UNIVERSITY OF SOPRON
FACULTY OF FORESTRY

DOCTORAL (PHD) THESIS

Short-term effects of thinning on epigeous macrofungi sporocarp production

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1. Introduction

Tending is the process of shaping already established young tree stands into ideal conditions and structure in order to meet their functions more perfectly. The most common implements of tending are thinnings which are done in practice by felling trees. From the removal from the stump to the preparation at the landing, thinnings have a significant impact on the stand, the soil and through that on the biomes living there. Fungi react to these, as they are very sensitive biomes to environmental changes in the forest. Today forestry receives more and more publicity. Besides wood producing and social functions its role in protecting diversity of local biomes gains significance as well, also satisfying environmental and nature protection functions expected from the industry. Based on the abovementioned I chose the examination of the short-term impact of thinnings on the fruiting body appearance of agaricoid fungi as the subject of my thesis. I aimed to answer the following questions, goals within this topic:

- To investigate what short-term impacts thinnings can have on the appearance of fruiting bodies of agaricoid fungi. How the characteristics of the funga form, are there any differences in the composition of fungal communities and did they really change because of the thinnings. Didn't they form differently solely because of the weather characteristics of the current year. My goal is to discuss which changes in stand structure or ecological characteristics can cause eventual differences.
- During thinning the stocking of the timber is usually done at forest landings. My goal is to investigate what special micro-habitats what kind of mycologic characteristics and funga have.
- My most significant research site are the forests around Sopron. So my goal is to gather data about the fungi of the area, as well as to explore mycologic characteristics and the domestic importance of the region by related stand structure investigations.

Based on available literature it can be said that investigations done so far report about several mycological advantages and disadvantages related to thinnings. My topic choice was motivated by the fact that there was no direct research done in Hungary so far examining the impact of thinnings on different fungi, however there were several standpoints made about this.

2. Material and methods

To examine the effects of thinnings I marked out 10 pairs of sample plots and investigated them between 2012 and 2015, each pair for three years. I determined the size of the sample quadrants in 900 m^2 and set them up accordingly in the Sopron-hills, in the Dudlesz-forest and around Sárvár. Harvesting works had to be done within 1-2 years in thinned plots and had not been done in the control plots for at least 5 vegetation periods which provides the necessary 4 years of difference between the disturbed and control sites recommended by literature. I made stand structure and coenologic investigations in the center of the plots on 500 m^2 supplemented with on-site soil examinations. Sub-compartments of the plots as well as their most important data can be found in the table below:

id.nr.	forest id. control; thinned plot	trees sp.	climate indicator	soil
1.0;1.1	Sop. 107/A; Sop. 109/F	spruce	beech	PBFS
2.0;2.1	Sop. 132/I ;Sop. 132/F	beech, oak	beech	CBFS
3.0;3.1	Sop. 132/I; Sop. 132/F	sessile oak,	oak-hornbeam	ABFS
4.0;4.1	Sop. 126/E; Sop. 126/B	oak, beech	oak-hornbeam	CBFS
5.0;5.1	Sop. 6/A; Sop. 5/B	pines	oak	RE
6.0;6.1	Sop. 31/A; Sop. 31/B	oak, hornbeam	oak	BS
7.0;7.1	Sop. 31/C; Sop.30/A	turkey oak	oak	CBFS
8.0;8.1	Sop. 40/A; Sop. 38/B	turkey oak	oak	CBFS
9.0;9.1	Vép 37/B; Vép 33/C	oak-hornbeam	oak-hornbeam	RFS
10.0;10.1	Bejc 6/D; Bejc 12/D	deciduous mix	oak-hornbeam	CBFS

I examined landings in 8 places around Sopron in the hills and in the Dudlesz. Mycologic data collecting was based on fruiting body counting and species appearance at the landings (frequency). For species determination fungariums and/or photo documentation were made. Determination was done based on morphological and ecological characteristics of the species. Based on the found literature I prepared the life-strategy grouping of taxa. I evaluated the received data with classic mathematical statistical methods and besides that also with social ecology methods. These were the Jaccard- and Bray-Curtis- similarity indexes, the Rang-abundance and the species saturation curves for the total taxa groups. I compared fungi communities with the Shannon-index and the Rényi diversity-ordering. I also prepared the nature conservation evaluation of the taxa found on the landings and in the stands based on domestic literature.

3. Results and discussion

Stand structure and coenologic investigations showed that because of thinning there can be a great difference in closure and because of that in temperature, herb closure, etc. conditions. I managed to indentify 258 fungi taxa totally which I classified into 75 genera based on the used literature. I detected 222 in the control parcels and 208 in the thinned stands. There are totally 36 species which were only found in thinned plots and 50 which were only found in the control parcels. I found totally 4 121 fruiting bodies in the control plots and 3 647 in the thinned areas. The expectation examination showed no significant difference between the plot pairs. The similarity dendrogramms of the plots did not group the thinned and control stands separately. They basically gave similar results than the phytogeographic grouping emphasizing cultivated conifer stands which got to a totally separate branch. If we view the results from the point of fungi communities the interventions have minor negative effects on the fruiting body appearance of ectomycorrhizal communities. For saprotrophic communities no positive or negative effect could be showed with confidence, for lignicole species a slight negative and for terricole species a slight positive impact could be seen. Considering taxonomic differences it is rather to be concluded that by these two functional groups thinnings cause simply changes but their judgement to either direction would be very much pectoral. Results show that fungi react differently to thinnings in different stands. The obvious reason for this can be led back to the morphologic and social characteristics of dominant tree species and on the whole to the attributes of forest coenoses. Thinning has a different impact on an open monodominant oak stand than on a closed hornbeam-beech forest. Examining the positive and negative effects of thinnings on a taxonomical level there are several examples for taxa in case of which thinning increases or decreases the production of fruiting bodies. According to that it is visible that interventions have a different impact on a species level as well and both disturbed and undisturbed stands have their own typical indicator species. Examining the dominant characteristic species it can be concluded that there are several species in the region which rather avoid disturbance than to tolerate it however this difference is very small (<5%). The comparison of years with different climatic conditions points out that however weather conditions affect fruiting body production more than thinnings, the impacts of them take effect independently as well. Nature conservation evaluation and the IUCN grouping of Hungarian fungi gave a neutral result on control and thinned stands. Observing the ecological effects of thinnings we can point out three

main effect-elements: closure decrease, soil disturbance and the change in deadwood-state. In my opinion all other effects can be originated from these. These effects depend highly on the characteristics of the stand. Since the control stands were previously thinned as well, it can be said that the impacts of thinnings can only be seen until a given time period - the next phase of stand development. My recommendations for thinnings based on the results are meant to drive these factors towards favourable tendencies.

During the examination of fungi at landings I identified 119 species (or species complexes) during the research period in the plots. The functional group distribution of taxa is different from the one of forest plots. Increased soil compaction does neither favour floral root development nor mycorrhiza establishment which decreases the appearance of fungi partners. Taxonomic and nature conservation grouping pointed out that several rare species appear as well so these are mycologically important habitats. Because of their special environment forest landings provide opportunities for several pioneer species which otherwise would not or would only very rarely appear under natural circumstances. These species are suitable for indicating forest landings or similar natural or artificial forest environments. During my years of research I increased the knowledge of the local funga with 111 new taxa around Sopron and found 18 species endangered in the region totally. The mycologic evaluation of tree stands showed the importance of local typical conifer forests in the Hungarian funga. During coenologic studies of fungi the possibility of mycologic classification of tree stands was already brought up a long time ago. Since the appearance of fungi taxa strongly depends on site conditions as well besides tree species the following question arisies: why not using fungi for typologic classification in those stands where herbaceous plants don't make this possible?

4. Summarizing results, theses

Based on my results it can be said that thinnings done appropriately do not decrease the species and fruiting body number of agaricoid fungi but can rather change their composition. Establishing landings increases the species composition of fungi communities in forests because many species find their habitat only under such circumstances. The characteristics of the forests around Sopron are due to the climatic conditions and conifer stands. Based on my research and the results found in literature the indicator role of fungi can sometimes be used in practical forestry as well.

Based on my research results I expessed the following scientific results and theses new to Hungarian science:

1.1. Based on my results I found out that thinnings carried out professionally, humanely and with less vigor (<20%) in domestic native hardwood and cultivated conifer stands managed with cutting do not significantly decrease the species and fruiting body number of agaricoid fungi but can rather result in the change of their composition. Changes in microhabitats and herbaceous vegetation cover because of thinnings can change the funga of the given stand. I found out that in the examined stands the occuring environmental changes because of the thinnings done under domestic technological circumstances: soil compaction, eventual changes in soil temperature and moisture, increase in herbaceous cover, etc. usually have a negative effect on the fruiting body (pilotecium) diversity of ectomycorrhizal fungi, however they have a neutral effect on the diversity of saprobiotic fungi communities segregated in the same way.

1.2. I found out that thinnings have a different impact on fruiting body appearance in the stands with different characteristics which I investigated. Because of the different ecological and silvicultural characteristics of different tree species and stands, tending interventions have a different impact on them and their environment. Agaricoid fungi with different ecological needs react differently on micro-environmental changes caused by thinnings. Some species react neutrally, but it can cause the fruiting bodies to appear or disappear temporarily for some others.

1.3. During the evaluation of the tree stands I examined, I found out that thinnings done with different vigor affect the fruiting body appearance of agaricoid fungi differently. This is especially true for different types of stands. Of course a sanitational cut or a commercial thinning has a totally different ecological effect in a given stand, and a harvest of 15% vigor has a totally different impact on an open oak stand than on a closed beech forest which thereby affects the fruiting body apperance of agaricoid fungi in a different way.

1.4. During the research period the fruiting body production of fungi in the sample plots was different each year. Based on my results this can be led back to the meteorological conditions of the research period and the previous years which have a strong impact on fruiting body appearance. Since the differences between the sample plots showed a bigger diversity over the years than between the treated and untreated quadrants, it can be said that weather conditions have a greater impact on tree stands at a given time and place than thinnings. However they affect them independently according to my results.

2.1. Based on the mycological research done on forest landings I got results which show that their establishment increases the agaricoid species composition of forest stands since several species can only find their habitat in such circumstances established by humans. Forest landings can provide habitat for several rare fungi species, so these microhabitats are favourable from a fungi conservation point of view within the forest biome.

2.2. I have shown that on the forest landings I investigated – however due to the altered ecological environment the taxa of saprobiotic fungi communities became dominant – fruiting bodies of ectomycorrhizal fungi species did not disappear either, which has a favourable impact on reforestation.

3.1. It is a well known fact from literature that fungi can be used widespreadly as indicator organisms. During my research I sucessfully used fungi for forest typological stand classification and based on my results they are also suitable for characterizing unwooded forest habitats such as landings. According to that it can be said that the indicator role of fungi can also be used in practical forestry or even for solving forest planning questions during the classification of stands or other habitats.

4.1. I chose the most important area of my research to be the forests around Sopron. Based on the referred literature the appearance of altogether ~563 fungi taxa in the area were published in the last 20 years (between 1995 and 2015). In the data gathering and processing stage of my thesis I documented the appearance of 111 new taxa totally and expanded the funga of the area around Sopron. Besides the 111 new species I also recorded the reappearance of 18 taxa which did not appear in the last 20 years on the research site and so they locally count as critically endangered.

4.2. During the mycologic evaluation of the main tree stands in the area I pointed out that the mixing with conifer species has a significantly positive impact on species count and diversity of local fungi communities. Since several conifers are considered to be native in the area we can view fungi appearing with these stands as positive too. Under domestic conditions these are the mycologic specificies of the region. So from a mycologic point of view it is practical to maintain and preserve conifer stands in the future.

5. Conclusion, recommendations

The new scientific results arisen from the thesis group into four topics. These are the ecological impacts of thinnings on the fruiting body appearance of fungi, mycologic specificities of forest landings, indicator role of the fruiting body appearance of fungi as well as its importance in forestry and the mycologic characteristics of the region.

Harvesting activities used during cultivation can have a significant impact on fungi. Out of several harvesting methods thinnings are the ones that embrace the longest time in the lifespan of the forest. Based on my research results these effects cause minor temporary degradations in mycorrhizal fungi communities and also cause changes in the composition of saprotrophic communities. The comparison of years with different weather conditions pointed out that however weather conditions have a stronger impact on fruiting body appearance than thinnings, they affect them almost independently. Based on this it can be recommended that - in order to protect the fungi communities of a stand – more vigorous interventions are better done at a young age of the trees when the funga is still in a developing stage. At an older age more often and more careful interventions are to be aspired which are less disturbant. This is a more favourable process not only from a mycological, but also from a silvicultural point of view in case of several stands (oak, beech).

Forest landings get very little scientific attention based on the literature I found. According to the research of forest landings it can be said, that despite they are an everyday stage of forestry they provide habitat for numerous groups of living beings so this research can be important from not only a mycologic point of view but from several others as well.

The results of the research however leave many open questions in this topic. Out of these the results of long-term impact assessments are worth to be underlined. Using the results of the dissertation can be useful for mushroom pickers because of the taxonomic and coenologic data but also for people working in forestry. The recommendations for thinning works can help to carry out nature-like forestry and to preserve its biological bases. The forest stand grouping method based on the funga used in this dissertation can be used in exceptional cases for forest planning or scientific research as well.

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