

## RAMP Experimental Research Results Summary 2008 Report

### Section I: Field Level Experiments – Yield / Damage / Thresholds

#### Parajulee: Boll Susceptibility window for *L. hesperus* in TX cotton

Conducted field experiments to determine a heat-unit based boll susceptibility threshold.

**Results:** *Lygus hesperus* could cause external lesions on bolls throughout boll development but it could not cause internal damage to bolls that are older than 350 HU. The pressure required to puncture the carpel wall increases significantly when bolls mature past 250 HU. It appears that cotton bolls are safe from *Lygus* damage when 0.76 lb/ft<sup>2</sup> pressure is required to puncture the boll. A preliminary regression model has been developed from 2007 data to predict boll susceptibility in relation to HU. The 2008 data will be incorporated to develop a more robust model. Field experiments to determine boll susceptibility differences among cotton cultivars and under 5 different nitrogen treatments were conducted. Preliminary analyses suggest that boll maturity did not significantly vary with cotton variety or nitrogen fertility rate.

#### Parajulee: Compensation of *Lygus* and fleahopper-induced fruit loss in cotton

Research began in 2007. We established 4 treatment regimes for each set of the study. Bugs were released for 3 consecutive weeks before or after initiation of flowering. Plant mapping was conducted weekly until crop cut-out. Percentage fruit loss for each experimental scenario was calculated. Yield and lint quality data were used to relate to the percentage fruit loss. **Results:** Our analysis indicates that while one needs to consider plant compensation potential, input variables (fertility, moisture), and environmental stress in making insect management decisions, protection of 30% fruit shed during early squaring and 25% during early flowering may not be necessary for the Texas High Plains.

#### Rosenheim: Incorporating the key predator *Geocoris* into thresholds for *Lygus* control in cotton

We have completed 2 seasons of field experimentation to quantify the effect of *Geocoris pallens* (a key predator of *Lygus* eggs and nymphs) and *Zelus renardii* (a key predator of *Lygus* adults) on the suppression of *Lygus* and the square retention and yield of cotton. **Results:** Despite the fact that *Zelus* is a predator of *Geocoris*, control of *Lygus* is most effective when both predators are combined. *Geocoris* populations appear to be limited by cannibalism. The intensity of cannibalism increases strongly, and the rate of *Geocoris* egg laying decreases strongly, as *Geocoris* densities increase.

## **Naranjo & Ellsworth: Yield / Damage : Density Relationships for *Lygus* spp. in Lesquerella**

Observational studies were continued to quantify and characterize the feeding behavior of *Lygus hesperus* on lesquerella plants. **Results:** On average, bugs spent about 64% of their time in nominal activities such as resting, walking and grooming. They spent about 7% of their time in probing various plant parts and about 29% in feeding on plant structures. The majority of time spent in feeding was on fruiting structures followed by feeding on stems, flowers, flower buds and leaves. Patterns were similar between females and males. These patterns are correlated with preliminary replicated field studies where damage to flower buds and fruit are positively correlated with lygus bug density. In turn, damage to these structures led to negative correlations between yield and plant bug density, and between seed oil quantity and bug density. Survey results indicated that lesquerella harbors large reproducing populations of lygus bugs and a wide diversity of natural enemies common to many crops in the western USA including alfalfa and cotton. Lesquerella apparently acts as a sink of lygus bugs from overwintering hosts and alfalfa and may act as a source to other susceptible crops such as alfalfa and cotton during its late winter and spring production cycle. The pest will most likely need to be managed in this crop both because of its potential as a direct pest and as a source of migrating pests to other crops in the region. Selective control options should be emphasized as lesquerella may also be a potential source of natural enemies providing biological control in the region.

## **Naranjo & Ellsworth: Yield / Damage : Density Relationships for *Lygus* spp. in Guayule**

Observational studies were continued to quantify and characterize the feeding behavior of *Lygus hesperus* on guayule plants. **Results:** On average, bugs spent about 60% of their time in nominal activities such as resting, walking and grooming. They spent about 8% of their time in probing various plant parts and about 32% in feeding on various plant structures. The majority of time spent in feeding was on flowers followed by feeding on leaves, stems and flower buds. Patterns were similar between females and males. Field survey studies demonstrate that lygus bugs are present in and reproduce guayule over an extended portion of the season but are most abundant during late spring and early summer. Guayule flowers over an extended portion of the spring, summer and fall. A wide diversity of natural enemies are also present in guayule, with spiders abundant most of the year but winter and predatory beetles and predatory bugs present mainly during spring and summer. Guayule probably acts as a sink of *Lygus* bugs from overwintering hosts but does not appear to be an overwintering host. Guayule in turn may act as a source to other susceptible crops such as alfalfa and cotton during portions of the season. Field and greenhouse studies are planned to examine the relationship between *Lygus* bug density and plant damage and yield. Given that the yield of guayule (latex) is produced in the woody stems, it seems unlikely that *Lygus* bugs will have a measureable impact on latex production, however, they could be important in guayule nursery operations for seed production.

## **Section II: Field Level Experiments – Insecticide Efficacy and Selectivity**

### **Godfrey, Parajulee, Kerns: Evaluating efficacy of registered and experimental insecticides for *Lygus* management in cotton**

Two insecticide efficacy tests were conducted in Texas in 2008 and an insecticide residual test was conducted in 2007. Insecticides evaluated in 2008 included cypermethrin, flonicamid, acephate, thiamethoxam, oxamyl and novaluron. **Results:** At low population densities, all of the insecticides proved effective, but at high populations thiamethoxam appeared weaker than the other treatments. *Lygus* on the High Plains appear to be highly sensitive to a broad range of insecticides. Based on the insecticide residual study conducted in 2007, high rates of cypermethrin, flonicamid and oxamyl provide the longest residual control, approximately 80% at 7 days. Acephate and bifenthrin exhibited moderate residual activity, 80-100% mortality at 3 days. Endosulfan appeared to be short lived.

### **Ellsworth: Determination of deployment options for reduced-risk and other effective chemistry for *Lygus* control in cotton**

See report “2008 *Lygus* Small Plot Efficacy Trials” on the RAMP website:  
<http://cals.arizona.edu/apmc/RAMP.html#reports>

### **Naranjo & Ellsworth: Evaluation of the selectivity of reduced-risk approaches to *Lygus* control**

Community analyses of data from a replicated large plot field study indicate that both flonicamid and metaflumizone selectively impact *Lygus* and other problematic plant bugs such as cotton fleahopper while having little or no impact on a wide diversity of predaceous arthropods that can contribute significant levels of suppression to other pests such as the sweetpotato whitefly. These findings provide growers and consultants with effective options for the management of *Lygus* bugs. In addition, along with transgenic Bt cotton for selective control of caterpillars, IGRs and other selective insecticides for management of whitefly, these compounds have the potential to equip producers with a complete arsenal of selective options that will contribute to more biologically-based management of all key pests of cotton in the region.

## **Section III: Landscape Level: Patterns, Processes and Mechanisms**

### **Blackmer & Naranjo: Influence of biotic and abiotic factors on *Lygus* movement**

New flight mills were constructed and refined to evaluate the effect of wind speed on *Lygus* flight. Software was developed to monitor and record data from the flight mills. The mills are now fully operational and studies to examine the relationship of flight performance to temperature at fixed humidity are currently underway. **Results:** Based on flights of ca. 1300 male and female *Lygus* (age range 1-11 day old, mated and virgin) in a vertical flight chamber, flight initiation and orientation relative to wind speed was influenced by age and sex. Mating

status had no effect on either flight initiation or orientation to a vegetative cue. Flight initiation of both sexes declined with increasing wind speed but less so for males. Both males and females showed a steep decline in orientation to vegetative cues with increasing wind speed. The youngest and oldest females were less likely to initiate flight at any wind speed while only the youngest males initiated flights less frequently compared with older males. Males and females less than 5 days of age were essentially non-responsive to vegetative cues while there was no difference in this orientation behavior for both genders > 5 days of age. Collectively, these studies will help to characterize the flight behavior of *Lygus* bugs relative to important environmental variables and will be of value to other members of the proposal team that are developing simulation models of *Lygus* movement on local and regional scales.

### **Parajulee: Influence of non-cotton hosts, host preference, and inter-crop movement of *Lygus* on landscape-level dynamics**

a) Evaluating the influence of roadside alfalfa on *Lygus* population dynamics adjacent to cotton. A modified blower was used to sample *Lygus* and arthropod predators in 4 study sites in Lubbock County, Texas, each with relatively pure roadside alfalfa stands adjacent to cotton fields. **Results:** Roadside alfalfa significantly influenced the *Lygus* densities in adjacent cotton, with most *Lygus* movement from alfalfa to cotton occurring around peak flowering stage of cotton. There was a significant negative correlation in *Lygus* densities between cotton and adjacent alfalfa, indicating a clear intercrop movement between the two crops.

b) Host preference study has been completed in the field. **Results:** Alfalfa and Russian thistle are more attractive for *Lygus* to colonize and increase population numbers when they are intermingled with cotton, sunflower, and pigweed plots. We have completed two years of this study and a publication is being developed. Further studies are being conducted in the laboratory to quantify the reproductive fitness and growth potential of *Lygus* in these selected hosts. c) *Lygus* activity in alfalfa and cotton has been monitored following application of protein markers to quantify the inter-crop movement behavior and timing of movement of *Lygus*.

c) Mark release and recapture study showed that *Lygus* move between alfalfa and cotton in both directions, but more number of *Lygus* moved from alfalfa to cotton than from cotton to alfalfa during cotton blooming stage. Field marking study showed that 6% non fat milk spraying in alfalfa gave highest number (40%) of positively marked *Lygus* whereas 4% egg white sprayed plot had (90%) of positively marked *Lygus*. Thus egg white is found to be superior field marking protein as compared with non fat dairy milk.

### **Carriere, Ellsworth, Dutilleul, Goodell & Parajulee: Development of landscape-level pest management guidelines to reduce *Lygus* infestations in cotton**

The *Lygus* data obtained in 2007 in Arizona and California in the focal cotton fields were analysed with previously developed methods (Carrière et al. 2006). No significant spatial autocorrelation affected *Lygus* density or the area of crops across the study sites. Thus, the

statistical analyses presented below did not require correcting for spatial autocorrelation effects. The data collected in Texas in 2007 were transmitted to us last week and are currently processed.

We have been developing a software program that will allow entomologists to perform spatially explicit analyses of data as collected in this RAMP project. We plan to “road test” the program in November and distribute this program from a web-based platform to the scientific community in 2009.

Preliminary analyses of 2007 California data:

Forty-one focal cotton fields were sampled for *Lygus* density. Response variables were the density of *Lygus* adults, nymphs, or both in focal cotton fields (log X + 1 transformed). Multiple regression was first used to assess the effect of number of insecticide applications in focal cotton fields and flowering date on the density of *Lygus*, after correcting for the effect of crops (cotton, hay alfalfa, safflower, seed alfalfa, sugar beet and tomato) surrounding the focal cotton fields.

Number of insecticide applications in focal cotton field did not affect the density of adults, nymphs, or both ( $P > 0.10$ ). However, fields that flowered later tended to have a greater density of *Lygus* than fields flowering earlier ( $P < 0.06$  for adults:  $P < 0.01$  for nymphs or both).

Partial non-parametric correlation was used to assess source/ sink effects of the crops on *Lygus* density in focal fields (Carrière et al. 2006). After conducting extensive scale analyses, two rings of a width of 1.25 km were used in these analyses. Given the large size of fields in California, this scale of analysis was close to the minimum scale that could be used to analyse the data. Only crops located in the first ring were used in partial correlation analyses to detect source/sink effects occurring at a distance of less than 1.25 km. Crops in both rings were considered in partial correlation analyses assessing source /sink effects of crops located within a distance of 2.5 km. Results are presented in Table 1.

**Table 1.** Crops with significant source/ sink effects on *Lygus* density in focal cotton fields ( $P < 0.06$ ), and distance at which these effects occurred. Crops investigated were cotton, hay alfalfa, safflower, seed alfalfa, sugar beet and tomato. As no significant source/sink effects were detected for nymphs, results are only presented for adults and the sum of both.

Crop type	Distance (km)	Source/sink effects	
		Adults	Both
Cotton	1.25	Sink	Sink
Safflower	1.25	Source	Source
Seed alfalfa	1.25	Source	--
Sugar beet	1.25	Source	Source
Cotton	2.5	Sink	Sink
Seed alfalfa	2.5	Source	Source

As found in a previous study performed in Arizona (Carrière et al. 2006), results indicate that cotton is a sink for *Lygus* and that seed alfalfa is a source. These effects seem to extend at

distance of up to 2.5 km in California. We also identified two other crops that may act as sources of Lygus at a distance of up to 1.25 km: safflower and sugar beet.

#### Preliminary analyses of 2007 Arizona data:

Fifty-four focal cotton fields were sampled for Lygus density. Unfortunately, Lygus density was exceptionally low in these focal cotton fields. This greatly reduced the among-field variability in Lygus density, which in turn likely compromised the spatially-explicit statistical analyses.

As before, response variables were the density of Lygus adults, nymphs, or both in focal cotton fields ( $\log X + 1$  transformed). Multiple regression was first used to assess the effect of number of insecticide applications in focal cotton fields and flowering date on the density of Lygus, after correcting for the effect of crops (cotton, hay alfalfa, guayule, weeds) surrounding the focal cotton fields.

Number of insecticide applications in focal cotton fields was positively associated with the density of adults, nymphs, or both ( $P < 0.02$ ). This may suggest that farmers sprayed more when Lygus density was higher in a field than when it was lower. Flowering date only had a marginal effect on nymphs ( $P = 0.081$ ). Interestingly, the effect of flowering date appeared different than in California: fields flowering late in Arizona tended to have a lower Lygus density than fields flowering early.

Based on extensive scale analyses, two rings of a width of 0.5 km were used to evaluate source/sink effects in Arizona. Partial non-parametric correlation analyses did not yield any significant effects when data on all focal cotton fields were considered, likely because the very low density of Lygus in cotton fields that flowered late contributed in reducing the among-field variability in Lygus density. Accordingly, we used flowering date to select the 39 focal fields that flowered the earliest in the study area. Restricting our analyses to these 39 fields, the only effect detected involved guayule, which apparently acted as a sink for Lygus adults ( $P = 0.02$ ) or all Lygus ( $P = 0.07$ ) at a scale of 0.5 km. There was some marginal indication that cotton acted as a sink for Lygus adults ( $P = 0.071$ ) or all Lygus ( $P = 0.093$ ) at a distance of 1 km.

#### Discussion

The present analyses and previous work (Carrière et al. 2006) suggest that multiple regression analyses are unstable to evaluate the source/sink effects of crops. This lack of stability likely results from the generally high autocorrelation in the area of crops across rings. Given this, we only used multiple regression to evaluate the effect of insecticides and flowering date, while correcting for the overall effect of crops. Furthermore, we used partial non-parametric correlation analyses, which tend to be more stable than multiple regression analyses, to evaluate the nature and scale of the source/sink effects.

To be able to better understand the joint effect of all these factors, we plan to analyse the data with path analysis, which is currently incorporated as an option in the software program under development. We believe that path analysis will allow us to more precisely assess the nature and extent of source/sink effects while simultaneously considering the influence of other variables such as insecticide treatments and flowering date.

Until path analysis is used to complete the present analyses, results presented here should be considered preliminary.