Impacts of the Red Imported Fire Ant upon Predators, Aphids and Noctuid Eggs in Cotton Fields

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Abstract

The effects of the red imported fire ant, *Solenopsis invicta* (Buren) (IFA hereafter), on common predators, cotton aphid populations, and its predation on bollworm (*Helicoverpa zea* Bobbie) and beet armyworm (*Spodoptera exigua* Hubner) were evaluated under field conditions. Beat bucket samples showed that IFA, minute pirate bug, ladybeetles, spiders and cotton fleahopper are the most common predators in the cotton canopy. Moreover, density of lady beetles and *Scymnus* spp. was greater in the presence of IFA because they were able to respond to densities of cotton aphids, which were tended by IFA. Densities of minute pirate bugs, spiders and lacewing were less in the presence of IFA. Cotton aphid populations were ca. 5.5 times higher in plots with ants versus plots without ants, but did not reach the economic threshold. Predation of sentinel bollworm eggs, indicated by their absence after 24 h, was 2× higher in plots with ants versus plots without ants. Most predation of sentinel beet armyworm egg masses, measured via direct nocturnal observations, was due to IFA (68%) and cotton fleahoppers [*Pseudatomoscelis seriatus* (Reuter)] (21%) in plots with ants, and by the mite Abrolophus sp. (52%), spiders (13%) and minute pirate bug (Orius sp.) in plots without ants. The results of this study show that while IFA promote aphid populations early in the growing season, they are important predators of bollworm and beet armyworm eggs later in the season.

Introduction

The red imported fire ant, *Solenopsis invicta* (Buren) (IFA hereafter), arrived in the USA between 1933 and 1945 from Brazil (Callcott and Collins 1996) and currently is found in ca. 118 M ha in the southern states (USDA, APHIS, 1996). Among the biological factors facilitating range expansion of IFA are mass foraging, a venomous sting, territoriality, large colony size, and alate dispersal (Shoeler and Reagan 1987). Within the range of IFA, it is among the key insect predators present in cotton (Sterling et al. 1979), and according to Lopez et al. (1996) may be the most important fire ant species in USA cotton agroecosystems because of its distribution, abundance, and predatory aggressiveness. Cotton fields are colonized by foraging workers from colonies outside cotton fields and by new immigrant queens after mating flights (Lopez et al. 1996).

Impacts of IFA on cotton insect diversity are of particular interest if populations of predators and parasitoids of cotton pests are reduced. Lofgren (1986) provides a list of reports of predation on beneficial insects by IFA in different crops, and Vinson (1994) provides a review of predation by IFA in different ecosystems. Using D-Vac® samples and pitfall traps, Sterling et al. (1979) found that IFA did not negatively affect populations of predators in east Texas cotton. However, Reilly and Sterling (1983) found positive relationships between numbers of IFA foragers and cotton aphids (*Aphis gossypii* Glover), damsel bug (*Nabis* spp.), cotton fleahopper [*Pseudatomoscelis seriatus* (Reuter)] and minute pirate bug (*Orius* spp.), and concluded that IFA might eliminate cues such as exuvia, excreta and honeydew used by natural enemies of these species. More recently, Eubanks (2001) found that densities of IFA foragers had a negative correlation with all 16 herbivores and 22 of 24 natural enemies encountered in cotton and soybean fields during the entire season.

Aphis gossypii Glover is the most common aphid pest occurring on cotton in the United States. According to Henneberry et al. (2000) damage is due to direct feeding on leaves, which reduces yield, contamination of lint by honeydew and growth of associated fungi, and transmission of more than 50 plant viruses. IFA is known to interact with cotton aphids. For example, Reilly and Sterling (1983) found a highly positive association between cotton aphids and IFA in east Texas cotton field. Other observations suggest that fire ants tend cotton aphids on cotton early in the growing season (Sterling et al. 1979).

IFA is also known to prey on eggs and larvae of lepidopteran insects in agricultural landscapes, including pests species such as bollworm [*Helicoverpa zea* (Boddie)], tobacco budworm [*Heliothis virescens* (F.)], velvetean caterpillar (*Anticarsia gemmatalis* Hubner) and soybean looper [*Pseudoplusia includens* (Walker)] (Lofgren 1986). Furthermore, in Louisiana management of sugarcane borer (*Diatraea saccharalis* Fabricius) partially depends on the predatory activity of IFA (Reagan 1981). Using radioactive tagged eggs, McDaniel and Sterling (1979, 1982) found that IFA is the most common predator of tobacco budworm eggs on cotton plants in East Texas cotton and IFA was preying on third and fourth instar larvae. Nuessly and Sterling (1994) found that predation of radioactive tagged bollworm eggs is higher toward the top of cotton plants, and that IFA is responsible for 86% of egg mortality attributable to specific arthropods.

The objectives of this research were to assess the influence of IFA on common predators, cotton aphid population dynamics, and evaluate their importance as predators of bollworm and beet armyworm. Weekly samples of predators, aphid populations, reports of presence or absence of sentinel eggs and nocturnal observations of predation accomplished these objectives.

Materials and Methods

Study site. The study was conducted in a cotton field on the Texas A&M Stiles Farm Foundation in Williamson County, TX. The cotton variety used was Deltapine 436 RR (DP & L Co., Scott, MS). Eight plots of three ha each and arranged in two rows of four plots were located in the center of a ca. 60 acres cotton field. Four alternating plots were treated with broadcast applications of Extinguish® and Amdro® fire ant baits in spring 2001 to eliminate ants present in each plot (plots without IFA). The effective sampling area consisted of a square of 25m by 25m in the center of each plot, and foliar insecticides were not applied in this area. The remaining four plots were left untreated and served as controls (plots with IFA).

Canopy-dwelling predators. Ten species of canopy-dwelling predators were sampled weekly from June to August using the beat bucket technique, which consists of shaking cotton plants inside a 5-gallon white plastic bucket and counting all recovered predatory insects. Fifteen stations located in a diagonal transect were sampled inside the sample area of each plot. At each station, a sample of three consecutive plants was taken early in the morning (8:00-10:00 am). Predators that were recorded included minute pirate bug, cotton fleahopper, red imported fire ant, crab spider, jumping spider, other spiders, bigeyed bug, green lacewing, lady beetle, damsel bug, and *Scymnus* spp.

Cotton aphid dynamics. Cotton aphid populations were visually sampled from June to August using the key leaf technique (Hardee et al. 1994), which consists in sequentially sampling different parts of the cotton plant during the growing season to account for varying aphid colonization and feeding preferences. Each plot was sampled in 10 stations, starting in one corner of the sample area and crossing diagonally to the opposite corner. Each station consisted of five consecutive plants.

Bollworm predation. Twenty-five bollworm eggs of one-two day old were placed per day, one per terminal leaf of 25 plants, in each plot; therefore, each treatment had 100 eggs. Plants with sentinel eggs were in a single row and separated at least by two meters from each other. Each egg was handled using a fine brush and glued to leaves with gum arabic. Presence or absence of eggs was recorded after 24 hours. The proportion of eggs that disappeared after 24 hours was arcsine transformed. This experiment was repeated on 18 different days during mid and late season.

Beet armyworm predation. Night observations were conducted in order to determine predatory species and timing of predation events on lepidopteran eggs. During the summer, insect activity in cotton fields is greatest during the cooler hours of the day, from 6:00 pm to 7:00 am. Egg masses of beet armyworm [*Spodoptera exigua* (Hubner)] with ca. 40-50 eggs and individual eggs of bollworm were placed in two different but adjacent plants. Each egg mass was handled using forceps and glued to leaves with Elmer's® glue. This experiment started between 6:00 to 7:00 pm. Each plant was observed for a period of 5 seconds every 15 minutes. Predators feeding on the eggs were identified to genus level in the field, and the numbers and time of predatory events were scored for a period between 7:00 pm and 1:00 am. A predatory event was established when a predator was eating/removing an egg. This experiment was repeated three times in each treatment.

Statistical analysis. The numbers of ants in bait vials were compared between treatment and plots with IFA via ANOVA. The numbers of predators collected in beat bucket samples during the cropping season were compared between treatments via repeated measures ANOVA. Mean aphid numbers was compared between plots with IFA and plots without IFA using repeated measures ANOVA. The proportion of bollworm eggs that disappeared after 24 hr were arcsine transformed and treatments means were compared via ANOVA. The interaction of treatment × date was significant; therefore, dates were individually compared using ÷2 test.

Results and Discussion

Impact on common predators. Cotton fleahopper densities were significantly different between plots without ants and with ants ($P < 0.016$) (Fig.1b). Lady beetles densities were significantly higher early in the season in plots with IFA compared to plots without IFA ($P < 0.001$) (Fig. 1c). Spider densities were significantly higher during most of the season in plots without IFA compared to plots with IFA ($P < 0.001$) (Fig. 1d). The season long composition of spiders in plots without IFA was jumping spiders 4.5%, crab spiders 26.5% and "other spiders" 69.0 % and in the plots with IFA was jumping spiders 4.1 %, crab spiders 26.4% and "other spiders" 69.5 %. Season long minute pirate bug (*Orius* spp.) densities were significantly higher in plots without IFA versus plots with IFA ($P < 0.001$) (Fig. 1e). In general, an increase in minute pirate bug populations was evident during squaring and boll formation. *Scymnus* spp., damsel bug, bigeyed bug and green lacewing were collected in lower numbers in the beat bucket compared with other predators (Fig. 2). Bigeyed bug densities were significantly greater in plots with IFA ($P < 0.015$) (Fig. 2a). Green lacewing densities were significantly higher in plots without IFA compared with plots with IFA ($P < 0.013$) (Fig. 2c). Seasonal densities of damsel bug did not differ between treatments (Fig. 2b). *Scymnus* spp. densities were not different between plots without IFA and plots with IFA (Fig. 2d). It has not been shown that the reduction in densities of these predators has a negative impact on biological control of cotton pests, and in fact the additional predation provided by IFA may exceed the loss of predation due to the suppressed species.

Cotton aphid dynamics. Cotton aphid population was significantly higher in plots without ants vs. plots without ants (Fig. 3). Using accumulative numbers, plots without ants had 5.5× less aphids than plots with ants. Nevertheless, most of the increase was early in the season and the population in plots with ants did not reach the threshold level for insecticide application of 50 aphids/leaf (Fig. 3). The increase in the population of cotton aphids observed in the plots with ants is explained by a net positive effect of IFA upon these aphids.

Bollworm predation. Fourteen out of eighteen dates had significantly fewer bollworm eggs in plots with IFA vs. plots without IFA after 24 hr (Fig. 4). Plots with IFA had a mean absence of bollworm eggs of 58.5 ± 0.06 % compared to 28.2 ± 0.05 % (P = 0.0001) plots without IFA after 24 hr.

Beet armyworm predation. Forty-seven predation events on beet armyworm egg masses were witnessed in plots with ants vs. sixty-nine events in plots without ants during 18 hr of observations. In plots with ants most of the predation events were done by IFA and cotton fleahopper, followed by other predators, which had an erratic distribution (Fig.5). In plots without ants the majority of predation events were done by a mite, *Abrolophus* sp. (Acari: Erythraeidae), followed by spiders, cotton fleahopper, minute pirate bug which had a more uniform distribution (Fig. 5). Compared with other predators, IFA arrived first to the egg mass and then recruits removed all eggs in the mass in ca. 30-40 min. In contrast, *Abrolophus* sp. consumed one-two eggs in period of ca. 2 hr. Moreover, this study shows that IFA is the most frequent predator of bollworm and beet armyworm eggs considering behavioral factors such as mass foraging, recruitment and aggressiveness.

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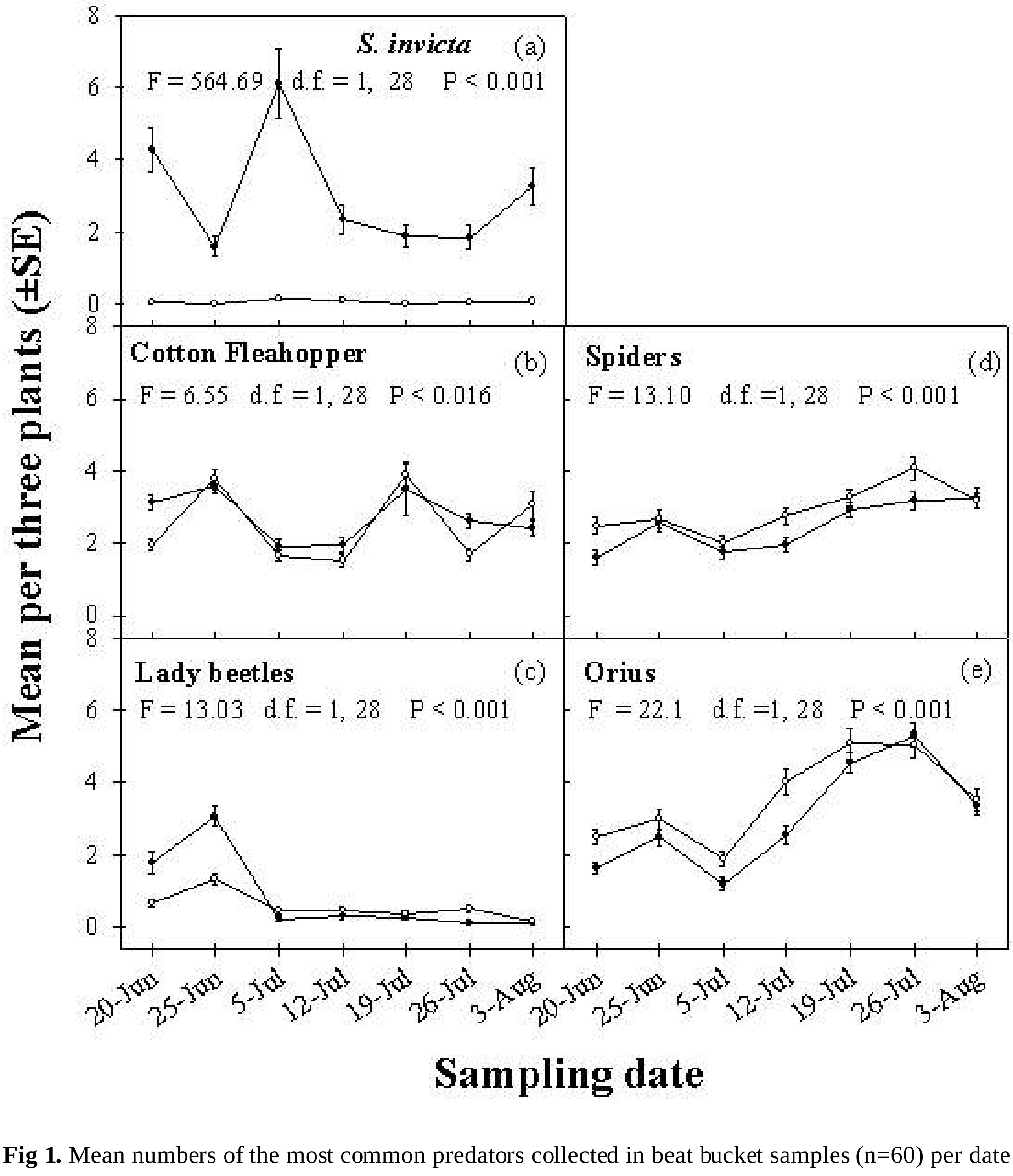

Fig 1. Mean numbers of the most common predators collected in beat bucket samples (n=60) per date in Thrall,

Texas 2001. Lines with dark circles represent individuals in plots with IFA and lines with empty circles represent individuals in plots without IFA. Lines were compared using repeated measures ANOVA. Bars = mean ± SE.

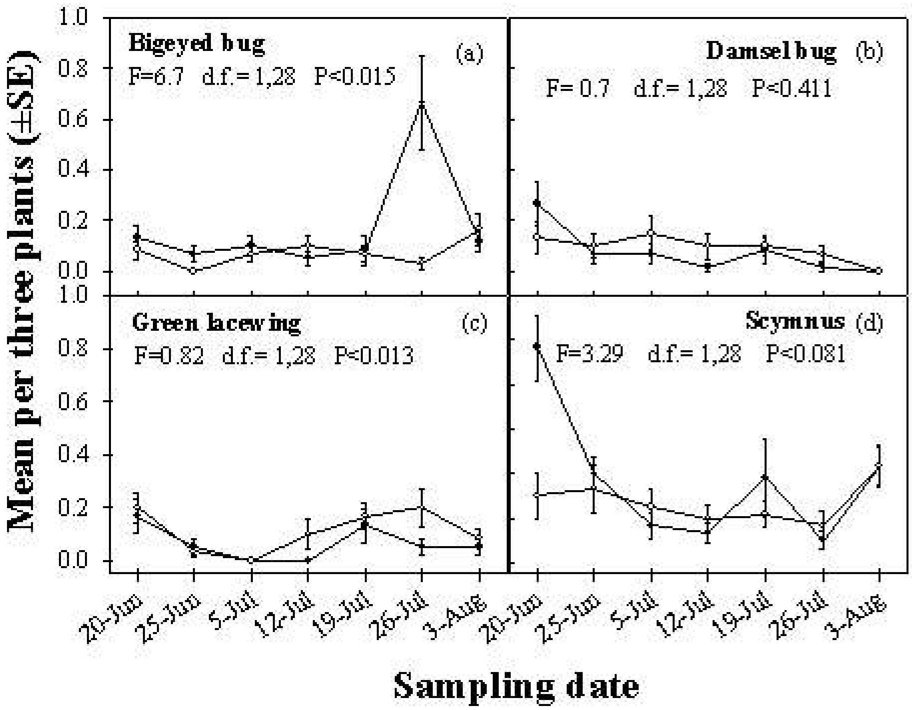

Fig 2. Mean numbers of the less abundant predators collected in beat bucket samples (n = 60), Thrall, Texas 2001. Lines with dark circles represent individuals in plots with IFA and lines with empty circles represent individuals in plots without IFA. Lines were compared using repeated measures ANOVA.

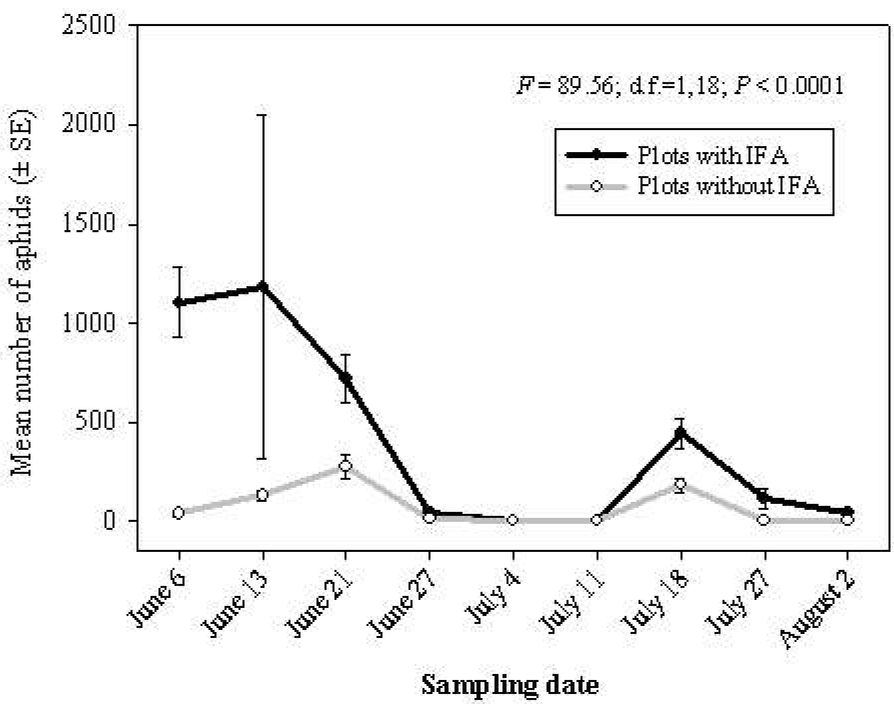

Fig. 3 Mean number of aphids per fifty plants in control and treatment plots, Thrall, Texas, 2001. Statistical comparison is via repeated measures ANOVA.

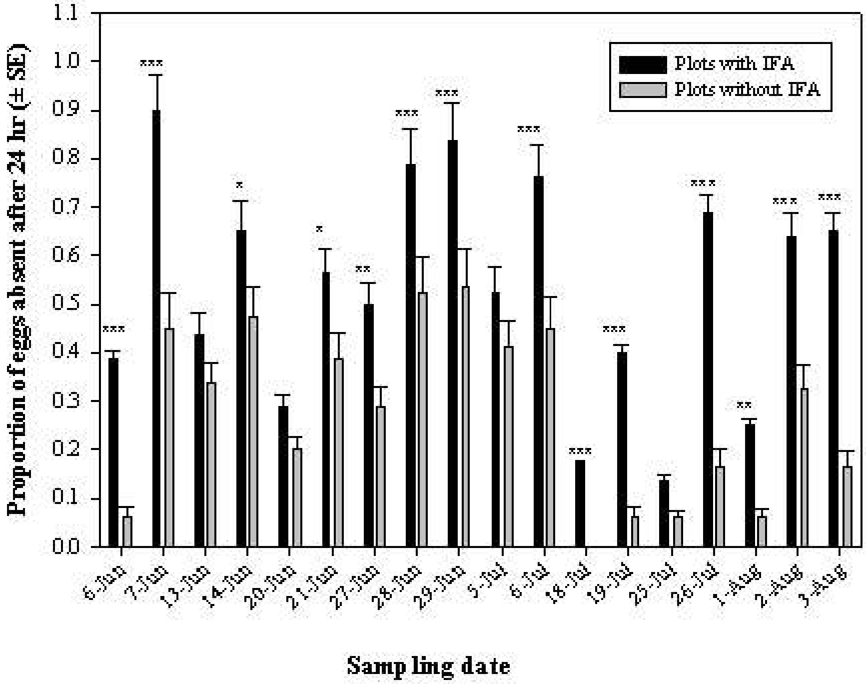

Fig. 4 Proportion of bollworm eggs absent after 24 hr in treatment and control plots, Thrall, Texas 2001. Individual dates were compared using χ^2 test, * = < 0.05; ** = <0.025; *** < 0.0001.

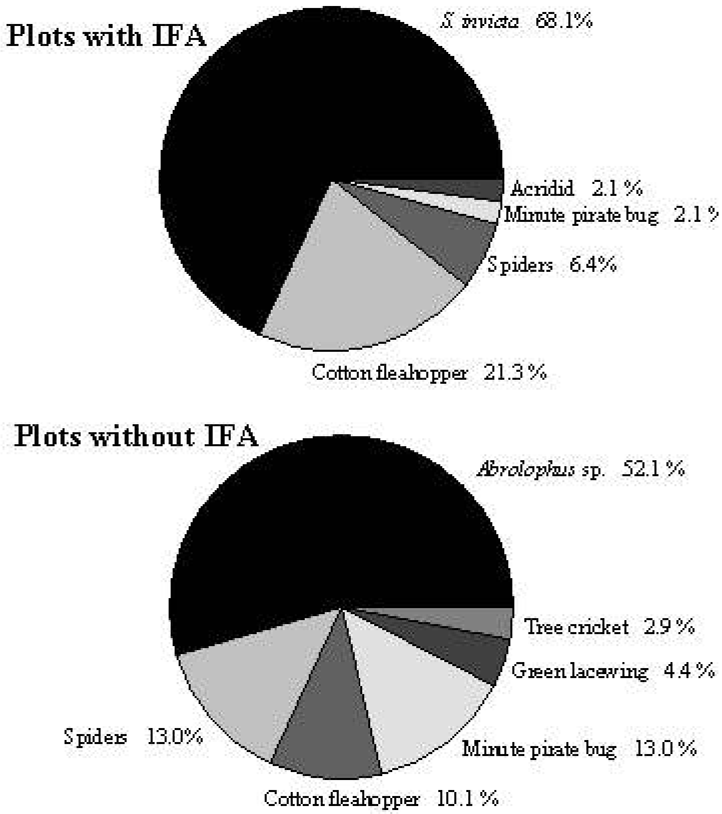

Fig. 5 Proportion of predation events on beet armyworm eggs corresponding to individual predator species in plots with IFA (n = 47) and plots without IFA (n = 69) in Thrall, Texas 2001.

A Field Evaluation of the Impact of Fire Ants on Quality and Yield of Peanuts in Comanche County, Texas.

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Summary: A single application of Extinguish™ fire ant bait in early June, 2002, reduced fire ant activity by 86-98 percent two months later in two peanut fields. However, there were no differences in quality, yield or value of peanuts harvested from plots in which fire ant activity was reduced compared to untreated plots were fire ants were present.

Objective: Fire ants and their mounds are often common in peanut fields and fire ants are known to feed on seeds and seedling plants of some crops. There is no published information regarding feeding damage by fire ants to peanuts. The objective of this study was to determine if fire ants caused a reduction in grade or yield of peanuts grown under irrigation.

Methods and Materials: Two commercial fields of irrigated peanuts in Comanche County were divided into eight square plots each of 2 acres. In each field, four alternating plots were treated with Extinguish fire ant bait to suppress fire ant numbers while the remaining four plots were left untreated as check plots. Extinguish fire ant bait is registered for use on many sites, including field crops.

Extinguish bait is collected by foraging ants, returned to the colony and fed to the queens. Queen fire ants stop producing fertile eggs and the colony slows dies out. Thus, control of fire ants with Extinguish may require one or more months, depending on how environmental conditions influence the rate of ant death.

Extinguish fire ant bait was applied once on June 8, 2001, at a rate of 1.5 lbs. per acre. The bait was applied using a Herd seeder mounted behind a four wheel Kawasaki Mule at 12 mph and with a swath width of about 30 feet.

The sandy soil and spreading nature of the peanut plants made finding fire ant mounds very difficult in peanut fields. To overcome this difficulty, fire ant numbers were estimated by trapping ants in small glass vials baited with candy and cat food. Prior to treatment, four glass vials were evenly spaced down the center of each plot and placed on the ground early in the morning of May 25. Foraging fire ants which discovered the bait recruited other workers from nearby colonies and began removing the bait. After one hour, the vials were quickly picked up and capped, capturing worker ants inside. Bait vials were frozen and the number of fire ants was recorded for each vial. Two months after the bait application, fire ant activity was again monitored on August 2 using 12 glass vials per plots to determine the impact of the Extinguish treatment.

A sample of 10-12 peanut plants was each pulled from two locations in each plot on September 6 and 100 peanuts were collected from each subsample (200 peanuts per plot). Each peanut was examined for the presence of holes in the shuck characteristic of feeding by fire ants, wireworms or other insects.

Peanuts were machine harvested from a plot six rows wide and 100 feet long (0.041 acre) in the center of each plot on October 4 and October 29 for the Hart and O'Brien field, respectively. Harvest weight, moisture, yield, and grade were determined for each sample.

Results and Discussion:

On May 25, prior to treatment, the average number of fire ants collected per vial in the Extinguish and Check plots was 26 and 31, respectively, in the Hart Field. These results demonstrate that ant activity was similar in both treatments prior to application of the Extinguish treatment.

On August 2, there were 85 % and 98 % fewer fire ants collected in baited vials in the Extinguish treatment than in the Check treatment in the O'Brien and Hart fields, respectively (**Table 1**). These results demonstrated that the Extinguish treatment significantly reduced the number of foraging fire ants two months after the application and that fire ant activity was low in the Extinguish treatment during the time of pod set and pod development. However, there were no significant differences in yield, grade and dollar value per acre of harvested peanuts between plots treated with Extinguish and not treated (**Table 2**). These results suggest that under conditions in these two fields, there was no evidence that fire ants resulted in any economic loss to peanut production. Also, the percentage of peanuts with holes through the shuck that are characteristic of insect feeding such as fire ants were similar in the Extinguish and Check treatments in both fields (**Table 3)**. Insect damage to the shucks was low, ranging from 0.6 % to 2.5 % and much of the damage appeared to be the due wireworms feeding through the shuck. These results also suggest that fire ants did not significantly damage peanut pods in these study fields.

Acknowledgments: Thanks to Charles Bingham for providing the study fields and assistance with this project and to Wellmark International for providing the Extinguish fire ant bait for this test.

Table 1. Mean number of fire ants collected per vial on August 2, two months after the application of Extinguish fire ant bait.

Field	Check	Extinguish	Percent Reduction
O'Brien	83	12	85 %
Hart	52	0.9	98 %

Table 2. Average yield, quality and value of peanuts harvested from plots treated with Extinguish fire ant bait and not treated for fire ants.

	Hart Field			O'Brien Field		
Treatment	Grade	Yield, lbs/acre	Value/Acre	Grade	Yield, lbs/acre	Value/Acre
Extinguish	63.3 a	3043 a	$843 a	67.8 a	3048 a	$892 a
Check	59.8 a	3238 a	$839 a	68.5 a	3543 a	$ 1046 a

Means followed by same letter in a column are not significantly different, LSD, a = 0.05

Table 3. Mean percentage of peanuts on September 6 with holes through the shuck resulting from insect feeding.

Field	Check	Extinguish
O'Brien	2.1 %	2.5 %
Hart	0.6 %	0.8 %

Peanuts collected September 6. 800 peanuts examined per treatment in each field.