Impact of Multicolored Asian Lady Beetle as a Biological Control Agent

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The multicolored Asian ladybeetle, *Harmonia axyridis* Pallas (Coleoptera; Coccinellidae), has become a well-known nuisance insect in North America (see other symposium summaries in this issue). Despite these negative aspects, *H. axyridis* also plays a beneficial role by suppressing pests in a variety of cropping systems (Koch 2003). The recent arrival of the soybean aphid, *Aphis glycines* Matsumura (Homoptera: Aphididae) into North American soybean production systems has created a situation in which the positive and negative aspects of this insect are highlighted. Here we discuss some recent studies exploring the role of *H. axyridis* in biocontrol of soybean aphid.

The soybean aphid is a major new invasive pest of soybean (*Glycine max* L.) in North America. First discovered in July 2000 in Wisconsin and adjoining states, it is currently distributed in 21 U.S. states and parts of Canada. In 2003, more than 42 million acres of soybean in the North Central United States were infested, and more than 7 million acres were treated with insecticides to control *A. glycines* (Landis et al. 2003). Populations exceeding 24,000 aphids per plant and 40% losses in seed yield have been reported (DiFonzo and Hines 2002). *Aphis glycines* overwinters on plants in the genus *Rhamnus* (buckthorn), with summer generations occurring on soybean. The exotic invasive shrub *Rhamnus cathartica* appears to be the key overwintering host for *A. glycines* in Michigan. Fall migration to *R. cathartica* by *A. glycines* gynopare and production of oviparae and overwintering eggs in the field has been observed with subsequent production of fundatrices and alate viviparous females and migration to soybean the following spring (Ragsdale et al. 2004). Alates arrive in soybean in early- to mid-June, soon after crop emergence (Fox 2002).

Natural enemies play a key role in suppressing soybean aphid populations (Fox et al. 2004). In China, where soybean aphid outbreaks are rare, coccinellids are among the most common natural enemies; however, soybean aphid colonies also typically experience parasitism rates of 40% (G. Heimpel, University of Minnesota personal observation). In the United States, 22 predator taxa are reported to attack soybean aphid, with generalist predators including *Harmonia axyridis, Coccinella septempunctata,* and *Orius insidiosus* dominating the natural enemy community (Fox and Landis 2003, Rutledge et al. 2004). The arrival of the soybean aphid in North America has created a vast new prey base for *H. axyridis* in soybean, a habitat formerly devoid of aphid prey. In soybean aphid outbreak years, soybean fields support large numbers of *H. axyridis* that can subsequently cause problems for homeowners and fruit producers.

In 2001-2003, we conducted a series of predator exclusion trials to examine the influence of predation on soybean aphid populations. In early season trials in 2001-2002, we used clip cages to protect establishing aphids from predation for 24 h (Fox and Landis, unpublished); for midseason trials, we used 1-m^3 field cages to investigate predator impacts on aphid population growth over 7 days (Fox et al., in press). In 2004, *H. axyridis* constituted 66% of the early season predator community, with all predators combining to reduce aphid density by 26-56% over exclusion cages. However, in 2002, *H. axyridis* emerged before aphids were present, and adults did not remain in soybean. In midseason trials, *H. axyridis* had recolonized fields and constituted 57% of the total predator community in 2001, contributing to a 54% reduction in aphid abundance. In 2002 and 2003, predator reduction of aphid density was very high (>90 in both years). In 2002, *H. axyridis* was the second most abundant

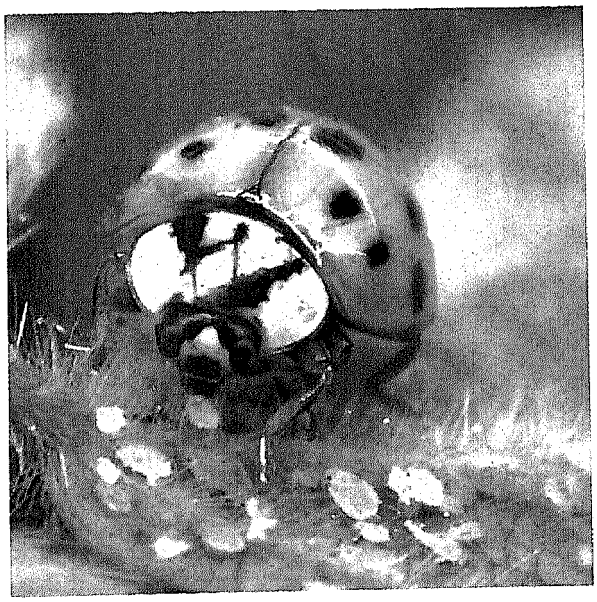

Fig. 1. Multicolored Asian lady beetle (*Harmonia axyridis* Pallas) attacking soybean aphid (*Aphis glycines* Matsumura) (Photo: D. A. Landis).

predator, constituting 25% of the community; whereas in 2003, it only represented 10%.

These studies suggest that *H. axyridis* is a variable but important part of the natural enemy community of soybean aphid. The overall predator community appears quite important in suppressing *A. glycines*, causing a 21-56% reduction in early season aphid establishment and a 54-95% reduction in midseason aphid population growth.

In 2003, a study in Michigan investigated the relative strength of top-down (natural enemies) versus bottom-up (plant effects) regulation of soybean aphid. Plant quality was varied using three agronomic treatments with aphid and predator populations sampled in each plot weekly throughout the summer. Aphid populations were 3- to 7-fold greater in the predator exclusion versus the sham or no-cage treatments, indicating a strong top-down effect, while the bottom-up signal was relatively weak and inconsistent. The natural enemy community in these trials primarily comprised *H. axyridis, C. septempunctata,* and *O. insidiosus* (ACC and DAL, unpublished data).

Overall, predator communities appear to exert consistent top-down suppression of *A. glycines* in Michigan; however, this is not always sufficient to prevent aphid outbreaks. Adult *H. axyridis* foraging in soybean in the early season appear to be important in reducing establishment of *A. glycines* and the rate at which colonies expand. If aphid densities increase to where they stimulate *H. axyridis* oviposition, the feeding of *H. axyridis* larvae appears to be an important factor in causing population crashes. There is a need to further understand the role of *H. axyridis* in suppression of the soybean aphid. In particular, the potential for *H. axyridis* to act as an intraguild predator, disrupting biocontrol by native or introduced parasitoids, should be investigated.

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Nontarget Effects of the Multicolored Asian Lady Beetle (Coleoptera: Coccinellidae): Case Study with the Monarch Butterfly (Lepidoptera: Nymphalidae)

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Exotic organisms often have adverse ecological effects in the habitats they invade. The multicolored Asian lady beetle, *Harmonia axyridis* (Pallas), is no exception. After the initial detection of *H. axyridis* in the southeastern United States, this exotic coccinellid rapidly expanded its range to cover much of the continental United States and southern Canada (Koch 2003). The voracious, generalist feeding behaviors of *H. axyridis* make it particularly likely to have adverse effects on insects that are not considered pests (which we classify as nontarget species).

Koch (2003) reviewed the known nontarget prey of *H. axyridis*. Most studies on nontarget impacts of *H. axyridis* have focused on intraguild interactions, primarily predation on various developmental stages of other coccinellid species such as *Adalia bipunctata* (L.), *Adonia variegata* (Goeze), *Coleomegilla maculata* (DeGeer), *Coccinella septempunctata* L., *C. s. brucki* Mulsant, *Cycloneda sanguinea* L., *Propylea japonica* (Thunberg), and *P. quatuordecimpunctata* (L.). In addition to coccinellids, *Chrysoperla carnea* Stephens has been documented as an intraguild prey of *H. axyridis*. A paucity of literature exists on predation by *H. axyridis* on nontarget insects outside the guild of generalist predators. However, through the use of laboratory and field studies, Koch et al. (2003) identified *H. axyridis* as a potential hazard to monarch butterflies, *Danaus plexippus* (L.).

To more thoroughly evaluate the risk of *H. axyridis* having an adverse effect on a nontarget species, a tool such as ecological risk assessment can be used. In this context, risk is defined as the joint probability of exposure and effect (NRC 1983). Exposure is the probability of temporal and spatial co-occurrence of the exotic predator and the nontarget prey. Effect is the probability of the predator feeding on the nontarget organism, if they co-occur. Here we present an overview of a risk assessment to evaluate the impact of *H. axyridis* on *D. plexippus*.

Case Study

Danaus plexippus is a summer resident of the upper Midwest. In this region, the primary host plant for larvae is common milkweed, *Asclepias syriaca* L. *A. syriaca* is a ubiquitous weed in many of the agricultural systems in which *H. axyridis* has become abundant, particularly in corn and soybean fields. This creates a situation where *D. plexippus* may be exposed to *H. axyridis*.