

OVERVIEW OF THE ROLE OF GENERALIST PREDATORS IN BIOLOGICAL CONTROL

Matthew H. GREENSTONE¹ and Robert S. PFANNENSTIEL²

¹ Insect Biocontrol Laboratory, USDA-ARS
10300 Baltimore Avenue
Beltsville, Maryland 20705, U.S.A.
greenstm@ba.ars.usda.gov

² Beneficial Insects Research Unit, USDA-ARS
2413 E. Highway 83
Weslaco, Texas, 78596, U.S.A.
rpfannestiel@weslaco.ars.usda.gov

SESSION 9 INTRODUCTION

The subject of generalist predators in biological control is rich, diverse, and stimulating. It is also frustrating, providing ample grounds for enthusiasm for their potential as significant agents of pest population suppression, along with well documented examples of near successes and patent failures. On the basis of ecological theory and extensive meta-analyses of the literature, generalists are apt to be, and have been *found* to be, significant biocontrol agents in many situations (Murdoch *et al.* 1985; Change & Kareiva 1999; Greenstone & Sunderland 1999; Symondson *et al.* 2002). Nevertheless the devil is in the details of habitat, crop phenology, interspecific interactions, and weather, and we are still trying to work out the conditions for success in employing generalist predators for biocontrol.

The broad selection of papers in this session nicely illustrates some of the challenges facing us as we struggle to discover the determinants of such success. Kindelmann and colleagues (this volume), who some might consider to have crashed the party by discussing a group of predators that are more narrowly stenophagous than most of those under discussion, show by means of a removal experiment that two coccinellid species do not reduce the peak numbers of their aphid prey, reinforcing what is becoming a depressing consensus that coccinellids are not effective regulators of pest populations. Furthermore, Harwood & Obrycki (this volume) find that one of those two species, *Harmonia axyridis* (Pallas), is more fit on a pure aphid diet than a mixed lepidopteran one. Being thus averse to using alternate prey as part of a "lying-in-wait" strategy until aphids arrive, coccinellids may be predisposed to avoid crops until aphids are too abundant to control, another blow to their potential effectiveness as pest population regulators.

On the other hand Harwood & Obrycki (this volume) find that the linyphiid spider *Erigone autumnalis* (Emerton) is unable to survive to adulthood on a pure pest (aphid or leaf hopper) diet, requiring a mixed diet including collembolans and flies to reach maturity. It is thus well suited to the lying-in-wait strategy, able to subsist on a variety of other insects until

pests arrive. However, because it prefers non-pest alternate prey to pests, it is probably less effective than it might otherwise be in regulating pest populations. This is exacerbated by the fact that in the alfalfa system studied by Harwood and Obrycki, pests and alternate prey tend to covary in abundance, rising or falling simultaneously. This is different from the verbal model that biocontrol practitioners like to use to describe the lying-in-wait strategy, in which high alternate prey numbers early in the season sustain predators until pest populations build up later.

Spiders are iconic generalists. In their study of the influence of landscape on spider species richness and biocontrol, Schmidt *et al.* (this volume) find that wheat field spider species richness is more strongly affected by the proportion of perennial non-crop habitats in the surrounding landscape than by the presence of directly adjoining non-crop habitats. The proportion of non-crop habitats in the surrounding habitats also influenced spider densities, with the most important spatial scale being smaller (0.19 – 0.53 km) for lycosids, which tend to walk, than for linyphiids (up to 3.0 km), which are more apt to balloon to and from overwintering sites. Knowledge of the influence of the surrounding landscape is important, because spiders may significantly depress aphid densities in this system; unfortunately, since spider densities fluctuate greatly from year to year, they may not be dependable regulators of aphid populations.

But as anyone who has followed coccinellids around a crop field or counted cereal aphids in linyphiid webs knows, even predators that show up too late to an infestation to single-handedly control a pest infestation, or that would rather eat detritivores than pests, can still dispatch phenomenal numbers of pests. They may therefore make significant contributions to pest control despite a few disappointing attributes. Pfannenstiel (this volume) remind us to think about the entire assemblage of generalists rather than focusing on particular groups of predators. He finds that there is strikingly little overlap in the nocturnal and diurnal predator assemblages of lepidopteran eggs in annual crops in the southern USA. He also discovers that spiders are prominent among the nocturnal assemblage, accounting for almost a quarter of egg mortality by a diverse suite of arachnid and insect predators operating at night. Besides showing that generalist arthropod predators impose very high mortality on lepidopteran eggs, Pfannenstiel (this volume) reminds us that there is a great deal that we still do not know about diel periodicity in predators and the relative importance of diurnal vs. nocturnal predation. Greenstone & Roberson (this volume) show that we also know almost nothing about the role of immature predators.

Snyder & Straub (this volume) find that the assemblage of predators attacking *Myzus persicae* (Sulzer) in potatoes is very diverse. In an experiment designed specifically to determine whether there is more or less intraguild complementarity or interference in assemblages made up of different specific predator species, they find that complementarity or interference effects do not affect aphid suppression. However, the identity of predators does, with a coccinellid being more effective than a thomisid spider in suppressing aphids.

Generalist predators are diverse and abundant, and it is critical that we define their role in both agricultural and natural systems. Predation events tend to happen cryptically and infrequently, and there have been significant obstacles to our ability to quantify and characterize predation in usually complex trophic webs. In this necessarily short collection of pa-

pers, we have been unable to highlight any of the exciting work on molecular gut analysis that is transforming our ability to study and understand the role of predators in biological control (Zaidi *et al.* 1999; Chen *et al.* 2000; Hoogendoorn & Heimpel 2001; Harper *et al.* 2005). Molecular techniques, in combination with the kinds of carefully designed experiments (Kindelmann *et al.*; Snyder & Straub) and exhaustive direct observation (Pfannenstiel) illustrated in this session, will facilitate our understanding of predator impact and ecology, and improve our potential for successfully manipulating them for biological control.

ACKNOWLEDGMENTS

We thank Ulli Kuhlmann and Mark Hoddle for inviting us to organize this session, the participants for their stimulating presentations and cooperation in assembling the manuscripts, and Heike Kuhlmann for all of her assistance before and during the Symposium in Davos.

REFERENCES

- Chang, G. C., and Kareiva, P. 1999. The Case for Indigenous Generalists in Biological Control. In "Theoretical Approaches to Biological Control" (B. A. Hawkins, and H. C. Cornell, Eds.), pp. 103-115. Cambridge University Press, Cambridge, UK.
- Chen, Y., Giles, K. L., Payton, M. E., and Greenstone, M. H. 2000. Identifying key cereal aphid predators by molecular gut analysis. *Molecular Ecology* 9:1887-1898.
- Greenstone, M. H., and Sunderland, K. D. 1999. Why a symposium on spiders in agroecosystems now? *Journal of Arachnology* 27, 267-269.
- Harper, G. L., King, R. A., Dodd, C. S., Harwood, J. D., Glen, D. M., Bruford, M. W., and Symondson, W. O. C. 2005. Rapid screening of invertebrate predators for multiple prey DNA targets. *Molecular Ecology*, (in press).
- Hoogendoorn, M., and Heimpel, G. E. 2001. PCR-based gut content analysis of insect predators: using ribosomal ITS-1 fragments from prey to estimate predation frequency. *Molecular Ecology* 10, 2059-2067.
- Murdoch, W. W., Chesson, J., and Chesson, P. L. 1985. Biological control in theory and practice. *American Naturalist* 125, 344-366.
- Symondson, W. O. C., Sunderland, K. D., and Greenstone, M. H. 2002. Can generalist predators be effective biocontrol agents? *Annual Review of Entomology* 47, 561-594.
- Zaidi, R. H., Jaal, Z., Hawkes, N. J., Hemingway, J., and Symondson, W. O. C. 1999. Can the detection of prey DNA amongst the gut contents of invertebrate predators provide a new technique for quantifying predation in the field? *Molecular Ecology* 8, 2081-2088.