N O T E

Efficacy of Multicolored Asian Ladybeetle (Coleoptera: Coccinellidae) as a Control for Aphids in Pecan Orchards[1]

M. Ghulam Abbas, Haider Karar, and James D. Dutcher[2]

Entomology Department, University of Georgia Tifton Campus, Coastal Plain Experiment Station, 2360 Rainwater Rd., Tifton, Georgia 31793-5766 USA

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Commercial pecan growers rely on natural controls to regulate populations of yellow pecan aphid (*Monelliopsis pecanis* (Bissell)), blackmargined aphid (*Monellia caryella* (Fitch)), and black pecan aphid (*Melanocallis caryeafoliae* (Davis)) (Hemiptera: Aphididae) in pecan orchards. The field biology (W. L. Tedders 1978, USDA Tech. Bull. 1579) and the reproductive rates of the 3 aphid species on pecan are well documented (Kaakeh and Dutcher 1992, Environ. Entomol. 21: 632 - 639). The multicolored Asian ladybeetle, *Harmonia axyridis* Pallas, is an effective biological control agent for aphids in pecan (LaRock and Ellington 1996. Southwest. Entomol. 21: 153 - 166). The efficacies of the immature life stages have been quantified (Williamson 2008. Encouraging natural defenses in pecan orchards. Ph.D. Diss., Univ. Georgia, Athens, 91 pp), but the efficacy of the adult has not been quantified against pecan aphids. Our objective was to measure the efficacy of the multicolored Asian ladybeetle adults against cultures of each aphid species and a mixed culture of the 3 aphid species on intact aphid-infested pecan foliage in the field by comparing the changes in aphid abundance over time in paired sleeve cages with and without ladybeetles.

Experiments were conducted in 2009 at the Horticulture Pecan Orchard of the University of Georgia Tifton Campus, Coastal Plain Experiment Station, Tift Co., USA described by Worley and Mullinix (1994, Georgia Agric. Expt. Sta. Bull. no. 426). Trees were managed for fertility, weed and disease control by standard recommended practices (Wells 2008. Southeastern Pecan Grower's Handbook, GA Coop. Ext. Service, 238 pp.). No insecticides were applied to the trees during 2009. Efficacy of adult *H. axyridis* ladybeetle was determined on intact pecan leaves on 'Kiowa' cultivar. The relative health of the aphid population was determined by rearing the aphids in clip cages on intact pecan leaves on 'Schley' cultivar by methods of Kaakeh and Dutcher

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[2]Address inquiries (email: dutch88@uga.edu).

(1992). Adult winged female aphids were collected from the population in the orchard and confined in clip cages on the lower surface of single pecan leaflets. Each clip cage was constructed from a 3.07 × 3.07 cm piece of self-adhesive, foam, weather stripping (0.48 cm thick) (3M Corp., Minneapolis, MN, USA) with a 2.56-cm diam. hole cut in the center. The self-adhesive side of the foam piece was covered with a 3.07 × 3.07 cm piece of nylon screen (11 × 11 per cm mesh). A 25-mm diam. carbone ring (Boye Co., Antioch, TX, USA) was fitted into the hole in the foam beneath the nylon screen. The cage was held in place on the leaf surface by a spring-loaded hair clip (part no. 55309N, Conair Corp., East Windsor, NJ, USA) with the nonadhesive surface next to the leaf surface. Aphids were retained in the circular leaf space for feeding and reproduction. One alate, parthenogenetic, female aphid adult was placed in the clip cage to produce nymphs. After 24 h, the adult and all except 1 of the nymphs were removed with fine brush, leaving 1 nymph per cage which was allowed to mature to a winged, parthenogenetic, adult aphid. All nymphs produced by the winged adult were counted every 1 - 3 d until the adult died. All nymphs remained in the clip cages with the adult until they matured to new adults at which time they were removed. The efficacy of the ladybeetles as biological control agents was measured by culturing the aphids on noninfested intact pecan foliage; adding three adult multicolored Asian ladybeetles to one-half of the cages and observing the number of aphids in the cages over a 5-wk period. On 28 July 2009, 4 - 5 compound leaves on a single shoot were enclosed in a 60 × 70 cm white insect rearing sleeve made from 2 Bug Dorm cages (part no. DC 300W-L-P, Taichung, Taiwan) and infested with 10 aphids per sleeve to establish 4 types of aphid colonies: (1) yellow pecan aphids alone; (2) black pecan aphids alone; (3) blackmargined aphids alone; and (4) mixed culture of yellow pecan, black pecan and blackmargined aphids (10 aphids of each species per cage). Three adult ladybeetles were released into the sleeves on 4 August, and the aphid population was monitored one time per week in the cages for 4 wks. Aphids were counted by removing the cage, enumerating the number of aphids then replacing the cage. Beetles were counted and, if a beetle died, then it was replaced. If a beetle laid eggs, then the eggs were left in the cage. Cages were selected at random a priori on 28-Jul from the pairs for the designation of the 2 treatments – '3 beetles' and 'no beetles'. Blackmargined aphids developed to significantly higher numbers in cages designated for inoculation with beetles on 4-August than in cages designated as 'no beetles'; however, we remained with the original treatment assignments on the treatment date. The trial was replicated 4 times and the weekly population counts were analyzed to calculate the mean, variance and standard error of the number of aphids per leaf in each of the sleeves. Single factor analysis of variance (Zar 2010. Biostatistical Analysis. 5th Ed. Sec. 10.1. Pearson Education, Inc. Upper Saddle River, NJ, USA. 944 p.) was calculated on each sample date to determine if the differences between the mean aphid abundance in cages with and without beetles were significantly different ($\alpha \leq 0.05$).

The populations of the 3 aphid species in the field had similar reproductive rates to the higher end of the published range for these species, indicating that the population was healthy (Table 1). Herein, aphid populations are referred to as 'controlled', in the efficacy trials, if the aphid abundance in the sleeves with beetles was significantly less than the aphid abundance in sleeves without beetles. Yellow pecan aphids were controlled by the multicolored Asian lady beetle adults on the first week (11 August), and control continued for the second (18 August), and third (25 August) weeks. After the fourth week, aphid population in the cages without beetles declined

Table 1. Population parameters (mean ± LSD*) for the aphid population used in the study and comparison with published values.

	Aphid species		
Population Parameter	Yellow Pecan Aphid	Blackmargined Aphid	Black Pecan Aphid
Life Span of Adult (d)	19.0	8.8	21.0
Nymph production/ adult	49.0	32.4	26.8
Time from birth to reproduction (d)	7.2	7.0	8.8
Estimate of rate of increase**	0.406	0.464	0.275
Published range of rate of increase†	0.285 - 0.354	0.332 - 0.428	0.205 - 0.262

* Least significant Difference, LSD = $2 \times t_{.05} \times \sqrt{(MSE/n)}$.

** Rate of increase $r_m = 0.74 \times (\log_e M_d/d)$ where d= prereproductive time, Md = number of progeny produced in a time equal to the prereproductive time, and 0.74 is an empirical constant (Wyatt & White 1977. J. Appl. Ecol. 14:757 - 766).

† Values from Kaakeh and Dutcher (1992 Environ. Entomol. 21: 632 - 639) and indicate the range of all measurements. *

to the same level as the cages with beetles (Fig. 1). Black pecan aphid populations were not controlled by the multicolored Asian ladybeetle adults until the third week (25 August), and control continued to the fourth week (1 September) (Fig. 2). Blackmargined aphids were controlled by the multicolored Asian lady beetle on the fourth week after inoculation; however, blackmargined aphids were significantly higher in the '3 beetle' treated cages than in the 'no beetle' cages at the time of the inoculation. Mixed cultures of the three aphid species were controlled by the multicolored Asian lady beetle adults after 4 wks of exposure to the adults. Yellow pecan aphids were controlled on the third and fourth weeks. Black pecan aphids were controlled on the second and third week. Blackmargined aphids were controlled on the fourth week. On 11 August, 1 wk after the inoculation of the cages with beetles, aphid abundance all 3 species of aphids was significantly higher in cages with beetles than in cages without beetles. Conversely abundances of all three species aphids were significantly lower in sleeves with beetles than sleeves without beetles on 1 September. On 25 August, yellow pecan aphids were significantly lower in sleeves with beetles than sleeves without beetles.

These results estimate the time required to control aphids on pecan foliage with adults of the multicolored Asian ladybeetle for each species of pecan aphid and for a mixed culture of the 3 pecan aphid species. The sequence of events that leads to the biological control of an aphid infestation in the pecan orchard is poorly understood. Weekly sampling of ladybeetles with yellow sticky boards and aphids with direct counts on the foliage in a pecan orchard is underway in our field trials to determine the synchrony between the predators and aphid prey in the tree canopy. Early results indicate that aphids first infest the foliage and then there is an increase in abundance

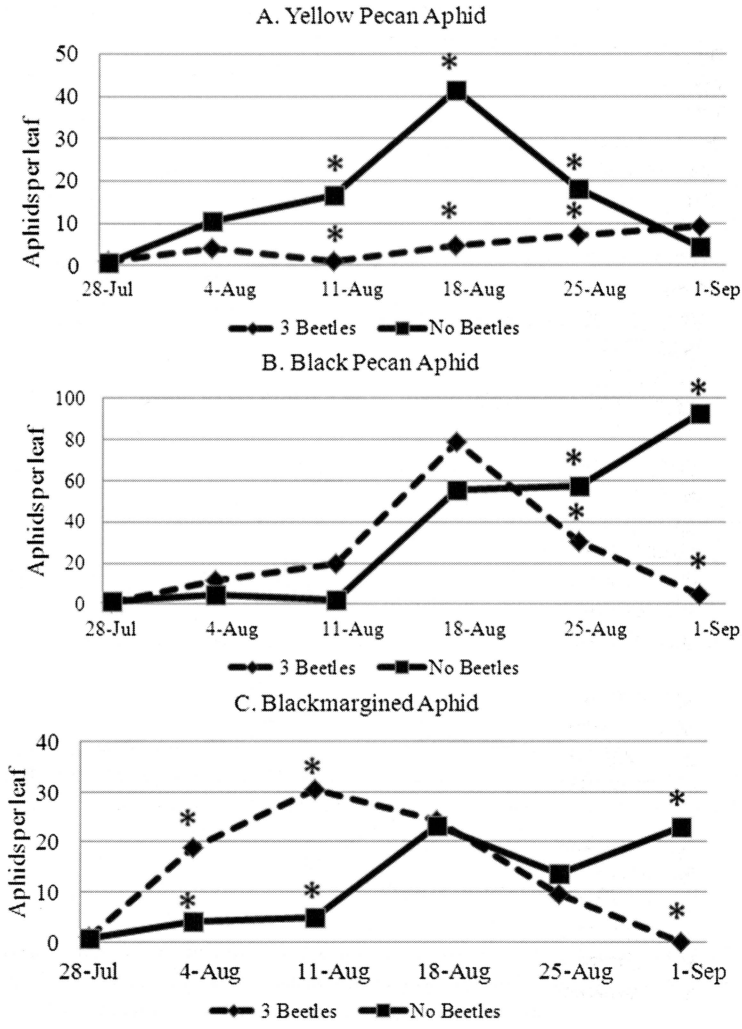

Fig. 1. Mean numbers of yellow pecan aphids (A), black pecan aphids (B), and blackmargined aphids (C) in sleeve cages enclosing pecan shoots with and without 3 *H. axyridis* adults. Significant differences between treatment means (with and without beetles) within dates are indicated with asterisks over each mean.

of multicolored Asian ladybeetles and other aphidophagous insects in the tree canopy. However, multicolored Asian ladybeetle adults are commonly found on the pecan foliage from bud break to harvest and then on the pecan stems and trunks on warm days during the late fall and early spring. The inoculation of the cages with beetles 1 wk after the cages were inoculated with beetles simulates a scenario where the beetles migrate into the pecan orchard as adults after aphid populations begin to increase in

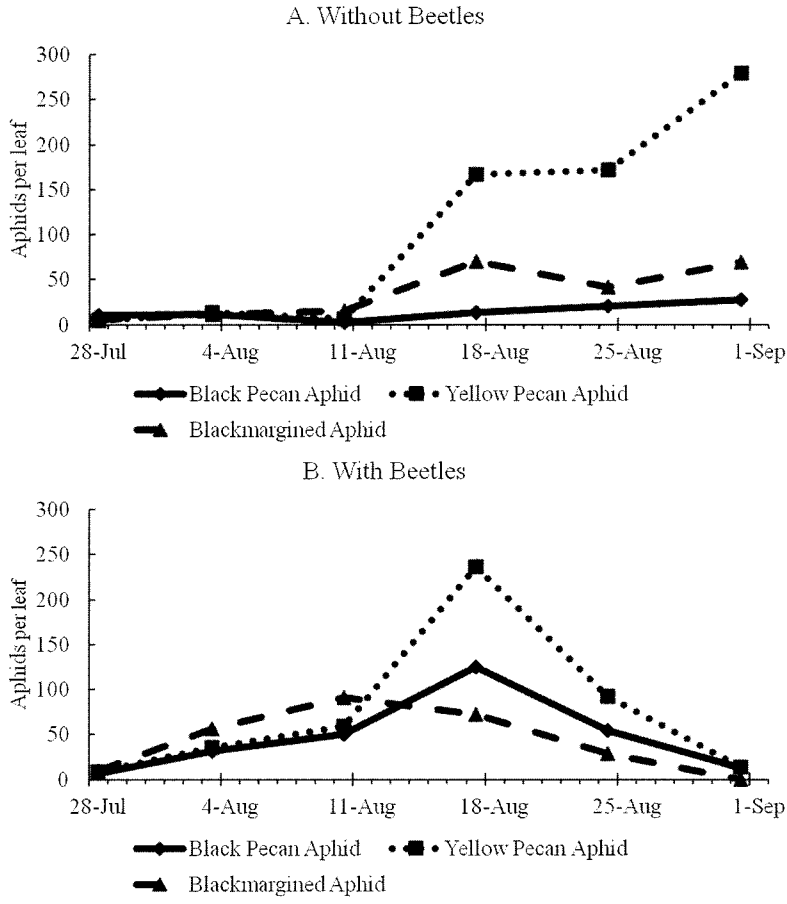

Fig. 2. Weekly estimates of the mean abundances of yellow pecan aphids, black pecan aphids and blackmargined aphids in a mixed culture on pecan shoots enclosed in sleeve cages without (A) and with (B) 3 *H. axyridis* adults per cage. Beetles were introduced on 4 August.

the trees. When the multicolored Asian ladybeetle adults are introduced to infestations of single species cultures of pecan aphids, control of yellow aphids occurs in less time than control of black pecan or blackmargined aphids.

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