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RATE OF CONSUMPTION OF COTTON APHIDS BY CONVERGENT LADY BEETLES IN THE LABORATORY

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Abstract

The rate of convergent lady beetle, *Hippodamia convergens* Guerin-Meneville, predation on the cotton aphid, *Aphis gossypii* Glover, was measured by assigning a single predator randomly to one of five prey density treatments in a petridish in the laboratory at 26.6 °C. Prey density treatments included 25, 50, 100, 210, and 400 aphids per petridish arena. Predation response was recorded 1 h, 4 h, 8 h, 16 h, 24 h, and 48 h after assigning predators to their prey treatments. Rate of consumption increased through time, with all 25 aphids eaten during the first 4 hours of the experiment. At the highest density, lady beetles consumed 40 aphids in 1 h, 100 aphids in 4 h, 150 aphids in 8 h, 270 aphids in 24 h, and nearly all 400 aphids in 48 h. Predators showed a curvilinear response in the time they used to consume their prey in relation to total available time. These data demonstrate that convergent lady beetles have potential to suppress larger populations of cotton aphids through continuous feeding by changing their predation efficiency during feeding. The analysis of age-specific mortality without prey or water showed that lady beetle adults could survive for an extended period of time. The ability of a predator to survive without prey for an extended period of time delays or prevents the rebound of pest populations and is a significant factor in natural biological control.

Introduction

The lady beetles have been considered the most important group of arthropod predators in cotton agroecosystems in Texas (Parajulee et al. 1997, Slosser et al. 1998, Parajulee and Slosser 1999). Parajulee et al. (1997) documented that the lady beetle complex comprised 75% of the total predators in irrigated cotton during a three-year study in the Rolling Plains region of Texas, and Slosser et al. (1998) observed that lady beetles comprised 62% of the total predators in dryland cotton during a five-year study in the Rolling Plains region. However, the proportion of lady beetles in the total predator complex in cotton can be influenced by vegetational diversity and weather patterns. Previous studies have demonstrated up to an 81% increase in lady beetles in the total predator complex when the cotton system was diversified with noncotton strip crops (Parajulee and Slosser 1999). These authors also reported a significant decline in lady beetle abundance during extreme environments; lady beetles comprised only 25 and 18% of the total predators during the hot, dry summer of 1996 and milder, wet summer of 1997, respectively. These reports suggest that the value of lady beetles as natural control agents can depend on climatic variation and habitat diversity. Of seven species of lady beetles reported from the Texas Rolling Plains and High Plains, the convergent lady beetle, *Hippodamia convergens* Guerin-Meneville, is perhaps the most important predator of cotton aphids, *Aphis gossypii* Glover, in Texas cotton. Slosser et al. (1998) reported that *H. convergens* was the dominant lady beetle species and lady beetles had been considered a significant natural control agent influencing the rate of cotton aphid decline in late August in the northern Rolling Plains. However, data on consumption rate of cotton aphids by lady beetles are not available for use in the development of a decision rule system that relates abundance of lady beetles to expected rate of cotton aphid suppression. The objective of this study was to quantify the rate of cotton aphid consumption by adult convergent lady beetles in the laboratory.

Materials and Methods

Lady beetle pupae were collected from a cotton field at the AG-CARES Farm near Lamesa, Texas on August 6, 2002, brought to the laboratory, and reared to adulthood. Upon adult emergence, adult beetles were reared on cotton aphids for 4 days. After the beetles were "conditioned" for 4 days, they were individually confined in petridishes (10 cm diameter) and were deprived of prey or water for 70 hours. The experiment was conducted in a growth chamber maintained at 26.6 °C and no photoperiod.

The rate of convergent lady beetle predation on the cotton aphid was measured by assigning a single predator randomly to one of five prey density treatments in a petridish. Prey density treatments included 25, 50, 100, 210, and 400 aphids per petridish arena. There were 15 replications for the three lower prey densities, while the two highest densities had 10 and 5 replications, respectively. Cotton aphids were collected from the field, and within one hour following collections were offered to predators afresh on the same cotton leaves from which the prey were collected. The total number of aphids consumed, hereinafter referred to as response, was recorded 1 h, 4 h, 8 h, 16 h, 24 h, and 48 h after assigning predators to a treatment. After 48 h, predators were again deprived of prey or water and monitored daily for their age-specific survivorship without access to prey or water.

We fit our response data to Holling's curvilinear Type II model (Holling 1959) using TableCurve 2D software (Jandel Scientific 2002). In this model, the number of aphids consumed (N_c) is a hyperbolic function of aphid density (N_o), as described by the equation $N_c = \frac{a' T_a N_o}{1 + a' T_h N_o}$, in which *a'* is the predator's rate of discovery of prey, T_a is the total time available (1-48 h in our case), and T_h is the prey handling/feeding time. The age-specific mortality rates were modeled as $\ln y = a + b/x$ for the first four densities and $\ln y = a + b/x^2$ for the highest density, where y is the age-specific proportional mortality and x is the predator age.

Results and Discussion

Predation by convergent lady beetle on different densities of cotton aphids yielded curvilinear Type II responses for all predation time periods evaluated (Figure 1). Rate of consumption increased through time, with all 25 aphids eaten within the first 4 hours of the experiment. At the highest density, lady beetles consumed 40 aphids in 1 h, 100 aphids in 4 h, 150 aphids in 8 h, 270 aphids in 24 h, and nearly all 400 aphids in 48 h. In 48 h, the relationship between aphid density and consumption rate was linear up to 400 aphids per predator (Figure 1). These data clearly show that the convergent lady beetle is a very potent predator that can suppress a large aphid population in a short period of time. Most other predator species rest for an extended period of time after they satiate from their initial prey consumption. However, the convergent lady beetle fed continuously for 48 h until all the aphids in the highest prey density were consumed. These data showed a similar trend to that reported by Dreistadt and Flint (1996) who found a density-dependent functional response of convergent lady beetles when fed cotton aphids infesting potted chrysanthemum. This study will be continued in 2003 to evaluate predation at higher aphid densities than those evaluated in 2002 in an effort to quantify the level of aphid abundance that can allow the lady beetle to consume to its satiation level.

Total time available for predators to handle their prey affected the prey handling time, which in turn would determine the predation efficiency. Convergent lady beetles showed a curvilinear response in the time they used to handle their prey in relation to the total available time (Figure 2). Predators handled their prey more slowly with increased total available time (T_a) up to 16 hours, indicating a gradual decline in their feeding efficiency per unit time and moving toward satiation. However, predators again increased their feeding efficiency with further increase in T_a without attaining satiation level. By 48 hours, predators were a more efficient handlers of prey than they were in the first hour of the trial. These data demonstrate that convergent lady beetles have potential to suppress larger populations of cotton aphids through continuous feeding by changing their predation efficiency during feeding.

The analysis of age-specific mortality without prey or water showed that a lady beetle adult could survive for an extended period of time (Figure 3). Data (not presented here) showed that the age-specific mortality of predators fed with 25, 50, 100, 210, and 400 aphids reached 100% on day 17, 8, 17, 12, and 19, respectively. The average mortality curve showed that 25% of the predators survived past one week with no prey or water while 7% survived 16 or more days (Figure 2). Because density-dependent mortality is not a significant population regulatory factor for convergent lady beetles in nature (Schellhorn and Andow 1999), the ability to survive without prey becomes critical. Also, the ability of adults to tolerate a long period of starvation may reduce the degree of cannibalism to conspecific immatures (Parajulee and Phillips 1995).

In summary, convergent lady beetle adults are voracious predators of cotton aphids. They showed a linear relationship between prey density and consumption up to 400 aphids in 48 hours. In addition, convergent lady beetles showed an extended survivorship without prey or water. The ability of a predator to survive without prey for an extended period of time is a significant factor in natural biological control as it delays or prevents the rebound of pest populations. In the field, convergent lady beetles usually disperse after aphid populations crash. However, the extended survivorship allows the dispersing predators sufficient time to locate another prey source.

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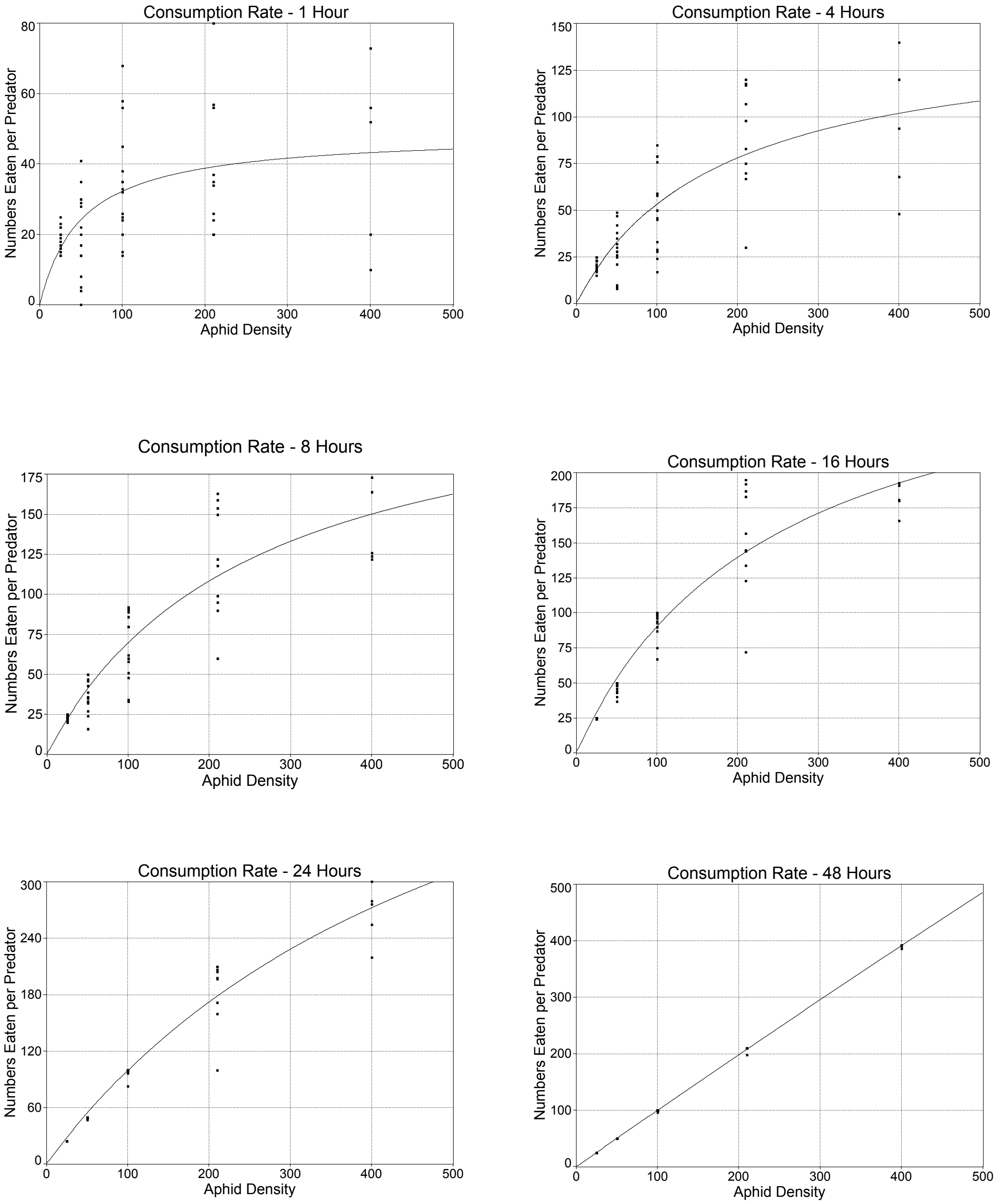

Figure 1. Consumption rate of cotton aphids by convergent lady beetle as affected by prey density and total predation time.

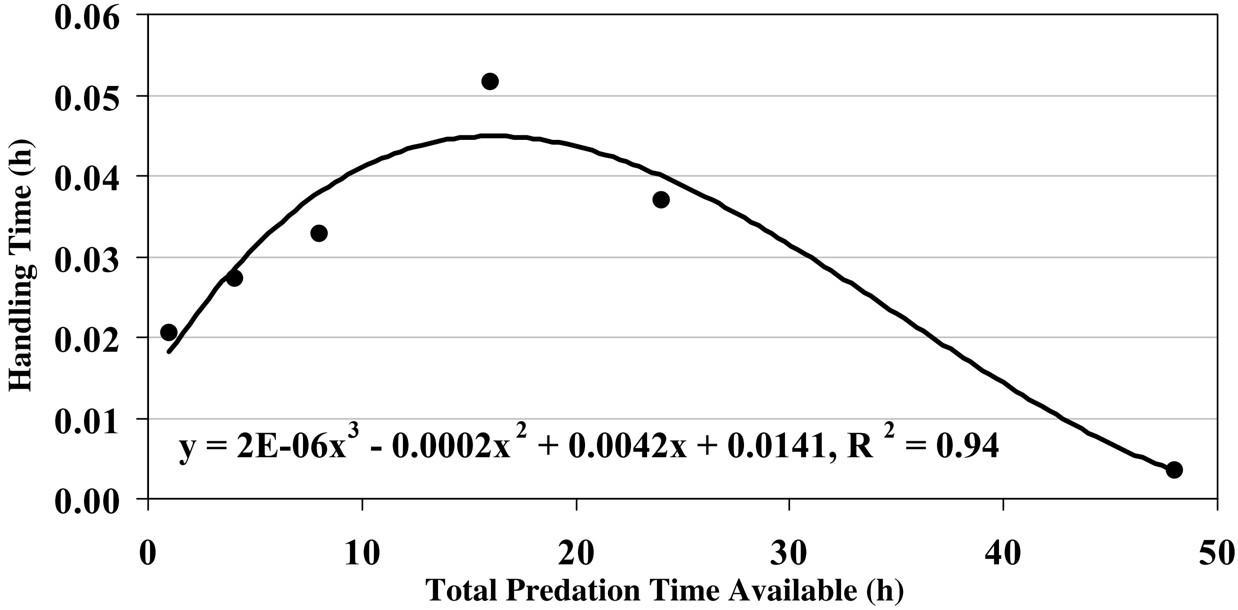

Figure 2. Relationship between total predation time available and prey handling time for convergent lady beetle.

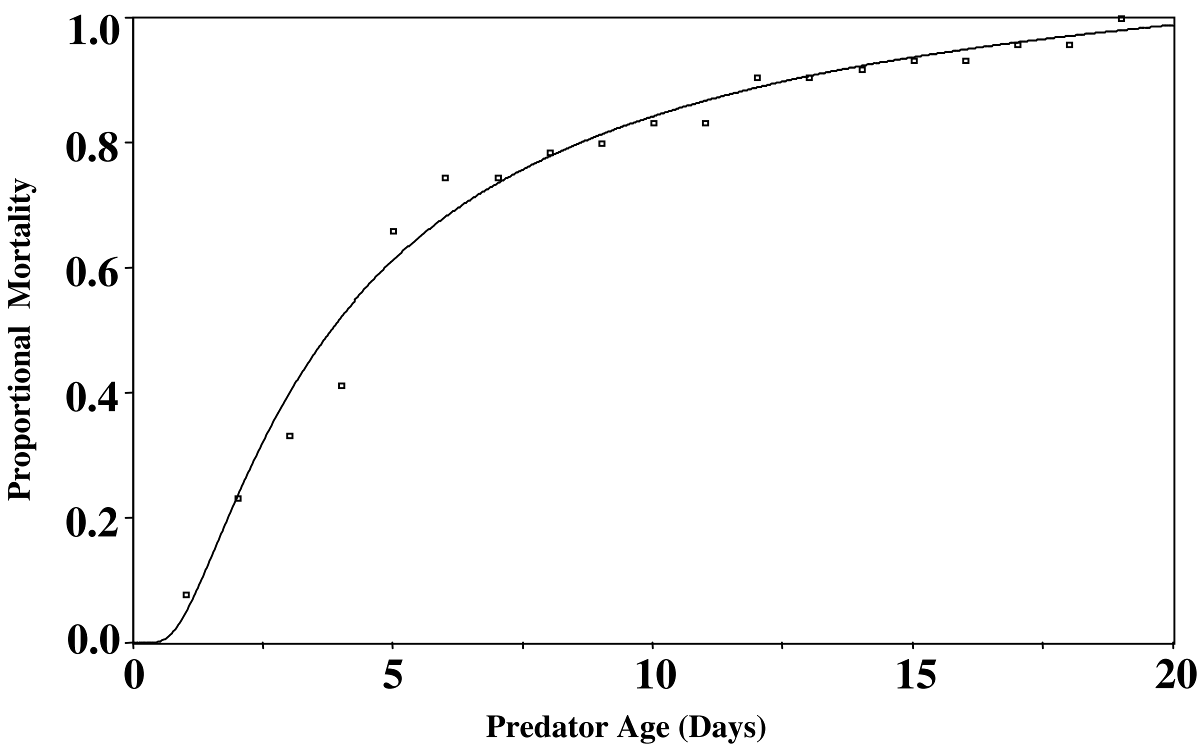

Figure 3. Age-specific mortality of an adult convergent lady beetle without prey or water. The data are averaged over six prey density treatments from Figure 1.