

# Selected aspects of ant ecology (Hymenoptera: Formicidae) in the conditions of seminatural grasslands of Slovakia

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**Abstract:** We refer on the impact of selected management practices and management cessation on ant communities in sub-montane cultural landscape in Slovakia. The research was performed in six different regions with special focus on secondary succession of semi-natural grasslands. We recorded specific response of ant assemblages to changes mediated by management cessation. Particular successional stages were inhabited by distinct ant assemblages when compared with actively managed grasslands, nevertheless the species diversity and number of specialized grassland species was higher in abandoned grasslands. The shrub encroachment allowed for coexistence of grassland and forest species and vital assemblages of original grassland ants persisted even at highly encroached grassland habitats. The ant assemblages of intensively managed grasslands were typical by the dominance of euryvalent and synanthropic species, which tend to be replaced by oligotopic grassland specialists in later successional stages. Nevertheless, these assemblages were relatively stable and showed no significant compositional changes even five years after management cessation and approximately 5% of shrub encroachment development. These results suggest high natural value of early and medium successional stages of abandoned grassland and relatively high stability of ant assemblages during early phase of secondary succession, with implications for restoration ecology of grassland habitats.

**Key words:** permanent grassland, secondary succession, biodiversity, management, cessation

## Introduction

Ants, in the environment of temperate permanent grassland, represent a very important group of insects in the term of their biomass, abundance and general distribution. They provide whole scale of ecosystem services (Del Toro et al. 2012) and have the function of ecosystem engineers (Folgarait 1998, Jouquet al. 2006). They are a part of a broad array of ecological relationships with plants and animals (Žďárek 2013), actively modify the course of secondary succession (Vlasáková et al. 2009), and have profound effect on physical and chemical properties of soil (Eldridge 1994, Frouz et al. 2003). Ants are used as bio-indicator organisms on a global scale, mainly in the assessment of ecosystem state and change (King et al. 1998, Peck et al. 1998, Perfecto & Vandermeer 2002, Wiezik et al. 2013).

The land-use change and particular management practices significantly influence the ecosystem structure and dynamics, and usually alter the diversity and structure of

biological communities (Wiezik et al. 2007, Halpern et al. 2012). Permanent semi-natural grasslands, traditionally managed in the form of extensive pastures and meadows, are regarded as one of the most important and at the same time the most endangered ecosystems in Europe (Knops et al. 1999, Dengler 2005, Habel et al. 2013). The maintaining of traditional management is crucial for preservation of these habitats. Such management creates high ecosystem heterogeneity with specific microhabitat features such as bare soil, rocks, grass tussocks and differentiated vegetation. Spatial and functional heterogeneity allows for high biodiversity; however both intensive management and its cessation dramatically reduce these features. Degradation of grassland ecosystems connected with the loss of biodiversity has been documented across whole Europe during last decades (van Dijk 1991, Habel et al. 2013).

Degradation mechanisms differ significantly between management practices. In the case of intensively managed grasslands the loss of biodiversity is caused by increased environmental disturbance, which exceeds the potential ecological valence of susceptible species. In Europe, typical activities of such management incorporate increased use of artificial fertilizers, intensive cutting and grazing, use of pesticides (Plantureux et al. 2005), and the introduction of tillage (Morris 2000). As a consequence, plant communities usually become simplified, dominated by fast-growing and competitive graminaceous species. Subsequently, the loss of diversity in many groups of sensitive organism, such as birds (Vickery et al. 2001) and insects (Morris 2000), is usually inevitable.

On the other hand, the cessation of management after abandonment of permanent grassland is connected with secondary succession, alternation of plant communities and shrub encroachment of the original grassland area. These processes alter the structure and dynamics of above-ground biomass, plant production and micro-climate conditions. Usually the soil exposure to sun light is dramatically reduced and the availability of water and nutrition is significantly altered. These changes strongly impact the original grassland plant and animal communities, adapted to environmental conditions of open grassland habitat (Reich et al. 2001, Mitlacher et al. 2002, Dierschke 2006, Van Auken 2009).

The response of grassland community on successional processes is related to the level of encroachments. The effect of shrub encroachment differs significantly between particular stages, but especially in early stages it may have positive effect on grassland community (Wiezik et al. 2013). Low and medium shrub encroachments may increase spatial heterogeneity and structural complexity of grassland habitat and positively affect the diversity of grassland communities (Duelli 1997, Reyes-López et al. 2003, Bestelmeyer 2005). This effect is especially pronounced in invertebrates, which count for major portion of grassland biodiversity (Morris 2000). Regarding enormous species diversity and substantial ecological specialization of particular species, specific and regionally conditioned response of communities is assumed (Bestelmeyer & Wiens 2001).

In the European region the effect of secondary succession on ants was assessed mainly in the Mediterranean within a relatively broad successional gradient (e. g. Gómez et al. 2003, Reyes-López et al. 2003, Ottonetti et al. 2006). In Central Europe such studies were rarely published (Gallé 1991, Dauber & Simmering 2006, Dekoninck et al. 2007). Only recently this issue was assessed also in Slovakia (Wieziková et al. 2010, Wiezik et al. 2010, 2011, 2013).

In this paper we review several studies we have conducted in the field of grassland ant ecology, with emphasis put on the effect of conventional cutting practices and cessa-

tion of this management form on ant assemblages. We also assess the long term effect of grassland abandonment on ant assemblages.

## **Materials and Methods**

During the period of 2008 – 2014 we conducted a series of ecological researches encompassing grassland habitats in six different orographic units in Slovakia (e. g. Štiavnické vrchy Hills, Kremnické vrchy Hills, Strážovské vrchy Hills, Zvolenská kotlina Basin, Turčianska kotlina Basin and Revúcka vrchovina Hills). These regions were chosen to span a range of environmental conditions characteristic of submontane landscapes of western Carpathians. In all units we selected seminatural grassland habitats and addressed several ecological issues connected with the effect of management and its cessation on ground-foraging ant assemblages. Altogether 74 individual grassland sites were part of the research. We used pitfall traps for sampling ants in all studies; for detailed information on study designs see Wiezik et al. (2011, 2013). The succession of ant communities in these studies was assessed by simultaneous comparisons of different successional stages, so called SFT approach (Space for Time substitution, sensu Pickett 1989).

In 2010 we established a permanent study plot within mesic cultivated grassland in Kremnické vrchy Hills in order to investigate the long-term effect of grassland abandonment on ant assemblages. In this plot we placed 45 pitfall traps which operate monthly during a period of 100 hours, during the whole growing season spanning from April to October each year. The design of the study allows for detailed evaluation of shrub encroachment in the vicinity of each trap and for long-term assessments of composition and seasonal dynamics of ant assemblages. In 2014 we obtained five seasons of continuous measurements, which are reviewed in this paper.

## **Results and Discussion**

From 74 individual grassland sites we sampled altogether 35 822 workers of ants belonging to 46 different species and 4 subfamilies (Wieziková et al. 2010, Wiezik et al. 2010, 2011, 2013, Wieziková & Wiezik *in prep.*)

### ***Effect of management***

In our study of managed grasslands and early succession stages of abandoned grassland habitats in Štiavnické vrchy Hills (Wieziková et al. 2010, Wiezik et al. 2011), management in the form of intensive cutting had a significant effect on total epigeaic activity and total species richness of ants. Recently abandoned grassland sites were more species rich and the epigeaic activity of ants there was greater than in annually managed grasslands. This trend was even more pronounced for the Opportunist functional group, which had a six times higher average activity and two times higher average species richness at abandoned sites. Neither of these characteristics was significantly affected by moisture. Habitat moisture, however, was shown to affect species composition. These results were further corroborated by our broad-scale research of successional stages (Wiezik et al. 2013). Across all four regions, the abandoned grassland in early successional stages had higher species richness (although not significantly so) compared to managed grasslands.

Management is recognized as vital for preserving the open structure of grassland habitat, nevertheless for ants it represents main disturbance factor, i. e. the removal of biomass (Andersen 2000). Its effect may be direct (mortality of ants, destruction of ant-hills) or indirect (removing of vegetation and prey), in both cases it concludes in decreased abundance of particular species. As a consequence, only resistant species of ants may benefit from such disturbance regime, forming distinct communities usually dominated by euryvalent or synanthropic species like *Lasius niger* and *Myrmica rugulosa* (Wiezik et al. 2013). Intensively cut meadows hence differ significantly from abandoned grasslands which are inhabited by specialized grassland communities of oligotopic ant species (Wiezik et al. 2011, 2013).

### *Ants of grassland successional stages*

We compared ant assemblages in a chronosequence of managed grasslands and three different grassland successional stages, which were selected on the base of the level of shrub encroachment (Wiezik et al. 2013). As mentioned before, the managed grasslands differed in their composition from early successional and all other stages. The differentiation was highest in the late successional stage with shrub encroachments exceeding 50% of the original grassland area. The assemblage in this stage was formed by oligotopic grassland ant species, which were characteristic also for low and medium encroachment level, moreover the copious shrub encroachment allowed for establishment of populations of several forest species like *Temnothorax crassispinus* and *Stenamma debile*. Hence, the late successional stage was the only stage with significantly higher species richness compared to managed grassland. Several studies in shrub-encroached grassland indicated that the response of fauna to shrub encroachment might be both positive and negative (Rosenstock & van Riper 2001, Blaum et al. 2009, Rodhouse et al. 2010). Quite interestingly, this phenomenon might be as well pronounced in forest habitats (Hradsky et al. 2015).

We have observed differences also between particular encroachment stages. *Formica pratensis* was indicator species of early successional stage. While being absent from managed grasslands, its activity and frequency decreased in later successional stages. Similar trend was apparent also in other grassland species like *Lasius psammophilus*, *Formica rufibarbis* and *F. cunicularia*. On the other hand, species like *Myrmica sabuleti* were recorded in higher frequencies and activities from the later stages.

Abandoned grasslands can play a crucial role for the preservation of temperate grassland ant communities in Central Europe (see also Wiezik et al. 2011). However, the challenge in using abandoned grasslands for the conservation of grassland ant species remains in the need to limit the natural woody plant encroachment to relatively low levels. Prolonged periods of unchecked woody species colonization of grasslands are likely to lead to the conversion of the original grassland ant community to community dominated by forest ants (Gómez et al. 2003). Thus, while land abandonment favors grassland ants, it is the early shrub encroachment stage that offers the best conservation potential for grassland ant species (Decaëns et al. 1998). It remains unclear what level of shrub encroachment may trigger such conversion; in our case even densely encroached habitats were able to sustain viable populations of grassland ants. Nevertheless, we suggest limiting the woody plant encroachment to relatively low levels of 20% (Dahms et al. 2010).

### *Succession of ants in early successional stages*

After establishment of permanent research plot in 2010 in the Kremnické vrchy Hills, the grassland habitat was virtually free of any former disturbance including the grazing of wild ungulates. The secondary succession and consequent shrub encroachment was relatively rapid. Already in the first year of management cessation, we identified several individuals of woody species (Fig. 1), after five consecutive growing seasons the shrub encroachments covered 5% of the original grassland area, what corresponded with early successional stages in former study (Wiezik et al. 2013).

Using 45 individual pitfall traps we sampled altogether 19 879 workers of ants, belonging to 15 species. The original ant community was typical by profound dominance of *Lasius niger*, which is a typical species of actively managed grassland habitats in Slovakia (Wiezik et al. 2013). It counted for almost 94% of total sampled workers. Nevertheless, it was accompanied by relatively rich assemblage of grassland species, forming a diverse community. The seasonal species richness peaked at 8 – 9 species (Fig. 2).

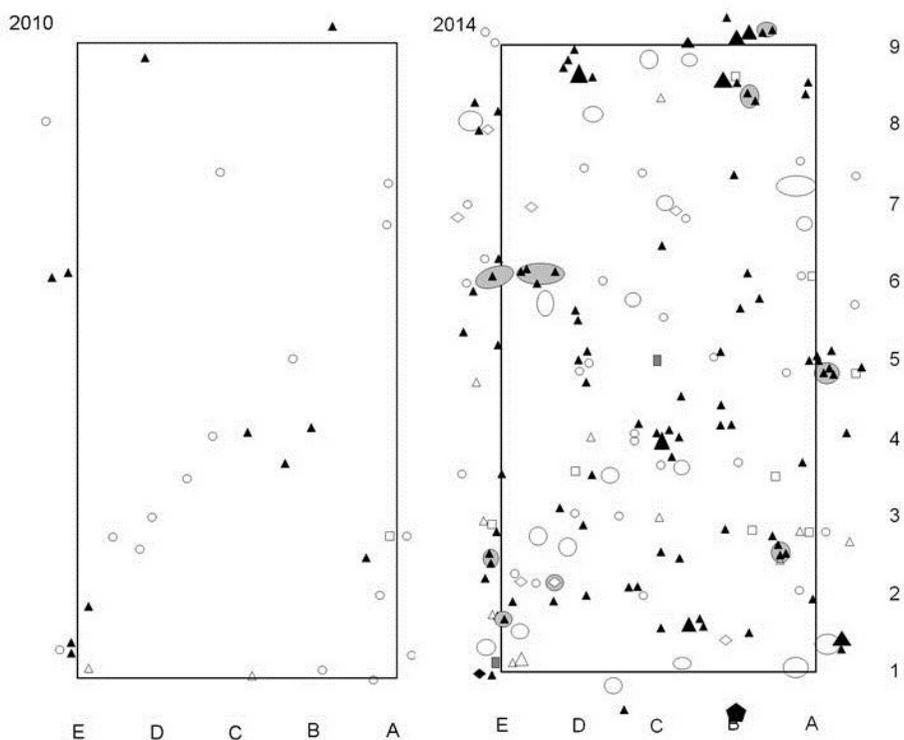


Figure 1. Shrub encroachment at 25 x 45 m grassland area in 2010 and 2014. Depicted is localization and extend of shrub individuals. Individual woody species are depicted as follows: *Rosa canina* – plain circle, *Prunus spinosa* – black triangle, *Pyrus pyraster* – plain square, *Carpinus betulus* – plain diamond, *Malus* sp. – plain triangle, *Crataegus* sp. – black pentagon, *Acer campestre* – grey rectangle. Encroachments exceeding 1m<sup>2</sup> are represented by larger symbol. Pitfall traps were placed in the grid transections marked by numbers (1 – 9) and letters (A – E).

Regardless of the rapid shrub encroachments at the research plot, the composition of ants remained virtually the same during whole period. We didn't observe any alternations in relative proportion of ants, beside certain drop in abundance of several subdominant species during the period of 2013 – 2014.

According to the level of shrub encroachment the habitat fits into the class of early successional stage. In the previous study (Wiezik et al. 2013) such stage was characteristic by distinct ant community, with typical presence of *Formica pratensis*. We anticipated similar pattern also in this study, however couldn't confirm the establishment of its colony during the first five years. We recorded only a single worker of *F. pratensis* in 2013. It is hence questionable, whether the chronosequence pattern observed across different regions will occur also in this particular case, or whether the course of secondary succession may be different based on differences in habitat conditions (such as soil humidity and slope orientation) or absence of natural disturbance regime. Regardless of the specifications of actual development, long-term assessments of ant succession are very rare in European region (Gallé 1981). Hence our study will play an important role in addressing this issue and clarifying several questions about the succession of ant communities in abandoned grassland habitats.

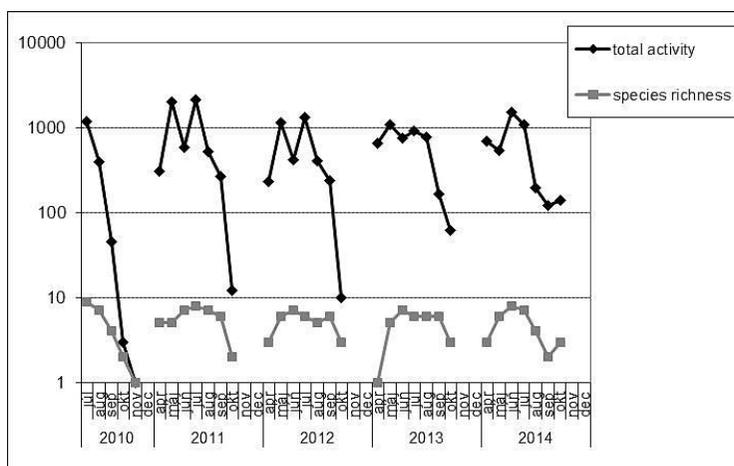


Figure 2. Total epigeic activity and species richness of ants during 2010 – 2014 growing seasons at abandoned mesic grassland, Kremnické vrchy Hills, Central Slovakia.

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