

Predation and cannibalism of lady beetle eggs by adult lady beetles

Ted E. Cottrell*

United States Department of Agriculture, Agricultural Research Service, Southeastern Fruit and Tree Nut Research Laboratory,
21 Dunbar Road, Byron, GA 31008, USA

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Abstract

The introduced lady beetle *Harmonia axyridis* now occurs across much of North America. This species is a strong intraguild competitor that may negatively impact local populations of native Coccinellidae. A laboratory examination of coccinellid egg predation, including cannibalism, revealed that eggs of two native species, *Coleomegilla maculata* and *Olla v-nigrum*, had significantly higher egg predation than did *H. axyridis* eggs. The addition of an alternative food source reduced egg cannibalism and predation. However, in the absence of an alternative food source, both native species attacked exotic eggs less than native eggs whereas, the exotic *H. axyridis* attacked all egg species similarly. This laboratory study shows that under conditions of low food availability, native coccinellid eggs would suffer from both cannibalism and predation whereas, cannibalism would be the larger threat to *H. axyridis* eggs.

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1. Introduction

The introduced multicolored Asian lady beetle, *Harmonia axyridis* (Coleoptera: Coccinellidae), has established in many habitats over much of North America (Chapin and Brou, 1991; Coderre et al., 1995; Colunga-Garcia and Gage, 1998; Krafur et al., 1997; LaMana and Miller, 1996; Tedders and Schaefer, 1994). Many different traits could have facilitated establishment of *H. axyridis* in North America and may include high fecundity (Michaud, 2002), aggressive behavior (Kajita et al., 2000; Michaud, 2002; Yasuda and Ohnuma, 1999), high mobility (With et al., 2002), large body size (Michaud, 2002), low susceptibility to a parasitoid (Hoogendoorn and Heimpel, 2002), low susceptibility to pathogens attacking native coccinellids (Cottrell and

Shapiro-Ilan, 2003), and a polyphagous diet (Hodek and Honék, 1996).

This polyphagous predator can be important as an aphid predator (Fox et al., 2004; Tedders and Schaefer, 1994) or potentially harmful through a variety of ways (Koch, 2003; Koch et al., 2003). One potentially harmful impact of *H. axyridis* is intraguild predation upon native lady beetles. Intraguild predation among coccinellids in natural situations has been documented when aphid prey become scarce (Hironori and Katsuhiko, 1997; Musser and Shelton, 2003; Schellhorn and Andow, 1999a). In fact, most studies that have examined the interactions of *H. axyridis* with other coccinellids have shown *H. axyridis* to be a strong intraguild competitor (Kajita et al., 2000; Sato et al., 2003; Takahashi, 1989; Yasuda and Ohnuma, 1999; Yasuda et al., 2001). Although unlikely that a coccinellid, i.e., *H. axyridis*, would subsist entirely on other coccinellid species, it is likely that *H. axyridis* would be favored when encountering other species. For example, a laboratory study by Cottrell and Yeorgan (1998c) showed that

* Fax: +1 478 956 2929.

E-mail address: tcottrell@saa.ars.usda.gov.

H. axyridis was capable of completing development on a diet consisting of *Coleomegilla maculata* eggs. In that study, larval interactions also were examined and typically found to favor *H. axyridis*. Furthermore, Musser and Shelton (2003) reported that *H. axyridis* does prey upon the native *C. maculata* in corn fields. Negative impacts upon native coccinellids by established exotic coccinellids is not unprecedented as Elliot et al. (1996) suggested that the exotic *Coccinella septempunctata* may have reduced populations of certain native coccinellids in the US.

Egg predation may play a role as to how *H. axyridis* could impact native coccinellids. Laboratory data by Cottrell (2004) showed that larvae of the exotic *H. axyridis* were capable of completing development solely on eggs of the native *C. maculata* or *O. v-nigrum* whereas, larvae of those native species did not complete development on *H. axyridis* eggs. In addition, when native larvae attacked an *H. axyridis* egg cluster, many eggs within the cluster were only partially consumed. That data would suggest that eggs of the native *C. maculata* and *O. v-nigrum* would be susceptible to both egg cannibalism and egg predation whereas, *H. axyridis* eggs would be more susceptible to cannibalism in the field.

Although the occurrence of egg cannibalism and predation most often focuses on larvae, adults also come into contact with coccinellid eggs. However, less is known about egg cannibalism and predation by adult Coccinellidae, especially native egg predation by exotic adults. In addition, even less is known about egg cannibalism and predation by adult male and female coccinellids although it could be expected that males would feed less. Obata and Johki (1990) documented that male *H. axyridis* spent more time moving and at a faster rate than did female *H. axyridis*. Those males appeared to be preoccupied with mate finding and commonly passed over encountered aphid prey. Therefore, the objective of this laboratory study was to examine egg cannibalism and egg predation by the exotic *H. axyridis* and two native species, *C. maculata* and *O. v-nigrum*, that overlap spatially and temporally in various habitats. This was done using male and female adults of each species in no-choice tests and again for adults of each species when provided with, or without, an alternative food supply.

2. Materials and methods

2.1. Insect colonies

Laboratory colonies of *O. v-nigrum* and *H. axyridis* originated from adult beetles collected from pecan orchards at the USDA, Agricultural Research Service, Southeastern Fruit and Tree Nut Research Laboratory at Byron, GA, USA. The *C. maculata*

colony originated from overwintering adult beetles collected near Lexington, KY, USA. Field-collected adults of each species from the USDA laboratory at Byron, GA were added intermittently to the colonies. Each species was housed in 9-cm diameter petri dishes in an environmental chamber at $25 \pm 1^\circ\text{C}$ and a photoperiod of 14:10 (L:D) h. *Olla v-nigrum* and *H. axyridis* were fed pecan aphids (*Monellia caryella* and *Monelliopsis pecanis*), frozen lepidopteran eggs (*Helicoverpa zea* and *Ephestia kuhniella*), supplemented with a beef-based diet (Cohen, 1985), and water provided with a moistened cotton dental wick. The polyphagous *C. maculata* was fed the beef diet and supplemented with lepidopteran eggs (Cottrell and Yeargan, 1998a). Aphids were reared on foliage of greenhouse-grown seedling pecans (Cottrell et al., 2002). Green florist's paper was used to line lids of petri dishes containing adult female coccinellids (Cottrell and Yeargan, 1998a). The paper provided an ovipositional substrate for the lady beetles that could be easily removed and replaced. Egg clusters used in all studies were from mated, laboratory-reared coccinellids. Egg clusters were collected daily and stored at $10 \pm 1^\circ\text{C}$. The quantity of egg clusters needed usually required collection of eggs for several days; eggs used in studies were ≤ 7 -day-old.

2.2. Adult feeding assays

Feeding assays were done using laboratory-reared *C. maculata*, *O. v-nigrum*, and *H. axyridis* adults against eggs from each of those species. Male and female beetles were assayed separately. For each sex, similar-aged beetles (i.e., 2- to 3-week-old) were starved for 18 h and then individuals of each species were randomly assigned to a plastic dish containing a single cluster of *H. axyridis*, *O. v-nigrum* or *C. maculata* eggs (on an approximately 5 cm² piece of green florist's paper) and a moistened cotton dental wick. All eggs used in feeding assays were from laboratory-reared beetles maintained for egg production and never from beetles used in these feeding assays. Numbers of eggs per cluster were counted before the assays began and only clusters with similar numbers of eggs (within and between species) were used. Mean numbers of eggs per cluster (\pm SE) for *C. maculata*, *O. v-nigrum*, and *H. axyridis* were 19.4 ± 0.3 , 20.7 ± 0.7 , and 21.1 ± 0.4 , respectively, for the assay using females and 18.7 ± 0.3 , 20.4 ± 0.8 , and 20.4 ± 0.7 , respectively, for the assay using males. Assays were done in an environmental chamber using a completely randomized design. Environmental conditions were $25 \pm 1^\circ\text{C}$ and a photoperiod of 14:10 (L:D) h. Numbers of eggs attacked (i.e., partially consumed + entirely consumed) were determined with the aid of a dissecting microscope at 3, 6, 12, and 24 h after the assay began. Each adult species \times egg species combination was replicated 13

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