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Effects of vegetation management by mowing on ground-dwelling arthropods

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ABSTRACT

Species-rich grasslands are rare in the Netherlands and need consistent vegetation management to retain their characteristic biodiversity. Roadside verges are important refuges for grassland plants since the mowing management no longer aims at traffic safety only but also strives for botanical diversity. Although arthropods are highly abundant in roadside verges, the effect of different mowing practices on this group is largely unknown. During 4 years, we studied ground beetles, weevils, ants and ground-dwelling spiders with pitfall traps in experimental plots in roadside verges with five different mowing treatments: (i) no management, (ii) and (iii) mowing once a year with and without hay removal, (iv) and (v) mowing twice a year with and without hay removal. This was done in a plant productivity gradient; the experiment was repeated in low-, medium- and high-productive verges. In the low-productive site, the effect of management on the arthropods only existed in a higher abundance in plots mown twice per year with hay removal. In the medium- and high-productive sites, mowing twice a year with hay removal resulted not only in highest abundances but also in highest arthropod species richness. Mowing twice without hay removal and mowing once with removal showed intermediate values, while mowing once per year without removal and particularly the absence of management resulted in low diversity and low abundance. To promote ground-dwelling arthropods in medium-to-high-productive grassland verges, we recommend a management of mowing twice a year with the removal of hay. It is reasoned that some form of rotational management, aiming at leaving some vegetation refuges intact after mowing events, may further promote arthropod survival. However, caution should be taken that these refuges are not too large, as overall suitability for ground-dwelling arthropod decreases rapidly in such patches. Out of several studied vegetation characteristics, the number of flowering plant species (medium-productive verge) and total flower abundance (high-productive verge) appeared to represent suitable, and easily monitored, proxies that significantly mirror arthropod diversity.

1. Introduction

Grasslands can be species-rich ecosystems harbouring plant and animal communities of considerable nature conservation interest. Since in the Netherlands, grassland consists of plagioclimax vegetation, it must be managed to preserve its specific character and species composition (e.g., Bakker, 1989; Dolek and Geyer, 2002; Barbaro et al., 2004; Baur et al., 2007; Dekoninck et al., 2007; Kampmann et al., 2008; Rudmann-Maurera et al., 2008). In Western Europe, semi-natural grassland vegetation almost exclusively originates from some form of agricultural land-use, i.e., grazing or hay production. These grasslands are rapidly degrading in ecological quality as traditional land-use is replaced by more intensive forms of agricultural practices (Robinson and Sutherland, 2002; Schmitt and Rákosy, 2007; Dostálek and Frantík, 2008) or as these lands are abandoned, resulting in succession to vegetation types with shrub and tree dominance (Morris et al., 1994; Pärtela et al., 1998; Schneider and Fry, 2005; Öckinger et al., 2006; Wenzel et al., 2006; Marini et al., 2008).

In the Netherlands, the biodiversity situation is critical; about two-thirds of the land surface is covered with intensive agricultural areas. In these areas, species richness is low and many species are restricted to river dikes and verges of roads, railways and water courses, provided these are properly managed (Sýkora et al., 1993; Liebrand and Sýkora, 1996; Noordijk et al., 2009a,b). Unquestionably, roads have many negative effects on ecological processes (see reviews in Forman et al., 2002; Spellerberg, 2002). On the other hand, roadside verges in the Netherlands occupy a vast area stretching for 80,000 km (not considering roads in urban areas) and, together with dikes, comprise the largest area of species-rich

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grasslands. Sýkora et al. (1993, 2002) and Schaffers (2000) provide detailed overviews of the grassland plant communities occurring in Dutch roadside verges. These grassland verges not only act as refuges for many species, but due to their linear outline they may also function as corridors in the highly fragmented landscape of the Netherlands (see also Vermeulen, 1994; Tikka et al., 2001; Karim and Mallik, 2008; Noordijk, 2009).

Grassy roadside verges are generally managed by mowing, not only to secure traffic safety, but also to maintain high plant diversity. A lack of biomass removal rapidly leads to a change in plant composition, and generally a decrease in species richness (Bobbink et al., 1998; Schaffers et al., 1998; Piesschaert et al., 2005). This is mainly caused by the high atmospheric nitrogen deposition in the Netherlands. Although the effects of mowing management are well studied for plant species composition and diversity, effects on arthropods are insufficiently known (WallisDeVries et al., 2002; Dennis et al., 2007). More insight is urgently needed to be able to formulate guidelines for the conservation and management of arthropods, also since there are indications that they are more vulnerable and have a higher rate of extinction compared to other groups of organisms (Thomas and Morris, 1994; Thomas et al., 2004).

It is impossible to study all arthropod groups in one research project, as arthropods are very rich in species, with a myriad of different life strategies and niches (Morris, 1981; New, 1995; Di Giulio et al., 2001; Samways, 2005). In this paper, we study the effects of mowing management on the diversity and abundance of four arthropod groups mainly with a ground-dwelling way of (adult) life: spiders (predators), ground beetles (predators and omnivores), ants (predators and omnivores) and weevils (specialised herbivores). These groups are rich in species and involve different feeding guilds and life-history traits. During 4 years, we studied the effects of five grassland management treatments in experimental plots on the arthropod groups mentioned, as well as on changes in vegetation characteristics.

2. Materials and methods

2.1. Study sites and experimental design

The experiment was conducted in three highway verges, reflecting a gradient in nutrient-richness of the soil (Fig. 1). The three sites will be referred to in this paper as 'low-productive', 'medium-productive', and 'high-productive'. The low-productive site is located on a sand and gravel body next to highway A15 in the east of the Netherlands (Province of Gelderland close to the town Bemmel, 51°54′N–5°54′E). The sand-body was intended for future widening of the road and this location harbours scarce vegetation of the *Festuca ovina* subsp. *cinerea* type [*Trifolio-Festucetalia ovinae*]. Plant biomass production is very low: around 80 g/m^2 per year (measured in mid-September). The medium-productive verge is located on a lime-rich soil alongside highway A76 in the most southern region of the Netherlands (Province of Limburg, close to the city Heerlen, 50°51′N–5°57′E). The vegetation consists of a species-rich hay-meadow *Arrhenatheretum elatioris*, with a plant biomass production of around 670 g/m^2 per year (measured in mid-September). The high-productive verge is situated on dense river-clay soil, alongside highway A15 in the east of the Netherlands (Province of Gelderland close to the town Valburg, 51°54′N–5°48′E) and close to the low-productive site. This verge is covered with an *Arrhenatheretum elatioris* hay meadow and plant biomass production is around 780 g/m^2 per year (measured in mid-September, the difference with the medium-productive verge is significant).

Fig. 1. The three roadside verge locations: from above the low-productive, the medium-productive and the high-productive.

In the years before the start of the experiment, both the low- and high-productive sites were mown for hay twice a year. The medium-productive site was not mown in the 4 years before the start of our experiment but had been under a regular mowing regime before that. In each site, a 300 m long stretch of initially homogenous vegetation was subdivided into 25 contiguous plots of 12 m × 15 m for the application of five different management treatments, each replicated five times in a randomised-block design. Treatments were: no management (0), mowing once a year in early autumn with or without hay removal (1M+ or 1M), and mowing twice a year in early summer and early autumn with or without hay removal (2M+ or 2M). These treatments reflect common management practices in Dutch roadside verges (1M+ and 2M+)