Biological Control 48 (2009) 168–180

Contents lists available at ScienceDirect

Biological Control

journal homepage: www.elsevier.com/locate/ybcon

Temporal relationships between the generalist predator, *Orius insidiosus*, and its two major prey in soybean

Ho Jung S. Yoo *, Robert J. O'Neil

Department of Entomology, Purdue University, Smith Hall, 901 W. State Street, West Lafayette, IN 47907-2089, USA

A R T I C L E I N F O

Article history:
Received 25 April 2008
Accepted 13 October 2008
Available online 19 October 2008

Keywords:
Orius insidiosus
Aphis glycines
Neohydatothrips variabilis
Soybean aphid
Thrips
Alternative prey
Numerical response
Spinosad

A B S T R A C T

The generalist predator, *Orius insidiosus* (Say) is an important early-season predator of the soybean aphid, *Aphis glycines* Matsumura, a newly invasive pest of major concern in soybean crop management. We conducted a 3 year, multiple field study to characterize the dynamic relationships between the predator, the pest, and alternative prey in soybean. Using field sampling data, we showed that thrips were the only alternative prey to be well-established in fields prior to *O. insidiosus* arrival and were likely to promote predator colonization of soybean fields prior to the arrival of soybean aphid. The predator displayed a reproductive numerical response to thrips in one of the 3 years and a primarily aggregative response in another year. The predator did not respond numerically to soybean aphid in the majority of fields. Experimental manipulations of thrips populations in field plots temporarily reduced thrips densities but had a minimal effect on *O. insidiosus* densities, suggesting that the predator is resilient against temporary reductions in a major resource. In the 2 years *O. insidiosus* populations were well-established in fields prior to soybean aphid arrival, soybean aphid remained at low levels throughout the season. In the year soybean aphid arrived early with respect to the growing season and before *O. insidiosus* populations were established, soybean aphid reached outbreak levels in all fields. Future research efforts on the factors determining soybean aphid population dynamics need to address the relative importance of early-season soybean aphid colonization and generalist predator population dynamics on the potential for soybean aphid population outbreaks.

1. Introduction

The soybean aphid, *Aphis glycines* Matsumura (Hemiptera: Aphididae), is a serious pest of soybean throughout much of North America (Ragsdale et al., 2004). Field studies have demonstrated that generalist predators dominate the natural enemy community attacking the soybean aphid in soybean (Bechinski and Pedigo, 1981; Fox et al., 2004; Rutledge et al., 2004; Schmidt et al., 2008). In Indiana soybean, the insidious flower bug, *Orius insidiosus* (Say) (Hemiptera: Anthocoridae), is an important predator of the soybean aphid, particularly early in the soybean cropping season (Rutledge et al., 2004; Desneux et al., 2006; Harwood et al., 2007). In soybean, *O. insidiosus* feeds upon a number of prey species including thrips, aphids, mites, whitefly nymphs, insect eggs, leafhopper nymphs and lepidopteran larvae (Isenhour and Marston, 1981; Isenhour and Yeargan, 1981; McCaffrey and Horsburgh, 1986; Coll and Ridgway, 1995; Rutledge et al., 2004), as well as plants (Armer et al., 1998; Lundgren et al., 2008). Among their prey, thrips, primarily soybean thrips, *Neohydatothrips variabilis* (Beach) (Thysanoptera: Thripidae) and *Frankliniella tritici* Fitch (Thysanoptera: Thripidae) are common in the early-season, when soybean aphid is colonizing soybean fields.

Generalist predators have a common set of behavioral and ecological characteristics that influence their abilities to control pest populations in cropping systems. Generalists, for example, can be attracted to fields by non-target prey early in the season, build to moderate numbers before target pests arrive (Toft, 2005), and potentially can prevent an outbreak of the pest species (Symondson et al., 2002). Generalists may respond numerically to a population increase in the non-target ("alternative") prey and subsequently exert greater predation mortality on the target prey population, an indirect effect commonly referred to as "apparent competition" between prey (Holt, 1977). Or, predators may fail to respond numerically to alternative prey. In such cases, the alternative prey may 'distract' the predator and reduce predation pressure on the target prey, resulting in a positive indirect impact of alternative prey on target prey (Abrams and Matsuda, 1996; Eubanks and Denno, 2000; Lester and Harmsen, 2002; Koss and Snyder, 2005; van Veen et al., 2006). Although several laboratory studies have suggested a mixed role for alternative prey on *O. insidiosus*-soybean aphid interactions (Butler and O'Neil, 2007b; Desneux

* Corresponding author. Current address: Division of Biological Sciences, University of California, San Diego, 9500 Gilman Drive, MC-0116, La Jolla, CA 92093-0116, USA. Fax: +1 858 534 7108.
E-mail addresses: hojungyoo@gmail.com, hisyoo@ucsd.edu (H.J.S. Yoo).

1049-9644/$ - see front matter © 2008 Elsevier Inc. All rights reserved.
doi:10.1016/j.biocontrol.2008.10.007

and O'Neil, in press), no field study has directly investigated how alternative prey influence the establishment of *O. insidiosus* in soybean infested by soybean aphids or how alternative prey impact *O. insidiosus*—soybean aphid dynamics in the crop.

For this study, we conducted extensive field studies of the soybean arthropod predator-prey community over a 3 year period. Our overall goal was to characterize and compare relationships between the predator and its two major prey, with a particular focus on understanding how alternative prey (thrips) affect the predator's early-season impact on the target prey (soybean aphid), and whether this relationship can be characterized as apparent competition. We expected that thrips are largely responsible for attracting and sustaining *O. insidiosus* in soybean fields early in the growing season (Isenhour and Marston, 1981), and that this interaction contributes greatly to *O. insidiosus*' establishment in fields prior to soybean aphid arrival. We further hypothesized that early establishment gives *O. insidiosus* the potential to attain densities high enough to impact soybean aphid population growth during years of low soybean aphid immigration. Finally, although the predator is polyphagous, laboratory evidence suggests thrips are a preferred (Butler and O'Neil, 2008; Desneux and O'Neil, in press) and high quality prey for *O. insidiosus* (Butler and O'Neil, 2007b). Thus, we hypothesized that *O. insidiosus* populations would be dynamically linked to thrips populations in the field, and that their relationship would be stronger than that with soybean aphid.

We tested our hypotheses using a combination of surveys and field experiments. First, we used a survey of multiple fields to examine early-season insect availability at the time of *O. insidiosus* arrival in fields, as well as *O. insidiosus* density at the time of soybean aphid colonization. Second, we examined the numerical response of the predator to thrips and soybean aphid to evaluate the relative strengths of their relationships throughout the season. Finally, we reduced thrips densities temporarily in large field plots, to determine whether a direct predator population response (i.e., decline) followed by an indirect soybean aphid population response (i.e., increase) could be found in support of our hypothesis that the alternative and target prey interact via apparent competition. Although previous laboratory (Rutledge and O'Neil, 2005) and small field plot studies (Desneux et al., 2006) have suggested that *O. insidiosus* can suppress soybean aphid population growth at small spatial scales, our study will be the first to document *O. insidiosus* impact at the larger, field scale.

2. Materials and methods

2.1. Field survey of soybean arthropods, 2004–2006

We conducted a survey of multiple soybean fields in 2004–2006 to obtain population density estimates for arthropods in the canopy throughout the soybean growing season. The fields were located in north-central Indiana and were cultivated according to standard agronomic practices for the region (Appendix A). In 2004, 14 fields were selected along two transects, extending 70 km due north and 110 km northeast of the Purdue University campus (West Lafayette, Indiana). In 2005, eight fields were selected along the northeast transect, up to 140 km from campus. In 2006, six fields were selected along the northeast transect. In all of these aforementioned "transect" fields, a rectangular plot (0.3 ha in 2004, 0.4 ha in 2005 and 0.2 ha in 2006; Appendix A) was selected at least 10 m from the field edge and marked with vinyl flags. In each year of the survey, one additional "large-sample" field was monitored using larger sample sizes than in transect fields (N = 10–20 plants in each transect field and N = 48–96 plants in each large-sample field; Appendix A). These large-sample plots were unmanipulated control plots used in various field experiments conducted each year at the Purdue University Agronomy Center for Research and Education (ACRE) in Tippecanoe County, IN. The transect and large-sample survey fields differed in location from year to year because soybean is typically a rotated crop in Indiana.

From approximately the cotyledon stage to plant senescence, plots were sampled at least weekly using a systematic sampling design (large-sample fields) or a stratified random sampling design (all other fields). For sampling, whole-plants were uprooted or broken at the soil line and visual counts of all arthropod taxa on the plant were made. Although this procedure is likely to have dislodged a proportion of relatively mobile arthropods such as *O. insidiosus* adults (Schmidt et al., 2008), observers were trained to minimize disturbance of the foliage during sampling and the procedure was used consistently in all 3 years of sampling. Based on previous sampling and direct observation efforts (Kampmeier, 1984; R.J.O., unpublished data) we excluded from counts highly mobile, ground-dwelling, or large adult arthropods which are unlikely prey for *O. insidiosus*, or would rarely be found in our sampling effort. This sampling method, however, also excluded adult coccinellids, which are known to be important predators of aphids in soybean, particularly at high aphid densities and in many areas of soybean cultivation (e.g., Fox et al., 2004; Costamagna and Landis, 2006; Donaldson et al., 2007). We therefore also conducted sweep net sampling for highly mobile arthropods every one to two weeks in 12 of our survey fields. In 2005, we sweep-sampled four transect fields eight times, from 4 August to 22 September, and the large-sample field 13 times, from 21 June to 13 September. In 2006, we sweep-sampled all six transect fields 10 times, from 13 July to 21 September, and the large-sample field nine times, from 14 July to 20 September. In these fields, we conducted 2–4 samples of 25 (2005) and 20 (2006) sweep strokes each while walking along rows, starting at random locations within our flagged plots.

All fields were sampled by the whole-plant method as described above, with the following exceptions. Of the nine fields surveyed in 2005, four were sampled for all insects through July, followed by soybean aphid counts only through the remainder of the season. Data from these four fields were included in all analyses involving early-season data, such as insect arrival dates, but were not used in analyses requiring season-long counts of the predator or other prey. The remaining fields were sampled for all insects weekly until plant senescence, and were included in all analyses. Additionally, when mean aphid density exceeded 250 per plant in 2005, we counted aphids only on subsamples of each plant. The subsampled counts were converted to whole-plant estimates using a previously derived linear relationship between the subsamples and whole-plant aphid totals, which we describe as follows. Using training data from 120 infested plants sampled independently of the current study, we had developed a simple model relating the sums of aphid counts on three nodes of each plant to counts on the entire plant. A node was defined as the open leaf, petiole, flowers and fruit at a node and on the portion of stem below the node down to, but not including, the previous node. A linear regression (with a zero intercept) of the training data yielded the model: total aphid count on plant = $3.76 * X$ ($F_{1,119} = 681.93$, $P < 0.0001$, $R^2 = 0.85$), where X = sum of aphid counts from the 1st, 5th, and 9th sequential nodes down from the apex of the plant. The median (range) of total aphid counts in the training data was 389 (101–5070) aphids per plant. To obtain whole-plant estimates in our surveys during high aphid infestations, we multiplied our subsampled counts by a factor of 3.76. This method of subsampling and whole-plant estimation was utilized from late July to early September 2005, when mean aphid abundance in a field was expected to exceed 250 per plant, but not after aphid populations were expected to have crashed below 100 per plant.