Temporal and Spatial Distribution of *Helicoverpa zea* and *Heliothis virescens* (Lepidoptera: Noctuidae) Moths in Pheromone Traps across Agricultural Landscapes in Arkansas[1]

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Abstract Pheromone trap captures of *Helicoverpa zea* (Boddie) and *Heliothis virescens* (F.) from 2002 - 2005 were used to examine the distribution of these species across a multiple crop environment in southeast Arkansas. The greatest number of *H. virescens* moths was collected during 2003, but densities were low compared with *H. zea* throughout the study. Overall, fewer *H. virescens* moths were captured next to Bt corn and Bt cotton than next to nonBt cotton and early-maturing soybean. A significant relationship was not detected between pheromone trap captures of *H. virescens* and the percentage of these moths that fed on cotton as larvae. More *H. zea* moths were captured in traps located next to Bt corn and nonBt corn during the month of June than in traps located next to cotton, sorghum, or soybean, whereas traps located adjacent to early- and late-maturing varieties of soybean, Bt cotton, nonBt cotton, and grain sorghum captured greater numbers of moths than those traps located next to corn during July. Therefore, the distribution of *H. zea* appeared to be influenced by corn acreage during the month of June. Later in the season, this species was widely distributed across the agricultural landscape. Compared with 2 other regions of AR, fewer *H. zea* moths were captured during the month of June and more *H. virescens* moths were captured during August in Mississippi Co., an area of intense cotton production.

Key Words *Heliothis virescens*, *Helicoverpa zea*, pheromone trap, landscape

The bollworm, *Helicoverpa zea* (Boddie), and tobacco budworm, *Heliothis virescens* (F.), are highly polyphagous insects, both capable of utilizing numerous cultivated and wild host plants (Kogan et al. 1989). Differences in the availability and suitability of these plants may have dramatic effects on pest population dynamics in a region. The seasonal abundance and number of generations of *H. virescens and H. zea* in an area each year are influenced by temperature, host sequence and host suitability (Isely 1935, Fitt 1989).

Moth traps baited with components of female sex pheromone have been used for 3 decades to obtain population estimates of these insects by monitoring adult males over time across a given area (Slosser et al. 1987, Goodenough et al. 1988, Leonard et al. 1989a, b, Parajulee et al. 1998, 2004, Adamczyk and Hubbard 2006). The occupied area and proximity of host plants to a particular pheromone trap can influence

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trap captures at a trapping location. This relationship changes over the season as some hosts become more or less attractive during the year. Slosser et al. (1987) observed a pattern of *H. zea* moth captures being significantly correlated with areas planted to wheat during spring months, and as the wheat matured, greater numbers were captured near cotton, guar and grain sorghum. Using marked *H. zea* moths, Culin (1995) noted that sorghum, cotton and corn had positive effects on the numbers caught in pheromone locations in 1 year of a 2-yr study.

Pheromone trap captures are assumed to be indiscriminate in the capture of moths, and individuals that developed on local or distant host plants may be trapped as adults at a particular location. This fact makes the relationship between adult populations estimated by trap captures and populations present on nearby host plants difficult to interpret. Captures may represent long-range movement as well as local dispersal. Tingle and Mitchell (1981) found that trap captures of *H. virescens* were most closely related to larval populations and damage in tobacco 1 - 2 wks after captures. In cotton, Johnson (1983) reported a relationship between pheromone trap captures of *H. virescens* adults and field populations of eggs. Harstack et al. (1983) noted that trap captures of *H. zea* began to increase 1 - 2 days before increases of eggs in the field, and continued to increase as egg counts increased. Leonard et al. (1989a) found that trap captures of *H. zea* and *H. virescens* were related to egg populations during late June and July in Louisiana in an area where cotton was the principal crop.

Pheromone traps provide an effective means of obtaining population estimates of adult males, but numerous factors may contribute to variability in captures. Cool temperatures reduce the effective plume size of pheromone emission (Harstack and Witz 1981) and also reduce the activity of males to a pheromone source (Hendricks and Harstack 1978). Wind direction and velocity affect the dispersal of pheromone (Hendricks and Harstack 1978, Hendricks et al. 1980). Parajulee et al. (1998, 2004) observed a significant negative relationship between wind velocity and pheromone trap captures of both *H. virescens* and *H. zea*. Competition between pheromone traps and native females has been noted to reduce trap efficiency when many females are present (Hendricks et al. 1973, Harstack and Witz 1981, Witz et al. 1992b). Patterns of moth captures have been related to lunar cycles (Hendricks and Harstack 1978, Parajulee et al. 1998), precipitation (Parajulee et al. 2004), previous trap captures (Slosser et al. 1987, Parajulee et al. 1998, 2004), and trap placement relative to the edge of a particular field (Witz et al. 1992a).

With an understanding of the constraints associated with pheromone trap captures, we conducted field research during 2002 - 2005 to explore distribution patterns of *H. virescens* and *H. zea* moths captured in these traps. The primary purpose of this study was to examine the relationship between measured distribution of *H. zea* and *H. virescens* male adults and the relative abundance of proximate host crops on a local scale. Temporal and spatial distributions of these insects also were observed throughout diverse production regions in Arkansas.

Materials and Methods

Pheromone traps. The Harstack pheromone trap (Harstack et al. 1979) was used with traps placed at least 50 m apart at each sample site. Each trap was rebaited with either *H. zea* or *H. virescens* pheromone (Hercon Environmental, Emigsville, PA) at least every 2 wks. Moths were collected from pheromone traps on an approximate weekly basis, except for collections from Mississippi Co., AR, where moths were collected on a daily basis. Trap captures were converted to average daily captures by dividing the total number of moths collected by the number of days from the previous collection.

Trap interfaces. To examine the relationship between pheromone trap captures of adult males and the proximate crop, pheromone traps were placed at the interfaces of various crop types from 2002 - 2005 in Drew and Desha counties, AR. At each trapping location, cotton planted with a variety expressing an insecticidal toxin derived from the bacterium, *Bacillus thuringiensis* Berliner (Bt), adjoined pheromone traps on one side, whereas various other crop types adjoined traps on the opposite side. At each crop-interface location, 2 pheromone traps were baited with either a *H. virescens* or *H. zea* pheromone strip. The crop types adjoining a trap location included: Bt cotton, nonBt cotton, Bt corn, nonBt corn, grain sorghum, early-maturing indeterminate soybean (maturity groups III or IV), and late-maturing determinate soybean (maturity group V or VI). The number of replicates for each year is presented in Table 1. A split-plot design with a two-factor factorial (year and interface) main plot and a single factor subplot (month) was used to examine differences between interface type and average daily captures for a given month (Proc GLM, SAS Institute 2001). Means were separated using Fisher's protected LSD test.

Trap captures and land coverage. To examine the relationship between crop hosts and pheromone trap captures on a larger scale, during 2002 and 2003, the area of various land types (cotton, corn, rice, sorghum, soybean, and noncrop) within 1.6, 3.2, 8.0 and 16.1 km from pheromone trap locations in Drew and Desha counties, AR, was estimated. Identification of crops within a 1.6 km radius of each pheromone trap location was ascertained by surveying field perimeters and recording the crop type on aerial photographs for each location. In cooperation with Monsanto Company (St. Louis, MO), this information was used to estimate the area of different crop and noncrop land

Table 1. Type and number of replicates of pheromone trap location interfaces in Drew and Desha counties, AR, during 2002 - 2005.

Interface	Number of replications			
	2002*	2003**	2004†	2005†
Bt cotton/ Bt cotton	4	4	4	8
Bt cotton/ nonBt cotton	4	4	4	3
Bt cotton/ Bt corn	—	2	4	4
Bt cotton/ nonBt corn	4	4	4	3
Bt cotton/ grain sorghum	4	4	3	—
Bt cotton/ early soybean	4	4	3	4
Bt cotton/ late soybean	4	4	3	3

*Three traps baited with *H. zea* pheromone at each trapping location. Captures of three traps averaged for a site. No *H. virescens* traps.

**Two traps baited with *H. zea* pheromone and one with *H. virescens* pheromone at each trapping location. Captures of the two *H. zea*-baited traps averaged to give number of *H. zea* collected at a site.

†One trap baited with *H. zea* pheromone and one trap baited with *H. virescens* pheromone at each trapping location.

variables up to 16.1 km from each trapping location for both years (Jackson et al. 2008). The land coverage information was used to test relationships between average daily *H. zea* trap captures during 2002 and 2003 for a given month and the area of crop and noncrop land attributes within a given distance surrounding a location. All relationships were analyzed using the correlation procedure in SAS (SAS Institute 2001).

Gossypol analysis. During the 2004 and 2005 growing seasons, samples of *H. virescens* moths were collected to determine if they originated from cotton or noncotton hosts. Moths were sent to a research laboratory at Monsanto Company for analysis of the presence of gossypol using high performance liquid chromatography mass spectrometry/ mass spectrometry (Orth et al. 2007). Gossypol is a polyphenol specific to the tribe of plants Gossypieae within the family Malvaceae which includes cotton (Fryxell 1979). During 2004, *H. virescens* moths collected from 3 pheromone trap locations in Desha/Drew counties and 3 trap locations in Little River Co. (103 and 179 moths, respectively) were examined. During 2005, collections from 27 trapping locations in Desha/Drew counties and from 12 locations in Mississippi Co. (512 and 763 moths, respectively) were examined. For each county during each year, the relationship between the percentage of moths found to be positive for gossypol and the average number of moths captured within those trap locations was studied (Proc Corr, SAS Institute 2001).

Comparisons of trap captures across Arkansas. Distribution patterns observed on temporal and spatial scales within southeast Arkansas were compared with larger-scale distributions across Arkansas. This comparison was made by using pheromone trap captures of *H. zea* and *H. virescens* from 3 Arkansas regions (SW, NE, SE) exhibiting different cropping environments for the years 2003 - 2005. Crop acreage in Little River Co. in southwestern Arkansas is devoid of cotton. Mississippi Co. in northeastern Arkansas is comprised largely of cotton acreage. Drew and Desha counties in southeastern Arkansas are heterogeneous cropping environments where cotton, soybean, corn, sorghum, and rice are grown in at least moderate acreages. Cumulative monthly trap captures averaged over all traps at each location were analyzed in a split-plot design with a two-factor (year and location) main plot and a single factor (month) subplot (Proc GLM, SAS Institute 2001). Means were separated using Fisher's protected LSD test.

Results

Trap captures in relation to crop interfaces. Comparatively fewer *H. virescens* moths (relative to *H. zea*) were captured during 2003 - 2005 in southeastern Arkansas. A year-by-month interaction was detected for the captures of *H. virescens* moths at the various crop interfaces ($F = 15.27$; df = 5, 149; $P < 0.0001$). Greater numbers of *H. virescens* moths were captured during 2003 in the months of June, July and August than during these same months in 2004 or 2005. The greatest average daily numbers of *H. virescens* moths were captured during June 2003 (2.0 ± 0.2) and September 2005 (1.9 ± 0.4) during the 3 yrs of the study. A significant difference was detected for the interface type main plot factor ($F = 2.67$; df = 6, 56; $P = 0.0237$) (Fig. 1). Pheromone traps located at the interfaces of Bt cotton/early soybean and Bt cotton/nonBt cotton captured greater numbers of *H. virescens* moths than the Bt cotton/Bt cotton and Bt cotton/Bt corn interfaces. Traps located at the Bt cotton/nonBt corn and Bt cotton/sorghum interfaces captured greater numbers of moths than traps located between Bt cotton and Bt corn.

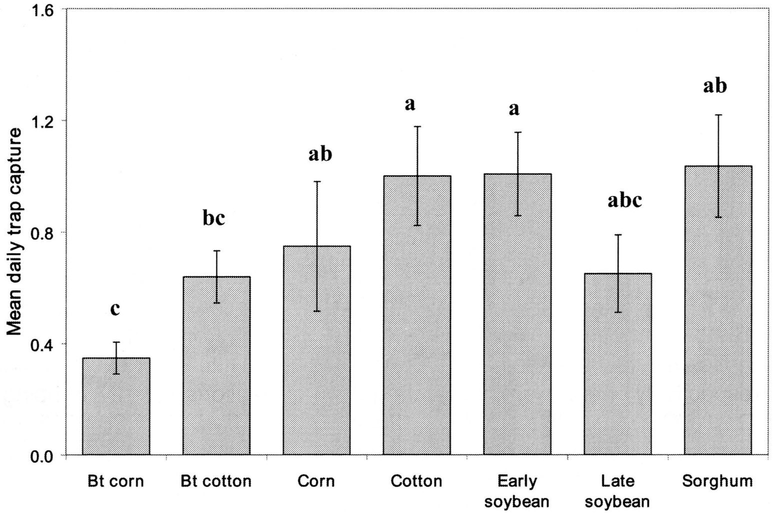

Fig. 1. Mean ± SEM daily capture within a month (June – September) of *H. virescens* in pheromone traps located at different crop interfaces (Bt cotton is located on one side of all trap locations) in Desha/Drew counties, AR 2003 - 2005. Means indicated by different letters are significantly different (LSD test, *P* < 0.05).

A year-by-month interaction also was detected for trap captures of *H. zea* at the crop interfaces (F = 5.82; df = 7, 175; P < 0.0001). During 2002, 2003 and 2005, greater numbers of *H. zea* moths were captured during July than other months. In 2004, captures during the months of June and July were not significantly different, but captures were greater in these months than in August or September. The greatest overall average daily *H. zea* captures occurred during July 2005 (35.9 ± 4.0), whereas the fewest number of moths was recorded for September 2004 (1.9 ± 0.4).

A month-by-interface interaction was detected for *H. zea* trap captures (Fig. 2). Greater numbers of moths were captured at the interfaces of Bt cotton/Bt corn and Bt cotton/nonBt corn during the month of June, whereas greater numbers of moths were captured during the month of July for all other interface types. During June, the greatest numbers of *H. zea* moths were captured at the interfaces of Bt cotton/Bt corn. During July, more *H. zea* moths were captured at the Bt cotton/nonBt cotton interface than all other interface types, except Bt cotton/Bt cotton.

During the 2002 and 2003 growing seasons, forewings of *H. zea* moths from the established pheromone trap locations in Drew and Desha counties were used by Monsanto Company to estimate the percentage of moths within a sample that had fed upon plants possessing C_3 or C_4 physiology. The stable carbon isotope ratio of 13C/12C within *H. zea* wings was used to estimate the type of host plant of larval origin. Plants having C_3 physiology such as cotton and soybean have less 13C relative to 12C than C4 plants such as corn or grain sorghum (Smith and Epstein 1971). Methods and results of these anaylyses are included in Head et al. (2010).

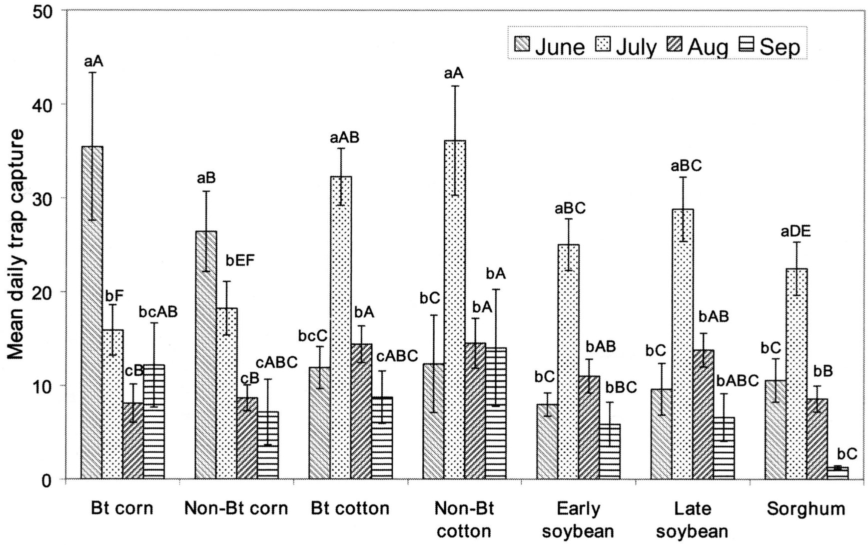

Fig. 2. Mean ± SEM daily capture of *H. zea* moths in pheromone traps located between a field of Bt cotton and a field of different crop types in Desha/ Drew counties, AR, 2002 - 2005. Different lowercase letters indicate a significant difference between months within a crop interface. Different uppercase letters indicate a significant difference between crop interfaces within a month.

Trap captures in relation to crop pattern. Figures 3 and 4 provide a graphical summary of the tests for possible relationships between trap captures of *H. zea* in 2002 and 2003, respectively, and percentage of land area in different crops around trap sites. Of the 336 relationships examined in 2002, 22 exhibited significant correlation coefficients (r). In 2003, 45 relationships between *H. zea* trap captures and percent of land area in different crops were found to be significantly related.

Siginificant relationships in 2002 included none for soybean, 2 for cotton, 6 for corn, 4 for sorghum, 3 for rice, and 7 for the area in noncrop land. A positive relationship between trap captures and cotton was observed during 1 wk in August, whereas a negative relationship was observed during 1 wk in July. All significant relationships between trap captures of *H. zea* and corn occurred during August with 4 being positive and 1 negative. All significant relationships with sorghum and rice were positive and occurred during July and August. Five of the 7 significant relationships between noncrop land and *H. zea* trap captures were positive.

During 2003, 9 significant relationships between *H. zea* trap captures and the land area in soybean were observed, with all but one of these being positive and all but one of the positive relationships occurring during June. All 6 of the significant relationships between *H. zea* captures and the land area in cotton were positive. All but 1 of the 10 significant relationships between *H. zea* trap captures and corn were positive, with all of these positive relationships occurring during June or the first week in July. Of the 4 significant relationships with sorghum, 3 of these were negative. Four of the 7 significant

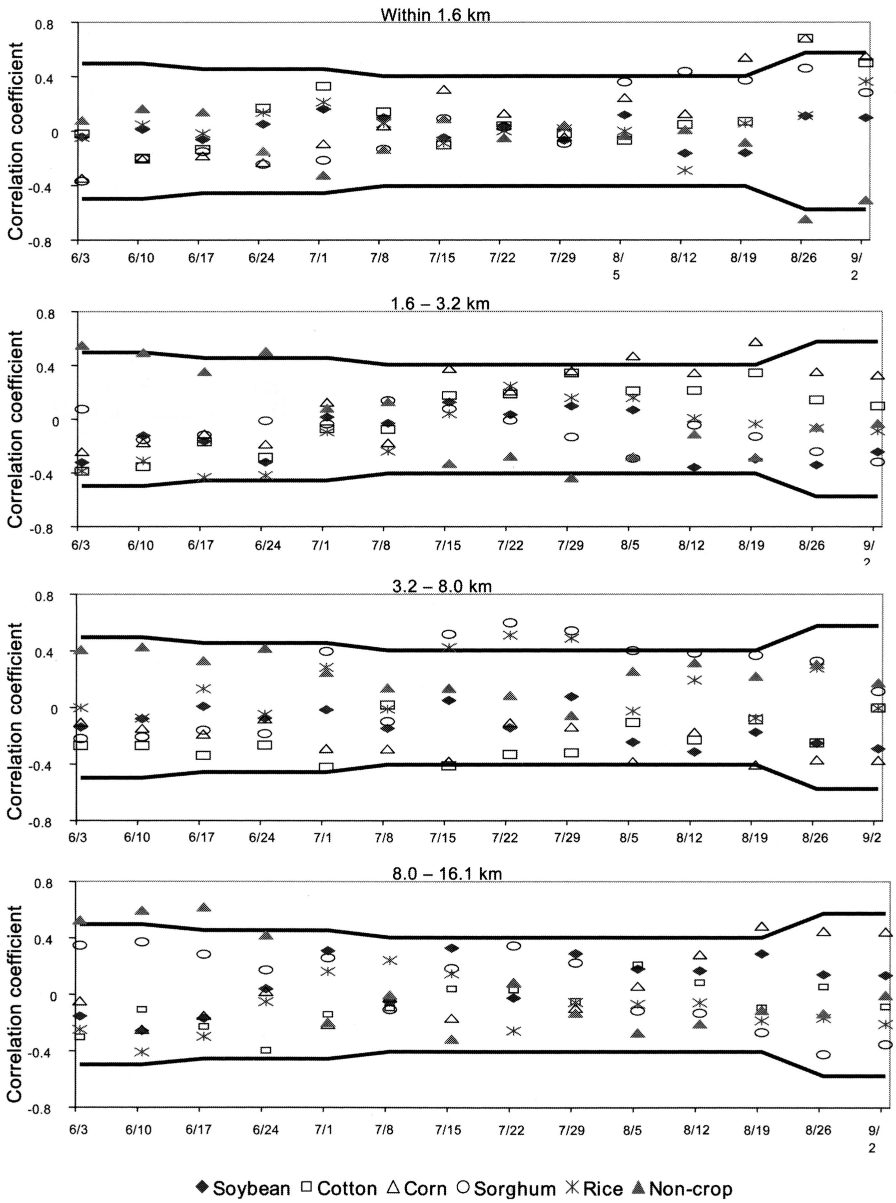

Fig. 3. Relationships between trap captures of *H. zea* and the percentage of crop land within various distances from trapping locations during 2002 in Desha/Drew counties, AR. Values above upper solid line or below bottom solid line are significant ($P < 0.05$).

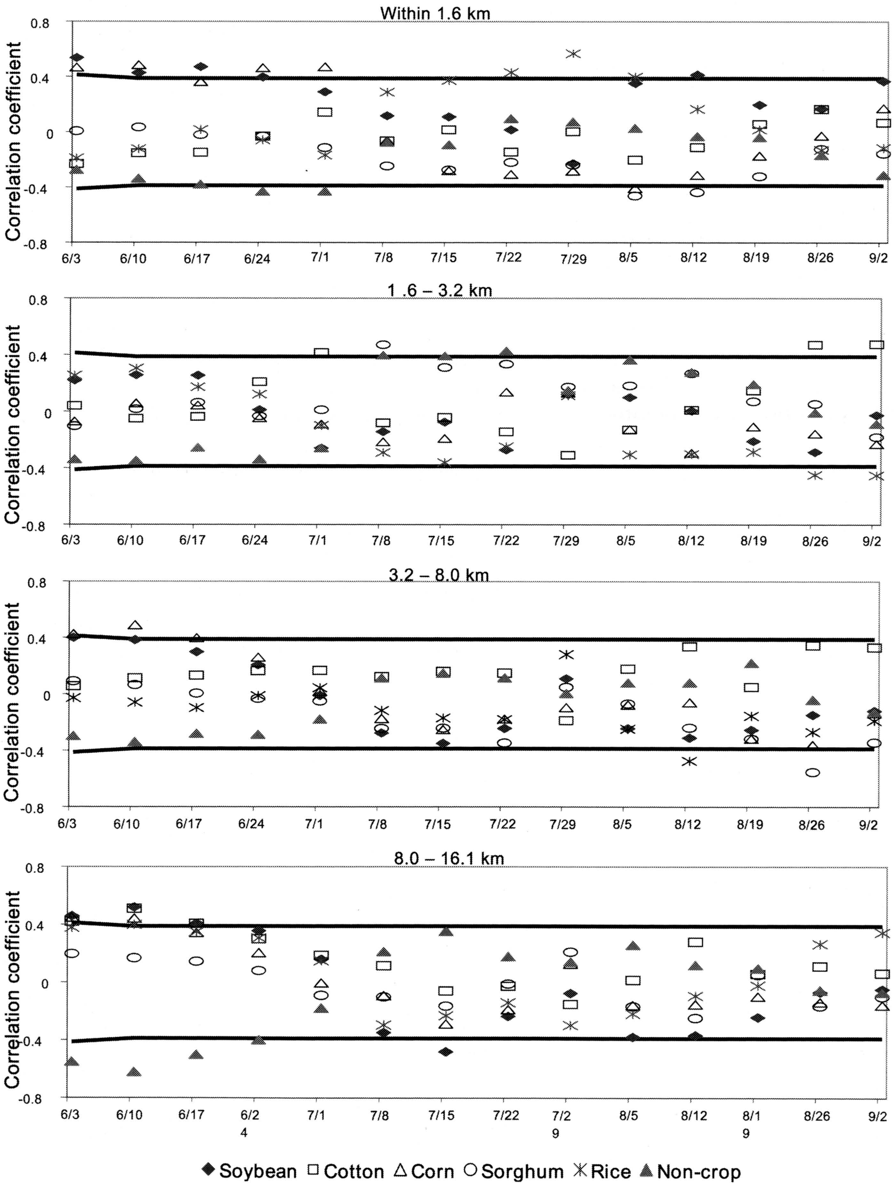

Fig. 4. Relationships between trap captures of *H. zea* and the percentage of crop land within various distances from trapping locations during 2003 in Desha/Drew counties, AR. Values above upper solid line or below bottom solid line are significant ($P < 0.05$).

relationships between *H. zea* trap captures and rice were positive, whereas 6 of the 9 significant relationships between *H. zea* captures and noncrop land were negative.

Adults of *H. virescens* positive for gossypol. No significant relationship between average weekly trap captures of *H. virescens* and the percentage of these moths that fed upon cotton as larvae was detected among the 4 year and county combinations studied. During 2004 in Desha/Drew counties, a negative correlation coefficient was observed (r = -0.1370; n = 11; P = 0.688) (Fig. 5), whereas a positive correlation coefficient was observed during 2005 for this county (r = 0.0907; n = 18; P = 0.720). Positive correlation coefficients were observed in 2004 in Little River Co. (r = 0.2233; n = 17; P = 0.389) and in 2005 in Mississippi Co. (r = 0.1466; n = 114; P = 0.617).

Trap captures across Arkansas. Data were compiled from pheromone traps located in 3 distinct areas of Arkansas to examine the spatial and temporal distribution on larger regional scales across the state. The areas included Mississippi Co. (Northeast), Desha/Drew counties (Southeast), and Little River Co. (Southwest) for the years 2003 - 2005. The estimated land area in crops planted for each county are summarized in Table 2. The number of traps located in each county ranged from 5 - 26. A year-by-month by location interaction was detected for the average cumulative monthly captures of *H. virescens* moths (F = 6.09; df = 8, 266; P < 0.0001) (Fig. 6). The greatest numbers of moths were captured in Desha/Drew counties and Little River Co. in June 2003, with no other significant differences detected between months within a specific year for these 2 locations. During the 3 yrs of the study, the greatest number of moths captured in Mississippi Co. was in the month of August for each year. The greatest number of *H. virescens* moths captured for all locations and all years occurred in Mississippi Co. in August 2003.

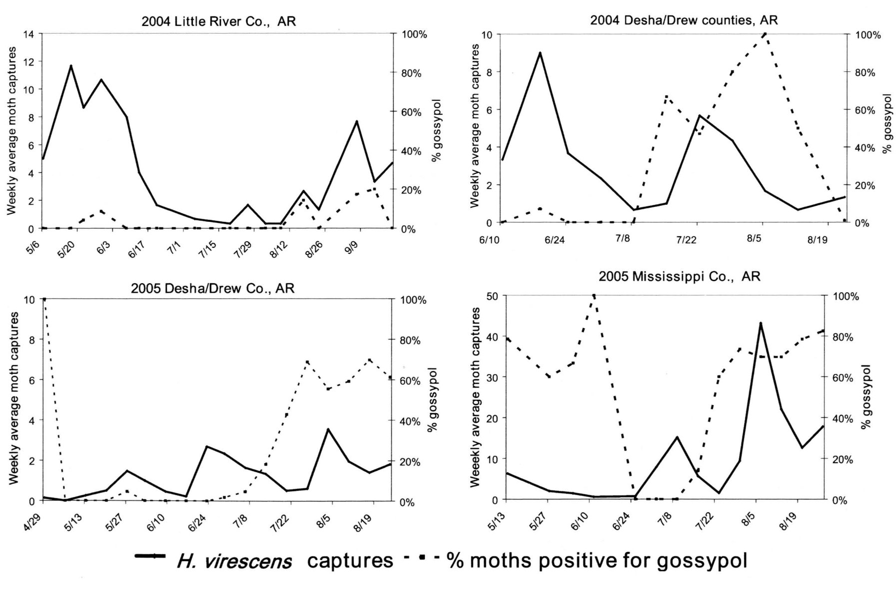

Fig. 5. *Heliothis virescens* trap captures and percentage of moths positive for gossypol.

Table 2. County estimates of various crops planted in three Arkansas counties in hectares (% of total land area within a county). (USDA National Agricultural Statistics Service 2011).

Crop	Little River Co.	Desha/Drew Co.*	Mississippi Co.
		2003	
Corn	3,035 (2.2%)	1,619 (0.8%)	5,463 (2.4%)
Cotton	0 (0.0%)	21,246 (10.3%)	101,333 (43.6%)
Rice	<3,966 (<2.9%)	11,837 (5.7%)	16,187 (7.0%)
Sorghum	1,012 (0.7%)	2,276 (1.1%)	5,989 (2.6%)
Soybean	5,059 (3.7%)	23,269 (11.3%)	67,380 (29.0%)
Total crop land	13,071 (9.5%)	60,247 (29.2%)	196,353 (84.4%)
		2004	
Corn	3,237 (2.35%)	1,599 (0.8%)	6,475 (2.8%)
Cotton	0 (0.0%)	19,263 (9.3%)	92,390 (39.7%)
Rice	<1,781 (<1.29%)	12,849 (6.2%)	17,199 (7.4%)
Sorghum	0 (0.0%)	1,781(0.9%)	1,700 (0.7%)
Soybean	5,261 (3.82%)	22,764 (11.0%)	71,427 (30.7%)
Total crop land	10,279 (7.46%)	58,254 (28.2%)	189,190 (81.3%)
		2005	
Corn	2,833 (2.1%)	1,619 (0.8%)	4,371 (1.9%)
Cotton	0 (0.0%)	21,954 (10.6%)	96,072 (41.3%)
Rice	<1,983 (<1.4%)	14,225 (6.9%)	20,113 (8.7%)
Sorghum	0 (0.0%)	<526 (<0.3%)	1,052 (0.5%)
Soybean	4,856 (3.5%)	44,111 (21.4%)	66,571 (28.6%)
Total crop land	9,672 (7.0%)	82,434 (39.9%)	188,179 (80.9%)

*Values are the average acreage of Desha and Drew counties.

As with *H. virescens*, there was a year-by-month-by-location interaction for pheromone trap captures of *H. zea* ($F = 2.88$; df = 8, 266; $P = 0.0043$) (Fig. 7). In the Desha/Drew counties location, greater numbers of *H. zea* moths were captured during the month of July during 2003 and 2005, whereas in 2004 captures in June and July were not significantly different, but both were greater than the month of August. In Little River Co., trap captures in June were greater than in August 2003, whereas May trap captures were greater than all other months during 2005. In Mississippi Co., the greatest number of *H. zea* moths was captured in July during 2003, and the fewest number of moths was captured in June during 2004 and in May and June during 2005.

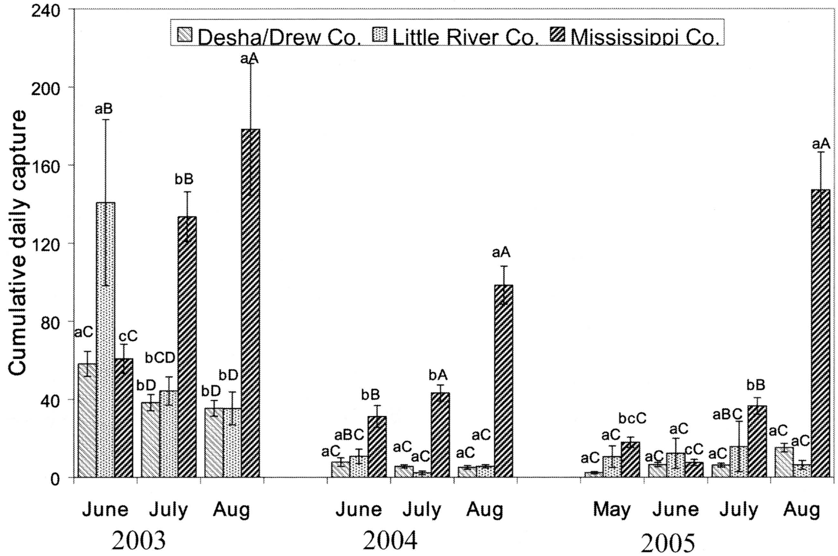

Fig. 6. Mean ± SEM cumulative daily capture of *H. virescens* moths in pheromone traps located in three Arkansas counties, 2003 - 2005. Different lowercase letters indicate a significant difference between months within a year and location. Different uppercase letters indicate a significant difference between months within a year at different locations (LSD test, *P* < 0.05).

During May of 2005, the greatest number of *H. zea* moths was collected in Little River Co., whereas the least was collected from Mississippi Co. During the month of June, fewer *H. zea* moths were captured in pheromone traps located in Mississippi Co. than in the other locations during all 3 yrs. During July, captures in Desha/Drew counties were greater than those of the other 2 counties in 2004 and 2005, but more moths were captured in July 2003 in Mississippi Co. than either other location. In August 2003, the greatest number of moths was captured in Mississippi Co., but in August 2005, trap captures in Desha/Drew counties were greater than the other 2 counties.

Discussion

Pheromone trap captures of *H. zea* and *H. virescens* in an area may be influenced by trap location relative to the crops grown within an area. On a local scale, *H. zea* appeared to be concentrated around corn in the month of June in southeast Arkansas and after that was more widely distributed. The greatest numbers of moths captured in the month of June were located at the interfaces of Bt cotton/Bt corn and Bt cotton/nonBt corn, whereas the greatest numbers captured at the other interface combinations was in July. The 2002 and 2003 *H. zea* moth trap captures from AR and similar pheromone trap interfaces in GA, LA, MS and NC were examined in Jackson et al. (2008). Higher numbers of *H. zea* moths were captured in traps adjacent to corn in most of the other states examined for the month of June. Slosser et al. (1987) reported

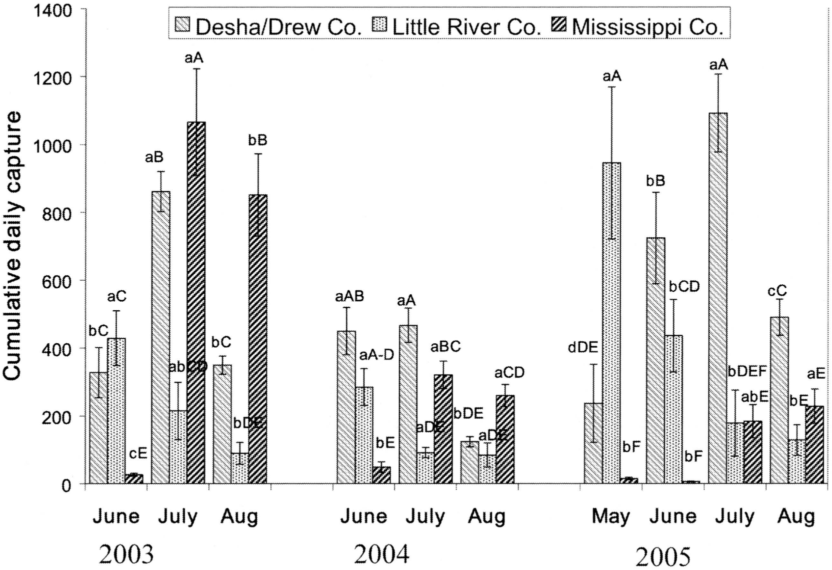

Fig. 7. Mean ± SEM cumulative daily capture of *H. zea* moths in pheromone traps located in three Arkansas counties, 2003 - 2005. Different lowercase letters indicate a significant difference between months within a year and location. Different uppercase letters indicate a significant difference between months within a year at different locations (LSD test, $P < 0.05$).

similar results of *H. zea* moths being concentrated around wheat in the spring months, and as it matured, greater numbers were found around other crops.

On a larger scale, estimating crop acreage at varying distances from a trap location could potentially provide information about possible influences of crop hosts on trap captures. A relationship between trap captures and a given host within 1.6 km, but not a greater distance, may indicate that the range of movement is limited to the smaller scale. A problem with using exploratory correlations is that one expects to find a significant relationship in 1 of 20 correlations at the 0.05 significance level by chance alone. During each year, 336 correlations were examined for *H. zea*. On average, 17 correlations are expected to be significant due to chance alone. During 2002, only 22 correlations were found to be significant for *H. zea*. However, 45 correlations were found to be significant during 2003 for *H. zea* and estimates of different crop acreages, which is almost 3x the number expected by chance. Most of the significant relationships observed were between percentage land area planted to corn and trap captures in June and August. Significant relationships with the percentage of land planted to cotton were sporadic.

Analytical analyses, such as C_3/C_4 moth wing sampling (Gould et al. 2002) and gossypol detection in moths (Orth et al. 2007), are providing methods to quantify the contribution of various hosts to the population growth and dynamics of insects including *H. zea* and *H. virescens*. Although the C_3/C_4 analysis does not distinctly determine the actual host that an *H. zea* adult fed upon as a larva, it provides insight to the contribution of one group over another group of plants. It has long been recognized that corn is a preferred host of *H. zea* (Isley 1935, Hardwick 1965). The percentage of moths captured and estimated as derived from C_4 plants was above 90% from July to the midAugust in 2002 and 2003 (Head et al. 2010). Corn still appears to have a dominant effect on overall seasonal densities of *H. zea*. However, other hosts must be key reservoirs for this insect during the early and late parts of the season. These would appear to be critical times for possible resistance evolution.

Gossypol analysis of adult *H. virescens* should provide evidence that an individual insect either fed on cotton as a larva or did not. We did not find a significant relationship in number of *H. virescens* moths captured and the percentage of these moths thought to have originated from cotton. This suggests that peak populations of *H. virescens* adults were not necessarily the result of larvae developing on cotton at these collection sites. In contrast to the gossypol analysis, overall trap captures of *H. virescens* suggested that cotton is a key host in its population dynamics.

Higher cumulative trap captures of *H. virescens* occurred in Mississippi Co. during the month of August in all 3 yrs studied, whereas captures were greater in July than in June during 2003 and 2005. Trap captures of *H. virescens* in Drew/Desha and Little River counties generally decreased from June through August. Cotton acreage in Mississippi Co. is approximately 5x that in Desha/Drew counties, and practically no cotton was grown in Little River Co. during the 3 yrs of the study. This suggests that numbers of *H. virescens* increase during the growing season in areas with higher concentrations of cotton, and therefore the probable importance of cotton to the population dynamics of *H. virescens* in Arkansas.

Pheromone traps have been used to obtain estimates of *H. virescens* and *H. zea* since the late 1970s (Harstack and Witz 1981, Hendricks and Harstack 1978). Although these traps may be more efficient than field survey methods used for sampling, they only capture adult males, which may not be indicative of the distribution of adult females. However, 2 previous studies have concluded that pheromone trap captures could be used to estimate densities of both male and female moths, one in field corn (Latheef et al.1993) and the other in cotton (Witz et al. 1992b). Although weather variables can influence the efficiency of captures, human error and variability among individuals counting moths collected in pheromone traps should be much less than the error and variability among individuals sampling either immature or adult populations in the field.

Early in the summer, *H. zea* appeared to be concentrated around corn, and then widely dispersed after corn matured. Plants with C_4 physiology appeared to be the major source of moths of *H. zea* during most of the growing season. When compared with southern Arkansas, a larger percentage of total captures of *H. zea* and *H. virescens* moths occurred in northern Arkansas later in the growing season; thus, the indication that crop structure can explain the population dynamics of *H. zea* and *H. virescens*, but more work is needed. Perhaps more innovative tracking of life history and more efficient sampling procedures will further elucidate these relationships. Average trap captures over larger areas, exhibiting differing cropping patterns, provide evidence of the importance of cotton to the population dynamics of *H. virescens* and corn to *H. zea*.

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