

Short communication

## Diversity of cereal aphid parasitoids in simple and complex landscapes

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### Abstract

Structurally complex landscapes may enhance local species richness and interactions, which is possibly due to a higher species pool in complex landscapes. This hypothesis was tested using cereal aphid parasitoids (Hymenoptera, Aphidiidae) by comparing 12 winter wheat fields in structurally complex landscapes (>50% semi-natural habitats;  $n = 6$ ) and structurally simple landscapes dominated by agricultural lands (>80% arable land;  $n = 6$ ). Surprisingly, landscape structural complexity had no effect on aphid parasitoid species diversity. In complex landscapes 12 and in simple landscapes 11 species were found; 9 species occurred in both landscape types. Hence, arable fields in high-intensity agricultural landscapes with little non-crop area can support a similar diversity of cereal aphid parasitoids as structurally complex landscapes. This finding suggests that cereal aphid parasitoids may find necessary resources even in simple landscapes, making generalisations concerning the relationship between landscape composition and biodiversity in arable fields difficult.

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### 1. Introduction

Structurally complex landscapes are characterized by high proportions of semi-natural habitats such as field margins, hedges, fallows and grasslands. Several studies have shown that increasing landscape complexity can enhance local biodiversity in farmland and thereby may support important ecosystem services such as biological control (Holt et al., 2002). A link between landscape composition and the local biodiversity in farmland has been suggested for several groups of organisms (e.g. Aebischer, 1991). Spill-over effects of species across non-crop–crop interfaces may result in increased species richness in crops located in complex landscapes compared to simple land-

scapes (Tscharntke et al., 2005). According to Duelli and Obrist (2003), more than 60% of the animal species found in an agricultural plot are likely to depend on the availability of semi-natural habitats. However, there are also studies that did not find a positive effect of landscapes complexity on biodiversity (e.g. Costamagna et al., 2004). The insurance hypothesis predicts that a high diversity of species or functional groups stabilizes ecosystem processes, because the resulting functional redundancy allows a diversity of responses to environmental change and reorganisations following disturbance (Yachi and Loreau, 1999).

The three most common aphid species of winter wheat fields in Germany are *Sitobion avenae* F., *Metopolophium dirhodum* Walker and *Rhopalosiphum padi* (L.). They are attacked by a range of aphid parasitoids (Hymenoptera: Aphidiidae). These parasitoids are solitary endoparasites and can act as important biological control agents in

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agricultural systems. Their abundances can vary widely between landscapes (Thies et al., 2005), but little is known about their diversity in relation to landscape complexity. In this study the diversity of aphid parasitoids was examined in winter wheat fields in structurally complex and simple landscapes. Structurally complex landscapes should support a higher diversity of cereal aphid parasitoids compared to structurally simple landscapes because they should provide (i) more potential alternative host species due to a higher plant diversity, (ii) a higher amount of potential food resources for adult parasitoids due to higher nectar availability, (iii) more shelter from disturbances by agricultural practices and potential overwintering sites due to a higher proportion of semi-natural habitats.

## 2. Material and methods

The study was performed around the city Göttingen, Lower Saxony (North Germany) in 2004. Cereal aphid parasitoid communities were studied in conventionally managed winter wheat fields in 12 agricultural landscapes that were located in non-overlapping sectors. In conventionally managed fields, insecticides are mainly sprayed May–June. Half of the fields were located in structurally simple ( $n = 6$ ) and the other half in structurally complex landscapes ( $n = 6$ ). Landscape complexity was quantified using the percentage of arable land in a radius of 500 m around each of the 12 fields. This radius has been shown to be appropriate to measure effects of landscape complexity on cereal aphid parasitoids (Thies et al., 2005). Percent arable land ranged between  $89.5 \pm 4.0\%$  in simple and  $42.7 \pm 0.7\%$  in complex landscapes. The latter category typically contained more field margins, hedges, fallows and grasslands.

Parasitoids were sampled in cereal fields using sweep netting in July. In each field one transect ran through the field centre, and one transect ran parallel to the field edge, therefore weed species could not totally be excluded from the sweep nettings at the field edge. The transect through the field centre started and ended a few meters from the edges to prevent edge effects. Sampling consisted of walking the transect a single time while sweeping the top of the vegetation at both sides. The sweep netting was carried out on warm and mostly sunny days and not after rain. To exclude possible effects of diurnal activity of the different species, sampling was conducted at different times of the day (all between 09.00 and 19.00 h) at four dates per field in July. Additionally, aphids were counted per 100 stalks in the field centres on two dates (June and July) in insecticide-free areas ranging from  $12 \text{ m} \times 10 \text{ m}$  to  $24 \text{ m} \times 20 \text{ m}$  (depending on machine track distances) to show the undisturbed aphid population growth in the two different landscape types.

Female parasitoids ( $n = 1038$ ) were identified to the species level using the key of Tobias and Kiriyak (1995), whereas males ( $n = 566$ ) could only be determined to genus level. Nineteen individuals could not be sexed, and were

therefore excluded from the statistical analyses. Individuals of the genus *Aphidius* that could not be identified to the species level were classified as *Aphidius* spp. *A. ervi* Haliday and *A. microlophii* Pennacchio and Tremblay were all named as *A. ervi*.

The species richness of the parasitoid samples from the field and the estimated number of parasitoid species calculated using the jack-knife technique (Colwell, 2005) were highly correlated (Spearman's rank correlation:  $\rho = 0.80$ ;  $P = 0.002$ ), thereby showing little sensitivity for sampling effects. Therefore, the original data were used to calculate the Shannon–Wiener index for parasitoid species richness in simple and complex landscapes. Parasitoid density and species richness were converted to density and richness per 200 m, because the fields had different lengths. Differences in aphid density, parasitoid density and species richness between the two landscape types were tested using the Kruskal–Wallis test. The data per field were merged for the statistical analysis (i.e., data for the four sampling dates as well as data for field centre and edge). All statistical analyses were performed using R (R Development Core Team, 2006).

## 3. Results

In total 1623 parasitoids of  $\sim 14$  species were collected in 12 wheat fields at four sampling dates. The total number of parasitoid individuals/200 m (mean  $\pm$  S.E.:  $9.6 \pm 0.6$ ) and the number of individuals/200 m of the six most abundant species did not differ significantly between complex and simple landscapes (total no. of individuals:  $\chi^2 = 0.03$ ,  $P = 0.87$ ; individuals of the six most abundant species: all  $P > 0.4$ ). In contrast to our expectations, landscape complexity had no effect on the total number of parasitoid species/200 m (complex landscapes:  $0.83 \pm 0.07$ ; simple landscapes:  $0.67 \pm 0.02$ ;  $\chi^2 = 0.41$ ,  $P = 0.52$ ) and parasitoid diversity (Shannon–Wiener index: complex landscapes:  $0.53 \pm 0.11$ ; simple landscapes:  $0.56 \pm 0.01$ ;  $\chi^2 = 0.03$ ,  $P = 0.87$ ; Fig. 1). Aphid densities (mean/100 stalks:  $316 \pm 63$ ) did also not differ between simple and complex landscapes ( $\chi^2 < 0.01$ ,  $P = 1.00$ ).

## 4. Discussion

The results of this study show that structurally complex and structurally simple landscapes supported a similar diversity and density of cereal aphid parasitoid species. Thus, the hypothesis that complex landscapes with a high proportion of non-crop habitats support a higher parasitoid diversity and higher densities than structurally simple landscapes by providing alternative hosts, food, and overwintering sites is not supported by this study.

Species richness of generalist aphid predators such as spiders has been shown to be higher in cereal fields in

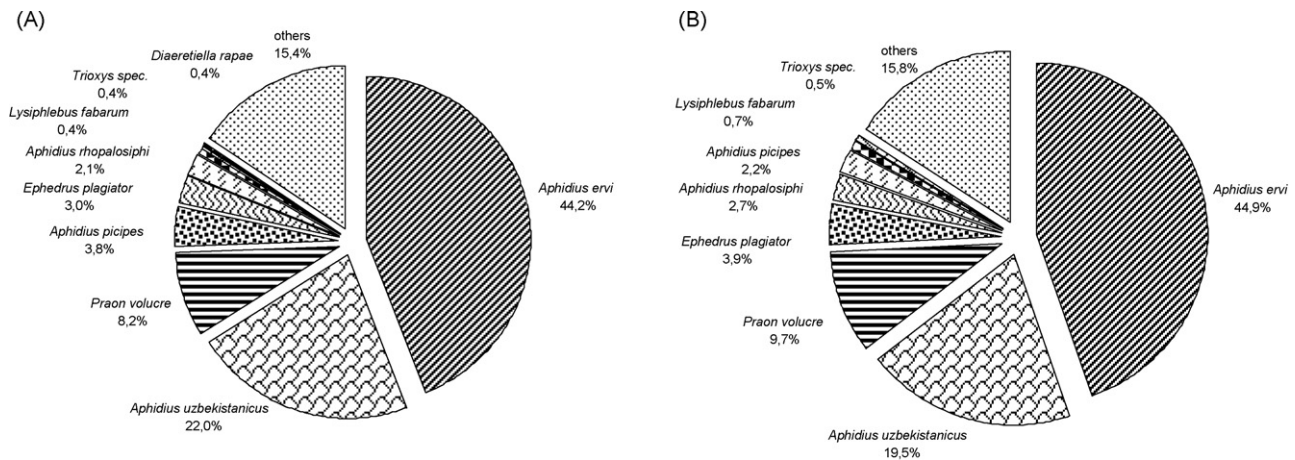


Fig. 1. Species composition (%) of cereal aphid parasitoids in winter wheat fields collected by sweep netting in simple (A) and complex (B) landscapes;  $H_s$  (simple landscapes):  $0.56 \pm 0.01$ ;  $H_s$  (complex landscapes):  $0.53 \pm 0.11$ .

complex versus simple landscapes (Schmidt et al., 2005). In the studied complex landscapes a higher diversity of plants has been found and should therefore provide a higher diversity of plant-associated potential hosts for cereal aphid parasitoids (for the host range of cereal aphid parasitoids, see Kavallieratos et al., 2004). However, the results of this study contrast with expectations of patterns driven by colonization of specialized aphid parasitoid species from non-crop habitats to cereal fields. The number of species caught in this study was relatively high in both landscapes compared to other field studies, e.g. from Denmark (Sigsgaard, 2002), Belgium (Frere et al., 2007), and Slovakia (Praslička et al., 2003).

The results of this study can be explained in two ways. First, parasitoids of cereal aphids seem to be spatially and temporally closely linked with their host species and may not need to switch to alternative host species, given that regions dominated by cereals typically provide continuously cereal aphids. Cereal aphid parasitoids may also not require alternative vegetation as overwintering sites, as they are suggested to predominantly overwinter as prepupae within their host (Starý, 1970) and hatch from aphid mummies in spring. Hence, within-field populations of aphids colonizing winter cereals in autumn may support a high diversity regardless of the composition of the surrounding landscapes. Second, in both structurally complex and structurally simple landscapes, cereal fields supported similar numbers of aphid hosts, and therefore may provide similar amounts of honeydew as food source for adult parasitoids. Although nectar is often a more suitable food source when compared to honeydew (Wäckers, 2000), parasitoids of honeydew producing hosts could have evolved adaptations to optimize exploitation of this food (Wäckers et al., 2008).

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