School of Doctoral Studies in Biological Sciences

University of South Bohemia in České Budějovice
Faculty of Science

Effects of management and natural disturbance on oribatid mites in montane forest

Ph.D. Thesis

Mgr. Jitka Farská

Supervisor: prof. RNDr. Josef Rusek, DrSc.

Biology Centre of the ASCR, Institute of Soil Biology, České Budějovice

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Annotation

The thesis studied effects of forest management and natural disturbance on oribatid mites in montane forests in South Bohemia (Czech Republic). We focused on the influence of (1) spruce monoculture establishment on the former beech forest, (2) management intensification in spruce forest and (3) forest dieback after bark-beetle outbreak. The impacts were pronounced especially like changes in species composition and distribution of functional traits.

Declaration [in Czech]

Prohlašuji, že svoji disertační práci jsem vypracoval samostatně pouze s použitím pramenů a literatury uvedených v seznamu citované literatury.

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Jitka Farská

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List of papers and author's contribution

The thesis is based on the following papers (listed chronologically):

I. **Farská, J.**, Prejzková, K., Rusek, J., 2013. Spruce monoculture establishment affects functional traits of soil microarthropod communities. Biologia 68, 479-486. (IF 0.506)
Jitka Farská participated in soil sampling and microarthropods extraction, determined oribatid mites, assembled and statistically analyzed all data, wrote the manuscript, and completed revisions.

II. **Farská, J.**, Prejzková, K., Rusek, J., 2014. Management intensity affects traits of soil microarthropodcommunity in montane spruce forest. Applied Soil Ecology 75, 71-79. (IF 2.106)
Jitka Farská participated in soil sampling, chemical analyses and microarthropods extraction, determined oribatid mites, assembled and statistically analyzed all data, wrote the manuscript, and completed revisions.

III. **Farská, J.**, Prejzková, K., Rusek, J. Soil microarthropods in non-intervention montane spruce forest regenerating after bark-beetle outbreak *(submitted to Ecological Research).*
Jitka Farská participated in soil sampling, chemical analyses and microarthropods extraction, determined oribatid mites, assembled and statistically analyzed all data, wrote the manuscript, and completed revisions.

Contents

1 General introduction

1.1 Montane forests, their management and natural regime

Without human pressure, the most of Central European mountain regions would be covered with beech (*Fagus sylvatica*) and spruce (*Picea abies*) forest. Due to intensive management and land use during the last centuries, the majority of the natural forest was removed to provide agricultural land or turned into coniferous monocultures. In the present day, these ecosystems, with their associated species, are one of the most endangered in the world (Bengtsson et al., 2000). For example, only 0.2 % of Central European deciduous forest is estimated to remain in a relatively natural state (Hannah et al., 1995). Similarly, only very small part of a montane spruce forest can be now considered like uninfluenced by human.

The forest management usually conducted in the Central Europe results in even-aged, even-spaced monocultures of conifers, especially Norway spruce, because this species is highly suitable for planting in regular stands and provides valuable timber. The management practices include treatments, like thinning, planting of seedlings or clear-cutting, which result in disturbance to the ecosystem.

To make forestry sustainable and maintain ecosystem functions and services, it is important to understand the impacts of these forestry practices on various components of the ecosystem. In addition, the study of natural processes and forest dynamics can help us to understand to responses of the ecosystem to disturbance (Marshall, 2000). This knowledge could help us to adapt the forestry techniques to mimic natural disturbance regime and enhance natural recovery processes.

Natural disturbances are one of key drivers of the forest dynamics, but their regime strongly differs between beech and spruce forests. The beech forest has a typical fine scale-level of disturbance with single or small-size windthrows (Šamonil et al., 2009). Conversely, the large-scale, high-severity events such as windstorms and insect outbreaks are of a great importance for structure and functioning of montane spruce forest (Svoboda et al., 2012).

The Šumava Mountains altogether with their surroundings represent great opportunity to study the effects of forest management as well as natural disturbance due to the high diversity and variability in the history of the stands. In lower altitude, we can find remains of old-growth beech forests surrounded with spruce cultures. The top part of the mountains constitutes one of the biggest forested areas in Central Europe and the history of its forests is shaped with big windstorms and following bark beetle (*Ips typographus*) outbreaks. The expansion of clear-cuttings started in the area in the 19th century and was supported with the large-scale windthrow and following bark beetle calamity in the 1860s and 1870s (Lysý, 1989). However, some parts of mountain spruce forest stayed undamaged and developed without silvicultural practises to the present. They are often established like nature reserves now.

In 1990s, large area of natural and semi-natural spruce forests suffered next bark beetle outbreak that killed almost all mature trees. The part of this area was left to regenerate naturally without salvage logging, because it is a part of core zone of the Šumava National Park where natural processes are supposed to govern a development.

1.2 Soil part of forest ecosystem

Forest management affects structure and function of the whole forest ecosystem. Although changes in the soil part of the ecosystem are not so obvious, they are of equal importance like aboveground changes. We can distinguish (1) effect caused by the change of tree species – in most cases replacement of deciduous tree (beech, oak) with conifers (spruce, pine) and (2) effect of forestry practices themselves (clear-cutting, planting, thinning etc). The impact of massive natural disturbance can have some common features with the management practices, but there are important differences as well.

1.2.1 Change in tree species

Spruce forest establishment is known to lead to organic matter accumulation, decreased pH and microbial activity, while increasing the C:N ratio (Mardulyn et al., 1993; Nihlgård, 1971; Scheu et al., 2003).

Beech and spruce litters differ in their chemical composition and decomposition rates (Albers et al., 2004); the decomposition in spruce forest is hindered by high content of phenolic compounds and low phosphorus and nitrogen availability (Šantrůčková et al., 2006).

The factors described above affect soil microbiota and microarthropods directly or indirectly. Although the microbial biomass in beech leaves exceeds that of spruce needles (Albers et al., 2004), it has been shown that spruce litter has a higher fungi-to-bacteria ratio than beech (Parkinson et al., 1978). Thus, the high amount of fungi colonising spruce litter could support fungivorous microarthropods such as oribatids.

This might explain why Oribatida generally tend to achieve higher numbers in coniferous forests than in deciduous ones (Arpin et al., 1986; Wallwork, 1983). In addition, oribatids may benefit from lower pH in spruce stands. Their densities were observed to increase with soil acidity (Hågvar and Amundsen, 1981). Soil acidification implies a decrease in litter decomposition rates (Ulrich, 1986) and may correlates with an accumulation of soil organic matter. A thick organic layer would increase habitat space for the soil fauna and the organic matter therein also serves as a food substrate. The accumulation of needles in various stage of decomposition provides a heterogeneous habitat that may host abundant microathropod community (Anderson, 1978; Sylvain and Buddle, 2010).

In terms of biodiversity, replacement of beech forest with spruce plantation is known to lead to a significant decrease of Collembola species richness in Pyrenees (Deharveng, 1996).

1.2.2 Forestry practices

Forestry practices simplify and unify the structure of forest floor, changes understory vegetation and nutrient fluxes in soil (Federer et al., 1989; Ferris et al., 2000; Grigal, 2000), and decreases the amount of dead wood (Fridman and Walheim, 2000). They usually result in disturbance to the system and affect its functioning.

For example, many studies showed that clear-cutting causes severe changes of whole ecosystem. The near-surface environment in large forest openings differs markedly from that of the forest interior. Large openings exhibit greater shortwave radiance, more extreme surface temperature, higher soil temperature, lower humidity and increased wind speeds (Carlsson and Groot, 1997; Hashimoto and Suzuki, 2004; Lee, 1978; Stoutjesdijk and Barkman, 1992; Chen et al., 1995).

Fundamental changes are not limited only to microclimate – leaf litter and woody debris input changes, as well as soil structure, moisture, nutrient fluxes or organic matter content. Soil porosity can decrease and large soil aggregates can become less stable (Perry et al., 1987). The organic matter on the soil surface is redistributed and the upper soil layers can be compacted (Marshall, 2000). Soil moisture can either increase (Herring, 1968) or decrease (Seastedt and Crossley, 1981). Some important nutrients, espacially nitrogen, often leach from clear-cutting soil and forest fertility is reduced (Paul and Clark, 1996). Amount of soil organic matter can decrease (Nourbakhsh, 2007), but it can also increase due to great input of woody debris and litter after clear-cutting (Seastedt and Crossley, 1981).

The contribution of litter types to the organic layer changes dramatically during a forest rotation. The first years after clear-cutting are characterized by the addition of large amounts of herbaceous components, whereas later in intermediate stages of the forest cycle, canopy closure leads to increasing input of fresh spruce litter and reduction of herbaceous understory (Chauvat et al., 2007).

The disturbances and changes described above influence soil microbiota and fauna and, concurrently, processes in which these organisms participate, such as decomposition or nitrogen cycling (Jones et al., 2003). Numbers of soil animals are generally reduced by clear-cutting, but data about some groups are somewhat contradictory (Marshall, 2000). In general, organisms associated with late-successional stages are negatively affected whereas pioneers are favoured (Aström, 2006). The total abundance and species diversity of higher taxonomic groups seem to be relatively resistant, but at the species level the effects on community structure are remarkable (Siira-Pietikainen et al., 2003).

Many studies showed clear-cutting decreased Oribatid mite abundance and altered their community structure (Blair and Crossley, 1988; Lindo and Wisser, 2004; Lóšková et al., 2013; Malmström et al., 2009). On the other hand, Hasegawa et al. (2013) found no effects on Oribatida total abundance after clear-cutting and the response seems to be dependent on local edaphic and climatic conditions. The decrease in abundance was ascribed to soil compaction (Lindo and Wisser, 2004), delayed development of fungi on the organic substrate (Huhta et al., 1967), elevated temperature and reduced soil moisture (Blair and Crossley, 1988) or limited food resources (Marshall, 2000). The important factor affecting the soil community after harvesting of forest can be elimination of root-mycorrhizal connections and decline of fungal community (Brant et al., 2006; Siira-Pietikäinen et al., 2001).

1.2.3 Natural disturbance

Although large-scale natural disturbance (in our case massive bark beetle outbreak) have some features common with the forestry practices (e.g. clear-cut), there are important differences as well. One of the common features is a detrimental impact on tree canopy. The tree crowns have a substantial influence on forest microclimate. They provide shadow, change the light climate, slow down the wind, moisten the air through evapotranspiration and decrease the temperature fluctuations. The study carried out in the Šumava National Park confirmed that forest dieback and creation of dried forest and openings led to a significant warming and decline in a wetness index in the Březník area (Hais and Pokorný, 2004).

Concurrently, it is important to stress that natural processes ongoing in the non-intervention forest mitigate the impact of the disturbance. The microclimate is generally less extreme in decayed spruce forest compared to clear-cut (Hais and Kučera, 2008; Hojdová et al., 2005), probably due to high reflectance of dead trees and high density of vegetation that may protect soil from drying and overheating. Furthermore, lying and standing dead trees result in a complicated microrelief with many shaded places.

The abundant dead wood is a substantial part of the dead forest ecosystem and fulfills important functions therein. It provides sheltered microsites protecting microbiota and microarthropods against desiccation, because soil beneath logs remains moist after the forest floor has dried (Jabin et al., 2004; Johnston and Crossley, 1993). The importance of these refugees probably increases during droughts and under other conditions of stress. Besides high amount of woody debris, the litter depth increases immediately after outbreak due to massive needle shedding. The subsequent decomposition of needles releases high amount of nutrients to soil (Kaňa et al., 2013).

Literature data about soil biota in forest naturally regenerating after this kind of disturbance are very scarce, although the knowledge of recovery mechanisms could be very useful to make conventional forestry practices less harmful to soil community.

1.3 Oribatid mites

In the study, I focused on Oribatida – the major group of soil microarthropods that is expected to be sensitive to the factors described above and plays an important role in ecosystem functioning. They are considered to be an efficient tool for biodiversity assessment and also an assessment of their functional and life-history traits seems to be really fruitful.

1.3.1 Importance in ecosystem

Oribatida are dominant microarthropods in many ecosystems (especially hardwood and coniferous forest). They often compose over 50 % of total microarthropods and their communities reach several hundreds of thousand individuals per square metre (Niedbala, 1980). Their role is especially important in northern forest ecosystems where larger soil macrofauna have a low density (Swift et al., 1979).

They have an important role in organic matter decomposition and nutrient cycling – two key processes of ecosystem functioning (Luxton, 1981) and are connected with primary decomposers through complex bottom-up and top-down effects (Marshall, 2000; Neher et al., 2012). The soil microbiota and fauna complement each other in the comminution of litter, and in mobilisation and immobilisation of nutrients within the soil system.

Detritivorous Oribatid mites with chelate mouthparts process a portion of the annual litter input converting detritus, litter and microbial biomass into smaller fragments and faeces (Kunst, 1968). For example, juveniles of Phthriacaridae family and *Adoristes ovatus* develop inside decomposing spruce needles (Edsberg and Hagvar, 1999). Thus, they make the interior of needles better accessible, create additional surface and modify substrates for continued microbial colonization. The conversion of organic matter into faecal pellets modifies the material, increases bacterial populations in the faeces and release products with a high concentration of nutrients (Norton, 1986; Rusek, 1986; Shaw and Pawluk, 1986; Teuben and Verhoef, 1992).

Different functions are fulfilled by fungivorous oribatids. In general, feeding on mycelium releases nutrients immobilised in long-living hyphae and enables their fast turnover in the ecosystem (Wallwork, 1983). On the other hand, some principles can slow down nutrient cycling. For example, *Tectocepheus velatus* is an opportunistic detrito-fungivore capable of ingesting plant material and contents of fungal cells (Siepel and de Ruiter-Dijkman, 1993). This species could inhibit decomposition by remaining nitrogen-rich cell walls and thus immobilisation of this important nutrient (Siira-Pietikainen et al., 2008). Besides the direct effect on nutrient cycles via grazing, microarthropods can influence composition of fungi community and contribute to maintenance of its diversity. The grazing on dominant fungi species *Marasmium androsaceus* enables other fungi to grow, because *M. androsaceus* is restricted to upper litter layer where the grazing pressure is low (Frankland, 1998).

1.3.2 Assessment of changes

Soil fauna constitute a huge, often disregarded, reservoir of biodiversity. Oribatids are highly diversified on a local scale and occur in high number of species and abundances. For these reasons they are considered to be an efficient tool for the evaluation of impact of environmental changes. Concurrently, they are very sensitive to changes in abiotic and biotic conditions (Niedbala, 1980) and are not able to escape unfavorable conditions due to their limited long-distance dispersal (Ojala and Huhta, 2001). Oribatids are suitable indicators of historic processes (Borcard et al., 1995), because the changes in their communities can stay pronounced for a long time. They are generally slowly recovering part of an ecosystem (Lindberg and Bengtsson, 2006) due to their low mobility (Ojala and Huhta, 2001) and small reproduction capacity of some species (Dindal, 1990).

In general, a response of the community to changes can be described in terms of abundance, diversity and species composition. The studies by Lindberg and Bengtsson (2006) and Siira-Pietikainen et al. (2003) showed the only measurement of total abundance was not sufficient to evaluate the recovery of community and its response to environmental changes or disturbance. Although the total abundance of higher taxonomic groups can show no effect, the species richness, diversity and community composition are often affected or recover more slowly. Thus, the detailed determination to the species level and a proper evaluation of changes in community is necessary.

In addition to this taxonomic approach, the asssessment of functional traits seems to be a sensitive indicator of community change and suitable in revealing and explaining underlying mechanisms. The functional trait approach is more focused on interactions and processes facilitating the identification of general patterns and the synthesis of interdisciplinary knowledge (Makkonen et al., 2011; Vandewalle et al., 2010).

In the study, I focused on morphological and life-history traits (sensu Violle et al., 2007; ‘feeding’, ‘reproduction’, ’body size’) that might provide insight into the roles in ecosystem functioning that the microarthropods fulfill, and into the physiological or morphological mechanisms that are responsible for species fitness and occurrence.

The changes in the contribution of feeding guilds might indicate changes in the functioning of the ecosystem. The various feeding groups differ in food components that are able to digest and, thus, play different roles in decomposition. Predominantly detritivorous species have strong chelicers capable of litter fragmenting and can breakdown cellulose in plant tissues. On the contrary, fungivores specialized in a digestion of fungal hyfae have chitinase and trehalase enzymes (Siepel and de Ruiter-Dijkman, 1993).

Reproductive strategies are probably important factor affecting the survival of soil microarthropods and their colonisation after disturbances (Prinzing et al., 2002). The reproduction relates with the establishment of population or genetic diversity.

Body size relates to vertical distribution in the soil and to dispersal ability and both these characteristics were found to be of great importance in the recovery processes (Malmström, 2012; Lindberg and Bengtsson, 2006).

Besides the traits mentioned above, there are naturally many other characteristics affecting the composition and functioning of oribatid community. Unfortunately, detailed information was not available for most of the species found and therefore they could not be involved into the study.

2 Aims and hypotheses

The general aim of the thesis was to describe the effects of management and natural disturbance on oribatid mites in montane forests, in terms of their abundance, diversity, species composition and functional traits.

The management effects contained the impact of (1) spruce monoculture establishment on former beech stand and (2) overall management intensification in spruce forest. In addition, the study focused on oribatids in a dead forest naturally regenerating after bark beetle outbreak.

Specific hypotheses:

(h1) replacement of beech forest with spruce increases Oribatida abundance and decreases their diversity

(h2) replacement of beech forest with spruce shifts species composition towards detritivorous, parthenogenetic oribatids resistant to disturbance

(h3) management intensity in spruce forest does not affect Oribatida abundance, but decreases the diversity

(h4) with management intensification in spruce forest, the species composition changes towards detritivorous, parthenogenetic species

(h5) the community in naturally disturbed forest is dominated by a few disturbance-tolerant, opportunistic, detritivorous species

3 Summary of results

The thesis is based on three papers. Paper 1 deals with the replacement of natural beech forest with spruce monoculture (**hypotheses 1 and 2**). Paper 2 evaluates the impact of management intensification in spruce forest (**hypotheses 3 and 4**) and Paper 3 describes oribatid community in the naturally disturbed spruce forest (**hypothesis 5**).

Paper 1

Spruce monoculture establishment affects functional traits of soil microarthropod communities.

This paper aimed to study the effect of the spruce monoculture establishment on a former beech stand on a case study from the Kleť Mt. We contrasted structure and density of Oribatida communities in a natural beech forest (Kleť Nature Reserve) and a nearby spruce artificial forest. The spruce monoculture establishment increased oribatid densities significantly. Additionally, it changed greatly the community structure in terms of species composition and functional traits. In the spruce monoculture, groups susceptible to disturbance were suppressed whereas *Tectocepheus velatus* increased. The trophic structure changed as well with opportunistic detritofungivorous species increasing in the monoculture at the expense of fungivorous species. Conversely, no significant differences were recorded in the occurrence of sexual vs. parthenogenetic species and the effect on diversity indices was ambiguous.

Paper 2

Management intensity affects traits of soil microarthropod community in montane spruce forest.

This study examined the influence of forest management intensity on oribatids in montane spruce forest in Šumava Mts. The comparison of the communities in unmanaged, mild managed and intensively managed spruce stands showed remarkable changes accompanying management intensification. There were significant shifts (1) from fungivory and carnivory to detritivory and (2) to parthenogenesis in intensively managed forests. Although there was no remarkable influence of management intensity on total densities or diversity indices, the shifts in species composition and functional groups suggested that soil functions and processes were affected by forest management. Trait assessment indicated a shift in roles Oribatida play in decomposition; fragmentation and comminuting of undecomposed litter seems to gain importance in the intensively managed forest, whereas fungivorous species affect primary decomposers through feeding on mycelium in the unmanaged forest.

Paper 3

Soil microarthropods in non-intervention montane spruce forest regenerating after bark-beetle outbreak.

The last chapter describes Oribatid community that suffered massive natural disturbance and now is regenerating without human intervention. The study was carried out in an old-growth Norway spruce forest that gradually decayed after a massive bark beetle (*Ips typographus*) outbreak and until now was left to regenerate naturally.

Our results indicate that the disturbance caused important changes and the soil functions connected with Oribatida seem to be still affected by the bark beetle outbreak. Trait assessment showed an overall predominance of parthenogenesis and high abundance of detritivorous oribatids. High abundance of detritivores differs remarkably from the situation in undisturbed, old-growth forest. The species composition with the most dominant species *Tectocepheus velatus* and *Platynothrus peltifer* seems to confirm that disturbance decreases the abundance of sensitive species and thus allows an increase in a few opportunistic ones. Although the details, which determine the identity of successful species, remain unknown, parthenogenesis, high reproduction rate and detrito- or detritofungivorous feeding were the common features of the most dominant species in our study.

Nevertheless, the occurrence of sensitive sylvicolous species suggests that the ecosystem has a potential to recover. The impact of disturbance was likely mitigated by forest regeneration and natural processes ongoing in non-intervention regime (abundant dead wood, complicated microrelief with sheltered microhabitats etc.)

4 Conclusions and future prospect

The effects of forest management and natural disturbance on oribatid mites were examined in this thesis. We used various aspects and approaches to describe the changes in Oribatida community. Besides the traditional assessment (total abundance, diversity indices and species composition), we focused also on functional traits. The combination of both these approaches enabled us to study the processes in more detail and, concurrently, in a broader ecological context. This last chapter will try to generalize and summarize the results obtained.

The replacement of beech forest with spruce monoculture impacted soil ecosystem more seriously than only management intensification itself. It changed not only species composition and distribution of functional traits, but also increased remarkably Oribatida abundance and affected soil chemistry. Although the impact on density can be negative in short-time, e.g. immediately after clear cutting (Blair and Crossley, 1988; Lindo and Visser, 2004; Lóšková et al., 2013); in long-term, we found that the change to coniferous forest increased total numbers of Oribatida. The high Oribatida abundance can be caused by lower pH (Hågvar and Amundsen, 1981), higher fungi-to-bacteria ratio (Parkinson et al., 1978) or accumulation of litter providing heterogeneous habitat in spruce forest (Sylvain and Buddle, 2010).

In both studied cases of forest management, we found similar changes in species composition and functional trait distribution. Athough these changes were not accompanied by remarkable effects on species diversity, they indicated shift in functioning of the community and negative impact on its vulnerable components. Moreover, the changes in Oribatida community probably reflect and relate to processes in other parts of ecosystem (especially fungi and bacteria, but other abiotic and biotic components as well).

Thus, the recorded significant shift from fungivory to detritivory/detritofungivory accompanying forest management might suggest a shift in ecosystem functioning and in the roles that Oribatida fulfill. In the managed forest, the fragmentation and comminuting of litter into smaller fragments and faeces seems to gain importance at the expense of effects through primary decomposers. The high dominance of detritivores and detrivofungivores might indicate an accumulation of recalcitrant organic matter providing a favorable food resource and habitat. The Oribatids could hypothetically represent a self-regulating negative feedback in the decomposer system. The high amount of suitable food source – undecomposed litter – could increase the abundance of detritivorous microarthropods and, consequently, these microarthropods would fragmentate the litter and, thus, enhance its decomposition. The accumulation of needle litter was often described in spruce plantations (Cassagne et al., 2004; Gauquelin et al., 1996; Nihlgard, 1971) and was usually accompanied by a decrease in pH, moisture and cation content (K, Ca, Mg), but the detailed insight into processes connected with primary decomposers and microarthropods in these stands needs additional studies.

The results about reproduction mode are not so straightforward. Despite high contribution of parthenogenetic species in the intensely managed spruce forest (Paper 2), no difference was recorded between beech forest and spruce monoculture (Paper 1). Data in the literature are similarly contradictory. On the one hand, parthenogenetic species were found to recover quickly after drought (Lindberg and Bengtsson, 2005) and Norton (1994) assumes parthenogenesis to be an advantageous trait for colonizers, because parthenogenetic species can reproduce faster and establish a population from very few individuals. Conversely, sexually reproducing microarthropods were faster to recolonize soil in a mesocosm experiment (Domes et al., 2007) and quickly increased their numbers several years after clear-cut burning (Malmström, 2012). The theory by Hamilton (1980) predicts sexual reproduction to be superior to parthenogenesis in unstable habitats because high genetic diversity allows for a faster response to a changing environment. This ambiguousness in results is probably caused by the high heterogeneity of life-history tactics within parthenogenetic species. They can be either fast-reproducing and disturbance tolerant (e.g. *Tectocepheus velatus*) or euedaphic, small-size and K-strategic species (e.g. Brachychthonidae) (Maraun and Scheu, 2000).

In terms of species composition, the most obvious feature was high dominance of *Tectocepheus velatus* in managed and disturbed forests. This ubiquitous species is tolerant to disturbance (Maraun et al., 2003) and is able to dominate under conditions of strong anthropogenic stress when sensitive species are suppressed. It typically occurs at high abundance in habitats like arable soil and colliery dumps (Frouz et al., 2001; Luptáčik et al., 2012). On contrary, species such as Suctobelbidae or *Lauroppia neerlandica* occurred more in unmanaged forest and were negatively affected by the management.

The species composition naturally corresponds with the distribution of functional traits. The "functional approach", moreover, has an advantage that allows to identify the general patterns and to transfer information on the whole-community level. It is a promising novelty that began to be more widely used in last years (e.g. Makkonen et al., 2011; Malmström, 2012; Karasawa and Hiiji, 2008). Nevertheless, its utilization is necessarily dependent on availability of detailed information about species. Lacking data for many characteristics even for widespread species constitute serious limitation for this assessment. Moreover, the results obtained by different techniques can differ considerably. For example, feeding or trophic position can be examined with food-choice experiments, gut content analyses, stable isotope ratios, cheliceral morphology or enzymatic capabilities and the synthesis of knowledge is necessary. Next problem is that certain features are phylogenetically correlated and combined in the same species, therefore their separation is difficult.

For further understanding of changes in Oribatida community and their relationship with other parts of soil ecosystem many questions still need to be adressed. How are fungi and bacteria affected? What determine the identity of successful Oribatida species? Are the changes caused by previous disturbance or by change in environmental conditions? Especially, the study of the recovery ongoing on non-intervention sites could provide interesting information about natural processes therein. For example, the dead wood is known to be important for spruce seedlings (Jonášová and Prach, 2004) and it could serve like a sheltered source for colonization.

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RESEARCH ARTICLES

PAPER 1

Spruce monoculture establishment affects functional traits of soil microarthropod communities.

Farská, J., Prejzková, K., Rusek, J. (2013)

Biologia 68, 479-486

Abstract

Structure and density of soil microarthropod communities (Oribatida and Collembola) were studied in one natural beech forest and one spruce monoculture planted on a former beech stand in South Bohemia (Czech Republic). The spruce monoculture establishment increased microarthropod densities (93 000 ind m^{-2} in the natural beech forest vs. 400 540 ind m^{-2} in the spruce monoculture for Oribatida; 66 360 ind m^{-2} in the natural beech forest vs. 136 360 ind m^{-2} in the spruce monoculture for Collembola); additionally, it changed greatly the community structure in terms of species composition and functional traits. In the spruce monoculture, groups susceptible to disturbance were suppressed. The oribatid trophic structure changed as well with opportunistic herbifungivorous species increasing in the monoculture at the expense of fungivorous species. Similarly, hemiedaphic collembolans increased in the monoculture at the expense of euedaphic species. We conclude that the "functional approach" seems to be fruitful in revealing soil fauna response to environmental change.

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PAPER 2

Management intensity affects traits of soil microarthropod community in montane spruce forest.

Farská, J., Prejzková, K., Rusek, J. (2014)

Applied Soil Ecology 75, 71-79

Abstract

This study examined the influence of forest management intensity (3 unmanaged, 3 mild managed, 5 intensively managed stands) on soil microarthropods in montane spruce forest. We particularly focused on Oribatida and Collembola which play important roles in organic matter decomposition and nutrient cycling. Our results showed a significant shift from fungivory and carnivory to detritivory in the Oribatida community accompanying management intensification. Similarly, parthenogenetic oribatid mite species contributed more to the community in intensively managed forests and the presence of Collembola species with developed furca increased with management intensification. Although there was no remarkable influence of management intensity on total densities or diversity indices, important and significant shifts in species composition and functional groups showed that soil functions and processes were affected by forest management. Trait assessment indicates a shift in roles Oribatida play in decomposition; fragmentation and comminuting of undecomposed litter seems to gain importance in the intensively managed forest, whereas fungivorous species affect primary decomposers through feeding on fungi in the unmanaged forest.

PAPER 3

Soil microarthropods in non-intervention montane spruce forest regenerating after bark-beetle outbreak.

Farská, J., Prejzková, K., Rusek, J.

submitted to Ecological Research

Abstract

We studied Oribatida and Collembola in an old-growth Norway spruce (*Picea abies*) forest that suffered a massive bark beetle (*Ips typographus*) outbreak in the 1990s and gradually decayed. It was left to regenerate naturally without human intervention. There was a high abundance of a few tolerant species and lower numbers of sensitive silvicolous ones. The most dominant species were *Tectocepheus velatus, Platynothrus peltifer* and *Isotomiella minor.* Although the details, which determine the identity of successful species, remain unknown, parthenogenesis, high reproduction rate and detrito- or detritofungivorous feeding were the common features of the most dominant species in our study. Trait assessment showed an overall predominance of parthenogenesis and high abundance of detritivorous oribatids. The soil functions connected with Oribatida and Collembola seem to be still affected by the bark-beetle outbreak and our results indicate that the disturbance caused important changes in the functioning of the whole soil ecosystem.

jijiji@seznam.cz

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University of South Bohemia in České Budějovice
Faculty of Science
Branišovská 31
CZ-37005 České Budějovice, Czech Republic

Phone: +420 387 772 244
www.prf.jcu.cz, e-mail: sekret@prf.jcu.cz