Impact of field and landscape parameters on herbivorous insects in oilseed rape

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Abstract: Der Einfluss von Feld- und Landschaftsparameter auf die Abundanzen wichtiger Rapsschädlinge (Rapsglanzkäfer - *Meligethes aeneus* und *M. viridescens*, Nitidulidae, Coleoptera; Gefleckter Kohltriebrüssler und Großer Rapsstängelrüssler - *Ceutorhynchus pallidactylus* und *C. napi*, Curculionidae, Coleoptera; Kohlschotenmücke - *Dasineura brassicae*, Cecidomyiidae, Diptera) wurde untersucht. In Raps-Untersuchungsfeldern wurden die Beziehungen zwischen Schädlingsabundanzen und Feld-/Landschaftsparametern in 29 von strukturarm bis komplex reichenden Landschaftssektoren auf acht räumlichen Skalen (Radien 250 - 2000 m) untersucht. Die Abundanzen der Stängelrüssler waren signifikant positiv korreliert mit der Bestandesdichte des Raps und der Bodenqualität. Die Abundanzen der Rapsglanzkäfer reagierten auf allen Radien signifikant negativ mit dem Anteil an Rapsfläche und positiv mit der Bestandesdichte. Die Dichte der Kohlschotenmücke war jeweils auf dem kleinsten Radius signifikant positiv mit dem Anteil an Gehölzen korreliert, negativ mit dem Anteil an Rapsfläche.

Key words: *Brassica napus*, Landscape ecology, Pest-crop interactions, Spatial scales

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In agroecological research it has been appreciated only fairly recently that plant-insect interactions and other ecological processes depend on scales much larger than a single habitat (Wiens et al. 1997). Crop-pest interactions have mainly been studied on single pest species by focusing either on the impact of field parameters or on landscape structure but only rarely included both factors (Östman et al. 2001). Here we investigated how the abundances of three major insect pest species in oilseed rape (OSR) responded to field parameters and landscape characteristics at various spatial scales.

Pest species considered in the current study include (i) ceutorhynchid stem weevils that lay eggs in leaf petioles or midribs of OSR plants while the larvae tunnel in the stems; (ii) pollen beetles that feed on pollen and destroy flower buds and (iii) brassica pod midge that lay eggs into OSR pods where the hatched larvae consume the seeds as well as tissue of the pod walls and cause the pods to split prematurely (Alford et al. 2003). Studying these different groups of pests is especially important because they attack different parts of the crop, use different habitats as overwintering sites and also differ in their mobility; with the exception of pollen beetles these pest species have never been studied in a landscape context.

The specific objectives of this study were to determine (i) whether the major OSR pest species differ in their relation to field and landscape characteristics and (ii) at which spatial scales landscape variables are effective.

Materials and methods

The study region (about 300 km^2), which is situated about 40 km east of Vienna, mainly consisted of farmland cropped according to integrated pest management guidelines. Within this region 29 OSR fields comprising a complexity gradient ranging from structurally poor to more complex landscapes were randomly selected for collecting pest abundance data related to landscape and field parameters. Landscape parameters calculated were proportions of OSR fields, non-crop area, area of grassy fallows and woody areas. Scale effects were investigated by calculating landscape parameters at 8 circular sectors ranging from 250 to 2000 m radius around the 29 study plots. Field parameters calculated were OSR stand density, soil index and nitrogen fertilization. Stem weevil larvae were sampled by removing 25 randomly chosen OSR plants of each of the 29 OSR fields, stems were dissected subsequently and weevils therein counted. Adult pollen beetles were sampled during flowering of OSR on 25 randomly chosen OSR plants of each of the 29 fields by putting plastic bags over the top raceme, cutting off the raceme and counting pollen beetles present in the laboratory. Brassica pod midge larvae were assessed in 100 randomly chosen pods from the top racemes of OSR plants of each study field after dissecting the pods in the laboratory. For analysing the impact of field and landscape parameters on herbivorous insects in oilseed rape, uni- and multivariate regression analysis models were calculated.

Results

Univariate regression analyses revealed that the density of stem weevil larvae was significantly positively correlated with OSR stand density (Fig. 1), and a further 10% of the variance was explained by soil index based on a significantly positive relation. Adult pollen beetles were significantly negatively associated with the area of OSR at all eight radii tested (Fig. 2). Moreover stand density showed a significantly positive relationship with pollen beetle density explaining 14% of the variance. There was a positive significant relation between brassica pod midge larvae and percent woody areas at the smallest scale tested (Fig. 3).

The multivariate regression model for the stem weevils ($r^2 = 0.550$, $P = 0.019$) consisted of two variables, soil index (partial $r^2 = 0.335$, $P = 0.001$) and proportion of woody areas at a radius of 250 m (partial $r^2 = 0.116$, $P = 0.017$). The plot of the partial effects showed that species abundance is highest when soil index values were slightly above average and proportion of woody areas is high. The multivariate regression model for the pollen beetles ($r^2 = 0.770$, $P < 0.001$) consisted also of two variables, the area of OSR at 1000 m radius (partial $r^2 = 0.368$, $P < 0.001$) and soil index (partial $r^2 = 0.102$, $P = 0.0137$) with a distinct negative response to OSR area and a curvilinear relationship to soil index.

Maximum pollen beetle abundance is predicted by this model at lowest levels of OSR area and average soil index values.

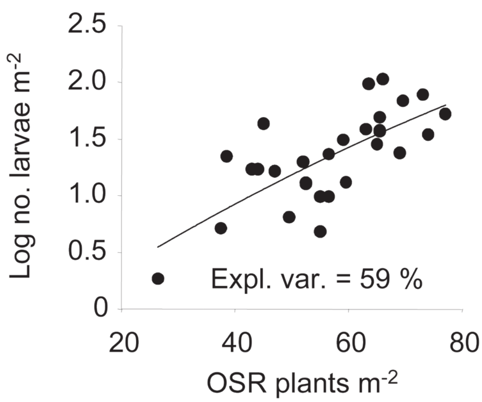

Fig. 1. Relationship between abundance of stem weevil larvae (*C. pallidactylus* + *C. napi*) and OSR stand density derived from univariate regression analyses.

Discussion

Stand density and soil index were the field parameters mainly affecting pest abundance. The curvilinear shape of the relationship between abundance and soil index with a maximum at average levels indicates that at low soil index OSR quality was not suitable for pests, and at a higher soil quality the crop could have exhibited a better ability to protect itself from herbivores via the production of secondary compounds (CIPOLLINI & BERGELSON 2002).

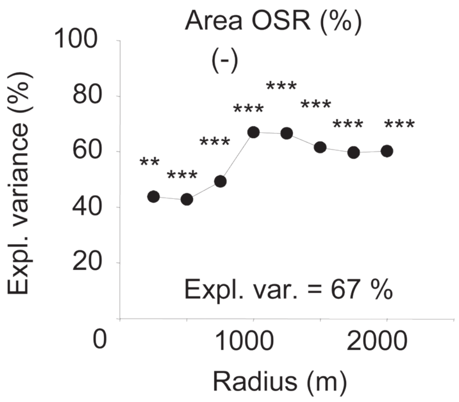

Fig. 2. Relationship between abundance of adult pollen beetles (*M. aeneus* + *M. viridescens*) and OSR area.
Asterisks denote statistical significance:
** $P < 0.01$, *** $P < 0.001$.
(-) means negative relationship.

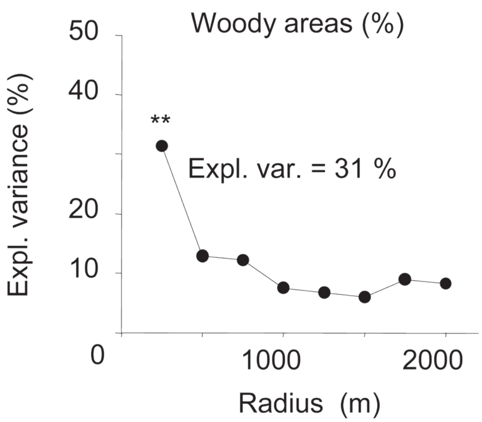

Fig. 3. Relationship between abundance of pod midge larvae (*D. brassicae*) and woody areas.
Asterisks denote statistical significance: ** $P < 0.01$.

Pollen beetles were negatively associated with OSR area in the landscape revealing that they were concentrated in landscapes with less OSR area and diluted when more OSR area was available. Because of the annual generation cycles of pollen beetles these patterns could be expected to mirror the situation regarding the areas of OSR and overwintering sites of the preceding year that enabled the buildup of a certain landscape pest pool that was then dispersed among available OSR area in the current year (HOKKANEN 2000). However, since in our region OSR cropping history and non-crop areas did not change considerably during the last years, we assume that pest migrations between investigated landscapes are most likely responsible for these findings.

Pod midge abundance was positively related to woody areas. This finding seems somewhat surprising because pod midge adults are reported to emerge from the OSR field of the last year and in the following spring migrate to the current OSR fields (ALFORD & al. 2003). Our understanding of landscape effects on pod midges is still too scarce to finally interpret our findings.

Overall, there is a great need for more multi-scale assessments performed in different regions to adequately pinpoint how habitat parameters and their spatial configuration can affect the abundance of pest populations.

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