

HIPPODAMIA VARIEGATA (GOEZE) (COLEOPTERA: COCCINELLIDAE) DETECTED IN MICHIGAN SOYBEAN FIELDS

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ABSTRACT

Since its initial detection near Montreal, Canada in 1984, the variegated lady beetle *Hippodamia variegata* (Goeze) (Coleoptera: Coccinellidae) has spread throughout the northeastern United States. In 2005, this immigrant Old World species was detected in Michigan for the first time. Twenty-nine adults were found in soybean fields in 4 counties: Ingham, Gratiot, Kalamazoo, and Saginaw. The first individuals were found in Gratiot County on 22 June 2005; we continued to detect individuals until 18 Aug 2005 (2 individuals collected in Saginaw Co.) when sampling ended. Prior to this study, *H. variegata* had not been known to prey on the soybean aphid, *Aphis glycines* Matsumura (Homoptera: Aphididae). The establishment of soybean aphid throughout the north-central U.S. may aid the spread of *H. variegata* throughout the region.

INTRODUCTION

The use of exotic lady beetles (Coleoptera: Coccinellidae) in classical biological control projects was fueled by the early success of the vedalia beetle, *Rodolia cardinalis* (Mulsant), introduced from Australia to suppress populations of the cottony cushion scale, *Icerya purchasi* Maskell (Homoptera: Monophlebidae), in California in 1889. Since this early biological control effort, many exotic lady beetles have been released in North America, including *Coccinella septempunctata* L., *Harmonia axyridis* (Pallas), *Propylea quatuordecimpunctata* (L.), and *Hippodamia variegata* (Goeze). Releases of variegated lady beetle, *Hippodamia variegata* (Goeze), were made by the U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine (PPQ) in midwestern and western states from 1957 to 1983 and 1987 to 1993 (Ellis et al. 1999). *Hippodamia variegata* was released for the biological control of the greenbug, *Schizaphis graminum* (Rondani) (Homoptera: Aphididae), the Russian wheat aphid, *Diuraphis noxia* (Mordvilko) (Homoptera: Aphididae), and other aphid pests (Ellis et al. 1999). Despite multiple releases this coccinellid apparently did not establish (Gordon 1985, Gordon 1987, Dysart 1988, Wheeler, Jr. 1993, Ellis et al. 1999). Gordon (1987) first documented the establishment of *H. variegata* in North America in 1984 when a population was found near Montreal in eastern Canada. The range of *H. variegata* in Canada now includes the provinces of Quebec, Ontario, Nova Scotia, New Brunswick, and Prince Edward Island (Gordon and Vandenberg 1991, McNamara 1991, Cormier et al. 2000, Majka and McCorquodale 2006). Results from a 1992 survey by Wheeler, Jr. (1993) documented the spread of *H. variegata* into Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont. Since this survey, *H. variegata* has been reported from Maine (Ellis and Adams 1993) and Delaware (Ellis et al. 1999). While many introductions of *H. variegata* have been made, the original Canadian population was thought to be accidentally introduced into North America by transoceanic shipping through the St. Lawrence

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Seaway (Schaefer and Dysart 1988, Day et al. 1994). Genetic analysis supports this hypothesis as the number of allozyme alleles collected from northeastern U.S. populations was unshared with 10 geographically diverse USDA cultures (Krafsur et al. 2005).

Building on the 1992 survey by Wheeler, Jr. (1993), Ellis et al. (1999) surveyed for *H. variegata* in 11 states (CT, DE, MA, MD, ME, NH, NY, PA, RI, VA, and VT) in 1993 to examine potential habitat preferences for this species. They found *H. variegata* in all states surveyed except Virginia and Maryland and reported 34 new county records. *Hippodamia variegata* was found in aphid-rich crops including alfalfa, clover, rye and vetch, and in weedy field borders and woodland edges. It also was observed in apple, blueberries, broccoli, strawberries, and sweet corn (Ellis et al. 1999). This habitat diversity led the authors to conclude that landscape diversity in the northeast may be responsible for the coccinellid's successful establishment and spread. In contrast, the failure of *H. variegata* to survive in major wheat-growing areas of the north-central and western U.S. was attributed to the larger size of wheat fields and overall reduced habitat diversity in these regions compared with the Northeast (Ellis et al. 1999).

The survey by Ellis et al (1999) was published prior to the detection of the soybean aphid, *Aphis glycines* Matsumura (Homoptera: Aphididae), in 2000 in Wisconsin. This invasive species has since spread throughout the north central U.S. and Canada and dramatically changed the availability of suitable coccinellid prey in soybean agroecosystems. Feeding by *A. glycines* on soybean leaves, stems, and pods reduces photosynthetic rate, plant growth, and seed yield (Wang et al. 1996, DiFonzo and Hines 2002). Due to the economic and ecological threats posed by this immigrant aphid, research is underway at Michigan State University, with collaborators at the University of Wisconsin, University of Minnesota, and Iowa State University to determine how landscape variables affect predator community diversity and abundance in soybean agroecosystems. Here we report the detection of *H. variegata* in the north central U.S.

METHODS

Potential predators of the soybean aphid were sampled weekly in soybean fields from late May to mid August in 13 sites in 12 counties (2 Michigan sites were in Kalamazoo County) located throughout the north central states of Michigan, Wisconsin, Minnesota, and Iowa (Table 1). At each site, four 1 acre plots were established. In the center of each plot a T-post was erected with holes every 10 cm large enough to hold a 0.61 cm dowel. A PHEROCON AM (Great Lakes IPM, Vestaburg, MI) unbaited yellow sticky card trap was attached to the dowel and suspended just above the plant canopy. As plants grew, the dowel was moved up the pole to keep the trap at canopy level. Sticky traps placed in the field for 7 days were then removed and all adult coccinellids were counted and identified. After *H. variegata* was found in Michigan, a soybean field in Ingham County at the Michigan State University Entomology Farm was also surveyed on 24 Aug 2005 by visually inspecting 40 plants within the field. Specimens were identified by comparing them with specimens in the A. J. Cook Arthropod Research Collection at Michigan State University. Voucher specimens were deposited into this collection.

RESULTS

Hippodamia variegata was found on sticky cards at all four sites sampled in Michigan. Twenty-six adults were found in soybean fields in three Michigan counties: Kalamazoo Co. (7 specimens from the Michigan State University Kellogg Biological Station and 3 specimens from near Schoolcraft, MI), Saginaw Co. (7 specimens from Michigan State University Beet and Bean Farm), and Gratiot Co. (7 specimens from near Breckenridge, MI) (Fig. 1). The first individuals were

Table 1. Location of 13 soybean fields sampled with yellow sticky card traps for coccinellids. Site 14 is a soybean field in Ingham County, MI which was surveyed for *H. variegata* by visually inspecting 40 plants on 24 Aug 2005.

Site	Location	Coordinates (WGS 84)		City	County	State
		N	W			
1	Michigan State University Beet and Bean Farm	43° 23' 10.89"	84° 6' 49.96"	Saginaw	Saginaw Co	MI
2	Michigan State University Kellogg Biological Station	42° 24' 15.25"	85° 22' 42.83"	Hickory Corners	Kalamazoo Co.	MI
3	Grower-Cooperator Field - Crapo Rd.	43° 22' 51.35"	84° 31' 33.94"	Breckenridge	Gratiot Co.	MI
4	Grower-Cooperator Field - Oakland Dr.	42° 7' 45.66"	85° 36' 42.02"	Schoolcraft	Kalamazoo Co.	MI
5	University of Wisconsin West Madison Agricultural Research Station	43° 3' 51.77"	89° 32' 18.52"	West Madison	Dane Co.	WI
6	University of Wisconsin Arlington Agricultural Research Station	43° 18' 59.94"	89° 20' 5.85"	Arlington	Columbia Co.	WI
7	University of Wisconsin Hancock Agricultural Research Station	45° 37' 34.98"	90° 32' 51.47"	Hancock	Waushara Co.	WI
8	University of Minnesota Southwest Research and Outreach Center	44° 8' 29.31"	95° 10' 30.10"	Lamburton	Cottonwood Co.	MN
9	University of Minnesota UMore Park	44° 43' 57.94"	93° 6' 20.25"	Rosemount	Dakota Co.	MN
10	Iowa State University Central Iowa Research and Demonstration Farm	41° 58' 50.60"	93° 38' 13.86"	Ames	Story Co.	IA
11	Iowa State University McNay Research and Demonstration Farm	40° 58' 25.75"	93° 24' 54.64"	Lucas	Lucas Co.	IA
12	Iowa State University Northeast Research and Demonstration Farm	42° 55' 46.98"	92° 33' 57.72"	Nashua	Floyd Co.	IA
13	Iowa State University Sutherland Research and Demonstration Farm	42° 55' 37.99"	95° 31' 53.18"	Sutherland	O'Brien Co.	IA
14	Michigan State University Entomology Farm	42° 41' 26.68"	84° 29' 48.30"	East Lansing	Ingham Co.	MI

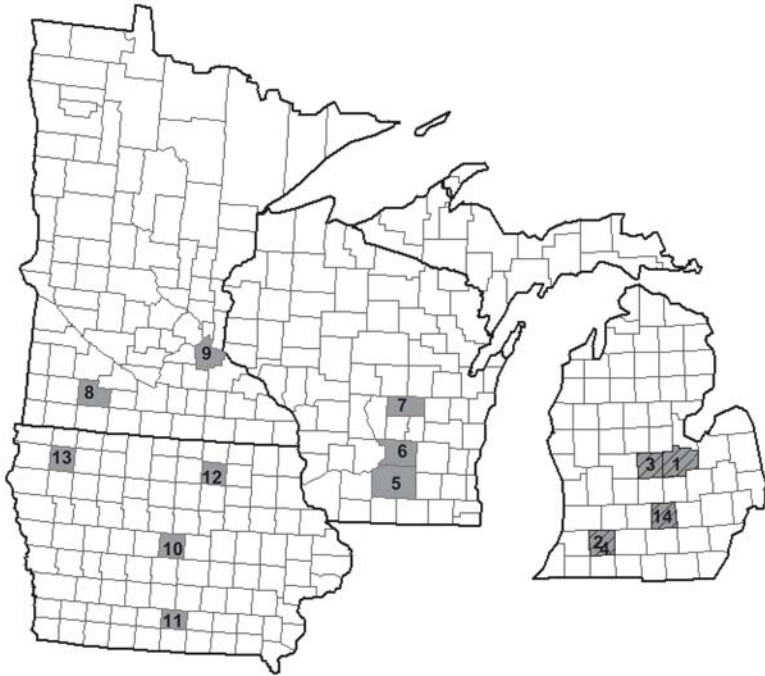


Figure 1. Counties shaded in gray were surveyed for *H. variegata*. Sites listed in Table 1 are numbered 1-14. Counties marked with hatched lines indicate detection of *H. variegata*.

found in Gratiot County on 22 June 2005; we continued to observe adults until 18 Aug 2005 (2 individuals collected in Saginaw Co.) when sampling ceased. Three *H. variegata* were also found during the visual inspection of soybean plants at the Michigan State University Entomology Farm in Ingham Co. (Fig. 1). *H. variegata* was not detected in Wisconsin, Minnesota, or Iowa.

DISCUSSION

Since the Ellis et al. (1999) survey, *H. variegata* has spread westward into southern Michigan landscapes. While unsuccessful releases targeted *S. graminum* and *D. noxia*, it appears that the current *H. variegata* populations are utilizing soybean aphid as a food source. Prior surveys did not include soybean as a potential habitat, and no previous evidence suggests that *H. variegata* feeds on soybean aphid in the U.S. or Asia. We do not know if soybean aphid has facilitated the range expansion of *H. variegata*; however, the increase in available prey is likely to aid its establishment throughout Michigan and potentially across the north-central soybean-producing states.

Increasing evidence suggests that intentional and unintentional introductions of exotic coccinellids have resulted in the displacement of native coccinellids (Putman 1955, Wheeler, Jr. and Hoebeke 1995, Elliott et al 1996, Colunga-Garcia and Gage 1998, Michaud 2002, Snyder et al. 2004). Putman (1955) found that the introduction of *Stethorus punctillum* Weise displaced the native *Stethorus punctum* (LeConte) in orchards on the Niagara Peninsula. Wheeler and Hoebeke (1995) attributed the decline of *Coccinella novemnotata* Herbst to the

population increase of *C. septempunctata* in the northeastern U.S. In South Dakota, Elliott et al. (1996) found that the establishment of *C. septempunctata* resulted in a 20-fold reduction in populations of *Coccinella transversoguttata richardsoni* Brown and *Adalia bipunctata* (L.). In Michigan, Colunga-Garcia and Gage (1998) found a decrease in populations of *Brachiacantha ursina* (F.), *Cycloneda munda* (Say), and *Chilocorus stigma* (Say) after the establishment of *H. axyridis*.

The establishment of *H. variegata* in Michigan, along with the presence of two other exotic coccinellids; *H. axyridis* and *C. septempunctata*, may have implications for native coccinellid biodiversity. Michigan has seven native *Hippodamia* species, two of which are found in soybean: *Hippodamia convergens* Guerin-Meneville and *H. parenthesis* (Say). In 2005 we did not detect *H. convergens* in Michigan soybean fields, although it was found previously by Fox et al. (2005). We know that *H. axyridis* has been implicated in the decline of native Michigan lady beetles (Colunga-Garcia and Gage 1998). The presence of *H. variegata*, along with the exotics *H. axyridis* and *C. septempunctata*, may further increase competitive pressure on native coccinellid populations.

Wheeler, Jr. and Stoops (1996) encouraged research to monitor the range of exotic coccinellid populations in managed and unmanaged systems and emphasized the importance of baseline data collected before the arrival of the exotic species. Sites have been established throughout Michigan, Wisconsin, Minnesota and Iowa for an on-going study that will continue to examine the effects of landscape complexity on the diversity and abundance of soybean aphid predators. In all states except Michigan we have baseline data on native coccinellids prior to the establishment of *H. variegata*. We will monitor these sites to determine if the range of *H. variegata* extends to additional states and will evaluate any impacts on the diversity and abundance of native coccinellid species.

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