BIOTIC SUPPRESSION OF THE COTTON APHID (HOMOPTERA: APHIDIDAE) IN THE GEORGIA COASTAL PLAIN

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Abstract

The effects of natural enemies on cotton aphid population density was monitored using four cage types to exclude or include predators and/or parasitoids. The treatments examined were total exclusion, partial exclusion, open cage, and uncaged control. Aphid densities were significantly higher in the total exclusion treatment than in any other treatment, indicating the importance of natural enemies in the suppression of cotton aphids. The small coccinellid, *Scymnus* spp., appears to have been the most important predator of cotton aphids throughout the study. The results of the current study indicate that aphids are initially suppressed by the entomopathogenic fungus, *Neozygites fresenii*, and are kept at low levels thereafter by parasitoids and predators, most notably *Scymnus* spp., preventing further outbreak.

Introduction

Cotton aphids, *Aphis gossypii* Glover, can be serious pests of cotton throughout the Cotton Belt. Pest management changes in the cotton agroecosystem throughout the southeastern United States have provided an opportunity to enhance integrated pest management (IPM) in cotton production. A major component of the IPM system is the use of natural enemies to suppress pest populations. Important natural enemies of the cotton aphid include the entomopathogenic fungus, *Neozygites fresenii* (Nowakowski), various parasitoids, and generalist predators. The beneficial insect fauna in cotton is highly diverse (Whitcomb and Bell 1964). Historically, the importance of generalist predators has received less attention than that of specialist natural enemies such as entomopathogenic fungi and specialist parasitoids.

The insects most commonly credited with significant control of aphids are the coccinellids, chrysopids, and syrphids (Frazer 1988). Predaceous hemipterans such as anthocorids, lygaeids, and nabids may play important roles as well, as they are often found in such high densities in cotton (Coll and Ruberson 1998). The interactions between these insects are often quite complex, with intraguild predation likely playing a major role in the system. This may make it difficult to determine the predator-prey dynamics of the cotton system and their effect on pest populations. There is a need for a further understanding of the role of natural enemies in the control of the cotton aphid. The current study was designed to characterize the impact of natural enemies on cotton aphid populations.

Materials and Methods

Field work was conducted in an untreated 4-acre cotton plot in Worth County, Georgia. DPL5415 cotton was planted on 11 June 1998 at 3 seeds per foot with 36 inch row spacing. Four treatments of three different cage types and an uncaged control treatment were used to evaluate the impact of natural enemies on cotton aphids. The cage types used during the study were: total exclusion with a mesh size of 105 microns to exclude all natural enemies, partial exclusion with a mesh size of 1190 microns to exclude large predators, and open cage with a mesh size of 105 microns to determine any cage effects. Each cage type was placed over a single leaf at the eighth node of separate cotton plants selected randomly throughout the field. Total and partial exclusion cages were closed and sealed at the proximal end of the plant stem with paddle wire. A garden stake was rolled up into the distal end of the cage and attached to a bamboo stake by clothes pins to suspend the cages and hold the edges of the cages away from the leaf. Open cages were left open at the proximal and distal ends and were suspended around the leaf by attaching the cage to the node above with paddle wire. Uncaged leaves were left fully exposed. Each cage type was replicated 14 times on separate cotton plants. Seven of the plants in each treatment were sprayed with tanglefoot at the base of the plant, at the base of the stem to which the cage was attached, and at the base of the bamboo stake to exclude ants. Any other leaves or debris in contact with the study leaves were removed.

All but four adult aphids were removed from each leaf on 28 August 1998 to ensure that all leaves had the same aphid density at the beginning of the experiment. Aphid density on each leaf was recorded three times per week from 31 August-5 October 1998. When aphid density on any leaf had been reduced to zero, four new adult aphids were placed on the leaf so that the experiment could continue. All cages were re-sealed after sampling. Predators, mummies, and fungus-infected aphid cadavers found inside cages were recorded. Three ground cloth samples also were conducted once per week in the plot to further sample predator density. Data was analyzed using Analysis of Variance (ANOVA) and Tukey's test. Means were separated using Duncan's multiple range test (SAS Institute 1985).

Results

Aphid densities peaked on 11 September at 53.4 aphids per leaf and on 23 September at 44.3 aphids per leaf in the total exclusion treatment (Figure 1). Peaks in aphid density were

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reached on 2 September in the partial exclusion, open cage, and uncaged control treatments at 14.2, 23.6, and 21.6 aphids per leaf, respectively (Figure 1). Aphid densities were significantly (F=39.73; df=3, 45; p=0.0001) higher in the total exclusion cages than in any of the other cages and lowest on the uncaged control leaves during the study (Table 1).

Fungus-infected aphid cadaver density peaked on 11 September at 7.1 cadavers per leaf in the total exclusion treatment (Figure 2). Cadaver densities peaked on 16 September and 21 September at 2.2 cadavers per leaf in the open cage treatment (Figure 2). Fungus-infected cadaver densities peaked on 9 September at 0.36 cadavers per leaf in the uncaged control treatment and on 16 September at 0.07 cadavers per leaf in the partial exclusion treatment (Figure 2). Although no significant (F=1.90; df=3, 45; p=0.128) differences were observed with respect to densities of fungus-infected aphid cadavers between the four treatments, fungus-infected cadaver densities were highest in the total exclusion cages (Table 1).

Mummy density peaked at 1.5 mummies per leaf and 0.93 mummies per leaf on 2 September in the open cage and uncaged control treatments, respectively (Figure 3). Mummy densities in the partial exclusion treatment remained peaked at .071 mummies per leaf from 31 August-11 September and again on 16 September (Figure 3). No mummies were observed in the total exclusion treatments. Mummy densities were significantly (F=3.43; df=3,45; p=0.0166) higher in the open cages than in the total exclusion cages but not in the partial exclusion cages and uncaged treatments (Table 1).

The predator most frequently discovered inside the cages was *Scymnus* spp. *Scymnus* spp. densities peaked on 8 September at 0.78 individuals per leaf in the open cage treatment (Figure 4). *Scymnus* spp. densities in the uncaged control treatment peaked at 0.286 individuals per leaf on 2 September (Figure 4). Densities of *Scymnus* spp. in the partial exclusion treatment peaked on 9 September and 11 September at 0.21 individuals per leaf (Figure 4). No *Scymnus* spp. were observed in the total exclusion treatment (Table 1). *Scymnus* spp. densities were significantly (F=7.28; df=3, 45; p=0.0001) higher in the open cages than in the other cage types (Table 1). *Scymnus* spp. densities were also significantly (F=3.19; df=15, 45; p=0.0001) affected by date and a significant (F=2.12; df=45, 45; p=0.0001) date by cage interaction was observed.

Chrysopid densities were significantly (F=3.22; df=3, 45; p=0.022) higher in the uncaged control than in the open cage and total exclusion treatments but not the partial exclusion treatment (Table 1). A significant (F=1.39; df=45, 832; p=0.04) date by cage interaction appeared to affect chrysopid densities as well. No predators were observed in the total exclusion treatment.

Weekly ground cloth samples revealed that *Scymnus* spp. were the most abundant predators overall during the study. *Scymnus* spp. occurred at significantly (F=100.66; df=7, 96; p=0.0001) higher densities than *Hippodamia convergens*, hooded beetles, nabids, *Orious insidiosus*, and *C. carnea* but not *Geocoris punctipes*. Predator densities were significantly (F=2.35; df=5, 96; p=0.046) affected by date. Total predator densities in the plot peaked on 8 September at 2.25 predators per row meter (Figure 5). *Scymnus* spp. densities peaked on 4 and 8 September at 2.67 *Scymnus* per row meter (Figure 5). *Geocoris punctipes* densities peaked on 8 September at 4 individuals per row meter (Figure 5).

Discussion

The current study indicates that arthropod natural enemies are important factors in the suppression of cotton aphid populations. Small predators and parasitoids which were able to enter the partial exclusion cages appeared to suppress cotton aphid populations to a level which was not significantly different from that of the uncaged control and open cage treatments, where all natural enemies could feed on aphids (Figure 1). This indicates that small predators such as *Scymnus* spp. larvae and young chrysopid larvae may be more important predators of cotton aphids than larger predators such as the larger coccinellids, lygaeids, and nabids. Kerns and Gaylor (1993) also suggest that small predators may be more efficient mortality agents of aphids because they are better adapted to handling small prey items than are most large predators.

Spores of the entomopathogenic fungus, *N. fresenii*, were able to enter all cage types, including the total exclusion treatment, and infect the aphids present either through the mesh openings or while cages were being sampled. Aphid densities were reduced after the development of fungal epizootics in all treatments. With the exception of the total exclusion treatment, fungus-infected cadaver densities peaked in all treatments approximately 5-10 days after aphid densities peaked. This is consistent with the findings of Steinkraus et al. (1996) who suggest that *N. fresenii* can reduce large aphid populations by 90% within 7-9 days once epizootics begin as a result of the short life cycle of this fungus, which is completed in 3-4 days. The synchronization of the peaks in aphid and fungus-infected cadaver densities in the total exclusion cages was most likely a result of the high aphid densities in these cages. After the fungal epizootic reduced aphid densities, they remained at low levels in all cage types except the total exclusion cages. Aphid densities were able to rebound after the fungal epizootic in the total exclusion treatment most likely as a result of the absence of predators. This underscores the importance of *N. fresenii* and arthropod natural enemies in the suppression of cotton aphid populations.

Although the parasitoid *Lysiphlebus testaceipes* is a major control factor of cotton aphids in California (King et al.

1988), it did not appear to have a large impact on aphid populations in our study. During the current study, mummies were observed in all cage types except for the total exclusion cages (Figure 3); however, mummies were never abundant in any treatment, indicating that although they most likely contribute to the suppression of cotton aphids, parasitoids are not as important in this respect as are *N. fresenii* and the cotton aphid's predator complex. This may be a result of the sporadic nature of parasitoids in the field. It is possible that parasitoids contributed to the reduction in aphid density during the initial decrease observed in the current study, although *N. fresenii* appears to be primarily responsible. Since parasitoids such as *L. testaceipes* are attracted to dense populations of aphids, they probably had very little effect on cotton aphid populations after the initial decrease.

Although large predators may be more visible and therefore appear more abundant in cotton systems, they may not be as important as other small predators such as *Scymnus* spp. in the suppression of aphid populations. Several small predators were observed in the current study on leaves in the partial exclusion cages, including *Scymnus* spp., chrysopids, *Orius*, and fire ants. Of these, only *Scymnus* spp. larvae and chrysopids occurred at high enough densities to warrant analysis. These predators were observed in all cage types except the total exclusion cages, where all arthropod natural enemies were excluded. Chrysopids were observed on leaves in the uncaged treatment most often as eggs. In the treatments where predators, most notably *Scymnus* spp. were observed, aphid densities remained at low levels throughout the remainder of the study. This was not the case in the total exclusion treatment were these and other predators were not present. Ground cloth samples revealed that *Scymnus* spp. and *G. punctipes* were the most abundant predators in cotton throughout the study. Although *G. punctipes* is known to feed on cotton aphids, this predaceous bug is a generalist feeder and may be more important in the suppression of other pest species such as the cotton bollworm.

Summary

The results of the current study suggest that small predators are important to the regulation of cotton aphid populations. It appears that aphid populations may build to a certain density before being reduced to low population levels by the entomopathogenic fungus, *Neozygites fresenii*. After reduction by the fungus, the aphid predator complex, of which *Scymnus* spp. and other small predators appear to be a very important part, keep aphid densities at low levels and prevent further outbreaks. These results illustrate the importance of understanding the complex interactions that occur between natural enemies in the suppression of pest species. In order to effectively utilize the natural enemies present in a system, one must make management decisions based on this understanding that will allow the system the opportunity to protect itself.

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Table 1. Mean Densities/leaf of cotton aphids, fungus-infected cadavers, mummies,and *Scymnus* spp from 14 leaves in each cage type (Letters that are different across rows denote significant differences).

Factor	Total Exclusion	Partial Exclusion	Open Cage	Uncaged Control
Aphids	28.56a	6.18b	5.58b	4.66b
Fungus-Infected Cadavers	0.69a	0.004a	0.56a	0.06a
Mummies	0b	0.07ab	0.16a	0.09ab
Scymnus spp.	0c	0.06b	0.125a	0.044bc

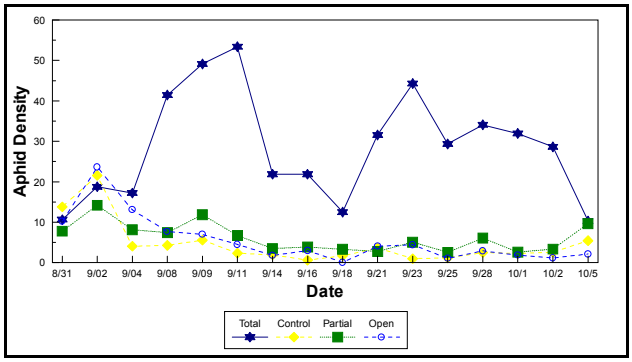

Figure 1. Mean cotton aphid density per leaf in each cage type.

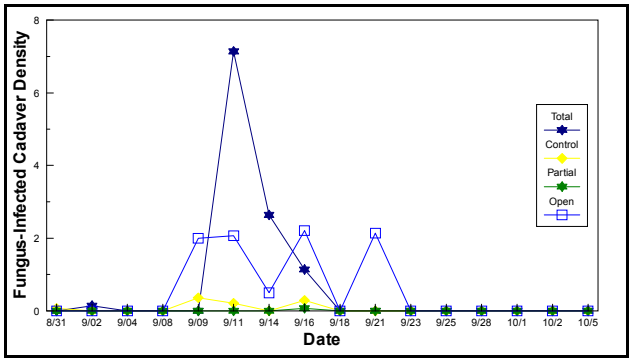

Figure 2. Mean density of *N. fresenii*-infected aphid cadavers per leaf in each cage type.

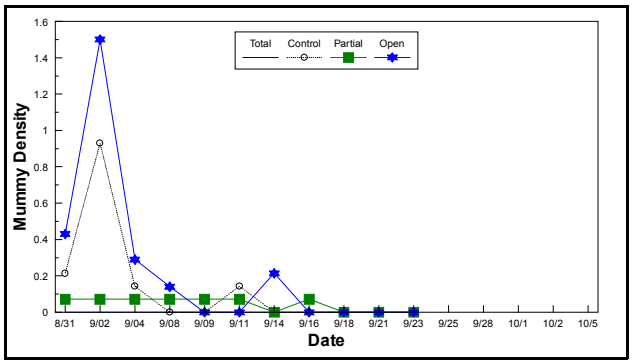

Figure 3. Mean density of parasitized aphids (mummies) per leaf in each cage type.

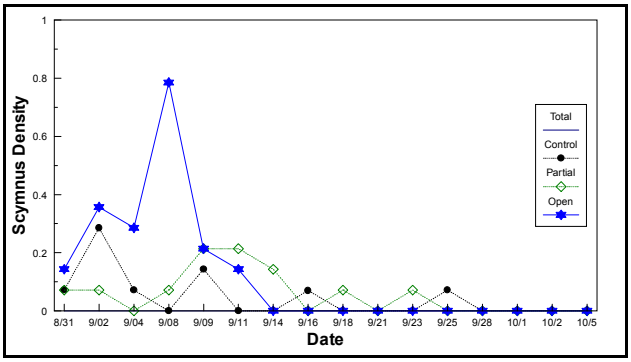

Figure 4. Mean density of *Scymnus* spp. per leaf in each cage type.

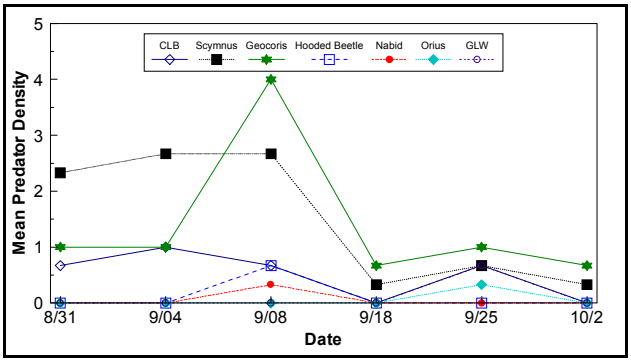

Figure 5. Mean weekly density of predators observed by ground cloth samples.