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**Two Predator Model Systems for the Biological
Control of Diaspidid Scale Insects**

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Two Predator Model System for the Biological Control of Diaspidid Scale Insects GRANT IS-2359-93

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Abstract

Hemisarcoptes (Acari: Hemisarcoptidae) is a parasite of scale insects (Diaspididae), tenacious pests of vascular plants. *Hemisarcoptes* also has a stenoxenic phoretic (dispersal) relationship with *Chilocorus* (Coleoptera: Coccinellidae). *Chilocorus* feeds on diaspidids, transports mites as they feed, and has been applied to the control of scales, with limited success. U.S.-Israeli cooperation focused on this mite-beetle interaction so that a two-component system could be applied to the control of scale insects effectively.

Life history patterns of *Hemisarcoptes* were investigated in response to host plant type and physical parameters. Field and lab data indicated that mites attack all host stages of scales tested, but preferred adult females. Scale species and host plant species influenced the bionomics of *Hemisarcoptes*. Beetle diet also influenced survival of phoretic mites. Mites use a ventral sucker plate to extract material from *Chilocorus*, that is essential for development. Seven alkaloids were found in the hemolymph of

Chilocorus and three were characterized. Examination of the subelytral surface of *Chilocorus* indicated that microsetae play a role in the number and distribution of mites a beetle transports. While *Hemisarcoptes* can be inoculated into agroecosystems using various indigenous or imported *Chilocorus* species, the following are preferred: *C. bipustulatus*, *C. cacti*, *C. distigma*, *C. fraternus*, *C. orbus*, and *C. tristis*.

Objectives of the Original Research Proposal:

Mites of the genus *Hemisarcoptes* are parasites of scale insects (Diaspididae) worldwide and offer a special opportunity to contribute to the control of these serious pests of perennial vascular plants. The mites occur on all continents, possibly with the exception of the under-studied continent of South America. The beetles are also cosmopolitan, contain about 70 species, and are most prevalent on the African continent.

The life cycle of *Hemisarcoptes* is complex. While most of the members of the ontogeny are parasitic on scale insects, the deutonymphal stage (hypopus) is a dispersal stage which is phoretic on beetles of the genus *Chilocorus*. In order to fully implement the mite in biological control settings, two distinct areas needed to be investigated: 1) the influence of the scale insect and its host plant on the mite bionomics and 2) the influence of the beetle host on the mite survival and dispersal.

This work was funded to investigate the various aspects and patterns of host (scale insect) utilization by the mite *Hemisarcoptes*. And, to understand the phoretic interaction well enough to determine which mite-beetle associations would offer the best combination for biological control.

Effect of Environmental Factors on the Bionomics of Hemisarcoptes

Field and laboratory studies of *Hemisarcoptes coccophagus* indicated that the type and taxon of scale insect influences the bionomics of the mite (Izraylevich et al. 1995, Izraylevich and Gerson 1995b, Houck and OConnor 1996, Gerson and Izraylevich 1997) and its morphology (Houck and OConnor 1998) as does local climatic conditions (Houck and OConnor 1996). Field and lab data concerning *H. coccophagus* and *H. cooremani* indicated that mites would attack all host stages of latania, oleander scale, cactus scale, oriental scale and California red scale but preferred adult females. This preference was density-independent on young females and density-dependent on ovipositing females (Izraylevich and Gerson 1995a). And, scale species and host plant species influenced the feeding pattern of *Hemisarcoptes*.

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A detailed and comprehensive summary of the host utilization by *Hemisarcoptes* can be found in Gerson and Izraylevich (1997).

Hemisarcoptes-Chilocorus Interactions:

Prior to the initiation of this work it was assumed, on morphological criteria, that approximately 50mya deutonymphs of *Hemisarcoptes* formed a co-evolved relationship with *Chilocorus* for the purposes of dispersal among patchy and transient habitats.

Initial behavioral studies, extending from this grant work, indicated that phoretic deutonymphs of *Hemisarcoptes* could not survive in the absence of contact (5-21 days) with beetles of the genus *Chilocorus* (Houck 1994). Radiolabeling studies (Houck and Cohen 1995) indicated that this was due to the fact that hemolymph was extracted from the beetles during mite dispersal. This finding questioned the paradigm that deutonymphs were demographic stages evolved for the purpose of dispersal among temporary habitats, but that the relationship was one of parasitism of the beetle by the mite. This was an important shift in interpretation of the relationship between *Hemisarcoptes* and *Chilocorus*. An extensive model of this evolutionary interplay was developed (Houck 1994, Houck 1998). The work of Ji et al. (1996) further supports this finding as it indicated that the diet of *Chilocorus* (Coccidae vs. Diaspididae) influenced mite survival.

To determine the potential nature of the material now known to be available to the mite, the hemolymph of *Chilocorus* was chemically examined using mass spectroscopy, ultraviolet spectroscopy and NMR techniques. Seven different alkaloids were discovered and three have been characterized: the first was a novel heptacyclic compound (*Chilocorine A*), the second was a unique spirocyclic dimeric alkaloid (*Chilocorine B*), and a third was a different dimeric alkaloid (*Chilocorine C*) (McCormick et al. 1994,

Xiongwei et al. 1995, Huang et al. 1998). These compounds are part of the defensive arsenal used by the beetle to defend itself against predators. *Chilocorus* reflexively bleeds when attacked by predators, directing these caustic chemicals at the intruder. These defensive chemicals were found not to hinder the development of *Hemisarcophaga* which appears to be unaffected by such caustic and toxic products (Houck 1994, Houck 1998).

A second observation (Houck 1994, Izraylevich and Gerson 1995d) indicated that the distribution of *Hemisarcophaga* on the subelytral surface of various species of *Chilocorus* was not random according to beetle species or across the elytral surface of a single beetle of one species. But the pattern could be described according to the patterning of microsetae (Houck 1998, Houck et al. 1998). Using this pattern of setation, beetles could be categorized in terms of acceptability as biocontrol hosts for the dissemination and distribution of mites in agricultural settings. Beetles with many long and dense spines provided little or no access for attachment by the mites. Beetles with some regularly placed areas predictably devoid of spines or with short dispersed spines were the best candidates to seed mites into agroecosystems. Using microsetal characteristics as a criteria, the following beetles would be preferred and should be most successful in the initiation of the mites into areas of high scale density: *C. bipustulatus*, *C. cacti*, *C. distigma*, *C. fraternus*, *C. orbus*, and *C. tristis* (Houck 1998, Houck et al. 1998).

Additional Value Added Component of the Research:

Because astigmatid mites have frequently been found to be produce immuno responses in humans, *Hemisarcoptes cooremani* was examined to see if it presented any potential allergic response on the part of horticulturists or agricultural workers (Moran et al. 1998). *Hemisarcoptes* was found to cause a potential immune response similar to that of the house dust must. This must be considered when mass rearing is considered, and a dust mask is suggested to prevent inhalation of mites proteins and frass.

Description of Cooperation:

The Israeli component of the work focused on the behavior and bionomics of the mite *H. coccophagus*, while the U.S. workers focused mainly on the interaction of *H. cooremani* and its interaction with *Chilocorus cacti*.

Extensive cooperation and collaboration between Texas Tech University and the Hebrew University of Jerusalem resulted in synergist and emergent research. Visits between the collaborators were very advantageous to the sharing and cooperation. The cooperative and congenial manner of interaction enhanced both the scientific knowledge base as well as international good will and lasting friendships. This collegiality was extended through seminar participation publication and cultural exchange. The cooperation has resulted in 20 completed publications and several in preparation.

COMPLETED PUBLICATIONS GENERATED BY GRANT IS-2359-93

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