Vuilleminia comedens, Xerocomellus ripariellus, Xerula pudens, Xylodon brevisetus, X. pruni.*

Change of fruiting period

Generally the knowledge concerning the mushroom phenology is scarce but it seems that climate change has an impact on the fruit period in many European countries, further those changes differ strongly between geographical locations and groups as well and species (Kauserud et al. 2008, Andrews et al., 2017).

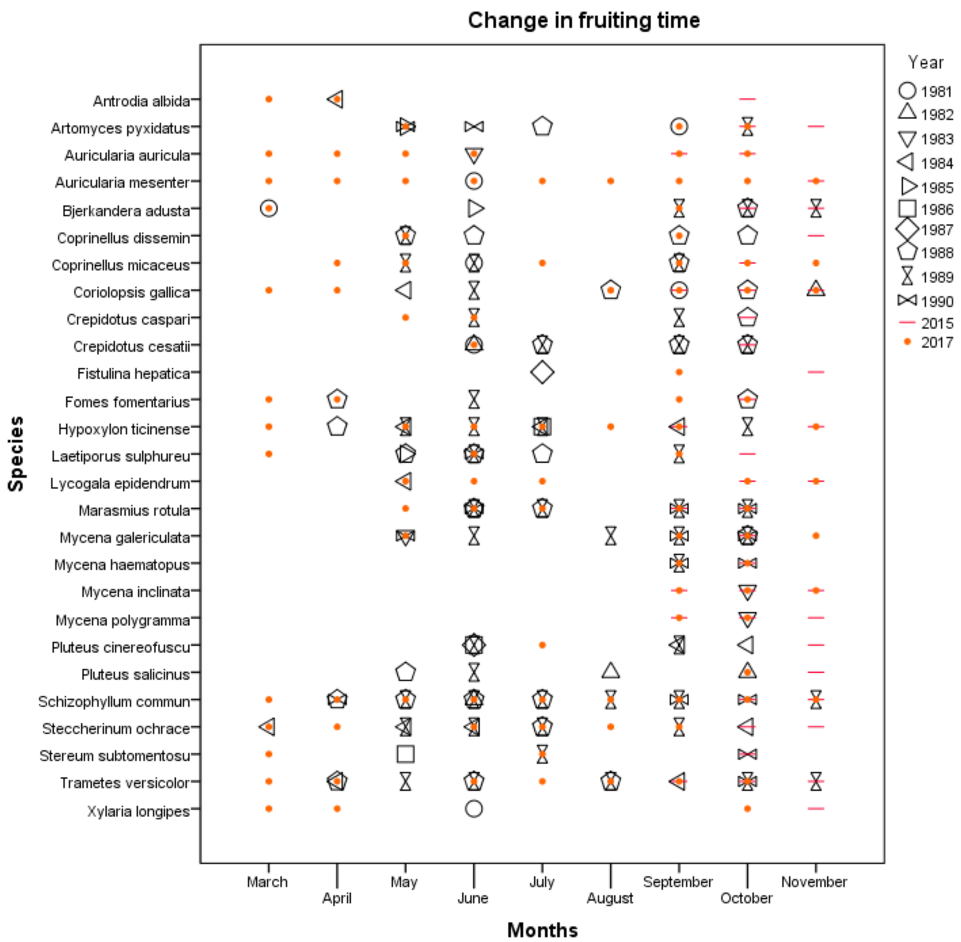

Fig. 86: List of species which were found in all three studies and their fruiting time.

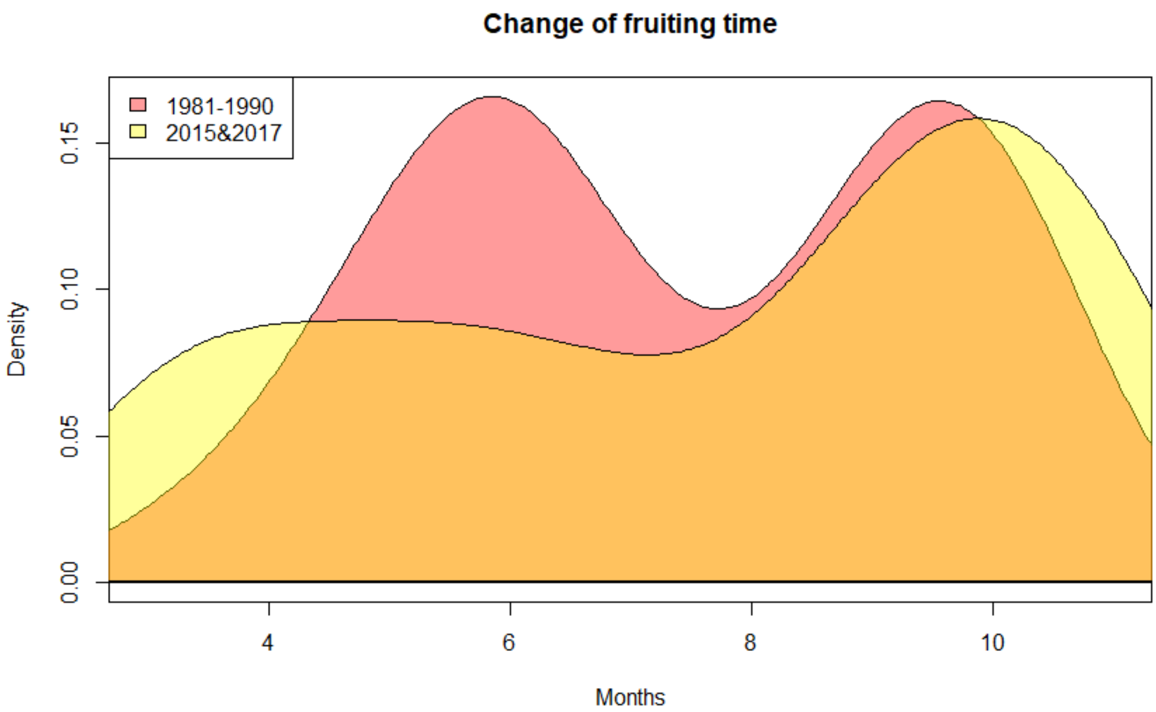

Fig. 87: Density plot based on the frequency of months fruit bodies were produced by species found in the long-time study and again in 2015 and 2017.

By checking if an orange (2017) dot or red string (2015) is within another symbol or not we can see if the fruiting time of a certain species has extended, shifted, shrunk or remained equal (Fig. 86).

For Austria a general widening of the annual fruiting period has been found as well as a delay of the mean annual fruiting date, but some species also start to produce fruit bodies earlier than in former times (Kauserud et al. 2012). So simply by considering the enormous number of fungal species (Blackwell, 2011) it seems difficult to draw general rules.

By comparing the fruiting season of the species which have been found in the long time study (Krisai-Greilhuber, 1992) and again in 2015 (Stulik, 2016) as well as in 2017, it seems that the number of species which fruit in March and November has increased (Fig. 86 and 87). The number of species producing fruit bodies in June has decreased. However to draw solid conclusion on a possible change in the fruiting behaviour more and longer investigations are needed. Also it should be considered that some sporomata in March from liginicolous fungi were probably remains of the past season and the study in 2015 werde conducted only between September and November (Stulik, 2016).

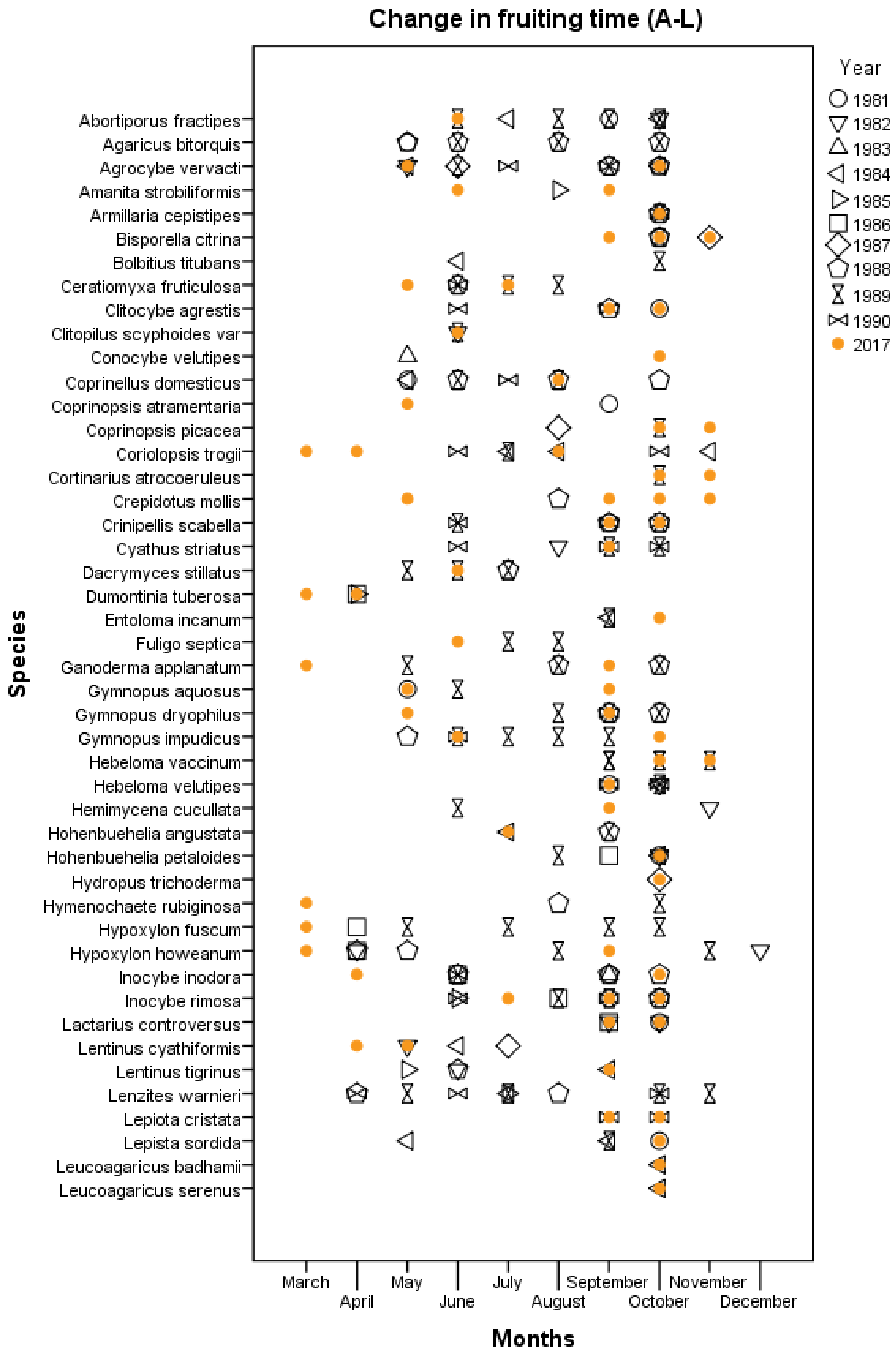

Fig. 88: List of species (A-L) which were found in the long time study and again in 2017 and their fruiting time.

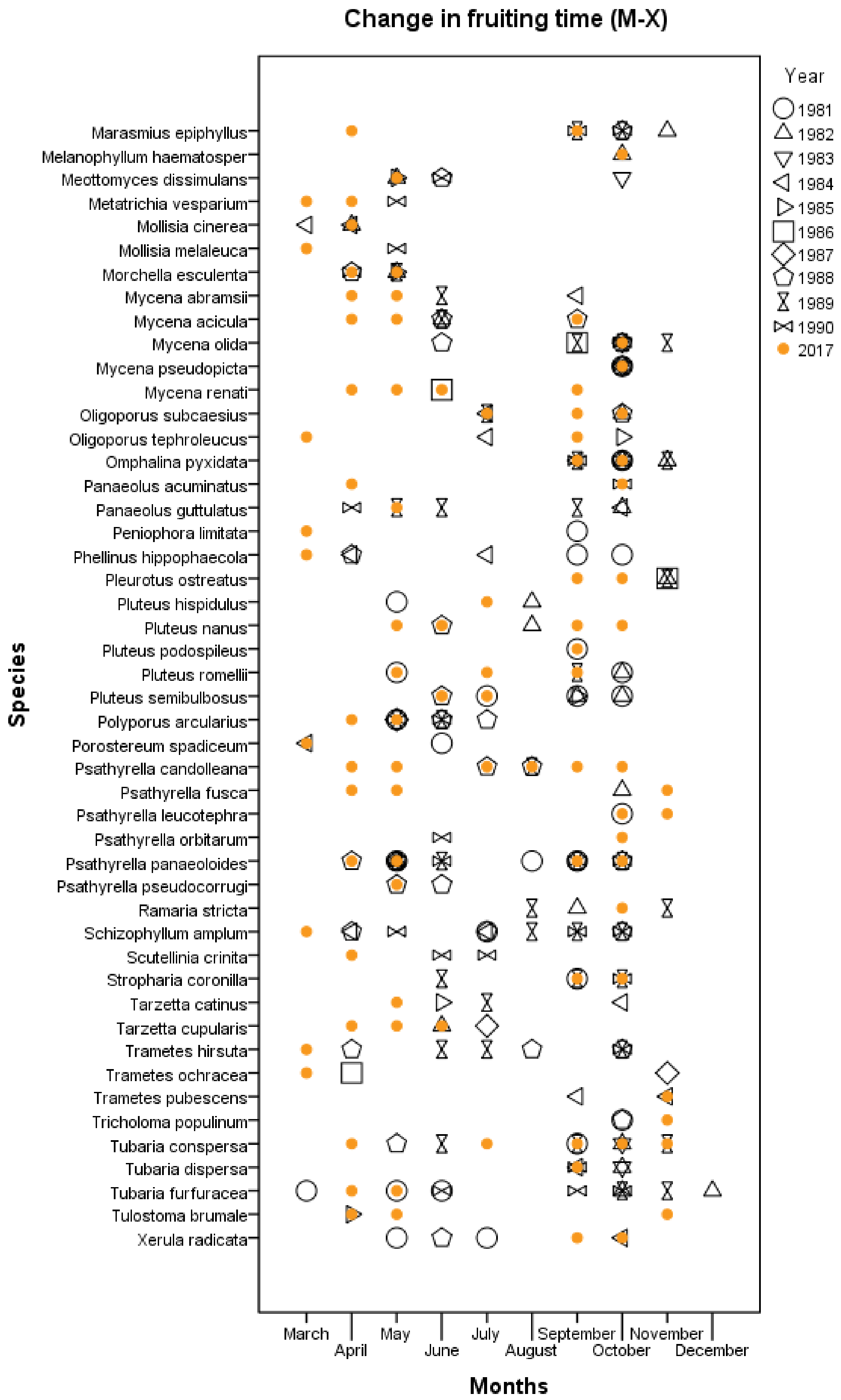

Fig. 88: List of species (continued, species M.-X.) which were found in the long time study and again in 2017 and their fruiting time.

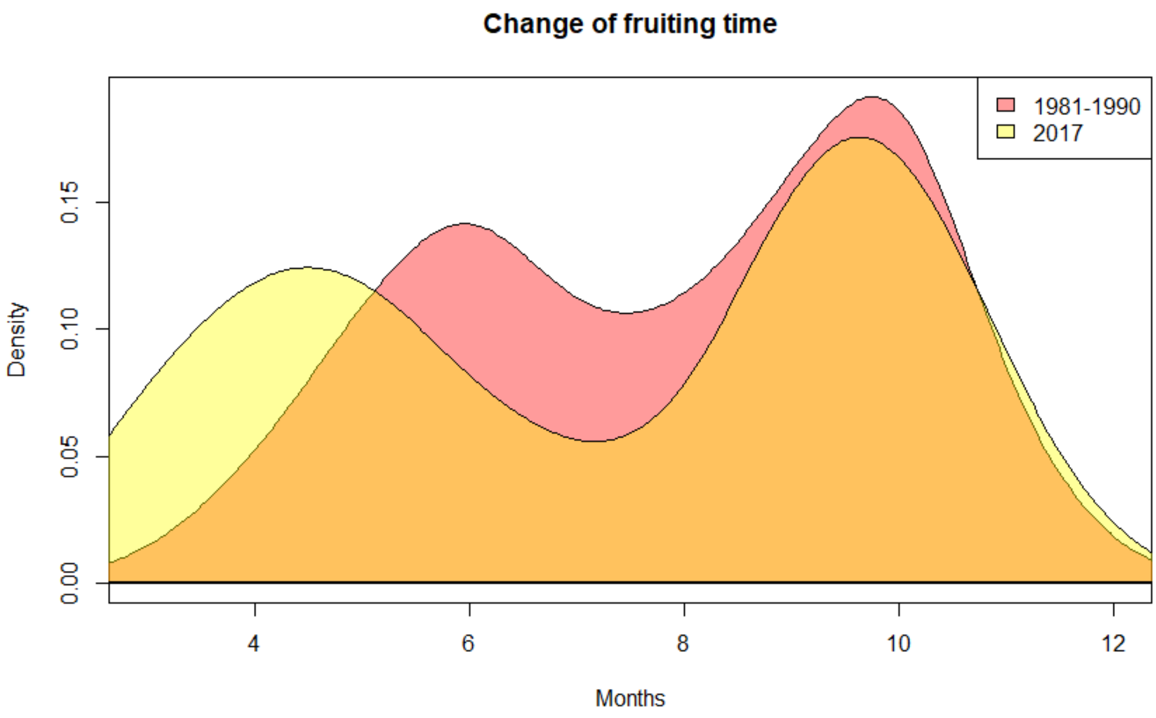

Fig. 89: Density chart based on the frequency of months fruit bodies were produced by species found in the long-time study and again in 2017.

It seems that more species found during the long time study and again in 2017, started to fruit earlier this year than in former times (Fig. 87-89). So for many of those species the fruiting season started a little bit earlier but did not extend. This is also owed to the fact that during the long time study in some years the sampling took place until December while in this year the last sampling was conducted at the beginning of November. However the previous mentioned shift in fruiting time is not equal for all species and groups of fungi (Kauserud et. al., 2008). Here again it must be mentioned that one year of sampling simply does not provide enough information for such complex processes as the changing of the fruiting period.

Change of plots

Change of mycoflora in grasslands

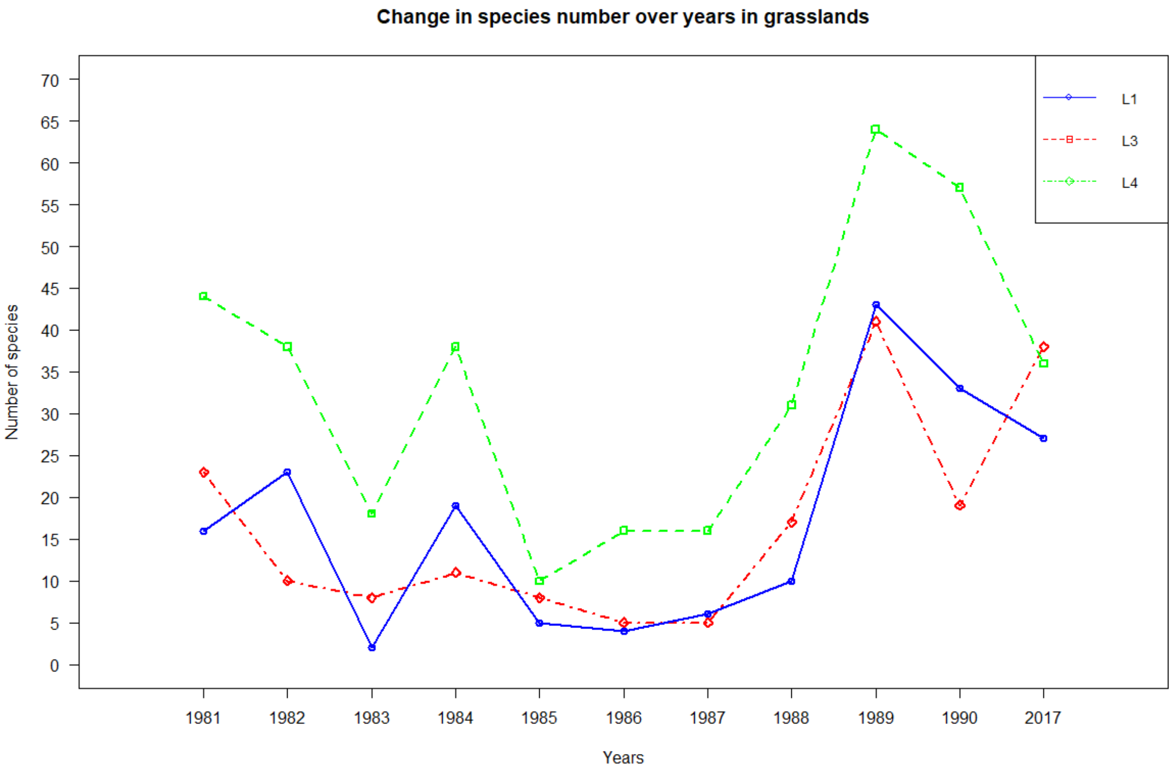

Fig. 90: Line chart of the change in species number over years of sampling at the grasslands.

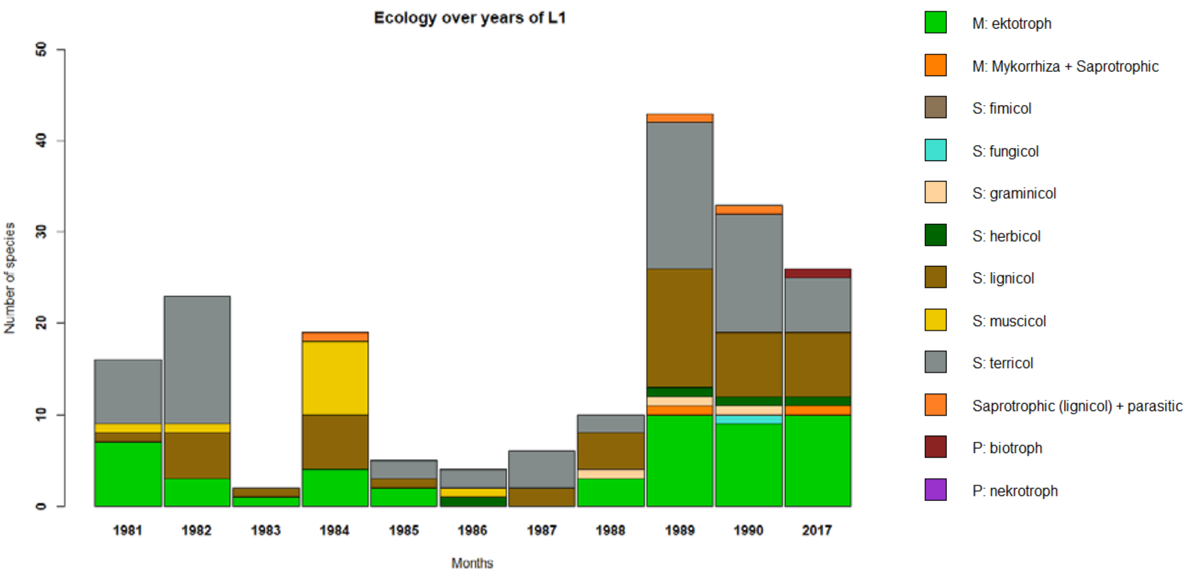

Fig. 91: Barplot of the change in ecotypes at L3 over the years of sampling.

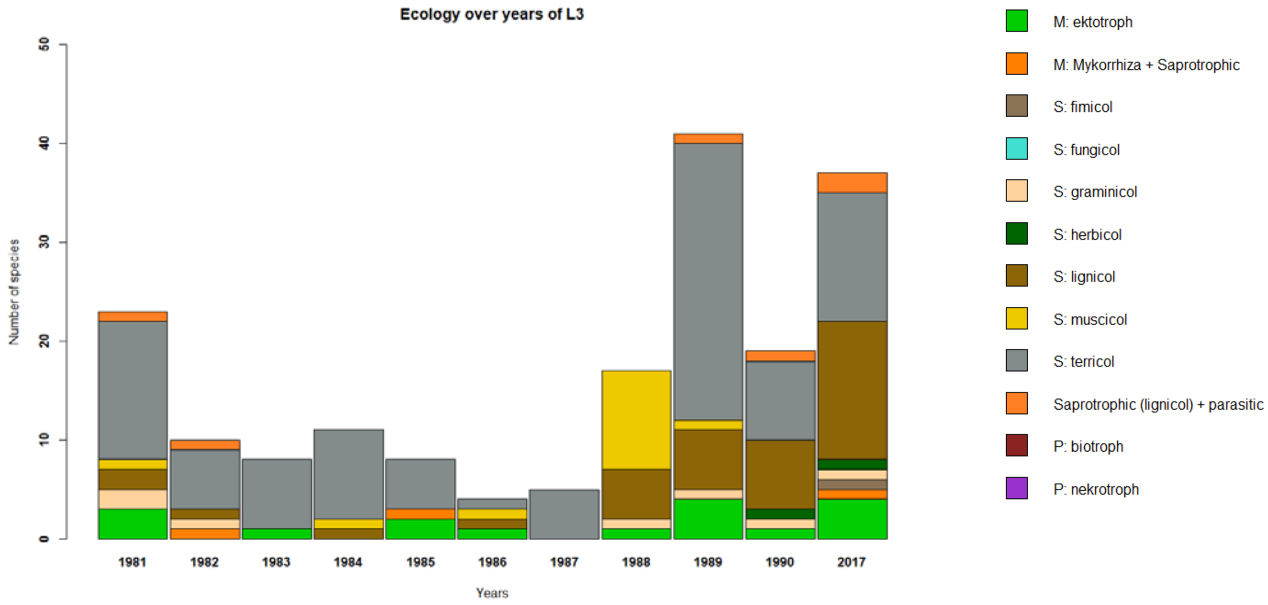

Fig. 92 Barplot of the change in ecotypes at L3 over the years of sampling.

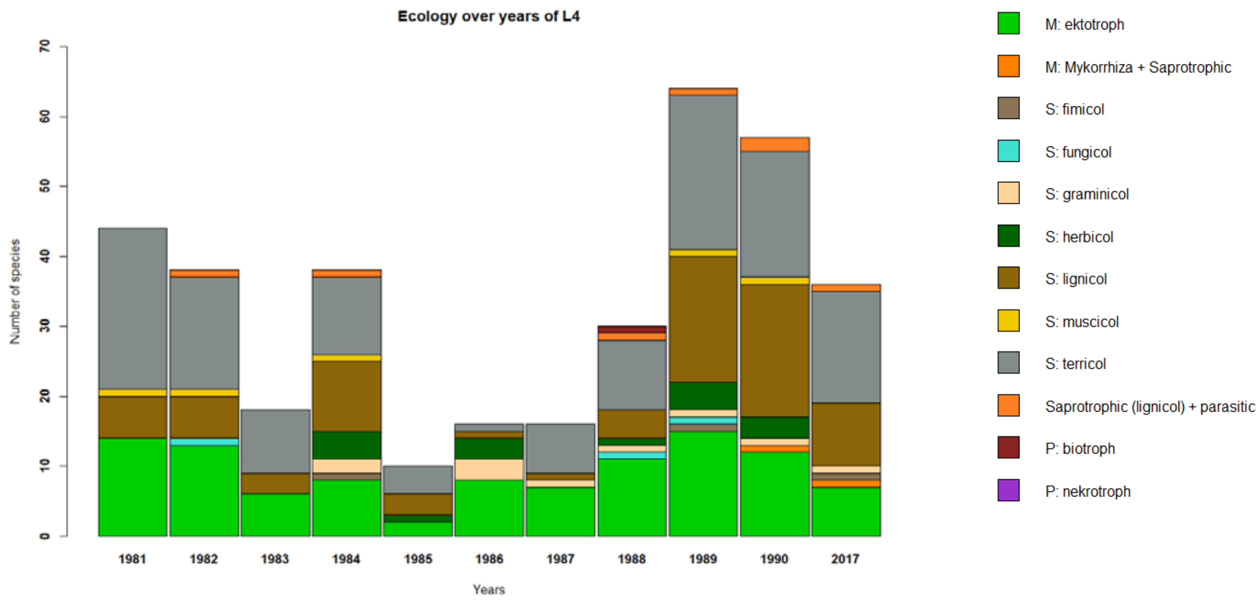

Fig. 93: Barplot of the change in ecotypes at L4 over the years of sampling.

	Plots		
Years	L1	L3	L4
1981	16	23	44
1982	23	10	38
1983	2	8	18
1984	19	11	38
1985	5	8	10
1986	4	5	16
1987	6	5	16
1988	10	17	31
1989	43	41	64
1990	33	19	57
2017	27	38	36

Tab. 33: Table of the number of species found in each year at the different grassland plots.

The average number of species that were found on L1 was 17.09, for L3 it was 16.81 and 33.45 for L4. So in 2017 the number of species found on each grassland plot was always above the average (Fig. 90, Tab. 33). Number of species (Fig. 90) as well as abundance of ecotypes varied over the years (Fig. 91-93).

In the grassland plots L3 and L4 mowing was conducted (see Material and Methods) which can be detrimental for the subground mycelium because it is carried out with heavy machines. The species number at these two grasslands was higher than at L1 where no mowing was performed. Maybe the fact that no mowing was performed at L1 was responsible for the highest number of mycorrhizal fungal species of all grassland plots (Fig. 38). The effect of mowing on the fungal species number has led to inconsistent results i.e. in some studies a decline was found in others an increase (cf. Arnolds, 1992). Without this type of vegetation management the dry grasslands would almost certainly be colonized by shrubs completely after a while (Schratt-Ehrendorfer, 2011).

Some fungi in grasslands tend to appear in a circular fashion i.e. fairy rings (cf. Arnolds, 1992) but this phenomenon was not witnessed during this study. Frequently feces from deer and wild boars were seen at grassland plots. New mycorrhizal fungal species found at L1 could have been introduced by wild boars, which were absent in the long-time study but witnessed this year, which can disperse fungal spores and alter the mycoflora of a certain location (Soteras et al., 2017; Livne-Luzon et al. 2017).

Genera considered characteristical for dry grasslands are *Conocybe, Dermoloma, Entoloma, Hygrocybe, Lycoperdon, Mycena* and *Stropharia* although they appear in other locations as well (cf. Blakesley and Buckley, 2016). However species of the genus *Dermoloma* and *Hygrocybe* were not found in this study at all. *Dermoloma* species appeared at the grasslands before, but *Hygrocybe* species were found in the long-time study at the grasslands (Krisai-Greilhuber, 1992). It should be considered that in grassland simply fungi do not produce sporomata every year (cf. Heilmann-Clausen and Vesterholt, 2008). Species from the other mentioned genera were found during this year at the grassland plots i. e. *Conocybe moseri var. moseri, C. subxerophytica, C. velutipes, Entoloma incanum, E. rusticoides*, *Lycoperdon excipuliformis*, *Atheniella flavoalba*, *M. pseudopicta* and *Stropharia coronilla*.

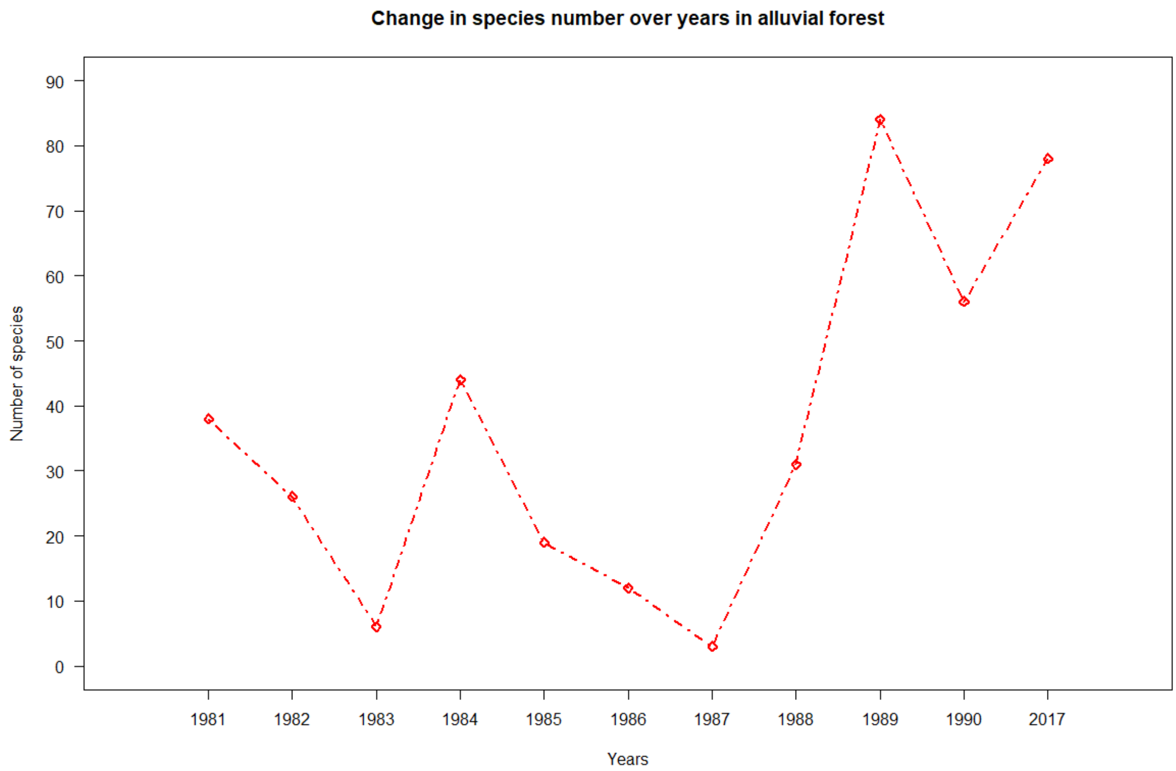

Fig. 94: Change of species number at L2 over the years of sampling.

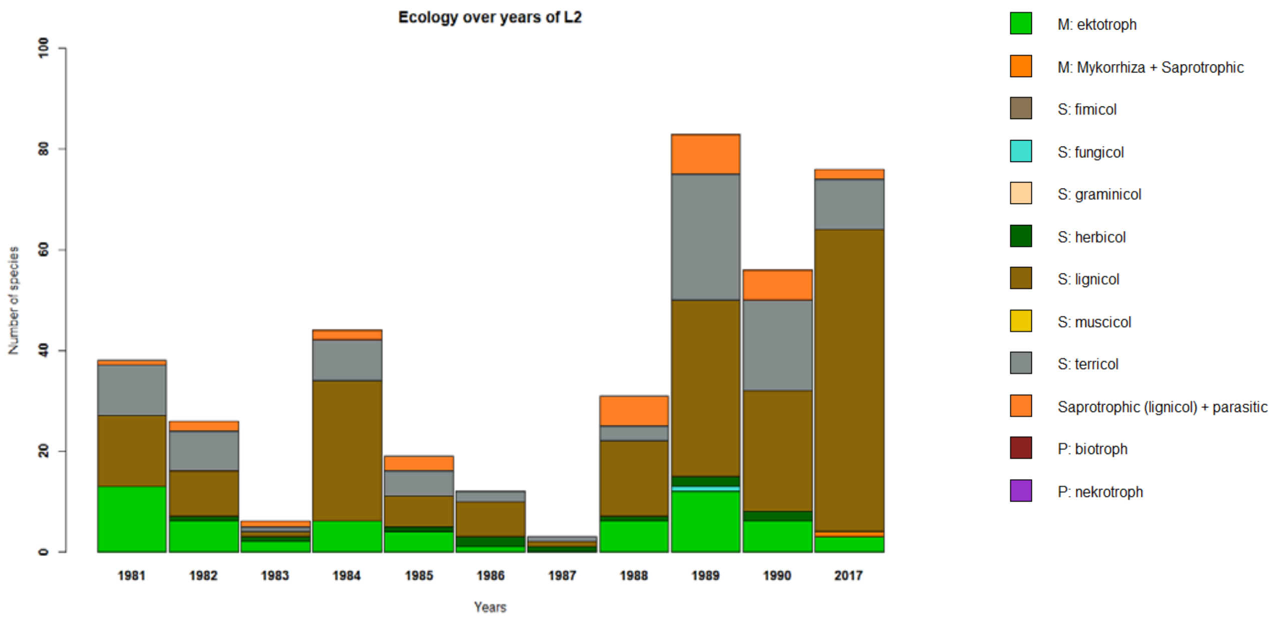

Fig. 95: Barplot of the composition of ecotypes found in each year.

Years	Number of species
1981	38
1982	26
1983	6
1984	44
1985	19
1986	12
1987	3
1988	31
1989	84
1990	56
2017	78

Tab. 34: Number of species found in each year at L2.

Most species were found at L2 in 1989, in this year the number was lower but higher than in most years (Fig. 94, Tab. 34). Compared to the last years of the long-time study in which a sampling at L2 took place, no herbicol species were present this year and the number of mycorrhizal fungal species has apparently decreased (Fig. 95). Also during the long time study the abundance of ectomycorrhizal species was fluctuating (Krisai-Greilhuber 1992, Straatsma & Krisai-Greilhuber, 2003). The lower number of EM species found this year could also be a result of forest aging (Egli, 2011) and/or the very densly growing trees (Ayer et al. 2006).

Maybe the presence of wild boars (*Sus scrofa*) and the nitrification and damage those animals caused at the soil of this plot was responsible for the decline of these two ecotypes. However wild boars should not be considered negative for EM fungi only, on the contrary they seem to act as important dispersal agents of EM spores as well (Livne-Luzon et al. 2017; Soteras et al. 2017). Forestry management works carried out by the usage of heavy machines, as witnessed sporadically during this study is probably more detrimental for the mycelium in the soil.

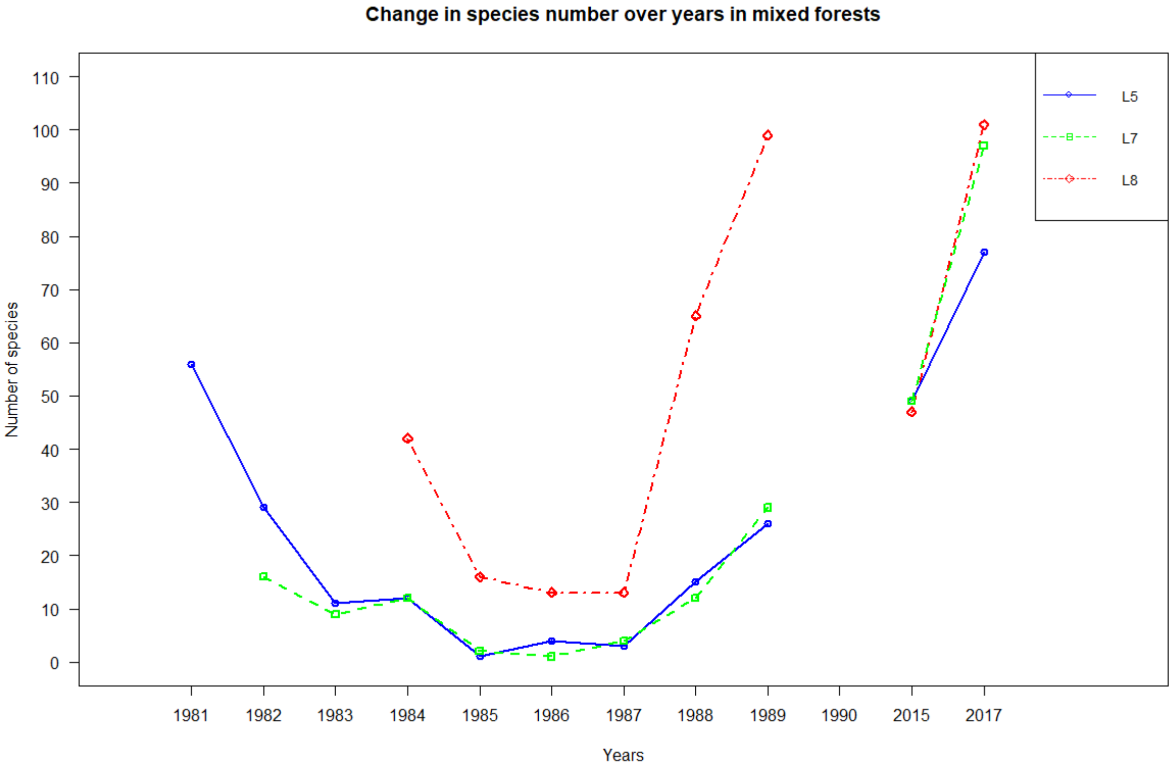

Fig. 96: Change of species number of the forest plots.

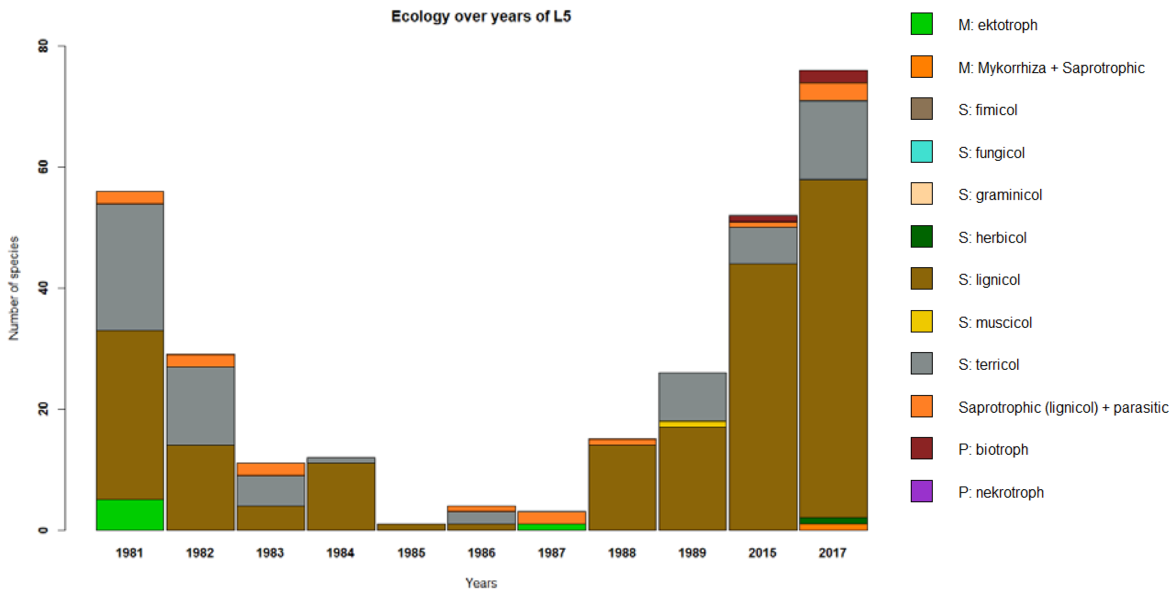

Fig. 97: Number of species and amount of ecotypes at L5 over the years.

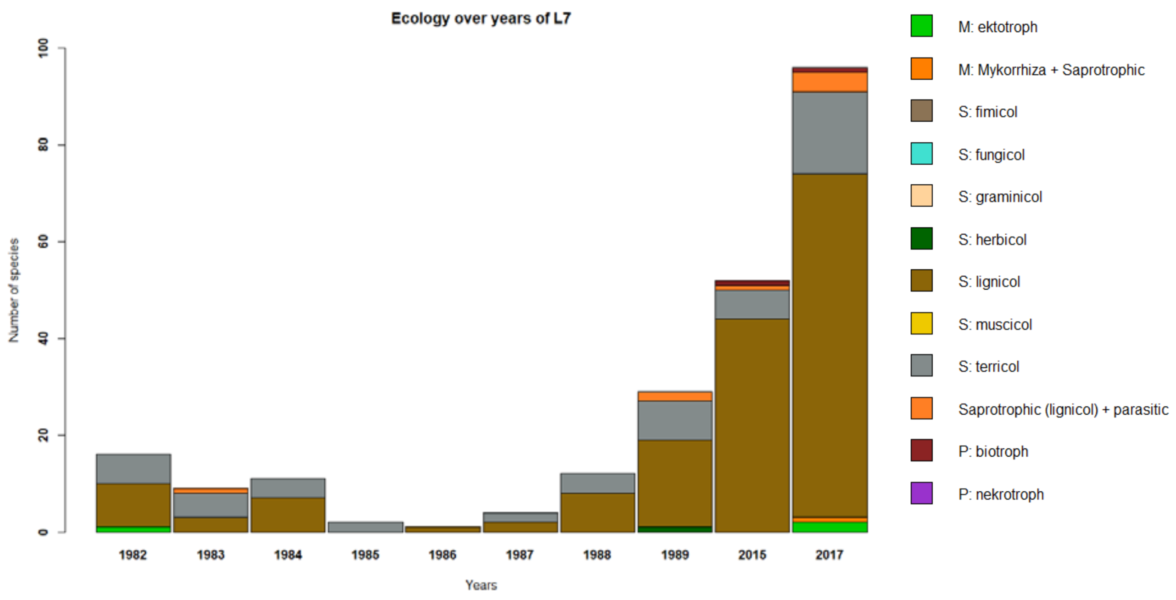

Fig. 98: Number of species and amount of ecotypes at L7 over the years.

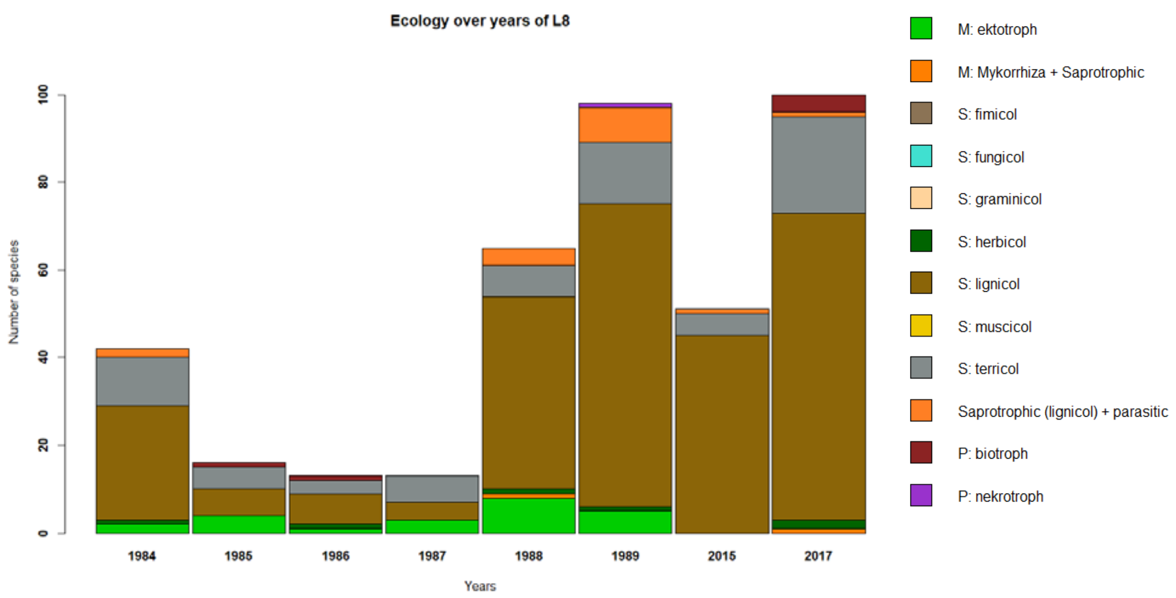

Fig. 99: Number of species and amount of ecotypes at L8 over the years.

<table>
<tr><th></th><th colspan="3">Plots</th></tr>
<tr><th>Years</th><th>L5</th><th>L7</th><th>L8</th></tr>
<tr><td>1981</td><td>56</td><td>NA</td><td>NA</td></tr>
<tr><td>1982</td><td>29</td><td>16</td><td>NA</td></tr>
<tr><td>1983</td><td>11</td><td>9</td><td>NA</td></tr>
<tr><td>1984</td><td>12</td><td>12</td><td>42</td></tr>
<tr><td>1985</td><td>1</td><td>2</td><td>16</td></tr>
<tr><td>1986</td><td>4</td><td>1</td><td>13</td></tr>
<tr><td>1987</td><td>3</td><td>4</td><td>13</td></tr>
<tr><td>1988</td><td>15</td><td>12</td><td>65</td></tr>
<tr><td>1989</td><td>26</td><td>29</td><td>99</td></tr>
<tr><td>1990</td><td>NA</td><td>NA</td><td>NA</td></tr>
<tr><td>2015</td><td colspan="2">49</td><td>47</td></tr>
<tr><td>2017</td><td>77</td><td>97</td><td>101</td></tr>
</table>

Tab. 35: Table of the number of species found at L5, L7 and L8.

Eventhough in 2015 L5, L7 and L8 were evaluated (Fig. 96, Tab. 35), the results i.e. species number of L5 and L7 were fused because the dry weather of this year led to a very low number of species (Stulik, 2016). By considering the number of species found throughout the years of investigations, it seems that the construction works of the gas pipe system near Mühlleiten and therefore in close proximity to the plots L5, L7 and L8, were not negative for the mycoflora concerning the sheer number of fungal species. However no fruit bodies were seen at the place earth was dug up. In these three plots most species formerly not found in the Lobau where discovered.

In order to clarify if the construction works were harmful to the mycelium in the soil and to which extant this was the case more surveys will be necessary.

Lignicolous species represented the biggest proportion of the present species at these three plots (Figs. 97-99). Of course activities affecting the underground environment probably will not be detrimental for this ecotype which lives and feeds on dead wood.

By comparing the number and proportion of terricolous species of this year with the results of previous investigations (Krisai-Greilhuber, 1992; Stulik, 2016) it seems that also terricolous fungi were not harmed by the construction works. Their abundance and relative proportion to the other ecotypes seems in fact bigger (at L7 and L8) or within the normal range (L5). L5 and L7 generally feature a low number of mycorrhizal fungi or sometimes none at all.

Interestingly the number of lignicolous species has increased at L5 and L7, whereas at L8 a high number of this ecotype has been found before in 1989. In northern Europe the increased CO_2 and warmer temperatures have led to a higher productivity of wood in forests (Lindner et al. 2010). Maybe this phenomenon, combined with leaving of dead wood, was responsible for the increased number of lignicolous species found at L5 and L7. Further, during the long-term study these two plots where once thinned considerably which of course influenced fungal production severely.

At L5 mycorrhizal fungal species were not found this year but at this plot mycorrhizal fungi were generally rare. A small number of mycorrhizal fungal species was found at L7, while during the long time study only in 1981 this ecotype was encountered here. During the long time study mycorrhizal species were present each year at L8, but not in 2015 and 2017. Acidification of soil, air pollution, an increased level of nitrogen and decreasing tree vitality seem to be the main factors responsible for the decline of mycorrhizal fungi in European forests (Arnolds, 1991). Due to fact that L5, L7 and L8 are situated right next to a small village, a street and agricultural fields, the previously mentioned factors were given and maybe responsible for the lower number of mycorrhizal fungal species found in this year and before in 2015 (Stulik, 2016). Further, it may be the case that the dry weather conditions in summer time 2015 and 2017 also led to a lower tree vitality and thus to a lower production of carbohydrates by the trees which are the nutritional basis for EM fungi and enable fruit body production. For ealuation if and up to which extent the construction works concerning the gas system were responsible for the low number of mycorrhizal fungal species found this year, more studys in the next year would be necessary.

The maize field right next to L8 was almost certainly fertilized with nitrogen in order to increase productivity of cropplants. Studies showed that input of ammonium and nitrate reduce the number of mycorrhizal fungal species in forests whereas saprotrophic fungi are affected to a much lower extent (summarized by Egli, 2011). So maybe also in this case (at L8) soil fertilization for agricultural purpose was responsible for the absence of mycorrhizal fungal species. Another important fact is that the trees were growing much more densely at L8 than in the other two plots (L5 and L7). In forests with trees growing in high density the number of mycorrhizal fungal species as well as fruit body productivity is lower compared to forests with less dense forest vegetation, saprotrophic species on the other hand were not affected by density levels (Ayer et al. 2006).

In beech, spruce and oak forests an amount of less than 20 % of mycorrhizal fungal species of the whole species number of a certain forest can be considered as a “lethal” level of disturbance (Fellner and Peskova, 1995), but it is not fully elucidated if the abundance of mycorrhizal fungal species is suitable to draw conclusions on the health of a certain forest (Egli, 2011).

Conclusion

Alltogether 246 fungal species were found during March and November 2017 at seven observation plots within in the Lobau, which differed in their vegetation type. Number of species varied between plots and months. The seasonal fluctuation of the number of species varied in the typical fashion with a low abundance during summer and a high amount of fruit bodies in autumn.

Generally alluvial forests displayed more fungal species than dry grassland plots. This discrepancy was mainly caused by the high abundance of lignicolous species in the first vegetation type. The relative amount of mycorrhizal fungal species was higher in the grasslands than in the forests. Compared to fomer studies conducted at the very same plots the amount of ectomycorrhizal species has declined in forest plots, whereas it remained mostly stable in the grassland plots.

Even in such a well investigated area as the Lobau 51 species formerly not recorded there could be found during this study.

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Appendix

Zwischen März und November 2017 wurden sieben Standorte innerhalb der Lobau bezüglich der Biodiversität der dortigen Großpilze untersucht und mit Erkenntnissen aus vorherigen Studien (Krisai-Greilhuber, 1992 und Stulik, 2016) verglichen. Bei den Untersuchungsgebieten handelte es sich um drei Heißlände, einen Pappelauwald, sowie zwei Hartlaubauwälder. Bestandsaufnahmen fanden im nahezu wöchentlichen Rhythmus statt. Insgesamt wurden 246 Großpilztaxa erhoben.

Die Anzahl sowie die Ökologie der gefundenen Taxa variierte zwischen den Standorten und Monaten, die jeweilige Artenzahl war nicht von der Größe des jeweiligen Standorts abhängig. Während der Sommermonate wurde die geringste Zahl an Fruchtkörpern angetroffen, im September und Oktober hingegen die höchste.

In den Waldstandorten konnten mehr Taxa festgestellt werden, als in den Heißländen. Dieser Umstand war dem höheren Vorkommen von lignicolen Pilzen geschuldet, die in ersterem Standortstyp deutlich häufiger anzutreffen waren. Insgesamt war der Anteil der Mykorrhizapilze geringer im Vergleich zu vorangegangenen Untersuchungen. Dieser Ökotyp kam auf den Heißländen verhältnismäßig häufiger vor als in den Waldstandorten.

51 Großpilztaxa die bisher noch nicht in der Lobau angetroffen wurden, konnten im Rahmen dieser Studie gefunden werden. In jedem Monat sowie auf jedem Standort konnten einige dieser neuen Großpilze erhoben werden.