Herbivores Suppression by Generalist Predators in Desert Agroecosystems

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By

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ABSTRACT

Agricultural landscapes are heterogeneous ecosystems that consist of a mosaic of patches in time and space and consist of both arable and non-arable components. Arthropods living in arable annual crops suffer mortality caused by agricultural practices such as tilling, harvest and pesticide applications. In such systems, natural enemies must survive in the fields between successive cropping seasons, or re-colonize the crop fields from the surrounding natural habitats each season. Therefore, migration from surrounding habitats is crucial in order to maintain populations of natural enemies of insect pests in crops. The goal of my research was to investigate the role of spiders (Arachnida: Araneae) as natural enemies of insect pests in a desert agroecosystem, and to understand the spatial dynamics of spiders in arid agroecosystems.

Desert agroecosystems differ from temperate ones in their pronounced contrast between crop and natural habitats, where irrigated and fertilized crops are islands of high productivity in an arid matrix. These contrasting conditions between arable and non-arable habitats in arid regions could either enhance or hamper movement of spiders between these landscape components. Therefore I assumed that the potential for pest suppression by spiders will be influenced by the movement patterns of spiders between the natural desert habitats and crop fields. Furthermore, I suggested that availability and density of additional non-pest prey and the presence of other predators will affect pest suppression by spiders in the system.

Initially, I examined the importance of the surrounding arid habitats as a source of spiders in wheat crops in the Negev desert of Israel. To do so, I sampled spiders in both arid natural habitat and adjacent wheat fields using pitfall traps and visual searches. In addition, I sampled spiders in wheat fields during winter, using emergence traps at increased distance from the field edge. I used stationary and movable emergence traps to distinguish between crop resident species from those that migrant into the fields from surrounding habitats. I found that the spider assemblage in wheat was dominated by three families: Linyphiidae, Theridiidae and Gnaphosidae, and recognized four functional groups that differ in habitat preference, movement patterns and population dynamics. Thirty three percent of the collected individuals were classified as crop residents, whereas more than 50% were migrants from the surrounding habitats. Spider assemblage in wheat fields was dominated by migrant

species that arrive from the surrounding natural habitats and inhabit the crop throughout the season. From extensive sampling I concluded that the surrounding habitats influence the composition of spider assemblage in the fields, in spite of the marked contrast in structure and productivity between the adjacent managed and natural habitats. I proposed that the combined contribution of resident and migrant functional groups could potentially suppress insect pest populations in this desert agroecosystem.

To test this suggestion, I examined the consumption of the bird cherry-oat aphid, *Rhopalosiphum padi* L. (Homoptera: Aphididae), an aphid pest in wheat fields, by three numerically-dominant spider species from both the migrant and resident functional groups. In a 48-hour microcosm experiment, the resident species *Mermessus denticulatus* (Banks) (Araneae: Linyphiidae; Erigoninae) consumed more aphids than another resident species *Bathyphantes cf. extricatus* (O.P.-Cambridge) (Araneae: Linyphiidae; Linyphiinae) and a migrant species *Enoplognatha gemina* Bosmans & Van Keer (Araneae: Theridiidae). The difference in aphid consumption may be due to the ability of erigonid spiders to forage actively on the vegetation in addition to using their webs to catch prey. Next, I tested the effect of density of an additional non-pest prey on the ability of the *M. denticulatus* to reduce aphid populations. In a seven-week microcosm experiment, I provided springtails (*Sinella curviseta* Brook (Collembola: Entomobryidae)) in high and low densities as additional prey to mated erigonids before introducing aphids into the system. I found that spiders in the low-density springtail treatment built more webs on the vegetation, and caused a 50% reduction in aphid populations compared to controls with no spiders. Yet aphid abundance was not reduced significantly by spiders in the high-density springtail treatment. I concluded that availability of additional prey reduces aphid suppression by the spider, but only under intermediate levels of food supplementation. Erigonids, which occur in high densities in wheat fields in the Negev desert, may be involved therefore in aphid suppression in these agroecosystems.

To test whether spiders suppress aphid pests in arid agroecosystems, I established an open-top cage experiment in the field, and compared the influence of aerial migrants, crop residents, and the entire spider assemblage on aphid populations. I used open-topped cages to minimize cage-effect on microclimatic conditions. Yet the spiders managed to overcome physical barriers constructed around the openings and moved in and out of cages. As a result, a low number of spiders was found in the treatment cages at the end of the experiment, spiders were found in control cages, and spider density was similar in all cages ate the end of the experiment. It is not possible, therefore to determine whether spiders had a negative impact on aphid populations in my experiment. I found, however, that the number of coccinellid egg clusters deposited in the cages was correlated positively with the number of spiders found at the end of the experiment in cages assigned to the resident functional group treatment. This could result from intraguild interactions between specific spider functional groups, other predators and coccinellid beetles, yet this hypothesis remain to be studied.

Finally, I developed a spatially-explicit individual-based model to test the effect of spider dispersal mode (cursorial or aerial) and habitat preference on the abundance of spiders in cultivated fields over the cropping season. Simulation output was then used as an aid in the interpretation of spider abundance patterns found in the field. I modeled the spatial and temporal dynamics of different spider functional groups during one crop cycle. I calculated the population size and distribution across the crop in the end of the season for each functional group and then compared population dynamics in wheat from the field study with population dynamics obtained from the model. I found that spider dispersal mode plays a major role in determining spider abundance in fields. I concluded however, that species-specific data on life history traits and on movement characteristics are needed in order to make the model more realistic. A more realistic model could then be used to optimally design the spatial arrangement of arid agroecosystem that would maximize prey suppression by generalist predators.

To summarize, wheat fields in the Negev desert of Israel may benefit from biological control as an ecosystem service provided by natural enemies migrating from the surrounding arid natural habitats. The spider assemblages in wheat fields, consisting of migrant and crop resident species, were shown to consume insect pests in microcosm experiments. Yet the extent to which spiders could suppress insect pests in arid agroecosystems is affected by biotic and abiotic factors, such as availability of additional prey and spider mobility that were tested in the present study. Additional field research is clearly needed to gain mechanistic understanding of the effect of complex trophic interactions on pest populations in arid agroecosystems.

Key words: Aphididae, Araneae, Arthropods, Assemblage, *Bathyphantes extricatus*, Cages, Coccinellidae, Collembola, Dispersal, Emergence Traps, *Enoplognatha gemina*, Erigoninae, Entomobryidae, Foraging, Functional Groups, Generalist Predators, Gnaphosidae, Habitat Contrast, Individual Based Model, Linyphiidae, *Mermessus denticulatus*, Movement Patterns, Multivariate Analysis, Natural Arid Habitats, Negev Desert, Pest Suppression, Pitfall Traps, Predator-Prey Interactions, *Rhopalosiphum padi*, *Sinella curviseta*, Springtails, Theridiidae, *Triticum aestivum*, Visual Search, Wheat.