Scale-dependent impact of landscape characteristics on spider diversity in winter oilseed rape fields

Thomas Drapela, Dietmar Moser, Johann G. Zaller & Thomas Frank

Institute of Zoology, University of Natural Resources and Applied Life Sciences, Vienna

Abstract: Skalenabhängiger Einfluss der Landschaft auf die Diversität epigäischer Spinnen in Winterrapsfeldern

Die Intensivierung der Landwirtschaft stellt weltweit eine der bedeutendsten Bedrohungen der Biodiversität dar. Maßnahmen, die die Diversität der Landschaft erhöhen werden daher als eine zentrale Möglichkeit gesehen, den Verlust von Arten in Kulturlandschaften zu stoppen und durch die Förderung von Nützlingen einen Betrag zu einer Reduktion des Pestizideinsatzes zu leisten.

Wir untersuchten den Einfluss der Landschaft auf epigäische Spinnen (Araneae) in 29 Winterrapsfelder in einer durch landwirtschaftliche Nutzung dominierten Region östlich von Wien (Österreich). Spinnen – generalistische Prädatoren, die ein bedeutsames Potenzial in der natürlichen Schädlingskontrolle aufweisen – wurden während der Feldsaison 2005 mit Barberfallen erfasst. Die umgebenden Landschaften wurden hinsichtlich Zusammensetzung, Diversität und Komplexität charakterisiert (Landschaftsausschnitte mit 250 bis 2000 m Radius). Zusätzlich wurden Feldparameter, vor allem die Bewirtschaftung betreffend, in die Analyse einbezogen. Die Datenanalyse erfolgte mit Generalized Linear Models. Unsere Ergebnisse zeigten, dass die Spinnengemeinschaften hinsichtlich Diversität und Individuenzahlen auf unterschiedliche Landschaftvariablen auf unterschiedlichen Skalenebenen reagieren. Für die Gesamtartenzahl war der Anteil an gehölzdominierten Habitaten in der näheren Umgebung der Felder der wichtigste, fördernde Faktor. Die Anzahl der häufigen Arten und die Gesamtindividuenzahlen hingegen nahmen mit dem Anteil an Brachen bzw. der Lauflänge an Wegrainen in größerem Umkreis der Felder zu.

Diese Ergebnisse unterstreichen die Bedeutung von naturnahen Landschaftselementen, v.a. Brachen, für epigäische Spinnen als eine Gruppe von räuberischen Arthropoden in Agrarsystemen.

Keywords: epigeic spiders; Araneae; generalist predators; *Brassica napus*; spatial scales; generalized linear models; GLM; landscape ecology

T. Drapela, D. Moser, J.G. Zaller & T. Frank, University of Natural Resources and Applied Life Sciences Vienna, Department Integrative Biology and Biodiversity Research, Institute of Zoology, Gregor Mendel-Strasse 33, 1180 Vienna, Austria. E-mail: thomas.drapela@boku.ac.at

Agricultural intensification is a major threat to biological diversity worldwide. Land management activities enhancing landscape diversity are therefore regarded as a key strategy to halt species loss in cultural landscapes. Diverse and abundant communities of predatory arthropods, e.g. spiders (Araneae), have a high potential to suppress pest populations (SYMONDSON et al. 2002) and could therefore contribute to allow reductions of pesticide use. Crop fields alone are usually not able to sustain diverse and individual-rich populations of predatory arthropods, because agricultural management results in disturbances and habitat deteriorations (harvest, soil cultivation, pesticide application) that kill or drive away large parts of the populations. Therefore semi-natural and perennial habitats in agricultural landscapes are considered to be of great importance for beneficial arthropods. On the one hand they offer refuge habitats in times when arable fields are hostile, e.g. fields with bare grounds during winter (SCHMIDT & TSCHARNTKE 2005). On the other hand, viable populations of predatory arthropods in semi-natural habitats can serve as sources for (re-) colonisation of arable fields (SCHMIDT & TSCHARNTKE 2005). Because of these exchanges between crop and non-crop areas it is important to include the surrounding landscape when investigating field-scale processes.

We investigated the relations between spider assemblages in arable fields and the surrounding landscape in 29 fields of winter oilseed rape (OSR) in an agricultural landscape in eastern Austria. The objectives of this study were to estimate (1) how much spider assemblages in oilseed rape fields are influenced by the surrounding landscape, (2) the relative influence of landscape variables compared to field-scale variables and (3) at which spatial scales landscape variables are effective.

Material and Methods

The study area was situated in an agricultural region about 40 km east of Vienna (Austria; coordinates of the central area: 16°57' E, 48°04' N). Within this study area we chose 29 winter oilseed rape fields. The landscapes surrounding the selected OSR fields represented a gradient from structurally simple to structurally complex landscapes. From January 2005 within each study field an area of 1 ha was excluded from pesticide applications and used for sampling epigeic predators, insect pests and crop plants.

Epigeic spiders were sampled using three pitfall traps per study field, which were emptied biweekly from March until at the end of June 2005. Adult spiders were determined to species level with nomenclature according to Blick et al. (2004). Catches of all sampling periods were pooled for data analysis. For each study field we calculated the total number of spider species, number of abundant species (i.e. species that each account for at least 1% of all individuals from the respective field) and the total number of spider individuals.

The surrounding landscape of each study field was analysed in terms of landscape composition and diversity. We calculated respective proportions of non-crop area, fallows and woody areas (forests, copses, hedges, shrublands and similar habitats dominated by woody plants), the total length of road-side strips and of hedges, respectively, and we estimated landscape diversity using the Shannon-Index in eight circular landscape sectors with radii from 250 to 2000 m around each study field using the software packages ArcGIS 9.1 and ArcView GIS 3.3 (ESRI Redlands, CA, USA).

Additionally we included a set of field variables into the analyses: soil index, soil cultivation intensity index, nitrogen fertilisation, pesticide use in autumn 2004, OSR cover in late autum/winter 2004, OSR stand density.

We used Generalized Linear Models (GLM) to estimate the effects of landscape and field variables on the spider assemblages. We performed a forward stepwise selection and backward elimination procedure to select the significant predicting variables (Yee & Mitchell 1991). To detect scale-dependent effects we compared the predictive power of landscape variables at the eight circular landscape sectors around each study field (r = 250-2000 m) in an univariate approach. As landscape variables gained from such a nested investigation design are highly correlated, we allowed only the most significant of such a group of variables to be included into a multivariate GLM model. The statistical analyses were performed with S-PLUS 7.0 for Windows (Insightful Corp., Seattle, U.S.A.).

Results

A total of 12065 adult spiders belonging to 117 species from 20 families were caught in the study OSR fields. The number of spiders caught per field varied between 206 and 783 specimens. The total number of species laid between 25 and 48 species, the number of abundant species between 9 and 21 species. A quarter of all species was found on just one field, most of them with just one specimen. Only seven species occurred on all 29 fields, another ten species on at least 25 fields. The spider assemblages were dominated by typical agrobiont spiders, like *Pardosa agrestis* (Lycosidae), *Meioneta rurestris*, *Oedothorax apicatus*, *Erigone dentipalpis*, *Trichoncoides piscator* (all four Linyphiidae), *Drassyllus pusillus* (Gnaphosidae) and *Ozyptila simplex* and *Xysticus kochi* (both Thomisidae). The family of Linyphiidae was the most diverse with 35 species, followed by the Lycosidae (20 species), Gnaphosidae (19 species), Thomisidae (eight species), Theridiidae (seven species) and Salticidae (six species). All other 14 families were represented with less than five species each.

The univariate step in GLM analyses showed for all three spider assemblage characteristics that landscape variables were the best explaining variables. While the total number of species was positively related to the proportion of woody areas in the surrounding landscape (Tab. 1), the number of abundant species increased with higher proportions of fallows (Tab. 1). The best explanatory variable for spider numbers was the total length of road-side strips (Tab. 1). The three spider assemblage characteristics clearly differed in their relationship to spatial scales. Whereas the maximum effect on the total number of species lay at small scales (r = 500 m), the effect on the number of abundant species was highest medium to large scales (r = 1250 m). Spider numbers showed their strongest response at large scales (r = 1750 m). Field variables showed no significant effects. No second variable could enter the model for any of the three dependent variables.

Tab. 1: Relationships between the total number of species, the number of abundant species and the number of individuals and the respective best explanatory variable as derived from GLM analyses.

Dependent variable	Explanatory variable	Explained variance (%)	P
Total no. species	Prop. woody areas (r = 500 m)	37.8	0.002
No. abundant species	Prop. fallows (r = 1250 m)	34.7	0.026
No. individuals	Total length road-side strips (r = 1750 m)	44.7	< 0.001

Discussion

Although we found quite high species numbers per field, up to one third of a field's species set occurred in just one individual. Most of these rarely caught species can be regarded as vagrants and came into the OSR fields from habitats like hedges, copses, forest edges, shrubby fallows etc. Therefore the proportion of woody areas was the most important explanatory variable for the total number of species. The finding that this relation showed a clear maximum at small scales (radius of 500 m), indicates limited dispersal of species from these habitats into the open, agricultural landscape.

The number of abundant species, mostly typical agrobiont spiders of the open agricultural landscape (Nyffeler & Sunderland 2003, Samu & Szinetár 2002, Tóth & Kiss 1999), on the other hand was positively related to the proportion of fallows. For these species fallows are of great importance. They play an important role as overwintering sites or refugial habitats during or after times of disturbances in the arable fields, e.g. harvest (Pfiffner & Luka 2000, Lemke & Poehling 2002, Schmidt & Tscharntke 2005). These results show that fallows support local species pools which result in higher diversity of agrobiont spiders in arable fields.

The response of abundant species to the surrounding landscape was found at rather large scales (maximum at radius of 1250 m). Many agrobiont spiders exhibit traits of pioneer species with high dispersal power (Samu & Szinetár 2002, Sunderland & Samu 2000). Most of the dominating species in the present study are capable of ballooning (Bell et al. 2005). Therefore they are able to cover large distances in the open agricultural landscape (Thomas et al. 2003) and relations to landscape characteristics were found at rather large scales.

The number of spider individuals is strongly related to the total length of road-side strips at large radius (1750 m). These results could indicate that road-side strips (or the roads themselves) function as some kind of corridors along which spiders move, respectively which facilitate movement and dispersal of spiders; or road-side strips form a network of perennial, suitable habitats embedded in a landscape dominated by periodically disturbed arable fields.

Our results clearly underline the importance of semi-natural and perennial habitats in agricultural landscapes. Fallows in particular support agrobiont spiders and they should be present in sufficient numbers and distribution in agricultural landscapes to help sustaining viable arthropod predator populations.

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