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Different response of two Hemiptera species groups to sown wildflower strips: True bugs and leafhoppers

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ABSTRACT

Sown wildflower strips should promote the species diversity of several insect groups in order to be an effective tool for the compensation of biodiversity loss in agricultural environments. We studied the responses of two herbivorous insect groups, Heteroptera (true bugs) and Auchenorrhyncha (leafhoppers), to the properties of wildflower strips in a three-year (2008–2010) study in southern Finland. The experiment was replicated in six reed canary grass fields. The insect groups showed opposite responses; the abundance of Auchenorrhyncha was lower while the abundance and species richness of Heteroptera was higher in wildflower than control strips. During succession, both species richness and abundance of Auchenorrhyncha increased unlike Heteroptera. This difference could largely be explained by dietary differences. Auchenorrhyncha, including several grass feeders, could not take advantage of the increasing dicot species richness like Heteroptera species. This was also a likely reason for the unexpected finding that only Heteroptera species richness depended on the placement of the strip, being higher near field margins than in mid-field. We conclude that the optimal planning and implementation of wildflower strips call for the definition of clear goals, the knowledge of the requirements of target species as well as considering the cropping system involved.

1. Introduction

Intensification of agricultural production has led into a decline in the area of semi-natural grasslands and other non-crop habitats which are regarded as key habitats for supporting agro-biodiversity (Stoate et al., 2009). In Europe, the loss of these habitats is compensated by introducing short-term habitats into agricultural environments. Sown wildflower strips appear to be one of the most promising tools for such compensation (e.g., Haaland et al., 2011). More information on the benefits of wildflower strips for the species diversity is needed, especially of herbivorous insects playing a vital role in the food webs of agricultural environments (van Veen et al., 2006).

Wildflower strips are aimed at enhancing the species diversity of insects by providing habitat and increasing food resources at the field scale (Haaland et al., 2011). The ability of wildflower strips to enhance the species diversity of herbivorous insects depends on the seed mixture used in the establishment (Jacot et al., 2007; Marshall, 2007; Pywell et al., 2007; Woodcock et al., 2005). For many grass-feeding insects, such as leafhoppers, the benefits of increased richness of broad-leaved plant species in wildflower strips may be limited (Huusela-Veistola and Vasarainen, 2000). Vegetation structure has also an important role for some species groups, such as leafhoppers (Frank and Künzle, 2006; Zurbrükk and Frank, 2006) and bugs (Kruess and Tscharntke, 2002; Kőrösi et al., 2012). For them, the vegetation succession of wildflower and grass strips plays an important role since species richness has been shown to increase in the course of time (Huusela-Veistola and Vasarainen, 2000; Luka et al., 2006).

Wildflower strips are often planned to promote primarily one target such as pollination or conserving the biological control of agricultural pests (Haaland et al., 2011). The requirements for the optimum management of single targets are well established, e.g., sowing nectar plants for pollinators (Korpela et al., 2013), while the multi-target benefits for biodiversity are less studied (Haaland et al., 2011). In order to benefit agro-biodiversity in general, wildflower strips should support a wide array of insects. Hemiptera is among three major phytophagous insect orders with

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Lepidoptera and Coleoptera (Chapman, 2009) but the less mobile herbivores belonging to this or comparable orders may gain limited benefits of wildflower strips planned to support pollination. Even though colonisation is a key issue in the success of wildflower strips for biodiversity, the importance of the placement of the strips has rarely been studied experimentally (Korpela et al., 2013). Wildflower strips are usually placed near field margins in order to ease management (Pfiffner and Wyss, 2004; Kinross et al., 2004) but sometimes they are placed mid-field for ecological compensation areas (Boller et al., 2004).

In the present study, we aimed at exploring the benefits of wildflower strips sown with seed mixtures originally planned for pollinators (see Korpela et al., 2013) for the species diversity of two herbivorous insect groups, true bugs (Heteroptera) and leafhoppers (Auchenorrhyncha). Both of these groups are common, abundant and species rich in farmland habitats. Auchenorrhyncha is known to be sensitive to habitat change (Biedermann et al., 2005) and Heteroptera to correlate positively with total arthropod species richness (Duelli and Obrist, 1998). The insect groups belong to the same order but differ in terms of species richness and diet breadth. Auchenorrhyncha group is composed solely of herbivores, the majority of them being monocot feeders in the field layer (Söderman, 2007), whereas the more species rich Heteroptera group includes both herbivores with a wider selection of host plants and predators (Rintala and Rinne, 2010).

In addition to the effects of seed mixture, we studied experimentally the effect of the placement of the strips. The placement can be assumed to affect the colonization and species turnover of the wildflower strips. We hypothesized the species richness of both groups to benefit on wildflower strips but the response in species richness to be stronger and the change in species assemblage over years to be greater in Heteroptera than in Auchenorrhyncha due to differences in their biology (Söderman, 2007; Rintala and Rinne, 2010). Further, we hypothesized that the wildflower strips placed near field margins will be colonised more effectively than those in the mid-field resulting in higher species richness and differing species assemblage (Holland et al., 2012; Korpela et al., 2013). The experiment was carried out in reed canary grass bioenergy fields representing a species poor cropping system (Vepsäläinen, 2010).

2. Methods

2.1. Experimental design

A field experiment was established in Jokioinen, south-western Finland (60°85′N; 23°46′E) in May 2007. The experiment consisted of six reed canary grass (*Phalaris arundinacea* L.) field blocks separated by forest (minimum distance between field blocks was 380 m). Reed canary grass was sown on two field blocks (V and VI) in 2006 and on others in 2007. In each field block, replicates of six wildflower strip (T1–T6) and three reed canary grass control treatments (C1, C3 and C5) were established (Fig. 1). The minimum distance between the treatments within a field block was 25 m. Five of the wildflower strips (T1–T5) were sown using a seed mixture of *Centaurea jacea* L. (10 seeds m^{-2}), *C. phrygia* L. (5 seeds m^{-2}), *Leucanthemum vulgare* Lam. (10 seeds m^{-2}), *Trifolium repens* L. (0.5 kg seeds ha^{-1}) and *Agrostis capillaris* L. (1 kg seeds ha^{-1}), and one (T6) with *C. jacea* (50 seeds m^{-2}). Wildflower strips were sown on 29th and 30th May, 2007.

The wildflower strips differed from each other in terms of shape and placement within a field block (Fig. 1). As regards to shape, one (T4) was 10 m × 25 m whereas the other wildflower strips were 5 m × 50 m in dimension. As regards to placement, one wildflower strip (T2) was directed toward the center of the field from the field margin, whereas the other strips were placed at the edge of the field either parallel to field margin between agricultural fields (T1 and T4) or next to forest (T5), or in the middle of the field block (T3 and T6). Control treatments (C1, C3 and C5) were delimited reed canary grass areas (5 m × 50 m) placed in a similar way than wildflower strips T1, T3 and T5. C1 was lacking in study field parcels III and IV, as there were no suitable field edges where transects could have been placed. The experimental fields were fertilized and their vegetation was cut for bioenergy each year in April or May. Herbicides or insecticides were not used.

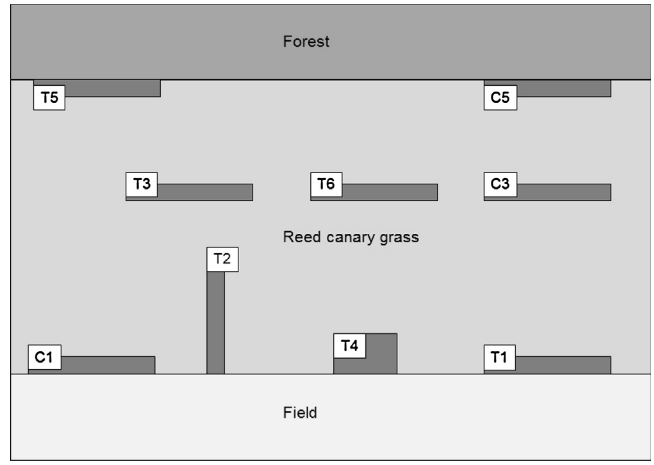

Fig. 1. A schematic illustration of the study design (not to scale) within the study field parcels (n = 6). T1–T6 represent the wildflower strip treatments sown with meadow plants and C1–C5 reed canary grass controls. The dimensions of each strip were 5 m × 50 m except T4 which was 10 m × 25 m. The minimum distance between the strips within a parcel was 25 m.

2.2. Sampling

The sampling of Hemiptera was conducted in each experimental plot three times during the growing season between late May and August in 2008–2010. The samples were collected with sweep net (diameter 30 cm), each sample consisting of 60 sweeps. The insects were dried and identified to species. Nomenclature of Auchenorrhyncha follows that of Söderman (2007) and Heteroptera Rintala and Rinne (2010). Some Heteroptera juveniles could not be identified to species and therefore all juveniles were excluded from the data. In addition, altogether 6Heteroptera samples (5 samples in 2008 and 1 sample in 2010) and 14 Auchenorrhyncha samples (5, 7 and 2 samples in 2008, 2009 and 2010, respectively) were excluded due to contamination by fungus or were lost during the study. Plant species were identified and coverage was estimated by species using a scale of 9 classes (1:<0.125%, 2:0.125–0.5%, 3:0.6–2%, 4:2.1–4%, 5:4.1–8%, 6:8.1–16%, 7:16.1–32%, 8:32.1–64% and 9:>64%) in each experimental plot in August each year.

2.3. Data analyses

Two sets of data analyses were conducted. Firstly, the impact of wildflower strip treatment was studied by comparing wildflower strips (T1, T3 and T5) with equally placed reed canary grass control treatments (C1, C3 and C5). Secondly, wildflower strips (T1–T6) were compared among each other. In both sets of analyses, species diversity and species composition were analyzed. Since the data in the two set of analyses were partly overlapping, the results of the latter analyses are reported in detail in appendices.

Species diversity was analyzed by comparing differences in the abundance, species richness and Shannon diversity index values of Heteroptera and Auchenorrhyncha as well as cover and species