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Flower abundance and vegetation height as predictors for nectar-feeding insect occurrence in Swedish semi-natural grasslands

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ABSTRACT

With steadily shrinking areas of species-rich semi-natural grasslands in Europe, the management of the remaining fragments becomes ever more crucial for the preservation of key elements of biodiversity in the agricultural landscape. Detailed knowledge about species-wise, as well as group-wise, relationships can provide guidelines for conservation management and a basis for predictions about different management scenarios. In the present study, we related the occurrence of species of bumblebees (N = 12), butterflies (31) and day-flying moths (4) and their total richness in 424 sites in southern Sweden to three grass sward attributes, (i) flower abundance, (ii) height of the grass sward and (iii) within-site variation in height of vegetation. The abundance of nectar-bearing flowers proved overall the best predictor of richness and in most of the occurrence-based species-wise models. However, both high grass sward height and high variation in grass sward height contributed significantly to species richness and occurrence of individual species. There was a tendency for bumblebees to respond less positively to flower abundance and vegetation height than butterflies and moths. One expectation was that grassland specialists, red-listed species, or species decreasing in other part of Europe, would be more responsive to tall vegetation or flower abundance but there was no support for this in the data. Hence, management strategies that promote common species will also benefit all, or most of, the rare ones as well.

1. Introduction

With ever shrinking acreage of species-rich grassland (Schmitt and Rákosy, 2007; Stoate et al., 2009; Dover et al., 2011), its management needs to be fine-tuned to achieve the conservation objectives (Sjödin et al., 2008; van Klink et al., 2015). Although best management practice for conservation of species-rich grassland is built on an increasing foundation of research, it is almost exclusively based on vascular plants (Wahlman and Milberg, 2002; Wallis de Vries et al., 2002; Marriott et al., 2004; Milberg et al., 2014; Tälle et al., 2015, 2016). However, there is an increasing awareness that management needs to consider also other components of biodiversity in species-rich grassland, most notably nectar-feeding insects, like bumblebees, butterflies and day-flying moths (Littlewood et al., 2012; van Klink et al., 2015). The existing taxonomic bias is mainly due to the larger spatial areas needed for meaningful experiments, and the larger seasonality and the mobility of insects that makes it harder to assess invertebrate population trends. Data of lower level of evidence for insects can be gained by observation studies, e.g. monitoring data or correlation analyses between management type or intensity vs. richness or occurrence of target species (e.g. Sjödin et al., 2008). Nevertheless this means that data of high quality from replicated field experiments (hence data of the highest level of evidence, sensu Pullin and Knight, 2001) are plenty for vascular plants but few for invertebrates. Put another way, it is easy to establish, manage and monitor plots with vascular plants in focus, but expensive and space-consuming if invertebrates are involved. But it would be unfortunate if this bias towards high level evidence should limit our management targets to vascular plants only. Also, there is an increasing awareness of a potential conflict between plant and invertebrate management targets (Littlewood et al., 2012; van Klink et al., 2015). So, at this point in time, it seems crucial to broaden the evidence-base for conservation management of species-rich grasslands.

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In the present study, we focused on the nectar-feeding guild of invertebrates: bumblebees, butterflies and day-flying moths. They are often highlighted as of particularly importance due to the ecosystem function they provide by being pollinators (Kearns et al., 1998; Svensson et al., 2000; Carvell, 2002; Goulson et al., 2008; Potts et al., 2010; Goulson, 2010). We set out to address the following assumptions: (i) Site-specific grass sward characteristics – height, variation in height, and its abundance of flowers with nectar – can explain the richness of nectar-feeding invertebrates (bumblebees, butterflies, day-flying moths) and the occurrence of individual species. These three grass swards characteristics could also potentially be used by managers to fine tune grazing during the grazing season. The expectation was that all three attributes would increase richness and positively affect the occurrence of a majority of the species recorded in managed species-rich grasslands. By grouping species, we were further able to address three key assumptions regarding the three grass sward characteristics: (ii) There is a difference in preferences between species considered as grassland specialists and other species; (iii) Bumblebees, butterflies and day-flying moths are similar in their responses; (iv) Declining species are more positively affected than others. The rational for the last assumption is that the cause for their decline might be diminishing food resources, and the potential negative feedback loop of reduction in nectar-bearing plants (Carvalheiro et al., 2014).

2. Material & methods

2.1. NILS

This study was based on data collected within the environmental monitoring program *The National Inventory of Landscapes in Sweden* (NILS) launched in 2003. 631 permanent sample units are systematically distributed across Sweden, each consisting of a 25 km^2 area in which parts of the landscape are sampled every fifth year (Svensson et al., 2009; SLU, 2011; Ståhl et al., 2011). One type of data collection, which started in 2006, concerns biodiversity data from one or several randomly selected species-rich semi-natural grasslands within these sample units (SLU, 2011). These species-rich grassland sites had previously been identified in a national inventory of grasslands (Jordbruksverket, 2005), covering 301,348 ha. Out of the total area surveyed, 90% was considered as “valuable grasslands” for biodiversity conservation (rich in species, rich in indicator species for traditional management, unfertilized, etc.). The valuable grasslands included 44,375 pastures (228,919 ha), 4166 meadows (6661 ha) and 8210 sites that were judged as “abandoned but still valuable” (34,546 ha; Jordbruksverket, 2005). The vast majority of the sites selected for NILS was grazed (approx. 65% by cattle, 15% by sheep, 20% by horse), but a small fraction (5%) was mowed for fodder (sometimes with aftermath grazing). Here, we use biodiversity survey data from NILS, representing a snapshot at peak of the butterfly flight period, on bumble bees, butterflies and day-flying moths.

2.1.1. Biodiversity sampling

Trained staff performs the inventories of the three insects group for NILS each summer (SLU, 2011). The inventories are done along predetermined transects in meadows and pastures. The length and number of transects vary between sites, adjusting for shape of the grassland and aiming for a total transect length somewhat proportional to the size of the area. The average number of transects per site are 8.4 ± 3.34 (average ± SD) while the total transect length is 827 ± 338 m. All specimens within five meters (butterflies and moths) or two meters (bumblebees) in front and to each side of the observer are considered. If needed, insects are captured for species-identification (SLU, 2011). The inventory is done three times during one summer per site for butterflies and moths and, coinciding with the second or third, once for bumblebees (SLU, 2011).

Inventory work is carried out during daytime when the weather conditions are suitable for butterflies (Wikström et al., 2009). That means winds below 8 m s^{-1}, temperatures above 17 °C, no rain and – for butterflies and moths – sun (SLU, 2011).

2.1.2. Inclusion criteria

As northern Sweden differs from southern, in species composition, in management of grassland and in density of grasslands, we included only the southern part (excluding data from the so called strata 7–10). We focus our study on data from 2007 to 2010, i.e. avoiding including the same site more than once, and excluding the first field season (2006) as the methods for grass sward description were slightly altered in the succeeding seasons. These two criteria lead to 424 pasture and meadow sites selected for the present study (Fig. 1).

In the current study, we excluded all records of unidentified specimens; they make up 6, 2 and 2% of the bumblebee, butterfly and moth datasets, respectively.

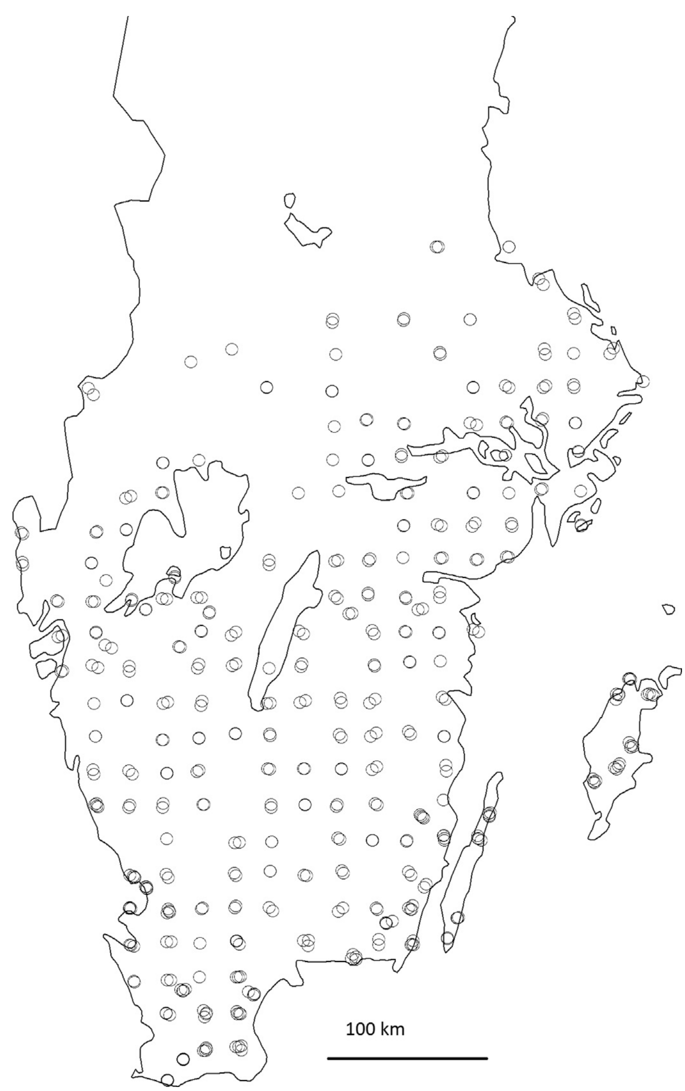

Fig. 1. Map of southern Sweden showing the distribution of the 424 grassland sites included in the study. N.b. that NILS involves a clustered design, hence several symbols are sometimes close together.