Midsouth Entomologist 9: 79-93

ISSN: 1936-6019
www.midsouthentomologist.org.msstate.edu

Abstracts of the 63rd Annual Conference of the Mississippi Entomological Association, October 17-18, 2016

Oral Presentations

Preliminary Results of a Systematic Review and Meta-Analysis of Transgenic Bt Cotton Efficacy. D. Fleming, F. Musser, and N. Little

Transgenic Bt (*Bacillus thuringiensis*) cotton with resistance to lepidopteran pests has been commercially available for 20 years. During this time five technologies or combinations of transgenic varieties have been made available. This paper discusses a systematic review of the known published literature and a meta-analysis of all available data, both published and unpublished. Data for this research were found using several major scientific databases (Google Scholar, EBSCO, etc.) and appropriate data entered into a database that currently has over 1,300 comparisons of transgenic Bt cotton to non-Bt varieties. Of these, approximately 900 were from published sources with the remainder having been provided by cotton researchers. The published data was compiled from approximately 100 sources, of which only six were refereed publications. The data presented in this paper is a preliminary analysis of transgenic Bt cotton efficacy that includes comparisons damage and yield, as well as, changes in efficacy over time for each technology.

A Closer Look at RNAi in Crops. M. Allen

A new technology called RNA interference (RNAi) is being used to produce GMO crops, beginning with maize or corn. This technology incorporates double stranded RNA into plants, which disables vital insect genes after it is consumed by the pest. The technology is based on gene sequences that are unique to corn rootworm, but some possibility for effects on closely related insects is still possible. Because ARS research produced expressed gene sequences from a beneficial insect, the lady beetle *Coleomegilla maculata*, sequences could be directly compared. Apparently homologous sequences to the transgene sequence from western corn rootworm were compared. Also a gene from the Colorado potato beetle proposed for incorporating into GMO potatoes were compared to those from *C. maculata*, as well as some genes from the red flour beetle, a genetic model organism. Some regions of high similarity were identified in the potato beetle and flour beetle gene sequences, suggesting that these sequences should be examined more closely before implementing RNAi technology in potato and possibly other crops. Further sequencing efforts on non-target organisms will help scientists make more informed decisions about implementing new technology.

RNA-Coupled Nanopore Sequencing as a Surveillance for Plant Pathogens in Plant and Insect Tissues. A. R. Bronzato, T. Wilson, D. Sherman, A. Stone, W. Schneider, and J. King

Plant pathogens are constantly emerging and spreading into new territories. As there are seldom any effective post-diagnosis solutions for infection, surveillance is key to their control. Over the last decade, the massively parallel sequencing (MPS) technologies have led to a sea change in biotechnological thought. As one aspect of its utility, MPS show potential for use in the detection of unsuspected human and plant pathogens. We present results from a proof of principle study testing the efficacy of a portable, real-time capable nanopore-based MPS technology for use in the detection of two plant pathogens. RNA were obtained from infected *Prunus persica, Myzus persicae*, and *Diaphorina citri* tissues and prepared to a whole transcriptome amplification (WTA)

analysis. The Oxford MinION device was applied coupled with the WTA samples to sequence the metatranscriptome of Candidatus Liberibacter asiaticus and Plum pox virus. Bioinformatics analyses were conducted in Linux and Windows platforms, using a series of open source third-party programs such as R programming language. Our results suggest that the combination of WTA and MinION sequencing could be useful to identify target virus and bacteria in plant and insect tissues, in the first seconds of started the run. The results also suggest that this approach could be capable of type-straining small-genome high titer pathogen and used to identifying unsuspected plant pathogens and determining the microbiome of both insect vector and infected plant tissues. While small hurdles still exist before this technology could be easily deployed in the field, there is a constant stream of developments in this field and we outline some future experiments that we plan to further test this promising methodology.

Utilization of Ladybird Beetles to Curb Aphids in Strawberry High Tunnels: Preliminary Results. E.W. Riddick

Native and exotic aphid species continue to pose a threat to the successful cultivation of small fruits in greenhouses, glasshouses, and high tunnels throughout the World. There is considerable interest in using biological controls (predators and parasitoids) to manage aphids in lieu of synthetic insecticides. The aim of this research is to evaluate the effect of predatory ladybird beetles to curb aphid populations on cultivated strawberry (*Fragaria* x *ananassa* Duchesne) in high tunnels in Stoneville, Mississippi, USA. The hypothesis that ladybird beetles can reduce aphid densities on strawberry plants was tested. In April 2016, plants were potted into two-liter nursery pots, containing organic potting mix, and arranged in rows on four metal benches in four replicate high tunnels (18 ft. wide, 24 ft. long). By early June, we detected one species of aphid (species undetermined), at extremely low densities on “daughter” plants, still attached by runners (stolons) to “mother” plants, in one high tunnel. To ensure that all high tunnels had aphids, we distributed infested daughter plants into the other high tunnels. On 12 August, we randomly selected 30 daughter plants, still attached to mother plants, and recorded the number of aphids (wingless adults and nymphs). On 15 August, we released second instar larvae of the ladybird *Coleomegilla maculata* DeGeer (Coleoptera: Coccinellidae), from our lab colony, at a ratio of 1 *C*. *maculata* larvae: 10 aphids, onto the benches containing the selected daughter plants, in three of the four high tunnels. Thereafter, aphid densities were recorded on 19 and 25 August, and 1, 8, and 15 September. The results revealed a rapid decline in aphid density in test high tunnels within four days after releases. On 19 August, aphid reduction was 71%, 86%, and 97% in the three test high tunnels; aphid reduction was 35% in the one control high tunnel. Interestingly, by the last day of sampling (15 September), aphid reduction was over 96% in test and control high tunnels. Host plant resistance and immigrating ladybirds (e.g., *Scymnus* species) might have contributed to aphid reduction in the control high tunnel by the last day of sampling.

The Heteroceridae of New Zealand. J. King and P. Lago

The variegated mud-loving beetles (Heteroceridae) are known to occur on all continents except Antarctica. However, it has long been accepted that they do not occur on New Zealand. For example, the family was not listed in Hudson’s index (1923) of the beetles of New Zealand, and in Lawrence *et al*.’s interactive key (1995) the author explicitly states that the family is not known to occur on New Zealand. Their absence is also mentioned in many taxonomic papers, as recently as 2016. In fact, *Heterocerus novaeselandiae*, the first species of heterocerid known from New Zealand, was described by Charpentier (1968). This species was described from a few specimens from Wedderburn and Iaiere Lake on the South Island. Here we present a second species of heterocerid from New Zealand that was discovered during our inspection of material from several museum collections along with new range maps for the two New Zealand species and a discussion of their relationship with the other Australasian heterocerids.

Euclid's Golden Section Ratio: A Potential Classification Standard for Remote Sensing Data. J. L. Willers, E. W. Schuster, and G. A. Milliken

The Golden Section Ratio is proposed as a classification standard for remotely sensed data, where for this presentation, the surface elevation from a LiDAR sensor is used as the illustration. The MAX value of the DATA for a defined AOI (area of interest) is the point A, and the MIN value of the DATA of the same AOI comprises the Point C, where these values define a case-by-case specific data range on the real number line. The task is to use the 'rule' to find point B, creating two sub-ranges AB and BC; then iteratively apply the rule at least 3 more times to define nested sub-ranges within each prior range interval of the AOI. This iterative process is comprises a classification standard, as the basic point of beginning for topography covariates derived from remote sensors, and are used with the spatial design of an experiment (SDOE) in agricultural research. A standard for classification of such data, is a necessary point of beginning of a SDOE analysis, because there are many other classification methods, leading to numerous issues that hinder SDOE analyses. These issues will be briefly discussed. We propose the Golden Section Ratio provides a non-arbitrary classification 'Standard' that resolves these issues.

Impact of Imidacloprid Formulation Alone and Mixtures with Other Pesticides on Honey Bee Survival and Physiology. Y.C. Zhu, J. Yao, J. Adamczyk, and R. Luttrell

Imidacloprid is the most widely used insecticides in the world for both seed treatment and foliar sprays. Previous toxicity studies were mostly done by incorporating technical grade imidacloprid into feeding solution, which might not include contact toxicity and potential synergistic toxicity from formulating reagents. In most crop systems, foliar sprays with imidacloprid formulations are usually applied multiple times in a season and tank mixing with other pesticides is also a common practice. The risk of foliar spray exposures to foraging bees and potential synergistic toxicity from insecticide mixtures have received significant less research attention. In this study, we applied imidacloprid formulation Advise 2FL using both feeding and spraying methods to simulate in-hive and field exposures. We also selected 7 representative pesticides from different chemical classes to examine how pesticide mixtures impact honey bee survival and physiology. Our data indicated that Advise 2FL at 4.3 mg/L (equal to 912 ppb, the maximal detectable residue level in pollens) incurred 36% mortality and 56% feeding suppression after 2-week feeding. Additive/synergistic toxicity was not detected from binary mixtures of Advise 2FL with different classes of pesticides at residue levels. Spray treatments twice a week for 7-8 weeks with ≤1 mg/L and once a week for 2 weeks with 4.3 mg/L Advise 2FL showed no adverse effect on bee survival. Concentration at ≥80 mg/L significantly reduced bee survival. Enzymatic data showed that activities of invertase, glutathione S-transferase, and acetylcholinesterase activities in imidacloprid-treated survivors were mostly similar to those found in control. In another spray experiment, Advise concentration was increased to 274 mg/L. Additive/synergistic toxicity was detected in binary mixtures of Advise 2FL with 5 representative pesticides, while other two pesticides showed no interaction with Advise. Esterase and acetylcholinesterase activities were suppressed by an organophosphate insecticide alone and the mixture with Advise. Finally we demonstrated that P450 oxidases played a major role in detoxify imidacloprid, while esterases and glutathione S-transferases were much less effective in detoxifying imidacloprid. Our data provided valuable information for guiding pesticide selection in premixing and tank mixing in order to alleviate toxicity risk to honey bees.

Morphometrics of the Tick *Dermacentor parumapertus* Neumann. G. M. Moraru, J. S. Portugal, III, A. Bedranova, S. McInnis, G. T. Baker, T. Becker, T. Smith, C. Paddock, and J. Goddard

Dermacentor parumapertus is an ixodid tick that occurs throughout much of the western United States. This tick is relatively host-specific, feeding on hares and rabbits, but also

on rodents as immatures. The literature reports a "variety" of the species, *D. parumapertus* var. *marginatus*, as having markedly different ornamentation. This was noted in comparing specimens from California, New Mexico, and Texas to specimens from other parts of the species' range. To explore this further, we examined adult *D. parumapertus* from Texas (n=32) and Utah (n=17) for specific morphological characteristics; we also compared these with specimens of a closely related species, *D. andersoni*. We measured variables such as the spurs, pregenital plate, punctations on the scutum, body width and length, spiracular plates, etc. We used *t* tests to compare specific characteristics between the groups and principal component analysis (PCA) to analyze whether or not certain groups of characteristics could be used to separate Texas from Utah specimens. These data are continuing to be analyzed. Information garnered from these analyses will help in understanding the taxonomy of this species and any potential varieties throughout its range.

Influences of Cultural Practices on Soybean Nectar Production. T. Smith, A. Catchot, J. Harris, N. K. Krishnan, J. Gore, and D. Cook

Soybean nectar attributes to a large percentage of the nectar used in honey production in honey bee systems. The amount of nectar produced in each cultivar differs between those cultivars. Previous research has been done in the past to identify which certain cultivars produce the highest quantity of nectar. The objective of these tests was to identify which modern cultivars produced the highest amount of nectar based on a series of cultural mechanisms. Tests were conducted during the 2016 growing season in the hills and delta region of Mississippi. The tests were also separated by planting date as well as being irrigated and non-irrigated. Flowers were pulled at peak nectar hours and weighed. After which the samples were centrifuged and placed in cold storage until analyzed by spectrophotometry.

Monitoring Tobacco Thrips *Frankliniella fusca* (Hinds), resistance to neonicotinoid insecticides in Mississippi. C. Darnell, A. Catchot, F. Musser, D. Cook, J. Gore, D. Dodds, and S. Moresello

Reduced insecticidal efficacy of neonicotinoid seed treatment against tobacco thrips, *Frankliniella fusca* (Hinds), has been observed in Mississippi. Dose-response bioassays with four commonly neonicotinoid insecticides, focusing on thiamethoxam and imidacloprid, were performed on field-collected adult female tobacco thrips during May and June, 2014-2016. In 2014, resistance to thiamethoxam was observed, but not to imidacloprid. However, in 2015, resistance to thiamethoxam intensified and resistance to imidacloprid was observed. In 2016 resistance levels dropped below levels from 2015. This is may have been due to a large migration of susceptible tobacco thrips into the population.

Diversity and Temporal Distributions of *Sphenophorus* spp. on Mississippi State University's Campus. R. J. Whitehouse

Some species in the genus *Sphenophorus* (Curculionidae; Dryophthorinae; Rhynchophorini), commonly known as billbugs, are common turf and crop pests. On the Mississippi State University campus, a few of the many species of *Sphenophorus* can easily be found on sidewalks. Presented here are the preliminary results of a study looking at the temporal distributions of *Sphenophorus* spp. found around Mississippi State University's campus, focusing on the area around Chadwick Lake. Each week, starting in March, weevils were collected off of sidewalks and their general abundance recorded. So far, it has been observed that *Sphenophorus cariosus* (Olivier) and *S. venatus* (Say) have been present from March to August at fluctuating levels of abundance. Some of the other weevils found during this study are *S. inaequalis* (Say) and *Naupactus peregrinus* (Buchanan). As the study continues, more *Sphenophorus* spp. will be collected to help determine their seasonal distribution.

Controlling Tarnished Plant Bug (Lygus lineolaris) in cotton (*Gossypium hirsutum*) through a transgenic approach. J. C. Corbin, A. Catchot, and J. Gore

Experiments were conducted to determine the impact of a new transgenic variety of cotton on the tarnished plant bug (*Lygus lineolaris)* populations and to assess future treatment thresholds in these varieties. By implementing this transgenic approach the number of insecticide applications necessary were reduced compared to non-transgenic isolines.

Evaluating Fall Armyworm Thresholds in Whorl Stage Corn. K. Croom, A. Catchot, D. Cook, J. Gore, and B. Henry

Currently, fall armyworm thresholds in whorl stage corn for the state of Mississippi are 100% infested plants before any insecticide treatment is warranted. Many have questioned the validity of this threshold. The purpose of this research is to research various infestation percentages in whorl stage corn and leaf loss as it affects corn yield. The paper addresses preliminary findings from 2016 research trials on how defoliation in whorl stage corn influences corn yield at various growth stages.

Kudzu Bug: A New Pest in Mississippi Soybeans? B. McRight, F. Musser, A. Catchot, and N. Bateman

The kudzu bug is a native of south east Asia, first arriving in the U.S. in Georgia in 2009. The bug was discovered in Mississippi in 2012, quickly spreading to nearly every county in the state. This research looks at the distribution of the kudzu bug across the state, the efficacy of insecticide treatments, and the threshold of this insect on vegetative stage soybeans.

Impact of Temperature on the Efficacy of Sulfoxaflor and Flupyradifrone in Grain Sorghum. B. Lipsey, A. Catchot, J. Gore, E. Larson, D. Cook, and F. Musser

The use of sulfoxaflor and flupyradifrone in temperatures under 15.5°C (60°F) has been believed to result in decreased efficacy in grain sorghum (*Sorghum bicolor*) when managing sugarcane aphids (*Melanaphis sacchari*). This study was conducted at the Mississippi State University R.R. Foil Plant Science Research Center to evaluate the efficacy of sulfoxaflor and flupyradifrone at 15.5°C (60°F) and 29.4°C (85°F). Asgrow '54-00' was planted and treated at the soft dough growth stage with sulfoxaflor and flupyradifrone as well as an untreated check. Two inch leaf disc were removed from the uppermost leaf below the flag leaf at 0 and 24 hours and 3, 5, 7, and 10 days after treatment. Leaf disc were placed in water auger plates and infested with 5 aphids per dish and divided for each temperature tested and placed in growth chambers. Aphid mortality was recorded at 48 hours. Sulfoxaflor and Flupyradifuron both provided good control at 29.4°C but significantly less mortality at 15.5°C. regardless of timing. This data confirms that growers will likely experience unacceptable control if treating sugarcane aphids during periods cooler temperatures.

Landscape-Level Contributions of Corn, Cotton, and Soybean in Mixed Production Systems for *Helicoverpa zea* Populations.T. Towles, A. Catchot, and J. Gore

Helicoverpa zea is a major pest of corn, cotton, and soybean and is commonly controlled through the use of foliar applied insecticides or transgenic crops expressing the B*t* gene. To prevent the selection of resistant populations, refuge systems have been implemented into the agroecosystem. To test the efficacy of these traits and efficiency of various refuge systems on *Helicoverpa zea*, an experiment was conducted at the Monsanto Learning Center in Scott, Mississippi. A field trial containing five refuge scenarios in field corn was established, each with different trait combinations, in the 2016 growing season. Treatments consisted of non-Bt plantings, solid plantings of Trecepta and VT Double Pro, and an 80:20 and 90:10 blended refuge (RIB). Each variety was planted in a 33.5m x

20.7m block. All blocks were allowed to be naturally infested with *Helicoverpa zea*. After the immature *zea* exited infested ears and entered the soil for pupation, whole corn plants were removed from the blocks. Four plots were established within each block to serve as replications. Twenty-five moth emergence traps were placed within each treatment and monitored weekly for adult emergence. All data was analyzed using SAS 9.4. Additionally, small plot cages were placed over planting of B*t* and non-Bt soybeans and cotton. Twenty-Five pairs of H. zea moths were released two times at peak bloom of both crops. Eggs and larvae were counted in each treatment to determine ovipositional preference and larval survival.

Thrips Management of Herbicide Injured Peanut in Mississippi. J. Moor, J. Gore, A. Catchot. J. Sarver, and D. Cook

Over the past several years, peanut acres in Mississippi have been steadily increasing due to lower commodity prices in other crops. Peanut is also a good rotational crop on both irrigated and non-irrigated lighter textured soils. Management of insect pests in peanut is complex. For the management of soil insects and thrips, at-planting insecticides are typically used. Historical research has shown little benefit from foliar control of thrips. However, some pre-emergence herbicides, used to manage weeds, can cause significant injury under unfavorable environmental conditions. It is uncertain how thrips impact herbicide injured seedling peanuts. The objective of this study was to evaluate the interactions between the use of foliar insecticides and commonly used pre-emergence and post-emergence herbicides. Treatments were arranged as a split-split-plot within a randomized complete block design with 4 replications. The main-plot factor was flood irrigation at 2 levels, flooded and not flooded. The irrigation factor was included to maximize herbicide injury. The sub-plot factor was herbicide application at 2 levels. They included a pre-emergence application of flumioxazin (Valor®, Valent Co.) or no flumioxazin. The sub-sub-plot factor was thrips management at 4 levels. They included at-planting application of imidacloprid (Admire® Pro, Bayer CropScience), 1 or 2 foliar applications of acephate (Orthene 90S, Valent Co.) and an untreated control. Foliar applications were made 7 and 14 days after flooding. Additionally, 5 plants were removed from each plot and weighed to determine biomass. Percent canopy closure was measured 55 and 64 days after planting. At the end of the season, plots will be harvested and yields will be determined.

Statewide Survey for Potential Zika Virus Mosquito Vectors. S. McInnis, G. Moraru, A. Bedranova, W. Varnado, T. Nations, D. Yee, J. S. Portugal, III, and J. Goddard

Zika is a mosquito-borne arbovirus transmitted primarily by mosquitoes in the genus *Aedes*. In the U. S., potential Zika vectors include *Aedes aegypti* and *Aedes albopictus*, although *Ae. aegypti* is considered a more efficient vector. From May 1 through August 31, 2016, 205 sites in 41 northern Mississippi Counties were sampled for potential Zika virus vectors by larval dipping once a month in tires, trash containers, and/or cemetery urns. Larvae were returned to the lab, where 1-2 specimens were retained in alcohol and the others reared to adults in 4 oz plastic containers. Larvae and adults were subsequently identified to species using standard taxonomic keys. During the 4-month study, approximately 1,250 specimens were collected, representing 10 species: *Aedes albopictus, Aedes triseriatus, Aedes japonicus, Culex restuans, Culex territans, Culex quinquefasciatus, Culex coronator, Culex salinarius, Culex nigripalpus*, and *Anopholes punctipennis*. The Asian Tiger mosquito, *Aedes albopictus*, was collected from every northern county, while no *Ae. aegypti* were found. This study demonstrates that the predominant potential Zika virus vector in north Mississippi is *Ae. albopictus* and control efforts should be developed toward that particular species.

Molecular analysis of Utah versus Texas Varieties of the Tick, *Dermacentor parumapertus* Neumann. J.S. Portugal, III, J. King, G. Moraru, T. Becker, T. Smith, C. Paddock, and J. Goddard

Dermacentor parumapertus Neumann is a poorly studied tick, found predominantly on black-tailed jackrabbits (*Lepus californicus*). This tick inhabits arid regions of western North America, and has one of the largest ranges of any North American *Dermacentor* spp. A recent study has highlighted differences in ornamentation between specimens collected in Utah and Texas, leading us to further investigate using phylogenetic analysis. We extracted DNA from 33 *D. parumapertus* (12 Texas, 18 Utah, 2 Arizona, 1 Nevada) and 4 *D. andersoni* (a closely related species). Two primers were used to target mtDNA regions of COI (~615 bp) and 12s (~350 bp), and three primers were used to target nDNA regions of ITS1 (~810 bp) and ITS2 (~360 bp and ~370 bp). Separate nuclear and mitochondrial DNA sequences were aligned, concatenated, and subjected to phylogenetic analysis. *Dermacentor albipictus* and *D. variabilis* were used as out-groups in this study. Trees were constructed by Maximum Parsimony, Maximum Likelihood (ML), and Bayesian analysis. Preliminary results suggested a monophyletic association between *D. parumapertus* and *D. andersoni* when compared to other *Dermacentor* spp. ticks. Preliminary concatenated mitochondrial results analyzed by the ML method showed that a "Northern clade" of *D. parumapertus* (all but 3 Utah ticks) separated from *D. andersoni* and the remainder of *D. parumapertus* with a bootstrap value of 100%. An "Intermediate clade" of *D. parumapertus* (Nevada, Arizona, and 3 Utah ticks), as well as the *D. andersoni* then separated out with high support (88% and 100% respectively), and a "Southern clade" (one Arizona and all Texas ticks) formed a weak grouping. Between-group mean distances ranged from 2.1% (Intermediate clade vs. North clade), to 1.4% (Southern clade vs. *D. andersoni*). Concatenated ITS2 results were similar to mtDNA. *Dermacentor andersoni* separated out from *D. parumapertus* with high support (96%), and all Texas specimens in the "Southern clade" separated out at 94%. Between-group mean distances for *D. andersoni* and *D. parumapertus* were ~1%, and within *D. parumapertus* were ~0.5%. These preliminary results demand continued investigation to determine the phylogenetic and taxonomic status of *D. parumapertus* and *D. andersoni*.

Value of Neonicotinoid Insecticide Seed Treatments in Mid-South Cotton (*Gossypium hirsutum*) Production Systems. J. North, J. Gore, A. Catchot, S. Stewart, G. Lorenz, F. Musser, D. Cook, D. Kerns, and D. Dodds

Neonicotinoid insecticides are currently one of two classes of chemicals available as a seed treatment for growers to control early season insect pests in cotton, *Gossypium hirsutum* L., production in the Mid-South, and they are used on nearly 100 percent of the cotton hectares. An analysis was performed on 102 neonicotinoid insecticide seed treatment trials from Arkansas, Louisiana, Mississippi, and Tennessee to determine the value of neonicotinoid seed treatments in cotton production systems across the Mid-South region of the United States. The analysis compared neonicotinoid insecticide seed treatments plus a fungicide to seed only treated with fungicide. When analyzed by state, cotton yields were significantly greater in each state when neonicotinoid seed treatments were used compared to fungicide only treatments. Cotton treated with neonicotinoid treatments yielded 84.0 kg ha-1, 149.0 kg ha-1, 117.0 kg ha-1, and 140.0 kg ha-1, higher than fungicide only treatments for Arkansas, Louisiana, Mississippi, and Tennessee, respectively. Across all states, neonicotinoid seed treatments yielded an additional 127.0 kg ha-1 compared to fungicide only treated seed. Average net returns from cotton with a neonicotinoid seed treatment was $1,849 per ha-1 compared to $1,686 per ha-1 for cotton with fungicide only treated seed across the Mid-South. Economic returns for neonicotinoid seed treatments were significantly greater than fungicide only treated seed in ten out of fifteen years. When analyzed by state, economic returns for neonicotinoid seed treatments were significantly greater than fungicide only treated seed in every state of the Mid-South. These data show that neonicotinoid seed treatments provide significant yield and economic benefits in Mid-South cotton compared to fungicide only treated seed.

Effects of Defoliation on Mississippi Soybean Yield. B.C. Thrash, A.L. Catchot, J. Gore, F. Musser, D. Cook, T. Irby and J. Krutz

Injury from defoliating insects is responsible for more yield loss to Mississippi soybean producers than any other feeding guild of insects. In 2014, defoliating insects alone cost Mississippi producers $37,081,635. Insects contributing to defoliation include bean leaf beetles, soybean loopers, velvetbean caterpillars, green cloverworms, armyworms, grape colaspis, flea beetles, and grasshoppers. Previous research has shown that excessive foliage loss that occurs during the R3-R5 growth stages can have devastating effects on yield. The objective of these tests were to refine the current treatment recommendations by simulating situations commonly encountered by producers. Tests were conducted during the 2015 growing season in the hills and delta region of Mississippi. Soybeans were defoliated at various levels and growth stages throughout the growing season to mimic the effects of compounding defoliation. Leaf area index and heights were recorded periodically throughout the season, as well as yields at the end of the season. Compounding defoliation resulted in yield loss that was additive in effect and lowered leaf area index values which correlated with lower soybean yields. Soybeans planted later in the season had larger yield reductions when defoliated at V4 than those planted earlier in the season. These tests could help producers by creating a variable threshold based on planting date or defoliation that occurred during previous growth stages.

Primary Pest Black Fly Species (Diptera: Simuliidae) Occurring in Mississippi. T. Nations and J. Goddard

Black flies are second only to mosquitoes as being notorious blood-feeding insects. In many parts of the world, black flies are a serious problem and transmit various diseases such as onchocerciasis (human) and leucocytozoonosis (animal). Black fly outbreaks were common in Mississippi during the first half of the 20th century, but ended for unknown reasons. There has been a resurgence of black fly problems in Mississippi 2009. This study was initiated as part of a broader project on black flies in Mississippi. To survey the species occurring in Mississippi we searched for any *bona fide* records or specimens in the Mississippi Entomological Museum (MEM), Mississippi State University. In addition, we sampled for black flies in 10 sites around the state near rivers and creeks known to have black fly breeding. Specimens were collected twice a month from February - July 2015 and again in 2016. And then, once a month the remainder of the two years. A total of 79 specimens were found in the MEM, comprising 14 species. Collections at the 10 sites during 2015 yielded 104 specimens and 2016 yielded 168 specimens, all being either *Simulium meridionale* or *S. jenningsi* (our two main pests). Seasonality of the two main pest species was March through July, with a peak in May. There was another, smaller emergence of *S.jenningsi* in October/ November.

The Influence of Planting Date on the Occurrence of Insect Pest in Mississippi Soybean. N. Bateman, A. Catchot, J. Gore, D. Cook, F. Musser, and T. Irby

In Mississippi, the early soybean production system introduced group 3 and 4 soybean in planted in late March through April as a way to avoid late season drought stress. The early soybean production system not only helped avoid drought, it also avoided late season insect pressure that is common in Mississippi soybean. In recent years there has be an increase in grain acres and a decrease in cotton acres, with soybean taking a large portion of these acres. With this increase in soybean acres, growers are spreading out planting dates from late March through July to better manage harvest. These late planted soybean are left vulnerable to late season caterpillar infestations which can impact yield.

In 2013 and 2014, seven planting dates of soybean were planted in both the hills and delta regions of Mississippi to quantify the seasonal occurrence of caterpillar pests. Only soybean planted after May 30 reached threshold for caterpillar pests in both years of the

study. Because only the later planting dates reached economic threshold, in 2015 three later planting dates of soybean were used. Treatments consisted of automatic diamide applications (Prevathon) to simulate Bt soybeans compared to threshold treatments. This paper will address the potential value of Bt soybeans to Mississippi producers and identify seasonal periods of greatest risk from insect pests in soybeans.

Sugarcane aphid, *Melanaphis sacchari* and Grain Sorghum: Implications for Honeybees, *Apis mellifera*. W. Crow, A. Catchot, J. Gore, S. Stewart, and S. Steckel

This paper will address honeybee, *Apis mellifera* populations at various grain sorghum growth stages with ranging amounts of sugarcane aphid, *Melanaphis sacchari* honeydew. In addition, this paper will also focus on the insecticidal uptake of seed treatments for the control of sugarcane aphids in grain sorghum pollen sources.

Populations of foraging honey bees in Midsouth crops. A. Whalen, A. Catchot, J. Gore, S. Stewart, G. Lorenz, D. Cook, F. Musser, J. Harris, and N. Krishnan

In recent years there has been a global decline in populations of both native and managed pollinators. Pesticides are considered by some to serve a role in these declines. A study was conducted to see when and at what densities honey bees forage agronomic crops in the Midsouth. Fields of corn, cotton, and soybean were visually sampled for foraging honeybees across Arkansas, Mississippi, and Tennessee. Honey bees were observed at three time intervals and at four distances into each field. Significantly more honey bees were observed in soybean during the mid-day time interval than in other crop-time interval grouping. No differences were observed between distances from the field edge in regards to number of foraging honey bees Based on these data, insecticide applications should be made in the evenings when honey bees are less active in crop fields. This allows for the most time for the residual activity of insecticides to diminish before foraging honey bee numbers increase in the morning and maximize in the middle of the day.

Poster Presentations

Pyrethroid Resistance in Helicoverpa zea in Mississippi. B. Catchot, F. Musser, and K. Knighten

Bollworm, *Helicoverpa zea*, and tobacco budworm, *Heliothis virescens*, are pests in numerous crops where they may be exposed to pyrethroid insecticides. Since both pests can have 5 or more generations per year in the southern U.S. on multiple crops, they have the potential to develop large populations. Both pests have the potential to cause substantial economic loss. While tobacco budworm has a history of resistance to pyrethroids, Heliothine larvae cannot be readily distinguished, so pyrethroids are sometimes used to try to control these worms. Knowledge of the susceptibility of bollworms and tobacco budworms to pyrethroid insecticides is therefore helpful for effective management of these pests.

Pherormone traps were placed in various locations across Mississippi, being changed every 2 weeks and monitored weekly from May until September. Healthy males were trapped and individually placed in 20 ml scintillation vials which were previously treated with 0 or 5 µg cypertherin vials (bollworm) or 10µg cypermethrin per vial (tobacco budworm). Moths were kept in the vials for 24 hours and mortality was checked.

Bollworm and tobacco budworm adults are highly mobile (Lingren et al. 1994, Beerwinkle et al. 1995), which would suggest that pyrethroid resistance would quickly spread from one region to another. Pyrethroid resistance in tobacco budworm has been well documented. Pyrethroid resistance in bollworms now appears to have spread to Mississippi. Field control of bollworm larvae with pyrethroids has been inconsistent for a

number of years, and now it appears that resistance is widespread enough to be readily detected in moth bioassays.

Both of the Heliothine resistance levels have increased since 2011. Bollworm resistance is highest in July when bollworm moths are emerging from corn suggesting that larval host quality plays a role in pesticide resistance. Tobacco budworm resistance is relatively flat from May through September. Even though pyrethroids are not applied for Heliothine control as frequently as in the past, there are still many applications made in the agricultural landscape targeting other pests to continually decrease pyrethroid susceptibility, making the selection of this class of chemistry for targeting Heliothines a risky decision.

Mississippi Mecoptera: Current Research and Future Prospects. J. Gesell and M. Thorn

The body of literature on Mississippi scorpionflies (Mecoptera) is briefly summarized. Literature examined ranges from Carpenter's 1931 treatise on Mecopteran biology to Stark and Lago's 2016 checklist of the Mississippi fauna. Areas of potential future research are discussed. Several species of Mecoptera lack larval descriptions and their life histories need to be characterized. Other species require additional sampling to further refine their spatial and temporal distributions. Current research efforts include the production of a key to the Mississippi Mecoptera. The last key to the Mecoptera that included Mississippi species was published in 1993 and only addressed species with an autumnal emergence. Since then several taxonomic changes have been made and new species have been described from the Mississippi fauna. This new key addresses these changes while adopting clearer and more accessible terminology for students of Mecoptera.

Student Engagement in Entomology and Microbiology: "From Microbes to Mosquitoes" - An Undergraduate Research Experience for Students Interested in the Biomedical Sciences. W. H. Dees, C. G. Struchtemeyer, C. E. Hennigan, C. M. Ardizzone, and J. R. Woolman

"From Microbes to Mosquitoes (MtM)" is an interdisciplinary, multi-institutional project designed to introduce undergraduate students to the scientific fields of entomology, ecology, and microbiology. This experiential learning project provides students the opportunity to: (1) participate in undergraduate research, (2) visit facilities supporting scientific operations and listen to presentations about opportunities in a variety of scientific fields/disciplines, and (3) participate in local-global networking events through attendance and participation at local, state and regional scientific and entrepreneur-based conferences. Two different student groups participate in the MtM project: (1) freshman/sophomore students majoring in science, many of whom are interested in the biomedical sciences, but may be at risk of changing majors or leaving their academic pursuit altogether due to academic struggles, and (2) student peer mentors (i.e. students who excel in the sciences and help faculty members mentor at-risk freshmen and sophomore students). Together, these students collect and process samples and analyze data relevant to field and laboratory investigations that pertain to mosquito midgut microbiota and environmental bacteria. During their time in the project, students may serve as field and/or laboratory research assistants. These students apply course content from their education to their selected topics and participate in a variety of professional scientific engagements (e.g., seminars, presentations by science professionals outside academe, and professional scientific conferences). The outcomes of the MtM project include: (1) retaining, advancing and placing students into professional scientific fields, and (2) nurturing a scientifically educated citizenry. To date, over 15 students have been involved in some aspect of this project. The goal of the project is to provide students with opportunities to personally engage with, learn about, and experience science outside the classroom.

Seasonal Trapping of Adult Female Mosquitoes in a City Park. C. M. Ardizzone, D. L. Johnson, W. H. Dees and J. Hightower

We are conducting a seasonal longitudinal survey at a 24-acre woodland park in an urban area of Lake Charles, Louisiana. The park is separated into two distinct areas: one is an open area with playground equipment, picnic tables, open shelters, a small conference center, exhibits, wetland ponds, and concrete walking paths with benches; the other is a preserved forest with nature trails. The mosquito survey was initiated in the summer of 2011. We use Centers for Disease Control and Prevention (CDC) light traps baited with CO_2 in the form of dry ice to collect mosquitoes. Mosquitoes are collected in the open area near the preserved forest in each of the four seasons. Temperature and humidity data are recorded during each trap night. To date, the predominant species collected (i.e. >50 in one trap night) are *Aedes atlanticus*, *Ae. taeniorhynchus*, *Ae. vexans*, *Coquillettidia perturbans*, *Culex erraticus*, *Cx. nigripalpus*, *Cx. salinarius*, and *Psorophora columbiae*. *Coquillettidia perturbans* numbers reached a record high in Spring 2016 (n = 81); no more than 50 of these mosquitoes had been trapped in one season since Spring 2013. After five years of trapping, *Uranotaenia lowii* was the most prevalent species in Summer 2016, surpassing *Culex* spp. (*Cx. erraticus and Cx. salinarius*) which had been the predominant species in the previous three summers (2013-2015).

Examining the Midgut Microbiota of Adult Mosquitoes. V. N. Hayes, C. M. Ardizzone, K. C. McDadeC. E. Hennigan, W. H. Dees, and C. G. Struchtemeyer

During parts of their life cycle, mosquitoes inhabit aquatic areas. This research explores the association between the midgut microbiota of adult mosquitoes and the bacteria in the aquatic environment they reside near. Preliminary experimentation and two initial field collections/analyses have been conducted as part of this research. Preliminary experiments were conducted to determine the proper procedures for sterilizing and dissecting adult mosquito midguts. Two sterilization and dissection procedures were tested, and a comparison of spread plate versus pour plate culturing methods was performed with varying amounts of mosquito midgut homogenates. The results of the preliminary experiments showed that homogenates from five adult mosquito midguts combined with the pour plate method produced optimal colony growth. To date, this protocol has been used to culture bacteria from two populations of adult mosquitoes collected from different aquatic areas. Captured mosquitoes were separated by genera and subjected to sterilization, midgut dissection, and cultivation of their bacterial midgut contents. In addition to culturing adult mosquito midguts, bacteria from water samples collected near each mosquito collection site were cultured and compared to the cultured mosquito midgut bacteria using colony morphological properties and the Gram staining procedure. The results of this work showed similarities and differences between the bacteria cultured from mosquito midguts and water samples.

Impact of *Beauveria bassiana* Strain NI8 on *Lygus lineolaris* (Hemiptera: Miridae) and Beneficial Arthropods. M. Portilla, R. Luttrell, G. Snodgrass, Y. C. Zhu, and E. Riddick

The virulence of *Beauveria bassiana* (Balsamo) Vuillemin (Ascomycota: Hypocreales) strain NI8 was assessed on *Lygus lineolaris* (Palisot de Beauvois) and on beneficial arthropods including *Apis mellifera* L., *Crysoperla rufrilabris* Burmeister*, Orius insidiosus* Say*, Hippodamia convergens* Guérin-Méneville, *Harmonia axyridis* (Pallas), *Coleomegilla maculata* De Geer, and field collections of jumping spiders (Aranea: Salticidae), and crab spiders (Aranea: Thomisidae). Insects were treated with four concentrations of NI8 (7 x 10^4, 10^5, 10^6 and 10^7 spores/ mL) directly via topical spray. LD_{50} and LS_{50} were estimated for all species except for the collective field samples of jumping and crab spiders. From the resulting data, no significant differences in mortality were observed among *L. lineolaris*, *A. mellifera* and *C. rufilabris*. All three species were highly affected when exposed to the highest test concentrations of *B. bassiana* with 99.0%, 98.2%, and 90.0%

mortality, respectively. Between 35 and 45% of the tested populations of *O. insidiosus*, *H. convergens*, field collected crab spiders, and *C. maculata* were infected at 7 x 10^7 spores / mL; whereas only 22% and 27%, respectively of the field collected jumping spiders and *H. axyridis* were killed at 10-d with the same concentration. No significant differences were found between the LD_{50}s measured for *L. lineolaris* (2.75 viable spores per mm^2) and *C. rufilabris* (2.11 viable spores per mm^2). Higher LD_{50} was needed for *A. mellifera* (43.45 viable spores per mm^2), 652-fold greater than LD_{50} needed *for L. lineolaris* was needed for *H. convergens* and LD_{50}s much greater than that were needed for the rest of the species. Results indicate that *C. rufilabris* will be highly affected by the NI8 strain of *B. bassiana* when applied for control of *L. lineolaris.* In contrast, *B. bassiana* appeared to have little to limited effects on the other beneficial arthropods assayed at the test concentrations targeted for *L. lineolaris* control.

Exotic Mini Trap-Jaw Ants (Hymenoptera: Formicidae: *Strumigenys*) in Mississippi. J. MacGown

Based on faunistic surveys of ants by the Mississippi Entomological Museum since 2001 and historical records, 30 exotic ant species have been reported from Mississippi. Several of these species, such as *Brachymyrmex patagonicus* Mayr*, Linepithema humile* (Mayr)*, Nylanderia fulva* (Mayr)*, Solenopsis invicta* Buren*,* and *S. richteri* Forel are considered to be invasive species that have negative impacts on native ecosystems and/or to human economics or health. However, the impacts of most exotic species that become established in new regions are less obvious. This is especially true for the minute, cryptic species in the genus *Strumigenys* of which four exotic species occur in Mississippi: *Strumigenys hexamera* (Brown)*, S. margaritae* Forel*, S. membranifera* Emery*,* and *S. silvestrii* Emery*.* Members of this genus are not considered to be pest species, but the affects of these exotic species on the 25 native *Strumigenys* species in Mississippi are unknown. Here we provide current distributions in Mississippi, brief descriptions, and biological information for these four exotic species of *Strumigenys.*

Campfire Firewood Habits and Non-native Woodborer Spread in Mississippi Parks. M. J. Thorn, J. J. Riggins, R. L. Brown, and J. Gordon

Non-native wood borers are being introduced to North America at an increasing rate. Introductions of pest species, such as the red bay ambrosia beetle (*Xyleborus glabratus*), emerald ash borer (*Agrilus planipennis*), soapberry borer (*Agrilus prionurus*), and Asian long-horned beetle (*Anoplophora glabripennis*), are already causing significant economic, ecological, and cultural harm. Firewood has been implicated as a vector of many non-native wood borers in the U.S., allowing for long distance dispersal and hastening the spread of these species. Intercept surveys will be performed at four Mississippi parks to give insight into how campers procure and move firewood, as well as, their camping habits, attitudes towards non-native wood borers, and regulations concerning the movement of recreational firewood. Camper attitudes and habits are an under researched area of non-native wood borer movement that this study seeks to add data to. Future work will extract and identify non-native wood borers from firewood collected from surveyed campers in Mississippi campgrounds.

An Exploratory Study Comparing the Bacterial Community in the Guts of Wild and Lab Raised *Anopheles quadrimaculatus* Our Native Malaria Vector. E. Moen, and J. King

The adult life-stage, and vector competence, of the mosquito is thought to be heavily impacted by the aquatic environment in which the larvae are reared. The microbial community obtained from their rearing environment is suspected to be one key factor in this interplay, primarily by the microbiome affecting the innate immune status of the mosquito and its ability to fight malarial infection. While many studies have looked at the microbial response through different life-stages and in relation to malaria infection, there is a lack in comparative analyses between lab strain, wild mosquitoes, and the rearing

microbial environment. This explorative study used wild caught (using CDC light traps) and lab strain mosquitos reared in typical lab conditions as well as in water collected from a wild mosquito collection site. Specifically, we will use Illumina-based 16S amplicon sequencing to determine the eubacterial content of the midguts from adult *An. quadrimaculatus* from an identical genetic background that were reared in 1) standard "clean" laboratory settings and 2) lab setting using water from a native habitat. As a control, we will also include 3) an analysis of the gut microbiome from wild caught adult *An. quadrimaculatus.* Through this continuing exploratory analysis, I plan to seek out the possible differences of lab strain and wild *An. quadrimaculatus* midgut bacterial content as a result of their rearing environment. This difference could be key to understanding the wild *Anopheles-plasmodium* response as well as studies looking to optimize the use of laboratory-based mosquito studies and the potential of using the microbiome as a way of mosquito abatement.

New State and County Records for *Oopterinus distinctus* and *Oopterinus perforatus*. R. J. Whitehouse

Species in the genus *Oopterinus* (Curculionidae; Curculioninae; Otidocephalini) are small, cryptic weevils that are rarely collected. *Oopterinus distinctus* (O'Brien) and *O. perforatus* (Horn) are the two species of this genus that can be found in the southeastern United States. Prior to this work, *Oopterinus distinctus* had only been reported from four counties in Arkansas. *Oopterinus perforatus*, though more commonly collected, had only been reported from three states in the southeastern United States: Arkansas, Georgia and Tennessee. In 2014, *O. distinctus* was collected in Colbert County Alabama. This collecting event, as well as specimens of *O. distinctus* collected in Louisiana and Arkansas, represent new state and county records for this species.

A Survey of Mississippi Mosquitoes' Blood Meal and Malaria Parasites. J. Aycock, J. Goddard, and D. C. Outlaw

Haemosporidians, along with many other pathogens, are transmitted to vertebrate hosts through the salivary glands of various mosquito species. Research on these vectors has been sorely lacking in the past couple of decades, particularly in linking relationship between the vertebrate host and the parasite. This survey will determine the vertebrate blood meal of various mosquito species throughout counties in Mississippi and will identify any haemosporidian parasites carried by the vector. Of ~27,000 mosquitoes collected in Mississippi in 2013 and 2014, 167 specimens are engorged with a viable blood meal. Each mosquito has been identified and processed for DNA extraction. Three polymerase chain reactions will be performed on each sample. The first will use the mitochondrial cyt *b* gene to determine the vertebrate from which the blood meal was taken, and each will be sequenced to species. The second assay will also use the mitochondrial cyt *b* gene to detect any malaria parasites, these will also be sequenced and identified to species. The last polymerase chain reaction will be used on select *Culex* spp. to confirm their identity utilizing 18S rDNA sequence. The species included are *Culex salinarius*, *Culex restuans*, and *Culex pipiens* complex. These data will help to form a more detailed picture about the relationships between these three organisms, particularly the mosquito and the vertebrate.

Natural Enemies in Mississippi Soybeans and Their Impact on Soybean Pest. N. Bateman, A. Catchot, J. Gore, D. Cook, F. Musser, and T. Irby

Natural enemies are commonly found in Mississippi soybean throughout the growing season and these are primarily made up of parasitoids and predators. Natural enemies are considered beneficial in cropping landscapes, due to their ability to maintain or lower pest populations. In most cases beneficial insects are over looked when making insecticide spray recommendations. This study was conducted to examine proper

integrated pest management (IPM) against non-IPM strategies and its effects on beneficial insects.

Studies were conducted in the 2013 and 2014 growing seasons, where soybeans were planted across seven planting dates late March through mid-July. There were three treatments applied to each planting date consisting of a completely untreated check, an IPM treatment, and a non-IPM treatment. The IPM treatment was only sprayed when insect pests reached economic threshold, whereas the non-IPM treatment was sprayed three times during reproductive growth of the soybean with Dimethoate. Plots were sampled weekly using a standard 38 cm sweep net and all beneficial insects and spiders were counted. It was determined that during these two years of research that populations of beneficial insects decreased later in the growing season. There were more caterpillar pest in the non-IPM plots as well as a decrease in beneficial insect numbers.

Evaluation of Foliar Application Timing Intervals for the Control of Tobacco Thrips (*Frankliniella fusca*) in Cotton Production Systems. W. Crow, A. Catchot, J. Gore, D. Dodds, T. Allen, D. Cook, S. Stewart, D. Kerns, N. Seiter, and G. Lorenz

Tobacco thrips, *Frankliniella fusca* (Hinds), are a consistent and predictable pest of cotton production systems in the United States because of their potential to delay maturity and reduce crop yields. On average, there is an increase in lint of 128 kg ha^{-1} when treated with an insecticide seed treatment. With the decline in efficacy of thiamethoxam, it is vital that we determine other non-neonicotinoid seed treatment options for effective Tobacco thrips control. Therefore, the objective of this study is to determine the best management strategy for controlling Tobacco thrips by evaluating various foliar insecticide timing intervals. Studies were conducted in 2015, in Mississippi, Louisiana, and Tennessee (USA) using a randomized complete block design with four replications. Treatments included foliar applications at the following intervals: cotyledon, cotyledon followed by two weeks after emergence, cotyledon followed by two and three weeks after emergence, only week two and only week three after emergence, an average of one thrips per plant, and if plants scored an average injury rating of two. All treatments were compared to an untreated check and an imidacloprid seed treatment. At the first sampling, treatment applications made at cotyledon followed by week two and cotyledon followed by week two and three reduced adult thrips below the untreated control, while imidacloprid and cotyledon followed by week two timings had fewer immature thrips than the one thrips per plant and average injury rating of two treatments. Thrips damage ratings were reduced to a 1.25 score when applications where made at cotyledon followed by week two and three. At the second sampling, all treatments reduced adult and immatures thrips densities below the untreated control. In respect to cotton yield, there were no differences among any treatment.

Laboratory studies of host-seeking behavior in colonized nymphal *Amblyomma maculatum* Koch Ticks (Acari: Ixodidae). J.S. Portugal, III, R. Wills and J. Goddard

Amblyomma maculatum Koch is an aggressive, three-host tick found in coastal regions of South and Central America, and increasingly in the south-central and southeastern United States. This tick presents a significant medical and veterinary threat, yet little is known about the ecology and off-host behavior of immatures. For this study, ticks were obtained from a colony maintained at Oklahoma State University, and used within six weeks of molting. Nymphal *A. maculatum* (3 replications, 80/replication) were placed in an aquarium containing purified sand, anchoring four alternating rows of field-collected *Andropogon virginicus* stems at one of four lengths: 5, 10, 20, and 30 cm. Behavior under four environmental conditions was evaluated: high temperature/high humidity “HH” (26.7°C, 65% R.H., VPD=1.22 kPa), low temperature/high humidity “LH” (18.2°C, 54% R.H., VPD=0.96 kPa), high temperature/low humidity “HL” (26.7°C, 29% R.H., VPD=2.48 kPa), and high temperature/high humidity with alternating days of wind “HHW” (27.6°C,

67% R.H., VPD=1.2 kPa, wind=5.2 km/h). These chambers maintained a constant 12:12 (L:D) photoperiod, mimicking conditions in Mississippi during peak activity (March), and observations were made during daylight hours for 3 days (4 for HHW). Mean questing height was 6.03 cm for HH, 4.45 cm for HL, 4.76 cm for LH, and 5.98 cm for HHW (7.22 cm no wind, 4.58 cm wind), with an overall mean questing height of 5.31 cm. Percentage of ticks observed questing was 14.06% for HH, 15.33% for LH, 8.64% for HL, and 12.76% for HHW (13.49% no wind, 12.03% wind) with an overall of 12.70%. Ticks quested significantly higher in HH than HL or LH, specifically on 20 and 30 cm stems, and quested significantly lower on 5 cm stems, suggesting this height was a limiting factor. Ticks quested significantly more often in HH and LH than HL, and selected 5 cm stems most frequently. Ticks exposed to wind quested significantly lower on 20 and 30 cm stems, suggesting a hygro-anemotaxic response. Dark conditions did not significantly affect questing height, and no measured variables significantly affected tick orientation overall. Our data suggests that lower R.H./higher VPD may affect behavior more so than temperature alone.

Development of an Amenable Model for Insect Gene Drive Studies in the Red Flour Beetle, *Tribolium castaneum*. T. van Warmerdam and J. King

CRISPR/Cas9 gene drive systems have the potential to dramatically alter insect populations in a short time period. Because of the inherent risk of unintended release of transgenic organisms, the development of these systems has been delayed. Through exhaustive research in the laboratory, we can ensure the safety of said systems and ameliorate the concern from their potential release. We are currently developing a novel gene drive model in the Red Flour Beetle, *Tribolium castaneum*, with included safety constructs to immediately halt the initial drive. The development of this system will help set precedent for the safety of future gene drives in insects with implications to public health and agriculture. Over the next several years we will gather data on the population dynamics of a gene drive and counter-construct in *T. castaneum.*