North Central Branch

Entomological Society of America

2001 Meeting Abstracts

1 Introduction. **D.B. Hogg**, Dept. of Entomology, Univ. of Wisconsin, Madison, WI 53706

2 The great soybean aphid outbreak of 2000. **J.L. Wedberg**, Dept. of Entomology, Univ. of Wisconsin, Madison, WI 53706

3 *Aphis glycines*: Life cycle and late season field observations in Illinois. **D. Voegtlin**, Center for Biodiversity, Illinois Natural History Survey, Champaign, IL 61820
The soybean aphid has a complex host-alternating life cycle utilizing a woody host on which overwintering eggs are laid and soybean as summer host. In temperate climates, such as the Midwest where the aphid has been found, survival is dependent on the successful migration to and from these primary and secondary hosts. Details and phenology of this life cycle will be covered. Late season observations in Illinois demonstrated the amazing ability of this aphid to disperse. Observations of general and within field distribution show very broad distribution rather than focused concentration of colonies. This pattern is similar to that observed in other pest species such as the green bug and the oat bird-cherry aphid. The implications of this will be discussed.

4 The invasion of the soybean aphid: Perspectives from risk assessment. **R. Venette**, USDA-APHIS & Univ. of Minnesota, St. Paul, MN 55108
Risk assessment, from the perspective of biological invasions, evaluates the likelihood of an exotic organism becoming established in a new geographic area and the consequences of its establishment. Although the presence of soybean aphid (Aphis glycines) in the north central United States has generated much concern, the true risks that this organism poses to agriculture remain to be evaluated formally. Continued spread and establishment of soybean aphid in soybean producing regions will depend greatly on the suitability of the climate. The known distribution of soybean aphid in Asia suggests that this organism might thrive in certain regions of the US while other areas may be less suitable. More northerly, inland states may be too cold and certain southern states may be too warm for populations of the aphid to persist and grow. Identifying those areas that are most likely to experience early and/or severe infestations will allow resources to be more effectively utilized to detect and control populations of the pest. Thus, formal risk assessment is a logical first step to plan the management of exotic pests.

5 Soybeans, viruses and the soybean aphid. **C.R. Grau**, Dept. of Plant Pathology, Univ. of Wisconsin, Madison, WI 53706

6 *Aphis glycines*: Prospects for virus transmission. **S. Halbert**, FDACS/DPI, Gainesville, FL 32614

7 Why *Harmonia* might (or might not) contribute to soybean aphid biocontrol. **W.E. Snyder**, Dept. of Entomology, Washington State Univ, Pullman, WA 99164
There are several reasons that the generalist predator Harmonia axyridis might contribute to soybean aphid biocontrol. In the beetles' favor, H. axyridis feeds on the soybean aphid in Asia, so the beetles are probably genetically pre-disposed to be effective soybean aphid predators. In the laboratory H. axyridis can complete development on a pure diet of soybean aphids. However, these beetles also possess several characteristics that could limit their effectiveness. Harmonia is attracted to larger aphid infestations, and so is unlikely to keep aphids at low enough densities to prevent transmission of aphid-vectored disease. Harmonia is also a fairly aggressive intraguild predator, feeding both on other predators (including conspecifics) and parasitoids, and so could reduce populations of other biocontrol agents. Field experiments would be the best way to begin to unravel the complex direct and indirect pathways through which H. axyridis can impact soybean aphids. To illustrate the complicated ecological role generalists can play, I will discuss several experiments in alfalfa where we manipulated predator densities to examine their contribution to pea aphid biocontrol.

8 Potential Role of Entomopathogenic Fungi in Soybean Aphid Control. **D. Steinkraus**, Dept. of Entomology, Univ. of Arkansas, Fayetteville, AR 72701
Aphis glycines is a new pest of soybeans. Although it was first reported in the U.S. in 2000, already reports of fungal epizootics have been reported from this host. We identified at least 3 species of fungi attacking this aphid from Michigan and Wisconsin. The soybean aphid is also closely related to the cotton aphid. For the past 10 years we have been studying fungal epizootics in the cotton aphid and have developed methods to utilize natural epizootics in cotton IPM programs. An overview of the potential role of entomopathogenic fungi in soybean aphid population dynamics will be presented during this talk.

9 Discussion and Recommendations for 2001. **C. DiFonzo**, Dept. of Entomology, Michigan State Univ., East Lansing, MI 48824

10 Alternative Management of Black Cutworms on Golf Course Putting Greens. **R. Chris Williamson**, 246 Russell Labs 1630 Linden Drive, University of Wisconsin, Madison, WI, 53706
The black cutworm, Agrotis ipsilon (Hufnagel) is considered one of the most important pests of golf course putting greens. Damage to the playing surface results in multiple insecticide applications each growing season. The objective of this research was to determine the effectiveness of peripheral insecticide treatments to areas surrounding golf course putting greens, and not the putting green itself. Six golf course putting greens were selected at a golf course in Southern Wisconsin that are frequently infested with black cutworm. The peripheral area, 10 m from the putting green, (i.e., the high-cut rough) surrounding three putting greens were treated with a conventional, synthetic pyrethroid (i.e., deltamethrin) every 21-28 d. The other three greens did not receive any treatment and served as the control. Each putting green was sampled weekly using a soap disclosing solution to determine larval populations. Peripherally treated putting greens had significantly fewer black cutworm larvae and damage than non treated greens. This black cutworm management approach may reduce the potential risk of exposure to golfers as well as minimize the overall input of pesticides used on golf courses by as much as 30%.

11 Management of High Plains Disease in Western Colorado Sweet Corn. **Robert W. Hammon**, 1910 L Rd, Western Colorado Research, Fruita, CO, 81521
High plains disease affects production of commercial sweet corn and sweet corn grown for seed. Crop risk from the disease can be determined by production system, proximity of alternate hosts, and planting date. Sweet corn grown for seed is in the highest risk category, as resistance to the virus is quite low in many inbreds. Commercial sweet corn and fresh market sweet corn fall into lower risk categories. Hare barley, Hordeum leporinum, was found to be an excellent host for both vector and virus, and its phenology closely matches observed infection of sweet corn. Sweet corn planted adjacent to winter wheat that has already headed was observed have high infection rates of High Plains Disease. Sweet corn planted adjacent to headed wheat had much higher infection rates than that planted adjacent to wheat that had not yet headed in planting date trials. For high risk plantings, elimination of weedy hosts of virus and vector along with chemical control aimed at the vector can reduce the risk. Furadan 4F applied in furrow at planting provided protection from virus infection for three to four weeks. Several inbred sweet corn lines were shown to be resistant to the High Plains Disease virus.

12 Annotations on adult corn rootworm control using commercial insecticides and a cucurbitacin-based adjuvant. **Robert W. Behle**, 1815 N. University St., USDA-ARS, Peoria, IL, 61604-3999
Research concerning area-wide management of the corn rootworm complex (Diabrotica spp.) across the corn belt has renewed interest in the development of baits to target insecticidal control at the adults. As a result, an adjuvant bait containing cucurbitacin, Cidetrak CRW®, has been developed in cooperation with Trece, Inc. (Salinas, CA). Benefits of this adjuvant include: reduced-rate applications of the insecticide, flexibility to select from commercially available insecticides, extended residual activity, and improved control of insecticide-resistant populations. Penncap M® (Elf Atochem, Philadelphia, PA) and Sevin® XLR Plus (Rhone-Poulenc, Research Triangle Park, NC) are two commercial insecticides that show good efficacy when used with Cidetrak. A series of laboratory experiments showed that treatments containing reduced rates of insecticide (1/10 the lowest label rate) with Cidetrak provided efficacious control of Diabrotica virgifera virgifera (LeConte) adults. Reduced rates of Sevin with Cidetrak had extended residual activity compared with similar treatments applied without Cidetrak when exposed to wash-off by rain and degradation by light energy. In general, organophosphate and carbamate insecticides tended to be more effective than pyrethroid-based insecticides when reduced rates were applied with the adjuvant. However, the feeding stimulant tends to improve the efficacy in situations that normally provide marginal control, e.g., when using less effective insecticides or when controlling insecticide resistant beetle populations. If the more effective insecticides (i.e., organophosphates and carbamates) are legislated off the market or resistant beetle populations expand, then use of cucurbitacin-based adjuvants may help to maintain high levels of pest control while using otherwise less effective insecticides

13 Cover cropping as a cultural strategy for reducing sugarbeet root maggot injury in the Red River Valley. **Mark A. Boetel**, Robert J. Dregseth, Allen J. Schroeder, Robert B. Carlson and Gary J. Brewer, 256 Hultz Hall, Department of Entomology, North Dakota State University, Fargo, ND, 58105
Our experiment was initiated in 1996 to assess oat cover crops in combination with soil insecticides as a potential integrated program for controlling sugarbeet root maggot (SBRM), Tetanops myopaeformis (Röder) larvae. Preliminary results demonstrated reduced feeding injury when an oat cover crop was used in combination with chlorpyrifos (Lorsban 15G) or terbufos (Counter 15G) at standard labeled rates (2 and 1.5 lb (AI)/ac, respectively). The project was expanded for 1999 and 2000 to include barley, wheat, rye, and oats. Cover crop seeding rates (0.75, 1.75, and 3 bu/ac) were also compared. Significantly reduced SBRM feeding injury was observed when oat, barley, or rye cover crop plots were used with terbufos at the standard application rate of 1.5 lb (AI)/ac during 1999 and 2000. Plots treated with terbufos at 1.5 lb (AI)/acre in combination with rye or barley at 1.75 bu/acre had statistically lower damage ratings than 0.75 bu counterparts. Rye seeded at 1.75 bu/ac into beets treated with terbufos resulted in lower damage ratings than all other treatments, and barley combined with terbufos was superior to all remaining entries. Interestingly, non-insecticide plots sown with rye at 1.75 bu had significantly lower SBRM feeding injury than no-cover plots that were treated with standard labeled rates of terbufos and chlorpyrifos during 2000. These findings demonstrate beneficial interactions between soil insecticides and cereal cover crops, and offer promise for future integrated SBRM control program development. Future work will focus on refining timing of herbicidal cover crop burn-down to optimize sugarbeet yield and quality.

14 Post-establishment movement and the importance of alternate hosts: addressing data gaps for resistance management of the western corn rootworm. **Bruce E. Hibbard**, 109 Curtis Hall, University of Missouri, USDA-ARS, Columbia, MO, 65211-7020, Thomas L. Clark, 205 Curtis Hall, University of Missouri, Columbia, MO, 65211-7020
If registered, the introduction of transgenic corn will offer a viable alternative to insecticides for managing the western corn rootworm, one of the most economically important pests of corn. Maintaining susceptibility to transgenic crops (resistance management) is in the interest of growers, the Environmental Protection Agency (EPA), and industry, but little is known about many aspects of corn rootworm biology. In 1998, we began a series of experiments to evaluate whether larval movement by the western corn rootworm occurs after initial establishment. In 1998 and 1999 two row spacings and two plant spacings were evaluated with a single infestation level. In 2000, infestation levels of 100, 200, 400, 800, and 1,600 viable eggs on a central plant was evaluated. Movement up to three plants down the row and across a 0.46 m row was clearly documented after initial establishment. In 2000 and a preliminary 1999 experiment, no significant post-establishment larval movement occurred at lower infestations levels. Larvae apparently move when plants are highly damaged and/or when competition for food exists, but the extent that this movement occurs under normal field infestations remains unclear. Another aspect of rootworm biology related to resistance management for which little information is available is the level of importance of alternate hosts in the life cycle of the western corn rootworm. Initial experiments in this area will be discussed.

15 Control of corn rootworm (*Diabrotica* sp.) using seed treatments of clothianidin. **Michael R. Schwarz**, Dean Christie and Chris K. Niebrugge, 8400 Hawthorne Rd., Bayer Corporation, Kansas City, MO, 64120-0013
Clothianidin, a new neonicotinoid insecticide from Bayer Corp. and Gustafson LLC, has been extensively tested as a seed treatment at low rates against major insect pests of corn, canola, and other crops. The compound is highly systemic and enters the transpiration stream through the cotyledons and roots of newly germinating seedlings and through the roots of developed plants. Insects become intoxicated mainly through

ingestion of protected plant tissues. In tests for control of Western, Northern, Southern, and Mexican corn rootworm (Diabrotica spp.), clothianidin demonstrates a consistent reduction of root damage that is comparable to currently registered organophosphate and pyrethroid soil insecticides. In 77 trials conducted from 1997 through 2000 across the corn belt, for example, clothianidin at 1.0 to 2.0 mg ai/kernal gave an average Iowa root damage rating (Iowa 1-6 scale, IRDR) of 2.90 to 2.73, respectively, similar to chlorpyrifos (2.81) and tefluthrin (2.56). Untreated checks averaged an IRDR of 4.27. Only 28% of clothianidin-protected roots gave an IRDR greater than 3.0, a good measure of treatment consistency, and similar to established organophosphate (33%) and pyrethroid (22%) corn soil insecticides. The high relative performance of this seed treatment compared to existing and future soil insecticides will be presented. The excellent fit for this compound in IPM and IRM strategies will also be briefly discussed.

16 Control of corn secondary pests using seed treatments of clothianidin. **Ray Knake**, Gustafson LLC, 1400 Preston Rd., Plano, TX 74120, Michael R. Schwarz and Dean Christie, 8400 Hawthorne Rd., Bayer Corporation, Kansas City, MO, 64120-0013
The neonicotinoid insecticide clothianidin, shows excellent control of most important secondary pests of corn when tested as a seed treatment at rates of 0.125 to 0.5 mg ai/kernal. The compound has good activity against wireworm (Melanotus spp.), seed corn maggot (Hylemyia platura, etc.), flea beetle (Chaetocnema pulicaria), chinch bug (Blissus leucopterus), white grub (Lachnosterna implicita), Southern green stink bug (Nezara viridula), grape colaspis (Colaspis brunnen), and black cutworm (Agrotis ypsilon). Intoxication occurs mainly by ingestion of protected plant tissues. Ingestion of active ingredient causes immediate cessation of feeding and other normal behavior, and eventual mortality. Consequently, evaluations of clothianidin performance must consider the presence of target individuals that are not active and causing further economic damage. Future strategies for IPM and IRM will also be presented.

17 Use of clothianidin as a seed treatment for control of flea beetles in canola. **William G. Hairston**, Ray P . Knake and Randy Scott, Gustafson LLC, Boise, ID
The neonicotinoid insecticide clothianidin, being developed by Gustafson LLC and Bayer Corp., has demonstrated excellent control of flea beetles when applied as a seed treatment to canola. At recommended planting rates of canola very low rates of active ingredient per acre are utilized. Clothianidin has a high level of efficacy while having a very favorable toxicological and environmental fate profile. Field performance and laboratory data demonstrating control of early season flea beetle damage, and effects on germination will be presented. Intoxication occurs mainly by ingestion of protected plant tissues. Ingestion of active ingredient causes immediate cessation of feeding and other normal behavior, and eventually mortality.

18 Gaucho® (Imidacloprid) Corn Seed Treatment for Secondary Soil Insect Control. **John T. Pitts**, Bill Hairston and Ray Knake, 8309 Hammontree Dr, Gustafson LLC, Urbandale, IA, 50322
Gustafson LLC and Bayer Corporation have developed Imidacloprid a new efficacious seed treatment for corn. This chemistry trade named Gaucho, affects insect pests by causing mortality, reducing reproduction, and reducing feeding. Gaucho is applied at a rate of 0.16 mg ai/seed for protection from secondary soil insect pests such as wireworms, seedcorn maggots, imported fire ants and flea beetles. Gaucho provides low odor, low mammalian toxicity, and convenience of handling. Gaucho provides seed corn protection against damage caused by wireworms. At Iowa State University in the year 2000 Gaucho reduced wireworm damage to 29% from 72% in the untreated. In 1999 tests in Missouri wireworm field studies showed reduced damage in Gaucho plots at 2.6%compared to 8.5%in the untreated.

19 Crucifer flea beetle (Coleoptera: Chrysomelidae) feeding injury in conventional vs. no-till canola production systems. **Denise L. Olson** and Janet J. Knodel, North Central Research Extension Center, 5600 Highway 83 S, North Dakota State University, Minot, ND, 58105
The crucifer flea beetle, Phyllotreta cruciferae Goeze, is the most economically important insect pest in canola and represents a major threat to this industry in the canola production centers of North Dakota, and Minnesota. An entire canola crop can be lost to overwintering populations of the crucifer flea beetle feeding on newly emerged canola seedlings during May and June. In response to this rapid destruction by flea beetles, producers plant seed treated with systemic insecticide. Alternative management practices have been researched including plant resistance, biological and cultural controls and the effectiveness of tillage practices on flea beetle population levels. We evaluated crucifer flea beetle feeding injury in conventional vs no-till canola production systems. During the spring of 1998, flea beetle feeding injury was significantly lower (25%) in dormant seeded canola planted under no-till conditions compared to an average of 56% in conventional and 67% in no-till spring planted canola. During the spring of 1999, the adult population was significantly lower and only 3-4% injury occurred in dormant seeded canola, compared to an average of 16% injury in conventional and 17% in no-till spring planted canola. There was no obvious differences in flea beetle feeding injury between the open pollinated and hybrid canola during both years. Both types of canola had less defoliation in the dormant seeded than the spring seeded canola . Sticky traps captured more flea beetles earlier in the dormant and no-till plots first and then the conventional treatment.

20 Site Specific Management of Sugarbeet Root Maggot*, Tetanops myopaeformis* Roder (Diptera: Otitidae) **Ian V. MacRae**, UMN Northwest Research & Outreach Center, 2900 University Ave., University of Minnesota, Crookston, MN, 56716
Sugarbeet root maggot (SBRM), Tetanops myopaeformis Roder, is the principal insect pest of sugarbeets in Minnesota and North Dakota. This insect overwinters as a larvae, pupating and emerging as an adult in the spring. High soil moistures, such as occur in the sugarbeet production areas of MN and ND during the pupation period of this insect, inhibit successful pupation. It was hypothesized that this relationship might be useful in developing site-specific management tactics for SBRM. For two years, commercial fields which had been planted into sugarbeets the previous year have been topographically mapped, and the pattern of successful emergence by adult SBRM recorded. The Geographic Information System (GIS) ArcView was used to interpolate digital surfaces estimating both the topography of the fields and the within field distribution of SBRM emergence. Levels of autocorrelation between specific within-field topographic areas and successful adult SBRM emergence will be demonstrated and management implications discussed.

21 Seed applied insecticide, Prescribe, for control of corn rootworm (*Diabrotica* spp.). **Ray P. Knake** and J. T.. Pitts, 1400 Preston Road, Suite 400, Gustafson LLC, Plano, TX, 75093
Imidacloprid, a highly systemic insecticide, applied to field corn seed at the rate of 1.34 mg/seed has been trademarked as Prescribe, registered with the EPA and is being developed and marketed by Gustafson LLC. Prescribe is applied to the seed by the seed company and is very effective against a number of insects that attack corn from seeding through mid-summer including corn rootworms. Rootworms are controlled by Prescribe in fields with moderate pressure of 4.5 or less on the Iowa 1-6 scale. Rootworm damage has been reduced by 1 to 1.5 points on this scale in most of the trials completed to date. Field performance data and performance relative to competitive soil applied insecticides will be discussed.

22 Evaluation of Naturalyte Insect Control by Spinotor 2SC Against Some Lepidoperan Pests in Egypt**. Janet Y. Kirollos**, Malak F. Gergis and Gomaa M. Khidr, 12 Nawal Street, Dokki. Giza, Plant Protection Research Institute, Cairo ,
European corn borer, Ostrinia nubilalis is a major pest of corn in Egypt. Also, the pink bollworm, Pectinophora gossypiella and the spiny bollworm Earias insulana are major pests of cotton. Studies conducted in 1999 and 2000 showed that application of Spinitor® provided excellent control of these different pests relative to recommended organophoshate or carbamate insecticides. Treatment with Spinotor® at a rate of 20 ml/feddan reduced infestation of O. nubilalis in maize by 75%, whereas Regent®, Fenithione® and Pyrban® reduced infestation by 60, 68 and 52%, respectively. On cotton, the use of Spinotor at a rate of 30 ml/f. reduced infestation of P. gossypiella by 70.3% and A. insulana by 93.6% compared with 58.4 and 60.3% and 74.5; 73.0% reduction, respectively, with the recommended chemical insecticides.

23 Bifenthrin: A New Planting Time Application Label for Control of Corn Rootworms and Other Seedling Insects. **Gail G. Stratman** and **Robert S. Hooten**, 10150 N. Executive Hills Blvd, Suite 520, FMC Ag Products, Kansas City, MO, 64153
Bifenthrin received its first federal label in corn in 1994 for control of foliar insects and mites in six states. In 1999, the labeling was expanded to the rest of the states in the U.S. and included sweet corn and a number of other crops. This wider availability brought a renewed interest in developing bifenthrin for control of insects on seedling corn as well. Over 55 trials were conducted in 1999 and 2000 across 15 corn growing states to evaluate the 2EC formulation of bifenthrin for control of corn rootworms (Diabrotica sp.), cutworms (Agrotis sp.), wireworm (Melantous cribulosus), seedcorn maggot (hylemyia platura), white grubs (Cyclocephala sp.), and other seedling insects. A majority of the data was collected by university and independent contract researchers in small plot replicated trials. 1999 and 2000 data was averaged across the locations and years. Bifenthrin provided rootworm control equal to or better than many of the standard products. The average root rating for bifenthrin was 2.5 on the Iowa 1-6 scale, which was similar to tethfluthrin, terbufos, and fipronil. The average level of damage in the check plot by rootworms was 4.5. In trials where tested, bifenthrin reduced damage by rootworms equal to or less than a 3.0 root rating in over 90% of the trials. In trials for black cutworm, wireworm, seedcorn maggot, and white grub; bifenthrin at 50% of the rate for rootworms, reduced the damage or insect populations equal to or better than currently used products at their full use rates. Bifenthrin provides another option for growers to manage a wide variety of pests with a liquid planting time insecticide.

D24 A Distributional patterns of the Rutelinae (Coleoptera: Scarabaeidae) in Ecuador: A study applying Parsimony Analysis of Endemisity (PAE). **Federico C. Ocampo** and Aura Paucar, W 436 Nebraska Hall, University of Nebraska, Lincoln, NE, 68588-0546.
Research on the Ecuadorian Rutelinae (Scarabaeidae) was conducted to determine the diversity of the group and to examine distributional patterns. Results showed that, in Ecuador, ruteline scarabs are distributed in all zoogeographical zones except the Galapagos. The Rutelines occupy a wide variety of habitats ranging from low land forest to the high Andes. Areas with the greatest diversity of Rutelinae species are the tropical habitats on both sides of the Andes. These areas have the highest level of endemicity. Parsimony Analysis of Endemicity (PAE) is an analytical method that permits to discover distributional patterns and delimit study units in historical biogeography. We used PAUP 4.2 to analyze 283 species Rutelinae of Ecuador in 50 quadrats. The distributional patterns obtained with PAE are useful from a conservation point of view and it can be used as a tool to make decisions in order to preserve areas with the higher level of endemicity.

D25 A Coevolution between a cockroach and its bacterial endosymbiont: A biogeographical perspective. **Jeffrey W. Clark**, 123 W. Waters Hall, Dept. of Entomology, Kansas State University, Manhattan, KS, 66506, Hossain Shoan, Center for molecular medicine and genetics, School of Medicine, Wayne State University, Detroit, MI, 48201, Craig A. Burnside, 100 West College Park Dr., South Georgia College, Douglas, GA, 31533, Srini Kambhampati, 123 W. Waters Hall, Dept. of Entomology, Kansas State university, Manhattan, KS, 66506
Cryptocercus are subsocial, xylophagous cockroaches that live in temperate forests. Like other cockroaches, Cryptocercus harbor endosymbiotic bacteria in their fat bodies. Two species of Cryptocercus occur in the palearctic, one each in eastern Russia and south-central China. In the USA, there are five species: one in the northwest and four in the southeast. Little is known about the relationship between the Eurasian and North American Cryptocercus or the causes of the disjunct distribution. Here, a molecular phylogeny for six of the seven Cryptocercus species and their endosymbionts is employed in an attempt to understand the evolution and biogeography of the genus. Our analysis showed that the North American Cryptocercus are monophyletic, suggesting that a single colonization event was followed by vicariance. There was complete concordance between the host and endosymbiont phylogenetic trees. Divergence estimates based on endosymbiont DNA sequences suggested that the palearctic and nearctic Cryptocercus diverged 70-115 million years (Myr) ago and the eastern- and western-USA species diverged 53-88 Myr ago. These divergence estimates were correlated with biogeographical events, and a hypothesis is presented to explain the current distribution of Cryptocercus. Our findings suggest that Cryptocercus has had a long evolutionary history, dating back to the Jurassic.

D26 B Repellent Activity of Catnip to the American Cockroach, Housefly, and Mosquito. **Erica J. Simbro**, Alexandria S. Ness, and Joel R. Coats, 112 Insectary, Iowa State University, Ames, IA, 50014
Extracts from the herb catnip that are known to repel adult male German cockroaches were tested for repellency against three other species of insects. In the current study extracts were obtained by steam distillation of the catnip and specific isomers of the herb were then removed by thin layer chromatography. American cockroaches (Periplaneta americana), houseflies (Musca domestica), and mosquitoes (Aedes aegypti) were placed in respective choice-test arenas to assess the repellency of these extracts based on time spent on or near treated filter papers.

D27 B Anal And Oral Secretions of the Burying Beetle (*Nicrophorus Marginatus)* Inhibit Bacterial Enzyme Activity. **Jeremy A. Kroemer**, William W. Hoback, Julie J. Shaffer, and Joanne M.Scalzitti, 905 W. 24th Street, University of Nebraska at Kearney, Kearney, NE, 68849
Burying beetles including Nicrophorus marginatus reproduce by burying and preparing small vertebrate carcasses (brood balls) upon which they lay their eggs and rear their young. Maintenance of the brood ball is accomplished through constant covering of the brood ball with substances secreted by the beetles. Brood balls have shown little evidence of microbial decay. We hypothesized that bacteriostatic activity was present in secretions from N. marginatus. We collected oral and anal secretions from N. marginatus and performed a series of biochemical assays to quantify activity and make preliminary characterizations of the substances. Our data demonstrate that a protein within the anal secretions is bacteriostatic and significantly inhibits bacterial ?-galactosidase activity in a dose-dependent manner (maximum inhibition 58%). Treatment of secretions with 10% TCA attenuated the inhibitory activity by 50%. To determine if a protease inhibitor was present, the effects of anal and oral secretions on bacterial subtilisin and proteinase K were examined. Anal secretions increased proteinase K activity by 88% above control, while oral secretions inhibited activity by 76%. Conversely, anal and oral secretions decreased subtilisin activity by 96% and 80% respectively. Finally, electrophoretic data demonstrate that both anal and oral secretions contain a protein that has a

molecular weight similar to serine proteinase inhibitors. These data suggest that some inhibitory activity may be due to serpins: a member of the gene superfamily of serine proteinase inhibitors. The ecological significance is that the presence of serpins in secretions may reduce competition for resources by inhibiting a wide range of bacterial enzymes.

D28 B Synergistic Effects of Two Triazine Herbicides on Toxicity of Chlorpyrifos Associated with Increased Acetylcholinesterase Inhibition in *Chironomus tentans*. Ying Jin-Clark, 123 Waters Hall, Kansas State University, Manhattan, KS, 66506, Michael Lydy, Department of Biological Sciences, Wichita State University, Wichita, KS, 67260, Kun Yan Zhu, 123 Waters Hall, Department of Entomology, Kansas state university, Manhattan, KS, 66506
Toxicities of two triazine herbicides (atrazine and cyanazine) and an organophosphate insecticide (chlorpyrifos) were evaluated individually and in binary combinations using the fourth instars of the aquatic midge, Chironomus tentans. Neither atrazine nor cyanazine alone exhibited significant acute toxicity to the midge. However, atrazine and cyanazine produced significant synergistic effects on the toxicity of chlorpyrifos. Although atrazine and cyanazine were not effective inhibitor of acetylcholinesterase (AChE) in vitro, the synergism of atrazine and cyanazine to chlorpyrifos was associated with increased in vivo inhibition of AChE in the midges. Our results suggest that the synergistic effect of these herbicides on the toxicity of chlorpyrifos may be due to the induction of cytochrome P450 enzymes that facilitate the oxidative activation of chlropyrifos to chlorpyrifos-oxon, a more potent AChE inhibitor .

D29 B Effects of Individual *Bt* Protoxins on Larval Survival and Growth of Kansas Dipel-Resistant and -Susceptible European Corn Borer Strains. **Huarong Li**, 123 Waters Hall, Kansas State University, Manhattan, KS, 66506, Brenda Oppert, 1515 College Avenue, Grain Marketing and Production Research Center, USDA-ARS, Manhattan, KS, 66502, Fangneng Huang, Randall A. Higgins, Lawrent L. Buschman and Kun Yan Zhu, 123 Waters Hall, Kansas State University, Manhattan, KS, 66506
Based on LC50s, Resistance ratios of the Kansas Dipel-resistant European corn borer for Cry1Aa, Cry1Ab, Cry1Ac, Cry2Aa and Cry1B were 105, 203, 3011, 64 and 16, respectively. All five protoxins inhibited larval growth of both Dipel-resistant and -susceptible European corn borer even at low concentrations. Cry1Ca and native E. coli proteins did not cause mortality of either strain. Native E. coli proteins, however, inhibited larval growth of both strains, whereas Cry1Ca appeared to promote larval growth of European corn borer at low concentrations. The regression equations relating larval weights of European corn borer and concentrations of Bt protoxins have been developed.

D30 C Biological Control of Purple Loosestrife (*Lythrum salicaria*) by Larvae of the White-Lined Sphinx Moth (*Hyles lineata*). **Brian C. Peterson**, Rick L. Simonson, Jay Cercle, Anne M. Cummings, Giovanna Diaz and Harold G. Nagel, 905 S. 25th Street, University of Nebraska at Kearney, Kearney, NE, 68849

Purple loosestrife is a rapidly spreading weed that has been listed as noxious in Nebraska as of January, 2001. Biological control of this weed species is currently being developed, however the efficacy of native insect species for biological control of purple loosestrife has not been tested. The purpose of this study was to determine the effectiveness of white-lined sphinx moth larva (Hyles lineata) for controlling populations of the noxious weed purple loosestrife (Lythrum salicaria). Experimental plots were established along the Platte River in south-central Nebraska. Adult H. lineata were collected and placed into screened tents where they laid eggs on purple loosestrife. Three larvae were then added to each experimental plot and the percent defoliation was measured. We found that 2-3 larvae can defoliate a medium-sized purple loosestrife plant within 3 days. Behavioral tests showed that adults which fed on purple loosestrife as larvae preferentially laid their eggs on this plant. Moreover in feeding preference trials, we found the larvae preferred loosestrife over all common Nebraska crop plants which we tested. Our data indicate that predation by birds and parasitism by insects are not significant factors when determining the survival rate of the larvae feeding on purple loosestrife. Sphinx moth pupae are currently being tested to determine if they can survive the over-wintering conditions of the Platte River. Our data suggest the white-lined sphinx moth may be an effective natural biological control organism for purple loosestrife.

D31 C Virulence of the fungus *Metarhizium anisopliae* on sugarbeet root maggot (Diptera: Otitidae) larvae in a laboratory bioassay. **N. B. Jonason**, M. A. Boetel, Department of Entomology, North Dakota State University, Fargo, ND 58105-5346, L. G. Campbell, Northern Crop Science Laboratory, USDA-ARS, Fargo, ND 58105.

Isolates of the entomopathogenic fungus, Metarhizium anisopliae (Metschnikoff) Sorokin have exhibited high levels of virulence to larvae of important dipteran insect pests, including the tsetse fly and the house fly. Also, preliminary investigations have demonstrated infectivity of M. anisopliae with all stages of our target insect, the sugarbeet root maggot (SBRM), Tetanops myopaeformis Röder. However, actual Lethal dose (LD50) and lethal time (LT50) values have not been established. Therefore, our investigation was carried out to determine these values using time-dosage mortality analysis and thereby, estimate the virulence of M. anisopliae to SBRM larvae. Fungi were cultured and a mixture of conidia and hyphae were obtained from the culture. Suspensions were adjusted to achieve concentrations of 1 X 108 conidia per ml of solution (1% polyoxyethylene-sorbitan monooleate), and the following serial dilution treatments were established for bioassays: 1 X 108, 1 X 107, 1 X 106, 1 X 105, 1 X 104, and 1 X 103 per ml. Additional treatments included 1% polyoxyethylene-sorbitan monooleate and water controls. The experiment was arranged in a completely randomized design with eight replications. Treatment applications consisted of drenching larvae (ten 3rd-instars per treatment) and placing them in petri dishes for subsequent mortality assessments. Larval mortality was assessed every 24 h. Cadavers were removed at each assessment and placed individually in petri dishes containing Potato Dextrose Agar to determine if mortality resulted from mycosis. Surviving larvae were allowed to pupate and emerge as adults. Results of bioassays and associated pupation assessments will be presented.

D32 C Differential effects of insect herbivory injury on remaining leaf tissue photosynthesis of post-reproductive common milkweed, *Asclepias syriaca.* **Kevin J. Delaney** and Leon G. Higley, 208 Plant Industry Bldg., Univ. of Nebraska-Lincoln, Lincoln, NE, 68583-0816

When some plants experience leaf consumption herbivory, photosynthetic rates drop in remaining tissue. For many plants, these rate decreases in photosynthesis are temporary and the plants recover. Yet, in the chemically defended species, Asclepias syriaca (common milkweed), rate reductions can last for over one month. Therefore, we choose to examine whether leaf consumption injury by three insect herbivores causes the same photosynthetic rate decreases in remaining tissue of postreproductive common milkweed. Insect herbivores in both studies are the milkweed tussock moth caterpillar, Euchaetes egle, the monarch butterfly caterpillar, Danaus plexippus, but the salt marsh tiger moth caterpillar, Estigmene acrea, is included only in the second study. In the first study, we find that injuries from both herbivores result in statistically significant photosynthetic rate reductions of A. syriaca across several CO2 levels (at one light level), though there is no difference in reduction between herbivores. We also find significant photosynthetic rate reductions across several light levels (at one CO2 level), and detect significantly larger light curve decreases due to D. plexippus vs. E. egle feeding. In a second study, we find that leaf consumption injury to A. syriaca from all three herbivore species result in significant photosynthetic rate decreases of remaining tissue. However, there is no difference in the magnitude of rate decrease between all three species. Our results suggest that two main forms of consumption injury affect photosynthesis in common milkweed leaf tissue, tissue consumption and midrib cutting. Thus, depending on how consumption injury occurs from different insect herbivores influences plant damage responses.

D33 C *Bt* Pollen and Monarch Butterflies: Research Update. **Patricia L. Anderson**, 723 9th St, Iowa State University, Ames, IA, 50010, Richard L. Hellmich, Genetics Laboratory c/o Insectary, Iowa State University, USDA-ARS Corn Insects and Crop Genetics Research Unit, Ames, IA, 50011, John M. Pleasants, Dept. of Zoology and Genetics, 234 Science II, Iowa State University, Ames, IA, 50011, Keith G. Bidne and Leslie C. Lewis, Genetics Laboratory c/o Insectary, Iowa State University, USDA, ARS Corn Insects and Crop Genetics Research Unit, Ames, IA, 50011

Research was conducted during the summers of 1999 and 2000 to determine if Bacillus thuringiensis (Bt) corn pollen presents a toxic risk to monarch butterflies, Danaus plexippus. Preliminary data from 1999 strongly indicate that pollen from Bt corn events MON810 and CBH351 do not influence monarch larval mortality or development at levels normally found near cornfields during pollen shed. With Bt corn event 176, the results were problematic when the pollen was considered only from a toxic view rather than a toxic plus exposure possibility. Weight and survival data indicate that larvae feeding on milkweed leaves with high (~150 grains/cm2) and moderate (~60 grains/cm2) amounts of pollen from the MON810 and CBH351 are not affected. At the very high levels of pollen (~600 grains/cm2) these same larvae were smaller than larvae from the control treatments, but survival was not different from that of the controls. Larvae feeding on leaves with pollen from the 176 type of corn were affected at each of the pollen density levels. Research results from 2000 also will be presented.

D34 C Why does European corn borer oviposit on tall corn? Disentangling plant age, height, and microclimate. **Jason P. Harmon** and David A. Andow, 219 Hodson Hall, 1980 Folwell Ave, University of Minnesota, St. Paul, MN, 55108

European corn borer, Ostrinia nubilalis Hubner (Lepidoptera: Crambidae) will preferentially oviposit on the biggest plant available if given a choice between corn plants in vegetative stages. While this pattern has been observed for 70 years, it remains unclear whether female preference is driven by corn height of development stage. To differentiate between female preference for tall plants and more developed plants, we performed two experiments using pairs of 2m strips of sweet corn, one on a bed of raised soil (25cm) and one on the adjacent ground. In the first experiment, sweet corn was planted on both strips simultaneously so plants were the same age, but had different absolute heights from the ground. In the second, younger plants were placed on the beds and older plants on the ground so they were the same height but different ages. Cages (2x2x2m) were placed over each pair of strips, and female corn borers were released into each cage. We found females preferentially oviposited on taller plants when equal age plants were presented, and on older plants when plants were equal height. The proximate cues used by females may relate more to microclimate than plant stature. Older and taller plants were both warmer than adjacent plants. In laboratory studies we found that female corn borers can detect small-scale heat gradients, and preferentially oviposit in warmer areas.

D35 Heat Tolerance and Physiological Altered Response in Entomobryids (Insecta: Collembola). **Kimberly D. Sturgis**, Stephan J. Diakoff and Richard L. Stewart, Math and Science, 515 25th St. NW, Malone College, Canton, OH, 44709

Sinella curviseta are abundant, widespread insects in the order Collembola. Members of this order exhibit a wide range of temperature tolerance that enables them to survive everywhere on Earth. Recently our investigations have detailed this species' higher temperature lethal limits. These springtails were reared continually at room temperature (approximately 23°C) with ambient light conditions and 100% relative humidity. They were transferred from rearing chambers to test tubes and exposed to varying temperatures in incubators. Their higher lethal temperature (HLT) was 39°C at 53% relative humidity with a two hour exposure. *Sinella curviseta* were subsequently pre-exposed at a lower stressor temperature, 37.5°C, for two hours. They were then placed in normal rearing conditions for approximately twenty-two hours and re-exposed at, or above the unexposed HLT. Altered responses were demonstrated, including survivorship of the pre-exposed group above their HLT. We speculate that a protein may be expressed by S. curviseta while it is being exposed to the stressor temperature or during its recovery period that enables them to survive above their unexposed HLT. Northern Blot Analysis is planned to isolate this protein. We are also investigating longer pre-exposure times at the stressor temperature to evaluate extending hardiness. *Sinella curviseta* are abundant, widespread insects in the order Collembola. Members of this order exhibit a wide range of temperature tolerance that enables them to survive everywhere on Earth. Recently our investigations have detailed this species' higher temperature lethal limits. These springtails were reared continually at room temperature (approximately 23°C) with ambient light conditions and 100% relative humidity. They were transferred from rearing chambers to test tubes and exposed to varying temperatures in incubators. Their higher lethal temperature (HLT) was 39°C at 53% relative humidity with a two hour exposure. *Sinella curviseta* were subsequently pre-exposed at a lower stressor temperature, 37.5°C, for two hours. They were then placed in normal rearing conditions for approximately twenty-two hours and re-exposed at, or above the unexposed HLT. Altered responses were demonstrated, including survivorship of the pre-exposed group above their HLT. We speculate that a protein may be expressed by S. curviseta while it is being exposed to the stressor temperature or during its recovery period that enables them to survive above

their unexposed HLT. Northern Blot Analysis is planned to isolate this protein. We are also investigating longer pre-exposure times at the stressor temperature to evaluate extending hardiness.

D36 C A Predictive Model for Habitat Association of Silphid Beetles Using A GIS Model. **Andrew A. Bishop**, William W. Hoback and Marc Albrecht, 905 S. 25th Street, University of Nebraska at Kearney, Kearney, NE, 68849, Sunil Narumalani, SNRS and CSD, 113 Nebraska Hall, University of Nebraska-Lincoln, Lincoln, NE, 68583
Burying beetles (Coleoptera: Silphidae) depend on vertebrate carcasses to rear their young. Because carcasses are a limited resource with patchy distribution, beetles face intense competition both among themselves and from other scavengers. However despite this competition, communities of greater than10 species continue to co-exist. We hypothesized that different beetle species co-exist by partitioning their niche through association with discrete habitat characteristics. At our study sites in south-central Nebraska, we sampled approximately weekly between March and October using pitfall traps baited with rat carcasses. During our study, we collected 11 species and more than 30,000 silphid beetles. We used geographical information systems (GIS), differentially corrected global positioning systems, and the ARCVIEW program to create a predictive model for each common burying beetle species (total 9species). Our principle model variables were soil type, land management practice, slope, aspect, and elevation. Soil type had the greatest effect with distinct groups of species being collected only in sandy soil, loam soil, or alluvial soil. Land management (irrigated cropland, dry cropland, rangeland, undeveloped) also exerted a large effect on species present. Irrigated cropland had the lowest number of silphids collected while rangeland and undeveloped land had similar numbers of individuals and species. Thus, our findings support niche segregation based on habitat association with modification through land management practice. These results have important implications for the management and possible re-introduction of the Federally Endangered American burying beetle, which had a historical range that included south-central Nebraska.

D37 C Variation in Western Corn Rootworm Egg Hatch Patterns of Selected Nebraska Populations. **Jenny A. Stebbing**, Lance J. Meinke, Blair D. Siegfried, Robert J. Wright and Linda J. Young, Department of Biometry, 103 Miller Hall, University of Nebraska, Lincoln, NE, 68583-0712

D38 C Improved Method for Assaying Transgenic Pollen Effects on *Ostrinia nubilialis* Larva. **Kate T. Kronback** and Patricia L. Anderson, 118 Genetics Laboratory, Iowa State University, Ames, IA, 50011, Richard L. Hellmich, Jeanette M. Dyer and Leslie C. Lewis, Genetics Laboratory c/o Insectary, Iowa State University, USDA, ARS Corn Insects and Crop Genetics, Ames, IA, 50011
There are unanswered questions about the effects of transgenic pollen on European corn borer, Ostrinia nubilalis, (ECB) and non-target Lepidoptera. European corn borer bioassays using pollen thinly spread on agar plates have resulted in high levels of mold and high larval mortality. A new bioassay was designed to feed ECB larvae pollen while minimizing mold growth, using pipette tips, micro-centrifuge vials, agar, and non-absorbent cotton. Mold was virtually eliminated and ECB mortality was reduced. The technique was used to determine the no observable effect level for ECB while feeding on transgenic pollen. Natural degradation was simulated by exposing transgenic pollen to UV light and dew cycles to determine what effect this may have on ECB larval mortality.

D39 C Host Range of the soybean aphid, *Aphis glycines* Matsamura. **Robbie J. Alleman** and David B. Hogg, Room 237 1630 Linden Drive, University of Wisconsin Madison, Madison, WI, 53706
The performance of the soybean aphid, Aphis glycines Matsamura, is being assessed on twelve legumes commonly found in Wisconsin and the Eastern United States. Aphids are being reared on excised trifoliate leaves on agar containing a soluble fertilizer. Parameters that are being measured are initial host acceptance by apterous adults, survival of first generation nymphs, incidence of alate adults produced, and the 4-day fecundity of apterous adults. A host suitability index will be calculated for each of the cultivars tested. Initial observations provide evidence for potential new hosts of this aphid.

D40 C Common Buckthorn as a Primary Host for the Soybean Aphid, *Aphis glycines* Matsumura (Hemiptera: Aphididae). **Bob A. Ellingson** and David B. Hogg, 1630 Linden Dr., 237 Russell Labs, University of Wisconsin-Madison, Madison, WI, 53706
The soybean aphid, Aphis glycines Matsumura, was detected for the first time in the western hemisphere in southern Wisconsin during the summer of 2000. Rhamnus davurica, the primary host plant of the insect in its native range, rarely occurs in the Midwest. Other Rhamnus species, most notably R. cathartica, are quite common in Wisconsin. Laboratory-reared soybean aphids were subjected to decreasing photoperiods, triggering the formation of the aphid's sexual generations which then successfully utilized R. cathartica cuttings as feeding, mating, and oviposition substrates. Preferred oviposition sites were within the crevices surrounding apical buds. Wild-growing R. cathartica near to previous year soybean aphid infestations were sampled at two strata, canopy and near-ground, and examined for aphid eggs. All samples were noteworthy in that they contained significantly fewer aphid eggs than expected. Data indicate that for reasons yet unclear, naturally occurring R. cathartica may be a poor overwintering host for the soybean aphid.

D41 C Multitrophic interactions, and grasshopper impact on prairie plant composition. **Gail Wilson**, David H. Friss, David C. Hartnett, Tim Todd and David Margolies, 124 Waters Hall, Kansas State University, Manhattan, KS, 66506
This study of the community level ecology of grasshoppers in native tallgrass prairie, was conducted in microcosms in a greenhouse. Microcosms contained soil typical of low phosphorus prairie soil. Four species of forbs, varying in mycorrhizal dependence, and 4 grass species, two cool, and two warm season, grass species were used. The study was arranged in a 2x2x2 factorial design, the treatments being presence or absence of grasshoppers, nematodes, and VA mycorrhizae. Mycorrhizae and nematodes were sieved from soil taken from Konza Prairie Biological Station. Mycorrhizae and nematodes are ubiquitous and abundant in grassland ecosystems, and play an important role in regulating plant species composition. Grasshoppers, in the second to third instar caught at Konza Prairie Biological Station were placed in the microcosms. We used Melanopus bivittatus, a large bodied, early emerging generalist feeder. We found that presence of mycorrhizae and grasshoppers significantly affected the relative plant composition in the microcosms, but nematodes did not. The effect of grasshoppers was similar to previous studies employing mechanical clipping.

D42 C Behavior of the saw-toothed grain beetle, *Oryzaephilus surinamensis* L., exposed to consumer food packaging materials. **Sharon V. Mowery**, 810 Pottawatomie Ave., Kansas State University, Manhattan, KS, 66502, Michael A. Mullen and James F. Campbell, 1515 College Ave., USDA/ARS Grain Marketing and Production Research Center, Manhattan, KS, 66502, Alberto B. Broce, 123 Waters Hall, Department of Entomology, Kansas State University, Manhattan, KS, 66503
Packaged consumer food losses due to insect infestation occur in value-added products, meaning those that

have undergone the costs of harvesting, processing, packaging, transportation and storage. Plastic packaging films have been used for some time to protect consumer food products from stored-product insect pests. However, pests can enter packages through minute flaws in packaging materials that result from improper packaging, improper handling, and chewing by other insects. The sawtoothed grain beetle is an important pest that frequently infests many packaged consumer food products. It is able to enter packages through holes less than 1mm in diameter. In this study, the sawtoothed grain beetle responded with an area-concentrated search to food odors that emanated from holes in packaging films, showing that odors escaping through packaging flaws do attract the sawtoothed grain beetle. The responses of the beetles to food odors seeping through the surface porosity of the packaging films were also assessed. The sawtoothed grain beetle can infest food products even if package flaws are too small for adult entry. Through a better understanding of the food-finding ability and mode of entry of insect pests, improved packaging designs can be developed in order to protect consumers from insect infestation.

D43 C Genetic variation among *Beauveria bassiana* ecotypes. **Brad S. Coates**, 111 Genetics Lab, c/o Insectary, Iowa State University, Ames, IA, 50011, Richard L. Hellmich and Leslie C. Lewis, 105 Genetics Lab/Iowa State University, c/o Insectary, USDA-ARS Corn Insects & Crop Genetics Research Unit, Ames, IA, 50011

Genetic divergence between isolates of the entomopathogenic fungus Beauveria bassiana is shown to exists within internal transcribed spacer (ITS) regions and group-Ic introns of the rDNA. Within the study, most isolates infecting Crambids (Lepidoptera:Crambidae)Pyralids (Lepidoptera:Pyralidae) , and Diabrotica species (Coleoptera:Chrysomelidae) were used. DNA sequencing, electrophoresis, and PCR-RFLP assays described haplotype variation within the fungus. Phylogenic relationships among B. bassiana haplotypes were constructed using PCR-RFLP and DNA sequence data, where insect host specialization of the isolate was the strongest determinant of genetic relatedness. Analysis suggest a close genetic similarity between isolates derived from Lepidopteran insect hosts where radiation from a single progenitor isolate have taken place. Isolates from Diabrotica species have lower levels of relatedness, and may have evolved from several ancestral isolates or earlier in evolutionary time.

D44 C Spatial and temporal distribution of corn rootworm beetles and correlations with biotic and abiotic factors. **Yong-Lak Park** and Jon J. Tollefson, 13 Insectary Bldg., Iowa State University, Ames, IA, 50010

When and where to control pests is a key question in site-specific pest management. Interpretation of spatial and temporal data is difficult, however, because pests interact dynamically with their host plant and environment, both spatially and temporally. This study was conducted to better understand the within-field spatial and temporal relationships of corn rootworm beetles and biotic and abiotic factors. A total of 42 agronomic, edaphic, environmental, insect, and geographic variables were sampled and their spatial and temporal distributions were characterized by geostatistics and mapped by GIS. Spatial correlations of beetle counts were detected after corn tasseling that persisted for one month. Total beetle emergence was weakly correlated with corn yield, moderately correlated to root injury, and strongly correlated with beetle counts. If such spatial and temporal correlations are consistent over subsequent years, it would be more economically justified to adopt site-specific pest management.

D45 C Effects of Tillage on Soil Arthropod Fauna in Central South Dakota. **Christopher W. Noble**, 2207A, Ag Hall, South Dakota State University, Brookings, SD, 57006, Paul Johnson and Tom Schumacher, 2140C, Northern Plains Biostress, South Dakota State University, Brookings, SD, 57006
Tillage methods are management practices in central South Dakota field crops that directly influence soil properties and biotic components. Assessing the effect of differing tillage methods on the soil arthropod fauna is the primary objective of this project. Tillage methods were grouped into three treatments (long-term grass [control], no-till, and tilled). Nine sites of differing crops and soil types were selected for replication. At each site the soil fauna was sampled in three fields of the same soil type and represented each management method. Four sub-samples from each field were pooled to make a field sample, each sub-sample included approximately one-liter of soil from at and below the surface. Pitfall traps were used to sample surface-active arthropods. Five sampling trips approximately 21-30 days apart were made during the season.

D46 C Using a desktop scanner to measure leaf injury; quick, cheap and good? **Matthew E. O'Neal**, Douglas A. Landis and Christina DiFonzo, 204 CIPS, Michigan State University, East Lansing, MI, 48824
Using public domain software and a Hewlett Packard desktop scanner (ScanJet 6200C), we have developed a protocol for measuring injury to plant leaves. We analyze a digitized leaf with the NIH Image software and measure area present and estimate area removed from a damaged leaf. We compared the accuracy and precision of our protocol to that of a LI-COR (model # Li-3050A) leaf area meter. Using 10 cm2 and 50 cm2 disks, we measured each 5 times on the both the leaf area meter and the desk top scanner. The mean area and standard error of the mean (+ SEM) estimated by the leaf area meter was slightly more accurate (10.04 + 0.02 cm2 and 50.05 + 0.04 cm2) than the desktop scanner (10.17 + 0.02 cm2 and 50.36 + 0.09 cm2), however the precision was comparable. We further tested the two methods by artificially damaging a soybean leaf (Glycine max), removing 40 holes of a constant size (13 mm2). Mean hole-size (+ SEM, n = 5 scans) estimated was more accurate and precise for the desktop scanner (13.0 + 0.0003 mm2) than the leaf area meter (17.2 + 0.0006 mm2). It is often not possible to compare a damaged leaf to its area before being damaged; a simple leaf area meter is limited in estimating leaf injury. Our protocol can estimate damaged leaves without measuring it before being damaged. Given this, and that the software is free, this method as several advantages over a leaf area meter.

D47 E Bumble Boosters: Doing Science as a Community of Learners. **Douglas A. Golick**, Dr. Marion D. Ellis and Dr. Leon G. Higley, Department of Entomology 208 Plant Industry BLDG., University of Nebraska-Lincoln, Lincoln, NE, 68583-0816
Bumble Boosters is a science education project funded by the Nebraska Lottery's Educational Innovation Fund. The project engages high school students from 40 schools located throughout Nebraska to conduct authentic research on bumble bees. Participating students gain both entomological content and an understanding of the process of scientific investigation. They also gain networking skills by interacting with other schools to address complex issues that they could not solve independently. The project introduces students to World Wide Web-based interactive instructional modules. Students can enter their findings and search the results of other participating schools using the project's online database. Educational project objectives are (1) to raise student and public awareness of the environmental importance of pollinating insects, (2) to increase students' understanding of the process of conducting scientific investigation, (3) to increase students' knowledge of insect biology and pollination ecology, (4) to increase students' abilities to network with other students and project leaders to solve a shared problem, (5) to increase students' abilities to utilize

Web-pages to learn and to share information. In addition to the educational mission of the project, participating schools will make valuable contributions to our knowledge of bumble bee distribution and abundance, attractiveness of artificial nesting domiciles, and floral preferences for individual bumble bee species.

D48 F Effect of *Bt* corn for western corn rootworm *Diabrotica virgifera* LeConte (Coleoptera: Chrysomelidae) control on non-target organisms. **Mohammad A. Al-Deeb** and Gerald E. Wilde, 123 Waters Hall, Department of Entomology, Kansas State University, Manhattan, KS, 66506
The western corn rootworm (WCR) Diabrotica virgifera virgifera LeConte (Coleoptera: Chrysomelidae) is an important pest of corn. The larvae feed on roots and adults on the foliage and silks of corn. Bt transgenic corn for corn rootworm control is not commercially available, but at this time different Bt events are being tested in the field and are reducing damage significantly. The possible effects of rootworm transgenic corn on non-target organisms need to be evaluated. The purpose of this study was to conduct field tests to evaluate the effect of Bt transgenic corn for corn rootworm control on several non-target organisms. A series of field experiments were conducted to determine effects of rootworm transgenic corn on above- and below-ground non-target organisms using pitfall traps and visual inspection. No significant differences in numbers of non-target organism were observed between rootworm transgenic and non-rootworm transgenic corn field plots. Overall, our results show that transgenic corn for corn rootworm control does not have a significant effect on the non-target organisms evaluated.

D49 F Soybean Growth and Yield after Simulated Leaf Injuries. **Rodney A. Madsen**, Thomas E. Hunt and Leon G. Higley, Dept. of Entomology, PI 202 East Campus, University of Nebraska, Lincoln, NE, 68583-0816
The bean leaf beetle Cerotoma trifurcata over winters as an adult and in the spring emerges causing damage to soybean in the early vegetative stages. Later generations feed during the reproductive stages of soybean. Other pests such as the soybean looper and grasshopper also cause damage in the reproductive stages. Because these early and late season injuries routinely co-occur, it is important to understand the consequences of multiple injuries throughout the growing season. A study was conducted at the Haskell Agricultural Lab in Concord, NE in the summer of 2000 that simulated multiple injuries on soybean. A randomized complete block with four replications and six treatments was used. The treatments consisted of a control, seedling defoliation, mid-level defoliation, high-level defoliation, seedling + mid-level defoliation and seedling + high-level defoliation. Target LAI (Leaf Area Index) was used to determine the extent of the mid and high-level defoliations. Preliminary results suggest that all these injuries on yield are indicated through size of canopy leaf area during pod filling.

D50 F Comparison of greenbug tolerant and susceptible hybrids for changes in chlorophyll content and photosynthetic rate. **Nandi J. Nagaraj**, John C. Reese, Mary B. Kirkham, Kenneth D. Kofoid, Leslie R. Campbell, 123 West Waters Hall, Department of Entomology, and Thomas M. Loughin, 101 Dickens Hall, Department of Statistics, Kansas State University, Manhattan, KS, 66506-0802
The effects of greenbug biotype K feeding on chlorophyll content and photosynthetic rate were recorded on resistant (CARGILL 607E) and susceptible (NC 272+) sorghum over a ten-day observation period. Three levels of greenbug infestations of 0, 1 and four days were used to infest an area of 5 cm X 2.5 cm on the newest fully expanded leaves of sorghum plants placed under artificial lights. Immediately after greenbug removal, reduced chlorophyll content and photosynthetic rate were observed in both resistant and susceptible lines. One-day greenbug feeding caused greater drops in susceptible line than the resistant line and recovery was more in the resistant line. However, at high level of four-day feeding damage, chlorophyll content and photosynthetic rate decreased heavily in both resistant and susceptible lines and not much recovery was recorded. Thus CARGILL 607E can physiologically tolerate greenbug damage at low levels of infestation. This data will also be helpful in predicting yield losses once the relationship between photosynthetic rate and yields are well understood.

D51 F Kansas Crop Consultant Adult Sampling Techniques Compared with Sampling Techniques used in the USDA/KSU Rootworm Areawide Management Project. **Christopher A. Daves**, Phillip E . Sloderbeck, Randall A. Higgins and George A. Milliken, D102A DICKENS, Kansas State University, Manhattan, KS, 66506

Crop pest management consultants within the state of Kansas were surveyed to determine the most prevalent sampling techniques and decision-making processes employed in the management of western corn rootworm (WCR, Diabrotica virgifera virgifera). Responses revealed crop consultants sampling adult WCR populations are using several techniques. By far the most common approach involved whole plant counts. Virtually no Kansas consultants reported they were employing sticky- or lure based traps in determining when to trigger insecticide treatments against adult corn rootworms. Information obtained from this survey guided development of a sampling program used to compare current consultant survey techniques with sampling procedures employed by researchers involved with the USDA-sponsored areawide rootworm management project. The study estimates minimum sample sizes and compares treat/no-treat decisions that Kansas crop consultants reach with those generated in the research-oriented areawide management program. The study may reveal whether consultants will need to modify established scouting practices if they were to implement a similar areawide rootworm management program. Gaining this understanding should benefit Extension specialists developing scouting procedures for areawide (vs. field-by-field) management of corn rootworms in Kansas corn fields. This poster also has been updated to correct a error in statistical analysis.

D52 F Presence and significance of Soybean Stem Borer, *Dectes texanus*, in Kansas soybean variety trials. **Michelle Kaczmarek**, Randy Higgins, Phil Sloderbeck, Larry Buschman and William Schapaugh, 2004 Throckmorton Hall, Kansas State University, Manhattan, KS, 66506

During the last two years, K-State and the Kansas Soybean Commission have supported numerous studies on the soybean stem borer (Dectes texanus texanus). The soybean stem borer adult is a small (15mm), gray longhorn beetle that causes insignificant damage by leaf-feeding. It lays eggs on the petioles of mid- to upper canopy leaves. Larvae are small (1.5-15mm), legless, and live entirely within the soybean plant, tunneling extensively within the leaf petiole and downward inside the main stem. When a larva reaches the plant base, it girdles the stem near ground level, increasing the likelihood that the plant will lodge, hence making harvesting much more difficult. At the end of the 2000 growing season, four varietal evaluation trials located in three different counties across the state were sampled. Each replicated trial had been established by researchers in the Agronomy Department and involved between 25 and 45 varieties of soybeans. For each variety and replication, five plants were examined. We recorded the number of plants girdled, number of plants falling over when lightly touched, number of plants a larva present within the stem, and number of plants with obvious signs of tunneling. Thus far, few significant differences among varieties have been detected. If soybean stem borers are present, virtually all varieties examined thus far seem to be affected in a similar manner.

D53 F Microsatellite Markers Linked to Eight Russian Wheat Aphid Resistance Genes in Wheat. **Xuming Liu**, C. Michael Smith and Bikram Gill, 123 Waters Hall, Dept. of Entomology, Kansas State University, Manhattan, KS, 66506, Vicki Tolmay, Republic of South Africa, Small Grains Institute, Bethlehem, SA

The Russian wheat aphid (RWA), Diuraphis noxia (Mordvilko), is a serious economic pest of wheat and barley. In the present study, microsatellite markers linked to RWA-resistant genes were identified using several near-isogenic lines and F2 mapping populations derived from crosses of susceptible wheats and resistant sources. Wheat microsatellite marker Xgwm111, on wheat chromosome 7DS (short arm), is tightly

linked to the Dn1, Dn2, and Dn5 genes, as well as a new gene, Dnx, at distances ranging from 1.5 to 3.8 cM. These Dn genes are located on wheat 7DS, near the centromere, instead of as previously reported on 7DL, and Dn1, Dn2, and Dn5 are allelic genes. The flanking markers Xgwm44 and Xgwm111 are linked to the Dn6 gene in the coupling phase near the centromere on wheat 7DS at 14.6 cM and 3.0 cM, respectively. This is the first report of the chromosomal location of Dn6, which is also either allelic or tightly linked to Dn1, Dn2, and Dn5, in contrast to previous reports that Dn6 was independent of Dn1, Dn2, and Dn5. Xgwm106 and Xgwm337 are linked to the Dn4 gene on wheat 1DS at 7.4 cM and 12.5 cM, respectively. Xgwm635 (wheat 7DS) clearly marked the location of the previously suggested resistance gene Dn8 in PI 294994. Xgwm642 (wheat 1DL) is linked to another new gene Dn9. Genetic linkage maps of Dn genes and markers can be used in wheat breeding programs to identify Dn genes and to select RWA-resistant wheats.

D54 F Genetic Mapping of an *Aegilops tauschii* Gene Transferred to Common Wheat Conferring Resistance to All Strains of Wheat Curl Mite. **Renu Malik** and C. Michael Smith, 123 Waters Hall, Dept. of Entomology, Kansas State University, Manhattan, KS, 66506, Gina L. Brown-Guedira, Throckmorton Hall, Kansas State University, USDA/ARS Plant Science Laboratory, Manhattan, KS, 66506, Kim D. Howell, Throckmorton Hall, Kansas State University, USDA/ARS Plant Science Laboratory, Manhattan, KS, 66506, Tom LL. Harvey, Dept. of Entomology, Agricultural Research Center, Hays, Kansas State University, Hays, KS, 67601

Genetic resistance to wheat curl mite (WCM), Aceria tulipae Keifer, holds great potential in direct and indirect suppression of WCM and wheat streak mosaic virus (WSMV). Here we report mapping of a gene temporarily designated Cmcx in common wheat derived from goatgrass, Aegilops tauschii, that provides resistance to all the six known strains of WCM. Monosomic analyses showed that Cmcx is located on wheat chromosome 6D and is inherited as a single dominant gene. Microsatellite mapping placed Cmcx on the distal end of the short arm of wheat chromosome 6D (6DS) towards the telomere. The microsatellite marker GDM141 is closely linked (4.2 cM) to Cmcx. Our results also show that a small chromosome segment containing Cmcx is terminally translocated from Ae. tauschii to the common wheat germplasm KS96WGRC40. This type of translocation avoids the problem of chromosome linkage drag, and allows free recombination with the centromere and easy removal of any unfavorable trait from the wild species, Ae tauschii. This is the first report of genetic mapping of a WCM (Cmc) resistance gene. Thus, microsatellite marker GDM141 can be used in wheat breeding programs for the selection of lines resistant to wheat curl mite.

D55 F Corn Rootworm Resistant Transgenic Maize and its Impact on Beneficial Insects. **Pete L. Clark**, E. A. Heinrichs and John E. Foster, 312 F Plant Industry Building, University of Nebraska, Lincoln, NE, 68583-0816

Transgenic maize for control of Diabrotica species will be on the commercial market as early as 2002. Our goal was to observe and report any damaging effects such as disease, mortality and reduced abundance of beneficial insects from this trangenic product. The transgenic line and its corresponding isoline were evaluated. Pitfall traps were used to catch beneficial insects. Many orders were observed. A major focus of the study was Collembola and Carabidae. Visual observations were also taken for this 10 week study starting in July 2000.

D56 B Toxicity of Different Insecticide Bait Mixtures to Insecticide Resistant and Susceptible Western Corn Rootworm Populations. **Srinivas Parimi**, Blair D. Siegfried and Lance J. Meinke, 202 Plant Industry Bldg., University of Nebraska, Lincoln, NE, 68583, Laurence D. Chandler, Red River Valley Agricultural Research Center, P.O. Box 5647, USDA-ARS, Fargo, ND, 58105
Insecticide resistant and susceptible populations of Western corn rootworm, Diabrotica virgifera virgifera L., were subjected to adult bioassays with different insecticide-bait mixtures. Four insecticides; methyl parathion, carbaryl, fipronil and indoxcarb were used in this study with Invite EC as a cucurbitacin bait. We observed differences in susceptibility levels between the resistant and susceptible populations with methyl parathion and carbaryl. Susceptibility to fipronil and to indoxcarb was found to be similar between the resistant and susceptible populations. Studies to quantify the amount of insecticide-bait mixture fed upon by the beetles are in progress.

D57 C Geographical variation of *Cotesia sesamiae* and selection for increased resistance against encapsulation. **Marianne Alleyne** and Robert N. Wiedenmann, 607 E. Peabody Dr., Center for Economic Entomology, Illinois Natural History Survey, Champaign, IL, 61801
The suitability of two New World pyralid hosts, *Diatraea saccharalis* and *D. grandiosella*, for development of a South African strain of the Old World braconid *Cotesia sesamiae* was studied. These host-parasitoid combinations were novel associations. The parasitoid strain was collected from *Busseola fusca*, reared for one generation in quarantine on *D. saccharalis*, and subsequent generations were used for these experiments. The results were compared to those obtained previously from similar host suitability studies on a Kenyan strain of *C. sesamiae*. The two strains did not vary in their ability to utilize *D. saccharalis* as a host, even the early generations of the South African strain were able to completely evade the host's immune system. Results also suggest that before release into the field there may be a benefit of rearing a parasitoid species on the target pest first; the total number of parasitoids emerging from the host may increase over the first few generations. However, this benefit may be transient. *D. grandiosella* often encapsulated the progeny of both strains. The severity of encapsulation did not decrease after rearing the South African strain for multiple generations on *Diatraea* hosts. *C. sesamiae* is unlikely to expand habitat preferences an host range beyond what we can study in an experimental setting. However, predictions about the effect of this type of natural enemy on novel association hosts can not made implicitly.

D58 C Dispersal of Northern and Western Corn Rootworms in the South Dakota Areawide Management Site. **Bryan W. French**, 2923 Medary Ave., USDA, ARS, NGIRL, Brookings, SD, 57006, Laurence D.. Chandler, 1307 North 18th Street, USDA, ARS, RRVARC, Fargo, ND, 58105, Dave A. Beck and Debra A. Hartman, 2923 Medary Ave., USDA, ARS, NGIRL, Brookings, SD, 57006
Corn rootworms (CRW) are serious pests of corn in the United States. The larvae feed on the roots and cause injury that can reduce yield. Farmers may soon be able to use Bt corn to control CRW populations. However, resistance among CRW to the Bt toxin could quickly evolve. To reduce resistance evolution, farmers will be required to plant a refuge of non-Bt corn. To keep resistance numbers low, sufficient gene flow among CRW populations must occur from the refugia to the Bt fields. Dispersal is a means by which gene flow occurs among populations. We investigated the dispersal of northern and western CRW within cornfields, and between cornfields and soybean fields in the South Dakota Areawide Management site. We placed Pherocon AM sticky traps at different heights between cornfields and soybean fields. We placed sticky traps horizontally within cornfields above the corn canopy to estimate emigration and immigration. We captured more northern than western CRW, and both were captured at the lowest height between fields. More CRW were captured between continuous (CC) and first year (FY) cornfields than between other combinations of fields. More western CRW were captured flying from soybean to CC than from CC to

soybean. We captured more western CRW flying from FY corn to soybean than from soybean to FY corn. More northern CRW emigrated from cornfields than immigrated into the cornfields, but just the opposite for western CRW. Western CRW numbers were low and may not indicate their migratory behavior into and out of cornfields.

D59 C A comprehensive Odonate survey of Tomlinson Run State Park, West Virginia. **Richard L. Stewart**, Math and Science Department, 515 25th St. NW, Malone College, Canton, OH, 44709, Stephen W. Chordas, 1315 Kinnear Rd., Ohio State University, Columbus, OH, 43212
Dragon and damselflies are interesting predators found throughout aquatic and semi-aquatic habitats throughout tropical and temperate regions of the world. An understanding of their distribution within Ohio and less-so for West Virginia is just beginning. In an effort to better understand the odonate fauna associated with the north-central portion of West Virginia, we collected during the spring, summer, and fall of 1999 and 2000 at Tomlinson Run State Park. Collection was entirely conducted with aerial or sweep nets by the authors. Once collected each odonate was placed in 70% ethanol for identification confirmation and reference. To date 19 species of Anisoptera, representing 5 families and 14 genera; and 20 species of Zygoptera, representing 3 families and 6 genera have been collected. While 39 species have been collected 4 more have been sight identified but remain elusive to collection. Collection will continue until all species of odonates have been represented in the collection. Forty-three species of odonates represents a surprisingly diverse assemblage for such a small region. We plan to continue these collections to gain a better understanding of Odonate diversity and distribution throughout West Virginia.

D60 C Secondary production and energetics of grasshoppers (Orthoptera: Acrididae) in annually burned and long-term unburned tallgrass prairie. **Clinton K. Meyer**, 377 P Plant Science, East Campus, University of Nebraska Lincoln, Lincoln, NE, 68583-0724, Matt R. Whiles, Department of Zoology, Southern Illinois University, Carbondale, IL, 62901, Ralph E. Charlton, Department of Entomology, 123 West Waters, Kansas State University, Manhattan, KS, 66506
The role of grasshoppers in tallgrass prairie energy and nutrient cycling was examined in 1998 and 1999. Abundance, biomass, and secondary production of acridids on Konza Prairie Biological Station, KS were estimated in annually burned and fire-excluded watersheds. A drop trap and suction device were used to intensively sample grasshoppers throughout the growing season. Grasshoppers were identified to species and instar, and categorized as grass- or forb-feeders. Abundance and biomass were integrated to estimate production using the size frequency method, and values for feeding groups were compared between burn treatments. Since burning stimulates grasses and reduces forbs, we hypothesized that grass-feeder production would be higher in burned areas, and forb-feeder production higher in unburned. During both years, there was a trend of higher grass-feeder production in burned watersheds (3.7 g m-2 y-1, 2.6 g m-2 y-1 in 1998 and 1999, respectively) compared to unburned (3.5 g m-2 y-1, and 1.7 g m-2 y-1 in 1998 and 1999). Conversely, forb-feeders had higher production in unburned watersheds (3.0 g m-2 y-1, and 1.7 g m-2 y-1 in 1998 and 1999) compared to burned (2.3 g m-2 y-1, and 1.1 g m-2 y-1 in 1998 and 1999). Based on production estimates and digestive efficiencies, grass-feeders consumed from 3-6% of grass production, and forb-feeders removed from 8-23% of forb production. Estimates of production, consumption, and nitrogen concentrations also indicated that an appreciable amount of N cycled through grasshoppers. Results of this study demonstrate the significance of these ubiquitous insects to tallgrass prairie ecosystem function.

D61 C Biology and behavior of high-flying western corn rootworm beetles. **Joseph L. Spencer**, Natural Resources Bldg., 607 E. Peabody Drive, Center for Economic Entomology, Illinois Natural History Survey, Champaign, IL, 61820-6917, Timothy R. Mabry, AW 101 Turner Hall, 1102 S. Goodwin, Department of Crop Sciences, University of Illinois, Urbana, IL, 61801, Adam Terando and Scott A. Isard, 220 Davenport Hall, 607 S. Matthews, Department of Geography, University of Illinois, Urbana, IL, 61801, Eli Levine, Natural Resources Bldg., 607 E. Peabody Drive, Center for Economic Entomology, Illinois Natural History Survey, Champaign, IL, 61820-6917

Scaffolding towers were used to collect western corn rootworm (Diabrotica virgifera virgifera, WCR) beetles flying at elevations of up to 10 meters above an east central Illinois soybean field. Females predominate in the population flying at 8-10 meters above soybeans, with the majority being newly mated. Physiological measures and behavioral evidence suggest stratification by height is a consequence of significant biological differences among females in WCR populations. In simple tests of beetle movement, WCR collected from highest elevations were significantly more active than beetles flying at ground level or beetles resting in corn.

D62 C A Spatially-Explicit, Stochastic Model Simulating Insect Adaptation to Corn Rootworm-Resistance Traits in Maize. **Nicholas P. Storer** and Thomas Meade, 9330 Zionsville Rd, Dow AgroSciences, Indianapolis, IN, 46268, Paul G. Bystrak and James R. Rouse, 301 Campus Drive, Mycogen Seeds, Huxley, IA, 50124

Over the next few years, transgenic maize hybrids that express novel rootworm-resistance traits are likely to be commercialized. Managing these traits to optimize their durability in the field will be crucial to their success. Here we describe a spatially-explicit stochastic computer model that simulates rootworm adaptation to one such trait. The model is used to investigate which factors in agricultural practices and in the insect biology and genetics have the most important effects on the relative durability of the trait. The model is further used to investigate how spatial heterogeneity in the landscape can affect local and regional adaptation by the pest populations.

D63 C Does Fertilizer Type and Rate Affect Black Cutworm Survivorship and Growth Rate on Creeping Bentgrass. **Allison T. Walston** and Chris Williamson, 1630 Linden Dr. Rm. 246, University of Wisconsin-Madison, Madison, WI, 53706

The black cutworm, Agrotis ipsilon (Hufnagel), is considered a major pest of creeping bentgrass, Agrostis palustris Huds, which is commonly used on golf course putting greens. The objective of this study was to determine the survivorship and growth rate of black cutworm larvae on creeping bentgrass fertilized with synthetic versus organic fertilizers. Urea, a synthetic fertilizer, and Milorganite, an organic fertilizer made of processed sewage sludge, were used to fertilize creeping bentgrass at three different rates: 25.6 kg, 50 kg, and 75.6 kg per hectare (0.5, 1, and 1.5 pounds per 1000 square feet), which represent normal ranges for fertilizer applications. Creeping bentgrass was grown in plastic greenhouse flats and the different fertilizer regimes were applied monthly. Neonate larvae were placed in petri dishes and fed grass clippings every two days. Larvae were kept in growth chambers maintained at 24°C. Survivorship and growth rates of the black cutworm larvae were measured.

D64 C Geostatistical analysis of the small-scale distribution of European corn borer larvae and damage in whorl stage corn**. Robert J. Wright** and T. A. DeVries, P. O. Box 66, Univ. of Nebraska, South Central Research & Extension Center, Clay Center, NE, 68933, Linda J. Young, Dept. of Biometry, University of Nebraska, Lincoln, NE, 68583, Keith J.. Jarvi, 601 E. Benjamin Ave., Univ. of Nebraska, Northeast Research & Extension Center, Norfolk, NE, 68701, R. C. Seymour, Adams County Extension, P. O. Box 30, University of Nebraska, Hastings, NE, 68901

The small-scale spatial distribution of European corn borer, Ostrinia nubilalis Hübner, larvae and damage in whorl stage corn, Zea mays L., was characterized using geostatistics. Spatial distribution of O. nubilalis larval

feeding damage was studied at Clay Center, North Platte, and Concord NE during June-July 1992-1994, and spatial distribution of O. nubilalis larvae and damage was studied at Clay Center in June 1997. Semivariograms were calculated to model the change in spatial correlation with increasing distance between samples. Spatial distribution of larval damage during 1992-1994 was best described using a spherical model. Damage was spatially correlated among plants at distances up to 2.838 m apart. The spatial distribution of larvae in 1997 was best described using an exponential model for 3 of 7 data sets, a spherical model for 1 of 7 data sets and no model fit 3 of 7 data sets. Larvae were spatially correlated among plants at distances up to 3.048 m apart. These data have implications for developing sampling plans for management of O. nubilialis, and for site-specific agriculture.

D65 E An agronomic and economic evaluation of transgenic *Bt* corn **Marlin E. Rice**, 103 Insectary, Iowa State University, Ames, IA, 50011, Clinton D. Pilcher, 1677 80th Street, Monsanto Company, Monmouth, IL, 61462

D66 E Insect problems spreading northward, is it due to weather or reduced tillage? **Phillip E. Sloderbeck**, Randall A. Higgins and Lawrent L. Buschman, 4500 E. Mary St., Kansas State University, Garden City, KS, 67846

Two insects, the southwestern corn borer (Diatraea grandiosella) and the soybean stem borer (Dectes texanus texanus) have apparently been spreading northward in Kansas the last few years. Much of the spread northward of the southwestern corn borer has been attributed to mild winters. The spread of problems associated with the soybean stem borer was not really attributed to any specific cause. However, a factor that may be attributing to the spread of both of these pests could be the increase in adoption of reduced tillage production practices. Both of these pests overwinter in crop residue associated with the base of the plant. No-till or reduced tillage practices leave the bases of plants intact and undisturbed in the soil, thereby providing better protection from winter conditions and allowing for easier adult emergence in the spring. Fall tillage or spring plowing has been shown to reduce spring emergence for both pests. With the significant winter weather that the State has been experiencing this winter it will be interesting to see if populations of these pests decline in northern Kansas during 2001 or if these borers continue to cause serious problems.

D67 E Using Aerial Imagery to Diagnose Defoliation Caused by Various Insect Pests of South Dakota. **David L. Mills** and Michael A. Catangui, 2207 A Ag Hall, South Dakota State University, Brookings , SD, 57007

Soybean plants can be damaged during the growing season by a number of insect pests delaying maturity and reducing yield. Scouting for insect damage is time consuming and costly. Through aerial imagery it may be possible to determine percent defoliation for an entire soybean field. The objective is to determine if aerial imagery may be a valuable tool in the diagnosis of insect damage on soybean during critical stages of growth, flowering and pod fill. In this study five treatments were used to simulate insect defoliation. Defoliation was accomplished by trimming the leaves from each side of the row then the top of the row. The treatments were No treatment (control), 100% (approximately all leaves removed), 50% at pod fill, 50% full bloom, and complete (sprayed). The leaves of each plant were individually scanned using a portable leaf area meter (Licor Li-3000A). Leaf area data was collected from ten plants in each treatment on 7-18-00 and 8-8-00. This data was used to determine percent of the leaf area lost to insect defoliation. Remotely sensed data was collected from two aerial over flights on 07-27-00 and 08-29-00. Four band multispectral images were collected. The field was also scanned on 7-7-00, 7-20-00, and 8-25-00 using a Cropscan Multispectral Radiometer. The results show that artificial defoliation of 38% -90% was detectable in the aerial images. Analysis is currently being conducted on the relationship between the defoliation treatments and pixel values from the remote sensing data and the Cropscan data.

D68 E Relationship of two detoxification enzymes to fluvalinate resistance in varroa mites **Jinquan Wu**, Blair D. Siegfried and Marion D. Ellis, 202 Plant Industries Bldg., University of Nebraska, Lincoln, NE, 68583-0816
Susceptible varroa mites were obtained from a honey bee population in which fluvalinate effectively controlled varroa mites. Resistant mites were from a population in which normal treatments did not result in effective control. Activities of general esterases, glutathione transferases, and cytochrome P450 dependent microsomal oxidases were compared for the resistant and susceptible populations for varroa. There were no significant differences in activity of general esterases or in activity of glutathione transferase using model substrate assays. Activity of microsomal oxidases was not detected in either population. These results indicated that resistance in this population of mites is not related to increased metabolic detoxification.

D69 F In-field Labeling of Western Corn Rootworm Adults Using Soil Applied Rubidium. **Sean Putnam**, Blair D. Siegfried, Lance J. Meinke, Thomas E. Hunt, David C. Gosselin, Edward F. Harvey and Kelli Warren, School of Natural Resource Sciences, University of Nebraska, Lincoln, NE, 68583
The feasibility of labeling of western corn rootworms adults using soil applied Rubidium (Rb) was investigated. Three different Rb concentrations were applied to seedling corn (V6-7) and cultivated into the soil. The plants were then manually infested with rootworm eggs to insure rootworm development and emergence from the treated plants. Emergence cages were placed over Rb treated plants and beetles collected in these traps were analyzed by atomic absorption spectroscopy to determine Rb concentrations. Preliminary analyses indicate a significant increase in Rb concentration at all treatment levels. These results will provide a basis for establishing in-field labeling techniques that may be suitable for mark-recapture experiments designed to measure dispersal of rootworm populations.

D70 F Relative Suitability of Forage Grasses as Over-Summering Hosts for the Russian Wheat Aphid. **Tom L. Harvey**, Agr. Res. Center, Hays, KS 67601, Kansas State University, Hays, KS, 67601, Dean Kindler, 1301 N. Western Road, USDA-ARS, Stillwater, OK, 74075, David Koch, Dept. of Plant Sciences, PO Box 3354, University Station, University of Wyoming, Laramie, WY, 82071, Keith Harmony, Ag. Res. Center, Hays, KS 67601, Kansas State University, Hays, KS, 67601
Forage grasses growing in field plots in Kansas and Wyoming were evaluated for relative suitability as over-summer hosts for the Russian wheat aphid. Aphid numbers varied greatly among grasses and between the two locations. Some of the grasses, especially in Wyoming, may serve to maintain a reservoir of aphids capable of moving into volunteer or early planted wheat.

D71 F Oxidative Responses of Resistant and Susceptible Buffalograsses *to Blissus occiduus* Feeding. **Tiffany M. Heng-Moss**, Fred P. Baxendale and Gautam Sarath, 202 Plant Industry, University of Nebraska, Lincoln, NE, 68583, Xinhi Ni and Sharon Quisenberry, Department of Entomology, Montana State University, Boseman, MT, 59717
Buffalograss, *Buchloe dactyloides* , is receiving considerable attention as an alternative turfgrass species because of its low maintenance requirements and relative freedom from disease and arthropod pests. Recently, however, the chinch bug, Blissus occiduus has emerged as an important insect pest of this native warm-season prairie grass. The deployment of insect-resistant turfgrasses offers an attractive approach for managing chinch bugs and other insect pests associated with buffalograss because it is economical, sustainable, and fits well with buffalograss' low maintenance reduced pesticide input philosophy. This research investigated the role of plant proteins in the defense response of buffalograss to *B. occiduus* . The objectives were two-fold: first, to compare protein content and enzyme activities (i.e., peroxidase and catalase) of

chinch bug resistant and susceptible buffalograsses and second, to analyze extracted proteins by native and denaturing gel electrophoresis to obtain information about protein profiles of resistant and susceptible buffalograsses. The enzyme activity assays and protein profiles suggest that chinch bug feeding may lead to an increased loss in catalase activity in susceptible buffalograsses. In contrast, resistant buffalograsses may be able to tolerate chinch bug feeding by increasing their peroxidase activity. Further research is needed to document the role of these enzymes in the defense response of buffalograss to chinch bug feeding, and to evaluate the potential value of these differences as markers for selecting chinch bug resistant buffalograsses.

D72 F Suitability of cereals and forage grasses as hosts for the rice root aphid. **S. Dean Kindler**, 1301 N. Western Rd., USDA-ARS-PSWRL, Stillwater, OK, 74075-2714, Louis SS. Hesler, 2923 Medary Ave., USDA-ARS-NGIRL, Brookings, SD, 57006, Kevin CeLLIA. Shufran and Norman C. Elliott, 1301 N. Western Rd., USDA-ARS-PSWRL, Stillwater, OK, 74075-2714
Rhopalosiphum rufiabdominalis, the rice root aphid, infests field grasses, wheat, barley, and other cereals. Reproductive studies on this aphid were performed for numerous cereals and forage grasses. Results of these studies indicated that R. rufiabdominalis reproduced best on cereal rye, followed by wheat, barley, and forage grasses.

D73 F The role of canola in the summer migration of green peach aphid, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) in the Red River Valley of the North. **Robert A. Suranyi**, Matthew W. Carroll, David W. Ragsdale, Edward B. Radcliffe and Ian V. MacRae, 219 Hodson Hall, 1980 Folwell Ave., University of Minnesota, Saint Paul, MN, MN 55108
Green peach aphid, Myzus persicae (Sulzer), is the most efficient vector of aphid-transmitted potato viruses. Canola is an important spring host for green peach aphids in the seed potato production area of the Red River Valley of the North. We investigated the population dynamics of green peach aphids on canola using leaf samples and green tile traps. To examine green peach aphid survival on canola following harvest, aphid colonies were collected until the crop was no longer viable. Green peach aphid emigration to potato peaked within 7 days after canola harvest with 12.7 winged green peach aphids per trap. Development of alatae was predominant in the colonies aphids collected on canola after harvest with 62 to 95% of third instars showing wing pad development. Canola retained green leaf tissue for 12 days post-harvest allowing sufficient degree-day accumulation for completion of wing development in surviving nymphs. Thus, canola may play a significant role in the disease cycle of potato viruses.

D74 F Evaluation of Radiometer Monitoring as a Tool for Estimating First Generation European Corn Borer Damage. **Wayne C. Bailey**, 1-87 Agriculture Building, University of Missouri, Columbia, MO, 65211, Bruce Hibbard, University of Missouri, 109 Curtis Hall, USDA-ARS, Midwest Region, Columbia, MO, 65211
In this study a radiometer was used to measure light reflectance from three isolines of field corn damaged at varying levels by European corn borer (ECB) larvae. At present, scouting for egg masses or visual estimates of damage are the best methods available for estimating levels of ECB infestations, but these activities are time consuming, expensive, and not very accurate. Because canopies of field corn damaged by first generation ECB feeding look visually different from non-infested canopies, it was thought that a radiometer may be better able to distinguish between these types of plant canopies. Although reflectance measurements from these canopies were collected at eight different wavelengths, data suggest that differences in plant canopy caused by ECB infestations can not be distinguished using radiometer measurements. It may be that the amount of ECB damaged leaf tissue is masked by the large amount of healthy tissues remaining on most infested plants. Placement of the radiometer above the canopy during monitoring and the row effect of the corn canopy also may have influenced the lack of correlation for these data.

D75 F Evaluation of Grazing and Mechanical Harvest to Manage Potato Leafhopper Populations in Alfalfa. **Terry L. Woods** and Wayne C. Bailey, 1-87 Agriculture Building, University of Missouri, Columbia, MO, 65211
The effect of harvest management on potato leafhopper populations in alfalfa was evaluated using grazing (cattle) and a traditional mechanical method of forage harvest. The grazing treatment was achieved by using forty-six beef cows to remove pure-stand alfalfa forage from research plots. Similarly, forage removal from mechanical harvested treatments was accomplished using a mower/conditioner, forage rake, and hay baler. Potato leafhopper populations were estimated from 10-sweeps per plot using a standard 38cm (15 inch) sweep net. Insect collections were conducted 1 day prior to and ten days after completion of forage removal for harvest 2 and 3. Data from this study indicate that grazed alfalfa plots supported potato leafhopper populations approximately 2 to 8 times greater than mechanically harvested plots. These population differences may be due to the mobility of adult and nymph leafhoppers. Field observations suggest that potato leafhopper adults and nymphs are mobile enough to avoid being eaten by grazing cattle, but are not fast enough to avoid being killed by a fast moving conditioner/mower.

D76 F Characterizing the Impact of *Bt* Corn Pollen on Non-target Lepidopteran Species Using a Risk Assessment Framework. **Jeffrey D. Wolt** and Thomas Meade, 9330 Zionsville Rd., Dow AgroSciences, Indianapolis, IN, 46268, Paul G. Bystrak, 301 Campus Drive, Mycogen Seeds, Huxley, IA, 50124, Robert K. Peterson, 9330 Zionsville Rd., Dow AgroSciences, Indianapolis, IN, 46268
Quantitative risk assessment affords an objective, stepwise approach for assessing ecological risk as a function of exposure and effect. Here, we utilize quantitative exposure and risk assessment methodology to probabilistically evaluate nontarget effects of Bt corn pollen on monarch butterfly larvae, Danaus plexippus. Methodology involving the joint probability of exposure and effect was used. Exposure analysis based on readily available literature showed pollen interception by the host for monarch (milkweed, Asclepias spp.) declined exponentially with distance from the pollen source. Estimates of exposure reflect conservative assumptions regarding quantity of pollen released off-source; the timing of pollen release relative to larval occurrence; and the interception, retention, and activity of Bt pollen occurring on milkweed leaves. Intergenus sensitivity of lepidopteran species was used to conservatively project effect to monarch larvae. When the 90th percentile of intergenera effect (LC50) was used as a conservative estimate of monarch sensitivity to Bt corn pollen for two differently expressed Bt toxins, the joint probability distribution indicated risk to monarch larvae was negligible beyond the near field edge of source corn fields. Subsequent field measurements of pollen distribution and interception by milkweed as well as preliminary effects determinations for monarch exposed to Bt toxin verify this approach. This methodology can be logically extended to analyze risks of plant-expressed toxins to non-target species through a variety of exposure routes.

D77 F Insect Resistance and Grain Yield of Cry1F (TC1507) <1>*Bt*. Corn. **Jon M. Babcock**, 13668 Magic Stallion Dr., Dow AgroSciences, Carmel IN, IN, 46032, James W. Bing and Paul G. Bystrak, 301 Campus Dr., Mycogen Seeds, Huxley, IA, 50124
Cry1F is a newBacillus thuringiensis (Bt) serovar aizawai transgenic corn trait that is being co-developed by Dow AgroSciences LLC, through its affiliate Mycogen Seeds, and Pioneer Hi-Bred International, Inc. Trials were conducted in 2000 to evaluate the insect resistance and grain yield of TC1507 containing elite Mycogen hybrids. Insect resistance to European Corn Borer (ECB, Ostrinia nubilalisHubner), Southwestern corn borer (SWCB, Diatrea grandiosellaDyar), Fall Armyworm (FAW, Spodopera frugiperda J.E.Smith), and Black Cutworm (BCW, Agrotis ipsilonHufnagel) was evaluated in a program of university, private contract, and Dow AgroSciences internal research trials. In all trials, elite hybrids containing the Cry1F event TC1507 were compared to the isogenic non-Bt hybrid. Individual hybrids of varying maturity

were selected for each trial location based on regional maturity optima. Resistance to ECB and SWCB was present at very high levels with virtually no foliar, stalk or ear damage measured. Highly significant differences were present between the non-Bt isogenic treatment and the Cry1F treatments. Resistance to FAW was also present at high levels with foliar injury levels significantly below levels present in the non-Bt isogenic treatment. BCW efficacy was evaluated in artificially infested barrier trials and highly significant levels of resistance to cutting and ultimately loss of stand were measured in the Cry1F treatments compared to the non-Bt isogenic treatment. Mycogen trials designed to evaluate the agronomic characteristics of TC1507 bearing elite hybrids demonstrate that grain yield and quality are equal to or better than that measured in the non-Bt isogenic hybrids.

D78 F Wheat Chromosome Location of Genes Expressing Greenbug Resistance**. C. Michael Smith**, 123 Waters Hall, Dept. of Entomology, Kansas State University, Manhattan, KS, 66506, Michael B. Flinn, Dept. of Biology, Southern Illinois University, Carbondale, IL, Sharon Starkey and Bikram Gill, Dept. of Plant Pathology, Throckmorton Hall, Kansas State University, Manhattan, KS, 66506
Eight genes from various Triticeae express resistance to the greenbug (GB), Schizaphis graminum, (Rondani). We report here the putative identification of molecular markers linked to the Gb3 and Gb6 gene, and a new gene, Gbx, that express tolerance resistance to GB feeding damage. Preliminary genetic linkage map data are also presented for an additional new gene, Gby, from Agropyron elongatum. Microsatellite markers XGWM44 and XGWM111, on wheat chromosome 7DS (short arm) differentially amplify Gb3 (resistant) and Gb0 (susceptible) DNA to reveal putative parental polymorphisms. XGWM33 and XGWM136, on wheat chromosome 1AS, differentially amplify Gb6 and Gb0 DNA similarly. DNA from segregating F2 populations from the cross [Ae. tauschii accession 1675 x 'Wichita'] was isolated and amplified using all known wheat microsatellite PCR primers for the D-genome of wheat. Segregation analyses indicated that XGWM44 was linked to Gbx on wheat 7DS at a distance of 8.8cM. XKSUD2, a sequence tagged site primer on wheat 7AL (long arm) and wheat 7BL, detected a polymorphic locus linked to Gby at a distance of 17.9cM. The wheat 7AL markers XGWM63 and XGWM332 also differentially amplify Gby. An initial genetic linkage map has been constructed for Gb3, Gb6, Gbx, and Gby that will be useful in further investigations for greenbug resistance genes. Additional studies are in progress to determine the degree of linkage of Gb3, Gb6,and Gby to microsatellite markers on wheat chromosomes 1 and 7.

D79 F Efficacy and Yield of *Bt* Corn Infested with Southwestern Corn Borer and Sugarcane Borer in Louisiana. **Boris A. Castro**, Thomas J. Riley, and Billy R. Leonard Dept. of Entomology, Louisiana State University, Baton Rouge, LA, 70803
The efficacies of selected Bt and non-Bt field corn hybrids were evaluated against artificial and natural field infestations of southwestern corn borer (SWCB), *Diatraea grandiosella* Dyar, and sugarcane borer (SCB), *Diatraea saccharalis* F.. The experiments were conducted at the Macon Ridge location of the Louisiana State University Northeast Research Station near Winnsboro, Louisiana during 1999 and 2000. Artificially infested experiments consisted of a split-plot design with 4 repetitions. Seed brands were used as whole plots and corn hybrids as subplots. Seed brands included Pioneer, Garst, and DeKalb seeds. Each subplot consisted of two rows (40 inches apart) and 25 ft in length. Analyses of borer injury to mid-whorl leaves, husk leaves and ear leaf sheath indicate a significant reduction in damage in all Bt corn hybrids compared to non-Bt hybrid isolines. Experiments subjected to natural infestations of SWCB and SCB were designed as a RCB with 5 repetitions. Plots consisted of 16 rows (40 inches apart) and 45 ft in length. Hybrids included Bt corn Pioneer 31B13 and non-Bt corn Pioneer 3223. Incidence and intensity of damage caused by borers were significantly less in the Bt corn hybrid as indicated by low numbers of injured plants per plot, low numbers of holes per plant, and less soil and ear-level lodging in the Bt hybrid compared to the non-Bt hybrid. Significantly greater yields were observed in the Bt corn hybrid compared to the non-Bt corn hybrid isoline when infested with SWCB and SCB.

D80 F Efficacy of CRY1F BT Corn Against The Southwestern Corn Borer and Corn Earworm. **Lawrent L. Buschman**, Phillip E. Sloderbeck and Merle D. Witt, 4500 E. Mary St., K-State SWREC, Kansas State University, Garden City, KS, 67846
A trial was conducted to evaluate the efficacy of a new transgenic event in field corn expressing the cry1F gene against the southwestern corn borer (SWCB), *Diatraea grandiosella* Dyar, and the corn earworm (CEW), *Helicoverpa zea* (Bobbie). The corn seed was supplied by Mycogen Seeds/Dow AgroSciences and was planted at the Southwest Research-Extension Center near Garden City, KS. Three hybrids were evaluated: an experimental hybrid M2395+ with Bt event TC1507 expressing cry1F, a standard non-Bt isoline M2395 and a commercial hybrid P33A14 with Bt event MON810 expressing cry1Ab. The experimental hybrids with event TC1507 and event MON810 reduced first and second generation SWCB damage to almost zero under substantial SWCB pressure. The artificial infestation of first generation SWCB produced a mean Guthrie rating of 8.8 on a scale of 1 to 9 in the standard corn hybrid. The natural infestation of second generation SWCB produced a mean of 34 cm of tunneling in the standard corn hybrid. The transgenic hybrids reduced kernel damage by CEW in the ear tip by about one half. The efficacy of the Cry1F experimental hybrid against SWCB and CEW appeared to be equal to that of the current standard Bt corn hybrids expressing Cry 1Ab.

D81 F Field Efficacy and Determination of High Dose for PS149B1 Protected Corn. **Paul G. Bystrak**, 301 Campus Drive, Mycogen Seeds, Huxley, IA, 50124, Nicholas Storer, 9330 Zionsville Road, Dow AgroSciences, Indianapolis, IN, 46268, James Rouse, 301 Campus Drive, Mycogen Seeds, Huxley, IA, 50124, Thomas Meade, 9330 Zionsville Road, Dow AgroSciences, Indianapolis, IN, 46268, Jim Bing, 301 Campus Drive, Mycogen Seeds, Huxley, IA, 50124, Jonathan Babcock, 13668 Magic Stallion Drive, Dow AgroSciences, Carmel, IN, 46032, Bruce Lang, 301 Campus Drive, Mycogen Seeds, Huxley, IA, 50124
PS149B1 is an unique strain of Bacillus thuringiensis that produces a binary delta endotoxin with activity against corn rootworm larvae. The genes encoding these proteins have been expressed in corn, with the result that the corn is protected against feeding by larval western and northern corn rootworms. In this poster, we present efficacy data showing that a number of events expressing these proteins afford high levels of protection from rootworms, and are capable of meeting the definition of 'high dose' for western corn rootworm as determined by Method 4 of the EPA Scientific Advisory Panel.

D82 F Mating Behavior and Egg Laying Ability of Two Closely Related *Diabrotica* (Chrysomelidae: Coleoptera) Subspecies. **Isaac O. Oyediran**, 202 Plant Industry Building, University of Nebraska-Lincoln, Lincoln, NE, 68583-0816, T L. Clark, Department of Entomology, University of Missouri, Colombia, MO, 65211-76020, L J. Meinke, E A. Heinrichs and J E. Foster, 202 Plant Industry Building, University of Nebraska-Lincoln, Lincoln, NE, 68583-0816
The mating behavior of two subspecies of Diabrotica, Diabrotica undecimpunctata undecimpunctata Mannerheim, the western spotted cucumber beetle (WSCB) and D. undecimpunctata howardi, the southern spotted cucumber beetle (SCB) Barber involved, courtship and mounting, and physical stimulation of the female by the male. 1) Antennal waving was faster in males than in females. WSCB males waved their antennae faster than SCB males (mean antennal waveing ranged between 41 and 69 per 5 minutes). 2) Antennal waving appeared to increase with increase in body weights in WSCB males ($r2 = 0.01$) and it decreased with increase in body weights in SCB ($r2 = 0.12$). 3) WSCB formed more mating pairs than SCB. 4) The time spent in copulation ranged between 1- 4 h, and this did not vary significantly between the WSCB and SCB. 5) Mean body weights differ significantly between the males and females of WSCB and

SCB. The mean body weight for WSCB males was 0.027 mg and 0.025 mg for SCB males. WSCB females had a mean body weight of 0.033 mg and SCB females had a mean weight of 0.029 mg. 8) Egg laying varied significantly between WSCB and SCB females. WSCB laid more eggs than SCB. WSCB females laid a mean number of 350 ± 61 and SCB females laid 140 ± 22 .

D83 F Efficacy of SpinTor 2 SC as a Control Agent Against the Apple Maggot. **Isaac O. Oyediran**, 202 Plant Industry Building, University of Nebraska-Lincoln, Lincoln, NE, 68583-0816, B D. Olson, P. O. Box 753, Dow AgroSciences LLC, Geneva, NY, 14456, E A. Heinrichs and J E. Foster, 202 Plant Industry Building, University of Nebraska-Lincoln, Lincoln, NE, 68583-0816
The efficacy of Spintor 2 SC (spinosad, a fermentation by-product based compound derived from a naturally occurring soil actinomycess bacterium, *Saccharopolyspora spinosa* was tested against the apple maggot *Rhagoletis pomonella* (Walsh). Spintor 2 SC effectively controlled the apple maggots. There was a significant difference in percent punctures reduction, number of egg laid and percent mortality of apple maggots between the control (untreated apples) and Spintor 2 SC. However there was no significant difference between Spintor 2 SC and the popularly used Guthion.

D84 F A five year study: persistence of Decis EC, Deltamethrin SC and Dursban TC in acidic, neutral and alkaline soils under field conditions when used for subterranean termite control. **Raj Shripat K. Saran**, and Shripat T. Kamble, 201 PI, Department of Entomology, University of Nebraska, Lincoln, NE, 68583-0816, Robert W. Davis, Aventis Environmental Science, 2605 Butler National Dr., Aventis Inc, Pflugerville, TX, 78660, James W. Austin, Pari Pachamuthu and No-Joong Park, 201 PI, Department of Entomology, University of Nebraska, Lincoln, NE, 68583-0816
Subterranean termites in the Midwestern region of the United States are commonly controlled in homes/ buildings by creating a continuous termiticide barrier in soil around the foundation. However, data are lacking on persistence of currently registered termiticides in various soils under field conditions. This research was undertaken to evaluate residues of deltamethrin (EC and SC) and chlorpyrifos (Dursban TC) in acidic, neutral and alkaline soils. The field experiment (1994-2000) included Deltamethrin EC (0.125% AI), Deltamethrin SC (0.125% AI) and Dursban TC (1.0% AI). A 1.5 liter of each termiticide was applied to a known quantity of alkaline (sodic-loam, pH 9.1), acidic (silty clay, pH 6.3) and neutral (loam, pH 6.6). Soil samples to determine termiticide residues were taken at 0, 6 month and yearly intervals. Deltamethrin and chlorpyrifos were extracted from soil samples and analyzed by HPLC and GC, respectively. The results indicated that the baseline termiticide data at zero post-treatment interval included: deltamethrin EC at 94, 83, 73 ppm, deltamethrin SC at 136, 96 and 75 ppm, and chlorpyrifos at 589, 445 and 406 ppm in alkaline, acidic and neutral soils. After one year, the residues were: deltamethrin EC at 54, 35, 49 ppm, deltamethrin SC at 20, 41, and 47 ppm, and chlorpyrifos at 13, 13 and 16 ppm in alkaline, acidic and neutral soils. After five years, we detected deltamethrin EC at 18, 19, 17 ppm, deltamethrin SC at 10, 19, and 21 ppm, and chlorpyrifos at 0.5, 1 and 1 ppm in alkaline, acidic and neutral soils.

D85 F Evaluations of green lacewing eggs for control of woody plant pests**. Loretta Mannix**, Whitney Cranshaw, Karen Kramer, Nihat Demeril, Zana Jerovamic and Matthew Camper, Colorado State University, Fort Collins, CO, 80523
Evaluations of methods for applying lacewing eggs to woody landscape plantings and nursery crops, specifically looking at egg survival or adherence after treated with various sticking agents, application of eggs sprayed through a backpack sprayer, and resulting predation of homopteran pests of crops and landscape plantings.

D86 F Detection of white grub damage in turfgrass using remote sensing. **Randy M. Hamilton**, Department of Entomology, 1158 Smith Hall, Purdue University, West Lafayette, IN, 47906
White grubs are the most destructive and economically injurious pests of turfgrasses in the Midwest and eastern United States. Currently the most widely accepted management practice is to annually apply a preventative pesticide without any knowledge of the location or extent of infestation. Preliminary results of a study investigating the use of remote sensing to detect white grub damage in turfgrass are presented along with the implications of this technology on pesticide reduction and site-specific turfgrass management. To test the possibility of using remote sensing to detect grub-induced stress in turfgrass, field and greenhouse plots were established with different levels of grub infestation during the summer and fall of 2000. Field spectrometers were used to precisely measure the visible and infrared light reflected from these plots, on multiple dates. Comparisons of the percent reflectance between treatments on each date were made. In the field, pesticides were used to establish three levels of grub infestation. In the greenhouse, containers of turfgrass were artificially infested with third-instar masked chafer grubs at three levels. The field studies were inconclusive due to low grub densities. The greenhouse study, although preliminary and somewhat inconclusive, does suggest that grub-induced stress may be discernible by remote sensing early enough to facilitate site-specific management. In conjunction with GPS technology, remote sensing of turfgrass stresses could facilitate directed scouting and site-specific management of these pests—ultimately reducing pesticide output.

87 Cutting Edge Research in Insect Taxonomy. **Srini Kambapatti**,
Department of Entomology, Kansas State University, Manhattan, KS 66506

88 Cutting Edge Research in Toxicology. **Blair Siegfried**, Department of Entomology, University of Nebraska, Lincoln, NE 68583
Insect Toxicology in Transition; Challenges and Opportunities. Insect toxicology is a discipline in transition. Traditional insect toxicologists are no longer being trained, and many departments are choosing not to fill positions as they become vacant. As a consequence, the interface between agricultural chemistry and pest management is being lost. However, a number of novel insecticide classes are currently being developed, and there will be a continued need for metabolism and mode of action research that has been a cornerstone of may insect toxicology programs. This is especially true in identification of novel target sites for both synthetic chemical insecticides as well as transgene products that offer enhanced specificity and increased efficacy. Insecticide resistance research still occupies a significant portion of many programs, although the focus of such research has shifted away from mechanism identification to molecular identification of target sites and mutations that confer resistance. Such information is critical to establishing preventative resistance management programs designed to delay the onset of resistance rather than to manage populations that have already become resistant. Insect populations and invertebrate communities also provide a tremendous source of information relating to ecosystem health. The response of these organisms at the molecular, biochemical and population levels can be an important indicator of the presence of contaminants and environmental impact.

89 Cutting Edge Research in Insect Physiology. **Louis Bjostad**, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523

90 Cutting Edge Research in Insect Genetics. **William Black**, Department of Microbiology, Colorado State University, Fort Collins, CO 80523

91 Cutting Edge Research in Insect-Host Plant Interaction. **C. Michael Smith**, Department of Entomology, Kansas State University, Manhattan, KS 66506

Cutting edge technologies used to develop arthropod resistant plants presently include molecular markers and bioinformatics tools to identify, map, and understand the function of plant genes expressing resistance. In addition to conventional plant genes under study, transgenes from the bacteria, *Bacillus thuringiensis* (Bt), which encode delta - endotoxin insecticidal proteins, are now expressed in cotton, maize, and potato cultivars. Although controversial, Bt crops are currently marketed and produced in Asia, Australia, Europe, and the U. S. Other proteins toxic to arthropods have been identified and transgenes encoding several of these inhibitors have been used to transform plants expressing insect resistance. Conventional genes and transgenes have been combined for enhanced and more stable insect resistance in cotton, maize and rice.

Molecular markers have been used to map insect resistance genes in several crops. Nevertheless, only one plant gene, the *Meu-1* gene of wild tomato, *Lycopersicon peruvianum,* expressing resistance to the potato aphid, *Macrosiphum euphorbiae*, has been sequenced. Bioinformatic computational tools to analyze, interpret, and utilize huge amounts of data being generated by genomic research on several major crop plants have already provided genetic maps, physical maps, and EST (expressed sequence tag) cDNA libraries of crop plant genes. Future insect resistance gene cloning and sequence determination will likely proceed via the use of plant comparative functional genomics studies involving genomic information from resistance gene analogs (RGAs) and defense response (DR) genes.

92 Cutting Edge Research in Biocontrol. **Robert Wiedenmann**, Center for Economic Entomology, Illinois Natural History Survey, Champaign, IL 61820

Biological control has always been a mixture of art and science, and has been largely successful with that mix. However, more-recent advances in biological control have required the need for greater focus on science. Research that encompasses taxonomy, ecology, biogeography and physiology both has been and will continue to be on the leading edge of developing greater predictability and safety for biological control. Two other research areas that will play a greater role in the near future are economic analyses and long-term community ecology studies, to document the true cost:benefit ratios of projects, and assure minimal impact on non-target species.

93 Cutting Edge Research in Chemical Ecology/Pheromone Biology. **Kenneth Haynes**, Department of Entomology, University of Kentucky, Lexington, KY 40546

For several decades research in chemical ecology has been driven by the pursuit of the identities of the chemical signals and cues that mediate interactions amongst organisms. The cutting edge of the field has been the development of sophisticated techniques for isolating and identifying the compounds. These identifications have been particularly demanding because microscale chemical approaches are often required, and these techniques have to be reinvented due to the unique biological characteristics of each interaction. Equally demanding has been the development of appropriate bioassays that are simple enough to be practical, but realistic enough to be biologically meaningful. Because of the diverse nature of these biological interactions, the development of an appropriate union between biology and chemistry will always be at a cutting edge of chemical ecology. The maturation of chemical ecology has opened many new fronts of research, each with a legitimate claim to being at the cutting edge of the field. Examples can be drawn from each of the areas represented in this symposium, and in particular at the union between these areas. At the interface between insect taxonomy and genetics, we have started to address issues of how pheromone signaling originated and how it diversifies as a part of the speciation process. Within toxicology and insect-plant interactions, important issues of how insects deal with toxins in their plants, and whether these relationships are co-evolving are questions that are still at a leading edge of chemical ecology. In insect physiology and molecular entomology, regulation of pheromone biosynthesis at the signaling side of communication, and signal processing at the receiving end are hot topics with the potential for big payoffs for the manage-

ment of insect pests. Within the union of biological control with many of these other areas, the example of plants signaling to parasitoids that they are under herbivore attack promises to be a stimulus for a new perspective on tritrophic interactions. The cutting edges of chemical ecology have diversified as this field of study has borrowed from and contributed to many other disciplines, but the base of this field is still anchored by chemistry and natural history, and these ancestors of the field still have much to contribute.

94 Cutting Edge Research in Molecular Entomology. **Carolina Barillas-Mury**, Department of Pathology, Colorado State University, Fort Collins, CO 80523

95 C Carcass Burial and Preparation by Burying Beetles Differentially Reduces Carcass Discovery by Four Genera of Silphidae. **Richard A. Thaden**, Andrew A.. Bishop and William W. Hoback, 905 S. 24th Street, University of Nebraska, Kearney, NE, 68849

Carrion beetles in the subfamily Nicrophorinae are unique in burying and preparing carcasses of vertebrate animals on which they rear their young. Although the burial process has been hypothesized to reduce competition from other silphids, experimental results have been mixed and no test has examined the effects of preparation on response by Nicrophorinae and Silphinae subfamilies. We tested the effects of carcass size, carcass burial, and carcass preparation on attractiveness to four genera of carrion beetles using two different study sites in south-central Nebraska. Using a moat-style trap, the effects of carcass size on the ability of Nicrophorus pairs to successfully bury carcasses was tested. When carcasses were large for parental beetles, response to traps was similar between experimental and control traps. Silphinae rapidly found unburied carcasses, however carcasses which were buried by parental beetles or by hand were rarely discovered. In contrast, hand burial of carcasses did not reduce response by Nicrophorinae. Two days of parental preparation of appropriately sized carcasses significantly reduced response by Nicrophorus beetles for a period of at least three days after removal of parental beetles. A hypothesized brood parasite, Nicrophorus pustulatus was only collected from parental carcasses suggesting that it responds to odors from parental secretions. These results support the hypothesis that both carcass burial and preparation are important strategies used by burying beetles to reduce competition. Our results may explain niche partitioning based on carcass size because of the inability of beetles to bury and prepare an inappropriately sized carcass.

96 A Generic Boundaries Among Asian Apistomyiini (Diptera: Blephariceridae: Blephariceridae) Based on Morphology of the Immature Stages. **Joel F. Gibson** and Gregory W. Courtney, Rm. 404, Science II, Iowa State University, Ames, IA, 50011

Flies of the family Blephariceridae display a unique biology among the Diptera. The immature stages are inhabitants of fast-flowing streams and waterfalls. Generic classification of the Tribe Apistomyiini has been hampered by a lack of specimens of all life stages from all genera. Asian representatives of this tribe include the Sri Lankan endemic Hammatorrhina, the "Himalayan" genus Horaia, and the widespread Asian and Australasian genus Apistomyia. Earlier hypotheses have suggested a close relationship between Apistomyia and Hammatorrhina with Horaia well removed within the tribe and more closely allied with the Australasian genus Austrocurupira. These conclusions have been based mostly on the morphology of the adults. Larval mouthparts, particularly the maxillary palpi, indicate a close, possibly sister-group, relationship between Apistomyia and Horaia, with Hammatorrhina also being closely related. Specimens from the mountains of Nepal and Northern Thailand appear to share characteristics of both Apistomyia and Horaia. These "intermediate" forms, which comprise multiple species, have not been described or assigned generic classification. There exists a lack of complete, detailed descriptions of all life stages of any of the Apistomyiini. Using scanning electron and light- micrography, complete descriptions of the immature stages of exemplary Apistomyia and Horaia have been created. Preliminary analyses of these morphological data indicate a close phylogenetic relationship between Apistomyia and Horaia.

97 C Reproductive Hosts of the Chinch Bug, *Blissus occiduus.* **Thomas E. Eickhoff**, Frederick P. Baxendale and Terrance P. Riordan, 202 Plant Industry Bldg., University Nebraska-Lincoln, Lincoln, NE, 68583-0816
Blissus occiduus is an important pest of buffalograss turf and potentially other crop and non-crop grasses. Ten late instar B. occiduus were caged on selected turfgrass, weed, and grass hosts in the greenhouse. Production of chinch bug offspring served to identify reproductive hosts. Buffalograss plants were killed by B. occiduus before offspring could be produced. Plants that produced high to moderate numbers of offspring were wheat (mean chinch bugs= 46.4), green foxtail (mean chinch bugs= 21.0), sorghum (mean chinch bugs= 19.5), rye (mean chinch bugs= 18.4), yellow foxtail (mean chinch bugs= 14.3) and barley (mean chinch bugs= 12.5). Plants producing relatively few offspring included: zoysiagrass (mean chinch bugs= 6.3), tall fescue (mean chinch bugs= 2.7), Kentucky bluegrass (mean chinch bugs= 2.2) and bentgrass (mean chinch bugs= 1.8), large crabgrass (mean chinch bugs= 0.2). No reproduction occurred on, perennial rye, fine fescue, fall panicum, bermudagrass and St. Augustinegrass.

98 C Hunger-induced activity: A partial model for how WCR adults move between suitable and unsuitable hosts. **Timothy R. Mabry**, AW 101 Turner Hall, 1102 South Goodwin Avenue, Department of Crop Sciences, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, Joseph L. Spencer, 607 E. Peabody Dr., Center for Economic Entomology, Illinois Natural History Survey, Champaign, IL, 61820, Scott A. Isard, 220 Davenport Hall, 607 S. Mathews St., Department of Geography, University of Illinois at Urbana-Champaign, Urbana, IL, 61801, Eli Levine, 607 E. Peabody Dr., Center for Economic Entomology, Illinois Natural History Survey, Champaign, IL, 61820
Historically throughout the Cornbelt, adult western corn rootworms (WCR) were rarely found outside of cornfields in large numbers. Today, over a large portion of the eastern Corn belt WCR adults are abundant outside of corn in crops such as soybean and alfalfa where they lay eggs and feed. WCR adults cannot survive on a diet of soybean: starvation assays revealed that feeding solely on soybean tissues is nearly equivalent to not eating at all. To avoid succumbing to starvation, WCR found in soybean fields must frequently return to corn to feed. Within as little as 6 hours of not eating, both activity levels and adult WCR responsiveness to corn odors increase. These data along with field observations allow development of a conceptual model for how adult WCR diet drives the WCR return to corn before the beetles starve in soybean fields. How this "partial" model fits in with hypotheses regarding the overall movement of WCR adults between corn and soybean fields will be discussed.

99 C Effects of Grazing Strategy on Invertebrate Diversity in Riparian Meadows of South-Central Nebraska. **Justin R. Krahulik** and William W. Hoback, Dept. of Biology, 905 West 25th Street, University of Nebraska at Kearney, Kearney, NE, 69949, Craig A. Davis, Whooping Crane Maintenance Trust, Inc., Wood River, NE, 68883, Jane E. Austin, USGS- Biological Resources Division, Northern Prairie Wildlife Research Center, Jamestown, ND, 58401
Documenting the effects of cattle grazing on the plant community of managed grasslands continues to be highly debated among range managers. However the effects of different grazing regimens on invertebrate diversity and abundance has received less attention. We assessed the impacts of different grazing management strategies on grassland arthropod communities along the Platte River in south-central Nebraska. We used pitfall traps to compare arthropod diversity and abundance during four sampling periods in 1999 between sites that were grazed continuously, alternated between grazing and idling, and idled continuously. Pitfall traps consisted of arrays (N= 15 per site, 8 sites) of four 475 ml cups with 0.3 meters of drift fencing placed between them and were opened for a 48 h period during each sampling period. Captured arthropods (N = 23,681) were identified to family (N = 104) and family-level Shannon and Simpson diversity indices for each of four guilds (predators, herbivores, detritivores, and mixed-feeders) were

calculated. Continuously grazed sites had the highest diversity (4.90) of herbivores, alternatively grazed had the highest diversity of detritivores, and idled sites had the highest diversity of predators (2.54) and mixed-feeders (2.33). Idled fields had significantly more spiders, carabids, ants, and isopods. Although grazing slightly increased overall diversity, the reduction in predators relative to idled fields suggests that idling can be an important management tool for enhancing arthropod diversity and potential biological control in managed grasslands.

100 F Within field distribution of sunflower midge using GIS. **Erin W. Hodgson**, 202 Hultz Hall, North Dakota State University, Fargo, ND, 58103, Ian V. MacRae, Room 111 - NW Experimental Station, 2900 University Ave., University of Minnesota, Crookston, MN, 56716, Gary J. Brewer, 202 Hultz Hall, North Dakota State University, Fargo, ND, 58103

Sunflower midge (SFM) larvae infest sunflower heads when plants enter early reproductive stages and heavy infestations result in decreased seed production. The within field distribution of sunflower midge is not known. Objectives were 1) to describe the spatial distribution of sunflower midge using Geographic Information Systems (GIS) and Global Positioning Systems (GPS), and 2) use regression analysis to attain a better estimate for combining eggs and larvae for population densities. Stratification of a systematic sampling method was done by superimposing a non-equal sized grid pattern on a 200 acre commercial sunflower field. Sixty four sampling points were plotted and each point had specific coordinates marked with the Ashtech BRG2 (Magellan, Santa Clara, CA), a differentially corrected GPS unit. Four randomly selected sunflower heads were collected from each point, three times per week for thirteen collection dates. Population densities of larvae and eggs were recorded and averaged for each collection date. Cumulative insect days were calculated and data were analyzed by using ArcView (ESRI, Redlands, CA), a spatial analyst program. Infestation started in the southwest corner and along the north-central field margin. These areas continued to have the highest populations, but eventually the infestation developed across the field with time. Sunflower midge density was lowest in the center of the field with higher density areas along the margins. Damage ratings taken at the end of the growing season were related to population densities.

101 F Effect of stalk strength, as measured by rind penetrometer resistance, on ECB damage and yield. **Sheri A. Martin**, Bruce E. Hibbard and Larry L. Darrah, 110 Curtis, University of Missouri-Columbia, Columbia, MO, 65211

Corn (Zea mays L.) is a major commodity in the world. A major pest of corn is the European corn borer (ECB), Ostrinia nubilalis Hübner. Yield can be decreased due to a number of factors including stalk lodging and a few major insects. Increased rind penetrometer resistance has been shown to decrease stalk lodging by increasing stalk strength. For this experiment, we looked at whether and how rind penetrometer resistance affects ECB feeding, both first and second generations, yield, leaf toughness, and rind penetrometer measurements. Selections of cycles 0, 3, 6, 9, and 12 were used in the low (decreased stalk strength) and high (increased stalk strength) directions for genotype MoSCSSS. This genotype has been selected for stalk strength using rind penetrometer measurements. Three replications, at each of six locations throughout central Missouri, were sampled in the summer of 2000. The cycles of selection were evaluated for first generation ECB damage using the Guthrie 9-point scale for field damage, and for second generation by counting of numbers and lengths of tunnels in the stalks. The damage was also compared to yield results to see if selection for increased or decreased stalk strength is correlated with higher or lower yield, respectively. Preliminary results show differences in first and second generation ECB damage between some cycles of selection, as well as yield differences between high and low cycles. Increases in stalk strength may make the plant less desirable to ECB larvae because of the thicker rind and also helps retain grain yields by reducing stalk lodging and breakage.

102 F Flight Behavior of Female Western Corn Rootworm Beetles Feeding on Transgenic Corn. **Ted A. Wilson** and Jon J. Tollefson, 14 Insectary, Iowa State University, Ames, IA, 50011

The movement of adult western corn rootworms, Diabrotica virgifera virgifera, that have survived on transgenic plants is an important component of a resistance management program if a refuge is used to ensure susceptible beetles are maintained in the population. The objectives of this study were to evaluate the dispersal potential of female western corn rootworms surviving as larvae on the roots or as adults exposed to the leaves or silk of transgenic plants. Monsanto transgenic plants evaluated have genes inserted into them that code for the production of Bacillus thuringiensis (Cry3Bb) protein. Beetles were collected from emergence cages placed over a transgenic corn plant cut off at ground level. Additionally, beetles were collected in emergence cages on non-transgenic plants and caged in mesh bags over the silk or leaves of transgenic plants for 5 days. Female beetles from both experiments were flown on a tethered flight mill for 24 hours. Preliminary results indicate few differences between the flight characteristics of beetles surviving as adult or larvae on transgenic corn as compared to non-transgenic corn or corn treated with Counter 20 CR applied in a T-band. Beetles from a transgenic event did fly significantly longer sustained flights (>20 minutes) than other treatments. Beetles caged on leaves of transgenic events had significantly higher mortality than beetles caged on leaves of controls. The flight characteristics of female western corn rootworms are highly variable. Results to date indicate few differences in flight performance, however, a larger data set may reveal significant differences between treatments.

103 F Impact of multiple insect stress and weed competition on the gas exchange rates and yield of field corn. **Scott W. Myers** and John L. Wedberg, 536 Russell Labs, 1630 Linden Drive, UW-Madison, Madison, WI, 53706

The European corn borer Ostrinia nubilalis (ECB) and western corn rootworm Diabrotica virgifera virgifera (WCR) are the two most destructive pests of corn in the Midwest. Field experiments were performed during 1999 and 2000 to evaluate the impact of the larval feeding of these insects, combined with weed competition from a stand of giant foxtail Setaria faberii. Two row widths were compared in ECB infested plots. The treatments consisted of: ECB infested plants in 0.76 m (30 inch); ECB infested plants in 0.38 m (15 inch) rows; CRW infested plants in 0.76 m rows; GFT (9 plants m2) in 0.76 m rows; ECB and CRW infested plants in 0.76 m rows; ECB and GFT infested plants in 0.76 m rows; and check plots of uninfested plants in both 0.76 m rows and 0.38 m rows. A portable photosynthesis system (LI-6400) was used to measure gas exchange rates in developing corn plants. Results showed that the ECB infested plots were significantly lower in yield compared to the respective check plots in both 0.38 m and 0.76 m rows. The CRW infested treatment, however, significantly affected grain yield only in 2000. This was most likely due to the poor establishment of manually infested CRW eggs. The interaction treatment of CRW x ECB showed a reduction in yield as did the interaction of GFT x ECB when compared to the 0.76 m row check plot. Results from measurements of gas exchange rates showed the a marked reduction in photosynthesis resulting from ECB and CRW infestations, however this trend was not apparent in the simultaneous measurements of intercellular CO2, and stomatal conductance.

104 F The Ultimate Model for Predicting Adult Corn Rootworm Emergence. **Timothy M. Nowatzki** and Jon J. Tollefson, Department of Entomology, 13 Insectary Building, Iowa State University, Ames, IA, 50011
Effective management of adult corn rootworms, Diabrotica spp., requires knowledge of their emergence pattern so scouting and insecticide applications can be accurately timed. The objective of this study was to develop and validate species and sex-specific models that reliably predict adult corn rootworm emergence with air degree-days. The models were developed from data collected in 57 Iowa cornfields over five years. Validation was accomplished by comparing the model to emergence data collected in 21 additional fields from a separate year. Results from this study should improve adult corn rootworm management by identifying when key events such as initiation, peak and completion of emergence can be expected. Scouting should be more efficient by eliminating unnecessary visits to fields. This is especially important in an areawide corn rootworm management program where scouts are monitoring a large numbers of acres.

105 F Evaluation of Rubidium and Cesium to mark southwestern corn borer (SWCB), *Diatraea grandiosella* Dyar, (Lepidoptera: Pyralidae) for dispersal studies. **Jawwad A. Qureshi**, Lawrent L. Buschman and Sonny B. Ramaswamy, 123 West Waters Hall, Department of Entomology, Kansas State University, Manhattan, KS, 66506
The current resistance management program for corn borers in Bt corn depends on dispersal of corn borer moths from a non-Bt corn refuge planting into Bt cornfields. Therefore, we need information on how much corn borer dispersal is likely to occur between cornfields. The rare earth elements, Rubidium (Rb) and Cesium (Cs), have been used by others to study dispersal of various insects. In the current study, these elements were evaluated for use in determining dispersal of southwestern corn borers (SWCB), Diatraea grandiosella, Dyar in cornfields. Corn plants were grown in the greenhouse and treated at the 6-8-leaf stage with RbCl and CsCl at rates of 100, 1000, or 10,000 ppm. After the plants dried, they were inoculated with SWCB neonates. Plants were dissected 5 weeks later to take plant samples to measure absorption and translocation of elements within the plant. Recovered SWCB larvae and pupae were held for moth emergence. The moths were tested to determine transfer of Rb or Cs into SWCB feeding on treated plants. Plant and insect samples were evaluated using a Perkin Elmer AAnalyst 100 Atomic Absorption Spectrophotometer (AAS). Both Rb and Cs were absorbed and translocated throughout the plant. In all plant parts they were detected at rates that differed significantly between treated and untreated plants and between treatment rates. SWCB survival appeared to be affected at the higher treatment rates. In this preliminary study the elements were not detected in SWCB at rates that could reliably distinguish between insects from treated and untreated plants. However, a significant difference in Cs level was observed between native populations of SWCB and the ones marked on corn plants treated with 1000-ppm of CsCl in the field at Southwest Kansas (Garden City). These moth samples were analyzed using graphite furnace AAS (Model AA800) at Mississippi State University. The SWCB was also reared in the lab on artificial diet marked with 1000-ppm each of Rb and Cs and were found to have no significant effect on the developmental aspects like pupation rate and adult eclosion.

106 F "Where are the Eggs Being Laid?" A Look at the Seasonal Oviposition Characteristics of a Western Corn Rootworm (Coleoptera: Chrysomelidae) Strain in East Central Illinois Corn and Soybean Fields. **Christopher M. Pierce** and Michael E. Gray, South-318 Turner Hall, MC-046, 1102 South Goodwin Avenue, University of Illinois, Urbana, IL, 61801
The widespread and long-term rotation of corn and soybean,Glycine max L., has been implicated in the selection of a new strain of western corn rootworm, *Diabrotica virgifera virgifera* Leconte, which has expanded oviposition sites to include soybean fields. Historically, female western corn rootworms would lay eggs almost exclusively in cornfields. To better understand the oviposition behavior of western corn rootworms in east central Illinois, we conducted research on the farms of 3 producers in Iroquois County, Illinois, near the epicenter of the crop rotation problem area. Each producer agreed to let us take egg and adult samples from adjacent 16.2-hectare corn and

soybean fields. Twenty soil samples were taken to depths of 10.2 and 20.4 cm in corn and soybeans from 6 July through 15 September in 1999. We determined that significantly more eggs were laid in soybeans than in corn. We also deployed Pherocon AM and vial traps in both crops to determine population densities of adults. Counts of western corn rootworms and the percentage of females were greater on Pherocon AM and vial traps in soybean than in cornfields. Twenty emergence cages were used in cornfields to monitor adult emergence. Peak emergence occurred 3 weeks after the first adults emerged. In 1999, the soybean fields in our study were the preferred oviposition sites for WCR; however, corn was not abandoned as an egg-laying site. In fact, late-planted corn served as a competitive sink for WCR eggs compared with the soybean fields.

107 F Popcorn as a Refuge for European Corn Borer and Corn Rootworms. **Colothdian D. Tate**, 118 Genetics Lab, Iowa State University, Ames, IA, 50014, Richard L. Hellmich and Leslie C. Lewis, 106 Genetics Lab, Iowa State University, USDA-ARS Corn Insects and Crop Genetics Research Unit, Ames, IA, 50011

EPA requires 20% refuge for European corn borer (ECB) resistant transgenic hybrids and may require the same for corn rootworm resistant transgenic hybrids. In this research, field corn (DK 580) and 3 McHone popcorn varieties (M-8368, M-140, and M-3374Y) were evaluated for their effectiveness as refuge for both insects. Treatments were plantings of field corn, the popcorn varieties individually, and combinations of 2 popcorn varieties or all 3 popcorn varieties. Plots were sampled weekly for corn rootworm beetles, using pill vial traps. Ten stalks were dissected to estimate ECB density, at the end of the season. Significantly more western corn rootworm beetles were collected from M-3374Y alone, the M-140 and M-3374Y combination, and the combination of all 3 popcorn varieties than in the field corn. No treatment had significantly more ECB larvae than the field corn. Studies also were conducted to test the impact popcorn refuge may have on ECB distribution in field corn. Three stands of M-140 separated by 61m were planted in the center of field corn at 3 locations in Iowa. At the end of the season, plants were dissected in the popcorn plot and at 0.76m, 1.52m, 3.05m, 6.1m, and 12.2m into the field corn. Tunneling damage and ECB densities were recorded for plants at each distance. Significantly more larvae were found in popcorn than in field corn. Larval density tended to decrease as distance from the popcorn increased. Popcorn was effective in attracting corn rootworm beetles and did not disturb ECB distribution within the cornfield.

108 C Predation of immature and adult potato leafhoppers by three predatory insect species. **Laura Anne Weiser** and John J. Obrycki, 4 Insectary, Iowa State University, Ames, IA, 50014

Empoasca fabae (Harris) (Homoptera: Cicadellidae), an important insect pest of alfalfa in the Midwest, is typically managed using insecticides. This approach not only kills *E. fabae* but also its natural enemies, which could be of importance in the suppression of *E. fabae*. Several insect predators have been observed feeding on immature and adult leafhoppers but few studies have quantified predation rates of *E. fabae* by multiple predatory species. Therefore, the current study examined the rate of predation of *E. fabae* by adults of three species commonly found in alfalfa, *Coleomegilla maculata* (DeGeer) (Coleoptera: Coccinellidae), *Nabis roseipennis* (Reuter) (Hemiptera: Nabidae), and *Orius insidiosus* (Say) (Hemiptera: Anthocoridae). Previous feeding studies of *E. fabae* nymphs and adults have only considered *N. roseipennis* or used unidentified leafhoppers. Individual predators and two densities of *E. fabae* (15 or 5 nymphs and 10 or 3 adults) were introduced into a feeding arena; individual fava bean plants (*Vicia faba*) caged with dialysis tubing. After 24 hours, adult *C. maculata* and *O. insidiosus* consumed 2 – 3 times more *E. fabae* nymphs than adults. In contrast, similar numbers of adult and nymphal E. fabae were consumed by *N. roseipennis* (0.09 ± 0.03 and 0.14 ± 0.02, respectively). Similar numbers of adult E. fabae were consumed by the three predatory species. However, *C. maculata* consumed significantly more nymphal *E. fabae* than *N. roseipennis*, but was not significantly different from *O. insidiosus*. Due to their high relative abundance in alfalfa fields, these predatory species may have a significant effect on *E. fabae* populations.

109 C Temporal and Spatial Aspects of Site Specific Management for the Green Peach Aphid, *Myzus persicae* (Sulzer), in Potatoes. **Matthew W. Carroll**, Ian Macrae, Robert Suranyi, Ted Radcliffe and Dave Ragsdale, 219 Hodson Hall, 1980 Folwell Ave., University of Minnesota, St. Paul, MN, 55108
Green peach aphid, *Myzus persicae* (Sulzer), is the primary vector of potato leaf roll virus (PLRV). Its summer migration is largely responsible for movement of PLRV from commercial potato fields into seed potato fields. In 1999, it was noted that green peach aphid (GPA) initially colonizes field edges. This provided an opportunity to target management tactics at the field margins. These efforts were successful but the spatial and temporal window within which site specific management is possible was not determined. The dispersal rate of GPA from the field margins into the field determines this window of opportunity and the decrease in treatment expenditures with respect to time. GPA populations were sampled twice weekly on a 46-acre field to determine their initial colonization and subsequent rate of spread across the field. The resulting temporal and spatial window of opportunity for site specific management was defined and will be discussed.

110 C Monarch larvae survive near *Bt* corn: two year field study**. Robert L. Koch**, William D. Hutchison and Robert C. Venette, 219 Hodson Hall, 1980 Folwell Ave, University of Minnesota, St. Paul, MN, 55108
Transgenic corn, engineered to express toxins from the bacterium, Bacillus thuringiensis (Berliner) (Bt), continues to be grown over ca. 19% of the Midwestern U.S. corn belt. In the laboratory, pollen from Bt corn increases larval mortality of the monarch butterfly, Danaus plexippus (L.). No field data have been published on monarch survival near Bt corn, but we hypothesize that larval mortality should be greater on milkweed, Asclepias syriaca (L.), plants that are closer to Bt corn than on more distant milkweed. We conducted two field studies to examine the effects of Bt corn on monarch survival. In 1999, milkweed growing near fields of Bt field corn (events Mon810 and DBT418) and non-Bt field corn were infested with first instar monarch larvae during corn anthesis. In 2000, potted milkweed placed at the four cardinal directions from a field of Bt field corn (event Bt 11), at distances of 0, 1, 2, and 8 meters, were infested with first instar monarch larvae during corn anthesis. In both studies, larval survival and development were monitored for seven days. Larvae survived equally well on milkweed near Bt corn as on milkweed near non-Bt corn. Survival tended to be higher at distances nearer the Bt corn field. However, direction of milkweed from the Bt corn field did not effect survival. These results suggest that exposure of monarch larvae to Bt pollen under field conditions is low or that other mortality factors overshadow any effect that Bt pollen may have on monarch larval survival.

111 C Oviposition Preference of the Western Corn Rootworm (Coleoptera: Chysomelidae) in East Central Illinois. **Silvia I. Rondon** and Michael E. Gray, 101 Turner Hall 1102 South Goodwin Avenue, University of Illinois, Urbana, IL, 61801
The rigid rotation of maize and soybeans has been the traditional management strategy to control the western corn rootworm, Diabrotica virgifera virgifera LeConte, throughout the Corn Belt of the United States. During the mid-1990s producers in east central Illinois and northwestern Indiana witnessed severe rootworm larval injury in rotated corn. One of the reasons attributed to the failure of this cultural strategy was the apparent behavioral shift in western corn rootworm oviposition to include soybean fields. At a location near Urbana, IL, we evaluated the potential usefulness of inserting other crops into the maize and soybean rotation. We arranged the following crops in a five by five Latin Square experimental design: 1) maize, Zea mays (L.); 2) soybean, Glycine max, 17.8 cm row; 3) soybean 76.2 cm row; 4) alfalfa, Medicago sativa L, and 5) oat stubble, Avena sativa L. Each of the twenty-five plots (replicated by crop treatments) was 0.1 ha in size. Surrounding the experiment, 48 rows of maize were planted (four dates) on each side of the overall

experiment. Planting dates ranged from 20 April through 1 June in 1998, 5 April through 28 May in 1999, and 6 April through 1 July in 2000. Adults were monitored using emergence cages, Pherocon AM sticky traps, vial traps, and malaise traps. Soil samples were taken following oviposition, eggs extracted, and western, northern, Diabrotica barberi Smith & Lawrence, and southern corn rootworm, Diabrotica undecimpunctata howardi, were identified through differences in their chorion sculpturing. Data from Pherocon AM sticky traps and vial traps revealed that females were more abundant than males in crops other than maize, and suggested that they may be seeking alternative crops in which to lay their eggs. However, eggs retrieved from soil samples in 1998 and 1999 indicated that maize continued to be a major sink for western corn rootworm eggs. In both years, there were twice as many eggs laid in maize than in the other crops. In 2000, there were no significant differences in egg densities between maize and soybeans in either row spacing treatment. The average number of eggs in maize increased three folds from 1998 to 2000 (19.2 to 60.8 eggs/0.45l of soil). However, in the other crops the increase in egg density was approximately sixteen times greater (2.7 to 42.7 eggs/0.45l of soil). Since oviposition occurs in other crops, a rotation of maize with crops such as alfalfa or oats is unlikely to work as an effective cultural strategy to deter western corn rootworm oviposition. In 1999, late-planted maize attracted more western corn rootworm females and concomitant egg laying compared with early-planted maize, but in the following year, there were no statistical differences.

112 B Identification of components of osage orange fruit and their repellency to German cockroaches **Chris J. Peterson**, Jun-Wei . Zhu and Joel R. Coats, 116 Insectary, Iowa State University, Ames, IA, 50011

The fruit of the osage orange tree, Maclura pomifera, was extracted by using several methods. The extracts obtained from each technique were analyzed by using gas chromatography and mass spectroscopy to identify components. This is the first report of volatile constituents from this fruit. Several compounds of terpenoid structure, mostly sesquiterpenoids, were detected in the extracts. The behavioral response of German cockroaches, Blattella germanica, to the extracts was evaluated in a choice arena and the extracts were found to be repellent. Individual compounds were isolated or purchased then tested. Several compounds were found to be repellent.

113 B Fumigation Toxicity of Natural and Synthetic Cyanohydrins and QSAR . **Dong-Sik Park**, Chris Peterson, Justin Grodnitzky and Joel R. Coats, 112 Insectary, Iowa State University, Ames, IA, 50011

After synthesis of some derivatives and analogs of cyanohydrins, insecticidal fumigation toxicity of natural and synthetic cyanohydrins was evaluated with five species of insects : lesser grain borer (Rhyzopertha dominica), red flour beetle (Tribolium castaneum), sawtoothed grain beetle (Oryzaephilus surinamensis), maize weevil (Sitophilus zeamais) and house fly (Musca domestica). The fumigation LC50 values were calculated by Probit analysis. Using toxicity data of these cyanohydrins and one species (house fly), the quantitative structure-relationships of cyanohydrins were examined as well. For house flies, all but one of the cyanohydrins tested were more toxic than TeloneTM. DMK, MEK, CHP, CPC, CPM, MVK and DDMK were as toxic as chloropicrin. CHP, MVK were as toxic as dichlorvos. For the lesser grain borer, all cyanohydrins tested were more toxic than TeloneTM. All but one of the cyanohydrins tested were more toxic than Chloropicrin. CHP, MVK and CHP-ace were as toxic as dichlorvos. CHP-me was the most toxic to red flour beetle, but was much less toxic to the sawtoothed grain beetle and maize weevil. CPM was the most toxic to the maize weevil. The octanol/water partition coefficient (Log P), polarizability and molar refractivity are the best descriptors to explain the relationship between the toxicity of cyanohydrins and toxicity to the house fly.

114 Introduction. **R. K. Krell**, 110 Insectary, Dept. of Entomology, Iowa State Univ., Ames, IA 50010

115 C.V. Riley Entomological Society: Student ambassadors for entomology at the University of Missouri-Columbia. **C. T. Luppens**, 1-87 Ag Building, Dept. of Entomology, Univ. of Missouri-Columbia, Columbia, MO, 65211
The C.V. Riley Entomological Society is a student-organized association of students, faculty, and staff at the University of Missouri-Columbia who share a common interest in entomology. The objectives of the society are to stimulate interest and increase knowledge in the science of entomology and to foster a spirit of fellowship among its members. The Society's members organize and participate in many activities that fulfill these goals throughout the year. These activities include: presenting insect displays at annual community events, taking part in social events, and arranging fundraisers to enhance the viability of these events. The activities will be discussed in detail during this presentation.

116 A full house of bugs and butterflies; opportunities for graduate student outreach at Michigan State University. **M. E. O'Neal**, K. Agle, J. Donovan, B. Simmons, L. Palombi and M. Mugg, 204 CIPS, Dept. of Entomology, Michigan State Univ., East Lansing, MI, 48824
The department of Entomology at Michigan State University has established two facilities for community outreach, the Bug house and the Butterfly house, each providing graduate students in entomology an opportunity to share their interest in entomology with the public. Participation ranges from volunteer, paid staff and assistantships to support graduate study. The Bug House is a museum of hands-on displays and an extensive collection of pinned and live specimens that visitors can explore t through guided tours or evening open-house. A nominal tour-fee supports a staff of undergraduate and graduate students guides. Attendance has continually grown, with 1896 students from 35 schools visiting last semester. The Bug House operates under a larger umbrella of outreach, which includes Bug Camp and a Student Mentoring Program. Bug camp is a summer program conducted by graduate students for school-age children to further explore their interest in entomology. The Student Mentor Program allows graduate students to volunteer within school classrooms, 1 day a week for a semester and culminates with a Science Fair held at the MSU Pavilion. The Butterfly House is a cooperative facility administered by the Departments of Entomology, Botany and Plant Pathology, and is currently located in the Plant and Soil Sciences Teaching greenhouse. Visitors can observe local butterflies in a free-flight environment, and study educational and life history displays. Tours are lead by graduate and undergradute students trained by a staff that includes an Entomology graduate supported through a research/outreach assistantship.

117 Bruner Club, Bug Bash, and Bumble Boosters: Graduate Student Outreach and Community Involvement at the University of Nebraska. **D. A. Golick**, Dept. of Entomology, 208 Plant Industry BLDG., Univ. of Nebraska, Lincoln, NE, 68583
The Bruner Club is a social, academic, and outreach club organized by University of Nebraska Entomology graduate students. Bruner Club members organize several social events that help them become acquainted with fellow graduate students and faculty members including; international dinners, sporting events, cook-outs, and canoe trips. Bruner Club members also raise money to support club activities and student travel funds by selling tee shirts and honey. Fundraising money is also used to support visiting scientists and lecturers. The Bruner Club's biggest outreach involvement is the Bug Bash . Bug Bash is held annually, and is a cooperative effort between the University of Nebraska Entomology Department and Lincoln Public Schools. Bruner Club members teach high school students eight thematic learning stations involving entomological concepts. These high school students, in turn, teach over 500 fourth graders entomology concepts through hands-on learning activities. Outside of Bruner Club graduate students have found many other ways

to become involved in outreach including teaching entomology content to behaviorally challenged elementary students, judging at the state fair, speaking to environmental groups, and the Bumble Boosters project. Through outreach activities graduate students have gained an increased sense of community involvement and helped improve the visibility of the entomology department.

118 2001: The Entomological Graduate Student Odyssey - Excellence in Education, Teaching, Research, Extension and Outreach at the University of Illinois**. C. M. Pierce**, S-327 Turner Hall, MC-046, 1102 South Goodwin Avenue, Dept. of Entomology, Univ. of Illinois, Urbana, IL, 61801
The graduate students in the Department of Entomology are a group with diverse backgrounds and interests. Yet, despite differing goals and experiences, the students are a cohesive group with a common voice (the EGSA - Entomology Graduate Students Association), engaging in group activities that are scientific, outreach, and social in nature. Graduate students play an integral part in the teaching and development of undergraduate students through the School of Integrative Biology as well as through the Department of Entomology and the courses it offers at the University of Illinois. The Department of Entomology provides graduate students with an amazing diversity of training and research experiences. The disciplines of evolution, ecology, behavior, physiology, neuroscience, and molecular genetics as well as pressing problems in agriculture and medical entomology, provide our graduate students with a broad and interdisciplinary training experience that allows them to be competitive for positions in science in the 21st century. The existence of the EGSA at the University of Illinois reveals that, after courses, prelims, research, teaching, and other commitments, we graduate students still have a lot of love for entomology to go around. The outward manifestation of this love is our goal to promote a better understanding of entomology through community outreach. Through such activities such as the Insect Film Fear Festival, the Insect Expo, the Bees and Beekeeping Short Course and countless others, graduate students have the opportunity to share their enthusiasm and knowledge with the community and promote the University throughout the state.

119 Insect Ambassadors: Motivating Kids to Learn about Science.
A. T. Walston and K. E. Haberkern, 1630 Linden Dr. Rm. 246, Dept. of Entomology, Univ. of Wisconsin-Madison, Madison, WI, 53706
The Insect Ambassadors are a select group of enthusiastic graduate and undergraduate students from the University of Wisconsin-Madison. These students volunteer their time to travel to local schools, clubs and organizations to give interactive presentations about insects and related arthropods. The purpose of the program is to teach members of the audience about insects, where they live, how they survive, and the positive things they do for our environment. In addition to presenting live and preserved arthropods, Insect Ambassadors provide facts and fascinating stories. Through this outreach program, the goal of the Insect Ambassadors is to stimulate children and adults to learn and to seek out information about insects. This program is registered as a non-profit student organization with the University of Wisconsin-Madison and is sponsored by the Department of Entomology. No fees are charged to the patrons, but donations are accepted. In less than one year approximately 1,500 children and adults from elementary school classes, boy-scout troops, day care center, and day camps have benefited from presentations. Activity ideas and resources for continued learning are provided upon request. Insect Ambassador volunteers enjoy working with participants of all ages and value the teaching experience. As the Insect Ambassador program grows, we hope to offer other services including collecting and pinning sessions for members of our community.

120 Graduate Students at Purdue University Bringing Entomology to the Masses. **P. Randolph**, Dept. of Entomology, Purdue University, West Lafayette, IN 47907
The Department of Entomology at Purdue University provides numerous opportunities for graduate students to be involved in outreach. Our department has been a leader in bringing the science and excitement of entomology to the masses. As a result, the students in our department have numerous opportunities, through events such as Bug Bowl, Insectaganza, and the Science Olympiad, to interact with and share their knowledge to a public which is truly fascinated, yet leery, of our subject matter. In addition to these events, typical activities students participate in include cockroach racing at the state fair, manning stations at insect festivals throughout the state, and classroom presentations.

121 Bringing the public back to the hive; Improving communications between faculty, graduate students and the general public. **M. Carroll**, Dept. of Entomology, Univ. of Minnesota, 219 Hodson Hall, 1980 Folwell Ave., St. Paul, MN 55108
There is a regrettable communication gap between scientists, their graduate students and the general population. While it is unthinkable that science can be conducted democratically, it is equally unthinkable to allow scientists to become insulated from both the public and the graduate students they employ. To address this issue, possible solutions will be presented to issues that often cause conflict between the graduate student and the major advisor and ways to allow a willing and concerned public to have a voice in scientific issues.

122 Pumpkins and Popcorn: Graduate Student Initiatives at Iowa State University. **R. K. Krell**, 110 Insectary, Dept. of Entomology, Iowa State University, Ames, IA, 50011
The Entomology Graduate Student Organization (EGSO) at Iowa State University organizes several events in the Department of Entomology and the local community. To sponsor these events, the EGSO holds at least one fundraiser each year. In the past, fundraising activities have included growing and selling pumpkins or popcorn, selling insect pins, and selling t-shirts and polo shirts. Each year, some of these funds are used to bring in an invited speaker to give a departmental seminar and a seminar for the university community. The EGSO also sponsors activities to increase communication between students and faculty. These activities include hosting a fall picnic, organizing a reception prior to each departmental seminar, inviting faculty as guests to informal brown-bag lunch discussions, and occasionally competing with faculty in sporting events. Graduate students contribute to the local community through outreach presentations using live insects from the department's insect zoo. Also, each year two graduate students serve as judges for the Iowa Science Fair and the EGSO sponsors a special award for an outstanding project involving insects. Occasionally, the EGSO has also taken on special projects like buying books for and creating a departmental library and writing a grant to purchase a digital video projector for a teaching lab. In all of these activities, students have gained valuable experiences beyond research and coursework and the department has gained from these contributions and increased visibility in the university and throughout the state.

123 Challenges of a Blended Department: The Evolving Role of the Student Club in Bridging the Gaps. **K. A. Kramer**, C120 Plant Sciences, Dept. of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO, 80523
In 1912, C.P. Gillette, Colorado State University's first entomologist, established The Entomology Club, giving it the distinction of being CSU's oldest student organization. After various name changes and numerous departmental affiliation shifts, it is now known as the Gillette Entomology Club (GEC). The club is now an affiliate of the Department of Bioagricultural Sciences and Pest Management. The current department integrates not only all aspects of entomology, but weed science and plant pathology as well. Departmental integration may be a growing trend among universities nationwide. Conceivably, even students within large departments not facing integration, may welcome a means of interacting within the discipline. The Gillette

Entomology Club has played a certain role in trying to maintain an entomological identity while still encouraging participation of students from the other disciplines. Student members take part in a wide variety of educational and outreach activities. In addition the club brings at least four invited speakers to campus each academic year. It is through these functions that the club not only reaches out to the community at large, but to the community on campus and within the department as well. It has provided a forum for interactions amongst students and faculty from the various disciplines that might otherwise not occur in the ordinary academic setting. Though the departmental relationship has continued to evolve over the years, the primary purpose remains the same: to promote education and enthusiasm in the field of entomology.

124 Concluding remarks. **R. K. Krell**, 110 Insectary, Dept. of Entomology, Iowa State Univ., Ames, IA 50010

125 Qualified Successes, Likely Failures and Prospects for Biological Control of Aphids in Field Crops. **David J. Horn**, Ohio State Univ.Ohio State Univ.Department of Entomology, Columbus, OH 43210
I review several apparent successes and failures of biological control against field crop aphids in the midwestern USA. These programs have relied on classical importation of exotic natural enemies as well as on augmentation of agroecosystems to encourage pre-existing biological control. Introduction of generalist predators and parasitoids such as the seven-spotted lady beetle ("C7") and several species of Aphidiidae have resulted in successful expansion of the natural enemy complex and have doubtless contributed to reduction in populations of such pests as pea aphid, spotted alfalfa aphid and Russian wheat aphid. However, the tendency of both exotic and native natural enemies to aggregate in areas of high aphid density limits their impact, and effective biological control sometimes occurs only after plants have sustained injury and yield loss is inevitable. Effective biological control of field crop aphids could be achieved by inundative releases of predators although this is not normally practical. More effort needs to be expended on developing agroecosystem alterations that enhance existing natural enemy complexes. Biological control of aphid species that transmit pathogens may remain difficult to achieve due to their lower economic injury levels.

126 Impact of Indigenous Coccinellids on Small Grain Aphids in Wheat, with Notes on the 1986 Russian Wheat Aphid Invasion. **G. J. Michels**, Jr., D. A. Owings & J. B. Bible, Texas A & M,Texas A & M, Research & Extension Ctr. Busland, TX 79012
Exclusion experiments conducted in Texas Panhandle winter wheat fields from 1993-1995 demonstrated that naturally-occurring predaceous coccinellids (primarily Hippodamia sp.) had a significant impact on Russian wheat aphid, Diuraphis noxia (Kurdjimov), and greenbug, Schizaphis graminum (Rondani), average aphid density and percentage aphid reduction in both irrigated and dryland habitats. Naturally-occurring predaceous coccinellids significantly reduced Russian wheat aphid and greenbug densities in irrigated and dryland winter wheat on a regular basis in the Texas Panhandle. The coccinellids were able to locate and attack isolated aphid infestations even when overall aphid density in the field was very low. Although the impact on aphid density varied from season to season and year to year, the percentage reduction in aphid density was relatively constant, averaging 54% for Russian wheat aphids and 63% for greenbugs across all years and all seasons. There was no evidence that naturally-occurring or established exotic parasitoids had a similar impact. In regard to the 1986 invasion of the Russian wheat aphid, coccinellid predators may have not been able to control the aphid due to favorable climatic conditions that allowed the aphids to build to extremely high densities. After 1990, warm and dry conditions may have eliminated favorable oversummering sites and green bridges for Russian wheat aphids in the Texas Panhandle, reducing overall aphid density, and allowing native coccinellids to maintain control.

127 Role of biological control and plant resistance in management of greenbugs in grain sorghums. **Robert J. Wright** & Z. B. Mayo, University. of Nebraska, CLay Center, NE 68933
The roles of sorghum plant resistance and biological control in management of greenbugs (Schizaphis graminum) have been examined in greenhouse, field cage, small plot and onfarm field studies in Nebraska. Both generalist predatory insects (lady beetles and chrysopids) and a parasitoid wasp(Lysiphlebus testaceipes) contribute to biological control of greenbugs. Although research has shown that resistant sorghum hybrids may have detrimental effects on the growth or survival of L. testaceipes and lady beetles, our research demonstrates these natural enemies play an important role in reducing damage from greenbugs in resistant and susceptible sorghum hybrids.

128 Habitat modification to enhance biological control of aphids in apple orchards. **Paul M. Whitaker,** 518 South Seventh Ave., University of Wisconsin Marathon County, Wausau, WI, 54401
Several aphid species are common secondary pests of apples throughout much of the northern hemisphere. Although aphids often reach damaging levels in apple orchards, a diverse assemblage of natural enemies often regulates aphid populations on apple trees, preventing damage from reaching unacceptable levels. Orchard management practices and habitat characteristics within and around an apple orchard can strongly influence aphid abundance in the orchard. In some situations, aphid abundance in an orchard may be directly affected by non-crop vegetation, such as when the non-crop vegetation includes alternate host plants for host-alternating aphids. It is increasingly apparent, however, that non-crop vegetation in and around an orchard influences aphid abundance in orchards indirectly, through effects on natural enemies of aphids. Non-crop vegetation has been shown to locally enhance natural enemies of orchard aphids by at least two mechanisms: the presence of alternate hosts or prey on the non-crop vegetation, and the provision of pollen and/or nectar as foods for natural enemies. This talk will summarize recent work from North America and Europe on the influence of habitat on several species of apple aphids and their natural enemies, including efforts to modify orchard habitats to enhance biological control of aphids.

129 Conservation of natural enemies of green peach aphid in potato production. **David W. Ragsdale**, JorgeRuano-Rossil and Edward B. Radcliffe, 1980 Folwell Ave., 219 Hodson Hall, University of Minnesota, St. Paul, MN, 55108
Potato producers throughout North America now must apply fungicides on a 5-7 day schedule to protect foliage from a recently introduced metalaxyl (Ridomil) resistant strain of Phytophthora infestans, the causative agent of late blight. Previous work in our laboratory showed that fungicides used for late blight control were detrimental to several species of entomopathogenic fungi. Beginning in 1995 growers began experiencing unprecedented yield and quality losses caused by direct feeding damage of green peach aphids. Yield losses exceeding 150 cwt/acre were not uncommon. Here we show that fungicides use alone cannot cause aphid populations to flare. However, when broad spectrum insecticides are used to control other potato pests like Colorado potato beetle or potato leafhopper, aphid predators and parasitoids are killed and release aphids from these natural control agents. When insecticides are used in combination with fungicides, aphid populations reach densities that are many fold larger than when either insecticides or fungicides are used alone. The most common aphid pathogens found in our studies are Entomophthora planchoniana, Pandora neoaphidis, and Zoophthora radicans (Entomophthorales: Entomophthoraceae) and Conidiobolus coronatus, Conidiobolus obscurus, Conidiobolus thromboides (Entomophthorales: Ancylistaceae). Common potato fungicides adversely affected all species of entomopathogens. The key to preventing aphid outbreaks was to avoid multiple applications of insecticides regardless of the number of fungicides used. Further work is needed to identify the key predators and parasites in the potato production system.

130 The potential for biological control of soybean aphid in the United States. **George E. Heimpel** & Zhishan Wu, Univ. of Minnesota, St. Paul, MN 55108
The soybean aphid (SBA), *Aphis glycines* Matsumura, is a pest of soybeans in northern and eastern Asia, and has recently invaded North America. While control of SBA in Asia consists almost entirely of insecticide use, the limited information available on biological control does indicate that coccinellid beetles and aphidiine parasitoids can impose substantial levels of mortality on SBA. In China, the coccinellids, *H. axyridis* and *Propylaea japonica*, as well as unidentified lacewing larvae and aphidiine parasitoids, were important control agents, and their combined impact on SBA mortality was increased by interplanting corn with soybeans. This result suggests that cultural methods might be effective in encouraging biological control by native or endemic natural enemies. The most detailed study on parasitism of SBA in Asia comes from Korea, where it was found that the level of hyperparasitism exceeded the level of primary parasitism by a factor of 2. The four most important primary parasitoids were *Aphidius cingulatus*, *Ephedrus persicae, E. plagiator,* and *Lysephlebus japonica* (all aphidiines), and the most important hyperparasitoid was *Asaphes vulgaris* (Pteromalidae). The potential for success of classical biological control by parasitoids may be enhanced in the U.S. because of limited insecticide applications in the U.S. soybeans and a potentially lower hyperparasitoid load than found in Asia. Of the aphid parasitoids commercially available in the U.S., we have found that 2, *Aphidius ervi* and *Aphelinus abdominalis*, do not oviposit into SBA.

131 Introduction of symposium. **J. Tollefson** Iowa State University, Ames, IA 50011

132 Registration of Genetically Engineered Corn for Corn Rootworm Control. **S. Matten**, R. Rose, A. Reynolds, USEPA, Office of Pesticide Programs, Environmental Fate and Effects Div., 401 M St. SW, Washington, DC 20460

133 Genetic Engineering for Control of Corn Rootworm Larvae**. K. Ostlie,** Dept. of Entomology, University of Minnesota, 219 Hodson Hall, St. Paul, MN 55108

134 Customer Acceptability of Corn Rootworm Transgenic Hybrids.

135 Sub-lethal effects of Transgenic Corn on Corn Rootworms**. L. Meinke,** Dept. of Entomology, University of Nebraska, Lincoln, NE 68583-0816

136 Impact of Corn Rootworm Transgenics on Non-Target Organisms. **B. Fuller,** South Dakota State University, Rm. 248-C, NPB, Box 2140C, Brookings, SD 57007

137 Resistance Management Challenges for Transgenic Corn Rootworm Hybrids. **M. Gray,** Department of Crop Sciences, University of Illinois UC, S-320 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801

138 Using Simulation Models to Plan the Deployment of Transgenic Corn Rootworm Hybrids. **D. Onstad**, C. Guse, Center for Economic Entomology, Illinois Natural History Survey, 607 E Peabody Drive, Champaign, IL 61820

139 E Untangling the Web: Experiences From Teaching a Distance Education Version of Insect Identification. **William W. Hoback**, 904 S. 25th Street, University of Nebraska Kearney, Kearney, NE, 68849, Leon G. Higley, Department of Entomology, 201 Plant Industry Bldg., University of Nebraska-Lincoln, Lincoln, NE, 68583-0816
Online courses are the most rapidly increasing form of educational delivery however, the ability of online classes to deliver experiences comparable to traditionally hands-on classes like Insect Identification has not been fully explored. As part of the Distance Masters Degree program at the University of Nebraska we developed an online Biology and Classification of Insects class. Students (N = 26) learned about insect classification, identification, and natural history though videotaped lectures, exploration of an online virtual insect collection, and by constructing a traditional insect collection. Assessment was conducted through online practicals (using specimens not seen before by students), exams, and the insect collection. Comparison with a students from a traditional classification class (N = 24) with the same practicals and collection requirements, revealed that online students scored higher on both the practicals (84% vs. 74%) and the insect collection (97% vs 91%). The overall satisfaction of online learners was also high. Our results show that successful online instruction is possible for traditional laboratory-based classes.

140 E The Bumble Boosters Web site: Supporting Science as a Community of Learners. **Douglas A. Golick**, Marion D. Ellis and Leon G. Higley, 208 Plant Industry BLDG. , University of Nebraska, Lincoln, NE, 68583
Bumble Boosters is a science education project funded by the Nebraska Lottery's Educational Innovation Fund. The project engages high school students from 40 schools located throughout Nebraska to conduct authentic research on bumble bees. Participating students gain both entomological content and an understanding of the process of scientific investigation. The Bumble Boosters project is supported by the Bumble Boosters Web site http://bumbleboosters.unl.edu . It features comprehensive reference information about bumble bee biology, morphology, the importance of pollinators in our environment, and interactive instructional modules. Students can identify bumble bee specimens based on hair color patterns using an interactive bumble bee identifier. Specimen collection records for schools can be viewed and submitted using the Bumble Boosters Online database. The Web site also features support materials for teacher use including lesson plans, a question and answer page, Bumble Boosters news updates, information on how to use teaching kit materials, and links to other bumble bee Web sites. In addition to reference information, the Bumble Boosters Web site supports networking and information sharing between partner schools. Partner schools communicate with each other to discuss the project's research problems using the Bumble Boosters List-serv. At the end of the project, cooperating schools' research results will be posted on the Bumble Boosters Web site.

141 B Digestion in the larger black flour beetle, *Cynaeus angustus* (LeConte). **Brenda Oppert** and Michele Zuercher, 1515 College Ave., USDA ARS GMPRC, Manhattan, KS, 66502, Kris Hartzer, Department of Entomology, and Patricia Walters, Division of Biology, Ackert Hall, Kansas State University, Manhattan, KS, 66506
As part of a larger project to understand digestion in stored product beetles, the digestive proteinases of Cynaeus angustus (LeConte) were studied. A common stored grain pest in the United States and Canada, C. angustus causes the most damage during larval stages of development. Grains that are prone to C. angustus contamination may be improved by introducing genes encoding proteins that are toxic to C. angustus. Therefore, we studied C. angustus larval stage digestive proteinases to identify proteinase inhibitors that may enhance seed resistance. Hydrolysis of casein was maximal around pH 6, but activity at alkaline pH without reducing reagents combined with the stimulation of activity with reducing reagents at

acidic pH suggested the presence of both serine and cysteine proteinases. Zymogram analysis indicated one major proteinase activity with higher activity at acidic pH and stimulated by reducing reagents. Hydrolysis with class specific substrates suggested the presence of both trypsin- and chymotrypsin-like proteinases. Inhibition by class specific inhibitors suggested that serine and acidic proteinases are important in C. angustus digestion. These results support a complex system of digestion in C. angustus. Supported by USDA-ARS (summer research internship to PW).

142 C Host discrimination in *Microctonus aethiopoides*, a parasitoid of alfalfa weevil adults, *Hypera postica*: Mathematical models and direct observations**. Abdul Aziz M. Mohamed** and David Hogg, 237 Russell Labs, 1630 Linden Drive, University of Wisconsin-Madison, Madison, WI, 53706

143 C Rearing Conditions and Food as Factors Affecting Development and Predation efficiency of *Typhlodromus mangiferus* Z&B (Acari:Phytoseiidae). **Makram A. Hanna**, Salwa M. Abdel-Halim and Maher F. Ramadan, Cairo University , Fayoum Branch, Faculty of Agriculture, Fayoum, NA
The predaceous mite *Typhlodromus mangiferus* Zaher&borolossy is one of 34 phytoseiid species known in Egypt. The role of these predators in suppression of mite and insect populations is not well appreciated unless present in large numbers. *T. mangiferus* therefore was reared in the lab. to determine the best conditions for colonization. The factors tested were temperature, ralative humidity, food, competition, and starvation tolerance. Durations, prey consumption for all stages as well as the number of eggs laid were observed. Mites were fed on eggs; immatures of the phytophagous mites *Tetranychus urticae* Koch ,*Eutetranychus orientalis* Klein and the white fly *Bemisia tabaci* Genn. Of five temperatures tested, 25 and 30 C were most suitable for immatures development, adult longevity, fecundity of females, and prey consumption. Higher temperatures enhanced egg hatching but reduced %hatch. Of four relative humidities tested, 73% at 25C was the most suitable. Females tolerated starvation for 4 days then died with no eggs laid, while satiated females lived for an average of 20.3 days. Partial starvation reduced fecundity and longevity. Prey immatures, especially of *E. orientalis* were more preferred by the predator than eggs. However, the polytypic diet was the best for colonization. The offspring of one average female in four weeks reached 35.9 compared to 18.6-27.5 on monotypic diets [eggs only] and 22.5-29.4 on ditypic diets [eggs+immatures of one prey species]. Competition for food reduced the number of eggs laid.

144 C Monarch Caterpillar Sensitivity to *Bt* Pollen: Laboratory Bioassays **Richard L. Hellmich**, Keith G. Bidne, James C. Robbins and Leslie C. Lewis, Genetics Laboratory c/o Insectary, Iowa State University, USDA, ARS Corn Insects and Crop Genetics Research Unit, Ames, IA, 50011
Laboratory tests were conducted to determine whether Bt pollen influences survival and weight of monarch butterfly, Danaus plexippus, larvae. Each larva was presented with two leaf disks from common milkweed, Aesclepias syriaca, in a small petri dish with an agar substrate. Pollen was suspended in water and applied to leaves with a thin layer chromatography sprayer. Three types of Bt pollen (BT11, MON810, and 176) were tested in separate tests. For most tests two the Bt pollen treatments were compared to no pollen and non-Bt near isoline pollen controls. Several densities of pollen were tested ranging from 5 to nearly 1,500 pollen grains/cm2. Results indicate that the no effect level for 176 pollen less than 15 pollen grains/cm2. On the other hand, the no effect levels of pollen for BT11, MON810 and Cry1F were greater than 750 pollen grains/cm2 and perhaps higher than 1,000 pollen grains/cm2

145 C Effects of elevated CO2 and O3 on aspen foliar quality and forest tent caterpillar performance. **Brian J. Kopper** and Richard L. Lindroth, 237 Russell labs, University of Wisconsin, Madison, WI, 53714

Elevated CO2 and O3 are known to alter the phytochemistry, physiology, growth, and reproduction of plants. Relatively little is known, however, about how these pollutants affect levels of herbivory. Forest tent caterpillar (Malacosoma disstria H¸bner) is an eruptive species on a wide range of deciduous trees and is widespread in North America. This study evaluated how elevated CO2 and O3 (alone and in combination) affected tent caterpillar performance on two genotypes of trembling aspen (Populus tremuloides Michx.). Forest tent caterpillars were reared from egg hatch through pupation on two aspen genotypes within the Aspen Free-Air CO2 Enrichment (FACE) array, where trees are exposed to elevated CO2 (ambient +200 µL/L), elevated O3 (ambient x 1.5 nL/L), both elevated CO2 and O3, or control treatments. We assessed larval development time, pupal mass, and consumption. In addition, aspen foliage was analyzed to assess pollutant-mediated changes in foliar quality. In general, the elevated CO2 treatment did not affect development time or pupal mass but reduced larval consumption. The O3 treatment decreased larval development time and increased female pupal mass but had no effect on consumption. Finally, the CO2+O3 treatment only reduced larval development time but these results depended on aspen genotype. Changes in insect performance were linked to changes in foliar quality. This study suggests that forest tent caterpillar performance will be minimally affected by elevated CO2 exposure and increase under elevated O3 exposure.

146 C Eggplant Culture, Insect Control, and Yield in Ohio**. Mark E. Headings**, 1328 Dover Road, The Ohio State University Ag. Tech. Institute, Wooster, OH, 44691

Eggplant (*Solanum melongena* L.) is a member of the Solanaceae family, which grows as a perennial in some warm regions of the world, but is cultured as an annual in some cooler regions. It is considered a warm-season crop and is thought to be native to India and China. Eggplants are grown on a limited commercial scale in the USA, with primary production occuring in states such as Florida and New Jersey. Field testing on the culture, insect control, and yield of the Black Beauty variety of eggplant was conducted under Ohio growing conditions during the Summer of 2000. The minimal insect feeding damage observed was caused by the Colorado potato beetle (*Leptinotarsa decemlineata*), Japanese beetle (*Popillia japonica*), and flea beetle (*Epitrix* sp.). Esfenvalerate, Thiodan, and Sevin insecticides were applied to young transplants early in the season, and Hot Pepper Wax and Neem extract were applied to three plots each later in the season. Three additional plots were not given any later insecticide treatments. At the end of the season, fruit was harvested and yield data were collected. It is suggested that eggplant has potential to become a viable alternative commercial crop in cooler climates, such as Ohio, if proper cultural and pest control practices are followed. Further investigations on insect feeding and control on eggplants are anticipated.

147 C Population Trends In Northern Corn Rootworms (Coleoptera: Chrysomelidae). **Michael M. Ellsbury**, 2923 Medary Avenue, Northern Grain Insects Research Laboratory, USDA, ARS, Brookings, SD, 57006, Sharon A. Clay, David E. Clay, Douglas D. Malo, and C. Gregg. Carlson, Plant Science Department, South Dakota State University, Brookings, SD, 57007
Georeferenced grid samples for northern corn rootworm , Diabrotica barberi Smith and Lawrence (Coleoptera: Chrysomelidae) were taken over a 6-year period from two study sites in eastern South Dakota. A site in Moody County, SD was sampled in 1995, 1997 and 1999 and the second site in Brookings Co., SD was sampled in 1996, 1998, and 2000. Both sites were farmed in corn rotated with soybean. Spatial variability in adult emergence at each site was characterized by semivariograms for each year of sampling and adult emergence distributions were graphically interpreted as contour maps overlaid on elevation for each field. The data indicate that during the period of sampling overall population levels of northern corn rootworm were increasing. The results suggest that a cropping system or management strategy as an alternative to the two-year corn/soybean rotation as practiced in the northern Great Plains may be needed to avoid pesticide use for management of extended-diapause northern corn rootworms.

148 D Sticky traps determine the presence of stable flies seasonally at range sites. **John B. Campbell** and David J. Boxler, 161 West University Drive, University of Nebraska, North Platte, NE, 69101
Stable flies previously considered a pest of only confined cattle, have in the past several years been noted as a pest of grazing cattle in the northern plains states. We deployed sticky traps around the perimeter of two pastues which were at least 10 miles from a feedlot or dairy. Eight traps were placed at the cardinal directions and at those directions bisectey .The traps were standard Williams traps (Williams 1973)modified by coating plastic envelopes with tac trap instead of the trap wings.The traps were placed at 1 meter above the ground and were changed weekly. Stable flies were trapped throughout the fly season.

149 D Efficacy of Stratacor Insect Repellent on Stable Flies Affecting Horses and Beef Cattle. **D.J. Boxler** and J.B. Campbell, West Central Research & Extension Center, University of Nebraska, North Platte, NE 69101.
Stratacor insect repellent was initially evaluated during the summer of 1999 using a 15% mineral oil formulation. A 0.05% concentration of permethrin was used as a comparison. Both products were applied to steers by spraying the legs and belly of an animal. Stable fly counts were recorded a 2 hr and 24 hr post-treatment. Stratacor insect repellent provided a reduction in stable fly numbers equal to permethrin. The same concentration of repellent was applied to the legs and belly area of several horses and using an untreated horse for comparison. Fly counts were recorded at 2 hr, 24 hr and 48 hr post-treatment, stable fly numbers were reduced by 84.5%, 65.5% and 23.5%, respectively. During the summer of 2000, two 15% dust formulations of Stratacor insect repellent were evaluated and compared to 0.05% concentration of permethrin for the control of stable flies on beef cattle. Fly counts were recorded at 2 hr, 24 hr, 48 hr and 72 hr post-treatment. Formulation A, reduced stable fly numbers by 95% at 2 hr, 66% at 24 hr,66% at 48 hr and 87% at 72 hr. Formulation B, reduced fly numbers by 94% at 2 hr, 27% at 24 hr, 73% at 48 hr and 69% at 72 hr.