Overview of *Lygus* Research and Outreach Program in the Texas High Plains: Serving the Clientele of the World's Largest Cotton Patch

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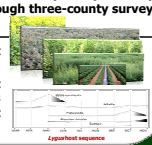
Introduction: Texas A&M Cotton Entomology research in the Texas High Plains began in 1937, but the focus on *Lygus* research was started in 2002. Our program has used *Lygus* as the model insect to answer various ecological questions in cotton pest management. In the past eleven years (2002-2012), more than 20 research projects were conducted on various aspects of *Lygus* biology, behavior, and ecology. Experiments were conducted in the laboratory, greenhouse, research farms, and growers' fields. *Lygus* research conducted in our program includes host-plant survey, life table analysis, host preference, intercrop movement, feeding biology, cotton plant/*Lygus* interactions, sampling, insecticide resistance, pesticide evaluations, overwintering biology, morphology, molecular ecology, cultural control, landscape structure, and economic threshold development.

Host Plant Survey

Sweep sampling

- Two years (2002-03) of general survey of 25 counties using sweepnet
- Two additional years (2004-05) of thorough three-county survey



- *L. hesperus* was most dominant *Lygus* species (>95%)
- Twenty-five reproductive plant hosts were identified, and Texas High Plains *Lygus* host-plant sequences were established

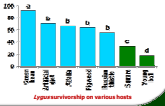
Lygus host sequence

Life Table Study

Lygus food sources

- *L. hesperus* were reared on six food sources from egg to adult in the laboratory

- Lowest survivorship and longest egg-to-adult life cycle were found for *Lygus* reared on 1-day old cotton bolls

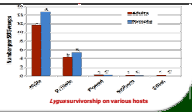


Lygus survivorship on various hosts

Host Preference Study

Layout and host mosaic in host preference study

- Two-year (2004-05) field study was conducted evaluating *Lygus* host preference in a mosaic of four prevalent weed hosts (alfalfa, Russian thistle, pigweed, sunflower) plus cotton
- *Lygus* colonization was highest in alfalfa followed by Russian thistle
- Reproduction correlated with colonization
- Cotton was not the prefered host for *Lygus*

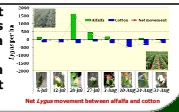


Lygus survivorship on various hosts

Intercrop Movement Study

Field marking with proteins and *Lygus* sampling

- Two-protein mark-capture study, using milk and egg, examined *Lygus* intercrop movement in an alfalfa-cotton system (2008-09)
- Marker proteins were detected using ELISA
- *Lygus* bidirectional movement suggests alfalfa serves both as source and sink depending on host phenological stages
- Increased alfalfa to cotton movement was observed at cotton blooming stage

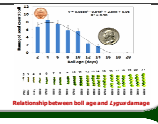


Net *Lygus* movement between alfalfa and cotton

Damage Potential Study

Cotton white flowers cup-caged *in situ*

- Cup-cage studies quantified *Lygus* damage potential to age-specific cotton bolls (2008-11)
- Single *Lygus* adults were allowed to feed 48 h on cup-caged bolls at various maturity levels
- *Lygus* injury caused external lesions in bolls at all maturity levels
- Bolls >25 mm dia or >350 heat units were safe from *Lygus* injury to cotton seed

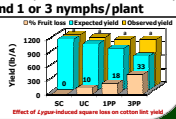


Relationship between boll age and *Lygus* damage

Cotton Crop Response

Lygus rearing, field release, and damage assessment

- Numerous studies quantified cotton yield compensation of *Lygus*-induced fruit loss under various production scenarios
- Four treatments were spray control, untreated control, and 1 or 3 nymphs/plant
- *Lygus* treatments caused a "stair-case" injury effect
- Plants compensated as high as 33% *Lygus*-induced square loss, typically via adding more lateral nodes

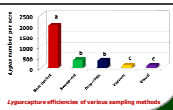


Effect of *Lygus*-induced square loss on cotton lint yield

Sampling Method

Visual, vacuum, sweepnet, beat bucket, and drop cloth sampling

- Five *Lygus* sampling methods were compared (2002-2003)
- *Lygus* capture rates and sampling efficiencies were established for each method
- *Lygus* densities were much below economic threshold levels throughout the season
- Beat bucket captured higher numbers of *Lygus* compared with other sampling methods

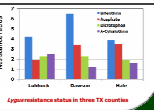


Lygus capture efficiencies of various sampling methods

Insecticide Resistance

Fig. Glass vial bioassay of field collected *Lygus* adults

- Spatial and temporal variations in pesticide resistance levels in *Lygus* were studied (2005-06)
- Four insecticides were evaluated using 20 ml glass vial bioassay
- Among the tested insecticides, resistance was not detected in Texas High Plains populations
- Acephate LC_{50} for *L. hesperus* increased continuously from April to November populations

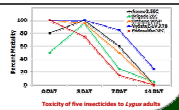


Lygus resistance status in three TX counties

Pesticide Evaluation

Bioassay determining *Lygus* mortality due to insecticide residue

- Five insecticides were evaluated at high doses
- *Lygus* were exposed to treated leaves for 48 h
- *Lygus* mortalities were determined by Petri dish bioassay
- Among five insecticides evaluated, Vydate and Endosulfan were most and least toxic to *Lygus* adults
- Vydate had the longest residual activity

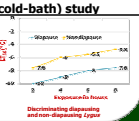


Toxicity of five insecticides to *Lygus* adults

Overwintering Biology

Determining emergence profile of overwintered adult *Lygus* and characterizing *Lygus* cold tolerance

- Dig-up cages and cone-cages were used to determine the *Lygus* winter survivorship and spring emergence profile
- Field collected and laboratory reared *Lygus* were used for cold tolerance (cold-bath) study
- Lethal temperatures (LT_{50}) discriminated diapausing and non-diapausing *Lygus*
- October released cohorts did not survive the winter, but November released cohorts survived at 12%; emergence peaked in February

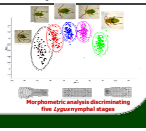


Discriminating diapausing and non-diapausing *Lygus*

Morphometric Study

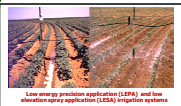
Digital imaging acquisition and digitization

- *Lygus hesperus* were reared on green beans from egg to adult
- Ontogenic digital images of each live insect were taken daily
- Images were digitized and morphometric analyses were done
- Measurements between 4 pairs of specific landmark points differentiated 5 nymphal stages
- Landmark technique was more efficient than outline base ontogenic shape analysis



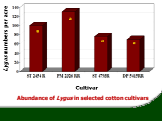
Morphometric analysis discriminating five *Lygus* nymphal stages

Cultural Control



Low energy precision application (LEPA) and low elevation spray application (LESA) irrigation systems

- Five cotton cultivars, two irrigation methods (LEPA and LESA), and three water levels (50, 75, and 100% ET) were evaluated to assess *Lygus* field activity (2002-03)
- No significant effect of cultivar, irrigation method, or irrigation level was detected on *Lygus* activity
- Marginally higher *Lygus* detected in LEPA and 100% ET replacement plots

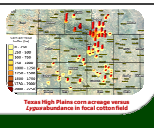


Abundance of *Lygus* in selected cotton cultivars

Landscape Level Study

Vegetation map of 50 focal fields and buffer circles

- *Lygus* were monitored in 50 focal cotton fields in the Texas High Plains for three years (2008-10)
- Habitats within 2-mile radius of each focal field were mapped and spatial analyses were performed
- *Lygus* abundances in cotton were higher in northern counties (Castro, Swisher, and Hale)
- Corn and alfalfa acreages were positively correlated with *Lygus* abundance in cotton

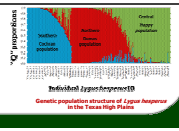


Texas High Plains corn acreage versus *Lygus* abundance in focal cotton field

Genetic Diversity Study

Capillary electrophoresis genotyping of *Lygus* populations

- *Lygus hesperus* microsatellite markers were developed by sequencing SSR enriched partial genomic DNA library
- Eight *Lygus* populations were genotyped using 10 SSR markers
- Ten SSR markers were identified and characterized
- Molecular marker analysis (SSR) identified 3 distinct genetic populations of Texas High Plains *Lygus*

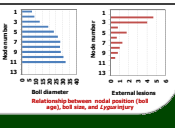


Genetic population structure of *Lygus hesperus* in the Texas High Plains

Economic Threshold

Single plant field cages for *Lygus* density evaluations

- Four *Lygus* densities (0, 1, 2, 4 bugs/plant) were evaluated
- ET is being developed for two distinct cotton phenological stages (0-350 and 0-550 HU from first flower)
- *Lygus* adults displayed preference for smaller bolls (<20 mm diameter) and the top 3-4 mainstem nodes
- This is the first year study of a multi-year ongoing project



Relationship between nodal position (boll age), boll size, and *Lygus* injury

Summary: Our programmatic effort on *Lygus* research has resulted in some significant outcomes for further scientific investigation and for grower adoption, including alternate host identification, characterization of feeding and movement biology, pesticide spray initiation and termination rules, molecular marker development, determination of genetic structure, pesticide resistance monitoring, morphological characterization, life table investigation, and crop protection product evaluation. The Cotton Entomology Program has contributed significantly to assisting Texas cotton producers, crop consultants, Extension agents, and the scientific community by expanding our cotton pest management knowledge and skills through research and outreach.

Acknowledgments: We would like to thank all current and former technicians, graduate students, and student workers for their contribution to our overall *Lygus* research effort over the last 11 years. Funding sources including federal, state, university, industry, and local agencies and our research collaborators are all appreciated.

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