

**NCR-148: Illinois State Report**  
**Synopsis of Activities in 2001-2002**  
**State Representatives: Scott Isard, Gail Kampmeier, and Joe Spencer**

**Participants in Movement and Dispersal Research.** Annalisa Ariatti (Geography), Larry Hanks (Entomology), Glen Hartman (USDA-ARS), Houston Hobbs (Crop Sciences), Scott Isard (Geography), Gail Kampmeier (INHS), Eli Levine (INHS), Tim Mabry (Crop Sciences), David Onstad (NRES), Joseph L. Spencer (INHS), and Dave Voegtlin (INHS).

**Cooperators:** Cleo D'Arcy (Crop Sciences), Mark Band (Keck Center), Les Domier (USDA-ARS), Mike Gray (Crop Science), Charlie Helm (INHS), Harris Lewin (Keck Center), Lei Liu (Keck Center), Randy Nelson (Crop Science), Phil Orwick (NSRL), Jose Pardinias (Keck Center), Susan Ratcliffe (Crop Sciences), and Hugh Robertson (Entomology), John Shaw (INHS), Lee Solter (INHS), Kevin Steffey (Crop Sciences), and Loyd Wax (USDA-ARS).

**Highlights of Movement and Dispersal Activities at Illinois.**

- Received funding from the Illinois Council of Food and Agricultural Research (C\_FAR) for "Crop Rotation Collapses as a Pest Management Tool for Western Corn Rootworms: In Search of a Solution." \$1,083,906 for 2000-2003.
- Received funding from the Illinois Soybean Program Operators Board (ISPOB) as part of the Soybean Pathology and Entomology Managed Area for project on insect vectors of bean pod mosaic virus. \$17,000 for 2002-2003.
- Received funding from North Central Pest Management Center for research and extension project "Soybean aphid internet reporting and mapping system." \$10,000 for 2002.
- Received funding from USDA CSREES Critical Issues in Crop Production Grant Program for project "Soybean Aphid Internet Reporting and Mapping System" \$15,000.
- Submitted proposal to North Central Integrated Pest Management Program (NC IPM) "Improving western corn rootworm management in rotated corn" \$79,460 requested over 2 years.
- Submitted proposal to NC IPM Program with Rufus Isaacs (MSU) "Pesticide Reduction in the Face of Japanese Beetle Invasion: Testing a Local IPM Strategy in the Context of Regional Invasion." \$75,000 requested for 2 years.
- Submitted proposal to NC IPM Program with Joe Kovach (OSU) "Multicolored Asian Lady Beetle Predictive Model and Movement Monitoring Program." \$127,383 requested over 2 years.
- Submitted proposal to NRI Grants Program "Behavioral resistance to crop rotation in *Diabrotica virgifera virgifera*: behavior, proximate mechanisms, and genetic differentiation. \$299,865 over 3 years.

**Relevant Publications (2000-2002)**

- Levine, E., J.L. Spencer, S.A. Isard, D.W. Onstad, and M.E. Gray. 2002. Adaptation of the western corn rootworm to crop rotation: evolution of a new strain in response to a management practice. *Amer. Entomol.* 48: 94-107.
- Ginzel, M. D., & L. M. Hanks. 2002. Evaluation of synthetic hydrocarbons for mark-recapture studies on the red milkweed beetle. *J. Chem. Ecol.* 28: 1037-1043.
- Reagel, P. R., M. D. Ginzel, & L. M. Hanks. 2002. Aggregation and mate location in the red milkweed beetle (Coleoptera: Cerambycidae). *J. Insect Behav.* (in press).
- Ginzel, M. D., G. J. Blomquist, J. G. Millar, & L. M. Hanks. 2002. The role of contact pheromones in mate location and recognition in *Xylotrechus colonus*. *J. Chem. Ecol.* (in press).
- Flow of Life in the Atmosphere: An Airscape Approach to Understanding Invasive Organisms. This book written by Scott Isard and Stuart Gage and published by Michigan State University Press, 2001.
- Onstad, D.W., J.L. Spencer, C.A. Guse, E. Levine, and S.A. Isard, 2001. Modeling evolution of behavioral resistance by an insect to crop rotation. *Entomologia Experimentalis et Applicata* 100: 195-201.
- Onstad, D.W., C.A. Guse, J.L. Spencer, E. Levine, and M.E. Gray. 2001. Modeling the adaptation to transgenic corn by western corn rootworm (Coleoptera: Chrysomelidae). *J. Econ. Entomol.* 94: 529-540.
- Hartman, G.L., L. Domier, L.M. Wax, C.G. Helm, D.W. Onstad, J.T. Shaw, L.F. Solter, D. J. Voegtlin, C.J. D'Arcy, M.E. Gray, K. L. Steffey, S.A. Isard, P.L. Orwick, 2001. Occurrence and distribution of *Aphis glycines* on soybeans in Illinois in 2000 and its potential control. *Plant Health Progress*, PHP-2001-02305-01-HN
- Irwin, M.E., W.G. Ruesink, S.A. Isard, and G.E. Kampmeier, 2000. Mitigating epidemics caused by non-persistently transmitted aphid-borne viruses: the role of the pliant environment. *Vector Research* 71: 185-211.
- Isard, S.A., J.L. Spencer, M.A. Nasser, and E. Levine, 2000. Aerial movement of western corn rootworm (Coleoptera: Chrysomelidae): diel periodicity of flight activity in soybean fields. *Environmental Entomology* 29: 226-234.

Soybean Aphid Internet Reporting and Mapping System ([www.pmcenters.org/northcentral/saphid/](http://www.pmcenters.org/northcentral/saphid/))  
Multicolored Asian Lady Beetle Reporting and Mapping System (<http://www.pmcenters.org/northcentral/MALB/>)  
Rotation-Resistant Western Corn Rootworm (<http://www.staff.uiuc.edu/~s-isard/Cornrootworm/>)  
Beetles in Illinois Soybean Fields ([www.staff.uiuc.edu/~s-isard/Beetles/](http://www.staff.uiuc.edu/~s-isard/Beetles/))

## APPENDIX II: TIMOTHY MABRY MASTERS THESIS

### THE EFFECTS OF SOYBEAN HERBIVORY ON THE BEHAVIOR AND ECOLOGY OF THE WESTERN CORN ROOTWORM (*DIABROTICA VIRGIFERA VIRGIFERA* LECONTE) VARIANT

#### ABSTRACT

Adults of the western corn rootworm, *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae) were collected near Urbana, IL (variant population) and were given the opportunity to feed on a soybean, *Glycine max* (L.) Merrill, pre-treatment diet prior to receiving a diet combination of corn, *Zea mays* L.; soybean; and/or only water. In order to determine the relative nutritional quality of the diet combinations, the number of days beetles survived following removal of the diet combinations was recorded. There was no relationship between willingness to feed on soybean pre-treatment and the ability to benefit nutritionally from soybean. Beetles previously feeding on corn, soybean, or only water survived starvation for  $8.3 \pm 0.15$  days,  $5.1 \pm 0.13$  days, and  $3.9 \pm 0.14$  days, respectively. Western corn rootworms can recover from at least two days of starvation or access to only soybean if subsequently given access to corn tissues for two days. Western corn rootworms laid eggs within one day of access to soybean or the onset of starvation.

Adult western corn rootworms flying directly out of a cornfield into a soybean field were captured near Urbana, IL (variant population) with an aerial net and maintained on soybean or only water until death. Of the beetles given access to soybean foliage, only 24% fed within 24 hrs after they were captured flying out of corn. Beetles given access to soybean foliage survived one day longer than insects given only water, but the soybean treatment had no effect on oviposition. Only 20% of beetles laid eggs without the benefit of additional corn consumption prior to death. The greatest proportion of females oviposited on the second and third days after flying out of corn. The mean eggs laid/female/day decreased with the number of days since beetles were captured flying out of corn.

Western corn rootworm larvae were collected near Urbana, IL (variant population) and Monmouth, IL (typical population) and reared to adults in the laboratory. Female beetles from each population were assigned to diet treatment rotations (corn and soybean) of different durations. The effects of diet treatment rotations on beetle survival, feeding, oviposition, and activity were analyzed. Beetles given daily access to corn did not consume corn every day. Among beetles provided with rotated corn and soybean diets, nearly all beetles consumed corn on days following access to only soybean. Oviposition was temporally associated with access to soybean, suggesting dietary stress can induce oviposition. There was no significant difference in the fecundity of beetles given daily access to corn compared with beetles given alternating diets of corn and soybean of different durations. The activity of beetles increased when switched from a diet of corn to soybean, and decreased when switched from soybean to corn. Beetles from the Monmouth population were more active than beetles from the Urbana population. The primary conclusion of this thesis is that soybean is an unsuitable host for the adult western corn rootworm resulting in nutritional stress that induces oviposition, lowers the threshold for feeding, and increases beetle activity.

## APPENDIX III: MANUSCRIPT BY JOE SPENCER, TIM MABRY AND TY VAUGHN USE OF TRANSGENIC PLANTS TO MEASURE INSECT HERBIVORE MOVEMENT SUBMITTED TO JOURNAL OF ECONOMIC ENTOMOLOGY

#### ABSTRACT

During laboratory observations of *Diabrotica virgifera* (LeConte) (Coleoptera: Chrysomelidae; western corn rootworm), beetles consumed corn foliage, pollen, silks or soybean foliage. Feeding was most sustained among beetles fed corn silks. The interval between consumption and appearance of a food item in feces (gut passage time) ranged from  $102.7 \pm 11$  min (mean  $\pm$  SEM) for soybean foliage to  $56.7 \pm 2.9$  min for corn silks. In a laboratory feeding study, protein expression tests identified *D. virgifera* adults that fed on corn plant tissues expressing Cry3Bb protein (Monsanto event MON863). Cry3Bb protein was detectable in *D. virgifera* adults for 16 hours after they fed on MON863 corn silks. The proportion of beetles testing positive for Cry3Bb protein was inversely proportional to the time since last feeding on MON863 tissue. No feeding deterrence or acute mortality were observed among MON863-fed insects. Approximately 20% of adult *D. virgifera* collected from in and around MON863 field plots and an adjacent soybean field tested positive for Cry3Bb protein, indicating that they had eaten

MON863 corn tissues during the last 16 hours. Based on the detection interval for Cry3Bb protein and the distance between MON863 sources and sites where Cry3Bb protein-positive insects were collected, 85.3% of male and female *D. virgifera* moved  $\frac{3}{4}9.1$  m/d through R2-R3 stage corn. Among *D. virgifera* that left corn and were captured in the adjacent soybean field, 86.4% of males and 93.1% of females moved  $\frac{3}{4}9.1$  m/d through soybean. Appropriate refuges for *D. virgifera* in transgenic corn should be narrow, in-field strips. Detection of transgenic plant tissues in the bodies of mobile insect herbivores represents a novel application of biotechnology to the study of insect movement.

#### APPENDIX IV: MANUSCRIPTS ON LONGHORN BEETLE BY LARRY HANKS

**Reigel, P. R., M. D. Ginzel, & L. M. Hanks. 2002. Aggregation and mate location in the red milkweed beetle (Coleoptera: Cerambycidae). J. Insect Behav. (in press).**

We examined behavioral mechanisms underlying aggregation and mate location in the red milkweed beetle, *Tetraopes tetrophthalmus* (Forster) (Coleoptera: Cerambycidae). Larvae of this species feed on rhizomes of common milkweed, *Asclepias syriaca* L., and adults feed on the flowers and foliage, aggregating on individual stems within milkweed patches. Adults preferred to aggregate on milkweeds that had multiple, large inflorescences. Males actively searched for females, often flying between host plants. Mate location did not appear to involve long-range pheromones or vision, but rather males landed on milkweed stems arbitrarily, whether females were present or not. Males remained for longer periods, and so tended to accumulate, on milkweed stems that had female-biased sex ratios. We conclude that aggregation of *T. tetrophthalmus* is cued by host plant characteristics, but dynamically influenced by the sex ratio of conspecifics present on individual stems.

**Ginzel, M. D., & L. M. Hanks. 2002. Evaluation of synthetic hydrocarbons for mark-recapture studies on the red milkweed beetle. J. Chem. Ecol. 28: 1037-1043.**

This study evaluates the potential for using blends of synthetic hydrocarbons in mark-recapture studies of insects. To test the durability of hydrocarbons, we applied a blend of five straight chain hydrocarbons (C24, C25, C26, C28, C30) to detached elytra of the red milkweed beetle, *Tetraopes tetrophthalmus* (Forster) (Coleoptera: Cerambycidae), mounted the elytra on pins, and placed them in an exposed location outdoors. The amount of hydrocarbons on the elytra did not change over time, even after two months of exposure to sun and rain. Synthetic hydrocarbons applied to the elytra of living beetles did not significantly influence their longevity or mating success in a laboratory study, and the amounts of hydrocarbons did not change with age. The invariability of hydrocarbon ratios over time suggests that blends could provide a nearly infinite variety of ratios to uniquely and indelibly mark individual insects with a hydrocarbon "fingerprint". This technique offers a convenient, safe, and durable means of individually marking insects, and may find application in field studies of larger bodied insects that are long-lived and sedentary.

**Ginzel, M. D., G. J. Blomquist, J. G. Millar, & L. M. Hanks. 2002. The role of contact pheromones in mate location and recognition in *Xylotrechus colonus*. J. Chem. Ecol. (in press).**

Adult male and female rustic borers, *Xylotrechus colonus* F. (Coleoptera: Cerambycidae), aggregate on cut logs and fallen trees that are the hosts of their larvae. Our studies show that male *X. colonus* actively search for females, and only respond to them after contacting them with their antennae. Stripping cuticular hydrocarbons from females with solvent rendered them unattractive to males, suggesting that males did not recognize females by mechanoreception alone. Re-applying solvent extract to washed females restored their attractiveness to males, confirming the role of cuticular hydrocarbons in mate recognition. Female cuticular hydrocarbon extracts contain *n*-pentacosane, 9-methylpentacosane, and 3-methylpentacosane, components that were either absent or present in very small amounts on males. We demonstrate that the contact pheromone is a blend of these three cuticular hydrocarbons.

#### APPENDIX V: RESEARCH REPORT

Crop Rotation Collapses as a Pest Management Tool for Western Corn Rootworms: In Search of a Solution

Principal Investigators: Michael Gray – Department of Crop Sciences; Mark Band – Keck Center for Comparative and Functional Genomics; Scott Isard – Department of Geography; Eli Levine – Center for Economic Entomology, Illinois Natural History Survey; Harris Lewin – Biotechnology Center & Keck Center for Comparative & Functional Genomics; Lei Liu – Keck Center for Comparative and Functional Genomics; Paul Mitchell- Texas A&M University; David Onstad – Department of Natural Resources & Environmental Sciences; Jose Pardinas – Keck Center for Comparative and Functional Genomics; Susan T. Ratcliffe – Department of Crop Sciences; Hugh Robertson – Department of Entomology; Joseph Spencer – Center for Economic Entomology, Illinois Natural History Survey

*Natural selection plays the central role in shaping the biological world, yet its glacial pace makes the evolutionary change occurring around us appear all but invisible. Occasionally, exceptional circumstances permit us to witness the process of natural selection. Such circumstances exist today in east central Illinois; the behavior of the western corn rootworm, Diabrotica virgifera virgifera, an important pest of maize is changing under intensive selection by crop rotation circumventing the most cost effective and environmentally benign management tool.*

### **Research Summary for 2002:**

Since the mid-1990s, a variant of the western corn rootworm has compromised the utility of crop rotation as an important pest management tactic for this perennial pest of corn. The variant plagues producers throughout east central Illinois and they have responded by increasing significantly their use of soil insecticides on rotated corn acres. In recent years, reports of first-year corn rootworm injury also have been reported by some growers in more northern Illinois counties such as Kane, Kendall, Lake, and LaSalle. In addition, reports of first-year corn rootworm larval damage also are common in other states such as Indiana and Michigan. Western corn rootworm abundance was monitored in nearly 500 different soybean fields from 101 Illinois counties during the summer of 2002. Based upon sampling data from similar statewide surveys (previous 5 years), there is evidence that the variant western corn rootworm is slowly moving to the north (northeast and northwest). Maps and more complete analyses of these data are available at <http://www.staff.uiuc.edu/~s-isard/Cornrootworm/>. Laboratory behavioral (egg laying and feeding) comparisons of adult western corn rootworms collected from Warren County, IL (variant has not colonized this location) and Champaign County, IL (colonized by variant western corn rootworm) indicates that adults from east central Illinois are no more likely to tolerate or thrive on soybean foliage than adults collected in northwestern counties of the state. In fact, a diet of soybean foliage is very stressful on adults collected from either region of the state. Exposure of western corn rootworm adults to soybean foliage does stimulate rapid egg-laying. Presumably, stressed adult females attempt to void themselves of eggs as quickly as possible. Beetles that consumed mixed diets of corn and soybean tissue produced as many eggs as insects that fed only on corn tissues. This indicates that consuming both corn and soybean may prevent vigor reductions associated with an exclusive soybean diet.

To date, pest management recommendations have primarily relied upon the use of Pherocon AM traps in soybean fields. Because egg laying in soybeans takes place over such a protracted period of time, we have discouraged farmers from applying a broadcast treatment to soybeans to prevent egg laying. We believe this practice would be futile and not cost effective. Our research has shown that both corn and soybean fields serve as suitable egg-laying sites for the western corn rootworm variant in east central Illinois. A common misconception is that western corn rootworms have abandoned corn in east central Illinois as an ovipositional site. This is far from true. In fact, late-planted corn and soybean fields both appear to compete for western corn rootworm eggs.

We have created a set of simple meteorological and behavioral models that can be used to predict the spread of the western corn rootworm variant throughout the Corn Belt. We used data collected in Illinois, Indiana, Michigan, and Ohio to create maps of observations to evaluate our model. We displayed data on these maps by using thresholds of 10 or 20 western corn rootworm adults per 100 sweeps or using capture data with Pherocon AM sticky traps. Densities above a threshold represented populations searching for plants other than corn and likely adapted to the corn and soybean rotation. Landscape diversity was represented by a proportion of non-corn, non-soybean vegetation on farmland in each county. Our models have led us to hypothesize that as the proportion of non-corn, non-soybean vegetation in a region increases, the short-term spread of the variant western corn rootworm decreases.

The expressed sequence tag database portion of our research is nearing completion and we have begun preliminary microarray hybridization assays. Sequencing of the cDNA library has been completed. A total of 20,736 reactions have resulted in 16,797 sequences. Following trimming and filtering, 16,172 sequences were further analyzed. We estimate that 7,000 unique sequences will result from this project. Eventually, we hope to detect gene expression differences in brain tissue of variant western corn rootworm adults (collected from east central Illinois) compared with non-variant adults (collected from northwestern region of Illinois).