UNIVERSITY OF COPENHAGEN

Review of the thesis "The role of wood decay fungi in the dynamics of a mountain spruce forest" submitted by Václav Pouska, 2011.

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The thesis deals with disturbance dynamics, regeneration and fungal biodiversity on dead wood in mountain spruce forests in the Bohemian Forest at the border zone between the Czech Republic and Germany. The thesis contains five articles, a short introduction, and a one page conclusion also giving some directions for future research. The five articles are either already printed or in press in acknowledged scientific journals with a good reputation within their fields (Impact factors in the range of 1.8-2.1). Václav Pouska is the first author on two papers, and the subordinate authors on the three other. In two of these he contributed with data collection and in all he was involved in data analysis and manuscript reading. Somewhat oddly, the fifth of the papers falls outside of the title of the thesis, as it does not consider the role of fungi in relation to forest structure.

The research field explored in the thesis is quite novel in a Central European context, but has been in focus in Fennoscandia for almost two decades. But even in this wider geographical context the thesis is novel by its strong focus on linking fungal diversity and forest dynamics. Otherwise, the thesis impresses more by its extent than by its depth. The five articles are based on four different but partly related datasets. In paper 1, 3 and 5 the datasets are rather small, considering the complexity of the research questions addressed.

I guess that the candidate has benefited in his learning from the wide frame of the project, but the quality of the research would have been greater with a more narrow focus allowing more in depth research on a lower number of research questions. However, the research presented is clearly sound and relevant, the papers are well written, and there is no doubt, that the thesis deserves a successful defence.

The introduction is written as a short review on each of the subjects covered by the thesis. It is well written, well balanced and shows that the candidate has a good overview on literature relevant for the subjects. However, I would have appreciated a more original view by the author on some of the issues reviewed and discussed.

Paper one focus on the connection between habitat factors, species richness and community composition in wood inhabiting fungi in relation to an elevation gradient in Trojmezná in the Sumava National Park. The study is plot based, including data from 12 plots, each being a circle with an area of 0.2 ha. Fungi were sampled at four occasions over three successive years per plot. Fungal species richness was found to increase with the total volume of dead wood per plot, and both decreased with altitude. The number of red-listed species per plot was most strongly related to the volume of dead wood in decay stage 2, even though very few records of red-listed species were actually made on dead wood in this stage of decay. Patterns of community composition was analysed using ordination methods, which did indicate a turnover in species composition with altitude. But due to the low number of sample plots and confounded effects, it was not possible to evaluate whether this effect was related to altitude per se or rather to differences in stand structure not related to altitude (i.e. it is indicated that the highest stands were younger than the lower stands).

Paper two is based on the same dataset as study 1, but focus on the 300 individual logs rather then the plot level, which greatly increases the sample size and hence the analytical power. The focus is on community composition, and indirect and direct ordination including variation partitioning is used as analytical tools. The indirect ordination approach clearly shows that the main gradient in species composition was related to the decay stage of the logs, in concert with earlier studies in the field. The direct ordination and variation partitioning approach further shows that the cause of tree death was influencing species composition, with some species preferring trees dead due to bark beetle attack, and others, including several red-listed species, trees dead due to wind break or butt rot. This result is novel and highly interesting, but due to the study design, it is not completely clear if the found differences are in part related to quantitative characteristics correlated with death cause. Especially it would be nice to know the decay stage distribution for logs in the different death cause categories.

Paper three is a collaborative project extending the sampling of wood inhabiting fungi to 88 plots in three sites in Germany and the Czech Republic. The three sites represent old grown, disturbed (by bark beetle attacks, with no removal of dead wood) and regularly logged forests, respectively. In comparison to study 1 and 2 sample plots were smaller (0.1 ha) and fungi were recorded only at one occasion per plot, resulting in a less complete sampling of fungal diversity. It is clear from Table 2 that agarics were not considered in the study, which is fair considering the sample protocol, but it is a problem that this is not mentioned in the material and methods section. Comparisons of species accumulation curves indicate that the species richness per ha was clearly highest in old grown stands, for both red-listed and non red-listed species. Comparisons based on dead wood volume resulted in a less clear difference between old grown and logged sites, while disturbed sites were clearly less species rich. Again the difference was evident for both red-listed and non-redlisted species. This strongly indicate that trees dead due to bark beetle attack were more species poor than trees dead due to other factors. At plot level dead wood volume (+) and canopy cover (-) were significant in explaining species richness, while red-listed species richness was related to radiation (-), wood volume (-) and average size of logs (+). This indicate that red-listed fungi on spruce dependent more on the quality of dead wood and shady condition, than on dead wood volume per se. Finally the study used ordination and additive partitioning of species diversity to explore the dataset. The first approach quite nicely separates plots from the three management categories in three clusters, while the latter approach indicate that variation among plots is the most important level in explaining total species richness for both red-listed and non redlisted species. Pseudo-replication is a crucial drawback of the study. Personally, I believe that the found differences are largely related to the differences in management classes, but a considerable higher number of real replicates (i.e. a higher number of independent stands in each management category) would be needed to test the impact of management independent of other stand differences.

Paper four explores the relation between characteristics of fallen logs and spruce regeneration, based on a total sample of 398 logs in the same study sites as used in study three. The study nicely illustrates the development of regeneration as log decay proceeds, but does also point to some interesting effects of decay type on regeneration. Thus, logs decayed by the white rotting Armillaria spp. and Phellinus nigrolimitatus had significantly more regeneration than logs decayed by the brown rotting Fomitopsis pinicola or by other species. Also log diameter (+), ground contact (+) and surrounding vegetation (polynomial) was found to influence regeneration, indicating that large logs with good ground contact and a moderate vegetation cover were most suitable for young spruces. Various explanations for the positive association between spruce regeneration and logs rotted by the two white-rotting fungi are discussed, including better nutrition capacity, higher mechanical stability and differences in mycorrhizal communities. A fourth factor, not discussed, could be differences in water holding capacity. It would be obvious to study the importance of these factors using a more experimental approach combined with detailed physical and chemical analyses of wood samples.

Paper five deals with forest structural patterns and regeneration along the same altitudinal gradient as studied in paper 1. However, the study mainly deals with structural differences between two compartments, stand A and B, differing in disturbance history, with one stand being clearly influenced by logging or a stand-replacing natural disturbance event some 200 yrs ago, and the other having clear old growth characteristics. The study is mainly descriptive and the reported results are not very novel or surprising. Most interesting is perhaps the result that a majority of the regeneration was confirmed to dead wood, even though this habitat occupied only 5 % of the forest floor. The study design is not well balanced, with 12 plots representing the old growth stand, and six plots representing the more disturbed stand. There is probably a good reason for this lack of balance (i.e. that the analysis of forest history was made after plot selection?), but this is not explained in the text.

The conclusion in the end of the thesis is really short, and does mainly provide some general summary statements as well as some vague directions for future research.

As a supplement to the above review, I want to pose some more overall questions which address issues across several of the papers constituting the thesis, but mainly its papers 1-3.

Wood dimensions/log diameter is mentioned in several places as a factor influencing species composition on decaying wood. But how is this aspect influencing species composition within the diameter range covered by studies in this thesis? And would other types of differences be seen if even finer dead wood was considered?

One issue of relevance to the above question is the process of dead wood formation. The thesis seems to show that tree dead due to bark beetle attack host quite different fungal communities compared to trees dead for other reasons. What are the possible explanations and how does tree dead as a factor interact (or not interact) with other factors e.g. forest structure, microclimate and dispersal/establishment dynamics of fungi?

Most of the studies are based on plots along elevation gradients, and there seem to be some turnover in fungal species composition (and forest structure) along this gradient. However, it is not really clear to what degree these differences are related to altitude per se, or to other factors correlated, by change, to altitude. Still I would like the candidate to consider how altitude (as expressed in microclimate) could affect fungal communities directly or indirectly.

Finally, I would like to ask the candidate for his thoughts on how his results could inform conservation priorities. I.e. what kind of stands should be prioritized for conservation, and within stands, how could we select tree to enhance fungal diversity under an economic constraint? Would the cessation of salvage logging be a cost-effective way to enhance fungal diversity or could other measures be more effective?

Yours sincerely,

Jacob Heilmann-Clausen

Evaluation of the PhD. thesis of Václav Pouska

Dissertation submitted by Václav Pouska under the title The Role of Wood Decay Fungi in the Dynamics of a Mountain Spruce Forest is presented as a set of five previously published peer-reviewed papers, fully focused on the issues of structure of the mountain spruce stands mainly in NR Trojmezná in the Bohemian Forest, which might be a mountain spruce stand, but not subalpine spruce forest, as stated in the title of Paper IV.

Introduction focuses on Wood size (Paper I, II), Conservation (paper III), and Fungi and forest regeneration (paper IV, V). The synthesis is processed in a form of short review and discussion. Aims are more focused on fungal biodiversity and spatial distribution in logs than on the role of wood decay fungi in the dynamic of a mountain spruce forest, as the title of the dissertation suggests. Theses brings new information on biodiversity of wood destroying fungi and their relations to the dead wood and spatial distribution in mountain spruce stands in paper I, II, III. Information on role of wood destroying fungi in the dynamics of mountain spruce stands are partially presented in paper IV and V. Some better introduction to hypotheses and syntheses of author's own observation could have given.

The author's role in publications team, he is primarily focused on the description of the occurrence and spatial distribution of lignicol macromycetes. All papers are based on the proven design based experiments, characterized by adequate statistical treatment. Expected partial synthesis on the findings about the role of wood fungi in dynamics of mountain spruce forests are found or developed in individual papers; even though the work is characterized by a very detailed discussion and detailed statistical analysis, interpretation of in-depth statistical analysis in my opinion is not exhaustive. Individual papers are primarily focused on the description of the structure and statistical evaluation of individual relationships with a detailed discussion.

I assume that the published papers have undergone the standard peer-review process. Therefore I would like to give few comments on the facts that should have been captured in the peer-review process already.

Fantastic topic of the dissertation considers being crucial, however the topic is very broad and difficult to grasp, it includes synthesis of findings from the forest ecology, management and history of forests, forest biology and fungal biology and pathology. Crucial complication for evaluation is dynamics of the studied system, when process of wood decay starts in living tress already and it takes several decades up to more than a century on living trees and up to 4(?) decades on lying stems.

It is obvious, that the author has an excellent field skills. Therefore, it is not clear to me why, in all his studies he treats all the identified species of fungi with the same importance. Why he does not distinguish important decomposer, already infecting hearth part of the living spruces, such as *Phellinus nigrolimitatus*, *P. chrysoloma*, *Heterobasidion spp.*, *Stereum sanguinolentum* (if it follow bark stripping), from marginal species, that colonize sapwood of already rotting logs – *Mycena* spp., *Gymnopilus* spp? Abundance is primarily evaluated on the frequency of fruiting bodies, without further analysis on portion of colonized/decayed wood. However, I fully understand methodical difficulties of this work. Simple classification or identification of wood decay, such heart rot or sap rot, or nectrotrophic pathogens to saprophytes, can significantly affect the relation obtained by further processing and partial conclusions presented in the papers.

Also, I welcome here the discussion on the dynamics of wood decay, especially the question of timing of infection. I am particularly concerned about the role nectrotrophic parasites, that colonize wood of living trees, often with similar strategies as endophytes – they colonize living hosts and fill niche for subsequent decay, when the host is dead and fallen, or when root rot, caused by Armillaria root rot and Heterobasidion root rot, reduce their physiological age and then break down. It is a long process, which in the mountain spruce stands can exceed hundreds of years is obvious and in the mountain spruce stands can obviously exceed century. However, this is another scientific story – Dynamic of Wood Decay and Forest Regeneration in Mountain Stands.

Comments

Dacryomyces – wrong spelling, correctly ***Dacrymyces***. The same mistake is in Paper I and II, in Paper III, the name is correct.

Why is *Dacrymyces stillatus* noted in Key words in Paper I, is it really such an important fungus for the decomposition of wood? I have not any comments about the abundant fructification on the surface of decayed logs, however for wood decay, this is marginal species colonizing surface of sapwood.

Laetiporus sulphureus – wrong identification in Paper I a II, correctly *Laetiporus montanus*, as is in Paper III.

Armillaria sp. – why the identification was not noted in the tables of Papers I-III, as the identification is presented in p. 17? – see *A. borealis* and *A. cepistipes*. Both species are characteristic for mountain spruce stands. I was surprised by some researches, how common Armillaria is as a root rot in this altitude, though the fructification is not common. More studies are necessary for the evaluation of the role of Armillaria in the dynamics of this mountain spruce stands, including individual falls.

Heterobasidion sp. – there are identified as *H. parviporum* in Paper III. I suppose that identification as *H. annosum* in Paper I a II is in sensu lato. Is it? Also, fructification of Heterobasidion in higher altitudes is not so common, though rot is abundantly present.

Questions (answers should be included in the presentations)

1. Did you record presence of main wood decaying fungi, such as Heterobasidion root rot, Bleeding Stereum and other main bracket fungi, on the bases of characteristic features of wood decay? How many trees were fallen due to the root rots? Was it possible to note significance of these root rots for the next regeneration in logs?
2. What is the role of wood decaying fungi in mountain spruce stands? What polypores play key role in mountain spruce stands disturbance, what species are important in decay of main volume of wood, what species are marginal or invade already decayed wood as secondary agents? Please, prepare some discussion for your presentation. Some groupings of recorded species are welcomed.
3. There are some red-listed species included in your study. You discuss in Paper III differences in biodiversity in old growth and formerly managed stands. Situation on Sumava Mts. has changed due to the bark beetle outbreaks. Are there enough refuges as are standing trees in particular size for some (rare) wood decaying fungi in Sumava actually? What is the risk, that species, such as *Leatiporus montanus*, *P. nigrolimitatus*, *P. chrysoloma* and others disappear from Sumava mountains due to the temporary (hundreds years?) lack of adequate stems of host trees? There are enough fallen stems with fructifications now, however infection starts in mature trees and it seems, that some age classes of living trees are missing now.
4. Is the abundance of *Fomitopsis pinicol*a decay typical phenomenon for mountain spruce stands or is it the result of stands disturbations, such as bark beetle outbreaks, air pollution in the past, etc.?
5. It makes sense to keep stripped logs in the forest for biodiversity reasons, even though they are lie under the canopy of matures stands? Did you find fruiting bodies of nectrotrophic parasites, such as *Phellinus* spp., *Laetiporus montanus* in stripped stems, if there are present? How common are hearth rots of nectrotrophic parasites, such as *Phellinus chrysoloma*, *Phellinus nigrolimitatus* in living stock of observed plots, in comparison to the fallen stems.

6. Some recommendations for the forest management in previously managed forest from the point of view of fungal biodiversity and regeneration in fallen logs – concept of no interventions against intervention with the aim to diversification of the stand spatially and in age before stand disintegration to keep diversity and amount dead wood it these stands?

Author has fully demonstrated the prerequisite for the scientific work. Following formal aspects, submitted theses meets all the demands required on doctoral thesis.
I strongly recommend the PhD committee to allow the candidate admission to the formal PhD defense.

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