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FINAL REPORT

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**Parasitoid Movement between Habitats and Biological
Control of Aphid Pests**

K.R. Hopper, M. Coll, P. Ode

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Project Title: Parasitoid movement between habitats and biological control of aphid pests

Investigators

Institutions

Principal Investigator (PI):

Keith R. Hopper

Beneficial Insect Introduction
Research Unit, USDA, ARS,
Newark, DE, USA

Co-Principal Investigator (Co-PI):

Moshe Coll

Dept. of Entomology, Faculty of
Agric., Food and Environ. Sciences,
The Hebrew Univ. of Jerusalem,
Rehovot, Israel

Collaborating Investigators:

Paul Ode

Beneficial Insect Introduction
Research Unit, USDA, ARS,
Newark, DE, USA

Keywords cotton, wheat, broccoli, watermelon, butternut squash, pumpkin, melon, *Aphis gossypii*, *Rhopalosiphum padi*, *Rhopalosiphum maidis*, *Schizaphis graminum*, *Aphis gossypii*, *Brevicoryne brassicae*, *Lipaphis erysimi*, *Aphidius colemani*, *Diaeretiella rapae*, *Aphelinus*, *Lysiphelbus*, host acceptance, host suitability, parasitoid host range, host plant attraction

Abbreviations commonly used in the report, in alphabetical order: none.

Budget: IS: \$129,000

US: \$151,000

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Signature
Principal Investigator

Signature
Authorizing Official, Principal Institution

Signature
Authorized Departmental Officer

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Publication Summary (numbers)

	Joint IS/US authorship	US Authors only	Israeli Authors only	Total
Refereed (published, in press, accepted)	1			1
Submitted, in review, in preparation	3			3
Invited review papers				
Book chapters				
Books				
Master theses			1	1
Ph.D. theses				
Abstracts				
Not refereed (proceedings, reports, etc.)				

Postdoctoral Training: List the names and social security/identity numbers of all postdocs who received more than 50% of their funding by the grant.

Cooperation Summary (numbers)

	From US to Israel	From Israel to US	Together, elsewhere	Total
Short Visits & Meetings	1	1		2
Longer Visits (Sabbaticals)				

Description of Cooperation:

Cooperation was indispensable for this project. The field work was done in Israel, but much of the identification and counting of field samples was done in the US. Complementary experiments on *A. colemani* were conducted in both countries, those in the US depended crucially on parasitoids collected in Israel. Finally, experimental design and interpretation of results was done cooperatively and the interaction was quite synergistic.

Patent Summary (numbers)

	Israeli inventor (s) only	US inventor (s) only	Joint IS/US inventors	Total
Submitted				
Issued (allowed)				
Licensed				

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Abstract. Aphids, like *Aphis gossypii*, *Myzus persicae*, and *Rhopalosiphum padi*, are major pests on crops. Increasing the efficacy of naturally occurring parasitoids through habitat management could provide a cost-effective, safe, and sustainable method for control of these aphid pests. However, to develop effective habitat management, we must learn more about dispersal of natural enemies among crops and about variation in prey/host ranges within natural enemy species. We planned to study these issues using the parasitoid *Aphidius colemani*, which is a major natural enemy of *A. gossypii*, *D. noxia*, and *M. persicae* across a variety of crops. Using observations and laboratory and field experiments, we planned to (1) determine the temporal and spatial dynamics of *A. colemani* on *A. gossypii*, *D. noxia*, and *M. persicae* in crop and non-crop host plants; (2) measure dispersal of *A. colemani* among crops and between non-crop and crop host plants; (3) measure genetic differentiation of neutral markers in *A. colemani* over time among various host plants and aphids; and (4) measure the ability of *A. colemani* to attack and develop in aphid species other than the one from which it emerged. However, we found that *A. colemani* moved little among aphid and host plant species. Indeed, populations of *A. colemani* on *A. gossypii* and *R. padi* appear to be sibling species which are reproductively incompatible and have different host ranges. Thus, we modified objective 1 to include sampling all parasitoids of aphids on a range of host plant species in two regions of Israel, the Judean plain and Jezreel valley. We de-emphasized objectives 2 and 3, and expanded objective 4 to include measurements of differences among species/populations in the *A. colemani* complex. We surveyed the distribution and abundance of aphid parasitoids among host plants and seasons in two regions of Israel (Judean plain and Jezreel valley). Contrary to our original hypothesis, parasitoid species often do not move among aphid and host plant species. For *A. colemani*, this failure to move among aphid and host plant species arises because the parasitoid species is actually complexes of sibling species with different host use patterns. In the regions studied in Israel, *A. colemani* occurred in high numbers almost exclusively on cereal aphids, like *R. padi*, in wheat, although this parasitoid was occasionally reared from other aphids and host plants, including *A. gossypii* in cotton. The preference of *A. colemani* depended on the aphid and host plant species from which it was obtained. Indeed, *A. colemani* from *R. padi* appears to be a different species than *A. colemani* from *A. gossypii*, based on host use, molecular markers, and reproductive compatibility. Our results show it is important to keep specific non-crop vegetation as parasitoid source near fields to enhance biological control. This vegetation must not harbor aphid species that may move onto crops but instead be infested with other aphids attacked by parasitoid of the aphids that are pests in the crop. Because host use patterns vary among populations and sibling species of parasitoids, host use of a target aphid must be verified for the parasitoid population proposed for conservation or augmentation biocontrol.

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Significance of main scientific achievements

The major scientific contribution of this project is the clear demonstration that parasitoid species often do not move among aphid and host plant species, contrary to our original hypothesis. In part, this is because global host range of a parasitoid species may reveal little about host use in a particular location. For *Aphidius colemani* (Hymenoptera: Braconidae), this failure arises because the parasitoid species is actually complexes of sibling species with different host use patterns. In the regions studied in Israel, *A. colemani* occurred in high numbers almost exclusively on cereal aphids, like *Rhopalosiphum padi* (Homoptera: Aphididae), in wheat, although this parasitoid was occasionally reared from other aphids, including *Aphis gossypii* (Homoptera: Aphididae) in cotton. The preference of *A. colemani* depended on the aphid and host plant species from which it was obtained. Indeed, *A. colemani* from *R. padi* appears to be a different species than *A. colemani* from *A. gossypii*, based on host use, molecular markers, and reproductive compatibility. Furthermore, different parasitoid taxa dominated aphid parasitism on different host plants species -- *Aphidius* spp. on wheat, *Lysiphlebus* spp. on cotton, *Aphelinus* spp. on cucurbits, and *Diaeretiella rapae* on crucifers. This segregation could result from (1) host species preferences of parasitoids, (2) host-plant preferences of parasitoids, (3) different responses to climatic conditions and host plant phenology (wheat and broccoli in winter, cotton in spring, squashes in summer), or (4) competition between parasitoids that has different outcomes on different plant species.

To reach these conclusions, we carried out three major studies: (1) we surveyed the distribution and abundance of aphid parasitoids among host plants and seasons in two regions of Israel (Judean plain and Jezreel valley); (2) we measured the effect of aphid-host plant combination on which parasitoids were reared and to which parasitoids were exposed on the attraction of these aphid-host plant combinations and the number of parasitoid progeny produced on them; (3) we measured host acceptance and suitability patterns of three species/populations of *Aphidius colemani* from different aphid-host plant species sources.

To determine whether parasitoid species were moving among aphid and host plant species, we surveyed abundances in a variety of crop and non-crop host plants in two regions of Israel: the Judean plain and the Jezreel valley. If parasitoid species were moving among aphid and host plant species, we would expect to find the same parasitoid

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species across aphid and host plant species. If we found this pattern, it would not necessarily mean that there was significant movement of parasitoids among aphids and host plants. However, if the taxa of parasitoids differed among aphids and host plants, this would mean that the parasitoids could not be moving among them. During 1999-2001, 440 samples of aphids were collected in 35 sites with a total of 30 host plant species in the two regions. These contained 17 aphid species which yielded over 13,000 parasitoid specimens in at least 11 species. The species composition of aphid parasitoids differed greatly among aphid species. Contrary to our expectation there was very little sharing of parasitoid taxa among aphid species, although the same taxa often did attack the same aphid species across several different host plant species. In an analysis of parasitoid guild structure of two aphid species, *Brevicoryne brassicae* and *Lipaphis erysimi*, in broccoli, *Diaeretiella rapae* constituted 81 and 75% of all parasitoids (including hyperparasitoids) recovered from *B. brassicae* and *L. erysimi*, respectively. *Aphidius* species were also represented at low levels. *Diaeretiella rapae* did not attack other aphid species in neighboring non-cruciferous crops; aphids in wheat and cotton were attacked primarily by *Aphidius* and *Lysiphlebus* species, respectively. Another factor that hampered parasitoid population build-up in broccoli was the action of hyperparasitoids, which were active throughout the broccoli-growing season (November-March).

For populations of *Aphidius colemani* originally collected from *Rhopalosiphum padi* in wheat and from *Aphis gossypii* in peppers, we measured the effect of aphid (*A. gossypii*, *R. padi*, and *Myzus persicae*) and host plant species (cucumber, pepper, radish, and wheat) on which parasitoids were reared and to which they were exposed (*A. gossypii*, *R. padi*, and *Myzus persicae*; pepper, radish, and wheat) on aphid-host plant attraction, numbers of aphids parasitized and adult progeny, and progeny body size. Both rearing aphid-plant combination and exposure aphid-plant combination affected all four variables measured. Wasps did better on the aphid-plant combination on which they were reared, except for wasps from *R. padi* on wheat which did better on other aphid-plant combinations. In another experiment with *Aphidius colemani* originally collected from *Aphis gossypii* in peppers, female parasitoids parasitized fewer *R. padi* than *A. gossypii*, *M. persicae*, and *Schizaphis graminum*, and fewer offspring successfully completed development in *R. padi* than in the other three host species. Parental host

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affected maternal body size and, through its effect body size, rate of encounter with hosts; otherwise, parental host species did not affect parasitism. Sex ratios of emerging adults were more male biased from *R. padi* than from the other three aphid species, suggesting that *R. padi* is a poor quality host for this population of *A. colemani*. Ovipositing *A. colemani* encountered *R. padi* at a slower rate, spent more time handling *R. padi*, and parasitoid offspring died at a higher rate in *R. padi* compared to *A. gossypii*. Thus our results indicate that oviposition behavior and offspring performance are correlated.

Finally, we compared host use patterns for *A. colemani* from three different sources: a field collection from *R. padi*, the other two from commercial insectary cultures originally collected and subsequently reared on *A. gossypii*. Both wasp source and aphid species affected number of aphids parasitized and number of adult progeny. These differences arose because of differences in encounter rate, acceptance for oviposition, and progeny survival.

Agricultural impacts of the research findings Our results show it is important to keep specific non-crop vegetation as parasitoid source near fields to enhance biological control. This vegetation must not harbor aphid species that may move onto crops but instead be infested with other aphids attacked by parasitoid of the aphids that are pests in the crop. Because host use patterns vary among populations and sibling species of parasitoids, host use of a target aphid by the parasitoid population to be used for conservation or augmentation biocontrol must be verified.

Details of cooperation

Cooperation was indispensable for this project. The field work was done in Israel, but much of the identification and counting of field samples was done in the US.

Complementary experiments on *A. colemani* were conducted in both countries, those in the US depended crucially on parasitoids collected in Israel. Finally, experimental design and interpretation of results was done cooperatively and the interaction was quite synergistic.

List of Publications:

Coll M, Hopper KR. 2002. Guild structure of aphid parasitoids in broccoli: influence of host and neighboring crops. In: Proceedings of the 4th International Workshop on the Management of Diamondback Moth and Other Crucifer Pests. P. Ridland (ed). 26 - 29 November 2001, University of Melbourne, Victoria, Australia.