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Prey selection of orb-web spiders (Araneidae) on field margins

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Abstract

In this study, prey composition and numbers of prey ingested by orb-web spiders (actual prey), as well as the food resources available in the habitat (potential prey), the retention efficiency of spider webs, and the prey selectivity of spiders, which bias the prey composition, were investigated for the garden spider *Araneus diadematus* and the wasp-like spider *Argiope bruennichi* in two field margin habitats in Bavaria, South Germany. The potential prey of both spider species on field margins consisted of a few flying prey taxa with a dominance of Diptera. In spider webs, mobile Diptera and some Hymenoptera were underestimated whereas small, broad-winged prey items such as Sternorrhyncha were overestimated compared to the composition of potential prey. Spiders avoided prey groups armed with strong mandibles or stings, such as Coleoptera and some Hymenoptera. A mean number of nine prey items in 7 h was consumed by orb-web spiders in field margin habitats consisting mainly of Diptera and herbivorous pest groups such as Sternorrhyncha.

Keywords: Web retention; Prey selectivity; Prey composition; Araneidae; Field margins

1. Introduction

Field margins are important population reservoirs of predators and parasitoids, which may immigrate as biocontrol agents into adjacent agricultural fields (Denys and Tscharntke, 2002). However, field margin habitats also provide resources for herbivorous pest species, which can build up in field margins, colonise the adjacent crop field and damage the crop plants (Norris and Kogan, 2000). Therefore, trophic interactions between herbivorous pests and predators need to be understood to assess the efficiency of the field margin biocoenosis in the suppression of pests (Nyffeler, 1999).

Orb-web spiders (Araneidae) occur on field margins in a high species richness and in considerable densities and thus may be effective predators (Nyffeler and Benz, 1978, 1989; Nyffeler et al., 1987; Barthel, 1997). Studies on trophic interactions of orb-web spiders, i.e., prey selection and prey composition exist for grassland (Kajak, 1965; Nyffeler and Breene, 1991) and arable land (Nyffeler and Benz, 1979; Nyffeler, 1982) but there is still a lack of studies conducted on field margins so far (Nyffeler et al., 1987).

In this study, the potential prey available, the retention efficiency of spider webs, the prey selectivity of spiders as well as the composition and number of the actual prey of spiders, which are biased by the former given parameters (Riechert and Luczak, 1982; Uetz, 1990), were investigated for two orb-web spider species, the garden spider *Araneus diadematus* (Clerck) and the wasp-like spider *Argiope bruennichi* (Scopoli) in two different structured field margin habitats. The aim of the study was the description and the quantitative assessment of interactions between orb-web spiders and potential prey on field margins.

2. Materials and methods

The study was conducted in Swabia and Frankonia (South Germany) in two different field margin habitats adjacent maize fields between July 7 and August 11, 2003. In

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Swabia, the field margin was artificially planted with stinging nettles (*Urtica dioica* L.), birdsfoot trefoil (*Lotus corniculatus* L.), wild mustard (*Sinapis arvensis* L.) and wild carrot (*Daucus carota* L.) in the end of April (field margin A). The field margin in Frankonia was a 9-year-old fallow land dominated by blooming common tansy (*Tanacetum vulgare* L.) (field margin B). Both field margins had a size of approximately 50 m × 7 m. Beside a single fertilisation of nettle plots with nitrogen before planting on margin A, no other agricultural measures were conducted on the field margins. The maize fields adjacent the margins were both sown in the end of April and herbicides but no insecticides were applied in the end of May 2003. The investigation was conducted under the following weather conditions (arithmetic means of daily means ± S.D.): air temperature of 22.95 ± 3.69 °C, wind velocity of 1.15 ± 0.36 m/s and precipitation (arithmetic mean of daily sums ± S.D.) of 1.16 ± 2.23 mm.

The potential prey of orb-web spiders was assessed by malaise and sticky traps. The used malaise trap (Townes, 1962) had a capture area of 1.8 m^2 and the collecting head was filled with 5% acetic acid. The sticky traps were constructed of transparent plastic plates in a size of 30 cm × 30 cm (0.09 m^2) and were covered with a clear film spread with Aurum® sticky, non-drying glue. After exposure on field margins, the films covered with non-drying glue and adhering items were collected. Subsequently, potential prey taxa were picked up from the films and stored in 70% ethanol for identification in the laboratory.

The prey items caught in spider webs as well as the prey consumed by spiders were recorded by direct observation of spiders and their webs for a standardised time period. To generate comparable test conditions, firstly orb-web spiders were kept in wooden frames to allow web building for several weeks in the laboratory before an exposure in the field. Therefore, adult females of *A. diadematus* and *A. bruennichi*, which may occur on field margins frequently (Barthel, 1997), were collected in various field margin habitats. The wooden frames, in which the spiders were housed, had a size of 30 cm × 30 cm. The open sides of the frames were reversibly closed by transparent plastic plates. The plates were spread with vaseline to distract spiders from attaching their webs on the plates (Zschokke and Herberstein, 2005). Spiders were fed with *Drosophila* flies and supplied with water every day. During the subsequent exposure in the field, the frames with spider webs and spiders were installed on metal posts in different heights according the natural vertical stratification of the spider species: frames with *A. diadematus* were established in a height of 80 cm, frames with *A. bruennichi* in a height of 20 cm (Nyffeler, 1982).

The field experiment was conducted during 3 days for each spider species and field margin habitat. On each experimental day, three to four wooden frames inclusive webs and spiders were exposed and observed 7 h a day from 1100 to 1800 h giving a total of 154 web hours (three to four spiders × 7 h × 3 days × two spider species, see Uetz, 1990). Spider webs were observed from a distance of 1.5–2 m to minimise a disturbance of potential prey and spiders. Simultaneously with the frames, malaise and sticky traps were installed. A malaise trap was set up in each field margin habitat, parallel oriented to the exposed frames. Altogether, 12 malaise trap samples were taken (one malaise trap sample × 3 days × two field margin types × two spider species). Additionally, sticky traps were established in a distance of 15–20 cm to each exposed wooden frame on both field margins. However, during the observation of *A. diadematus* on field margin A, only the malaise trap was installed. A total of 35 sticky trap samples were taken. For recording the potential prey of *A. diadematus*, 11 sticky trap samples were collected (three to four sticky trap samples × 3 days × one field margin type) and 24 sticky trap samples for *A. bruennichi* (four sticky trap samples × 3 days × two field margin types). All prey items which got entangled in spider webs, were eaten by the spiders and were sampled by malaise and sticky traps were counted and classified into the following taxonomic groups: Heteroptera, Sternorrhyncha, Coleoptera, Apidae, other Hymenoptera, Diptera and other taxa. As spiders ingest small prey items by web "recycling" without attacking, prey adhering on the web after the exposure duration was assigned to actually eaten prey (Nyffeler, 1982; Nentwig, 1985).

2.1. Statistical analysis

Analysis of variance (ANOVA) was conducted with the independent variables "prey" (seven different taxonomic groups) and "field margin habitat" ("field margin A" and "field margin B") as well as with the dependent variable "numbers of eaten prey" for both spider species separately. To test the homogeneity of variances, Sen and Puris non-parametric tests were conducted. Kolmogorov–Smirnov one-sample test was used for testing the normal distribution of data. The dependent variable was $\log x + 1$-transformed to create a normal distribution and the homogeneity of variance of the data set. Post hoc comparisons were conducted with the least significance differences (L.S.D.) test. ANOVA and L.S.D. tests were calculated using the software Statistica 5.0. All average values presented are arithmetic means ± 1 S.D. and the tests used are two-sided.

The prey retention efficiency of spider webs and the prey selectivity of spiders was analysed with indices based on the forage ratio (Savage, 1931 cited in Manly et al., 2002). The retention efficiency of webs was defined as the frequency of the prey groups caught in the spider webs divided by the frequency of these groups recorded as potential prey. Accordingly, the prey selectivity of spiders was defined as the frequency of prey groups eaten by the spiders divided by the frequency of these prey groups caught in spider webs. The significance of the retention efficiency of webs and the selectivity of spiders was evaluated by the Chi-square statistic for designs with known proportions of available